ARIZONA DEPARTMENT OF ENVIRONMENTAL QUALITY
COOPER & COMMERCE WQARF REGISTRY SITE
GILBERT, ARIZONA

OPERATIONS AND MAINTENANCE MANUAL

AIR SPARGE, SOIL VAPOR EXTRACTION, AND GROUNDWATER TREATMENT SYSTEMS

June 29, 2011

Prepared for:

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1. INTRODUCTION

This Operations and Maintenance (O&M) Manual was prepared by Hydro Geo Chem (HGC) for the Arizona Department of Environmental Quality (ADEQ) under Task Assignment EV10-0006 and Contract No. EV09-0100. This manual is for use in operating, monitoring, and maintaining remedial systems installed at the Cooper and Commerce Water Quality Assurance Revolving Fund (WQARF) Registry Site located at 619 West Commerce Avenue in Gilbert, Arizona (the Site), as shown in Figure 1. Remedial systems installed at the Site include an air sparging (AS) system, a soil vapor extraction (SVE) system, and a groundwater pump and treat system. Remedial systems have been installed as part of an Early Response Action (ERA) to remove tetrachloroethylene (PCE) from soil and groundwater underlying the Site. Granular activated carbon is used to control volatile organic compound (VOC) emissions from the SVE system and to remove VOCs from extracted groundwater.

1.1 Background Information

The Cooper and Commerce WQARF Registry Site was established after PCE was detected in groundwater samples from production wells operated by the Town of Gilbert. The impacted area has been estimated to extend to Encinas Street to the north, Neely Street to the east, the Neely Ranch Preserve to the south, and Ocotillo Drive to the west**.** The presence of PCE in this area is believed to be the result of releases from a former industrial facility operated by Unichem International, Inc. (Unichem). ADEQ initiated ERA activities that included release investigation and remedial efforts. Investigative efforts have included periodic monitoring of groundwater using wells installed around the Site, as shown in Figure 1. The AS, SVE, and groundwater treatment remedial systems are located in the former Unichem yard, which is now operated as part of a steel fabrication facility owned by Skyline Steel, Inc. The remedial system compound area and wells are shown in Figure 2. Skyline Steel is located at the east end of Commerce Avenue, a cul-de-sac that is accessed from Cooper Road approximately one-half mile south of Guadalupe Road. The site address is 619 West Commerce Avenue in Gilbert, Arizona.

The contaminants of concern in soil and groundwater are PCE and trichloroethylene (TCE). Contaminants of concern in the soil also include arsenic, chromium, copper, petroleum hydrocarbons in the C-6 to C-32 range, mercury, and lead.

ADEQ retained HGC to design and install the AS, SVE, and groundwater treatment remedial systems. The AS/SVE system was designed to remove PCE from subsurface (saturated and unsaturated) soil using the process of in situ air stripping via two dual AS/SVE wells. Prior to atmospheric discharge, the combined soil gas stream is treated for removal of volatilized PCE within two activated granular activated carbon canisters operated in series, as an air quality control requirement.

The groundwater extraction, treatment, and discharge system is designed to remove PCE from groundwater from a single extraction well, EW-101. Dissolved PCE is removed from the groundwater using two granular activated carbon adsorbers operated in series and discharged to Salt River Project's (SRP's) Lateral 9.5 canal south of the remedial system compound or to a Town of Gilbert sanitary sewer manhole. Treated groundwater is discharged to the SRP canal under an Arizona Pollution Discharge Elimination System (AZPDES) permit.

1.2 Remedial Action Timeframe

The objectives of the ERA are to address current risk to public health by reducing PCE concentrations in the soil and groundwater underlying the Site and to contain PCE contamination to minimize migration.

Operation of the AS/SVE system is intended to achieve soil remedial goals within the least duration possible. The primary soil remediation goal is to remove PCE from subsurface soil to levels that effectively mitigate further transport of PCE to the aquifer beneath the site. Achievement of this goal will also satisfy a secondary goal of reducing the presence of PCE in subsurface soil to levels that are less than the Arizona non-residential soil remediation level (SRL), currently established at 13 milligrams per kilogram (mg/kg).

Within the projected AS/SVE operating period, the rate of PCE removal from subsurface soil is expected to become diffusion-limited, as identified from a flattening curve of cumulative PCE recovery with time. Upon reaching this condition, the total SVE rate may be reduced, as a cost savings measure, without incurring a significant decrease in the prevailing PCE removal rate. This reduction may be facilitated by alternating the operation of the two AS/SVE wells while maintaining their design SVE rates, in addition to the intermittent operation of shallow SVE wells VP-104 and SVE-105. The operation of only one SVE well at a time will enable PCE to be recovered from potential "dead zones" within the subsurface soil located between the two SVE wells.

Operation of the groundwater pump and treat system is intended to achieve groundwater remedial goals over a period of several to many years, as the existing dissolved plume of PCE within the underlying aquifer is gradually removed by groundwater extraction, in combination with natural attenuation processes. The AS portion of AS/SVE system operations is intended to assist the groundwater extraction and treatment system in the removal of dissolved PCE from the upper portion of the affected aquifer beneath the former PCE release (source) area.

1.3 Management of Remedial Activities

Operation of remedial systems at the Site is under the overall direction of ADEQ, which contracts with consultants for the day-to-day operation and maintenance of the systems and periodic investigations relative to defining the extent of impacted soil and groundwater. HGC is the current consultant used by ADEQ to operate and maintain the remedial systems. An organization chart identifying the current personnel and their contact information is presented in Appendix A.

1.4 Site Access & Site Safety/Security

The Site can only be accessed from Cooper Road (south of Guadalupe Road) by travelling along Commerce Avenue to a cul-de-sac area. Extreme care must be taken while travelling along Commerce Avenue for the following reasons:

- Light industrial facilities exist along both sides of the road, resulting in various vehicles (fork lifts, service trucks, flatbed trucks, tractor trailers) entering and exiting these facilities.
- Vehicles are parked along both sides of the road, creating blind spots for vehicles entering the road.
- Pedestrians (facility workers) frequently travel from facility to facility either along or across the road.
- Occasionally, traffic must stop altogether on Commerce Avenue to allow large rigs to enter or exit a facility. Patience must be practised.

Upon reaching the south side of the cul-de-sac area, the Site is further accessed by turning right and proceeding cautiously through the driveway of Skyline Steel in a southerly direction through the storage yard and then easterly a short distance to the remediation compound enclosed within a chain link fence. As a further safety precaution, always yield to vehicular and pedestrian traffic within the Skyline Steel storage yard and proceed very cautiously.

While conducting local operations monitoring activities, a site-specific OSHA health and safety plan (HASP) must be followed. The HASP developed by HGC for this site is titled Health and Safety Plan Cooper and Commerce WQARF Site and dated May 28, 2010. Each new remediation equipment operator (Operator) must read and understand the HASP, as verified by the employee's signature applied to HASP signature page.

1.5 Purpose of This Manual

This Operation and Maintenance Manual is intended to provide the reader with general details concerning basic operation of the remedial systems at the Site. The remedial systems can only operate efficiently as the design intended if they are properly operated and maintained. Accordingly, this manual will serve as a guide for proper operation and routine maintenance.

This manual was prepared to be a living document in recognition the conditions at the Site may change and changes to the remedial system may occur in the future. This manual should be updated and revised as additional data is collected and as necessary when there are changes to equipment or system for various reasons.

2. REMEDIAL SYSTEM COMPONENTS

Descriptions of the major components of the AS, SVE, and groundwater treatment systems are presented in this section. Major components of each system are listed below. Construction drawings for the SVE system, AS system, and the groundwater remedial system and the groundwater system discharge line are presented in Appendix B. The well completion diagrams for the air sparge wells, vapor extraction wells, and Extraction Well EW-101 are presented in Appendix C. Equipment and instrumentation manuals are presented in Appendix D. Photographs showing system controls, instrumentation, and sampling locations are presented in Appendix E.

SVE System Components

- SVE wells AS/SVE-101, AS/SVE-102, VP-104, and SVE-105
- Soil gas Conveyance, SVE Flow Rate Measurement, and SVE Manifold
- Soil gas Condensate Separation and Transfer
- Vacuum Blower System
- Air to Air Heat Exchanger
- Carbon Canisters VGAC-1 and VGAC-2
- Treated Soil gas Discharge Stack
- Control Panel CP-1
- Control Panel CP-4 - Process Control/Telemetry

AS System Components

- Air Compressor AC-1/Air Receiver T-1 Packaged System
- Compressor Oil Filtration
- Oily Condensate Transfer/Separation/Recovery
- Air Pressure Regulator Compressed Air Conveyance Piping, Air Sparge Manifold, and Air Flow Rate Measurement
- AS wells of AS/SVE-101 and AS/SVE-102

Groundwater Treatment System Components

- Groundwater Extraction Well EW-101 and Pump
- Extracted Groundwater Conveyance, Flow Rate Measurement, and Particulate Matter Filtration
- Liquid-Phase Carbon Vessels LGAC-1 and LGAC-2

- Treated Groundwater Conveyance, Flow Rate Measurement, and Particulate Matter Filtration
- Treated Groundwater Discharge
- Control Panel CP-3
- Control Panel CP-4 - Process Control/Telemetry

2.1 Soil Vapor Extraction System Component Descriptions

2.1.1 SVE Wells AS/SVE-101, AS/SVE-102, VP-104, and SVE-105

Soil gas is extracted from the soil in the vadose (unsaturated) zone to the surface via the SVE wells by operation of the Vacuum Blower system (see Section 2.1.4). Dual-casing wells AS/SVE-101 and AS/SVE-102 can operate simultaneously or individually, each at a maximum flow rate of 150 standard cubic feet per minute (scfm) at a wellhead vacuum pressure of approximately 15 inches water column (WC). Shallow SVE wells VP-104 and SVE-105, both of which extract soil gas from depths of less than 50 feet below land surface (bls), can also be operated either solely or in combination with SVE Wells AS/SVE-101 or AS/SVE-102.

Well completion information for AS/SVE-101 and AS/SVE-102 is presented in Appendix D. The SVE Wells AS/SVE-101 and AS/SVE-102 were installed by HGC for ADEQ and are constructed with 4-inch diameter PVC casing extending to a total depth of 110 feet bls, with well screen (0.060-inch factory slots) between depths of 40 to 110 feet bls. The AS well casing is 2-inch diameter PVC that passes through the SVE casing to a total depth of 150 feet. The AS wells are screened between depths of 145 and 150 feet bls.

Each AS/SVE well head consists of a 4-inch diameter PVC tee with top port fitted with a well seal plate for passage of the AS well casing. Affixed to the well seal plate is a valve port. The valve port is intended for use in monitoring wellhead vacuum pressures and extracted soil gas quality. Each AS/SVE well head is completed below grade within a traffic-rated, concrete vault.

SVE Well VP-104 (also called VW-104) was installed by Hydro Search, Inc. in 1994 for a previous property owner. This well was installed within a former drywell which had been backfilled. An exploratory boring was drilled at the drywell location to a depth of 99 feet bls and then grouted to 50 feet bls. An extraction well was installed in the upper 50 feet of the boring. The extraction well was originally constructed with 4-inch diameter PVC, with solid casing extending from the ground surface to a depth of 5 feet bls and a screened interval between 5 and 50 feet bls with 0.040-inch factory slots. Since completion of the well, sediment has collected at the bottom of the casing such that the screened interval extends to a depth of about 38 feet. The drywell was located in an area suspected to be the primary PCE release point. The top of the casing is connected to a 3-inch diameter PVC riser pipe with a K-type packer to facilitate connection to the SVE manifold. The packer forms a rubber seal between the outside of the 3-inch diameter riser pipe and the inside of the 4-inch diameter well casing.

SVE-105 was installed by HGC for ADEQ. It is located west of the remedial compound where high PCE concentrations were detected in soil samples. SVE-105 was constructed with 4-inch diameter PVC, with solid casing extending from the ground surface to a depth of 5 feet bls and a screened interval of 0.060-inch factory slots between 5 and 50 feet bls.

The depth-to-water beneath the Site (vertical extent of unsaturated soil or vadose zone) ranges from 100 to 130 feet bls, depending upon seasonal weather conditions and operation of the groundwater extraction system.

2.1.2 Soil gas Conveyance, SVE Flow Rate Measurement, and SVE Manifold

Extracted soil gas is conveyed from the wellheads to the SVE manifold through underground piping constructed of 3-inch diameter PVC. The pipes are sloped towards the well heads to allow any soil gas condensate to flow back to the unsaturated soil via the SVE wells, in the opposite direction of soil gas flow. From VP-104, the extracted soil gas is conveyed a short distance above grade to the SVE manifold via the riser pipe. A condensate trap was installed with the underground piping for SVE-105 to capture condensate and allow for its removal. This condensate trap is located in a flush-mounted vault near the southeast corner of the remedial compound.

The SVE conveyance piping is connected to the manifold header by 3-inch diameter PVC pipe. Each riser features an averaging Pitot tube (FE-101, FE-102, FE-103, and FE-104) and 1/2-inch valve port for periodic measurement of soil gas flow rates and vacuum pressures, respectively. The differential pressures across the Pitot tubes are measured with a hand-held, digital differential manometer or water-filled manometer.

The SVE manifold header is constructed with 4-inch diameter PVC pipe, and features an ambient air intake for use during commissioning and certain shutdown procedures. The air intake consists of a 2-inch diameter ball valve and intake filter/silencer.

The SVE manifold and manifold-header are painted white to reflect solar radiation, thereby reducing sensible heat gain to the flowing soil gas streams. A temperature gauge (TI-101) is located on the manifold header for monitoring of soil gas temperature prior to entering the Condensate Separator.

2.1.3 Soil Gas Condensate Separation and Transfer

From the SVE manifold header, the combined soil gas stream from the SVE wells enters the top of the Condensate Separator (resembling a 55-gallon steel drum) through a tangential inlet. This inlet provision induces a cyclonic flow within the separator for impingement of soil gas condensate onto the separator wall. The separated condensate collects within the bottom of the separator. The soil gas stream exits the separator from the top and passes through a particulate filter before reaching the Vacuum Blower intake. The particulate filter removes any dust particles from the soil gas stream that are drawn into the SVE wells from the unsaturated soil.

The bottom drain port and valve assembly of the Condensate Separator is connected to a ¾ HP, 230 volt, 3-phase, 10 gpm centrifugal condensate transfer pump. The discharge side of the pump is equipped with a check valve to prevent any back flow of condensate while the pump is not in operation. The condensate is discharged through a 1½ -inch diameter PVC pipe to the compound sump. Activation of the pump is controlled by a hand, off, auto (HOA) switch located on the SVE control panel. In auto mode the pump is controlled by three float switches installed in the condensate separator tank; a low level switch (LSL), a high level switch (LSH) and a high-high level switch (LSHH). These switches are wired into the programmable logic controller (PLC) located in the SVE control panel. As condensate is collected in the tank and rises to the level of the LSH, the pump is automatically turned on through the PLC and continues to pump condensate into the compound sump until the condensate level falls below the LSL switch, at which point the pump is de-energized. As a safety provision should the pump fail to operate properly and condensate rises to the level of the LSHH, the entire SVE system is shut down and an alarm is called out to a responsible party through the Sensaphone system located in Control Panel 4. If the pump is operated in the hand mode, the PLC control of the pump is bypassed. Caution must be taken when running the pump in this mode so as to not let the pump run dry which could damage it.

The condensate that exits the discharge pipe to the sump will be subsequently transferred with any other liquids that are captured by the sump, such as storm water, to the groundwater treatment system and ultimately discharged either to the SRP Lateral 9.5 Canal or Town of Gilbert (TOG) sanitary sewer manhole.

2.1.4 Vacuum Blower System

From the Condensate Separator and particulate filter, the soil gas stream is conveyed through 4-inch diameter pipe to the Vacuum Blower intake. Installed within this intake piping is a vacuum relief valve (PV) that is adjusted to a set point of 7-inches of mercury vacuum. This valve serves as a common safety device for all SVE system components upstream of the Vacuum Blower. Should the vacuum pressure become excessive, the PV will open, allowing ambient air to enter the SVE system to relieve the excessive vacuum pressure condition. A vacuum pressure gauge (PI) is provided on the intake piping between the vacuum relief valve and Vacuum Blower for monitoring the intake vacuum pressure.

The Vacuum Blower is a positive displacement rotary lobe-type blower, manufactured by Roots (Model Number 59 URAI). The blower is driven by a 20 horsepower (hp), 230 volt, 3 phase, 1770 revolutions per minute (RPM), totally-enclosed fan cooled (TEFC), electric motor with single belt drive and associated belt guard. The blower and motor sheaves are sized for an SVE flow rate of 220 scfm at 2 inches of Hg vacuum pressure and a blower speed of 983 RPM. This SVE rate is slightly greater than the design rate of 200 scfm. Should a higher extraction rate be desirable in the future this can be achieved by changing the sheaves as the blower is capable of moving up to 300 scfm of air. The Vacuum Blower operates continuously as the prime mover for the extraction of soil gas from the SVE wells. A HOA selector switch is located on Control Panel CP-1 for operation of the Vacuum Blower motor. When the HOA selector switch is placed in auto mode, several safety features controlled by sensors are engaged to control the operation of the SVE system through the program in the PLC in conjunction with various relay circuits. These safety system shut down features are described below.

- An adjustable high temperature switch is located at the outlet of the blower. Normally it is set at about 130 ºF to protect the downstream PVC piping from being overheated. Should the temperature of the soil gas stream exceed this value, the SVE will shut down and an alarm condition will be called out to a responsible party through the Sensaphone unit.
- If the condensate level in the condensate tank reaches the level of the LSHH switch, the SVE system will shut down and an alarm condition will be called out through the Sensaphone unit.
- The SVE blower outlet is equipped with a high pressure switch that is currently set at 2 psig. Should the pressure in the outlet pipe from the SVE blower to the carbon canisters exceed this value, the SVE system will shut down by the PLC and an alarm condition will be called out through the Sensaphone unit.
- The SVE system is interlocked with the Air Sparge system through a relay activated by the SVE blower motor starter coil input circuit. If the SVE system is shut down for any reason the valves installed on each AS well will automatically close and an alarm condition will be called out through the Sensaphone unit.

For the purposes of this project, the SVE systems HOA selector switch should always be in the auto mode position for obvious safety reasons. The hand mode is used primarily by a qualified technician to troubleshoot problems that may arise during operation.

From the outlet side of the Vacuum Blower, a discharge silencer is provided for noise reduction. Additionally a pressure gage and sensor installed in the discharge pipe from the blower to the carbon canisters sends a 4 to 20 mA current signal that is wired into an analog input circuit in the Sensaphone system so that discharge pressure can be monitored remotely.

2.1.5 Air to Air Heat Exchanger

At the outlet of the Vacuum Blower, the extracted soil gas stream incurs a temperature increase (sensible heat gain) as a result of the heat of compression. This increase in temperature would typically cause a reduction in PCE adsorption efficiency within Carbon Canisters VGAC-1 and VGAC-2. For this reason, an Air to Air Heat Exchanger with integral fan is provided downstream of the Vacuum Blower to cool the gas stream with ambient air.

The Air to Air Heat Exchanger is constructed as a finned tube unit with 1 hp, 230 volt, 3-phase, forced draft fan and includes a butterfly-type bypass valve for regulation of outlet gas temperature. For this project, the fan must be in operation for proper cooling of the soil gas stream throughout most of the operating year. During the cold winter months typically from November to March the fan may be turned off as excess condensate is produced from drawing relatively warm, moist soil gas into cooler above ground conveyance piping. Therefore by keeping the heat exchanger off the outlet heat produced by the blower will aid in keeping the moisture in the gas stream in the vapor phase. A HOA selector switch is located on Control Panel CP-1 for operation of the fan motor. In auto mode, the fan motor is controlled by a thermostat switch located in the discharge pipe just down stream of the blower outlet. The thermostat is normally adjusted to about 130 ºF which is about 10 ºF cooler that the upper thermal limit that PVC pipe can withstand without damage. If the blower outlet gas temperature exceeds the set point value, the SVE system is shut down through the PLC and an alarm condition is called out to a responsible party through the Sensaphone unit. If the selector switch is placed in the hand position, the PLC control is bypassed. It is highly recommended that during the hot months from April through the end of October that the heat exchanger is run in auto mode.

A temperature indicator (TI) is provided just downstream of the heat exchanger for monitoring of soil gas temperature at this point, which is also considered as the inlet temperature to lead Carbon Canister VGAC-1.

The position of the heat exchanger bypass valve should be periodically adjusted such that the outlet gas temperature as indicated at TI is at an optimum or minimum value to realize the best possible operating efficiency at the carbon canisters. As this valve is partially closed, a greater portion of the vacuum blower discharge stream is forced through the heat exchanger for cooling, which causes an increased resistance to gas flow and corresponding increase in vacuum blower discharge pressure. This increase in discharge pressure also results in an increase in the heat of compression through the vacuum blower, which causes the gas discharge temperature to increase to the heat exchanger. The heat exchanger must then remove this added heat of compression to properly cool the gas. Hence, at certain times of the year, a portion of the vacuum blower discharge stream may need to bypass the heat exchanger to realize the desired, minimum gas temperature to the carbon canisters.

2.1.6 Carbon Canisters VGAC-1 and VGAC-2

As an air quality control requirement, the PCE vapor within the extracted soil gas stream must be removed prior to discharge to the atmosphere, unless the PCE recovery rate is less than 3 lbs/day. To satisfy this requirement, the soil gas stream passes through two adsorber canisters filled with granulated activated carbon. The canisters have been installed in series so PCE molecules are removed from the gas stream upon adsorption onto the surfaces of the carbon in the lead canister and the gas stream is polished as it passes through the lag canister. The capacity of the carbon to adsorb (hold) the PCE is dependent upon the operating temperature of the gas stream, the concentration of the PCE within the gas stream, and the gas flow distribution through the carbon bed. PCE adsorption capacities generally decrease with decreasing PCE concentrations, increasing gas temperatures, increasing moisture content, and gas flow becoming less distributed across the carbon bed. Gas flow distribution through the carbon bed improves with increasing gas flow velocities through the bed or increasing gas differential pressures vertically across the bed. The ultimate PCE capacity of the carbon bed is determined at the point in which PCE "breaks through" the lead carbon canister, defined as less than 90 percent of the PCE being adsorbed within the lead carbon canister.

From the Air-to-Air Heat Exchanger, the soil gas stream, being under a slight positive pressure (approximately 0.5 psig), is conveyed to the inlet of Carbon Canister VGAC-1 within a 4-inch diameter PVC pipe, 4-inch diameter heavy-duty hose, and then an inlet stub with a Camlock connector. Within the PVC pipe, the soil gas flow rate is periodically measured with an averaging Pitot tube (FE-104). The differential pressure across the Pitot tube is measured with a hand-held, digital differential manometer or water-filled manometer. The soil gas flow rate is calculated from the Pitot tube equation using the differential pressure across the Pitot tube, the discrete pressure measured from the static port of the Pitot tube, and the gas temperature indicated at the outlet of the Air-to-Air Heat Exchanger. At the bottom inlet pipe stub of VGAC-1, a 1/2-inch diameter valve port is provided for periodic soil gas sampling and gas pressure measurement with a manometer.

From the lead Carbon Canister, VGAC-1, the treated soil gas stream exits the top through a 4-inch diameter PVC pipe stub with Camlock connector, followed by a heavy duty hose to another 4-inch diameter PVC pipe stub with Camlock connector at the bottom inlet to the lag Carbon Canister, VGAC-2. Each pipe stub features a ½-inch valve port for monitoring of gas pressures and soil gas quality. The pipe stub from the outlet of VGAC-1 also includes a temperature indicator (TI-102) for monitoring of gas temperature changes across VGAC-1. From the lag Carbon Canister, VGAC-2, the treated soil gas stream exits the top through 4-inch diameter PVC pipe and then passes through the Treated Soil Gas Discharge Stack (see Section 2.7). An isolation valve is provided within this outlet pipe to facilitate periodic carbon replacement.

The Carbon Canisters consist of cylindrically-shaped steel tanks, having overall dimensions of 4 feet in diameter by 8 feet high, with access port on the top of the tank. A perforated screen is installed near the bottom of each canister for support of the carbon.

Each canister is filled through the access port with 2,000 lbs of fine-grained (12 x 30 mesh) reactivated carbon. Just prior to breakthrough of PCE from the lead canister, the spent carbon is to be replaced with fresh carbon. In accordance with requirements for the Maricopa County Air Quality permit, the carbon in both the lead and lag canisters must be replaced with fresh carbon after breakthrough occurs from the lead canister.

2.1.7 Treated Soil Gas Discharge Stack

The Treated Soil Gas Discharge Stack constructed with 4-inch diameter PVC pipe is supported between the two carbon canisters and connected to the top outlet of VGAC-2. The top of the open-ended stack extends 15 feet above grade, in conformance with the air quality permit. A ½-inch diameter valve port is provided on the stack, near grade, for periodic sampling of the stack gas stream.

2.1.8 Control Panel CP-1

Control Panel CP-1 is located on the east side of the SVE system skid as shown in the SVE Skid System diagram in Appendix D. This panel is in a NEMA 4 enclosure which contains standard electrical components (i.e., fuse blocks, terminal blocks, “Hand/Off/Auto” selector switches, and green pilot lights); step-down transformers (208 volts AC to 120 volts AC and 120 volts AC to 24 volts DC); an Automation Direct DL-105 Programmable Logic Controller (PLC) with a DirectView 1000 digital display screen; a Sensaphone 1104 Auto-dialer; the motor starters and associated current overload protection devices for the Vacuum Blower motor, Condensate

Transfer Pump motor, and Air to Air Heat Exchanger fan motor; and a 120-volt receptacle. The panel is constructed with a locking, external door and inner door containing the selector switches and indicator lights. This inner door must be opened to access the remaining components within the panel.

The following selector switches and indicator lights are located on the inside door of the Control Panel:

- Control Power - “On/Off” selector switch and green indicator light;
- Vacuum Blower (SVE Blower) - “Hand/Off/Auto” selector switch and green indicator light;
- Condensate Transfer Pump (Transfer Pump) - “Hand/Off/Auto” selector switch and green indicator light;
- Air-to-Air Heat Exchanger fan - “Hand/Off/Auto” selector switch and green indicator light; and
- System Reset Button - PLC reset

The following controls are located within Control Panel CP-1 for operation of the Condensate Separator and Condensate Transfer Pump motor, Vacuum Blower motor, and Air to Air Heat Exchanger fan motor:

2.1.8.1 Condensate Separator CS-1 and Condensate Transfer Pump P-1 Motor Controls

The HOA selector switch for the condensate pump motor should be kept in the Auto position at all times while the system is operating so accumulated condensate will be pumped into the compound sump when the LSL and LSH float switches are activated by rising condensate levels within the condensate tank. If the pump should fail and the condensate level rises to the point of activating the LSHH float switch, the AS/SVE system will shut down and an alarm called out to the responsible party via the Sensaphone unit.

Electrical power (240 volt, 3-phase) is supplied to the Condensate Transfer Pump motor starter and associated current (thermal) overload module from the 240 volt, 3-phase power supply to CP-1 via a common 100-amp circuit breaker. Should any current draw to the motor become excessive, the overload module will actuate to automatically shut down the motor by interrupting the motor starter solenoid control circuit (regardless of selector switch position).

Electrical power supply (120 volt) to the “Hand” position of the respective selector switch originates from the 120-volt power supplied from the step-down transformer. In the “Auto” position, the electrical control power supply is routed through the PLC. In either position, the green indicator light will energize when the motor starter solenoid circuit is energized via the selector switch.

When the condensate level within the Condensate Separator reaches the LSH, this normally-open switch will close to energize input circuit X1 of the PLC, causing output circuit Y1 of the PLC to energize and close the Condensate Transfer Pump motor starter solenoid circuit through the "Auto" position of the respective selector switch, thereby starting the Condensate Transfer Pump.

When the condensate level within the separator reaches the LSL with the Condensate Transfer Pump in auto operation mode, this normally-open switch, while closed when submerged, will open to de-energize input circuit X2 of the PLC, causing output circuit Y1 of the PLC to de-energize and open the Condensate Transfer Pump motor starter solenoid circuit through the "Auto" position of the selector switch, thereby stopping the Condensate Transfer Pump. The associated green indicator light also de-energizes.

With the selector switch in the "Hand" position, the Condensate Transfer Pump will operate continuously, regardless of the liquid level within the Condensate Separator. The Condensate Transfer Pump must not be operated when the liquid level within the Condensate Separator is below the low level switch as this would ultimately damage the pump as it is not designed to run under dry conditions.

2.1.8.2 Vacuum Blower B-1 Motor Controls

Vacuum Blower B-1 is to be operated for this project only with the HOA selector switch in the Auto position so that automatic safety shutdown sensors are activated and when triggered by a system fault will shut down the entire AI/SVE system. Should a system shutdown occur while the selector switch is in the Auto position, the System Reset button on Control Panel CP-1 needs to be pushed before the system can be re-started.

Electrical power (240 volt, 3-phase) is supplied to the Vacuum Blower motor starter and associated current (thermal) overload module from the 240 volt, 3-phase power supply to CP-1 via a common 100-amp circuit breaker. Should the current draw to the motor become excessive, the overload module will actuate to automatically shut down the motor by interrupting the motor starter solenoid control circuit (regardless of respective selector switch position).

Electrical power supply (120 volt) to the Hand position of the respective selector switch originates from the 120-volt power supplied from the step-down transformer. In the "Auto" position, the electrical power supply is routed through the PLC. In either position, the green indicator light will energize when the motor starter solenoid circuit is energized via the selector switch.

When the Vacuum Blower is operated with the selector switch in the “Auto” position, electrical power supply to the Vacuum Blower motor starter solenoid circuit passes through the PLC, as further described below, enabling the blower to automatically shutdown in the event of a high gas pressure, temperature condition, or high-high liquid level condition within the Condensate Separator.

Should the gas pressure at the Vacuum Blower outlet reach the 2 psig set point value of the high pressure switch (PSH), this normally-closed switch will also open (intrinsic) input circuit X4 of the PLC, causing (non-intrinsic) output circuit Y0 of the PLC to de-energize and open the Vacuum Blower motor starter solenoid circuit when the HOA selector switch is in the “Auto” position.

Should the gas temperature at the Vacuum Blower outlet reach the 130 °F set point value of the high temperature switch (TSH), this normally-closed switch will also open (intrinsic) input circuit X5 of the PLC, causing (non-intrinsic) output circuit Y0 of the PLC to de-energize and open the Vacuum Blower motor starter solenoid circuit when the “Auto” position of the HOA selector switch is used to operate the system.

Should the liquid level within the Condensate Separator reach the high-high liquid level switch (LSHH), this normally-closed switch will also open (intrinsic) input circuit X0 of the PLC, causing (non-intrinsic) output circuit Y0 of the PLC to de-energize and open the Vacuum Blower motor starter solenoid circuit through the Auto position of the selector switch.

In the event of an automatic shutdown of the Vacuum Blower, the System Reset button must be pushed to enable a restart of the SVE system. A time out feature is programmed into the PLC where CP-1 selector switches for the Condensate Pump and Heat Exchanger must be in the “Auto” position in order for the system to operate. If any of these switches are in the “Off” position the system will shut down 10 seconds after the SVE blower is placed in the “Auto” position. The time out feature is built into the system as an added safety measure.

2.1.8.3 Air-to-Air Heat Exchanger Fan Motor Controls

Electrical power (240 volt, 3-phase) is supplied to the Air to Air Heat Exchanger motor starter and associated current (thermal) overload module from the 240 volt, 3-phase power supply to

CP-1 via a common 100-amp circuit breaker. Should the current draw to the motor become excessive, the overload module will actuate and shut down the motor by shutting of power to the motor starter solenoid control circuit (regardless of respective selector switch position).

As described in Section 2.1.5, the Air to Air Heat Exchanger is to be operated for this project only with the respective HOA selector switch in the Auto position during the summer months which will shut down the AS/SVE system if the air stream at the outlet of the blower is greater then set point of 130 ºF established by adjusting the thermostat switch located at the blower outlet. During the winter months, the heat exchanger fan can be shut off as ambient air temperature is cool enough to ensure that the blower outlet temperature will not exceed 140 ºF which is the maximum temperature that PVC piping can withstand without suffering thermal distortion.

Electrical power supply (120 volt) to the “Hand” position of the selector switch originates from the 120-volt power supplied from the step-down transformer and then through the “Hand” terminal of the HOA selector switch for the Vacuum Blower. In the “Auto” position, the electrical power supply is routed through the PLC. In either position, the green indicator light will energize when the motor starter solenoid circuit is energized via the selector switch.

2.1.9 Process Monitoring/Control - Control Panel CP-1

Within Control Panel CP-1, the PLC (Automation Direct Model DL-105) and digital display screen and keypad (DirectView 1000) is provided to 1) locally monitor various process conditions and 2) function as the interlock relay device for automatic shutdown of the SVE system when abnormal operating conditions exist. The PLC is connected to various input and output circuits, as described below, including a common alarm output circuit (Y7) which is connected to the Sensaphone unit in CP-4. The PLC is connected to intrinsic (internal) digital input circuit loops that feature the following process status switches and respective input terminal connection locations:

- Condensate Separator LSHH circuit connected to terminal X0;
- Condensate Separator LSH circuit connected to terminal X1;
- Condensate Separator LSL circuit connected to terminal X2;
- High gas pressure switch (PSH) circuit connected to terminal X4;
- High gas temperature switch (TSH) circuit connected to terminal X5;
- Vacuum Blower motor starter auxiliary switch circuit connected to terminal X6;

- Condensate Transfer Pump motor starter auxiliary switch circuit connected to terminal X7;
- Air to Air Heat Exchanger motor starter auxiliary switch circuit connected to terminal X10; and
- System Reset switch circuit connected to terminal X11.

The PLC is also connected to digital output circuits that perform the following programmed functions from respective output terminal connection locations:

- Auto position of Vacuum Blower motor selector switch is energized (120 volt) from terminal Y0 when the following normally-closed switches remain closed: Condensate Separator LSHH, high gas pressure switch, and high gas temperature switch;
- Auto position of Condensate Transfer Pump motor selector switch is energized (120 volt) from terminal Y1 when the normally-open, Condensate Separator LSH is momentarily closed while the normally-open, Condensate Separator LSL is also closed; and
- A common alarm output is energized (24 volt DC) from terminal Y7 to the Sensaphone unit so that if the SVE system shuts down an alarm call out to a responsible party will be initiated.

A relay logic ladder (RLL) diagram of the inputs and outputs of the PLC is included in Appendix D.

2.2 Air Sparge System Component Descriptions

2.2.1 Air Compressor AC-1/CP-2/Air Receiver T-1 Packaged System

The air compressor (AC-1) produces compressed air for use in air sparge operations through the two sparge well casings in Wells AS/SVE-101 and AS/SVE-102. AC-1 is a 25 HP rotary screw compressor (Model UP6-25-125) manufactured by Ingersoll Rand. It has the capacity to deliver 102 scfm at 125 psig. The compressor is connected to a 240-gallon receiver tank equipped with a regulator that can be adjusted to maintain a pressure of up to125 psig. As a safety feature the tank is equipped with a mechanical pressure release valve that opens if the tank pressure exceeds 125 psig. The compressor and receiver tank package are controlled by Control Panel 2 (CP-2), which is integral to the compressor. The control panel utilizes an Intellys microprocessor that is equipped with a finger-touch membrane panel which provides access to all adjustments and key operating parameters. The controller automatically warns or stops the compressor and displays the fault on the microprocessor display screen to aid in troubleshooting. The Intellys system provides five display standards, four adjustable operating parameters, two fault warnings and eight fault shutdowns. The entire Compressor package is powered through a 480V, 3-phase, 50 amp fused disconnect located on the north side of CP-2. The operation manual and equipment cut sheets are provided in Appendix D.

2.2.2 Compressor Oil Filtration

The rotary screw compressor requires specifically designed synthetic oil based coolant to keep it lubricated and cool. Because of this need, the compressed air leaving the receiver tank continuously entrains a small amount of condensate water and coolant oil as an atomized mixture. To provide a clean downstream source of compressed air, the discharge pipe from the receiver tank is equipped with two inline filters connected in series. The first is a general-purpose coalescing/particulate filter designed to remove bulk particles and oil droplets 1 micron and larger. The second is a high efficiency coalescing filter designed to remove fine particulate matter .01 micron and less as well as oil and condensate. Each of these filters is equipped with a differential pressure indicator that is used to determine when the filters need to be replaced. The oil and water mixture trapped by each of the filters is automatically drained into an oil water separator tank described below. Filter operation and maintenance procedures provided by the manufacturer as well as replacement part numbers are located in Appendix D.

2.2.3 Oily Condensate Transfer/Separation/Recovery

The compressor receiving tank as well as the downstream particulate/oil filters drain into a PolySep 250 oil/water separator tank manufactured by Ingersoll Rand. The PolySep efficiently separates the oil from the condensate with an efficiency of up to 99.9 percent. For this project condensate water will be drained into the containment sump for treatment through the two carbon vessels prior to discharge from the remedial system. It is designed to operate on systems up to 60 HP at a maximum flow rate of 250 scfm. A Pneumatic no-loss drain valve that only opens when condensate is present, eliminating unnecessary loss of compressed air, accomplishes drainage from the tank. It does not require electricity, pre-setting or manual intervention. Manufacturer information is presented in Appendix D.

2.2.4 Air Pressure Regulation

Air pressure to sparge wells AS-101 and AS-102 is controlled through a PacE® pressure control regulator manufactured by Ingersoll Rand. The pressure regulator is mounted inline and down stream of the discharged air filter system and adjacent to the AS manifold. It features a high volume low pressure drop design, pneumatically controlled and is equipped with inlet and outlet pressure gages. It is designed to accept a maximum operating pressure of 150 psig. Pressure at the outlet side of the regulator is adjusted by observing the outlet pressure gage while turning the adjustment knob located between the inlet and outlet gages.

Compressed air from AC-1 is regulated to between 20-25 psig using the PacE pressure regulator.

2.2.5 Compressed Air Conveyance, Air Sparge Manifold, and Air Flow Rate Measurement

Air is conveyed from AC-1 to the sparge well manifold through 2-inch, SCH 40 carbon steel galvanized pipe. Between the pressure regulator and the sparge manifold the air conveyance line is outfitted with temperature and pressure indicators. The temperature indicator is required to insure the air stream does not become excessively hot as the sparge wells are constructed of PVC casing which has a maximum thermal specification of 140 ºF. The pressure indicator is used to adjust the regulator to the desired injection pressure. The air sparge header manifold is plumbed into the low regulated pressure side of the AC-1 line. Plumbed into the header of the air sparge manifold are three independent outlet pipes, which extend downward from the manifold pipe to underground piping. Each air sparge pipe assembly includes a 2-inch gate valve, 2-inch motor actuated ball valve and an averaging Pitot tube flow element. The gate valve is used to adjust the flow rate to the sparge well. The ball valves are equipped with motorized actuators that are controlled by a Hunter XC programmable irrigation controller which allows the operator to operate the air sparge wells intermittently on and off to optimize sparging efficiency. Two of the sparge assemblies are being used, one is connected to Well AS-101 and the other connected to Well AS-102. A third assembly was installed as a provision to allow for future system expansion should it be required.

The Hunter -XC irrigation controller has a system shutdown circuit that is wired into a normally open set of contacts in Relay No. 1 in CP-4. The relay coil is energized by power from the SVE motor starter contactor coil input located in CP-1. Should the SVE shut down for any reason, the interlock between the Hunter-XC and the SVE motor starter coil causes the motorized valve actuators to close, effectively shutting down the AS system. The Owners Manual and Programming Instructions for the Hunter controller are provided in Appendix D.

Below grade, just beneath the AS manifold, the air conveyance piping to the AS/SVE wells transitions from 2-inch, SCH 40, galvanized steel to 2-inch standard dimension ratio 11 (SDR-11) high density polyethylene pipe (HDPE).

2.2.6 AS wells of AS/SVE-101 and AS/SVE-102

Compressed air from AC-1 is sparged into saturated soils through underground piping extending from the Air Sparge manifold to the two air sparge wells AS/SVE-101 and AS/SVE-102. The air sparge system was design to operate intermittently, with each well delivering a maximum design flow of 100 scfm at a wellhead pressure of approximately 10 to 35 psig.

Well completion information for AS/SVE-101 and AS/SVE-102 is presented in Appendix C. As indicated for these wells, the SVE well casing is 4-inch diameter PVC pipe that extends to a depth of 110 feet bls with a screened interval between 40 and 110 feet bls. The AS well casings extend through the SVE casing and consists of 2-inch diameter PVC pipe extending through the bottom of the SVE casing to a depth of 150 feet bls, with a screened internal between 145 and 150 feet bls.

Each AS/SVE wellhead consists of a 4-inch diameter PVC tee with top port fitted with a well seal plate for passage of the AS well casing. Affixed to the well seal plate is a valve port. The valve port is intended for use in monitoring wellhead vacuum pressures and extracted soil gas quality. Each AS/SVE wellhead is completed below grade within a traffic-rated, concrete vault.

The depth-to-water beneath the Site ranges from 100 to 130 feet bls or 15 to 45 feet above the top of the AS screens, depending upon seasonal weather conditions and operation of the groundwater extraction system.

2.2.7 Process Monitoring/Control/Telemetry - Control Panel CP-4

Within Control Panel CP-4, a wireless Internet based telemetry system is provided for the AS/SVE (and groundwater extraction and treatment) system, consisting of a Sensaphone unit, for remote monitoring of certain operating conditions, control of certain operating parameters and to notify responsible parties of system failure alarms.

For the SVE/AS system, the Sensaphone unit receives digital input signals within intrinsic circuits from the following normally open or closed switches:

- High gas temperature switch (TSH) located at the Air to Air Heat Exchanger outlet. This normally closed switch will open should the gas temperature reach the switch set point value of 130 °F, resulting in a high gas temperature alarm condition within the Sensaphone unit and automatic call-out via a satellite network to a cell phone (voice or text messaging), to an email address, or both.
- Auxiliary switch (ZS) at motor starter located within Air Compressor AC-1. This normally open switch will close when the air compressor is in operation. In the open

position (air compressor down), an alarm condition will result within the Sensaphone unit and automatic call-out via a satellite network to a cell phone (voice or text messaging), to an email address, or both.

For the SVE/AS system, the Sensaphone unit receives one analog input (4-20 milliamps) signal within a 24 volt direct current (VDC) circuit from the gas pressure transmitter PT-110 located at Air to Air Heat Exchanger Outlet. This pressure transmitter, having a 0 to 5-psig range, is provided for remote monitoring of this gas pressure and as a means of automatically disabling the Air Sparge system should the SVE system shut down by loss of gas pressure or any other reason. The Sensaphone unit is programmed with a low gas pressure switch (PSL-110) set point of 0.5 psig and associated low-pressure alarm. Should the gas pressure reach this set point value the PLC in CP-1 is programmed to shut down the SVE system which will in turn de-energize relay coil R-1 located in CP-4. This will close the motorized valves to the AS wells at the AS manifold, effectively shutting down the entire AS/SVE system. Additionally, the Sensaphone unit will automatically call out an alarm condition to a responsible party via a cell phone, email or both. When the SVE system is restored to normal operating status (gas pressure above PSL-110 set point value), the Air Sparge Controller will then become enabled to operate the motorized ball valves. The Sensaphone Unit is also used to monitor the system remotely through the Internet at www: cell682.com by logging in using the proper User ID and Password. The unit can also be programmed remotely allowing the user to enable or disable alarming functions, change analog input control set points as well as viewing total run time and stop time durations for the devices connected to the discreet inputs. A historical log of alarming information is also viewable on line. The Sensaphone Operation and Programming Manual is provided in Appendix D.

2.3 Groundwater Treatment System Component Descriptions

2.3.1 Groundwater Extraction Well EW-101 and Pump

Ground water extraction well EW-101 is located about 24 feet north and 5 feet east of the northwest corner of the treatment system compound. The well is constructed of 6-inch diameter SCH 80 PVC to a depth of 190 feet bls with a screened interval between 125 and 185 feet bls. The bottom of the well is equipped with a 5 foot sediment trap. The well head is completed in a subsurface, flush mounted, traffic-rated Old Castle Model 575-LA concrete vault with dual spring assisted, bolt down, duel access doors. The well is outfitted with a 15-horsepower, 460 volt, 3-phase Gould's Model 5 CHC, 4 stage groundwater pump (P-1E) capable of producing 110 gallons per minute (gpm) at 205 feet of total dynamic head (TDH). The pump intake is set at

180 feet bls. The top of the pump is equipped with a 2.5-inch check valve to maintain a column of water in the discharge pipe while the pump is off and to prevent backflow from the treatment system. The discharge line from the check valve to the well head is constructed of 2.5-inch diameter, SCH 40 stainless steel pipe that exits through a 8-inch flange with a 2.5-inch pass through hole and annular seal. The well is also equipped with a 1-inch diameter, SCH 40, PVC sounding tube.

The pump is powered from a dedicated control panel (CP-3). Pump operation is controlled by a Global Water Model WL-450-250 pressure transducer set at a depth of 172 ft bls and is connected to Analog Input A6 on the Sensaphone unit located in Control Panel CP-4. The analog input is programmed to turn the pump on when the water level is 40-feet above the transducer and to turn the pump off when it is 5-feet above the transducer. The on and off action of the pump is accomplished through the Sensaphone unit output Channel Number 2. A manufacturer's specification sheet for the transducer is provided in Appendix D.

2.3.2 Extracted Groundwater Conveyance, Shut Down Pressure Switch, Flow Rate Measurement, Particulate Matter Filtration, and Treatment System Compound Sump Pump Operation

Groundwater pumped from EW-101 passes through the wellhead assembly consisting of a 2.5-inch tee at the end of the discharge line within the well vault. The long leg of the tee is equipped with a pressure gage. A groundwater discharge pipe is connected to the short leg of the tee and is equipped with a ½-inch ball valve for sampling purposes. The discharge line passes through the vault via a 3-inch diameter and 6-inch diameter dual-walled SDR-11 HDPE pipe. The 6-inch outer pipe of the dual walled pipe terminates at the concrete containment sump located at the northwest corner of the treatment system compound. It is designed to conduct any water that collects in the well vault to a sump in the treatment system compound slab. The 3-inch diameter inner pipe of the dual walled pipe exits the 6-inch pipe at the sump and transitions to 4-inch SCH 80 PVC. EW-101 discharge water is conveyed past an adjustable pressure switch and then through a flow element (FE-301) and operates as described below. See the remedial system construction drawings (Sheet PID-2) in Appendix B for further details.

- The adjustable pressure switch located 1-foot upstream of FE-301 is set to shut EW-101 pump down should the pressure in the conveyance pipeline exceed 50 psi. It is connected to and powers a relay coil installed in CP-3. A set of normally open contacts within the relay are used to energize the pump starter solenoid when the HOA switch is in Hand or Auto mode. The relay is configured to latch when the pressure switch is below its high pressure set point. Should the pressure exceed the high pressure set point, the relay is unlatched and power to the pump starter solenoid is broken which in turn shuts down the pump. <u>Prior to restarting the pump, the reset button mounted on the face panel of CP-3 must be pushed to re-latch the relay.</u>

- The FE-301 is wired to a flow indicator (FI-301) and transmitter (FIQ-301) located in CP-4. The flow transmitter is in turn wired into one channel of a data logger. A second flow element (FE-302) is located on the effluent side of the treatment system to account for additional water sent through the treatment system from the containment sump and from EW-101. It is configured similarly as FE-301 and its transmitter (FIQ-302) and flow indicator (FI-302) are also installed in CP-4. See section 2.3.4 for further discussion of the flow elements, transmitters, indicator, and logger configurations and operation.

Down stream of FE-301, the EW-101 pump discharge line is plumbed into a common manifold along with the sump pump discharge line. Piping from the containment sump consists of 2-inch diameter SCH 80 PVC that is plumbed into the 4-inch main influent line using a 2-inch x 4-inch tee. The sump pump discharge line is equipped with a 2-inch gate valve to isolate the pump from the main influent line should repairs or replacement be required. It is also equipped with a check valve to prevent back flow from the EW-101 discharge line. From the manifold, combined flows from EW-101 and the sump are passed through a bag filter (B-1) to remove particulate matter. After initial filtration, the influent water enters a series-connected primary leading vessel (LGAC-1) and then a secondary lagging vessel (LGAC-2), both containing liquid phase granular activated carbon (GAC). The two vessels contain 5,000 lbs of carbon for treatment to remove VOCs. The treated water then passes through a second bag filter (B-2) to polish the treated water of particulate matter prior to discharge into the SRP Later 9.5 canal or the Town of Gilbert Sanitary Sewer System.

Both influent and effluent bag filters are equipped with pre- and post- filter pressure gages. If the differential pressure across the filter exceeds 15 pounds per square inch (psi), then the used bag filters need to be removed and new ones installed. Instructions for this procedure as well as general operation and start-up guidelines for the bag filters can be found in the Barnebey Sutcliffe Operations and Maintenance Manual in Appendix D. The inlet bag filter canister is equipped with a valved bypass circuit so the treatment system can continue operating while the filters are being replaced or other work is being done on the canisters, if necessary.

The treatment system compound sump pump (P-2) is a STA-RITE Model STEP 20, ½ HP, 115 volt, single phase, pump and capable of pumping 20 gpm at 109-feet of TDH. When the pump control switch is in the auto position its operation is controlled by three level switches. The pump is energized when a high water level float switch (LSH) is closed and shuts off when a low-level float switch (LSL) is opened. These float switches are wired to Relay R4 in CP-4 which in turn is wired to the pump starter solenoid. If the pump fails to energize and a continual rise of water occurs within the sump, LSHH is closed which will cause a complete water treatment system shut down by energizing Relay R3 and de-energizing Relay R6 in CP-4. A shut down is achieved by opening a normally closed set of contacts in each of the relays that power the P-1E (R3: EW-101) and P-2 (R6: sump pump) motor starter solenoid coils. This will also initiate a system alarm condition alarm call out by the Sensaphone unit to a responsible party. The system cannot be restarted in auto mode until the water level in the sump is pumped to a level below the LSHH. This is achieved by turning on the relay bypass toggle switch mounted next to R6 and turning on the sump pump by placing the HOA switch in the hand position. When the water level is below the LSHH float, turn the HOA switch to the off position and toggle the R6 relay reset switch to the on and off position. This will re-latch and energize R6 which in turn will de-energize R3 allowing the system to be restarted in auto mode as described in Section 3.3. The sump pump HOA switch should now be turned to the auto mode so as to completely drain the sump.

2.3.3 Liquid-Phase Carbon Vessels LGAC-1 and LGAC-2 Influent and Effluent Pressure Gages

The ground water treatment system uses two liquid phase granular activated carbon vessels to remove hydrocarbon contaminants from water from Extraction Well EW-101 and additional water that collects in the treatment system compound sump. The carbon vessels are Model LD180, manufactured by the Barnebey Sutcliffe Corp (Appendix E). Each carbon vessel holds 5,000 lbs of activated granular carbon and is designed to operate at a maximum pressure of 100psi. The vessels are connected in a series configuration such that the influent enters and exits the first vessel (referred to as the lead vessel) and then enters and exits the second vessel (referred to as the lag vessel). The series configuration works to insure that water leaving the treatment system has been cleaned to acceptable standards. In this configuration the lag vessel acts as a backup to the lead vessel should contaminants break through the lead vessel. This configuration allows time to change-out the spent carbon in the lead vessel before breakthrough occurs at the lag vessel outlet. The series configuration of the carbon vessels is valved such that the lead – lag position of the two vessels can be reversed simply by opening and closing the appropriate valves on the manifold installed between the two vessels. This is a cost saving feature in that what was initially the lag vessel used to clean up any break-through contaminants can be quickly reconfigured to be the lead vessel which can continue to be used and monitored until break through occurs, optimizing the full capture capacity of the carbon prior to it being replaced. Each carbon vessel is equipped with a pressure relief valve, air vent, drain and back wash valves. The inlet and outlet at each carbon vessel is equipped with an analog pressure gage to monitor differential pressure across the carbon.

2.3.4 Flow Rate Measurement, Data Logging Particulate Matter Filtration and Effluent Pressure Transmitter

Flow rate is measured and totalized at two points in the influent to effluent conveyance circuit. One is installed on the influent line just inside the treatment compound and the other is installed on the effluent line just downstream of the carbon treatment canisters. Both locations use a Siemens Magflo Model 3100 sensor and transmit a 4-20 milliamp signal to a Siemens Magflo 6000 transmitter/signal converter located in CP-4. The transmitter is outfitted with a flow indicator and volume totalizer. The influent flow meter measures and totalizes the flow from EW101. The effluent flow transmitter measures the combined flow from EW-1 and any liquids in the sump that are pumped to the treatment system via a tee in the influent line, just upstream of the influent bag filter.

A data logger manufactured by Monarch is located in CP-4. The data logger is a 4 channel current reader that has been programmed to track specific data from the water treatment remedial system instrumentation. Channel 1 has been programmed to log influent flow rates. Channel 2 has been programmed to log effluent flow rates. Each channel has been programmed to log a data point at one hour intervals. Logged files are downloaded periodically into an Excel formatted file through the proprietary Monarch software. The Operation and Programming manual for the Monarch Data Logger unit is located in Appendix D.

Treated effluent exits the lag carbon vessel and passes through an effluent bag filter to polish the treated water of any remaining particulate matter. The bag filter is equipped with inlet and outlet pressure gages. If the differential pressure measured between the gages reaches 15 psi then the filter bags need to be replaced. Filter change-out instructions are located in Appendix D.

Between the lag carbon vessel and the effluent bag filter is a 0-30 psi Dwyer Model 637-1 pressure transmitter and indicator (PT-307) that is wired into the Sensaphone system in CP-4. This allows one to view the outlet pressure from the system remotely and to track the backpressure from the bag filter. If the pressure exceeds the high-pressure value programmed into the Sensaphone system an alarm will be called to a responsible party. This condition would also indicate a failure in the system pressure shut down switch discussed previously in Section 2.3.2.

2.3.5 Treated Groundwater Discharge

Effluent from the groundwater treatment system effluent bag filter on the west side of the treatment compound is directed through piping to below grade where it connects to a 4-inch diameter SDR-11 HDPE pipe. The discharge line extends southerly from the treatment compound to a concrete, flush-mounted vault located just north of the Skyline property line. Just prior to entering the vault, the single 4-inch diameter effluent line splits into two separate 3-inch diameter lines using a tee and elbows. These two lines enter the vault where three-inch gate valves and Badger flow meters/totalizers are located on each line. From the vault, one of the 3-inch pipes extends to the Salt River Project (SRP) Lateral 9.5 canal, where effluent is discharged. The other 3-inch pipe runs westerly along the north side of the SRP canal; extends southerly and crosses the canal along the bottom of a pedestrian bridge; and then runs easterly to a manhole on the south side of the canal. The manhole is part of the Town of Gilbert (TOG) sanitary sewer system. Each Badger totalizer is equipped with a Record-All magnetic pulse transmitter. A magnetic pulse is transmitted for each 100 gallons of liquid that passes through the flow meter. The pulse is received at a hydrographic station owned and maintained by SRP. The hydrographic station is located on the north side of the SRP canal just south of the Skyline Steel fence, approximately 8 feet south of the flow meter vault. The hydrographic station is equipped with two gages, one for each of the Badger flow meters. The hydrographic station is for use by SRP and the TOG to track of the quantity of treated water discharged into their respective systems.

2.3.6 Control Panel CP-3

Control Panel CP-3 is located about 10 feet east of the SVE blower skid. The panel enclosure has an outside power disconnect handle, which will not allow the enclosure door to be opened without de-energizing the control panel. The enclosure is also equipped with a lockable handle for general use. CP-3 contains the main electrical components used to operate the pump P-1E in Extraction Well EW-101. Power and protection to the pump motor is accomplished through a 480 Volt, 40 amp 3-phase circuit breaker located just upstream of the well pump starter. The pump is started by turning the HOA switch mounted on the CP-3 enclosure door to either the hand or auto positions. In the auto position the pump is energized and de-energized through the Sensaphone system pump control circuitry located in CP-4 working in conjunction with a water level transducer installed in EW-101. Currently the Sensaphone unit is programmed to turn the pump on when the water level is at 40-feet above the transducer and off when the water level is at 5-feet above the transducer. In the hand mode the protective control circuitry is bypassed and should only be used while a qualified party is on site and for circumstances when the treatment system undergoes testing and troubleshooting. The pump motor controller contactor starter coil and associated shut down elements such as the sump high-high level switch are protected by a single 10 amp slow-blow-fuse up-stream of the pump starter assembly. The pump is additionally protected by overload relays located below the pump starter coil and contactor assembly. Should an overload condition exist, the overload relays will be tripped and the pump will be shut down.

Should this occur, the pump controls must be reset by pressing the red reset button located below the pump starter block prior to re-energizing the pump starter circuit once the cause of overload condition is resolved. Also located on the door is a green indicator light that is energized when the pump is in operation. The electrical schematic for CP-3 is shown on electrical drawing sheet E-10 in Appendix B.

2.3.7 Control Panel CP-4 - Process Control/Telemetry

Control Panel CP-4 is located about 10-feet east of the SVE skid, mounted next to CP-3. CP-4 is the heart of the communications center for the entire treatment system. The major component within the CP-4 enclosure is the Sensaphone remote communication telemetry unit. It is equipped with eight digital and seven analog input channels that are used to interface with and monitor treatment system sensory devices as well as control pump EW-101 and shut down the air sparging system should the SVE unit shut down. Sensaphone system inputs are monitored via an Internet based web page where system parameters such as temperature, pressures and system run times can be viewed. When logged on to the Sensaphone unit via an Internet connection, sensor set point values and alarm conditions can also be changed as required. The Sensaphone unit is equipped with two output relays that are used to shut down the groundwater extraction pump and the air sparge system should any programmed operational set points be violated. If a programmed set point is violated, the system can be programmed to send out multiple alarm calls to cell phones, landlines, email, or as text messages.

CP-4 also contains the sump pump P-2 starter/controller assembly as well as the relay controls for the liquid level control switches located in the sump. Within the CP-4 enclosure is a bank of five multi contact relays. These are used to send out alarm and shut down signals to the telemetry system from the various treatment system monitoring and shutdown components as shown on electrical drawing E-11 and process control drawing PID-3; both are located in Appendix B. Additionally, the PLC installed in CP-1 for controlling the SVE system is wired into the Sensaphone digital input D1. If the SVE unit shuts down for any reason an alarm will be called out to a responsible party.

2.4 Remediation Equipment Compound

The remediation equipment compound, as depicted on Figure 1 and Drawings P-1 and P-2 in Appendix B, serves to keep unauthorized people from accessing the remediation equipment. The compound consists of an 8-feet high chain-link fence, having overall dimensions of 44 feet by 38 feet. There is a 14-foot wide double gate (for equipment access) on the east side, two 4-foot wide gates on the north and south side, and a 6 foot wide gate on the west side. All gates are secured with keyed padlocks.

An overhead light is located on the north side of the compound should night time activities be required. A switch for the light is mounted on the Distribution Panel.

2.5 Electrical Service Entrance

Electrical power is supplied to the compound from an Arizona Public Service Company (APS) owned utility transformer located about 140-feet north of the Electrical Service Entrance at the compound providing 200 amp, 480 volt, 3 phase power. Electric feeder cables are routed underground from the transformer to the treatment compound Electrical Service Entrance.

Electrical power supplied to the remediation equipment from the Electric Service Entrance is followed by the meter, the main switch cabinet, the distribution panel, and another panel labelled "LP". Located on the same electrical rack as the main switch cabinet, on the west side of the meter and main switch is the electrical distribution panel ("labelled DP"). Within the distribution panel are dedicated circuit breakers to power control panels CP-2, CP-3 and a 45 KVA transformer, which in turn supplies power to CP-1. Located next to the distribution panel is a separate cabinet ("labelled LP") that supplies power to CP-4 and an outdoor-rated GFCI receptacle mounted directly beneath the cabinet. The electrical service entrance, meter, main switch, "DP" and "LP" cabinets are mounted on a Unistrut rack located in the north east corner of the treatment compound. See electrical drawing Sheet E-6 in Appendix B for Electrical Service Entrance and Electrical Equipment Rack Details.

3. START-UP PROCEDURES

Start-up procedures for the AS, SVE, and groundwater treatment systems are presented in the following sections. These procedures are general and do not anticipate all conditions that may be encountered during start-up activities. Records of procedures used and of observations made during start-up activities should be maintained to assist in diagnosing any problems that may be encountered during start-up and for use in future efforts.

3.1 Soil Vapor Extraction System

Prior to start-up of the SVE system, the following readiness check should be performed:

- SVE system valves are set at the proper open or closed position;
- Main electrical power supply switch is in the off position and other switches are in the off position;
- SVE system valves are set at the proper open or closed position;
- If a system shut down has occurred, assure that the cause of the shut down no longer exists or has been corrected;
- SVE well heads of AS/SVE-1 and AS/SVE-2 are isolated from atmosphere (sample valve closed at wellhead seal plate);
- The SVE sample port valves are closed at SVE manifold;
- Manual air intake valve is open;
- Manual air intake filter is clean;
- Condensate Separator CS-1 is enclosed and evacuated of any liquid content;
- Condensate drain valve on CS-1 is open to Condensate Transfer Pump P-1;
- Discharge valve of P-1 is open for condensate transfer to compound sump;
- Vacuum Blower B-1 has received proper lubrication per manufacturer's instructions;
- Terminal numbers 2241 and 2242 for transfer tank high level switch (not part of this project) are permanently jumped within SVE system control panel (leading to input terminal X3 of DL-105 unit);
- Bypass valve at Air to Air Heat Exchanger is closed;
- VGAC-1 and VGAC-2 are charged with activated carbon;
- All sample valve ports at inlet/outlet of VGAC-1 and VGAC-2 are closed; and

- Inter-connecting hoses between VGAC-1 and VGAC-2 are positioned for soil gas up flow through VGAC-1, followed by up-flow through VGAC-2, and then through the Stack.

The start-up of the SVE system is to be performed as described below and in the order presented.

1. Remove top of Condensate Separator CS-1 (and in-line filter assembly) and check conditions. If necessary, remove any accumulated scale along vessel sidewalls and bottom. Check LSL, LSH, and LSHH for proper movement, if any, and clean/lubricate, as necessary. Apply tape to site gauge at positions of LSH, LSH, and LSHH.

2. If system has not been operated for a long period, simulate soil gas condensate recovery (from extracted soil gas stream) and transfer to the remedial compound sump by adding water to the Condensate Separator to a level between the LSL and LSH switches. With Control Panel P-4 energized, turn P-1 selector switch to "H" (hand). Briefly verify operation of P-1 and observe transfer of water to compound sump. Turn P-1 selector switch to "A" (Auto). Resume water addition to CS-1 until water level reaches LSH. Verify actuation of LSH and automatic activation of P-1. Verify automatic shut down of P-1 when water level within CS-1 reaches LSL. Check for and resolve any water leakage from this wet portion of the SVE system. Enclose CS-1 (and reconnect in-line filter assembly).

3. With SVE lateral isolation valves closed at SVE manifold and manual air intake valve fully open, initially start Vacuum Blower by turning respective selector switch to "Hand". Allow ambient air only to be drawn into air intake filter/silencer, through Condensate Separator to blower intake, and then exhausted through Carbon Canisters and Stack. Partially close manual air intake valve until vacuum pressure at Vacuum Blower inlet (PI) increases to design value of approximately 25-inches WC vacuum. Check for, and resolve, any excessive noise or vibration at Vacuum Blower. Verify no air intake through vacuum relief valve PV-201. Set point value of PV-201 should be much greater than 25-inches WC vacuum (at least 7 inches of mercury or 94-inches WC) for protection of the Vacuum Blower motor.

4. With Vacuum Blower inlet pressure at 25-inches WC vacuum, record motor amperage draw at Vacuum Blower motor starter (inside SVE system control panel). Adjust amperage set point at motor amperage overload switch to maximum rated value of motor, if not already adjusted. Verify actual motor amperage draw to be less than 80 percent of set point value.

5. Turn Vacuum Blower selector switch from "Hand" to "Auto" and proceed to commission automatic shutdown provisions of Vacuum Blower, as described below. If Vacuum Blower does not start, then any of three automatic shutdown provisions described below (high-high condensate level, high gas temperature, high gas pressure) is/are likely not functioning properly in combination with PLC (DL105 unit).

6. With Vacuum Blower selector switch turned to "Auto" and Vacuum Blower in operation, gradually open bypass valve at Air-to-Air Heat Exchanger, allowing process gas temperature (at TI) to increase. Verify automatic shut down of vacuum blower upon

actuation of TSH (open circuit across terminals 2321 and 2322 leading to input terminal X5 of PLC) when process gas temperature reaches TSH set point temperature of 140 ºF. Adjust set point of TSH, as appropriate, until actuation occurs at 140 ºF. Close bypass valve and resume Vacuum Blower operation.

7. With Vacuum Blower selector switch turned to “Auto”, verify closed circuit through PSH at Terminals 2281 and 2282 leading to input Terminal X4 of PLC. If circuit is not closed (blower not in operation), then verify set point value of 2 psi on low-pressure switch. If set point is properly adjusted and blower still does not operate, then temporarily jump across Terminals 2281 and 2282 and confirm a closed circuit to input Terminal X4 of PLC . If blower operates, then PSH has likely failed, requiring replacement. If blower does not operate, then check output terminal Y0 of PLC for 120 VAC output to selector switch. If power is not observed, then check PLC for proper programming or malfunction condition.

8. With Vacuum Blower selector switch turned to “Auto”, verify closed circuit through LSHH at Terminals 2080 and 2081 leading to input Terminal X0 of PLC. If circuit is not closed (blower not in operation), then temporarily jump across terminals 2080 and 2081 and confirm a closed circuit to input terminal X0 of PLC. If blower operates, then LSHH has likely failed or is stuck open. If blower does not operate, then check output terminal Y0 of PLC for 120 VAC output to selector switch. If power is not observed, then check PLC for proper programming or malfunction condition. If circuit to input Terminal X0 of PLC is closed and blower operates, then temporarily shut down blower and add water to Condensate Separator via ambient air intake provision (with intake filter removed) until water level, as observed in site glass, extends just above level of LSHH. Verify actuation of LSHH (after ten second delay as programmed into PLC) and inability to restart Vacuum Blower. If blower does restart, then LSHH has likely failed or stuck closed. Service LSHH as appropriate.

9. With Vacuum Blower in operation, check all PVC piping upstream of Vacuum Blower to AS/SVE wellheads for any audible indication of air leakage. Also, conduct soap test of all piping connections downstream of Vacuum Blower to Stack. Use soapy water and swab for soap test. Resolve any detected air leaks in upstream and downstream piping from Vacuum Blower.

10. With ambient air intake valve fully open, all isolation valves closed on SVE manifold, and Vacuum Blower in operation (selector switch turned to “Auto”), measure and record air pressures at outlet of Vacuum Blower (discharge silencer port), inlet to VGAC-1, outlet from VGAC-1, and outlet from VGAC-2 or base of Stack, using 60-inch water-filled manometer. Using a hand-held digital differential manometer or water-filled manometer, measure and record differential pressure across Pitot tube FE-104. Record air temperature at TI and the ambient air temperature. Calculate airflow rate at FE-104 from Pitot tube equation. At this flow rate, compare differential pressures across VGAC-1 and VGAC-2 with historical values and assess for any abnormal conditions (e.g., flow restriction).

11. With Vacuum Blower operating and ambient air flowing through system (see above), open AS/SVE-101 and AS/SVE-102 isolation valves at SVE manifold and then gradually close manual air intake valve. After 30 minutes, monitor and record differential pressures

across Pitot tubes FE-101, FE-103, and FE-104; vacuum pressures at each SVE well head, upstream of Condensate Separator and at intake of Vacuum Blower (PI); gas temperatures upstream of Condensate Separator (TI-101), downstream of Air to Air Heat Exchanger (TI), and between carbon canisters (TI-102); and gas pressures across carbon canisters. Using Pitot tube equations shown in Appendix F, calculate SVE rates from AS/SVE-101, AS/SVE-102, VP-104, and SVE-105 and compare with design values. Adjust either isolation valves on SVE manifold, as necessary, until SVE rates (Pitot tube differential pressures) are nearly equal. If design SVE rates are either reached or exceeded with manual air intake valve fully closed, then normal operating conditions are realized. If design SVE rates are not reached, then investigate and resolve cause of deficient SVE rates (e.g., greater SVE wellhead vacuum pressures than expected, restriction(s) in buried SVE lateral lines, inadequate Vacuum Blower speed).

12. Within four hours after initial SVE system operation for shut-down to replace carbon, collect one soil gas sample into a laboratory supplied Summa canister from valve port at VGAC-1 inlet, as described under Abbreviated QAPP (Appendix H). Complete a SVE System Operation Log sheet (Appendix I) at the time of sample collection. Submit gas sample to analytical laboratory for EPA Method TO-15 (full range) analysis. Submit completed SVE System Operation Log to Engineer.

3.2 Air Sparge System

Prior to start-up of the AS system, the following readiness check should be performed:

- The main discharge valve for the air compressor which allows air to flow from the compressor to the pressure regulator is in the open position;
- If a system shut down has occurred, assure that the cause of the shut down no longer exists or has been corrected.
- Electrical power switches for the air compressor, the motorized ball valves on the air sparge manifold, and the air sparge timer are in the on position;
- AS well heads for AS/SVE-1 and AS/SVE-2 are isolated from atmosphere by closing the sample valve on the wellhead tee plugs;
- Both AS lateral line isolation valves and motorized ball valves are closed on AS manifold;
- Air Compressor AC-1 has been lubricated in accordance with manufacturer’s instructions;
- Air Compressor AC-1 is configured for minimum air pressure operating range to Air Receiver AC-1;
- Compressed air supply to Oil/Water Separator is valved open;
- Suitable oil storage container is installed beneath oil outlet port of Oil/Water Separator;
- Air bleed valve is closed with outlet plug installed, nut loose;

- Pace Air Controller (PCV-201) is adjusted for no flow through unit;
- Sensaphone unit is operating; and
- SVE system is operating.

The start-up of the AS system is to be performed as described below and in the order presented.

1. With SVE system in normal operation, start Air Compressor AC-1 at Control Panel CP-1 as described in operator's manual. Observe increase in air pressure within Air Receiver T-1 to (minimum) upper range value set within AC-1. If air pressure does not reach this set point value, then further adjust set point of upper range value until air pressure reaches desired set point value. If air pressure exceeds upper range value, then bleed of air pressure by opening bleed valve with plug loosened.
2. Check to assure that oil/water separator is operating. If necessary, check operation by filing inlet chamber with potable water and verifying operation of internal pneumatic pump and transfer of water to resin container. Observe flow of water from resin container to grade and then stop flow of water.
3. Connect laptop computer to Sensaphone unit and access status of gas pressure sensed by PT-110. Temporarily shut down SVE system. Confirm loss of pressure and activation of low pressure switch at Sensaphone unit. Confirm disabling of Air Sparge Controller by attempting to manually open either motorized ball valve (XV-201 or XV-203). Restart SVE system. Confirm ability to open either motorized ball valve.
4. Gradually adjust Pace Air Controller until outlet pressure to air sparge manifold increases to 10 psig. Conduct soap test of all steel piping connections from Air Receiver T-1 outlet to isolation valves on air sparge manifold. Use soapy water and swab for soap test. Resolve any detected air leaks.
5. While the SVE system is in operation, check operation of each air sparge well. With Air Compressor AC-1 activated, adjust the Pace Air Controller to an outlet pressure to a value of approximately one psi less than calculated hydrostatic pressure of water column within AS well above top of well screen. The top of screen for both the AS wells is at a depth of 145 feet bls. Check the pressure using a gauge temporarily installed at AS wellhead valve port of AS/SVE-101 and position of the motorized ball valve (XV-201), which should be manually opened using the Air Sparge Controller (QK-101). Gradually open AS/SVE-101 isolation valve on the air sparge manifold and observe increase in air pressure at AS well head to be at the approximate same level as indicated on the Pace Air Controller. Check for air leaks, and if necessary, conduct a soap test of air sparge lateral at manifold and at well head. Resolve any indicated air leaks after shutting down Air Compressor and bleeding off air pressure within entire AS system. Check for any continuous flow of compressed air into AS/SVE-101 by monitoring FE-201 for any measurable differential pressure with a hand-held, digital differential pressure indicator. Any air flow leakage should be less than 10 scfm. Repeat this pressure test procedure for AS/SVE-102.
6. Program the Air Sparge Controller for air sparge pulse operation using data from modelling of site for SVE and AS. Initial pulsing should be one-half hour on and one-half

hour off for each AS well; alternating so only one of the wells is sparged at a time. If changes are required for on-off operation of the AS system, use the following directions:

a. Enter "On" times for AS/SVE-101 (Zone 1) and AS/SVE-102 (Zone 2) that match the identified air sparge pulse durations. If the air sparge zone recovery period for AS/SVE-101 is to be greater than the air sparge pulse duration for AS/SVE-102, then enter different times for the two zones.

b. Settings for Zone 1 also apply to Zones 3 and 5, which are also connected to open the motorized ball valve for AS/SVE-101. Settings for Zone 2 also apply to Zones 4 and 6, which are connected to the motorized ball valve for AS/SVE-102.

c. Set the start time for each program to agree with the desired amount of time each AS well is to be operated. For continuous operation, each program should be set to start after completion of the last Zone for the previous program.

d. Assign times for Zones 1 through 6 for each program to achieve operation of the AS system to operate for a full 24-hour period. Then set the programs to operate for each day of the week.

e. If continuous operation of the AS system is not desired, selected zones can be disconnected from the motorized ball valves and can be used to set time periods for no sparging.

7. To check operation of the AS system, conduct three air sparge pulse tests of AS/SVE-101 during a single day, followed by AS/SVE-102 on the following day, as described below:

a. Operate SVE system with only AS/SVE-101 in operation at 100 scfm and ambient air being drawn into the system via a partially-opened air intake valve to compensate for the 100 scfm loss of soil gas flow from AS/SVE-102. AS/SVE-102 is to be utilized as a vadose zone pressure observation well during air sparge pulse performance testing of AS/SVE-101.

b. Adjust Pace Air Controller until outlet pressure increases to 20 psig (under no flow condition). At Air Sparge Controller (QK-101), manually jog open motorized ball valve XV-201 to initiate the first of three air sparge pulse performance tests of AS/SVE-101.

c. Every five minutes, record air sparge manifold pressure at PI-202, air temperature at TI-201, differential pressure across FE-201, and AS wellhead pressure from pressure gauge temporarily installed at AS/SVE-101 wellhead tee valve port. Using air flow rate chart, estimate and record air flow rate for each data set. Using a 60-inch water-filled manometer, measure and record vacuum pressure at the SVE wellheads for AS/SVE-101 and AS/SVE-102 at five-minute intervals. Inspect data for indication of sparged air flow from saturated to unsaturated soil (air breakthrough condition), signifying the end of the pulse (likely less than two hours duration). Air breakthrough is confirmed by a step-wise increase in pressure (loss of vacuum) at the SVE well head of AS/SVE-101, likely followed by a step-wise loss of vacuum pressure at the SVE well head of AS/SVE-102. Prior to this observation, the air sparge rate may suddenly increase after approaching an asymptotic level, which signifies the actual occurrence of air breakthrough without any delayed response observed from a change in SVE wellhead vacuum pressure at AS/SVE-101.

d. Once air breakthrough is confirmed, terminate flow of compressed air by closing motorized ball valve from Air Sparge Controller. Continue to record AS wellhead pressure and SVE wellhead vacuum pressures every five minutes.

e. When SVE wellhead vacuum pressures return to levels observed prior to air breakthrough, any buoyantly upward-moving sparged air has likely been displaced from the saturated soil to the vadose zone, signifying an air sparge zone that has been adequately recovered (local water table surface approaching previous static condition) in preparation for the subsequent air sparge pulse.

f. During air sparge zone recovery period, assess performance test data for any indication of premature air breakthrough condition or air sparge rate that exceeded the design value of 100 scfm. Also, inspect SVE wellhead vacuum pressure data from AS/SVE-102 for any indication of radial extent of air sparge zone at breakthrough. Identify any change in air sparge manifold pressure necessary to realize an increasing air sparge rate during the air sparge pulse that approaches, but does not exceed, 100 scfm prior to air breakthrough. Ideally, the optimum air sparge manifold pressure should result in the maximum volume of air sparged prior to air breakthrough (maximum air sparge zone radius).

g. After adjusting the Pace Air Controller outlet (manifold) pressure, as may be indicated by reviewing the data in the previous step and confirming an adequately restored water table surface surrounding AS/SVE-101, conduct second and third air sparge pulse performance tests of AS/SVE-101 by repeating the above procedure.

h. Using the above procedure, conduct three successive air sparge performance tests of AS/SVE-102. Operate SVE system with only AS/SVE-102 in operation at 150 scfm and ambient air being drawn into the system via a partially-opened air intake valve to compensate for the 150 scfm loss of soil gas flow from AS/SVE-101. AS/SVE-101 is to be utilized as a vadose zone pressure observation well during air sparge pulse performance testing of AS/SVE-102.

i. Conduct first air sparge pulse test of AS/SVE-102 with Pace Air Controller adjusted to outlet pressure indicated from results of third air sparge pulse test of AS/SVE-101. Continue to adjust outlet pressure after each test until increasing air sparge rate (at regulated air pressure) asymptotically approaches 100 scfm prior to air breakthrough.

8. Upon completion of air sparge pulse performance testing of AS/SVE-101 and AS/SVE-102, identify optimum air sparge manifold (Pace Air Controller outlet) pressure for use during initial AS operations. Compare the air sparge pulse durations and air sparge zone recovery periods for AS/SVE-101 and AS/SVE-102 with those indicated in the modelling for the site. This test and adjustments to the cycle times may need to be periodically repeated to maximize remedial efforts.

3.3 Groundwater Treatment System

Prior to start-up of the groundwater treatment system, the following readiness checks should be performed:

- Check that all valves in the process piping are in the proper open or closed position. Extraction Well EW-1 discharge valve located between flow element FE-301 and the inlet manifold to bag filter F-1 should be in the open position.
- If a system shut down has occurred, assure that the cause of the shut down no longer exists or has been corrected.

The start-up of the groundwater treatment system is to be performed as described below and in the order presented.

1. Measure water level in extraction well EW-l with electric sounder and compare this measurement with the dedicated EW-1 pressure transducer reading in as displayed on a PC connected to the Sensaphone unit on analog input A6.
2. Energize the pump using the following steps. Use Drawing PID-2 in Appendix B as a reference for the groundwater extraction system component locations.
   a. Fully open the ball valve from the EW-1 groundwater discharge line at the manifold located upstream of Bag Filter F-1.
   b. Fully open the ball valves at the inlet and outlet to the bag filter canister and fully close the F-1 filter bypass circuit ball valve. Repeat the same procedure on the polishing bag filter canister located at the outlet of the liquid phase carbon vessel LGAC-2.
   c. Fully open the sump pump discharge valve plumbed into the same manifold as EW-1 discharge valve.
   d. Open the ½-inch ball valves to pressure indicators along the entire groundwater discharge and treatment circuit indicated on drawing PID-1 as: PI-301 thru PI-307.
   e. At the valve manifold located between the lead liquid phase carbon vessel LGAC-1 and the lag vessel LGAC-2 open and close the appropriate valves to configure the piping system such that the water flow stream enters the LGAC-1 at the inlet located at the bottom of the vessel and exits the outlet at the top of the vessel then moves through the manifold to vessel LGAC-2 and enters the inlet at the bottom of the vessel and exits from the outlet at the top of the vessel.
   f. If start-up is after a change-out of carbon in one of the LGAC vessels, the valves on the manifold are to be change so the former lag vessel becomes the lead vessel and the former lead vessel becomes the lag vessel. Changing the direction of flow through the two vessels requires that the air release valve/vacuum breaker must be relocated to the top of the lag vessel.

g. Open the 2-inch air vent ball valve on the venting lines located along the east side of the LGAC-1 and LGAC-2 vessels.

h. Located directly south of the treatment compound about 10 feet north of the east-west boundary fence is a flush mounted concrete vault with a steel cover. In it are two valves installed in parallel and outfitted with 3- inch flow meters. The eastern valve and flow meter assembly discharges effluent groundwater to the SRP Lateral 9.5 canal and the western assembly discharges to the sanitary sewer owned by the Town of Gilbert. Open fully the valve that will route the water to the desired discharge point.

i. Energize the EW-101 pump by turning the HOA switch in CP-2 to the auto position.

3. After the pump has been on for several minutes and while the pump is in operation, open the ¾-inch air vent valves installed on top of Bag Filter F-1 and F-2. When the bag filters are full and water begins to flow as an air-free stream from the air vents then close the valves. There may be a siphon condition at the outlet for F-2 so full venting of the F-2 canister may not be possible.

4. When water has filled Vessels LGAC-1 and LGAC-2, the 2- inch air vent valves at the top of each tank may be closed. Any additional entrained air will continue to be vented from a second open vent line also located at the top of each tank.

5. Once discharged water has begun flowing from its outfall point, observe the entire piping system from well vault to effluent discharge point and check for leaks. Should any be found repair as necessary.

6. Observe the flow rate from the effluent at the flow indicator display in CP-4 and adjust the EW-101 discharge ball valve at the manifold just upstream of Bag Filter F-1 so that the pump discharges at a rate of about 100 to 110 gpm.

7. Check to make sure that the Badger effluent totalizers are operating correctly by comparing total gallons discharged with the numbers displayed on the flow indicator in CP-4.

8. Record all groundwater extraction system data from pressure indicators, flow totalizers, flow meters, and Sensaphone unit on the appropriate record form.

9. Test the high-pressure system shut down feature by slowly shutting the 4-inch ball valve on the effluent line downstream of Bag Filter F-2 until it just exceeds the 50 psi value programmed into the Sensaphone system. At this point the groundwater system should shut down and call out an alarm condition. Having completed this test, reopen the effluent valve, place the HOA switch on the off position, push the reset button on CP-4, and the restart by placing the HOA switch in the auto position.

4. NORMAL OPERATING CONDITIONS

Normal operating parameters and conditions are presented below for the SVE system, AS system, and groundwater treatment system.

4.1 SVE System

1. Individual extraction rates from Extraction Wells AS/SVE-1, AS/SVE-102/ VP-104, and SVE-105 should be adjusted based on monitoring of VOC concentrations in soil gas from each individual well. Greater extractions rates should be set for wells containing higher VOC concentrations. The total extraction flow rate is not to exceed 300 scfm due to limitations in the air quality permit. Corresponding vacuum pressures at SVE manifold laterals (valve ports) may range up to the design value of 9-inches Hg. If this setpoint is exceeded a vacuum release valve will open bleeding atmospheric air into the gas conveyance system relieving the excess vacuum. Soil gas condensate production, if any, is to be removed from soil gas in the Condensate Separator. Condensate should not be present above the LSH level. If this condition is observed, the LSH switch may not be operating properly.
2. Incremental differential pressure across air intake filter/silencer attributed to particulate matter accumulation is less than 10-inches WC during hot weather operations (May through October) and 20-inches WC during cool weather operations (November through April).
3. Air flow rate from the SVE system should be less than 300 scfm, provided differential pressure across each Carbon Canister does not exceed 20-inches WC at combined soil gas/air flow rate. Temperatures of soil gas entering the VGAC canisters need to be less than 130 °F. The air-to-air heat exchanger is set to operate for the warmer months (May through October) and runs continuously when operating. If temperatures exceed 130 ºF, the SVE system will shut down automatically and an alarm condition called out through the Sensaphone unit.
4. Relative humidity of combined soil gas/air stream at inlet and outlet of each Carbon Canister is to be less than 90 percent of saturation for effective carbon adsorption of PCE without adverse affect of free moisture upon carbon adsorption capacities.
5. Combined soil gas/air stream is to be down-flowing through GAC-1 (lead vessel), followed by GAC-2 (lag vessel), before being discharged to atmosphere through the exhaust stack. Within GAC-1, PCE is being removed from soil gas/air stream by carbon adsorption without breakthrough to GAC-2, defined as less than 90 percent of PCE mass flow rate being adsorbed within the lead canister. Just prior to reaching the projected PCE breakthrough concentration, spent carbon is to be replaced with fresh carbon in GAC-1, while maintaining a “clean” carbon bed within GAC-2.

4.2 AS System

1. Under normal operating conditions the SVE unit must be on for the AS system to operate due to a relay interlock between the SVE motor controller and the AS system auto timer. If the SVE system is off, the auto valves in the sparge circuit remain closed. During the commissioning of the air sparge well flow rates and pressures were measured and subsequently modelled using computer generated simulations. It was determined that the optimal sparge cycle for each well AS/SVE 101 and AS/SVE 102 is 30 minutes on and 30 minutes off. The automated well valves should be programmed to alternate such that when AS-101 valve is open AS-102 valve is closed and visa versa.

2. Air pressure at the prescribed flow rates should be between about 20 -25 psi as measured at the wellheads depending on the level of groundwater. The pressure at the AS well head should be sufficient to overcome water column. Flow rates are controlled by adjusting the ball valve to each sparge well located between the sparge manifold and the motorized ball valves, while viewing the flow rates using a manometer connected to the inline pressure averaging Pitot tube.

3. Pressure upstream of the Pace air controller should be between 60 and 70 psi. The down-stream side of the controller should be regulated between 20 and 25 psi. The inline temperature at the regulated side of the air controller should not exceed 120 ºF.

4. The two series mounted in-line oil separator filters downstream of the air compressor receiver tank are equipped with sight glass differential pressure gages. These should be operating with the indicator in the white portion of the gage. If the indicator is in the red portion of the gage, the filters need to be replaced.

5. The Poly Sep 250 oil water separator is equipped with an auto drain outlet which drains the separated condensate water onto the treatment compound pad. Oil separated from the water is contained in a separate chamber that is equipped with an overflow drain which empties into an auxiliary vessel. When overflow occurs the Poly Sep 250 oil collection tank should be emptied and the oil properly disposed of. The tank is also equipped with an absorption module that should be replaced every 6 months to maintain optimal oil water separation efficiencies.

4.3 Groundwater Treatment System

Normal operating conditions for the groundwater treatment systems include the following:

1. EW-101 well pump should be pumping water at a rate of 100 to 110 gpm. This results in a drawdown of the water table of approximately 20 feet, as measured in the EW-101 casing. The depth of water in the EW-101 well casing is measured by a transducer, which sends a signal to the Sensaphone unit. The depth of water above the transducer is shown on the Sensaphone unit on analog channel A6.

2. Flow rates indicated by the Siemens flow meters for influent and effluent flows should be the same unless water from the compound sump is being pumped from the sump to the

LGAC vessels. The influent flow meter does not measure flow from the sump pump. Totalized values from the influent and effluent flow meter will be different because the quantities of liquids pumped from the sump into the system are not measured by the influent flow meter. However, the effluent flow meter records all flow through the treatment vessels including groundwater pumped by EW-101, stormwater, condensate, or other liquids that are drained into the treatment compound sump. The sump is further used to temporarily store and ultimately treat purge water generated during groundwater sampling of wells installed for monitoring the WQARF site.

3. Pressure as measured at the inlet to the Bag Filter F-1 should not be in access of 50 psi. If the pressure exceeds this value, the EQ-101 pump will be shut down. The differential pressure across the filter canister should not exceed 15 psi. Should the differential pressure approach or exceed this, the bag filters should be removed and replaced with new filters.

4. Pressure at the inlet to the lead carbon vessel LGAC-1 should be between 25 to 30 psi and the outlet pressure should be between 20 to 25 psi. Pressure at the inlet to the lag carbon vessel LGAC-2 should be between 20 to 25 psi and the outlet pressure measured at effluent line should be between 0 to 5 psi.

5. Pressure as measured at the inlet to the Bag Filter F-2 should not be in access of 5 psi. The differential pressure across the filter canister should not exceed 15psi. If the differential pressure approaches or exceeds this value, the filters should be removed and replace with new filters.

6. Totalizer readings from the Badger mechanical effluent meters should agree with the flow indicator in CP-4. If measuring indicators on the Badger meters are not moving when the groundwater treatment system is operating, the system needs to be shut down and the Badger meters opened and inspected. Small particles from the treatment system can become lodged internally, preventing operation of the measuring components within the meters. This has occurred after changing the carbon in one of the LGAC vessels. Remove any particles and close up the meter and then re-start the treatment system. Check the operation of the meter and compare the indicated flow rate with that indicated on the flow meters in CP-4. Flow rates from the Badger meters can be determined by timing the movement of the indicators on the meter using a watch or stop watch. Values shown on the Badger meters are in 100 gallons.

7. No leaks should be observed in the water conveyance system from the wellhead to the point of discharge.

5. OPERATION MONITORING AND MAINTENANCE

The remedial systems installed at the site were designed to operate with minimal adjustment provided system components are operating properly. Periodic site visits for monitoring system parameters and conducting routine maintenance as required for each component should be done on a regular scheduled basis. Periodic monitoring and routine maintenance are discussed in the following sections.

5.1 SVE System

5.1.1 Monitoring

Periodic monitoring of the SVE system should be conducted weekly if the system is continuously operated. If the system is to be operated intermittently, then monitoring should occur at the beginning and end of each “on” cycle, and once in between the beginning and end of the “on” cycle.

Periodic monitoring is conducted to check the operational status for normal/abnormal conditions and perform appropriate adjustments to maintain normal operation. During each site visit, the following should be conducted:

- Document the position of the ball valves on the extraction well inlet piping and identify which extraction wells are supplying soil gas to the SVE system.
- Estimate the percentage of flow from each extraction well based on the position of valves in the SVE lateral pipes.
- Measure and calculate the flow rates from each operating vapor extraction well by measuring the differential pressure across the Pitot tube in the piping just upstream of the SVE piping manifold (FE-101, FE-102, FE-104, and FE-105) using a hand-held digital differential manometer or 60-inch water filled manometer.
- Measure and calculate the flow rate to the lead GAC canister by measuring the differential pressure across the Pitot tube located just upstream of the lead carbon canister.
- Measure the pressure in each operating extraction well lateral, at each SVE well head, at the SVE manifold, at the blower intake, and at the blower discharge in inches of water.
- Measure the inlet and outlet pressures for both the lead and lag GAC canisters.
- Measure the VOCs in the extracted soil gas from the sampling port in each SVE well lateral and at each wellhead using a photoionization detector (PID).

- Measure the VOCs in soil gas from sample ports at the inlet and outlet of the lead GAC canister and at the outlet for the lag GAC canister.
- Measure the pressure drop at the filter intake.
- Measure the temperature of the effluent from the air-to-air heat exchanger and verify that it has not exceeded the SVE system shut down set point of 130 ºF.
- Measure the dry bulb temperature for soil gas from ports at the inlet and outlet of the lead GAC canister and the wet bulb temperature at the sample port for the inlet to the lead GAC canister. Measure wet bulb temperatures by placing a sock moistened with water over the temperature sensor and placing the sensor in the air flow from a sampling port. Using the psychometric chart in Appendix F and the measured temperatures, determine the relative humidity of each gas stream, which should always be less than 90 percent.
- Record the operating time for the SVE system from the Sensaphone output.

Monitoring data is to be recorded on the VGAC Adsorbers Operation Log Sheet and the SVE and AS Operation Log Sheet. Record date, time, ambient air temperature, and general weather conditions (sunny, cloudy, raining, etc.). Also describe any equipment repairs or other non-routine maintenance conducted during the site visit on these forms.

Adjust the flow rates for each extraction well as directed by the project Engineer by partially opening or closing isolation ball valves in the SVE laterals just upstream of the SVE manifold. Flow rates should be adjusted to maximize the VOCs entering the carbon canisters. Charts for determining the flow rates based on measurements from the Pitot tubes are presented in Appendix F.

Notify the Engineer immediately if the PID measures detectable concentrations of VOCs in air samples from the lead GAC canister outlet sampling port.

During cooler weather between October and April, observe liquid levels in the condensate recovery tank. If liquid levels are above the LSH level, the condensate pump should be on and actively pumping condensate from the recovery tank to the compound sump. The pump will automatically turn off once the condensate level is below the LSL float switch. During the warm months of April through September condensate does not normally collect in the condensate tank due to the high ambient air temperatures.

A soil gas sample needs to be collected in a Summa sample canister for every two weeks of operation. The collected sample will be tested in a certified laboratory for VOCs using EPA Method TO-15 to evaluate carbon loading.

Record the run time meter reading in hours and subtract the initial start-up reading. The difference in these readings is the cumulative SVE system operating time. Subtract the initial reading at the time of the last carbon change-out from the run time and record the difference in readings (in days) as net operating time since last carbon change-out. Obtain projected PCE breakthrough period (in days) from the GAC spreadsheet. From this projected breakthrough period, record projected PCE breakthrough date.

5.1.2 Planned System Shutdown

Prior to shut down of the SVE system for maintenance or other purposes, purge process piping and vessels of any VOC vapor by performing the following, if possible:

- While the vacuum blower is operating, open the manual air intake valve and then close the appropriate SVE lateral isolation valves.

After about 30 minutes of operation with only ambient air intake for VOC vapor to be displaced or purged from vacuum side of vacuum blower, shut down the system as follows:

- Shut down vacuum blower and heat exchanger fan motor by switching their respective HOA switches on Control Panel CP-1 to the "Off" position.
- Implement "lock out/tag out" provisions.
- Perform routine or other maintenance as required.
- Remove "lock out/tag out" provisions at CP-1 Cabinet.

Verify following normal operating conditions:

- Close manual intake valve.
- Close SVE well head and SVE lateral sample ports.
- Adjust the positions of SVE lateral line isolation valves to the previous settings.
- Adjust the position of the carbon canister manifold isolation valves to previous settings.

Push "Reset" button on Control Panel CP-1 and turn the SVE blower and heat exchanger HOA switches to the "Auto" position. This in turn will start the SVE system with all safety shutdown features activated.

5.1.3 Routine Maintenance

During each site visit, the following preventative maintenance activities should be conducted consistent with the Maintenance Plan as part of the Air Quality Permit, as shown in Appendix G. The following checks should be made during each site visit:

- Check the Vacuum Blower for unusual vibration, noise, or heat;
- Inspect the Control Panel CP-1 for proper functions;
- Check liquid levels in Condensate Holding Tank;
- Check belts for proper tension and adjust, as appropriate; and
- Verify proper lubrication of blower per manufacturer's instructions.

Each month, conduct the following preventative maintenance activities:

- Inspect surface piping, piping components (e.g., silencers, filters, hoses), and local instrumentation for any damage or weathered condition;
- Check Carbon Canisters and Vacuum Blower discharge piping for any process gas leaks.

Record results of operational status and adjustments on SVE and AS System Operation Log sheet. If any operating condition is not within normal operating range or functionality, then immediately notify the project Engineer and proceed to troubleshoot faulty operating condition. Once the problem has been identified make the necessary repairs and restore system to normal operation. Record the results of repairs or other non-routine maintenance/repair on a SVE System Preventative Maintenance Checklist form.

5.1.4 Carbon Canister Change-Out

Prior to shut down of the SVE system for carbon canister change-out, purge the carbon canisters and interconnecting piping of VOC vapors by opening the ambient air intake valve, shutting off each extraction well on the SVE laterals, and operating the system for 30 minutes. Shut down the vacuum blower and heat exchanger fan motor by turning on their respective HOA switches on CP-1 cabinet to the "off" position following the 30-minute purge period. When the SVE system is shut down, the AS system will automatically shut down.

Air permit requirements specify that both the carbon canisters must be changed out when break-through from the lead canister has occurs. Carbon change-out is generally performed by a carbon supply company, which will remove the existing carbon from the canisters and replace it with "clean" carbon. The carbon supplier will require that a sample of the carbon be obtained to test in its laboratory for profiling purposes. For this site, spent carbon is considered a listed hazardous waste under the RCRA, F002 code. This characterization dictates type and conditions for transportation, handling requirements, and the type of regeneration facility that can be used. A waste manifest will need to be completed and signed by an authorized representative of ADEQ before the spent carbon can be removed from the site.

Prior to the carbon supplier arriving at the Site, unbolt the top access cover of the canisters and ensure that vehicular access on the south side of the remedial equipment compound is not obstructed. The carbon supplier will remove spent carbon from each canister using a vacuum truck. If the carbon has already been profiled and the manifest completed and signed, the spent carbon can be pumped directly from the canisters to the vacuum truck and leave the site. Additionally the vehicle must be properly placarded.

The carbon supplier is to charge each canister with 2,000-lbs of virgin 4x8 mesh coconut granular activated carbon. After filling the two canisters, the top access covers need to be closed and sealed.

Within fours hours of starting the SVE system after changing the carbon, a sample of the soil gas entering the lead carbon canister is to be obtained and tested in a laboratory for volatile organic compounds by EPA method TO-15.

5.2 Air Sparge System

5.2.1 Monitoring

Periodic monitoring of the AS system should be conducted weekly if the system is continuously operated. If the system is to be operated intermittently, then monitoring should occur at the beginning and end of each “on” cycle, and once in between the beginning and end of the “on” cycle.

Periodic monitoring is conducted to check the operational status for normal/abnormal conditions and perform appropriate adjustments to maintain normal operation. During each site visit, the following should be conducted:

- Check operation of the control timer by turning the main switch to observe each function setting. Verify settings for each station, the operating time for each station, and the program operating times and days.
- Measure and calculate the flow rates from each operating sparge well by measuring the differential pressure across the Pitot tube in the piping just upstream of the AS piping

manifold (FE-201 and FE-202) using a hand-held digital differential manometer or 60-inch water filled manometer.

- Check the flow rates to each well making sure that they are consistent with system operation parameters; if not adjust as necessary.
- Measure the pressure at the air compressor outlet (PI-201) and at the AS manifold (PI-202). Record the pressures indicated for the inlet and outlet of the Pace Air Controller (PCV-201).
- Measure the temperature of the compressed air being sparged to the operating wells at the sample ports just upstream of the AS manifold (FE-201 and FE-202).

The AS system is designed to operate one sparge well at a time, so separate sets of monitoring data will need to be collected during the "on" cycles for both AS-101 and AS-102. Monitoring data is to be recorded on the SVE and AS Operation Log Sheet.

5.2.2 Planned System Shutdown

When required, shut the Ingersoll Rand compressor down by pressing the appropriate on/off switch on the finger-touch membrane panel for the Intellys microprocessor. To implement "lock out/tag out" provisions, de-energize using the main switch on Control Panel CP-2 and label and lock the DP-2 cabinet door.

5.2.3 Routine Maintenance

Periodic maintenance is to be conducted to check the operational status for normal/abnormal conditions and perform appropriate adjustments to maintain normal operation. During each site visit, the following should be conducted:

- Visually check the air compressor for any leaks, dust build up, or unusual noise or vibrations.
- Check the coolant level and replenish as necessary.
- Check the condition of the air filter into the inlet of the compressor and replace if needed.
- Each month or 100 hours of operation, clean package pre-filter or replace if needed.
- Follow the Ingersoll Rand Operations Manual (See Appendix D) guidelines for scheduled filter, coolant, drive belt, motor bearing lubrication and other maintenance requirements that are conducted on a routine basis.
- Check the Poly Sep 250 oil water separator tank for proper operation. Clean water only should be observed on the concrete equipment pad coming from the water side of the drain. If the oil chamber of the tank is full empty and properly dispose of the used oil.

- Inspect the entire air conveyance line from the air receiver tank point of discharge to the air sparge manifold checking for leaks, excessive wear or other problems.
- Read pressure measurements upstream and downstream of the Pace pressure regulator and if out of the normal operating range adjust as needed.
- Check oil separator filter differential pressure gages on each filter making sure that the indicator is outside of the red zone. If not replace filters as described in the filter maintenance manual located in Appendix D.
- At the air injection manifold, electrically jog the actuators on the motorized valves making sure that they fully open and close properly and that the Hunter valve control timer is in good working order.
- Record inspection and maintenance work on the SVE/AI Preventative Maintenance Checklist and the system operational parameters on the SVE/AI Operation Log.

5.3 Groundwater Treatment System

5.3.1 Monitoring

Periodic monitoring of the groundwater treatment system should be conducted biweekly if the system is continuously operated.

Periodic monitoring is conducted to check the operational status for normal/abnormal conditions and perform appropriate adjustments to maintain normal operation. During each site visit, the following should be conducted:

- Document the position of the main globe valve on the inlet piping from EW-101 to the Bag Filter F-1.
- Record the flow rate and totalized water discharged for the influent and effluent Siemens flow meter displays in CP-4. Compare these values to the design flow rate of 110 gpm. The flow rates for the influent and effluent should be about the same unless the remedial compound sump pump is operating.
- Connect a lap top computer to the Monarch data logger and down load flow data.
- Connect a lap top computer to the Sensaphone and display real time measurement values. Record the depth of the transducer and calculate the depth of water. Also record the length of time the pump has been on and the length of time that the pump has been off.
- Open the vault for the discharge lines located near the south fence for the Skyline yard. Open the tops of the Badger meters and record the totalized values. The values on the Badger meters are in 100s of gallons. Compare these values to those indicated on the influent and effluent Siemens flow meter displays in CP-4. Observe the movement of the Badger meter and record the change that occurs during a fixed period of time using a

stopwatch. Use these values to estimate the flow rate and compare with the flow rates indicated on the influent and effluent Siemens flow meter displays in CP-4

- Measure the temperature of the effluent from the sampling port near the effluent flow meter FT-302. Measure the pH of the effluent from a sample obtained from this sample port.
- Observe and record the pressures measured at the inlet and outlet for Bag Filter BF-1, and the outlet for Bag Filter BF-2; the pressures at the inlet and outlet for the lead carbon vessel; and the pressures at the inlet and outlet for the lag carbon vessel.

Monitoring data is to be recorded on the Groundwater Operation Log Sheet. Record date, time, ambient air temperature, and general weather conditions (sunny, cloudy, raining, etc.). Also describe any equipment repairs or other non-routine maintenance conducted during the site visit on these forms.

5.3.2 Planned System Shutdown

The groundwater pump in Extraction Well EW-101 is powered by circuitry located in Control Panel CP-3 and is shut down simply by turning the HOA switch to the off position. The pump in EW-101 is equipped with a check valve to insure that water does not siphon back into the well when the pump is de-energized. However, as an extra safety precaution immediately after de-energizing the pump, close the inlet valve to bag filter F-1 so that water from the carbon treatment vessels does not siphon back into the well should the check valve at the pump fail. Also, close the effluent valve at the outlet from bag filter F-2 to keep water in the tanks from siphoning out of the carbon vessels.

Prior to shutting down the groundwater extraction pump in EW-101, record the following system parameters for comparison when the system is restarted. See Early Response Action drawing sheet PID-2A in Appendix B to reference system components:

- Record inlet and outlet pressures at Bag Filters F-1 n F-2.
- Record pressures at inlets and outlets at LGAC-1 and LGAC-2 carbon vessels.
- Record flow rates and totalized flow for the influent and effluent as displayed on the Siemens Magflo meters located in CP-4.
- Record the water level in EW-101 as shown on the Sensaphone Cell682 analog input A6.

To restart the system, open the inlet influent valve to F-1 and the outlet valve at effluent filter F-2 and turn the HOA switch to the “A” auto position to re-energize the pump. The pump can also be turned to the “H” hand position to energize the pump. This should only be done to test system components and not used to run the treatment system while unattended as all safety shutdown features are bypassed in the hand mode.

If, in addition to shutting down the pump by using the HOA switch, the main power switch to CP-3 was also shut off, then upon restoring power to CP-3 the reset button mounted on the control panel cover must be pushed before the HOA switch can be used to energize the system.

Once the groundwater treatment system is operating, check all of the system gages and sensors to make sure that they are within acceptable ranges and that they compare favourably to the previously recorded values.

5.3.3 Routine Maintenance

During each site visit for conducting monitoring of the groundwater treatment system, check operational status for normal/abnormal conditions and perform appropriate operating adjustments and monitoring by conducting the following:

- While the system is operating check the discharge line from the wellhead through all of the treatment equipment to the system effluent outlet making sure that there are no leaks and that all sensors and gages are in good operating condition.
- Check the flow and pressure indicators in CP-4 making sure that they are operating within acceptable ranges. Adjust flow rate as required at manifold valve. Abnormally high-pressure readings would indicate clogged filters, line obstructions, or excessively closed valves.
- Check that the differential pressure across each Bag Filter Canister F-1 and F-2 does not exceed 15 psi. If differential pressure exceeds 15 psi, the treatment system will need to be shut down and the filter bags replaced in accordance with manufacturers recommendations' (see filter manual in Appendix D).
- Observe and record all of the pressure indicator readings from the inlet to the treatment system at Filter Canister F-1 to the outlet down stream of the polishing Filter Canister F-2 and making sure that they are within acceptable operating ranges.
- Open vault containing the Badger effluent totalizer meters and check for proper operation by comparing the totalizer value with the number displayed on the Siemens effluent flow indicator located in CP-4.
- If the effluent outfall point is into the SRP Canal, verify the flow into the canal and check the operation of the SRP digital meter in the box on the north canal bank. If the treated water is being discharged into the Town of Gilbert sanitary sewer then remove the manhole cover and check to make sure that the water is flowing into the structure as intended. The effluent water stream should be discharged in such a way that the discharged water stream lands middle of the sanitary channel.

- Measure the water level in EW-101 and check to see if the value agrees with the calculated value measured from the pressure transducer indicator in CP-4. If not then the transducer diaphragm may need to be cleaned.

Record the system operating parameters, any unusual observations, and adjustments made on Water Treatment System Log.

5.3.4 Carbon Vessel Change-Out

Carbon change-out is generally performed by a carbon supply company, which will remove the existing carbon from the lead vessel and replace it with "clean" carbon. The carbon supplier will require that a sample of the carbon be obtained to test in its laboratory for profiling purposes. For this site, spent carbon is considered a listed hazardous waste under the RCRA F002 code. This characterization dictates type and conditions for transportation, handling requirements, and the type of regeneration facility that can be used. A waste manifest will need to be completed and signed by an authorized representative of ADEQ before the spent carbon can be removed from the site.

Prior to changing the carbon in the groundwater treatment system vessels, the treatment system must be shut down, a sample of the carbon needs to be obtained, and the vessel containing the carbon that is to be changed needs to be drained. Typically, carbon in the lead vessel is to be removed and re-placed with new "clean" carbon. The lead vessel should be drained of liquid about one week before the carbon supplier is to remove the carbon from the vessel, although the amount of time required to test the carbon for profiling purposes needs to be considered. Some carbon suppliers require the test results for profiling the carbon be available when the carbon is removed from a site. If this is the case, then the treatment system should be shut down several weeks before the carbon is to be removed to allow for the laboratory to test the carbon sample and issue a final report that can be available at the time of change-out. Most carbon suppliers conduct the profile testing as part of their services.

Following shut down, close off the appropriate valves to isolate the lead vessel and adjust other valves to allow water to flow from the remedial compound sump pump through the lag carbon vessel and then to the treatment system discharge piping. Following isolation of the lead vessel, open the valve for the venting pipe that extends from the top of the vessel down the side of the vessel to allow the vessel to de-pressurize. The valve is located toward the bottom of the discharge pipe along the side of the vessel. Connect the end of flexible tubing to the drain pipe, which is located at the bottom of the vessel and place the other end of the tubing in the remedial compound sump and/or a storage tank. Open the manway opening at the top of the vessel and open the drainpipe valve to allow the vessel to drain. The vessel needs to be drained at least one week before the carbon supplier arrives on site to remove the carbon. If the carbon retains moisture, the carbon supplier will place the spent carbon in bags within the remedial compound to drain and allow the materials to dry for transportation.

Prior to the carbon supplier arriving at the Site, make sure the manway opening at the top of the lead vessel is open and ensure that vehicular access to south and west sides of the remedial equipment compound is not obstructed. Carbon supplier will remove spent carbon from each canister using a vacuum truck. If the carbon is sufficiently drained for free liquids and has been profiled, and the manifest has been completed and signed by ADEQ, the spent carbon can be pumped directly from the canisters to containers for transportation off the site. The vehicle must be properly placarded.

The carbon supplier is to charge each canister with 5,000-lbs of virgin 12x30 mesh coconut granular activated carbon. After filling the lead vessel, the top manway cover is to be closed and sealed.

Following carbon change out, the direction of the flow from the groundwater pump EW-101 is to be changed such that the lead vessel becomes the lag vessel and the lag vessel becomes the lead vessel. This is accomplished by adjusting the appropriate valves on the carbon vessels manifold. Note that the air relief valve on the top of the lag LGAC vessel will need to be moved to the lag vessel when the two vessels positions are swapped from their original lead/lag series configuration.

6. SAMPLING AND TESTING

6.1 SVE System Air Permit Compliance Testing

ADEQ has obtained an air quality permit for operation of the vapor extraction system. The air permit includes daily and twelve-month-rolling emission limits; 90 percent removal efficiency; maximum 2,100 ppmv inlet VOC concentration; and maximum 300 scfm flow rate. The permit conditions require that both carbon canisters be replaced before breakthrough occurs, and allows for estimation of the amount of VOCs in the carbon canisters based on the inlet VOC concentrations to the lead canister to achieve compliance. HGC has developed a spreadsheet that is used to estimate the VOC concentration in the two carbon canisters. Information from the monitoring discussed in Section 5.1 is input into the spreadsheet. Carbon is changed out when the amount of VOCs is estimated to be 2,700 pounds based on the carbon adsorbsion equations in the spreadsheet, unless VOCs are not detected in the lead VGAC outlet or the lab VGAC outlet using a PID. When VOCs are detected in the lag VGAC outlet flow, the SVE system is shut down and arrangements are made to change-out the carbon.

The permit requires testing within four hours of starting up the SVE system. This has been interpreted to include starting the SVE after replacing the carbon in the two carbon canisters.

All monitoring data is to be recorded on a log or similar documents and should include the mass flow rate and the hours of operation.

6.2 Groundwater Treatment System Permit Compliance and Testing

Samples of influent and effluent from the groundwater treatment system are obtained and tested to evaluate performance of the system, monitor carbon consumption, and monitor compliance with various permits and/or agreements that were obtained for the system operation. ADEQ has obtained an Arizona Pollution Discharge Eliminate System (AZPDES) permit from ADEQ; a Poor Quality Groundwater Withdrawal (PQGW) permit from the Arizona Department of Water Resources (ADWR), and a Wastewater Discharge permit from the Town of Gilbert (TOG). ADEQ has also entered into an agreement with the Salt River Project (SRP) to discharge to SRP's Lateral 9.5 canal.

Copies of the permits are presented in Appendix G. The testing required by the various permits for the groundwater treatment system is summarized in Table 1. Sampling and testing procedures are to follow the guidelines presented in the draft Quality Assurance Project Plan for Cooper and

Commerce WQARF Site Early Response Action Gilbert, Arizona, prepared by HGC and dated March 1, 2011.

6.2.1 Carbon Consumption Evaluation Sampling

Samples from the lead carbon vessel inflow and outflow are tested for VOCs using EPA Method 8260B on a monthly basis. The test results are used to monitor carbon consumption in the lead vessel. When VOCs are detected in the outflow samples, breakthrough is considered to have occurred and the groundwater treatment system is shut down. When breakthrough from the lead carbon vessel occurs, the carbon is the lead vessel is replaced.

6.2.2 AZPDES Permit Sampling

The AZPDES Permit requires sampling and testing at various frequencies as shown in Table 1. All samples for this permit are from the sample port located near the effluent flow meter FT-302. The permit requires weekly measurement of pH in effluent. Quarterly samples are to be tested for selected VOCs and acrolein, acrylonitrile, and 2-chloroethylvinyl ether. Semi-annual samples are to be testing for selected VOCs and total metals.

Results of laboratory testing conducted for this permit are presented on forms provided by ADEQ. Results of flow rate monitoring from the Siemens effluent flow meter located after the lag carbon vessel.

6.2.3 PQGW Permit Sampling

The PQGW permit contains no specific requirements for sampling and testing. Instead, this permit requires submittal of the results of testing performs by other permits related to the remedial work at the site. Since there is only one groundwater extraction well in operation for the treatment system, the results for the influent sample obtained as part of the carbon consumption evaluation will be used to demonstrate compliance for this permit. Should additional extraction wells be installed, additional sampling and testing will be required.

6.2.4 TOG Discharge Permit Sampling

The TOG Discharge Permit requires sampling only when effluent from the groundwater treatment system is discharged to its sanitary sewer system. This will only occur when SRP does not allow discharges to its Lateral 9.5 canal. SRP may not allow discharges to its canal during its dry-up period that occurs in November and December each year.

The TOG permit requires advance notice that discharge will be occurring to its sewer system and laboratory testing of sampling for selected VOC and total metal compounds. The compounds to be tested are shown in Table 1. Samples for the TOG Discharge permit are to be obtained from the sample port located near the effluent flow meter FT-302.

6.2.5 SRP Discharge Sampling

SRP requires annual sampling and testing for effluent from the treatment system. This sample is to be obtained from the sample port located near the effluent flow meter FT-302. This sample is to be tested for selected VOCs and total metals as indicated in Table 1.

The SRP agreement also requires semi-annual sampling of effluent in the canal, downstream of the discharge point. These samples are to be obtained at the inlet structure for the Lateral 9.5 canal where it crosses Cooper Road. The samples are to be tested for selected VOCs and total metals as indicated in Table 1.

7. TROUBLESHOOTING AND NORMALIZATION

7.1 SVE System

Troubleshooting guidance is presented below for the identified alarm conditions observed upon arrival at the Site or the observed condition upon attempted restart of the remediation equipment. Follow the maintenance shut down and restart procedures presented in Sections 4.0 and 5.0 if the remediation system is to be shut down and restarted as part of the troubleshooting and normalization effort. Complete a Failure Response and Troubleshooting Record form (Appendix I) and submit to Engineer.

The SVE blower skid is controlled from the skid mounted Control Panel CP-1 mounted on the east side of the skid. If the system is not working properly a trained field technician should work through the troubleshooting checklist below. If, after doing this, the system is still not working, then call a qualified electrician to troubleshoot and repair.

The SVE skid is powered through a transformer located next to CP-3 (refer to electrical drawing sheet E-2 in Appendix B). Next the transformer is a 240 volt100 amp, 3-phase disconnect switch. Make sure that the switch is in the on position.

Mounted on the front door of CP-1 is an LCD display screen that is used to indicate shut down alarm conditions. Check the display for any of the following alarm conditions:

7.1.1 Condensate Tank High-High Level Alarm

If this alarm is displayed check the condensate tank and see if it is full to the highest switch level as seen though the site glass. If it is, then check to see if the condensate transfer pump is operating properly. To do this first push the reset button on the door and place the HOA pump switch mounted on the CP-1 door in the hand mode. If the pump does not operate in the hand mode, then open the control panel door and push the red reset button on the overload relay located at the bottom of the pump motor starter/controller and try starting again in the hand position. If the pump still does not operate check for power at the 100-amp circuit breaker and reset if necessary. If the system is energized and none of the above solves the problem, then the pump motor itself may need to be replaced, or some other problem may be causing the malfunction that is beyond the scope of this trouble shooting guide to resolve and a qualified electrician should be called in to diagnose and repair. If the pump operates in the hand mode but not in auto, then use a continuity meter check to see that the low and high level switches in the condensate tank are operating properly and replace if necessary. Check the fuse in the intrinsic safety barrier connected to the X0 input on the DL-105 PLC. Make sure that the PLC is getting power on both the input and output side of the unit. If none of these efforts resolve the problem, call a qualified electrician to diagnose and repair.

7.1.2 High Pressure Alarm

If this alarm is activated check to make sure that there is no obvious obstructions between the outlet of the blower and the 4-inch exhaust stack at the end of the treatment circuit and make sure that all of the valves on the manifold between the two GAC vessels are opened for normal lead-lag operation. If all of the valves downstream of the blower are in their correct operating position then perform the following:

- Open the bypass valve on the air-to-air heat exchanger, push the reset button on CP-1 and try restarting the system. If it is now operating normally then the heat exchanger coils may be clogged and will need to be serviced by a qualified technician.
- If the pressure in the system remains high after eliminating the air-to-air heat exchanger then the problem may be due to excessive condensate collecting in the carbon vessels. Open the drain at the bottom of each canister and let condensate tanks drain and restart system.
- If opening the pressure indicators downstream of the blower indicates a pressure lower than the system shutdown value then the problem may be in the pressure switch itself. Check to make sure that the switch set point is correct and adjust if necessary, and then try restarting the system. If the system fails to start check the pressure switch for electrical continuity by removing the cover from the switch (located on the pipe run below CP-1) and placing continuity meter across the switch contacts to insure that the switch is closed. If the contacts are open then the switch needs to be replaced.

7.1.3 High Temperature Alarm

Air temperatures in the conveyance pipe exceeding 140 ºF cause a high temperature system shutdown alarm. The high temperature switch is a simple snap action single contact type switch mounted on the SVE pipe just downstream of the air-to-air heat exchanger outlet. The setting of 140 °F is the maximum allowed for SCH 40 PVC. If a shut down occurs it may be due to problems associated with the heat exchanger fan motor.

- If the motor is not energizing first, turn the cooler switch to the off position then open CP-1 door and press the red overload relay reset button on the cooler motor controller. Then press the PLC reset button located on the front of the CP-1 door. Having restarting the system, turn the heat exchanger to the auto position. If the system cooler fan still fails to energize then turn the HOA switch to hand mode. If the cooler energizes in this mode then the problem may lie in the PLC.

- If the cooler does not energize in the hand mode, then test the contacts on the temperature switch itself using an electrical continuity meter. In order for the fan motor to operate the contacts must be closed. If the temperature is below the set point on the temperature switch and the contacts prove to be open then it needs to be replaced.
- If all of the above fail to correct the problem then call a qualified electrician to diagnose and repair.

7.2 AS System

The main component of the AS system is the Ingersoll Rand rotary screw air compressor. If this is not working, test the fuses at the quick disconnect shown on drawing E-4 located in Appendix B to make sure that they are in good working order. If it has been established that power is available at the disconnect but the compressor is not working properly consult the Ingersoll Rand Troubleshooting Guide located in Appendix D for probable causes and solutions. If the air compressor and receiver tank are functioning but air flow to the sparge wells is not normal, investigate the following system components for proper function:

- Check the two Ingersoll Rand oil separator filters located in series downstream of the air receiver tank. Each filter is equipped with a differential pressure indicator window. The indicator needle should be in the white operating area of the gage. If it is in the red then the filters will need to be replaced. This will re-establish an unobstructed flow to the sparge wells.
- Check the Pace air regulator located down stream of the filters discussed above. The pressure on the inlet side of the regulator should be about 70 psig and the outlet side should be about 10 psig. Make adjustments as required.
- If pressure to the well manifold is within normal operating ranges but air is not being delivered to the wells check to make sure that the motorized ball valves are functioning by toggling power to each valve manually through the Hunter control timer located at the manifold. If power is getting to the actuator but the valve is not opening then either the actuator or the valve need to be replaced.
- If the Hunter controller is not powering up, test the fuse that powers up the controller located in CP-4.
- If power is getting to the Hunter controller but it is not powering up then it needs to be replaced.
- If power is getting to the Hunter control timer and the valves can be actuated manually but not through the auto timing circuitry then check relay-1 in CP-4 and test for electrical continuity across contact points 1-9 (see Appendix D sheet E-11). This set of contacts should be closed: if not, the problem may be due to a fault in pressure switch PSL-110

shown on drawings PID-1 and E-11 located in Appendix B. Check to make sure that it is not sending power to Relay-1. If it is, then the pressure switch will need to be replaced.

If all of the above have been performed without success then call a qualified electrician to troubleshoot and repair.

7.3 Groundwater Treatment System

If the groundwater treatment system shuts down without apparent cause, the following steps should be taken to identify the problem. See the electrical drawing set located in Appendix B for component identification and locations:

- Using a volt meter, check that there is power energizing Control Panels CP-3 and CP-4. If no power is present, then check to make sure that the circuit breakers connected to these panels located in power distribution boxes LP and DP have not been tripped. If so, reset and check power in CP-3 and CP-4. Power should be restored.
- If power to CP-3 and CP-4 was not disrupted, then check the relay located in CP-3 to see if LED indicator is on. If it is not, then the reason for the system shut down was due to excessively high pressure condition located somewhere in the treatment circuit between the groundwater pump in EW-101 well and the system outfall. To identify the problem, turn the HOA switch to the off position and press the relay reset switch mounted on the cover of CP-3. This will latch the relay to an energized state. To verify this, note that the LED relay indicator is lit. If it is not, then the relay is blown and will need to be replaced.
- If the relay is energized, then turn the pump on placing the HOA switch in the hand position and observe the pressure gauge at the inlet and outlet sides of the Bag Filter F-1. If the differential pressure is greater than 15 psi between the inlet and the outlet of F-1 and the inlet side of the filter registers a value equal to or greater than the pressure switch located just upstream of the bag filter (currently set at 60psi), then the filters are clogged and need to be replaced.
- If the outlet pressure gauge from F-1 measures a value equal to or greater than the inlet pressure switch set-point, then a constriction is caused by a blockage downstream of F-1. Check effluent Bag Filter F-2 pressure gauges as was done for F-1 described above.
- If it was determined that filters F-1 and F-2 were not the problem, then using the gauges at the influent and effluent side of each carbon vessel LGAC-1 and LGAC-2, try to isolate where the line constriction is. If a constricted portion of the treatment line can be identified check to make sure that all the valves and other components are in good working order and if not repair or replace.
- Check each valve at the manifold located between the LGAC-1 and LGAC-2 making sure that they are configured properly in regards to the water flow path through the treatment system and are in good working order. Repair or replace as necessary any malfunctioning component.

- If an excessively high system pressure registers at the outlet at F-2, then a line blockage exists somewhere outside of the treatment compound. If this is the case, check to see if the appropriate valve is open in the well vault housing the Badger mechanical flow meters that lead to the SRP canal or Town of Gilbert sanitary sewer system. If the valve is open and flow is restricted then this could indicate that there is a blockage within the flow meter itself. Disassemble the flow meter housing and clean as necessary.
- If when the HOA is turned to the hand position, the pump does not turn on, then push the reset button located below the HOA switch on the door of CP-3. This will reset the pump starter overload relays. Having done this, try starting the pump again by turning the HOA switch to the hand position. If the overload relays at the pump starter trip, this would indicate that something is wrong with the pump or that a short exists somewhere in the power feed line from the pump starter to the pump. Most often the problem lies within the pump and it may have to be pulled to repair. To determine if this is the case, shut the power off to CP-3 and lock out the knife switch following NEC guidelines. Having done this, disconnect the well pump from the electrical feed line located in the electrical disconnect enclosure inside the well vault. Re-energize CP-3 and press both reset buttons mounted on the panel door. Turn the HOA switch to the hand position. If the motor starter energizes and the overload relays do not trip out, then the problem is most likely related to the pump. If this is the case, then a qualified electrician should be called to pull the pump, diagnose the problem, and repair or replace if needed.
- If the pump and treatment system are operating normally when the HOA switch is in the hand position but not when it is in the auto position, then the most likely cause of the problem is a faulty pressure transducer. To verify this, connect a PC to the RS232 port on the Sensaphone unit located in CP-4. Using the Sensaphone to PC interface software connect to the Sensaphone unit and observe the value for analog input A6. If this value is not within the low and high range limits programmed into thee Sensaphone Output-1 (pump control), then the transducer will need to be recalibrated or replaced if necessary.
- If all of the above fail to correct the problem then call a qualified electrician to diagnose and repair.

TABLE

TABLE 1
REQUIRED TESTING AND TEST METHODS
COOPER AND COMMERCE WQARF SITE

Quarterly = Jan, Apr, Jul, Oct   Semi Annually = Oct and Apr   Annually = Oct

Parameter	Test Method	Weekly	Monthly	Quarterly	Semi-Annually	Annually
O&M REQUIREMENTS						
SVE SYSTEM O&M						
SVE O&M	TO-15		2			
SVE Carbon C/O	TO-15				X	X
WATER TREATMENT SYSTEM O&M						
WWTP O&M						
Influent - Ongoing	8260		1			
Lead Vessel - Ongoing	8260		1			
GW MONITORING						
Limited Monitoring	8260				12	
Full Monitoring	8260				26	
	13 PP Metals				18	
PERMIT REQUIREMENTS						
1.0 AZPDES PERMIT REQUIREMENTS						
Based on AZPDES Permit Modification dated June 29, 2009.						
1.1 Table 1 Effluent						
Chloroform	8260			X		
Tetrachloroethene	8260			X		
Trichloroethene	8260			X		
Boron	200.7				X	
pH	field	X				
1.2 Table 2 Effluent						
Arsenic	200.7				X	
Selenium	200.7				X	
Hardness ($CaCO_3$)	200.7				X	
1.3 Table 3a - Years 2, 3, and 4 only, Effluent						
Antimony	200.7					X
Arsenic	200.7					X
Beryllium	200.7					X
Cadmium	200.7					X
Chromium (total)	200.7					X
Chromium (VI)	SM 3500					X
Copper	200.7					X
Lead	200.7					X
Mercury	245.1					X
Nickel	200.7					X
Selenium	200.7					X

TABLE 1
REQUIRED TESTING AND TEST METHODS
COOPER AND COMMERCE WQARF SITE

Parameter	Test Method	Weekly	Monthly	Quarterly	Semi-Annually	Annually
Silver	200.7					X
Thallium	200.7					X
Zinc	200.7					X
Cyanide	SM 4500-CN					X
Hardness (CaCO3)	200.7					X
1.4 Table 3ba Effluent						
VOCs, full list	8260			X		
Acrolein	624			X		
Acrylonitrile	624			X		
2-chloroethylvinyl ether	624			X		
2.0 SRP AGREEMENT REQUIREMENTS						
Based on SRP Agreement dated June 7, 2010.						
Trichloroethylene	8260					X
Perchloroethylene	8260					X
1,1,1-trichloroethane	8260					X
1,1-dichloroethylene	8260					X
cis 1,2-dichloroethylene	8260					X
Trans 1,2-dichloroethylene	8260					X
1,2-dichloroethane	8260					X
Vinyl chloride	8260					X
Benzene	8260					X
Toluene	8260					X
Xylene	8260					X
Arsenic	200.7					X
Boron	200.7					X
Cadmium	200.7					X
Copper	200.7					X
Lead	200.7					X
Mercury	245.1					X
Selenium	200.7					X
Zinc	200.7					X
Alkalinity, as $CaCO_3$	200.7					X
Bicarbonate Alkalinity,	310.2					X
Chloride	E300					X
Hardness, dissolved $CaCO_3$	130.1					X
Nitrate -N	E300					X
Nitrite-N	E300					X
Sulfate	E300					X
Total Dissolved Solids	SM2540C					X
Fluoride	E300					X
Orthophosphate as P	E300					X
Barium	200.7					X
Calcium	200.7					X
Iron, total	200.7					X
Magnesium	200.7					X

TABLE 1
REQUIRED TESTING AND TEST METHODS
COOPER AND COMMERCE WQARF SITE

Parameter	Test Method	Weekly	Monthly	Quarterly	Semi-Annually	Annually
Potassium	200.7					X
Sodium	200.7					X
3.0 TOWN OF GILBERT REQUIREMENTS						
Based on Revised Town of Gilbert Wastewater Discharge Permit No 0311-MH22071, dated April 1,						
pH	field					X
Arsenic	200.7					X
Cadmium	200.7					X
Copper	200.7					X
Lead	200.7					X
Mercury	245.1					X
Selenium	200.7					X
Silver	200.7					X
Zinc	200.7					X
Cyanide	SM 4500-CN					X
Fluoride	E300					X
Molybdenum	200.7					X

FIGURES

Legend

- Monitor Well
- Extraction Well
- Well With Dedicated Pump (Not Currently Pumping)
- Well With Dedicated Pump (Currently Pumping)
- Skyline Steel Yard Where Cooper and Commerce WQARF Site Remedial System is Located

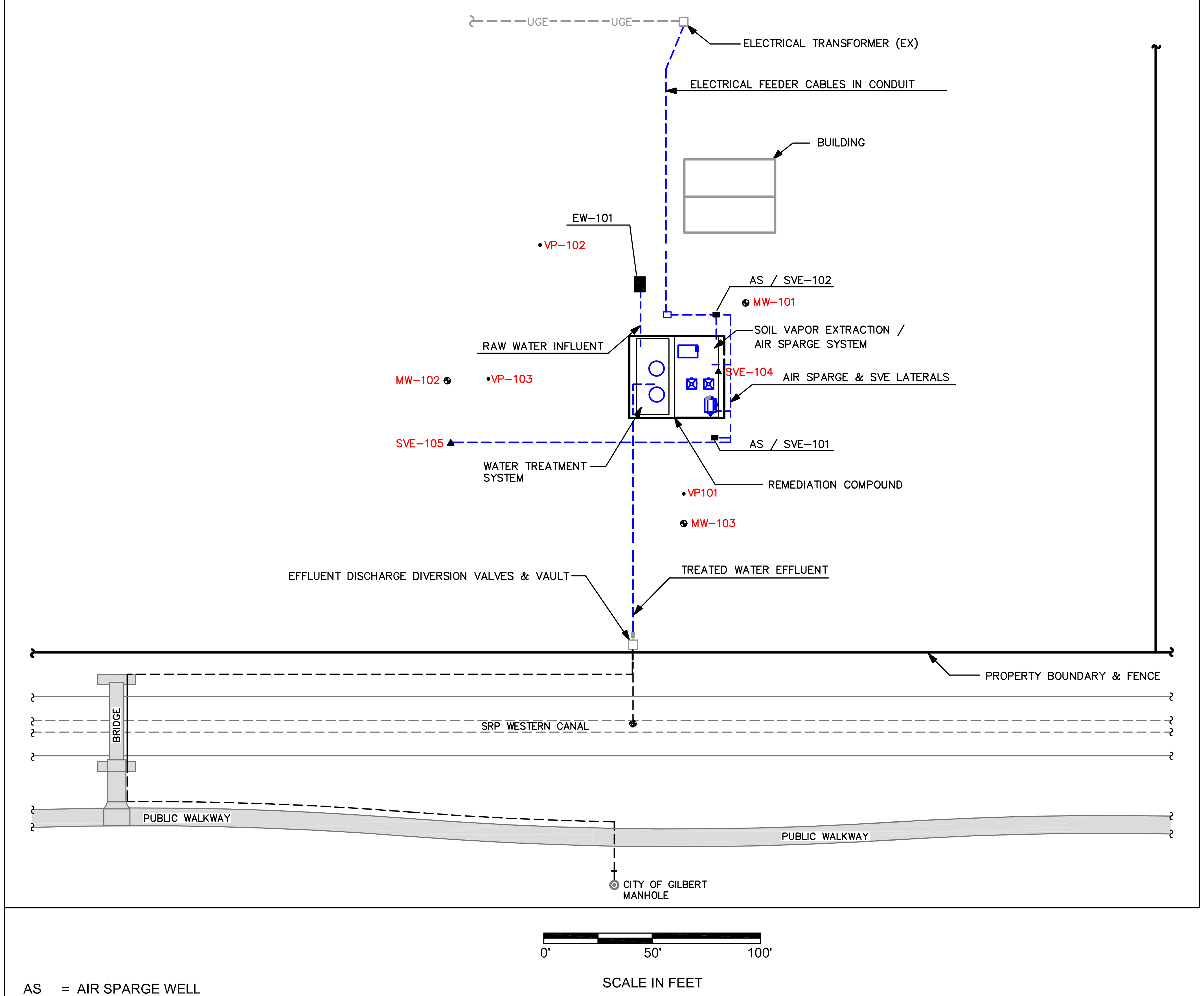
0 400 800 Feet

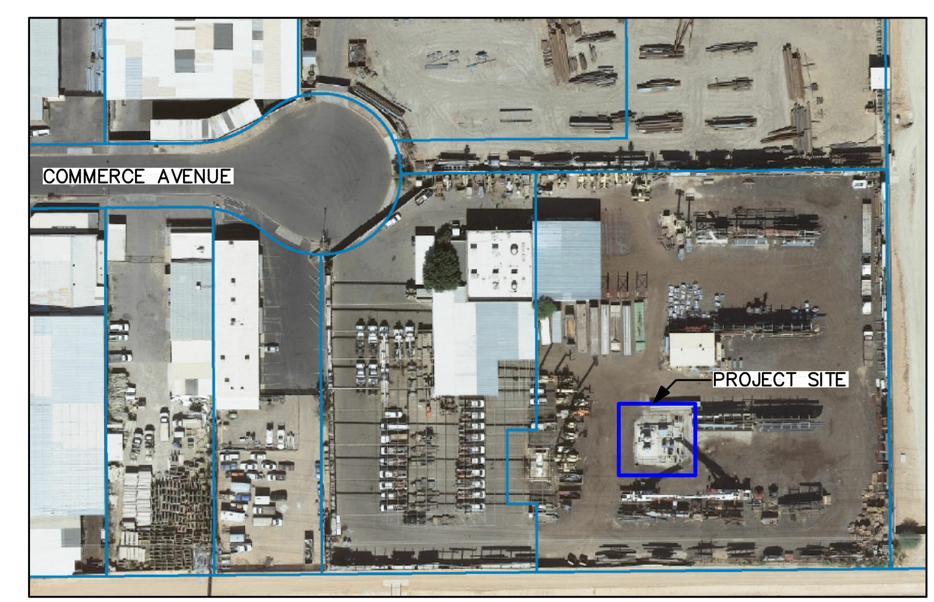
N

HYDRO GEO CHEM, INC.

COOPER AND COMMERCE WQARF SITE
AND MONITORING WELL LOCATION MAP

Approved	Date	Author	Date	File Name	Figure
CJ	02/07/11	AMC	02/07/11	201000205G	1





AS = AIR SPARGE WELL
EW = EXTRACTION WELL
MW = MONITOR WELL
SVE = SOIL VAPOR EXTRACTION WELL
VP = VAPOR MONITOR WELL

HYDRO GEO CHEM, INC.

COOPER AND COMMERCE WQARF SITE
SITE REMEDIATION SYSTEM PLAN

Approved	Date	Author	Date	Reference	Figure
CLJ	2/11/11	JAA	2/11/11	201000206A	2

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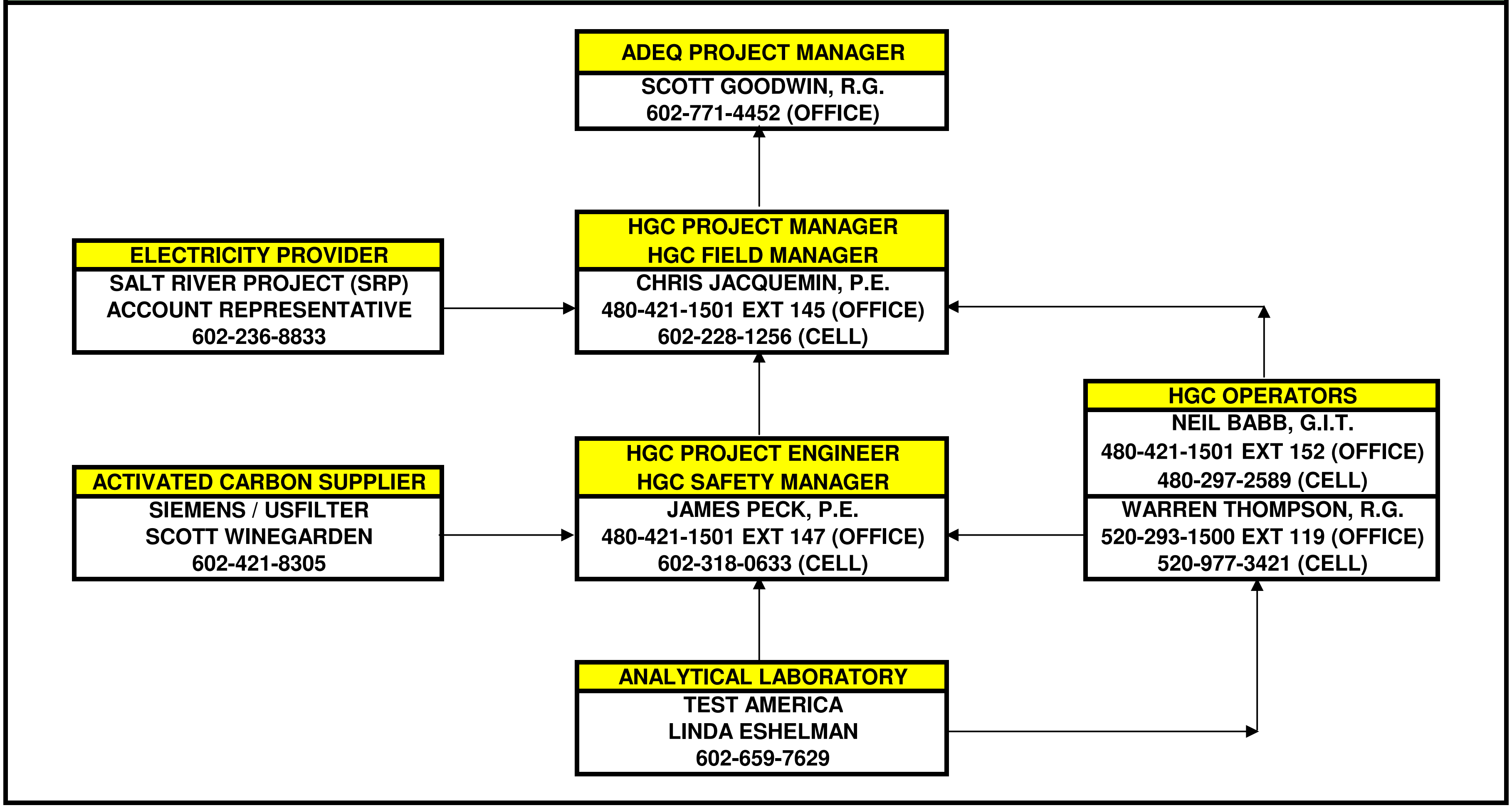
APPENDIX A

PROJECT ORGANIZATION CHART

ADEQ COOPER & COMMERCE WQARF SITE ERA
ORGANIZATION CHART



APPENDIX B

REMEDIAL SYSTEM CONSTRUCTION DRAWINGS

EARLY RESPONSE ACTION

DRAWING INDEX

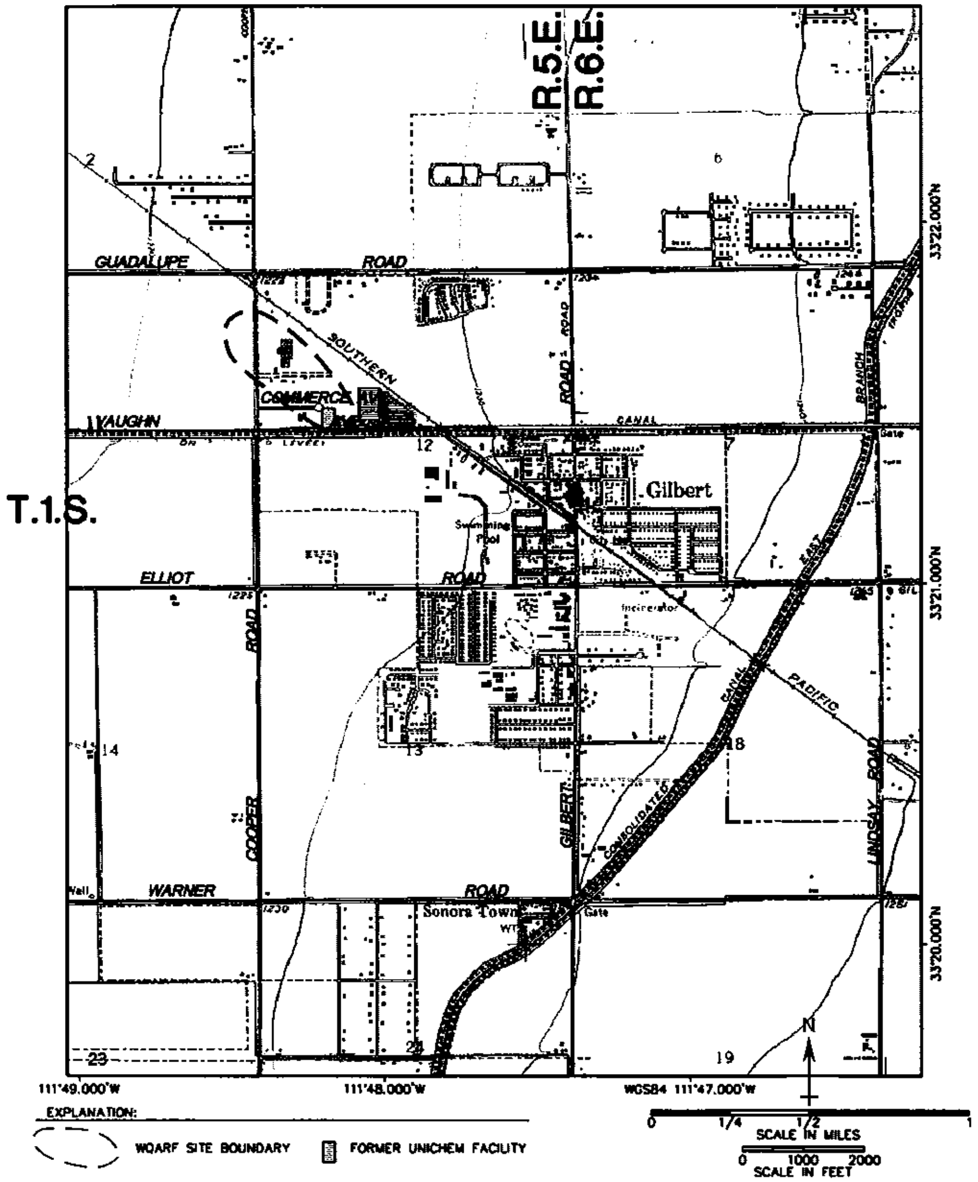
DWG No.	TITLE	REFERENCE NUMBER
1	COVER SHEET	8330014A
2	SYMBOLS AND ABBREVIATIONS	8330015A
PID-1	AS / SVE SYSTEM - PROCESS & INSTRUMENTATION DIAGRAM	8330016A
PID-2	GROUNDWATER EXTRACTION / TREATMENT SYSTEM - P & ID	8330017A
PID-3	PROCESS CONTROL & REMOTE MONITORING DIAGRAM - SENSAPHONE SKYMETRY UNIT	8330018A
P-1	PIPING / TRENCHING PLAN	8330019A
P-2	PROCESS EQUIPMENT LAYOUT	8330020A
P-3	WELLHEAD DETAILS	8330021A
P-4	PIPING / TRENCHING SECTIONS - ONSITE	8330022A
P-5	PIPING / TRENCHING SECTIONS - OFFSITE	8330023A
C-1	CONCRETE CONTAINMENT PAD AND SUMP	8330024A
E-0 to E-15	ELECTRICAL DESIGN	ELECTRICAL DESIGNS, INC.
P-1A	PIPING / TRENCHING PLAN - OFFSITE	(FUTURE)

GENERAL NOTES

(A) ALL CONSTRUCTION SHALL CONFORM TO CONTRACT DOCUMENTS, INCLUDING MOST RECENT REVISION OF BUILDING AND CONSTRUCTION REGULATIONS CODE OF THE TOWN OF GILBERT, ARIZONA, AS APPLICABLE.

(B) CONTRACTOR SHALL, AT HIS EXPENSE, OBTAIN ALL PERMITS NECESSARY TO CONSTRUCT THE EARLY RESPONSE ACTION FACILITIES AS DEPICTED IN THE CONTRACT DOCUMENTS. FURTHER, SUCH PERMITS SHALL BE OBTAINED PRIOR TO COMMENCEMENT OF CONSTRUCTION.

(C) CONTRACTOR SHALL VERIFY LOCATIONS AND ELEVATIONS OF ALL TIE-IN LOCATIONS AND UNDERGROUND UTILITIES. CONTRACTOR SHALL CONTACT ARIZONA BLUE STAKE (1-800-782-5348) FIVE WORKING DAYS PRIOR TO START OF CONSTRUCTION. THE LOCATION AND ELEVATION OF PIPES OR OTHER UNDERGROUND STRUCTURES OR PROPERTY LINES ARE NOT EXACTLY SHOWN ON CONTRACT DOCUMENTS, NOR ARE ALL UNDERGROUND PIPES OR STRUCTURES SHOWN ON CONTRACT DOCUMENTS.



LOCATION MAP - Gilbert, AZ

Registered Professional Engineer (Chemical)
CERTIFICATE NO. 26426
DANIEL A. DOWLER
Date Signed 3-25-08
ARIZONA U.S.A.
EXPIRES 9-30-2010

DRAWINGS FOR:

ADEQ Arizona Department of Environmental Quality

DEPARTMENT OF ENVIRONMENTAL QUALITY
COOPER AND COMMERCE WQARF SITE
GILBERT, ARIZONA

PREPARED BY:

HYDRO GEO CHEM, INC.
6340 E. THOMAS ROAD
SUITE 224
SCOTTSDALE, ARIZONA 85251
(480) 421-1501
http://www.hgcinc.com

REVISION HISTORY

No.	BY	DATE	DESCRIPTION

SCALE: AS NOTED	DATE	
DWG BY: JAA	12/21/07	
APPRV'D BY:		
CLIENT APPROVED BY:		

HYDRO GEO CHEM, INC.

ADEQ COOPER AND COMMERCE ERA

COVER SHEET

REFERENCE No. 8330014A
REVISION
DRAWING No. 1

SYMBOLS & ABBREVIATIONS

ABBREVIATIONS

@	AT
AMP	AMPERE
ANSI	AMERICAN NATIONAL STANDARDS INSTITUTE
AS	AIR SPARGE
ASL OR AMSL	ABOVE (MEAN) SEA LEVEL
ASTM	AMERICAN SOCIETY FOR TESTING AND MATERIALS
ATM	ATMOSPHERE
BGS	BELOW GROUND SURFACE
C	CONDUIT
CAP	CAPACITY
℄	CENTERLINE
CP	CONTROL PANEL
CS	CARBON STEEL
DIA	DIAMETER
DWG	DRAWING
E	EAST
EA	EACH
ELEV OR EL	ELEVATION
EQ	EQUAL (DIMENSION OR SPECIFICATION)
EW	EXTRACTION WELL
EX	EXISTING
F	FAHRENHEIT OR FILTER
FI	FLOW INDICATOR
FIG	FIGURE
FIT	FLOW INDICATOR TRANSMITTER
FIQ	FLOW INDICATOR TOTALIZER
FLA	FULL LOAD AMPS
F/MNPT	FEMALE/MALE NATIONAL PIPE TAPER (THREAD)
FT	FEET, FOOT OR FLOW TRANSMITTER
G	GREEN
GAL	GALLON
GALV	GALVANIZED
GND	GROUND
H	HIGH
HEX	HEAT EXCHANGER
HDPE	HIGH DENSITY POLYETHYLENE
Hg	MERCURY
HGC	HYDRO GEO CHEM, INC.
HOA	HAND / OFF / AUTO
HP	HORSEPOWER
HS	HAND SWITCH
ICFM	INLET (ACTUAL) CUBIC FEET PER MINUTE
ID	INSIDE DIMENSION
IN	INCH
IS	CURRENT SWITCH
JS	POWER SWITCH
L	LOW
LB	POUND
LGAC	LIQUID-PHASE GRANULAR ACTIVATED CARBON
LI	LEVEL INDICATOR
LSH	LEVEL SWITCH HIGH
LSHH	LEVEL SWITCH HIGH-HIGH
LSL	LEVEL SWITCH LOW
M	MOTOR
MN	MANHOLE
MIN, MAX	MINIMUM, MAXIMUM
MW	MANWAY
N	NORTH
NC	NORMALLY CLOSED
NO	NORMALLY OPEN OR NUMBER
NOS	NUMBERS
NTS	NOT TO SCALE
OD	OUTSIDE DIAMETER
PCV	PRESSURE CONTROL VALVE
PDI	PRESSURE DIFFERENTIAL INDICATOR
PE	POLYETHYLENE
PI	PRESSURE INDICATOR
PP	POWER POLE
PSH	PRESSURE SWITCH HIGH
PSIG	POUNDS PER SQUARE INCH, GAUGE
PT	PRESSURE TRANSMITTER
PV	PRESSURE RELIEF VALVE
PVC	POLY VINYL CHLORIDE
QK	CONTROL TIMER
RCRA	RESOURCE CONSERVATION AND RECOVERY ACT
ROW	RIGHT OF WAY
S	SOUTH
SCFM	STANDARD CUBIC FEET PER MINUTE
SCH	SCHEDULE
SDR	STANDARD DIAMETER RATIO
SRP	SALT RIVER PROJECT
SS	STAINLESS STEEL
SVE	SOIL VAPOR EXTRACTION
TDH	TOTAL DYNAMIC HEAD
THD	THREADED
TI	TEMPERATURE INDICATOR
TYP	TYPICAL
UG	UNDERGROUND
V	VOLT
VAC	VACUUM
VGAC	VAPOR-PHASE GRANULAR ACTIVATED CARBON
VP	VAPOR POINT
W	WEST OR WIDTH
W.C.	WATER COLUMN
XL	UNCLASSIFIED LIGHT
XV	UNCLASSIFIED VALVE
ZS	POSITION SWITCH

VALVES & FITTINGS

NORMALLY OPEN

- BALL VALVE
- GATE VALVE
- GLOBE VALVE
- BUTTERFLY VALVE
- CHECK VALVE
- PIPE REDUCER
- FLANGED CONNECTION
- UNION FITTING
- ELBOW DOWN
- ELBOW UP
- TEE DOWN
- PRESSURE CONTROL VALVE
- MOTORIZED BALL VALVE FLANGED ENDS
- FLOW DIRECTION

NORMALLY CLOSED

- BALL VALVE
- GATE VALVE
- VACUUM RELIEF VALVE
- PRESSURE RELIEF VALVE
- PRESSURE / VACUUM RELIEF VALVE
- MONITORING PORT (1/2" BALL VALVE)

P & I D SYMBOLS

- ELECTRICAL INTERCONNECTION
- ELECTRONIC INTERCONNECTION
- FLEXIBLE CONNECTOR
- CAPPED END
- PLUGGED END
- CENTRIFUGAL PUMP, VERTICAL DISCHARGE
- PSH — FIELD-MOUNTED INSTRUMENT (EX)
- FE 101 — FIELD-MOUNTED INSTRUMENT (NEW)
- HS — FRONT OF PANEL MOUNTED
- XL 302 — INDICATOR LIGHT
- IS 302 — REAR OF PANEL MOUNTED
- FIQ 301 — ELECTRONIC DEVICE OR INSTRUMENT

SYMBOLS

- WATER TABLE
- PP — POWER POLE
- —PL— POWER LINE
- —UGE— UNDERGROUND ELECTRIC
- FENCE
- PIPE SLOPE DIRECTION
- ϕ PHASE
- X — DETAIL NUMBER
- YY — DRAWING NUMBER

Registered Professional Engineer (Chemical)
CERTIFICATE NO. 26426
DANIEL A. DOWLER
Date Signed 3-25-08
ARIZONA U.S.A.

EXPIRES 9-30-2010

HYDRO GEO CHEM, INC.

ADEQ COOPER & COMMERCE ERA SYMBOLS & ABBREVIATIONS

Approved	Date	Revised	Date	Reference	Figure
DD	12/21/07		12/21/07	8330015A	2

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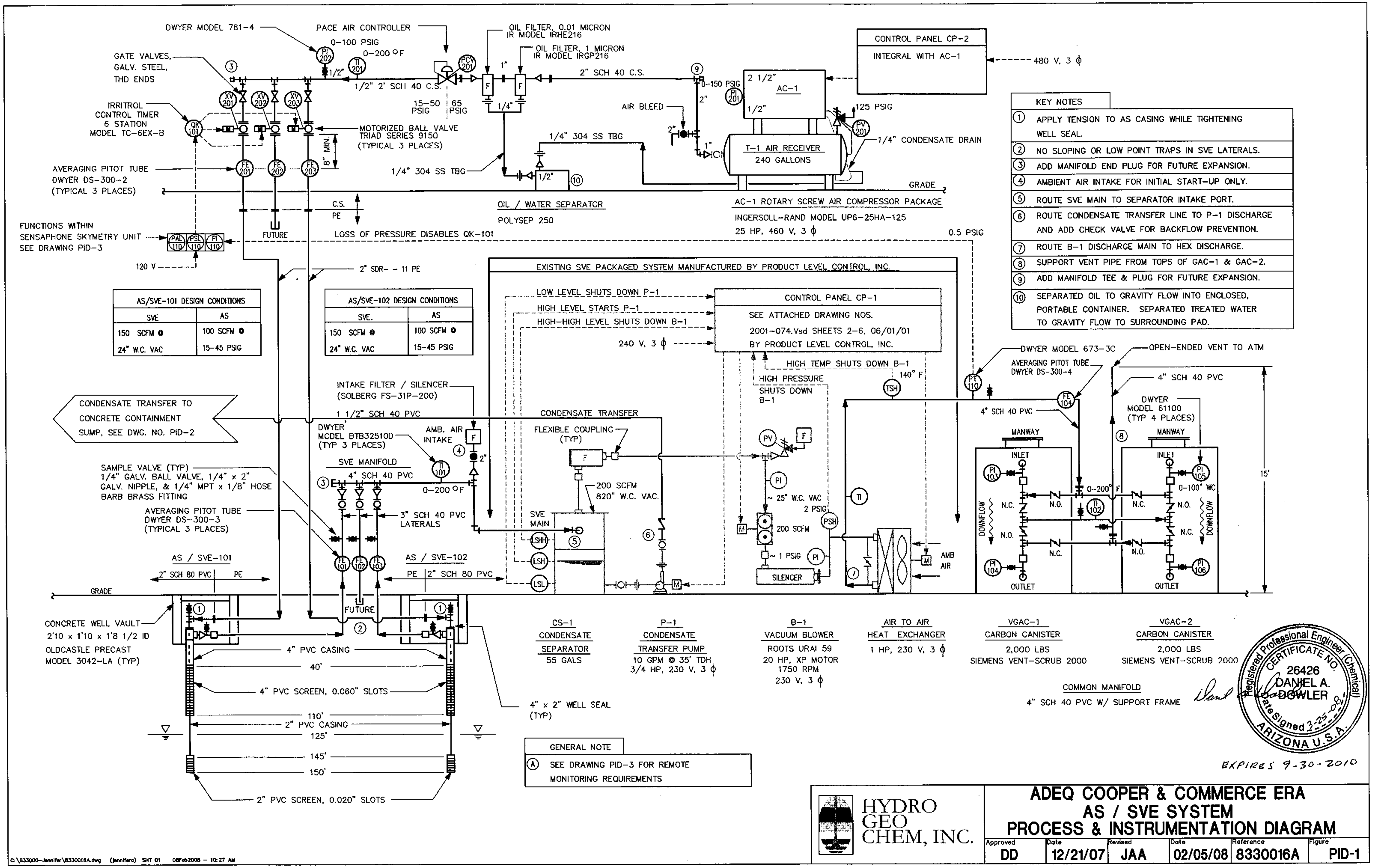

KEY NOTES

1	APPLY TENSION TO AS CASING WHILE TIGHTENING WELL SEAL.
2	NO SLOPING OR LOW POINT TRAPS IN SVE LATERALS.
3	ADD MANIFOLD END PLUG FOR FUTURE EXPANSION.
4	AMBIENT AIR INTAKE FOR INITIAL START-UP ONLY.
5	ROUTE SVE MAIN TO SEPARATOR INTAKE PORT.
6	ROUTE CONDENSATE TRANSFER LINE TO P-1 DISCHARGE AND ADD CHECK VALVE FOR BACKFLOW PREVENTION.
7	ROUTE B-1 DISCHARGE MAIN TO HEX DISCHARGE.
8	SUPPORT VENT PIPE FROM TOPS OF GAC-1 & GAC-2.
9	ADD MANIFOLD TEE & PLUG FOR FUTURE EXPANSION.
10	SEPARATED OIL TO GRAVITY FLOW INTO ENCLOSED, PORTABLE CONTAINER. SEPARATED TREATED WATER TO GRAVITY FLOW TO SURROUNDING PAD.

AS/SVE-101 DESIGN CONDITIONS

SVE	AS
150 SCFM @	100 SCFM @
24" W.C. VAC	15-45 PSIG

AS/SVE-102 DESIGN CONDITIONS

SVE.	AS
150 SCFM @	100 SCFM @
24" W.C. VAC	15-45 PSIG

GENERAL NOTE

(A) SEE DRAWING PID-3 FOR REMOTE MONITORING REQUIREMENTS

HYDRO GEO CHEM, INC.

ADEQ COOPER & COMMERCE ERA AS / SVE SYSTEM PROCESS & INSTRUMENTATION DIAGRAM

Approved	Date	Revised	Date	Reference	Figure
DD	12/21/07	JAA	02/05/08	8330016A	PID-1

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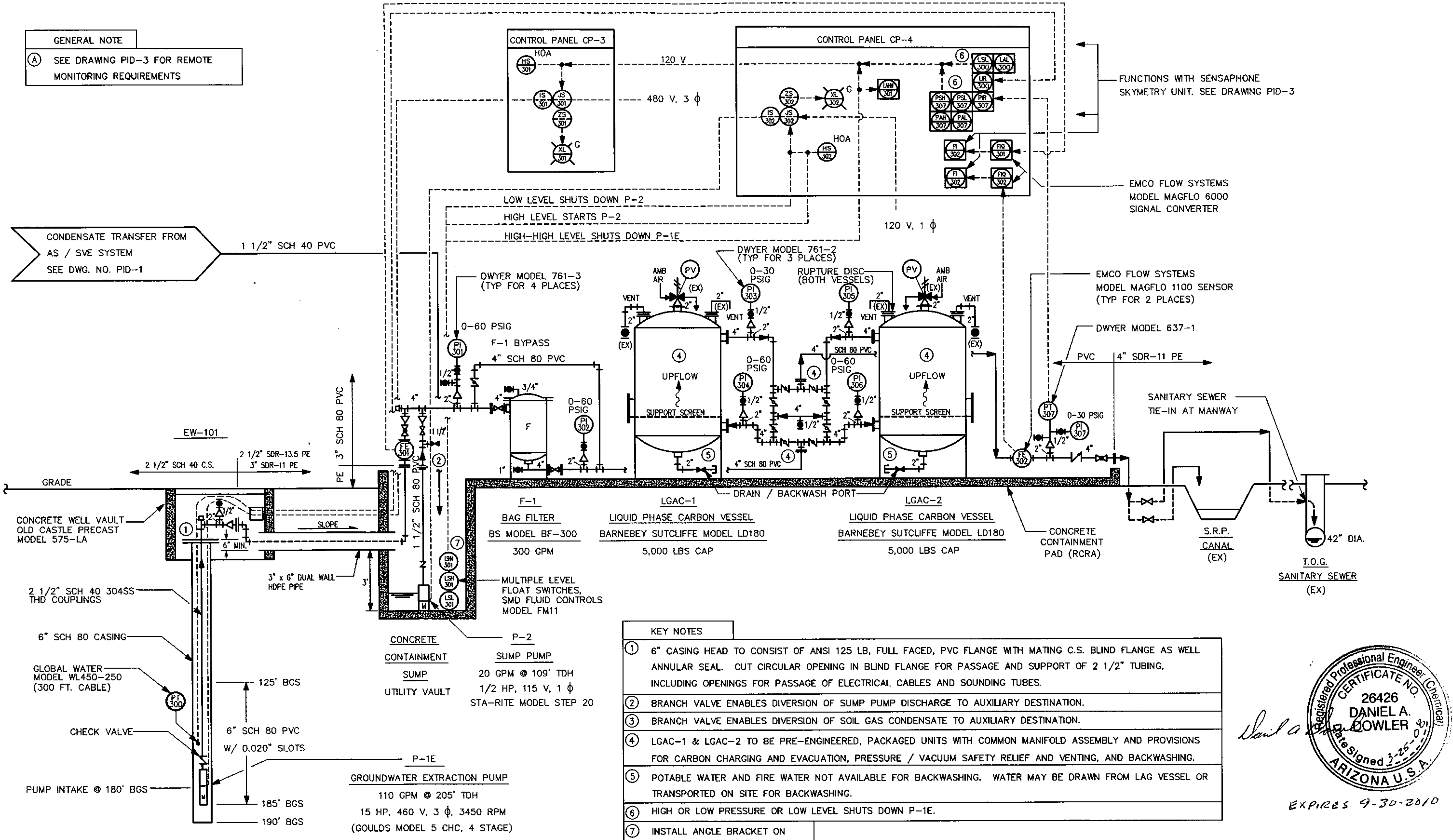

KEY NOTES

(1) 6" CASING HEAD TO CONSIST OF ANSI 125 LB, FULL FACED, PVC FLANGE WITH MATING C.S. BLIND FLANGE AS WELL ANNULAR SEAL. CUT CIRCULAR OPENING IN BLIND FLANGE FOR PASSAGE AND SUPPORT OF 2 1/2" TUBING, INCLUDING OPENINGS FOR PASSAGE OF ELECTRICAL CABLES AND SOUNDING TUBES.

(2) BRANCH VALVE ENABLES DIVERSION OF SUMP PUMP DISCHARGE TO AUXILIARY DESTINATION.

(3) BRANCH VALVE ENABLES DIVERSION OF SOIL GAS CONDENSATE TO AUXILIARY DESTINATION.

(4) LGAC-1 & LGAC-2 TO BE PRE-ENGINEERED, PACKAGED UNITS WITH COMMON MANIFOLD ASSEMBLY AND PROVISIONS FOR CARBON CHARGING AND EVACUATION, PRESSURE / VACUUM SAFETY RELIEF AND VENTING, AND BACKWASHING.

(5) POTABLE WATER AND FIRE WATER NOT AVAILABLE FOR BACKWASHING. WATER MAY BE DRAWN FROM LAG VESSEL OR TRANSPORTED ON SITE FOR BACKWASHING.

(6) HIGH OR LOW PRESSURE OR LOW LEVEL SHUTS DOWN P-1E.

(7) INSTALL ANGLE BRACKET ON SUMP SIDEWALL, 12" BELOW TOP. MOUNT FLOAT SWITCH UNIT TO BRACKET AT BULKHEAD FITTING.

HYDRO GEO CHEM, INC.

PROCESS & INSTRUMENTATION DIAGRAM

Approved	Date		Date	Reference	Figure
		JAA		017A	PID-2

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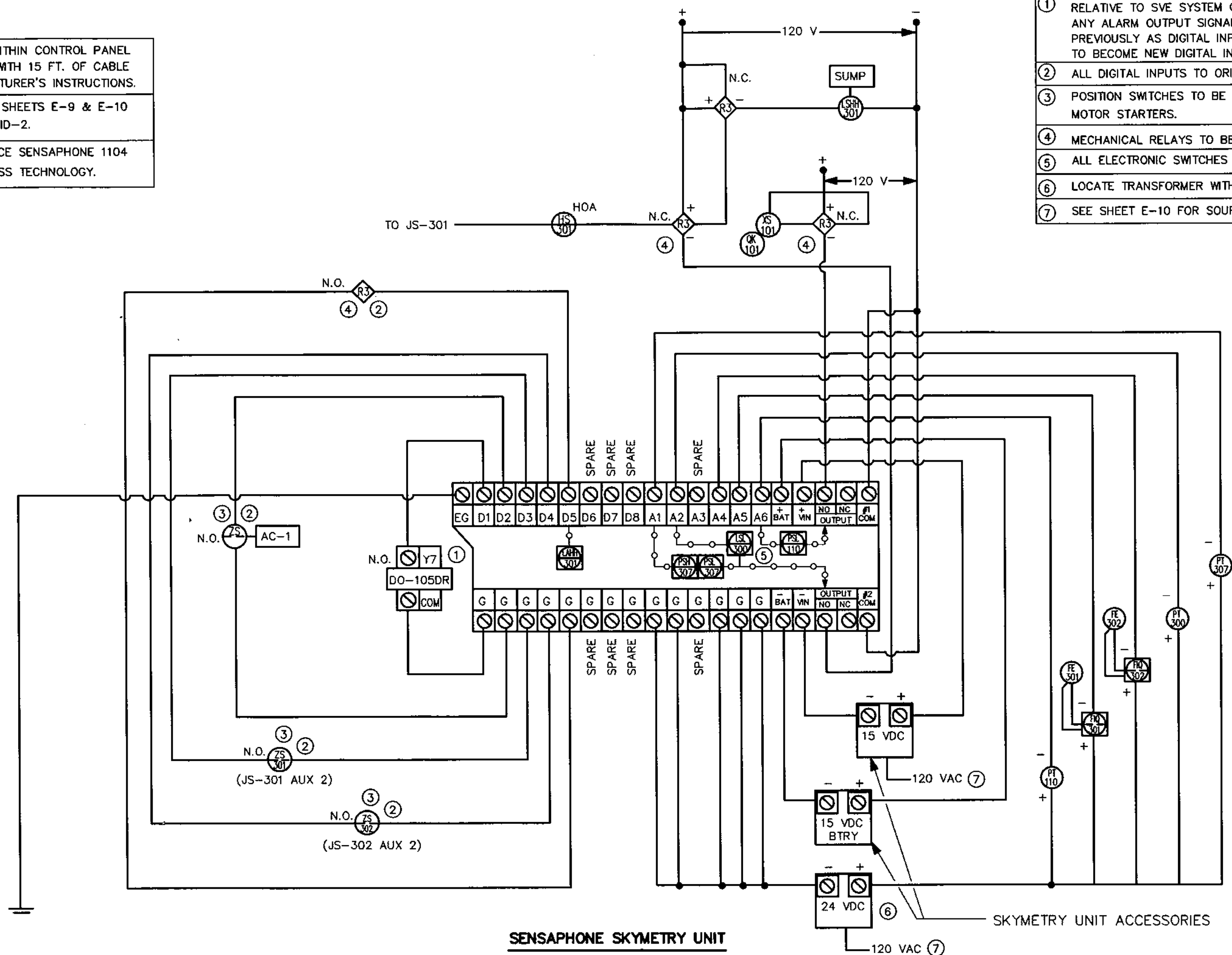
GENERAL NOTES	
(A)	INSTALL SKYMETRY UNIT WITHIN CONTROL PANEL CP-4. INSTALL ANTENNA WITH 15 FT. OF CABLE AS SPECIFIED IN MANUFACTURER'S INSTRUCTIONS.
(B)	WORK THIS DRAWING WITH SHEETS E-9 & E-10 AND DRAWINGS PID-1 & PID-2.
(C)	SKYMETRY UNIT TO REPLACE SENSAPHONE 1104 AUTODIALER USING WIRELESS TECHNOLOGY.

KEY NOTES	
(1)	RELATIVE TO SVE SYSTEM OPERATION CONTROL WITHIN CP-1, ANY ALARM OUTPUT SIGNAL FROM DO-105DR AT PORT "Y7", PREVIOUSLY AS DIGITAL INPUT SIGNAL TO SENSAPHONE 1104, TO BECOME NEW DIGITAL INPUT SIGNAL TO SKYMETRY UNIT.
(2)	ALL DIGITAL INPUTS TO ORIGINATE FROM NORMALLY OPEN CONTACTS.
(3)	POSITION SWITCHES TO BE AUXILIARY CONTACTS ON RESPECTIVE MOTOR STARTERS.
(4)	MECHANICAL RELAYS TO BE INSTALLED WITHIN CP-4.
(5)	ALL ELECTRONIC SWITCHES TO HAVE RESPECTIVE ALARMS.
(6)	LOCATE TRANSFORMER WITHIN CP-4.
(7)	SEE SHEET E-10 FOR SOURCE OF 120 VAC POWER SUPPLY.



SENSAPHONE SKYMETRY UNIT

(TERMINAL BLOCK)

Registered Professional Engineer (Chemical) CERTIFICATE NO. 26426 DANIEL A. DOWLER Date Signed 3-25-08 ARIZONA U.S.A.

EXPIRES 9-30-2010

HYDRO GEO CHEM, INC.

ADEQ COOPER & COMMERCE ERA
PROCESS CONTROL & REMOTE MONITORING DIAGRAM
SENSAPHONE SKYMETRY UNIT

Approved	Date	Revised	Date	Reference	Figure
DD	12/21/07	JAA	2/27/08	8330018A	PID-3

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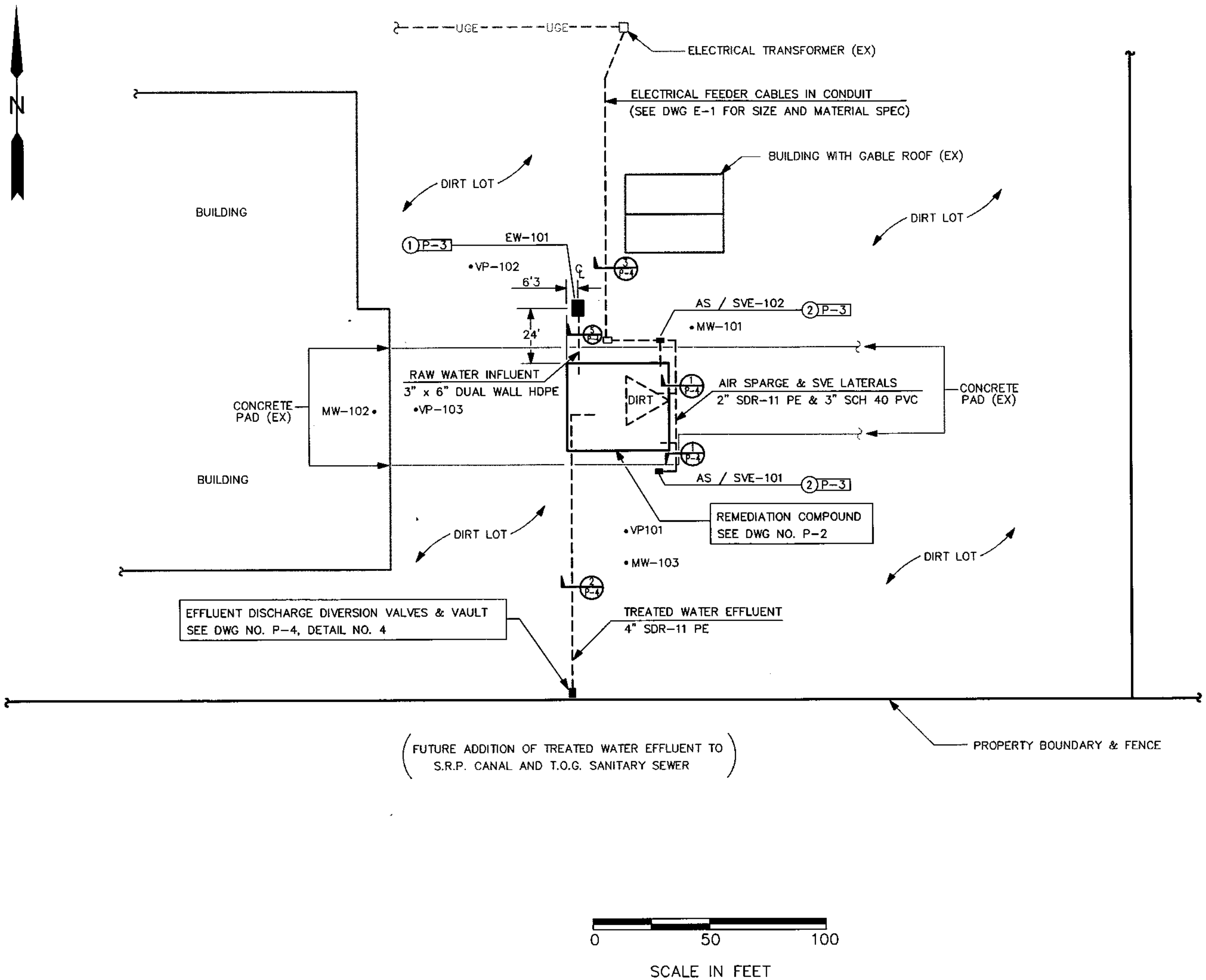
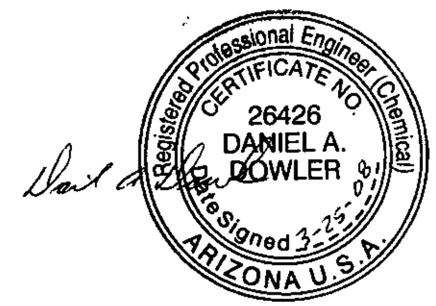


GENERAL NOTES

(A)	SAW CUT LINES FOR PIPE TRENCH SYSTEM WITHIN EXISTING CONCRETE PAD SHALL BE AT LEAST SIX (6) INCHES OFFSET FROM TRENCH LINES.
(B)	PROPERLY DISPOSE CONCRETE DEBRIS AND EXCESS SOIL TO APPROPRIATE LANDFILL. SAMPLE AND ANALYZE SOIL FOR WASTE PROFILING IN ACCORDANCE WITH DESTINATION LANDFILL REQUIREMENTS.
(C)	FIELD ROUTE ELECTRICAL FEEDER CABLES IN CONDUIT FROM EXISTING ELECTRICAL TRANSFORMER TO METER / MAIN SWITCH CABINET AT REMEDIATION COMPOUND. INSTALL AS SPECIFIED ON DWG NO. E-1.
(D)	ALL POLYETHYLENE PIPING SYSTEMS SHALL CONFORM TO LATEST REVISION OF AWWA C901, C906, OR CSA B137-1. STANDARD DIAMETER RATIO (SDR) SHALL BE AS SPECIFIED ON DRAWINGS. PIPE CONNECTIONS SHALL CONFORM TO ASTM D3261, IF BUTT FUSED, OR ASTM F1055, IF ELECTROFUSED. FLANGES SHALL BE ANSI 125 LB, FLAT FACED (FF), WITH BUTT FUSED NECK. FLANGE BOLTING SHALL BE MACHINE BOLTS, A-307 GRADE B, WITH HEAVY HEX NUTS, PLATED. FLANGE GASKETS SHALL BE FULL FACE, 1/8" THK, EPDM OR BUNA-N. INSTALLATION OF POLYETHYLENE PIPING SYSTEMS SHALL BE IN ACCORDANCE WITH ASTM STANDARDS D2657 AND D3261.
(E)	ALL PVC PIPING SYSTEMS SHALL CONFORM TO ASTM-1785, TYPE I GRADE I, NORMAL IMPACT; AND ANSI B31.3. RATING SHALL BE 100 PSI AT 100° F. FITTINGS AND PIPE CONNECTIONS SHALL BE SOCKET WELD, ASTM D-2467, USING WELD-ON 717 CEMENT (GRAY) AND WELD-ON P70 PRIMER (PURPLE). FLANGES SHALL BE SOCKET WELD, CLASS 125, ASTM D-2467, VANSTONE TYPE, FLAT-FACED. FLANGE BOLTING SHALL BE MACHINE BOLTS, A-307 GRADE B, WITH HEAVY HEX NUTS, PLATED. FLANGE GASKETS SHALL BE FULL FACE, 1/8" THK, EPDM OR BUNA-N. ALL SOCKET CONNECTIONS SHALL BE JOINED WITH SOLVENT CEMENT CONFORMING TO ASTM D-2564.
(F)	CONDUCT PNEUMATIC PRESSURE TESTING OF PIPING SYSTEMS AT 150% OF DESIGN PRESSURE PER ENGINEER'S REQUIREMENTS.
(G)	REFERENCE ELEVATION TAKEN AS GRADE AT 1224.67 FT AMSL.



EXPIRES 9-30-2010

HYDRO GEO CHEM, INC.

ADEQ COOPER & COMMERCE ERA
PIPING / TRENCHING PLAN

Approved	Date	Revised	Date	Reference	Figure
DD	12/21/07	JAA	02/07/08	8330019A	P-1

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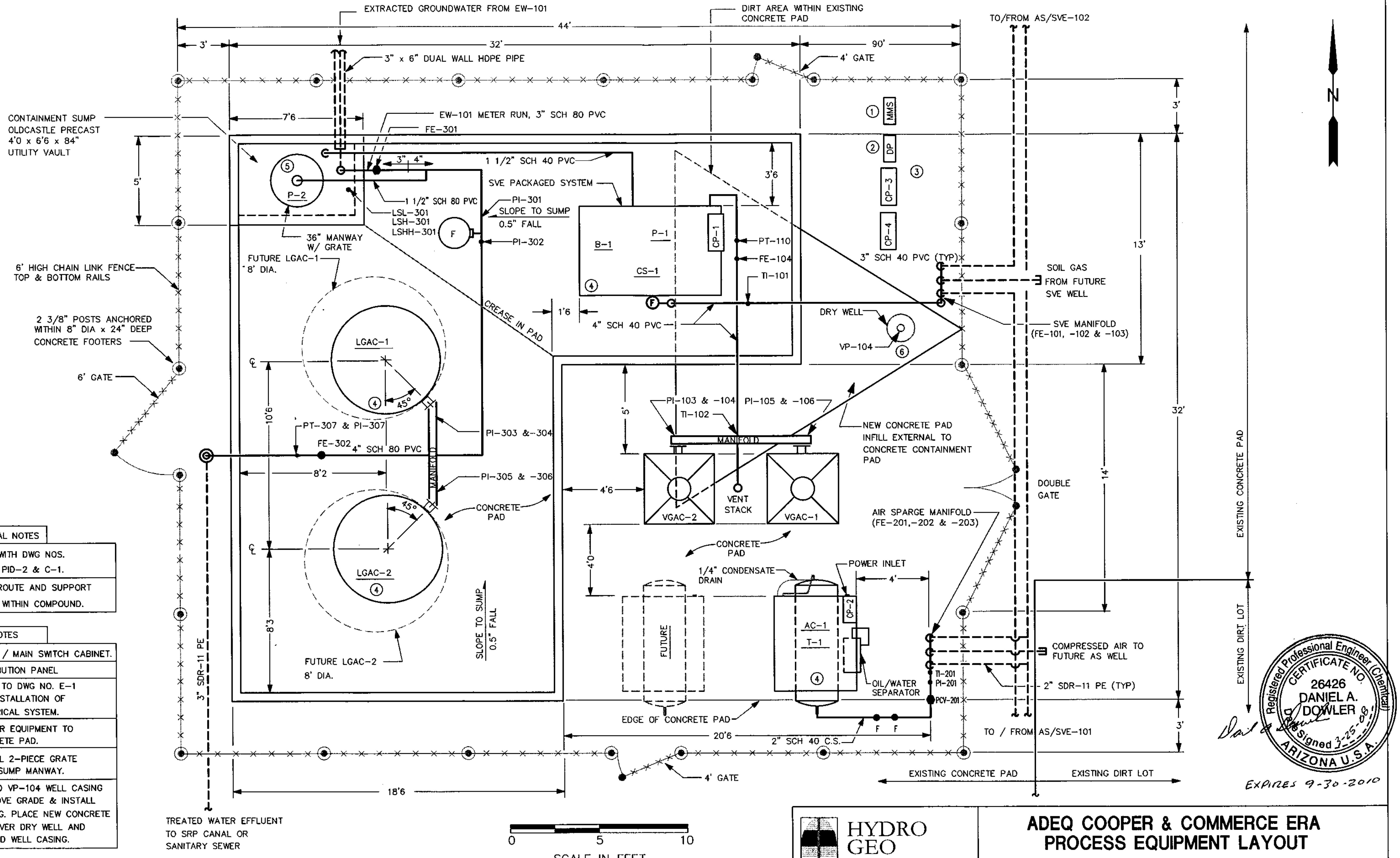

GENERAL NOTES
(A) WORK WITH DWG NOS. PID-1, PID-2 & C-1.
(B) FIELD ROUTE AND SUPPORT PIPING WITHIN COMPOUND.

KEY NOTES
(1) METER / MAIN SWITCH CABINET.
(2) DISTRIBUTION PANEL
(3) REFER TO DWG NO. E-1 FOR INSTALLATION OF ELECTRICAL SYSTEM.
(4) ANCHOR EQUIPMENT TO CONCRETE PAD.
(5) INSTALL 2-PIECE GRATE OVER SUMP MANWAY.
(6) EXTEND VP-104 WELL CASING 3' ABOVE GRADE & INSTALL J-PLUG. PLACE NEW CONCRETE PAD OVER DRY WELL AND AROUND WELL CASING.

Registered Professional Engineer (Chemical)
CERTIFICATE NO. 26426
DANIEL A. DOWLER
Date Signed 3-25-08
ARIZONA U.S.A.

EXPIRES 9-30-2010

HYDRO GEO CHEM, INC.

ADEQ COOPER & COMMERCE ERA PROCESS EQUIPMENT LAYOUT

Approved	Date	Revised	Date	Reference	Figure
DD	12/21/07	JAA	02/05/08	8330020A	P-2

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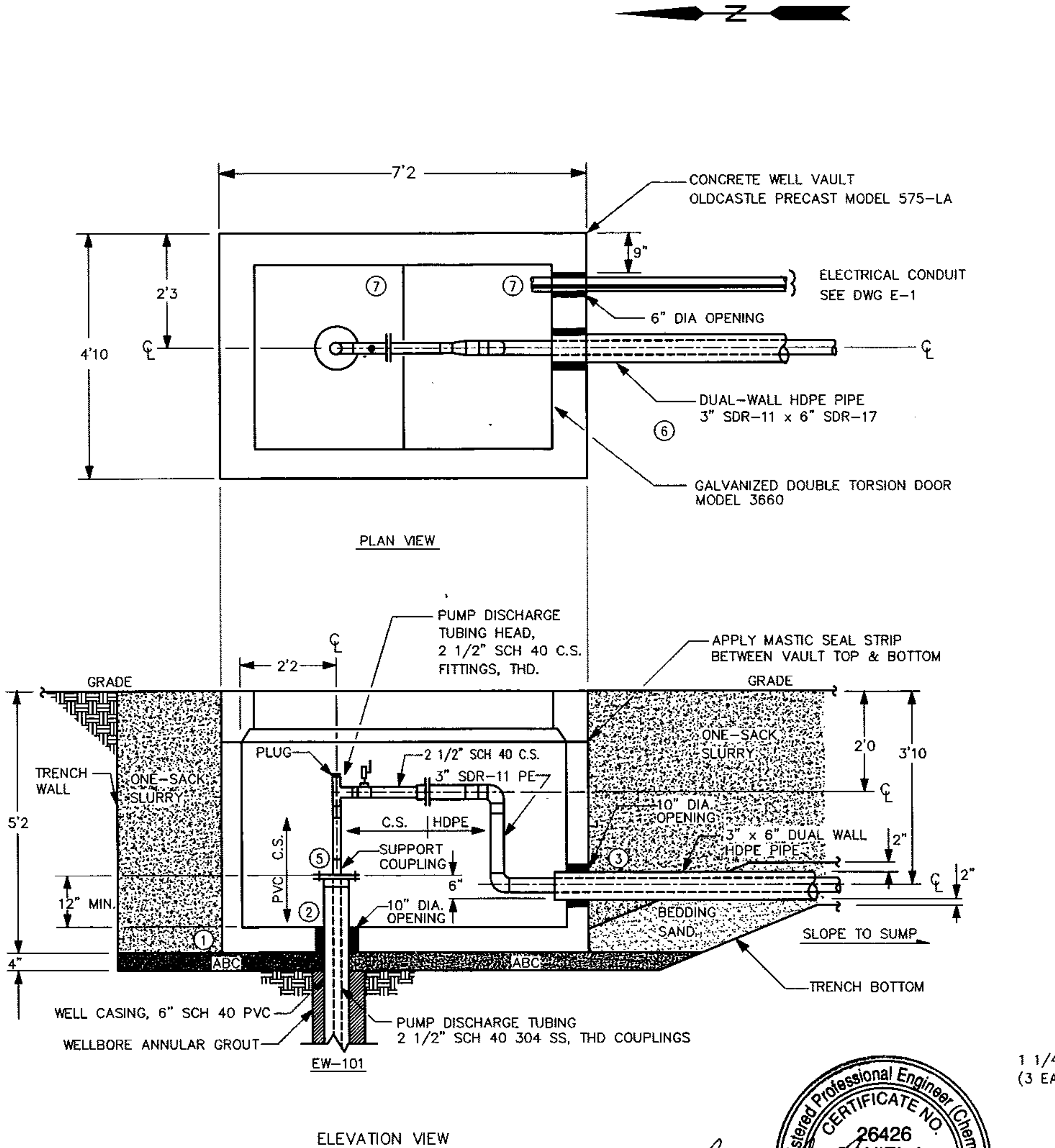
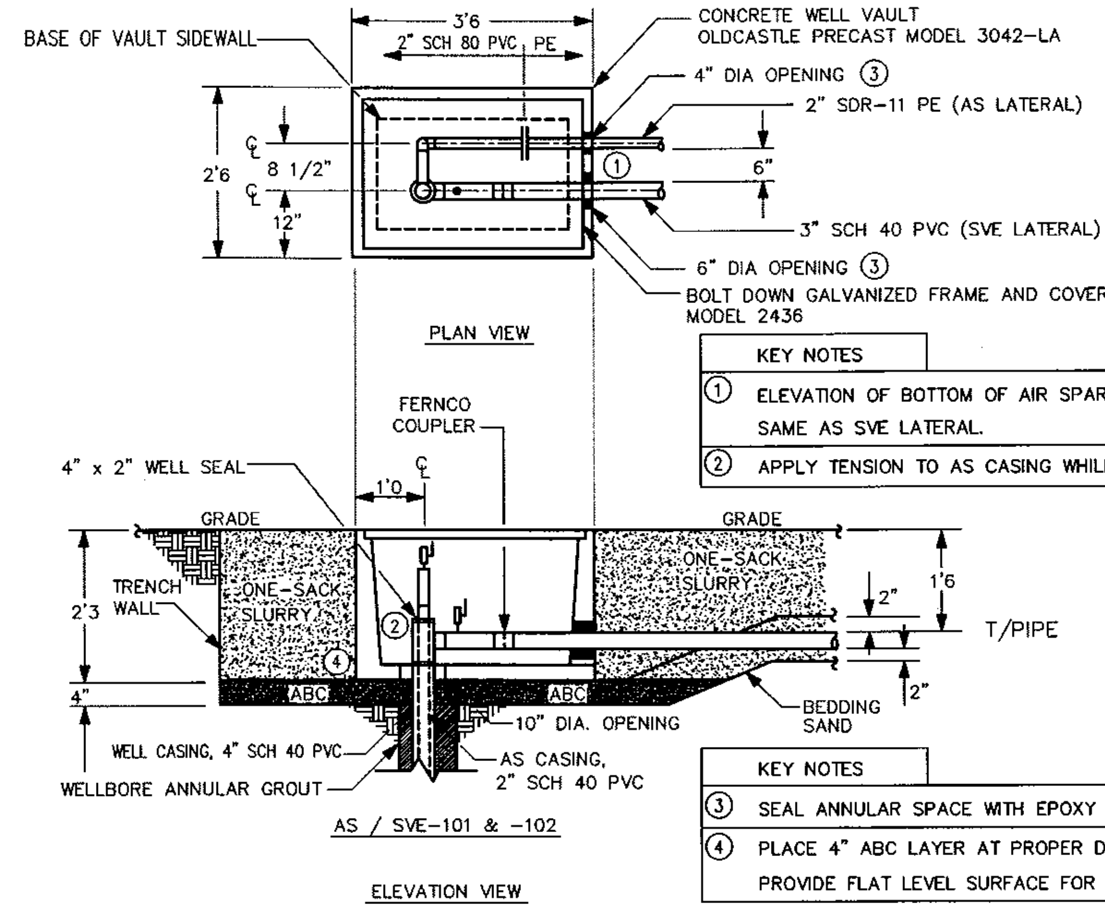


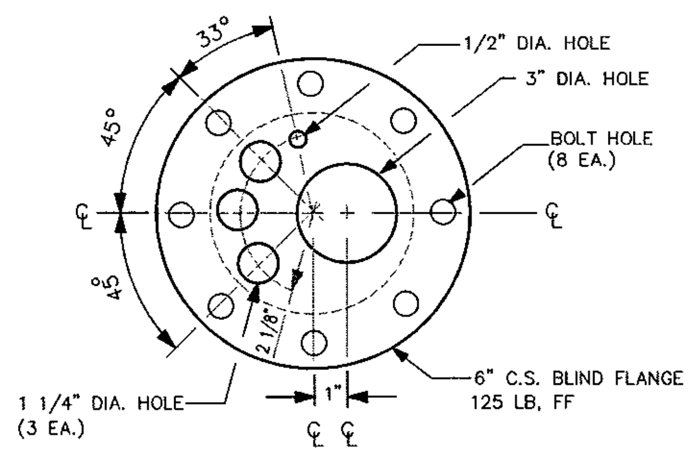
① EW-101 WELLHEAD & VAULT DETAIL
(WORK WITH DWG NOS. PID-2 & P-1)



KEY NOTES
① ELEVATION OF BOTTOM OF AIR SPARGE LATERAL SAME AS SVE LATERAL.
② APPLY TENSION TO AS CASING WHILE TIGHTENING WELL SEAL.

KEY NOTES
③ SEAL ANNULAR SPACE WITH EPOXY GROUT.
④ PLACE 4" ABC LAYER AT PROPER DEPTH BELOW GRADE. PROVIDE FLAT LEVEL SURFACE FOR PLACEMENT OF VAULT.

② AS / SVE-101 & -102 WELLHEAD & VAULT DETAIL
(WORK WITH DWG NOS. PID-1 & P-1)



WELL SEAL PLATE DETAIL

KEY NOTES
① PLACE 4" ACB LAYER AT PROPER DEPTH BELOW GRADE. PROVIDE FLAT LEVEL SURFACE FOR PLACEMENT OF VAULT.
② FILL ANNULAR SPACE WITH HYDRATED BENTONITE.
③ SEAL ANNULAR SPACE WITH EPOXY GROUT.
④ OUTER PIPE TO BE OPEN-ENDED.
⑤ CUT WELL CASING AND INSTALL PVC FLANGE. FABRICATE WELL SEAL PLATE PER DETAIL THIS DRAWING. WELL COMPLETION CONTRACTOR TO INSTALL PUMP, DISCHARGE TUBING, WELL SEAL PLATE AND SUPPORT COUPLING.
⑥ PROVIDE COMPLETE, ENGINEERED, DUAL-WALL SYSTEM.
⑦ SEE DWG E-1 FOR ELECTRICAL COMPONENTS INSTALLATION.

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EXPIRES 9-30-2010

HYDRO GEO CHEM, INC.

ADEQ COOPER & COMMERCE ERA
WELLHEAD DETAILS

Approved	Date	Revised	Date	Reference	Figure
DD	12/21/07		02/05/08	8330021A	P-3

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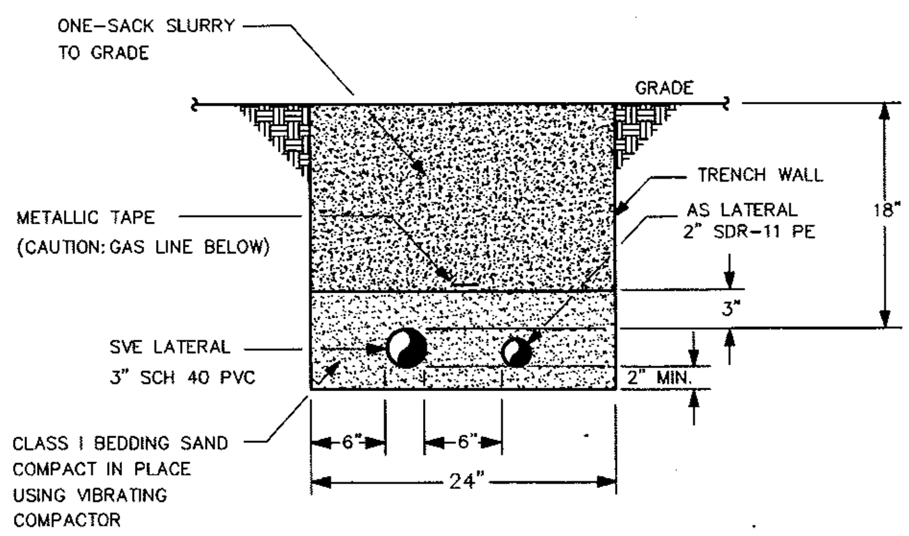
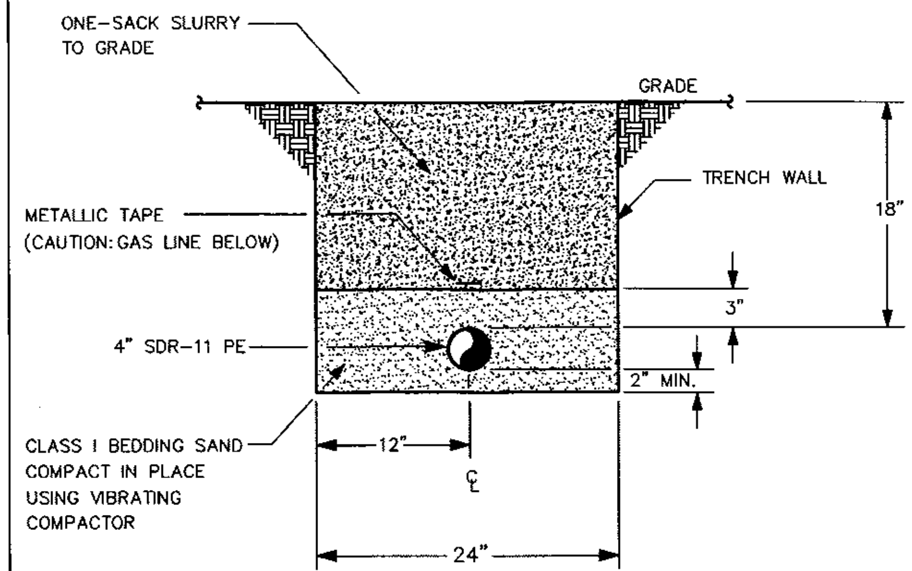
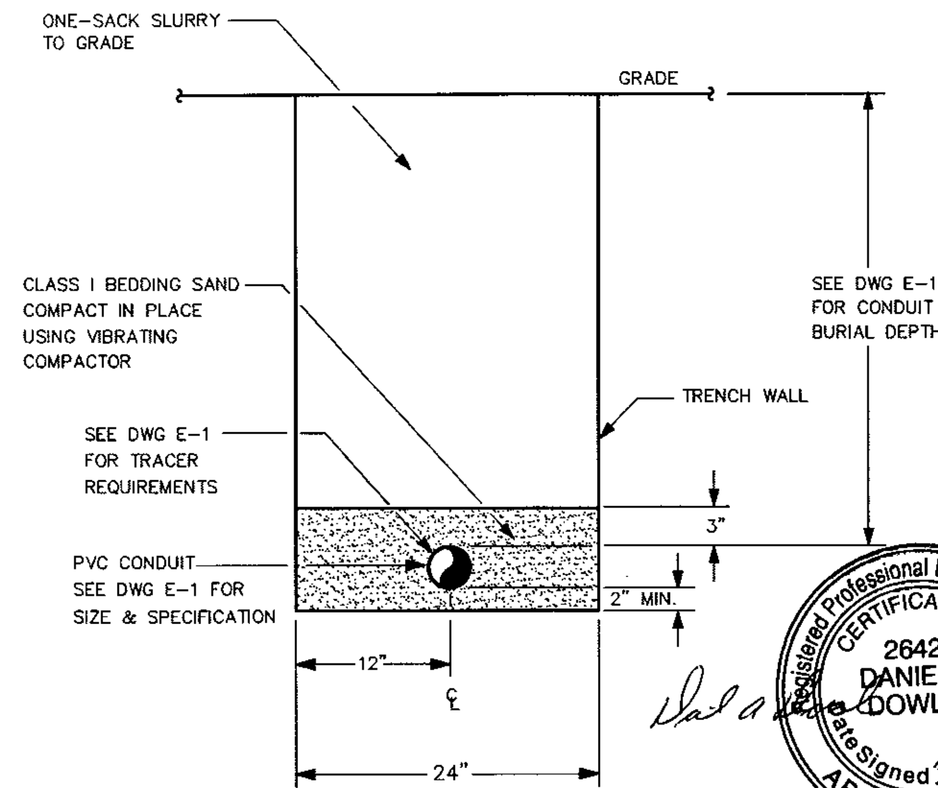


(1) AS / SVE LATERALS – PIPE TRENCH



(2) TREATED GROUNDWATER EFFLUENT MAIN – PIPE TRENCH



Registered Professional Engineer (Chemical)
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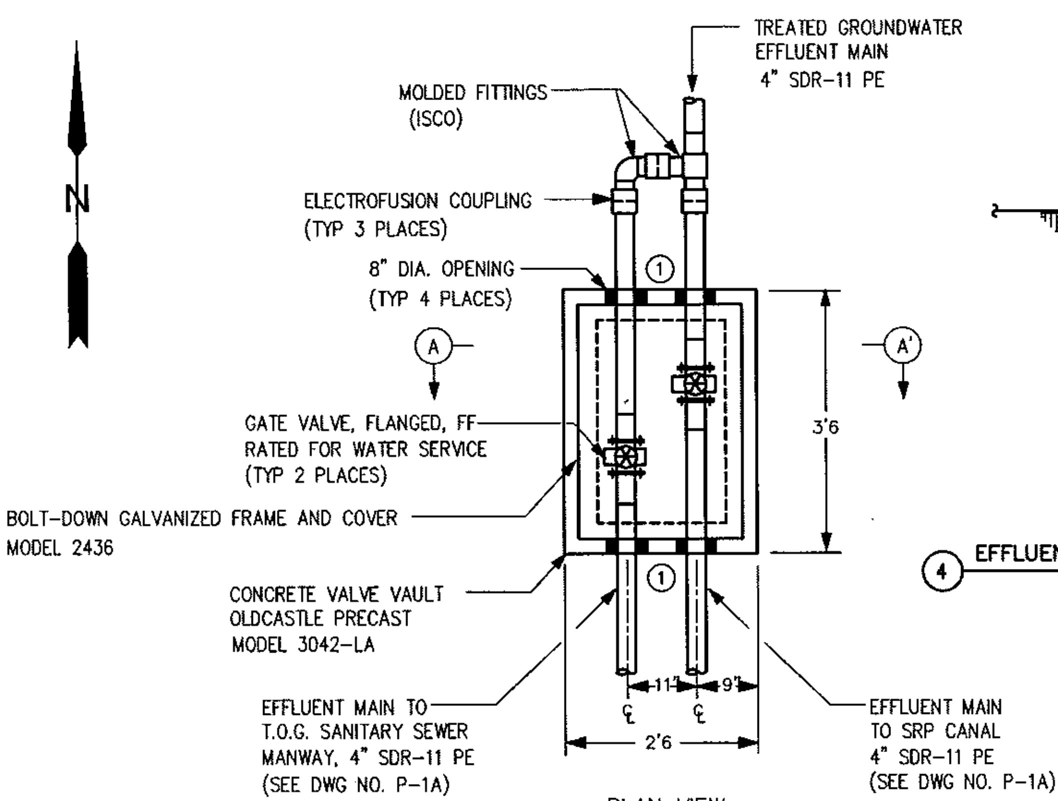
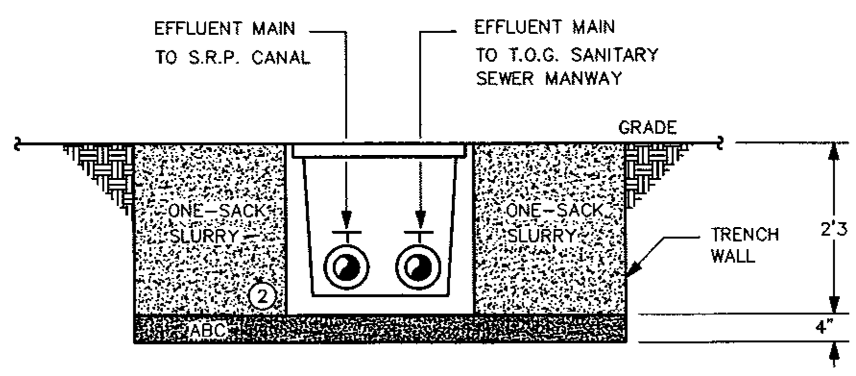
Date Signed 3-25-08
ARIZONA U.S.A.

(3) ELECTRIC FEEDER CABLES – CONDUIT TRENCH

EXPIRES 9-30-2010



PLAN VIEW



ELEVATION VIEW A-A'

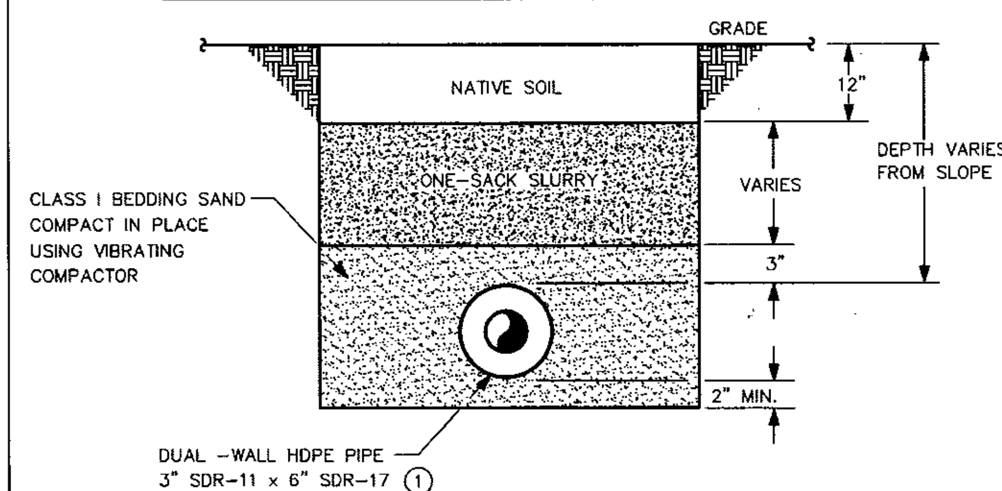
(4) EFFLUENT DISCHARGE DIVERSION VALVES & VAULT – PLAN & ELEVATION

KEY NOTES:

1. SEAL ANNULAR SPACE WITH EPOXY GROUT.
2. PLACE ABC LAYER AT PROPER DEPTH BELOW GRADE. PROVIDE FLAT LEVEL SURFACE FOR PLACEMENT OF VAULT.

KEY NOTES:

1. SLOPE PIPE FROM EW-101 TO CONTAINMENT SUMP.



(5) EXTRACTED GROUNDWATER INFLUENT MAIN – PIPE TRENCH

HYDRO GEO CHEM, INC.

ADEQ COOPER & COMMERCE
PIPING / TRENCHING SECTIONS - ONSITE

Approved	Date	Revised	Date	Reference	Figure
DD	12/21/07	JAA	02/05/08	8330022A	P-4

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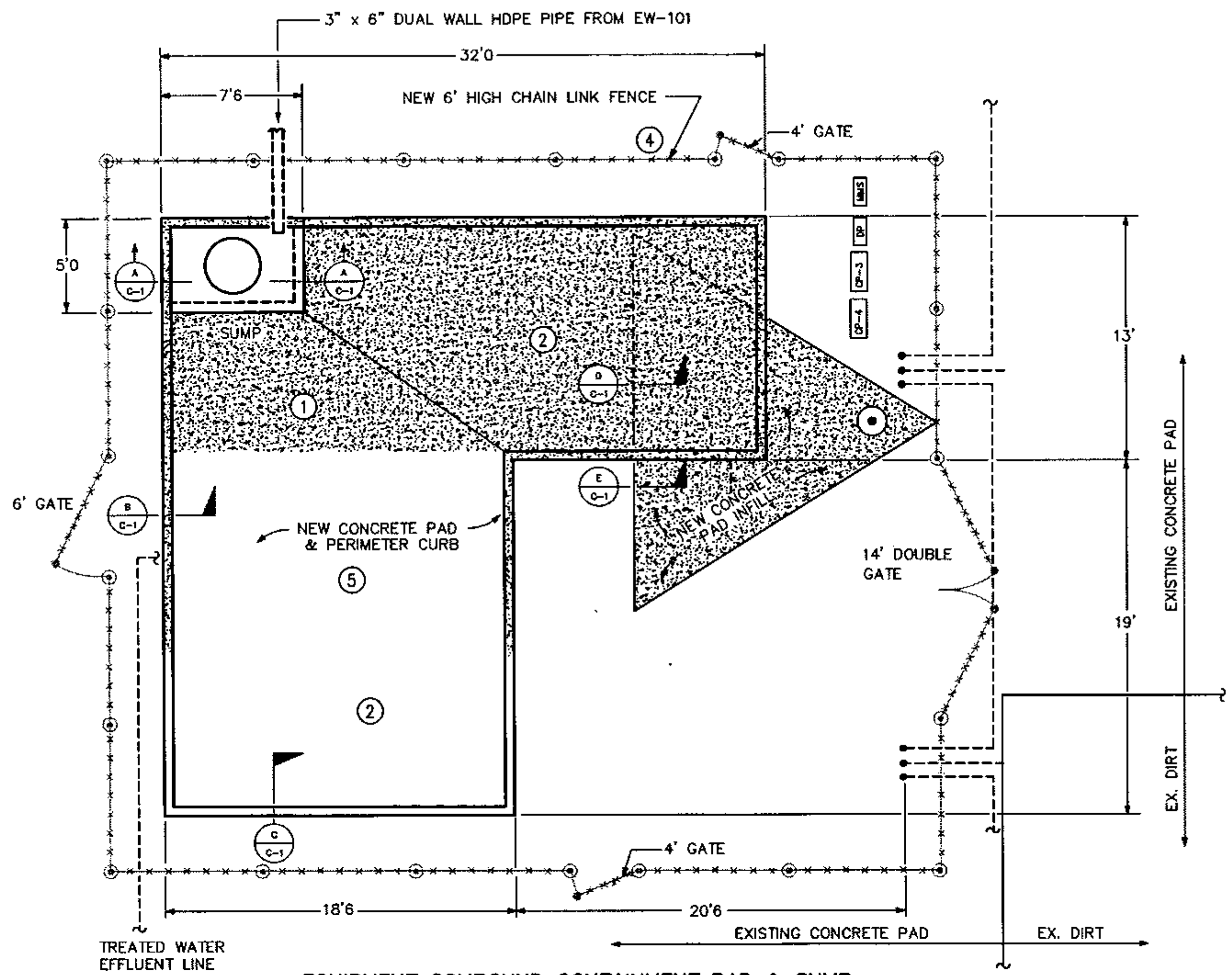
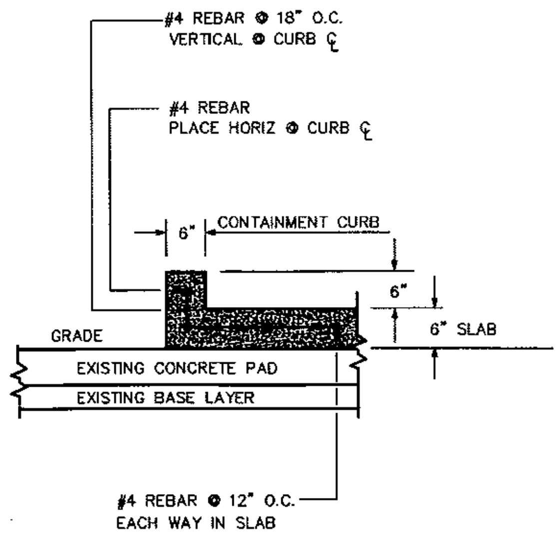
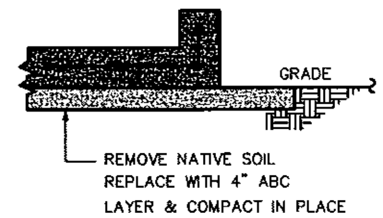


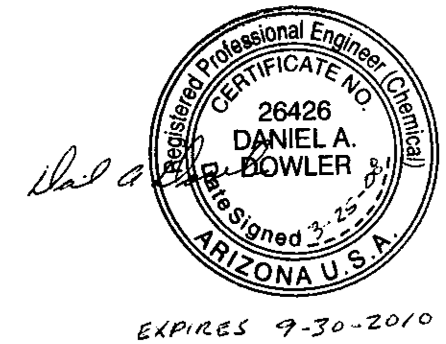
EQUIPMENT COMPOUND CONTAINMENT PAD & SUMP & ADJACENT CONCRETE PADS

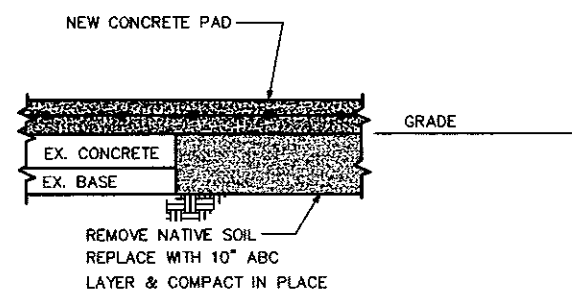


(B) CURB ON EX. PAD

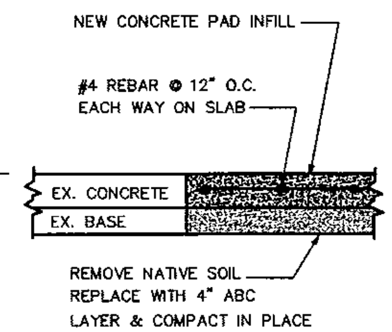


(C) CURB ON EX. DIRT ADJACENT TO DIRT AREA

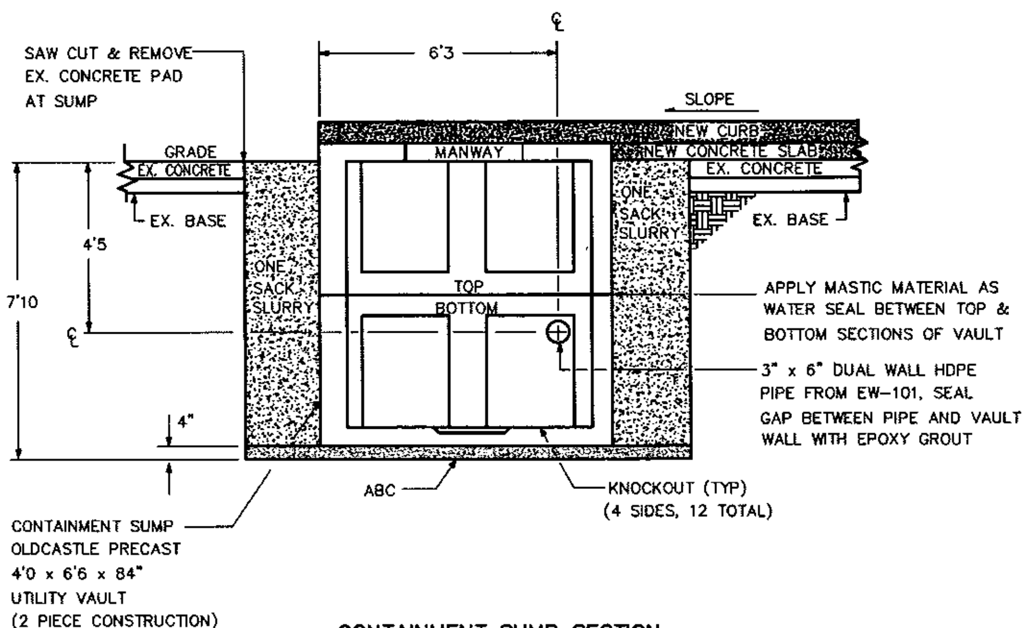




(D) PAD OVER DIRT AREA



(E) NEW CONCRETE PAD INFILL AT EX. PAD



(A) CONTAINMENT SUMP SECTION (WORK WITH DWG P-3, SECTION 1)

GENERAL NOTE

(A) EQUIPMENT COMPOUND CONTAINMENT PAD & SUMP, AS WELL AS 3" x 6" DUAL WALL HDPE PIPE, ARE REQUIRED UNDER RCRA, GIVEN TRANSFER AND PROCESSING OF GROUNDWATER CONTAINING PERCHLOROETHYLENE AND OTHER HAZARDOUS SUBSTANCES. ACCORDINGLY, CONTAINMENT PAD & SUMP MUST BE PROPERLY FINISHED TO PREVENT WATER LEAKAGE TO UNDERLYING SOIL.

KEY NOTES

1. 6" THK CONCRETE SLAB, #4 REBAR @ 12" E.W. AT MIDDEPTH OVER 4" ABC OR EX. CONCRETE SLAB.
2. SLOPE PAD TOWARDS SUMP WITH 0.5 INCH FALL.
3. ALL CONCRETE SHALL HAVE A 28-DAY COMPRESSIVE STRENGTH OF 3,000 PSI AS A MINIMUM.
4. CHAIN LINK FENCE TO HAVE TOP & BOTTOM GALV. RAILS (TYPE 1-2 3/8"); GALV. CORNER, TERMINAL & GATE POSTS (TYPE 1-2 7/8"); GALV. INTERMEDIATE POSTS (TYPE 1-2 3/8"); AND 2" MESH GALV. STEEL CHAIN LINK II GAUGE. POSTS TO BE SET 18" BELOW GRADE IN 12" DIA. x 24" DEEP CONCRETE FOOTERS.
5. SAW CUT CONTROL JOINTS 1/4" WIDE x 2" DEEP. FILL WITH ELASTOMERIC SEALANT.

HYDRO GEO CHEM, INC.

ADEQ COOPER & COMMERCE ERA CONCRETE CONTAINMENT PAD AND SUMP

Approved	Date	Revised	Date	Reference	Figure
DD	12/21/07		02/07/08	8330024A	C-1

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ELECTRICAL SYMBOLS LIST

	DUPLEX RECEPTACLE, NEMA 5-20R, 18" A.F.F., UNLESS NOTED OTHERWISE.
	JUNCTION BOX, SIZE PER N.E.C.
	JUNCTION BOX IN ACCESSIBLE LOCATION WITH FLEXIBLE CONDUIT CONNECTION TO LIGHTING FIXTURE OR EQUIPMENT AS NOTED.
S_M	U.L. LISTED H.P. RATED MANUAL DISCONNECTING MEANS, TYPE AND SIZE AS NOTED.
	MOTOR (SIZE AS INDICATED IN DRAWINGS)
	PANELBOARD
	DISCONNECT SWITCH, SIZE AND POLES AS SHOWN (i.e., 30/3); FUSED WITH BUSSMANN, LPNRK OR LPSRK TYPE.
	COMBINATION STARTER AND DISCONNECT SWITCH. SIZE AND FUSES PER MANUFACTURER'S RECOMMENDATION. (WEATHERPROOF WHERE OUTSIDE).
	STARTER PER N.E.C. (MIN. SIZE = 0) SUPPLIED BY OTHERS.
	STARTER PER N.E.C. (MIN. SIZE = 0) SUPPLIED THIS CONTRACT
	STUB-OUT, INSTALL INSULATED BUSHING TYPE AS REQUIRED.
	EQUIPMENT CONNECTION
	INDICATES CIRCUIT IN CONDUIT CONCEALED IN OR UNDER FLR. CONSTRUCTION OR BELOW GRADE.
	INDICATES CIRCUIT IN CONDUIT ABOVE GRADE
	INDICATES HOMERUN TO PANELBOARD OR AS NOTED. HASH MARKS INDICATES NUMBER OF CONDUCTORS. DETAIL INDICATES (2) PHASE CONDUCTORS, (1) NEUTRAL, (1) ISOLATED GROUND. EQUIPMENT GROUNDING CONDUCTOR NOT SHOWN. IF NO HASH MARKS PROVIDE 2 CONDUCTORS #12 A.W.G. MINIMUM. #12 A.W.G. CU. BOND, 3/4" CONDUIT MINIMUM.
	MOTOR STARTER (SINGLE-LINE)
	NORMALLY CLOSED CONTACT
	NORMALLY OPEN CONTACT
	EQUIPMENT GROUND
	POWER TRANSFORMER
G	INDICATOR LAMP LETTER INDICATES LIGHT OR LENS COLOR A-AMBER, B-BLUE, C-CLEAR, G-GREEN, R-RED, W-WHITE

ELECTRICAL ABBREVIATIONS

A/AMP	AMPERE
AC	ALTERNATING CURRENT
AFF	ABOVE FINISHED FLOOR
AFG	ABOVE FINISHED GRADE
AUTO	AUTOMATIC
BC	BYPASS CONTACTOR
BKR	BREAKER
C	CONDUIT
CKT	CIRCUIT
CB	CIRCUIT BREAKER
CO	COMPANY
COMM	COMMUNICATION
CON	CONDUCTOR
CPT	CONTROL POWER TRANSFORMER
CT	CURRENT TRANSFORMER
CTRL	CONTROL
CU	COPPER
ENCL	ENCLOSURE
ES	EMERGENCY STOP
EXIST	EXISTING
FLA	FULL LOAD AMPS
FM	FLOW METER
FS	FLOAT SWITCH
GND	GROUND
GRC	GALVANIZED RIGID (STEEL) CONDUIT
H	HIGH
HOA	HAND-OFF-AUTO
IC	INSTRUMENTATION CABLE
IER	INTEGRATED EQUIPMENT RATING
JB	JUNCTION BOX
L	LOW
LP	LEVEL PROBE
LS	LEVEL SENSOR OR SWITCH
LTC	LIQUID TIGHT FLEXIBLE CONDUIT
M	METER
MAX	MAXIMUM
MCA	MINIMUM CIRCUIT AMPACITY
MCB	MAIN C.B.
MFR	MANUFACTURER
MIN	MINIMUM
MLO	MAIN LUG ONLY
NC	NORMALLY CLOSED
NO	NORMALLY OPEN
NTS	NOT TO SCALE
OL	MOTOR OVERLOAD
PS	PRESSURE SWITCH
SDBC	SOFT DRAWN BARE COPPER
SDIC	SOFT DRAWN INSULATED COPPER
SES	SERVICE ENTRANCE SECTION
SLD	SINGLE LINE DIAGRAM
SPST	SINGLE POLE SINGLE THROW
SS	316 STAINLESS STEEL
STP	SHIELDED TWISTED PAIR (INSTUMENTATION CONDUCTORS)
SW	SWITCH
UTIL	UTILITY
V	VOLT
VA	VOLT-AMP
W	WATT
WP	WEATHER-PROOF
XFMR	TRANSFORMER

ELECTRICAL SHEET LIST

E-0	ELECTRICAL SYMBOLS AND ABBREVIATIONS LIST
E-1	ELECTRICAL SITE PLAN
E-2	POWER PLAN
E-3	GROUNDING PLAN
E-4	SINGLE-LINE DIAGRAM
E-5	PANEL SCHEDULES
E-6	ELECTRICAL EQUIPMENT RACK DETAILS
E-7	AIR SPARGE PULSE CONTROL SCHEMATIC
E-8	GROUNDING DETAILS
E-9	ELECTRICAL DETAILS
E-10	PANEL CP-3 SCHEMATIC
E-11	PANEL CP-4 SCHEMATIC
E-12	PANEL CP-3 LAYOUT
E-13	PANEL CP-4 LAYOUT
E-14	CONTROL PANEL GENERAL NOTES
E-15	ELECTRICAL SPECIFICATIONS

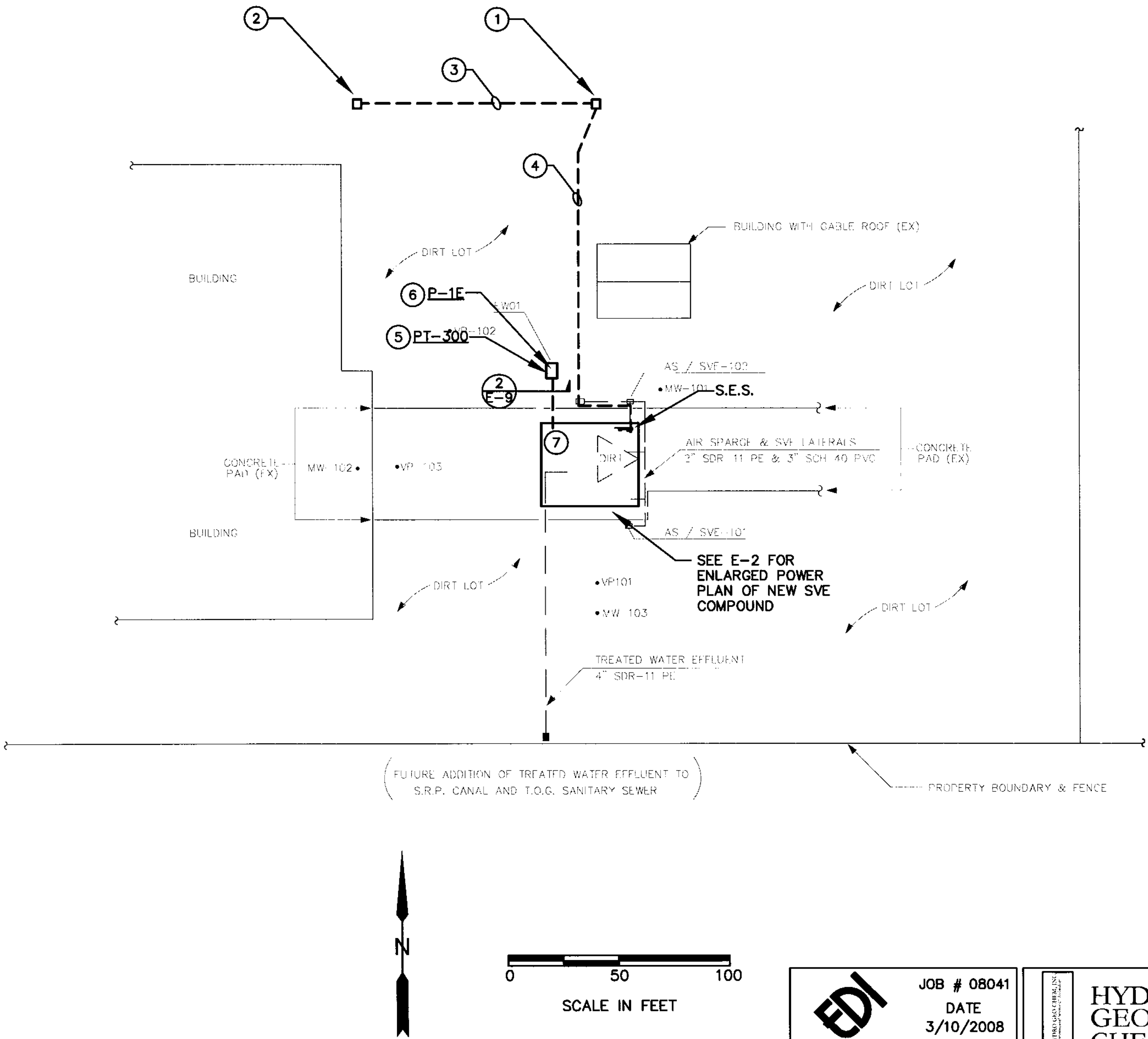
Registered Professional Engineer (Electrical)
CERTIFICATE NO. 41994
JEFFREY WALTER SITZLER
Date Signed 3-10-08
ARIZONA, U.S.A.
EXPIRES 3/31/08

ELECTRICAL DESIGNS INCORPORATED
JOB # 08041
DATE 3/10/2008
602-275-4365

HYDRO GEO CHEM, INC.

ADEQ COOPER & COMMERCE ERA
ELECT SYMBOLS AND ABBREVIATIONS LIST

Approved	Date	Revised	Date	Reference	Figure
JWS	03-10-08	-	-	08041E0	E-0



UTILITY CO. CUSTOMER REP.

CO. NAME

ARIZONA PUBLIC SERVICE

NAME

CUSTOMER REPRESENTATIVE

TELEPHONE NO.

(602) 371-6767

SITE UTILITIES NOTE:

THE ELECTRICAL CONTRACTOR SHALL COORDINATE ELECTRICAL SERVICE WITH UTILITY COMPANY. ROUTING OF INCOMING SERVICES SHOWN ON THE DRAWING ARE FOR BIDDING PURPOSES AND MAY VARY FROM ACTUAL REQUIREMENTS. THE CONTRACTOR SHALL COMPLY WITH UTILITY COMPANY REQUIREMENTS, WITHOUT ADDITIONAL CHARGESTO THE OWNER.

KEYNOTES

1. EXISTING DAMAGED UTILITY CO TRANSFORMER TO BE REPLACED. SEE SINGLE-LINE DIAGRAM ON SHEET E-4.
2. EXISTING UTILITY CO PRIMARY SWITCHING CABINET.
3. APPROXIMATE ROUTING OF EXISTING UTILITY CO PRIMARY CONDUITS.
4. PROPOSED ROUTING OF NEW UNDERGROUND SERVICE LATERALS. COORDINATE WITH UTILITY Co. FOR EXACT REQUIREMENTS. PROVIDE HEAVY TRAFFIC RATED CONCRETE PULLBOXES AS REQUIRED PER UTILITY Co. SEE SHEET E-2 FOR CONTINUATION.
5. PROVIDE NEMA 6P SUBMERSIBLE J-BOX AND 21 mm (3/4)" C. FROM INSTRUMENT TRANSMITTER TO CONTROL PANEL AS REQUIRED. INSTALL OWNER FURNISHED CABLING WITHIN RACEWAY SYSTEM. FIELD VERIFY EXACT ROUTING.
6. SEE SINGLE-LINE DIAGRAM FOR P-1E REQUIREMENTS. PROVIDE 60/3 N.F. NEMA 6P SUBMERSIBLE LOCAL DISCONNECT SWITCH. MOUNT HIGH ON SIDE WALL IN CONCRETE WELL VAULT.
7. FROM CP-3 AND CP-4. SEE CONTINUATION ON SHEET E-2. CONDUIT TO BE ROUTED A MINIMUM OF 24" BELOW GRADE IN SEPARATE TRENCH FROM GROUND WATER PIPING. FIELD VERIFY EXACT ROUTING. PROVIDE PULLBOXES AS REQUIRED PER NEC.

Registered Professional Engineer (Electrical)
CERTIFICATE NO. 41994
JEFFREY WALTER SITZLER
Date Signed 3-10-08
ARIZONA, U.S.A.
EXPIRES 3/31/08

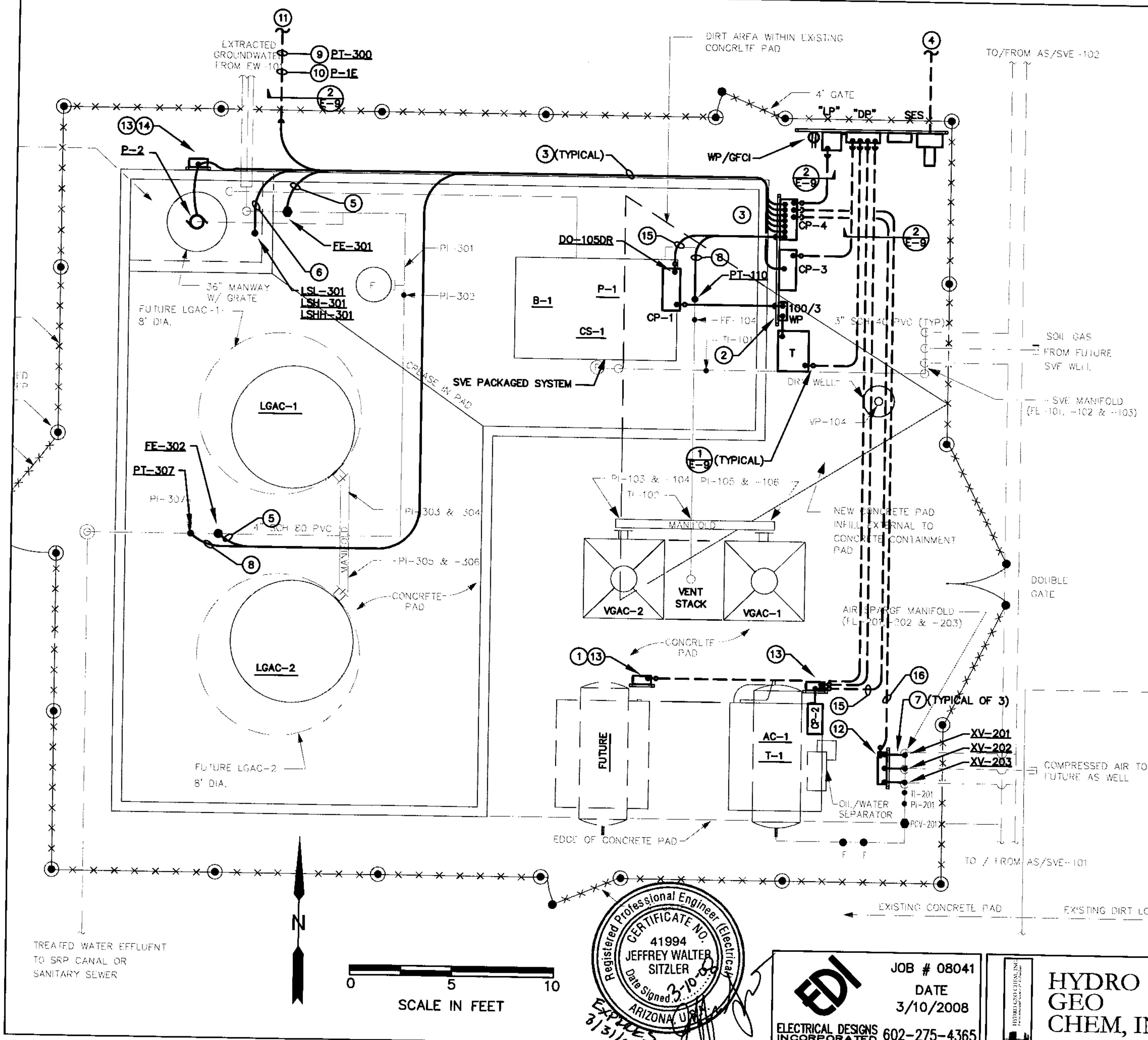
EDI
ELECTRICAL DESIGNS INCORPORATED 602-275-4365

JOB # 08041
DATE 3/10/2008

HYDRO GEO CHEM, INC.

ADEQ COOPER & COMMERCE ERA
ELECTRICAL SITE PLAN

Approved	Date	Revised	Date	Reference	Figure
JWS	03-10-08	-	-	08041E1	E-1



POWER KEYNOTES

1. APPROXIMATE LOCATION OF SPARE DISCONNECT FOR FUTURE AIR COMPRESSOR.
2. PROVIDE UNISTRUT SUPPORT RACK FOR ELECTRICAL EQUIPMENT. SEE DETAIL ON SHEET E-6. FIELD VERIFY EXACT LOCATION.
3. ROUTE CONDUIT A MINIMUM OF 12" A.F.G. FIELD VERIFY ROUTING AND SUPPORT AS REQUIRED.
4. PROPOSED ROUTING OF NEW UNDERGROUND SERVICE LATERALS. COORDINATE WITH UTILITY Co. FOR EXACT REQUIREMENTS. SEE SHEET E-1 FOR CONTINUATION.
5. PROVIDE 21mm (3/4") C. FROM CONTROL PANEL TO FLOW ELEMENT AS REQUIRED. INSTALL OWNER FURNISHED (1) 3-18 A.W.G. CABLE WITHIN RACEWAY SYSTEM. FIELD VERIFY EXACT ROUTING.
6. PROVIDE 35mm (1-1/4") C. WITH (6) 12 A.W.G. THWN-2 CU. CONDUCTORS FROM CONTROL PANEL TO NEMA 4X J-BOX. PROVIDE 21 mm (3/4") C. FROM J-BOX TO EACH INSTRUMENT AS REQUIRED. INSTALL OWNER FURNISHED CABLING TO INSTRUMENT TRANSMITTERS WITHIN RACEWAY SYSTEM. FIELD VERIFY EXACT ROUTING.
7. PROVIDE (2) 12 A.W.G. THWN-2 CU. AND (1) 12 A.W.G. CU. GND. IN LIQUID TIGHT METALLIC FLEX. ROUTE ABOVE GROUND FROM CONTROLLER TO EACH AUTOMATED BALL VALVE. FIELD VERIFY EXACT ROUTING.
8. PROVIDE 21mm (3/4") C. WITH (1) 18 A.W.G. S.T.P. FROM CONTROL PANEL TO NEMA 4X J-BOX. PROVIDE 21 mm (3/4") C. FROM J-BOX TO INSTRUMENT AS REQUIRED. INSTALL OWNER FURNISHED CABLING TO INSTRUMENT TRANSMITTER WITHIN RACEWAY SYSTEM. FIELD VERIFY EXACT ROUTING.
9. PROVIDE 21 mm (3/4") C. FROM INSTRUMENT TRANSMITTER TO CONTROL PANEL AS REQUIRED. INSTALL OWNER FURNISHED CABLING WITHIN RACEWAY SYSTEM. FIELD VERIFY EXACT ROUTING.
10. SEE SINGLE-LINE DIAGRAM FOR P-1E REQUIREMENTS.
11. TO PT-300 AND P-1E. SEE CONTINUATION ON SHEET E-1. CONDUIT TO BE ROUTED A MINIMUM OF 24" BELOW GRADE IN SEPARATE TRENCH FROM GROUND WATER PIPING. FIELD VERIFY EXACT ROUTING. SEE DETAIL 2 ON SHEET E-9.
12. AIR SPARGE PULSE CONTROLLER. MOUNT ON UNISTRUT SUPPORT STRUCTURE AT 5' AFG TO TOP OF CONTROLLER. FIELD VERIFY EXACT LOCATION. SEE SCHEMATIC ON SHEET E-7.
13. MOUNT DISCONNECT ON UNISTRUT SUPPORT RACK. FIELD VERIFY EXACT LOCATION. SEE SINGLE-LINE DIAGRAM ON SHEET E-4.
14. PROVIDE 30/2 N.F. NEMA 4X DISCONNECT SWITCH. SEE SHEET E-4 AND E-11.
15. PROVIDE 21 mm (3/4") C. WITH (1) 18 A.W.G. CU. S.T.P. SEE SHEET E-11 AND PID-3.
16. PROVIDE 21 mm (3/4") C. WITH (2) 12 A.W.G. THWN-2 CU. AND (1) 12 A.W.G. CU. GND. FOR POWER AND (2) 12 A.W.G. THWN-2 CU. CONDUCTORS FOR CONTROL FROM CP-4 TO AIR SPARGE CONTROLLER. SEE SHEET E-7 AND E-11.

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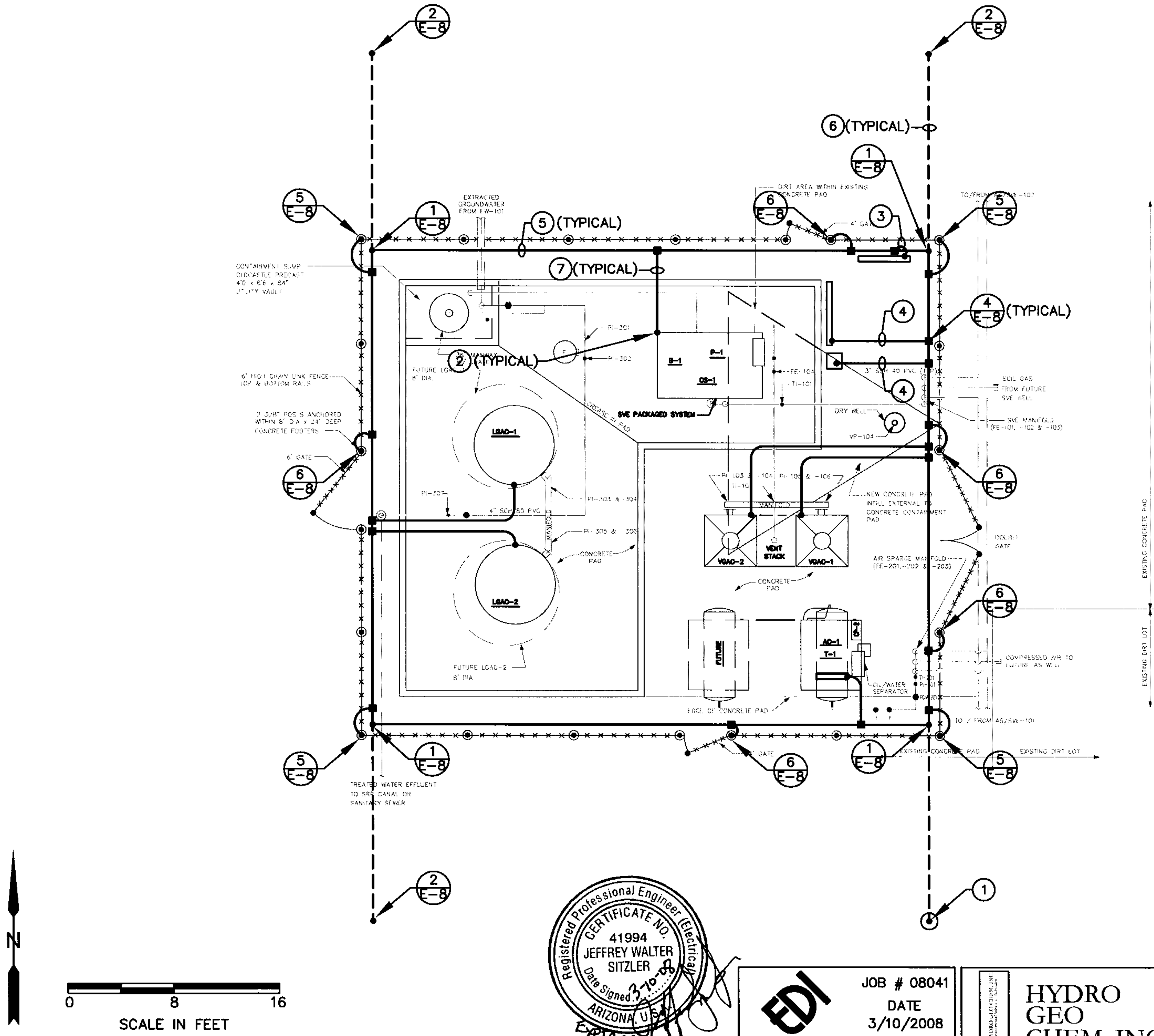
ELECTRICAL DESIGNS INCORPORATED
JOB # 08041
DATE 3/10/2008
602-275-4365

HYDRO GEO CHEM, INC.

ADEQ COOPER & COMMERCE ERA
POWER PLAN

Approved	Date	Revised	Date	Reference	Figure
JWS	03-10-08	-	-	08041E2	E-2



Registered Professional Engineer (Electrical)
CERTIFICATE NO.
41994
JEFFREY WALTER SITZLER
Date Signed 3-10-08
ARIZONA, U.S.A.
EXPIRES 3/31/08

KEYNOTES

1. TEST WELL.
2. GROUNDING TO STEEL SKID/EQUIPMENT FRAME.
3. GROUNDING TO NEW S.E.S.
4. GROUNDING TO NEW TRANSFORMER.
5. 4/0 A.W.G. S.D.I.C. SECURED TO CONCRETE PAD AND LOCATED WITHIN FENCE PERIMITER.
6. 4/0 A.W.G. S.D.B.C. 24" BELOW GRADE.
7. 2/0 A.W.G. S.D.I.C. SECURED TO CONCRETE PAD.

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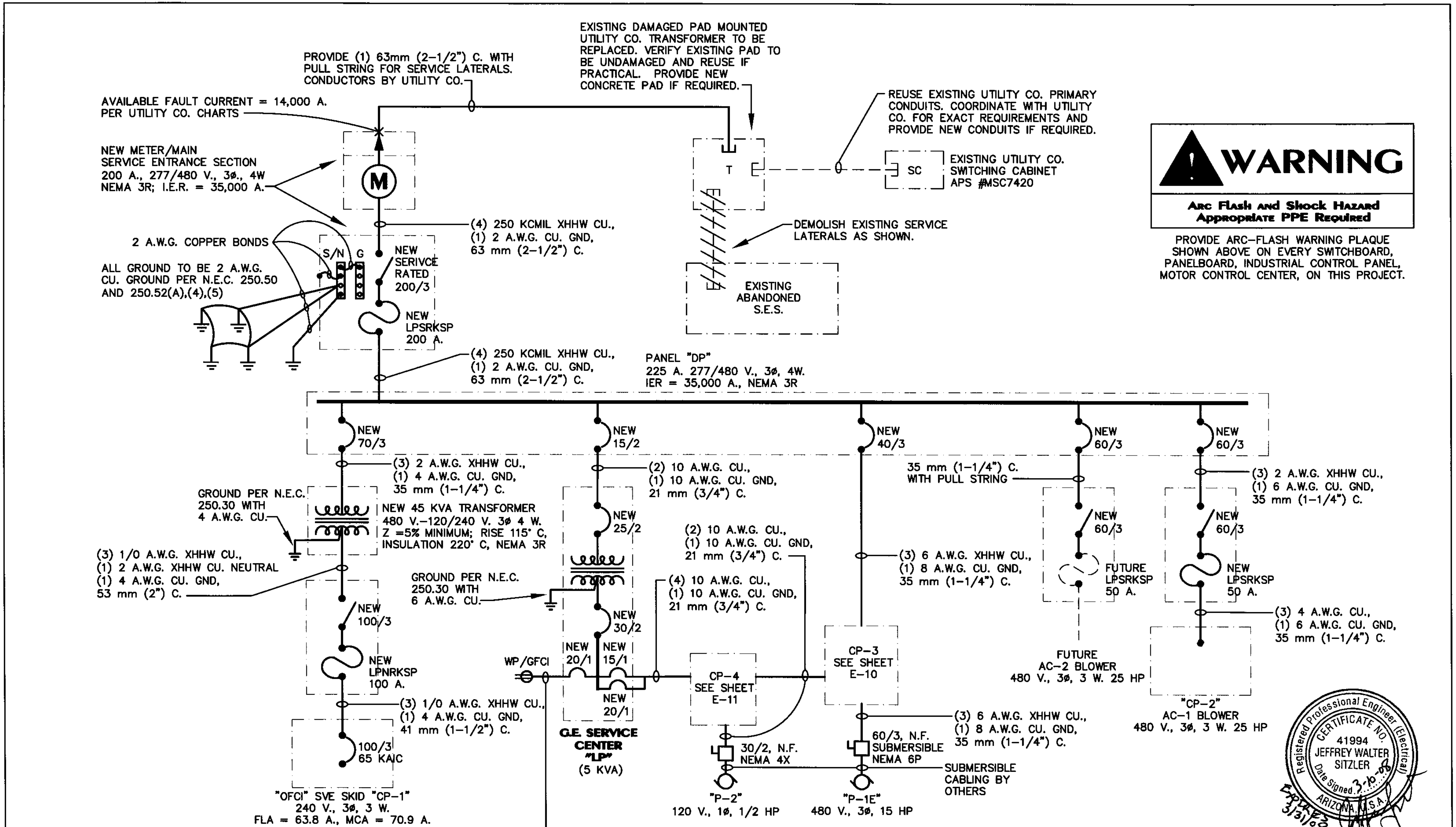
HYDRO GEO CHEM, INC.

ADEQ COOPER & COMMERCE ERA
GROUNDING PLAN

Approved	Date	Revised	Date	Reference	Figure
JWS	03-10-08	-	-	08041E3	E-3



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JOB # 08041
DATE 3/10/2008
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HYDRO GEO CHEM, INC.

ADEQ COOPER & COMMERCE ERA SINGLE-LINE DIAGRAM

Approved	Date	Revised	Date	Reference	Figure
JWS	03-10-08	-	-	08041E4	E-4

NEMA 3R

NEW PANELBOARD SCHEDULE "DP"

LOCATION: SEE SHEET E-2

C.B. RATING: 35,000 A.I.C.

VOLTAGE: 277/480 V., 3ø, 4 W. | **MAINS:** 225 A. M.L.O. | **MOUNTING:** SURFACE | **TYPE:** GE AD OR EQUAL

	USE and/or AREA SERVED	C/B	CIR NO	LOAD øA	LOAD øB	LOAD øC	CIR NO	C/B	USE and/or AREA SERVED	
*	P-1E 15 HP VIA CP-3	40/3	1	7275				60/3	SPARE (FUTURE AIR COMPRESSOR)	
				9616			2			
			3		7275					
					9616		4			
			5			7275				
						9616	6			
	CP-1 VIA XFMR	65/3	7	8840				60/3	CP-2 AC-1, 25 HP AIR COMPRESSOR	*
				12020			8			
			9		8840					
					12020		10			
			11			8840				
						12020	12			
	"LP"	15/2	13	1380						
				–			14	–	SPACE	
			15		1800					
					–		16	–	SPACE	
	SPACE	–	17			–				
						–	18	–	SPACE	
	TOTAL LOAD PER PHASE:			39131	39551	37751	**39551 VA ÷ 277V = 142.8 AMPS**			

* LOAD AT 125% PER N.E.C.

NEMA 3R

NEW PANELBOARD SCHEDULE "LP"

LOCATION: SEE SHEET E-2

C.B. RATING: 14,000 / 10,000 A.I.C.

VOLTAGE: 120/240 V., 1ø, 3 W. | **MAINS:** 25A MCB 30A MCB | **MOUNTING:** SURFACE | **TYPE:** 5 KVA GE SERVICE CENTER

	USE and/or AREA SERVED	C/B	CIR NO	LOAD øA	LOAD øB	CIR NO	C/B	USE and/or AREA SERVED
	CP-3/4 CONTROL POWER	15/1	1	1200			20/1	WP/GFCI RECEPTACLE
				180		2		
*	P-2, 1/2 HP, 12A	20/1	3		1800		20/1	SPARE
					–	4		
	SPACE	–	5	–			–	SPACE
				–		6		
	SPACE	–	7		–		–	SPACE
					–	8		
	SPACE	–	9	–			–	SPACE
				–		10		
	SPACE	–	11		–		–	SPACE
					–	12		
	TOTAL LOAD PER PHASE:			1380	1800	**1800 VA ÷ 120V = 15.0 AMPS**		

* LOAD AT 125% PER N.E.C.

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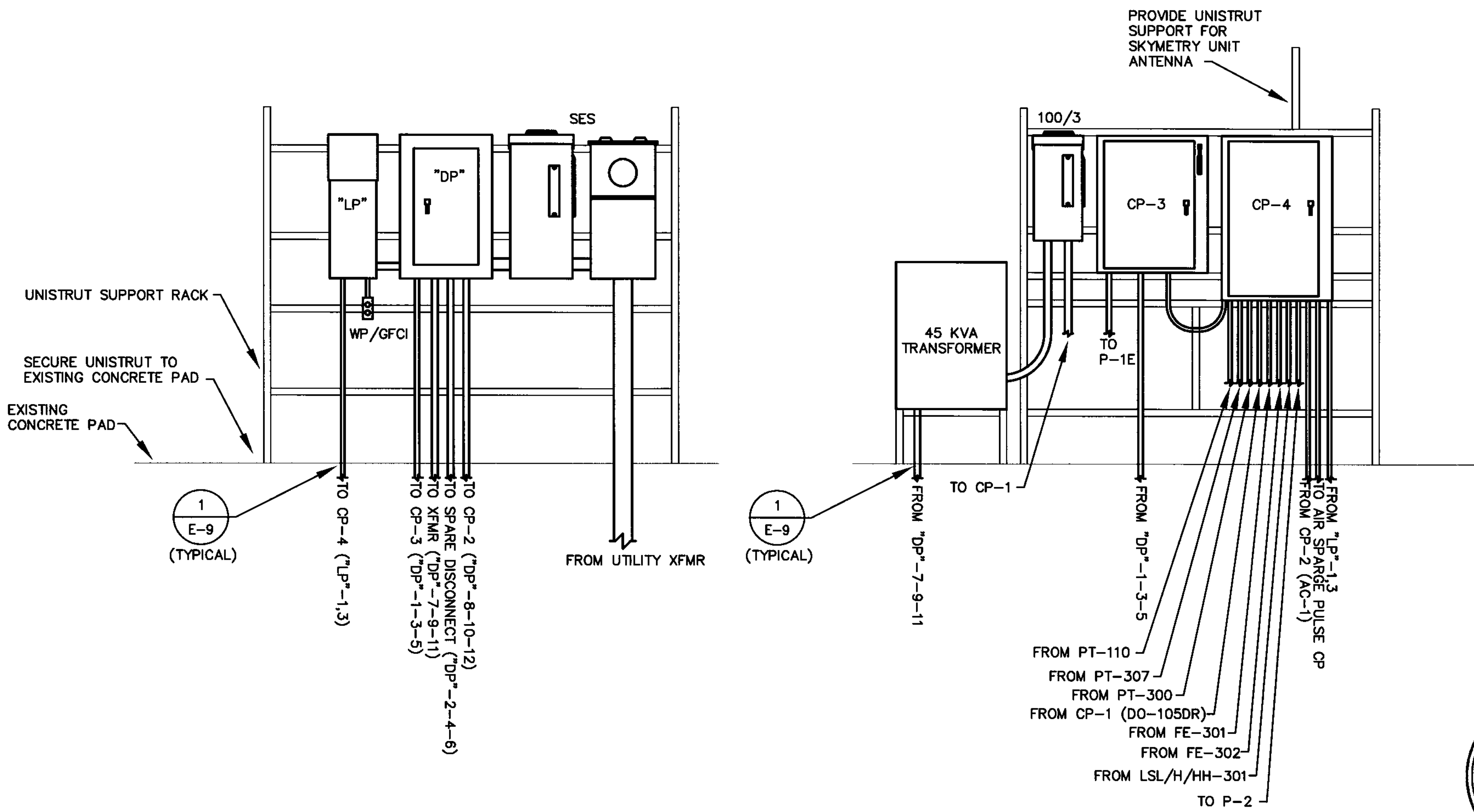
ELECTRICAL DESIGNS INCORPORATED 602-275-4365

JOB # 08041
DATE 3/10/2008

HYDRO GEO CHEM, INC.

ADEQ COOPER & COMMERCE ERA
PANEL SCHEDULES

Approved	Date	Revised	Date	Reference	Figure
JWS	03-10-08	-	-	08041E5	E-5



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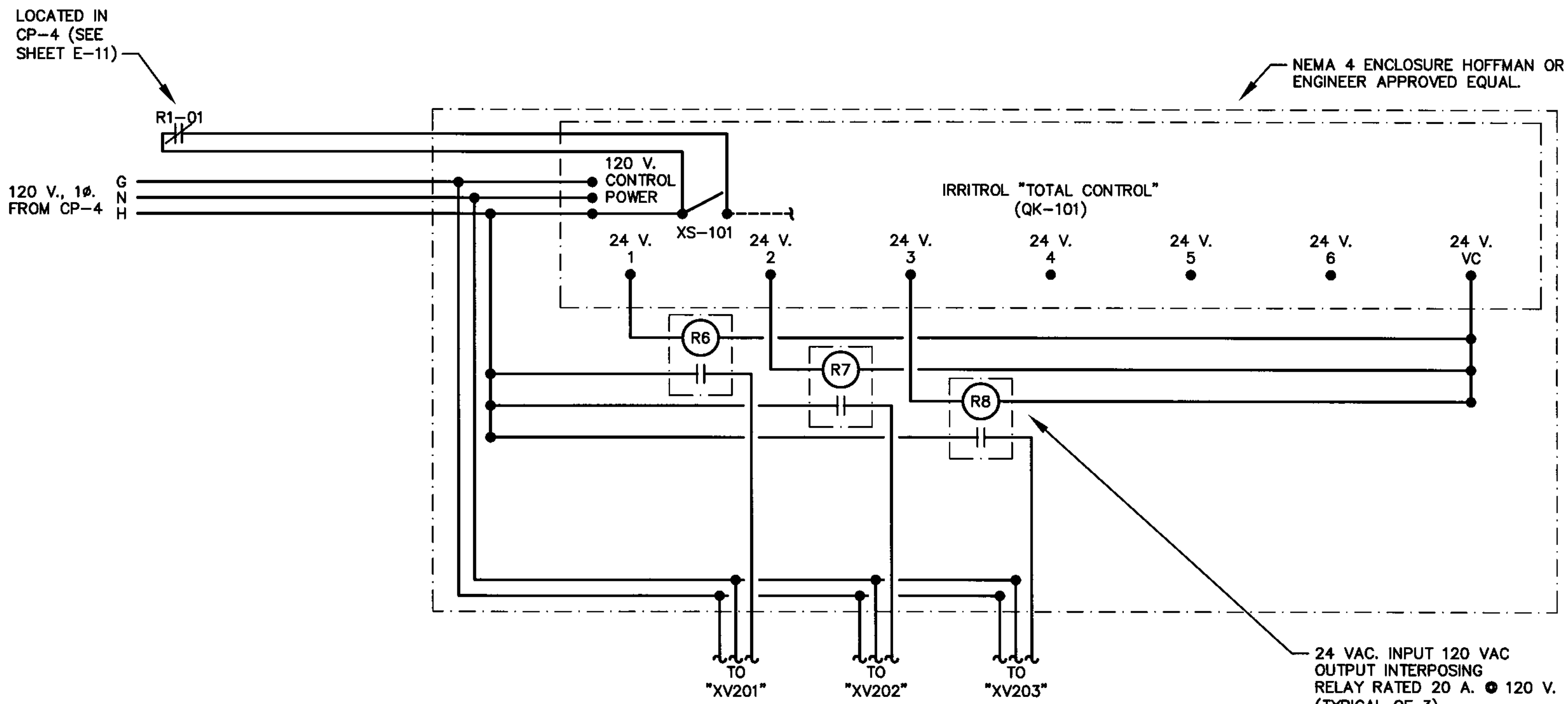
HYDRO GEO CHEM, INC.

ADEQ COOPER & COMMERCE ERA
ELECTRICAL EQUIPMENT RACK DETAILS

Approved	Date	Revised	Date	Reference	Figure
JWS	03-10-08	-	-	08041E6	E-6



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EXPIRES 3/31/08

ELECTRICAL DESIGNS INCORPORATED 602-275-4365

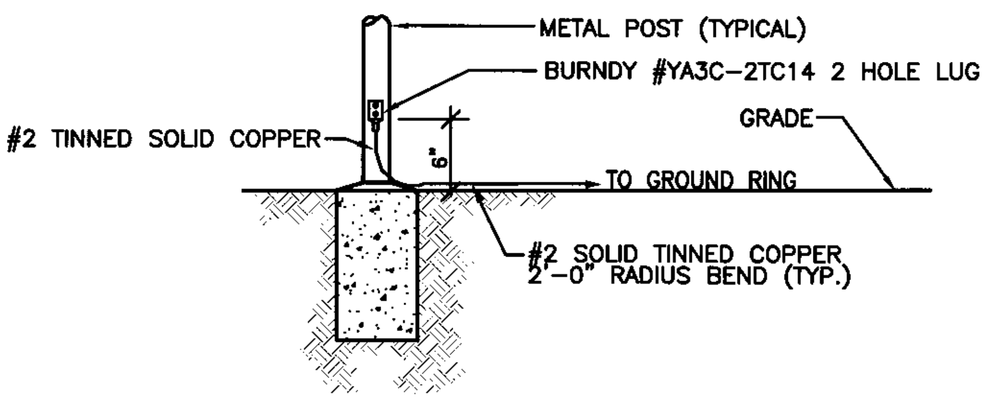
JOB # 08041

DATE 3/10/2008

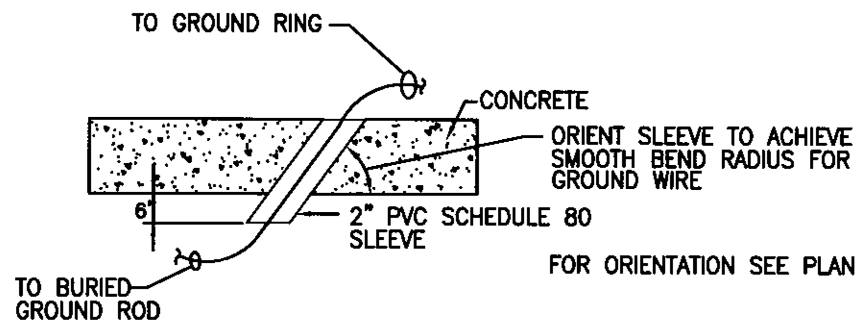
HYDRO GEO CHEM, INC.

ADEQ COOPER & COMMERCE ERA
AIR SPARGE PULSE CONTROL SCHEMATIC

Approved	Date	Revised	Date	Reference	Figure
JWS	03-10-08	-	-	08041E7	E-7

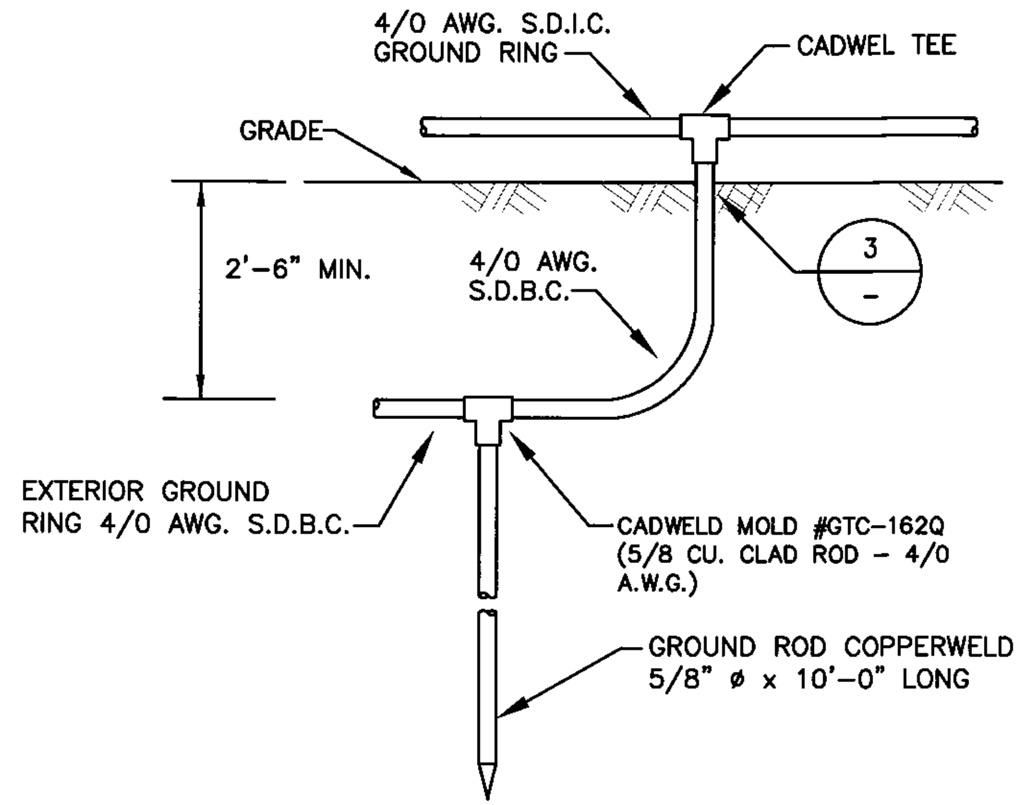


METAL POST GROUNDING DETAIL (5/–)



GROUNDING SLEEVE (3/–)

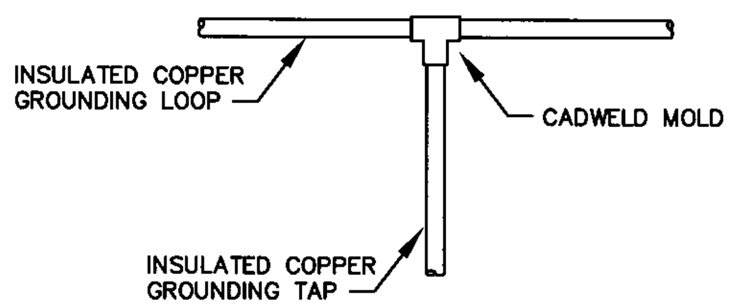
N.T.S.



GROUND ROD DETAIL (1/–)

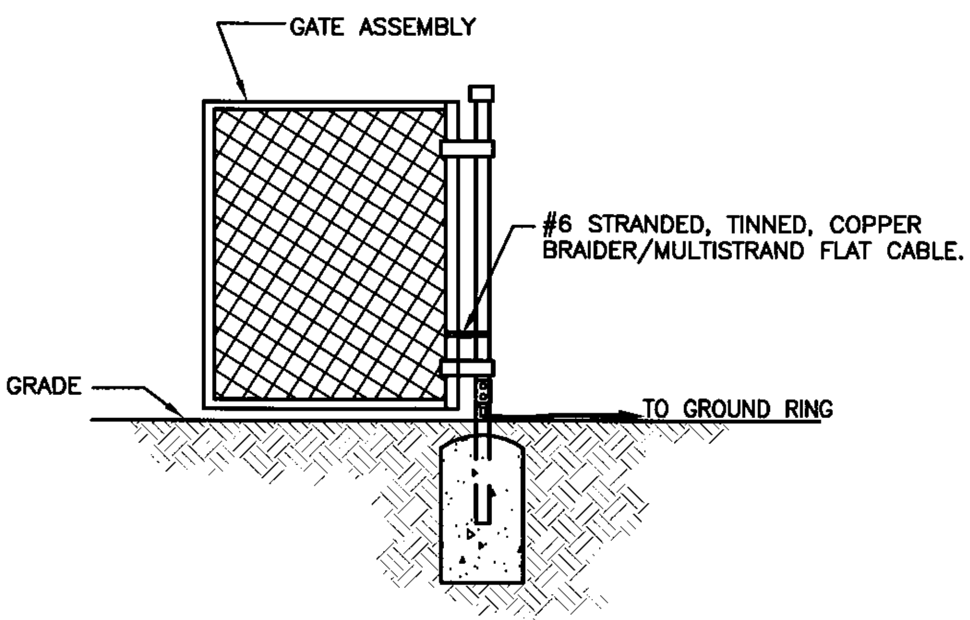
N.T.S.

CADWELD MOLD	RUN	TAP
#TAC-2Q2Q	4/0 A.W.G. CU.	4/0 A.W.G. CU.
#TAC-2Q2G	4/0 A.W.G. CU.	2/0 A.W.G. CU.
#TAC-2Q1T	4/0 A.W.G. CU.	2 A.W.G. CU.



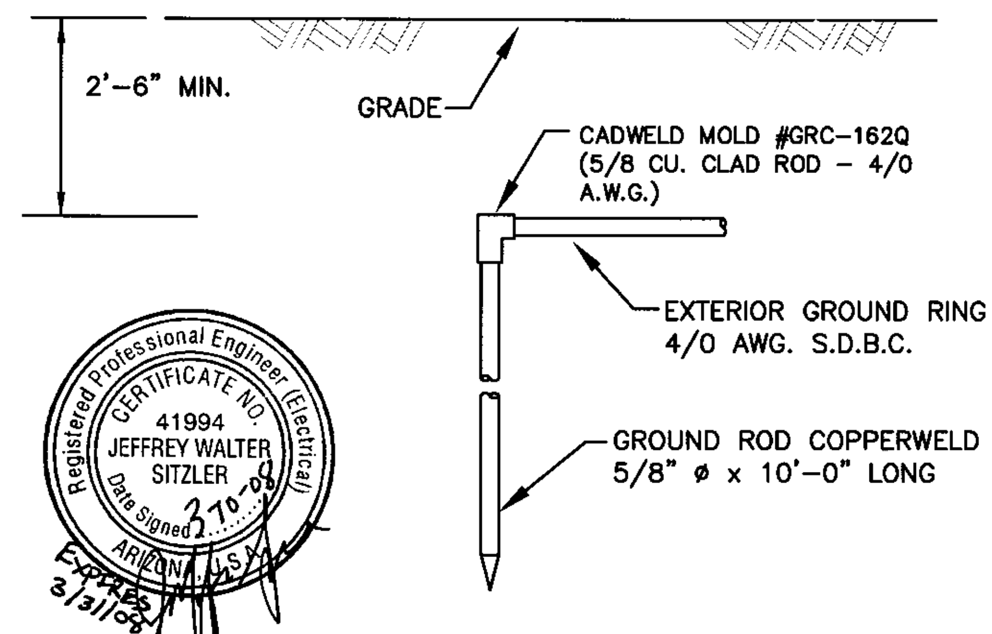
CADWELD TEE (4/–)

N.T.S.



SEE METAL POST GROUNDING DETAIL (5/–) FOR ADDITIONAL INFORMATION

GATE GROUNDING DETAIL (6/–)



GROUND ROD DETAIL (2/–)

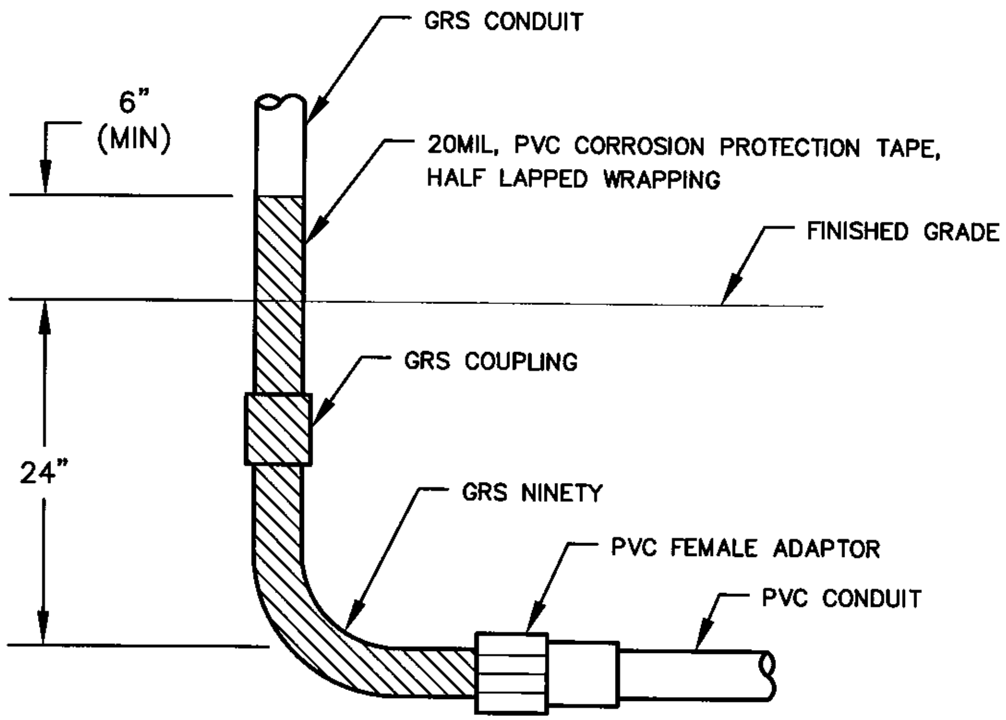
N.T.S.

JOB # 08041
DATE 3/10/2008
ELECTRICAL DESIGNS INCORPORATED 602-275-4365

HYDRO GEO CHEM, INC.

ADEQ COOPER & COMMERCE ERA GROUNDING DETAILS

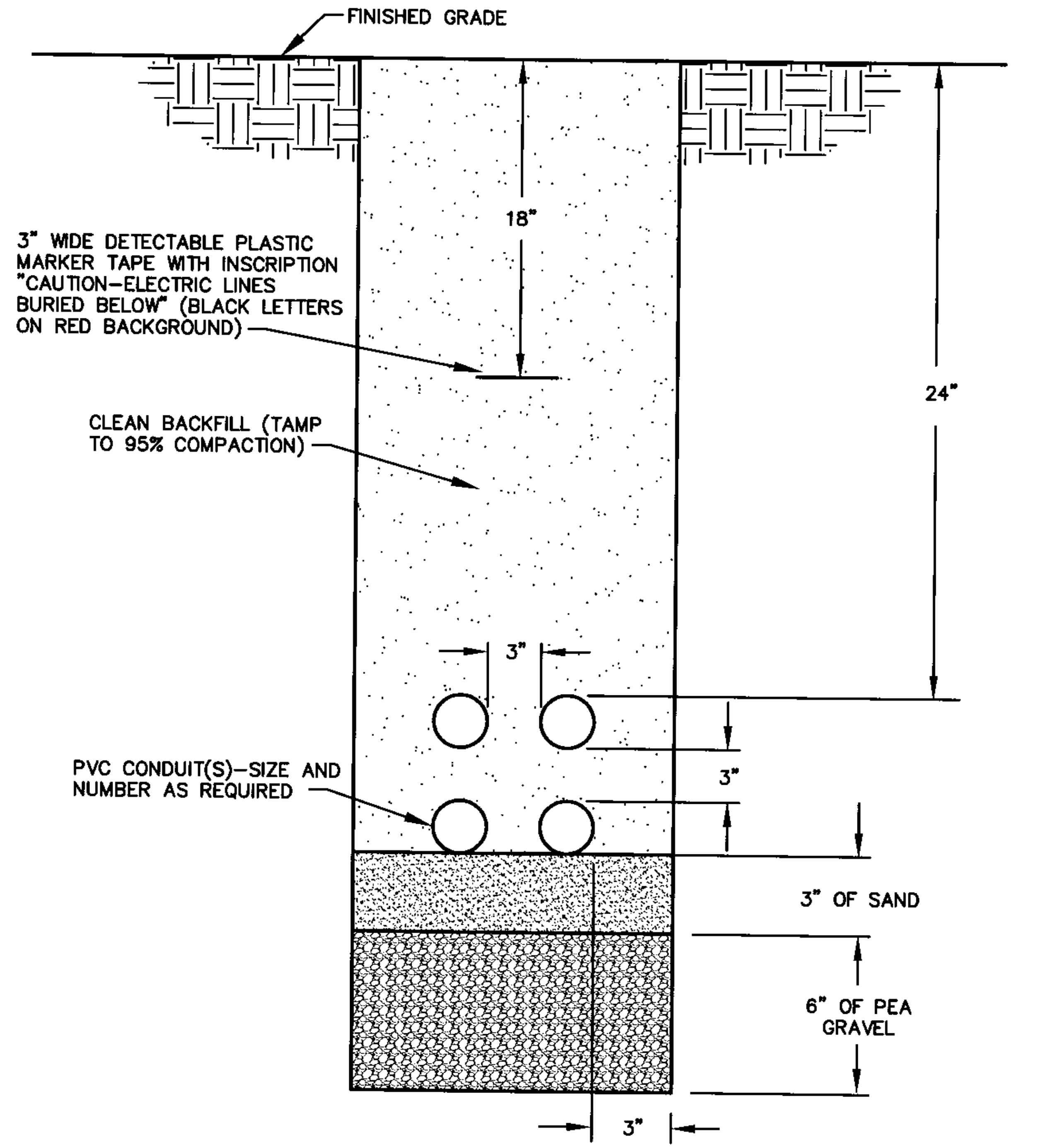
Approved	Date	Revised	Date	Reference	Figure
JWS	03-10-08	-	-	08041E8	E-8



NOTE: WHERE CONDUITS ARE RUN IN SLAB, THE 24" DIMENSION DOES NOT APPLY.

GRS STUB UP DETAIL

(TYPICAL) N.T.S. 1/–



NOTES:
ALL DIMENSIONS ARE MINIMUM. NUMBER OF CONDUITS SHOWN IS FOR EXAMPLE ONLY. MODIFY FOR FEWER OR ADDITIONAL CONDUITS AS REQUIRED.

PROVIDE MINIMUM OF 6" SPACE BETWEEN POWER AND SIGNAL CONDUITS.

NOTES:
WHERE CONDUIT TRENCH PASSES THROUGH CONCRETE PAD, SAW CUT AND REMOVE CONCRETE DURING TRENCHING. FINISH TRENCH BACKFILL BY INSTALLING BASE LAYER (ABC) FOLLOWED BY CONCRETE PATCH TO MATCH EXISTING.

DIRECT BURIED CONDUIT

(TYPICAL) N.T.S. 2/–

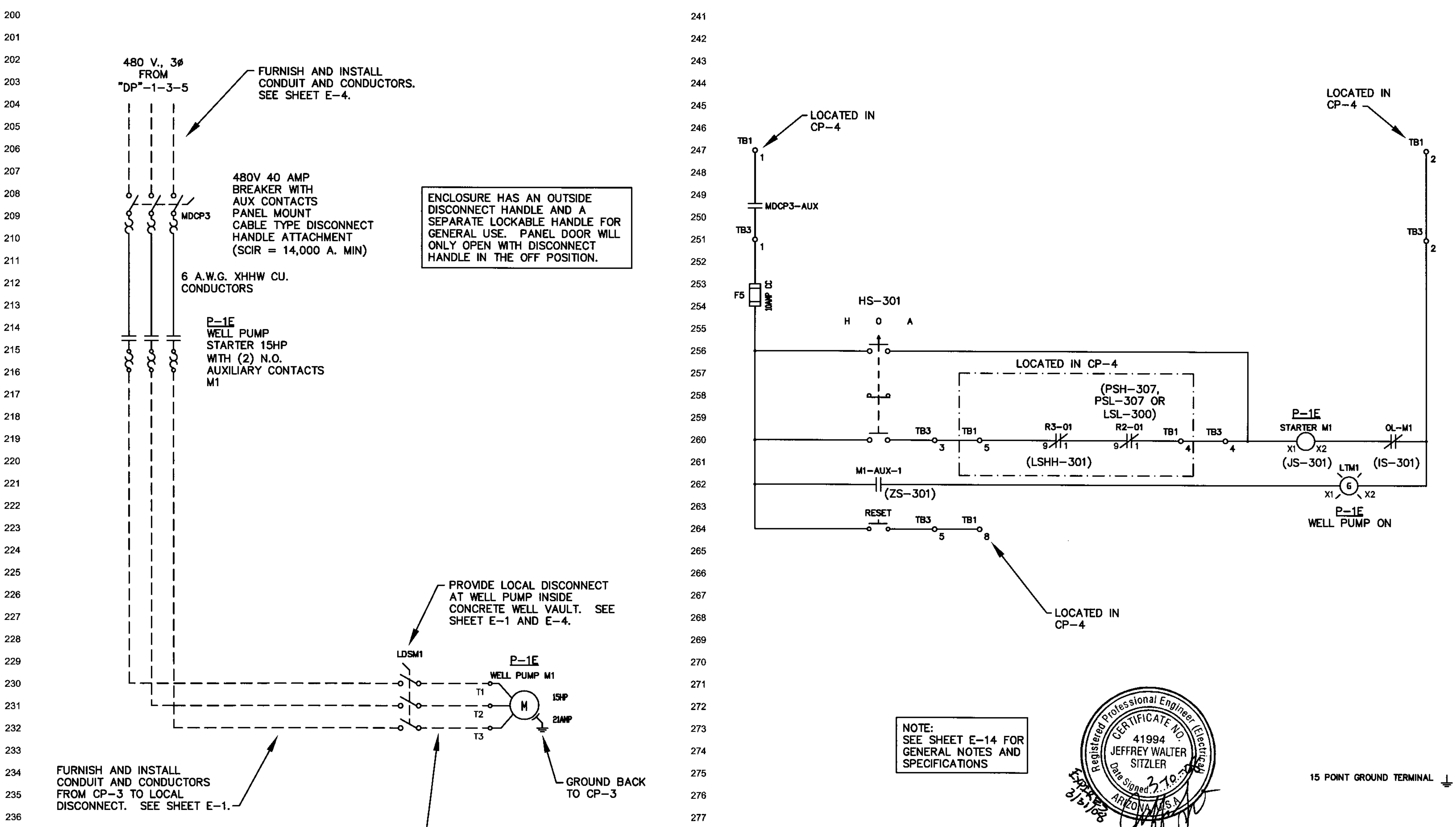
Registered Professional Engineer (Electrical) CERTIFICATE NO. 41994 JEFFREY WALTER SITZLER Date Signed 3-10-08 ARIZONA U.S.A. EXPIRES 3/31/08

EDI ELECTRICAL DESIGNS INCORPORATED JOB # 08041 DATE 3/10/2008 602-275-4365

HYDRO GEO CHEM, INC.

ADEQ COOPER & COMMERCE ERA
ELECTRICAL DETAILS

Approved	Date	Revised	Date	Reference	Figure
JWS	03-10-08	-	-	08041E9	E-9



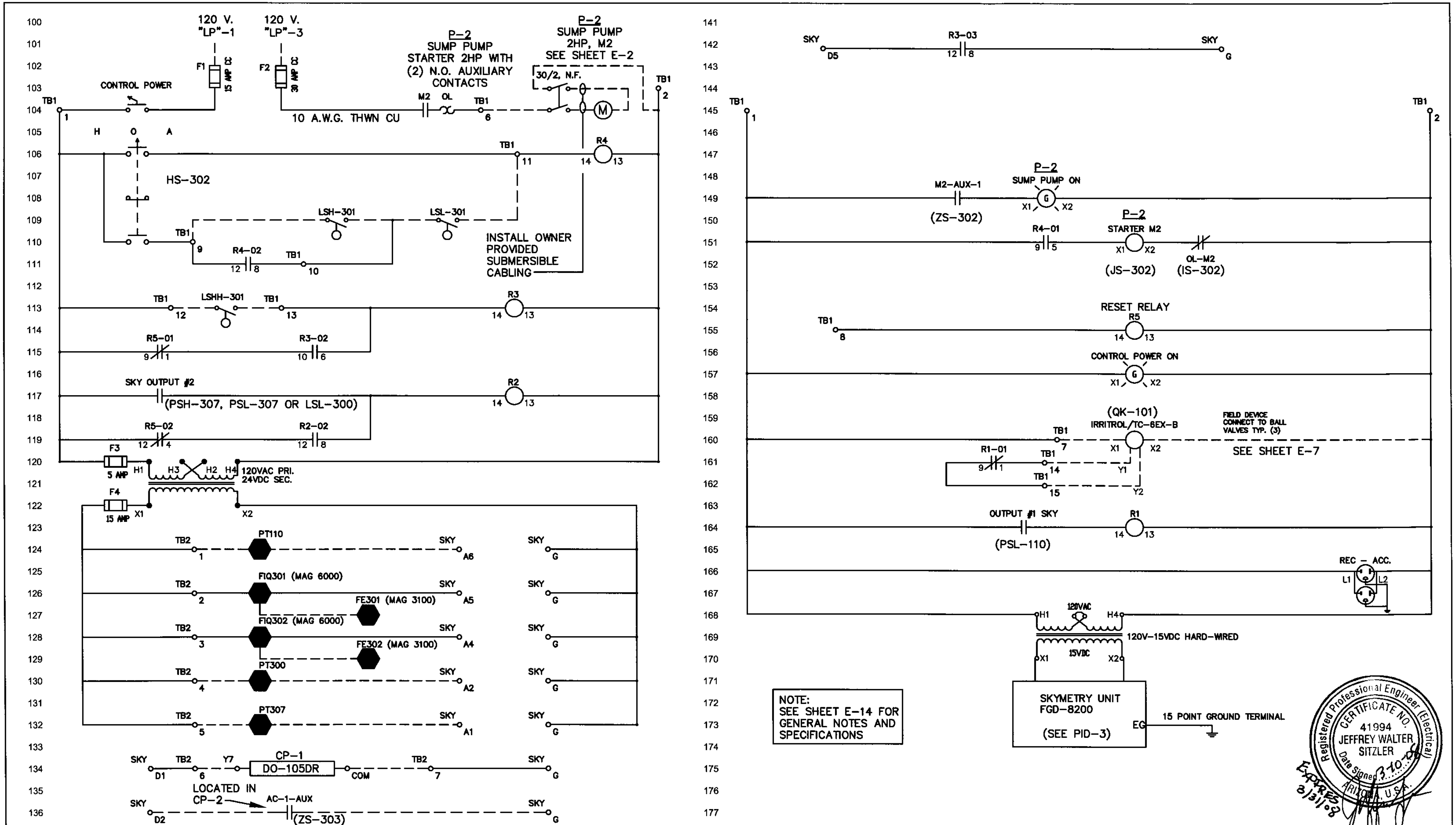
EDI ELECTRICAL DESIGNS INCORPORATED 602-275-4365

JOB # 08041
DATE 3/10/2008

HYDRO GEO CHEM, INC.

ADEQ COOPER & COMMERCE ERA
PANEL CP-3 SCHEMATIC

Approved	Date	Revised	Date	Reference	Figure
JWS	03-10-08	-	-	08041E10	E-10



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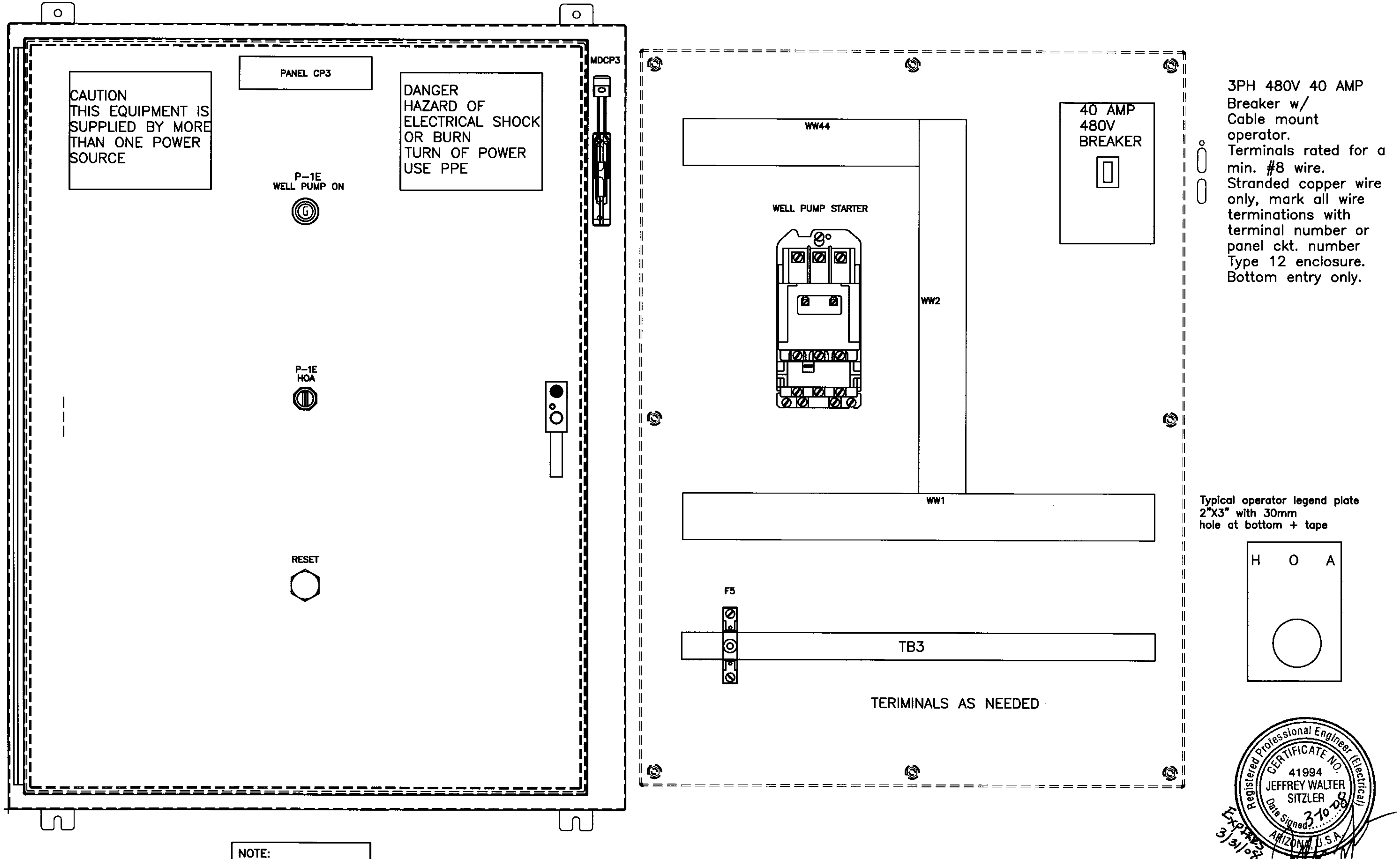
602-275-4365

HYDRO GEO CHEM, INC.

ADEQ COOPER & COMMERCE ERA
PANEL CP-4 SCHEMATIC

Approved	Date	Revised	Date	Reference	Figure
JWS	03-10-08	-	-	08041E11	E-11



NOTE:
SEE SHEET E-14 FOR GENERAL NOTES AND SPECIFICATIONS

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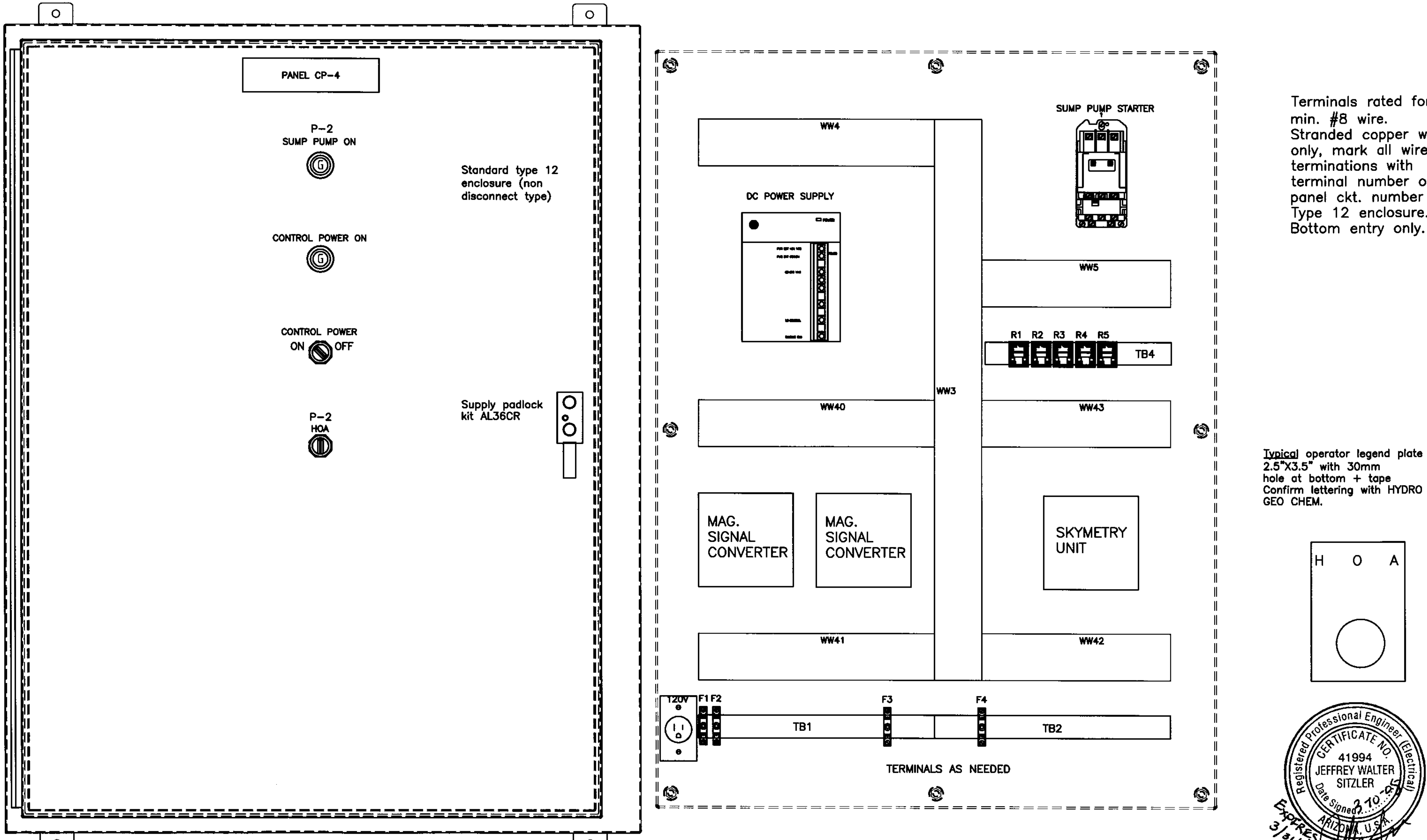
HYDRO GEO CHEM, INC.

ADEQ COOPER & COMMERCE ERA
PANEL CP-3 LAYOUT

Approved	Date	Revised	Date	Reference	Figure
JWS	03-10-08	-	-	08041E12	E-12



NOTE:
SEE SHEET E-14 FOR GENERAL NOTES AND SPECIFICATIONS

EDI
ELECTRICAL DESIGNS INCORPORATED 602-275-4365
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HYDRO GEO CHEM, INC.

ADEQ COOPER & COMMERCE ERA
PANEL CP-4 LAYOUT

Approved	Date	Revised	Date	Reference	Figure
JWS	03-10-08	-	-	08041E13	E-13

CONTROL PANEL GENERAL NOTES / SPECS

1. MINIMUM 14 A.W.G. CU. STR WIRE.
2. COLOR CODE ALL 24VDC WIRE (BLUE).
3. COLOR CODE 120VAC WIRE (RED–CONTROL), (WHT–NEUTRAL), (BLK–FUSE–HOT).
4. TERMINALS WILL BE RATED FOR 50A / 8 A.W.G. CU. WIRE MIN.
5. ALL TERMINATIONS SHALL BE MARKED WITH TERMINAL BLOCK, WIRE NUMBER, OR PANEL CKT. NUMBER.
6. ENCLOSURE WILL BE TYPE 12, WITH BACK MOUNTING PANEL.
7. ENCLOSURE WILL BE SET UP FOR BOTTOM ENTRY ONLY.
8. SUPPLY (2) SPARE FUSES PER PANEL FOR ALL TYPES AND SIZES.
9. TB1, TB2, TB3, SHALL HAVE (5) SPARE TERMINALS EACH.
10. PANELS SHALL BE CONSTRUCTED BY AN AUTHORIZED UL–508A PANEL SHOP.
11. CAUTION / DANGER LABELS TO BE PLACED IN THE UPPER PORTION OF THE PANELS PER DETAILS.
12. SKYMETRY UNIT WILL BE PROGRAMMED BY (HYDRO GEO CHEM, INC.)
13. MAG. SIGNAL CONVERTER SETTINGS BY (HYDRO GEO CHEM, INC.)
14. SKYMETRY UNIT ANTENNA TO MOUNT ON EXTENDED PANEL SUPPORT BY ELECTRICAL CONTRACTOR.

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HYDRO GEO CHEM, INC.

ADEQ COOPER & COMMERCE ERA
CONTROL PANEL GENERAL NOTES

Approved	Date	Revised	Date	Reference	Figure
JWS	03-10-08	-	-	08041E14	E-14

1.0) FURNISH AND INSTALL A COMPLETE ELECTRICAL SYSTEM AS DEPICTED FROM THE PLANS AND SPECIFICATIONS HEREIN – AS NOTED OR IMPLIED – NOT LIMITED TO WHAT IS SHOWN.

1.1) ALL DRAWINGS ARE SCHEMATIC IN NATURE AND ALL APPURTENANCES, BASES, PADS, SUPPORTS NOT INDICATED TO MAKE A WORKING SYSTEM MUST BE INCLUDED IN CONTRACTOR'S BID.

1.2) IF THERE APPEARS TO BE ANY ITEMS IN CONFLICT WITH THE DRAWINGS, INCONSISTENCIES WITH DESIGN OR INTENT, OR NEED FOR CLARIFICATION, IT IS THE CONTRACTOR'S RESPONSIBILITY TO CLARIFY THESE ITEMS PRIOR TO BID IN WRITING WITH THE ENGINEER. IF THE CONTRACTOR FAILS TO CLARIFY ANY QUESTIONS OR INCONSISTENCY, HE ACCEPTS RESPONSIBILITY TO CORRECT AT HIS COST ANY SUCH ITEM TO MEET INTENT AS DEFINED BY ENGINEER.

1.3) ANY PROPOSED DEVIATIONS FROM PLANS AND SPECIFICATIONS MUST BE APPROVED BY THE ENGINEER PRIOR TO COMMENCING WORK. ENGINEER LETTERS OF ACCEPTANCE OR REVISED PLANS REQUIRED DUE TO DEVIATIONS FROM PLANS AND SPECIFICATIONS WILL BE ADDITIONAL SERVICES TO BE PAID BY CONTRACTOR AT AN HOURLY RATE OF $120.00 PER HOUR. THE CONTRACTOR WILL BE REQUIRED TO PAY C.O.D. FOR ANY ABOVE REFERENCED DOCUMENTS.

2.0) GENERAL

2.1) ALL MATERIALS AND WORKMANSHIP WILL CONFORM TO THE MOST RECENT EDITIONS OF THE NATIONAL ELECTRICAL CODE, I.B.C. U.B.C. I.E.C.C., NFPA 72,75,101, & GILBERT CONSTRUCTION CODE AS REQUIRED BY THE ENGINEER, LOCAL AND STATE CODES AND ORDINANCES, AMERICANS WITH DISABILITIES ACT, E.P.A., AND UTILITY COMPANY REQUIREMENTS.

2.2) CONTRACTOR WILL SUPPLY INFORMATION AS REQUIRED TO ALL SERVING UTILITIES IN A TIMELY MANNER AS REQUIRED TO ASSURE SERVICE (POWER, TELEPHONE, ETC.) IS PROVIDED PER PROJECT SCHEDULE.

2.3) THE CONTRACTOR WILL HAVE A COPY OF THE MOST RECENT ADOPTED EDITION OF THE NATIONAL ELECTRICAL CODE, ON SITE, WITH THE CITY APPROVED PLANS AT ALL TIMES DURING THE PROJECT CONSTRUCTION.

3.0) MATERIALS AND METHODS

3.1) ALL FITTINGS MUST BE STEEL COMPRESSION TYPE; OR STEEL SET SCREW TYPE; DIE CAST FITTINGS ARE UNACCEPTABLE. ALL RACEWAYS MUST HAVE CODE SIZED COPPER EQUIPMENT GROUNDING CONDUCTOR. MINIMUM CONDUIT 21 mm (3/4") C. EXCEPT FIXTURE FLEXES BY MANUFACTURER. OVER 53 mm (2") CONDUIT TO BE RIGID OR I.M.C. (NOT E.M.T.) ALL WORK WILL BE IN CONDUIT; COMPLETED SYSTEM REAMED, AND SWABBED PRIOR TO CONDUCTOR INSTALL.

3.2) CONDUCTORS TO BE 600V., COPPER (98% CONDUCTIVITY). FEEDERS AND ANY CONDUIT EXPOSED TO THE AMBIENT WILL CONTAIN CONDUCTORS WITH XHHW-2 INSULATION, BRANCH CIRCUITS TO HAVE THHN OR THWN INSULATION.

3.3) MINIMUM LINE VOLTAGE WIRE SIZE IS 12 AWG FOR LINE VOLTAGE AND 10 AWG WHEN SEPARATE GROUNDED CONDUCTORS (NEUTRALS) ARE USED OR IN EXTERIOR. GROUNDED CONDUCTORS OF MULTI-WIRE BRANCH CIRCUITS (SHARED NEUTRALS) WILL BE 10 A.W.G. MIN. WIRING DEVICES TO BE SPECIFICATION GRADE, MINIMUM 20 AMPS FOR RECEPTACLES AND 20 AMPS FOR SWITCHES. HUBBELL OR ENGINEER APPROVED EQUAL. ALL SPECIAL RECEPTACLES AND GROUND FAULT PROTECTED DEVICES MUST BE PERMANENTLY MARKED WITH ENGRAVED COVER PLATES.

3.4) PVC COATED STEEL FLEXIBLE (SEAL-TITE) CONDUIT WILL BE USED FOR CONNECTIONS TO EQUIPMENT SUBJECT TO VIBRATION. (IE: TRANSFORMERS, MOTORS, ETC.)

3.7) TYPE MC CABLE IS ALLOWABLE IN USES PERMITTED BY THE N.E.C., LOCAL CODES, AND PERMISSION OF THE ENGINEER, <u>BOTH</u> ARE REQUIRED. PRIOR TO BID.

3.8) NONMETALLIC CONDUIT MAY BE USED BELOW GRADE OR UNDER SLABS OR IN CONCRETE OR MASONRY WALLS (EXCEPT AS PROHIBITED BY N.E.C., I.B.C. OR LOCAL CODES). WHEN BELOW GRADE OR UNDER SLAB, 914 mm (24") DEEP MIN. ALL NONMETALLIC CONDUIT WILL BE SCHEDULE 80 BY CARLON OR EQUAL. BELOW GRADE CONDUIT TO HAVE 16 A.W.G. COPPER TRACER WIRE WITH 12" SPARE ACCESSIBLE AT EACH END.

3.9) CONTRACTOR WILL PROVIDE LETTER TO ENGINEER CONFIRMING ALL EQUIPMENT AND TERMINATIONS ARE PROPERLY TORQUED – SIGNED BY LICENSED CONTRACTOR.

3.10) CONDUCTORS WILL BE STRANDED, HYDRAULIC CRIMP CONNECTIONS--ALL. CONDUCTOR INSULATION WILL BE CONTINUOUSLY COLOR COATED UP TO SIZE 500 KCMIL. ALL GROUNDING/BONDING CONDUCTORS WILL BE MULTI-CONDUCTOR TYPE (U.L. LABELED- ROPE STRAND BUILDING WIRE CLASS 'M') BARE OR INSULATED AS NOTED OR REQUIRED.

3.11) WHEN SOLID #14, #12, OR #10 ARE USED THEY ARE TO BE TWISTED BEFORE WIRE NUTS ARE INSTALLED AND WIRE NUTS WILL BE SPRING LOADED IDEAL, OR ENGINEER APPROVED EQUAL.

4.0) SERVICE

4.1) PROVIDE AND INSTALL NEW SERVICE SECTION AS SHOWN ON DRAWINGS WILL BE U.L. LABEL, 800A PER SQUARE INCH COPPER BUSSING – SILVER PLATED. METERING AND PRIMARY PULL SECTION BARRIERED FROM OTHER WORK AND APPROVED BY UTILITY COMPANY. SERVICE WILL HAVE AN INTEGRATED EQUIPMENT RATING (I.E.R.) EQUAL TO OR GREATER THAN UTILITY AVAILABLE FAULT CURRENT. SEE SINGLE-LINE AND VERIFY WITH UTILITY PRIOR TO ORDERING. ALL DEVICES WITHIN SERVICE TO HAVE INTERRUPTING RATING EQUAL TO OR GREATER THAN SERVICE BRACING INDICATED.

4.2) CONTRACTOR WILL COORDINATE WORK WITH UTILITY COMPANY AND INSTALL PER UTILITY COMPANY REQUIREMENTS.

4.3) PROVIDE GROUND TEST TO MEET IEEE (81) IN GREEN BOOK AND EMERALD BOOK PER NETA TESTING METHODS TO ASSURE 3 OHM MAXIMUM GROUND IMPEDANCE. TEST RESULTS WITH EQUIPMENT AND PROCEDURE CLEARLY DESIGNATED SUBMITTED TO ENGINEER FOR ACCEPTANCE AT EACH SERVICE AND DESIGNATED SYSTEM GROUND. SERVICE WILL BE "MEGGERED" AND A HIGH POTENTIAL TEST, BOTH AC AND DC., ON SERVICE AND DERIVED SYSTEM. SUBMIT CLEAR AND COMPLETE REPORT TO ENGINEER FOR APPROVAL.

4.5) ENCLOSURE TO MEET UL & PUBLIC UTILITY REQUIREMENTS-PHYSICALLY BARRIERED BETWEEN SECTIONS, LINE AND LOAD, BOTH BARRIERED.

4.7) FULL NEUTRAL BUSSING, FULL GROUND BUSSING AND NON-TAPERED BUSSING WILL BE STANDARD. ALL SPACE WILL BE FULLY BUSSED FOR FUTURE. ALL BUSSING WILL BE PHYSICALLY BARRIERED.

4.8) 24" PAST OPEN END OF ANY SERVICE DOOR WILL BE MAINTAINED PLUS WORK AREA PER 110.16 OF N.E.C.

4.10) SERVICE WILL BE FULLY MARKED WITH STEEL TAGS SHOWING U.L., AMPACITY VOLTAGE, WIRING, AND MIMIC BUS OR MICARTA – PLUS LABEL "<u>WARNING</u>-ELECTRICAL EQUIPMENT – <u>DANGER</u> – QUALIFIED PERSONNEL ONLY TO OPERATE OR OPEN EQUIPMENT." (QUALIFIED DEFINED BY NEC)

4.12) PROVIDE ARC FLASH PROTECTION WARNING PLAQUE ON SERVICE PER N.E.C. 110.16. SEE DETAIL THIS SHEET OR REFER TO ANSI Z535.4-1998.

4.13) ACCEPTABLE MANUFACTURERS: GENERAL ELECTRIC, ITT SIEMENS, CHALLENGER OR ENGINEER APPROVED EQUAL. SQUARE D, ENERCON, REDCO NOT APPROVED.

5.0) DISTRIBUTION

5.2) PANEL BOARDS (NEW): TO BE RATED AS SHOWN ON DRAWINGS WITH PLATED COPPER BUSSING, FULL SIZE CIRCUIT BREAKERS TO BE EQUAL TO GENERAL ELECTRIC OR AS APPROVED BY ENGINEER. NEMA ENCLOSURE AS REQUIRED BY CODE FOR LOCATION. BACK BOXES ENLARGED FOR DOUBLE NEUTRALS AND LUGS CAPABLE OF OVERSIZING-ISOLATED GROUND AND NORMAL GROUND BUS. ALL LUGS OR CONNECTORS TO BE 75° C RATED MINIMUM.

5.3) CIRCUIT BREAKERS WILL BE SWITCH RATED AND AMBIENT COMPENSATED FOR ALL CIRCUITS. PROVIDE SWITCHED NEUTRALS ON ALL CIRCUIT BREAKERS FEEDING CLASS 1 AND CLASS 2 AREAS WITH NEUTRALS. GFCI ON CIRCUITS WITH NEUTRALS TO DEVICES ABOVE CLASSIFIED AREAS. CIRCUIT BREAKERS SERVING HVAC UNITS AND MOTORS WILL BE HACR TYPE.

5.4) ALL EQUIPMENT (PANELS, DISCONNECT SWITCHES, STARTERS, ETC.) WILL BE MARKED WITH STEEL TAGS EMBOSSED WITH 1/4" HIGH LETTERS DESCRIBING EACH ITEM. CONDUCTORS WILL BE MARKED AT ALL TERMINATION AND JUNCTION POINTS (PANELS, JUNCTION BOXES, SPLICES, ETC.) WITH LABELS BEARING THE PANEL AND CIRCUIT NUMBER WHICH FEEDS EACH CONDUCTOR (PER NEC 210.5(C), 408.30). ALL CONDUCTORS WILL FOLLOW THE PCC COLOR CODES PRECISELY.

5.5) ALL PANEL BOARDS WILL HAVE TYPED DIRECTORY CARDS IDENTIFYING ALL CIRCUITS AND SPACES (REVISED FOR THIS WORK).

5.6) ALL TRANSFORMERS ARE TO BE ENERGY STAR (NEMA TP-1) COMPLIANT PER EPACT 2005/CFR 10 PART 431 AND WILL BE: 1) GENERAL ELECTRIC, U.P., OR ENGINEER APPROVED EQUAL, 2.) RATED FOR HARMONICS, K FACTOR OF 13 MINIMUM WITH 220° CELSIUS INSULATION AND 115 DEGREES CELSIUS RISE, AND 3) HAVE CAPABILITY FOR DOUBLE NEUTRAL LUGS. CONTRACTOR WILL PROVIDE ENGINEER WITH SUBMITTALS TO VERIFY IMPEDANCE VALUES, HARMONIC CAPABILITY, AND INSULATION PRIOR TO PURCHASE. ALL TERMINATIONS 75°C RATED MIN.

5.8) LABEL ALL PANELS/TRANSFORMERS/DISCONNECTS WITH "<u>WARNING</u>" – ELECTRICAL EQUIPMENT – <u>DANGER</u> – QUALIFIED PERSONNEL ONLY TO OPERATE ON OPEN EQUIPMENT.

5.9) PROVIDE ARC FLASH PROTECTION WARNING PLAQUE ON SWITCHBOARDS, PANELSBOARDS, MOTOR CONTROL CENTERS, AND INDUSTRIAL CONTROL PANELS, PER NEC 110.16. SEE DETAIL THIS SHEET OR REFER TO ANSI Z535.4-1998.

5.10) DISCONNECT SWITCHES WILL BE HEAVY-DUTY, QUICK-MAKE, QUICK-BREAK, HORSEPOWER RATED, NEMA 1 INDOOR, NEMA 3R GASKETED, (4X) NEMA 12, OR NEMA 7 AS APPLICABLE WITH CLASS RK-1 BUSSMANN FUSES AND REJECTION CLIPS, SIZED AS SHOWN ON DRAWINGS OR PROPER DISCONNECTS PER N.E.C. WILL BE PROVIDED FOR EACH PIECE OF ELECTRICAL EQUIPMENT.

5.11) MANUAL MOTOR STARTERS WITH THERMAL OVERLOADS WILL BE PROVIDED FOR ALL FRACTIONAL HORSEPOWER MOTORS. GENERAL ELECTRIC # CR101H, CR101Y, OR CR1062 AS REQUIRED OR PER ENGINEER; AMBIENT COMPENSATED AS REQUIRED.

5.12) MAGNETIC MOTOR STARTERS WITH THERMAL OVERLOADS, (4) AUXILIARY CONTACT SWITCHES, INTERNAL LINE VOLTAGE TO 24 VOLT TRANSFORMER (250VA. MIN) WITH PROPER PRIMARY/ SECONDARY PROTECTION, AMBIENT COMPENSATED, RED RUNNING LIGHT, HAND-OFF-AUTO, ACROSS THE LINE STARTERS TO 25 HP. WILL BE PROVIDED WITH EACH MOTOR AS SHOWN ON THE DRAWING (ONE HORSEPOWER TO 25 H.P.).

5.13) ACCEPTABLE MANUFACTURERS: GENERAL ELECTRIC, ITT SIEMENS, CHALLENGER OR ENGINEER APPROVED EQUAL. SQUARE D, ENERCON, REDCO NOT APPROVED.

5.14) IEEE 519 NOT MORE THAN 8% DIST. BACK TO S.E.S.

11.0) GENERAL

11.1) THE CONTRACTOR WILL VISIT THE JOB SITE AND FAMILIARIZE HIMSELF WITH ALL EXISTING CONDITIONS WHICH MAY AFFECT HIS BID OR WORK. NO ALLOWANCES WILL BE MADE AFTER THE BID FOR EXISTING CONDITIONS OR THE CONTRACTORS FAILURE TO VERIFY EXISTING CONDITIONS.

11.2) THE CONTRACTOR WILL GUARANTEE ALL MATERIALS AND WORKMANSHIP FURNISHED BY HIM UNDER THIS CONTRACT FOR A PERIOD OF TWO YEARS FROM THE DATE OF FINAL ACCEPTANCE OF THE WORK OF THIS CONTRACT BY THE OWNER AND THE ENGINEER AND PROVIDE A BOND TO VALIDATE THIS GUARANTEE. ANY DEFECTS DEVELOPING WITHIN THE PERIOD TRACEABLE TO MATERIALS OR WORKMANSHIP PERFORMED HERE UNDER, WILL BE MADE GOOD AT THE EXPENSE OF THE CONTRACTOR NOT THE OWNER OR ENGINEER. THE CONTRACTOR WILL ACCEPT AND FULLY UNDERSTAND THIS PROVISION PRIOR TO CONTRACT BEING AWARDED, AS NO CLAIM FOR EXTRA COMPENSATION WILL BE ALLOWED FOR CORRECTION OF FAULTY WORK OR DEFECTIVE MATERIALS. ANYTIME DURING THE CONSTRUCTION PERIOD, THE OWNERS REPRESENTATIVES AND THE ENGINEER RETAIN THE RIGHT TO REQUIRE THE CONTRACTOR TO REMOVE AND REINSTALL ANY EQUIPMENT OR MATERIALS NOT FOLLOWING THE STANDARDS AS PRESENTED HEREIN OR ON THE DRAWINGS WITHOUT COST TO THE OWNER OR ENGINEER.

11.3) PROVIDE 3 SETS OF SHOP DRAWINGS & SAMPLES(NON-RETURNABLE) FOR ALL EQUIPMENT, PRIOR TO ORDERING AND IN A TIMELY MANNER (WITHIN TEN DAYS OF BID AS DETERMINED BY ENGINEER) SO NOT TO DELAY WORK, TO ENGINEER FOR APPROVAL. (CONDUIT, SWITCHES, SWITCHBOARDS, PANELBOARDS, CONDUCTORS STARTERS, CONDUCTORS, TRANSFORMERS, FUSES (BUSSMANN ONLY), ETC.) WHERE SUBSTITUTIONS ARE MADE, CONTRACTOR WILL INCLUDE COMPARISON DATA & SAMPLES FOR BOTH THE SUBSTITUTE AND SPECIFIED ITEMS FOR REFERENCE PURPOSES.

11.4) CONTRACTOR WILL PROVIDE PROOF OF PERFORMANCE BOND WITH SHOP DRAWINGS AND/OR SUBMITTALS.

11.6) REFER TO MECHANICAL DRAWINGS AND SPECIFICATIONS FOR EQUIPMENT LOCATIONS, LOADS, AND ADDITIONAL REQUIREMENTS. CONTROLS BY MECHANICAL CONTRACTOR.

11.7) IF LOCAL POWER COMPANY REQUIRES SPECIFIC POWER FACTOR REQUIREMENTS TO BE MAINTAINED, CONTACTOR MUST NOTIFY OWNER THAT THIS REQUIREMENT MAY BE CAUSE FOR SPECIFIC POWER FACTOR CORRECTION. THIS IS NOT PART OF ENGINEERING DESIGN AND WILL CONSTITUTE ADDITIONAL DESIGN AND CONSTRUCTION.

Registered Professional Engineer (Electrical)
CERTIFICATE NO.
41994
JEFFREY WALTER SITZLER
Date Signed 3-10-08
ARIZONA, U.S.A.
EXPIRES 3/31/08

EDI
ELECTRICAL DESIGNS INCORPORATED 602-275-4365
JOB # 08041
DATE
3/10/2008

HYDRO GEO CHEM, INC.

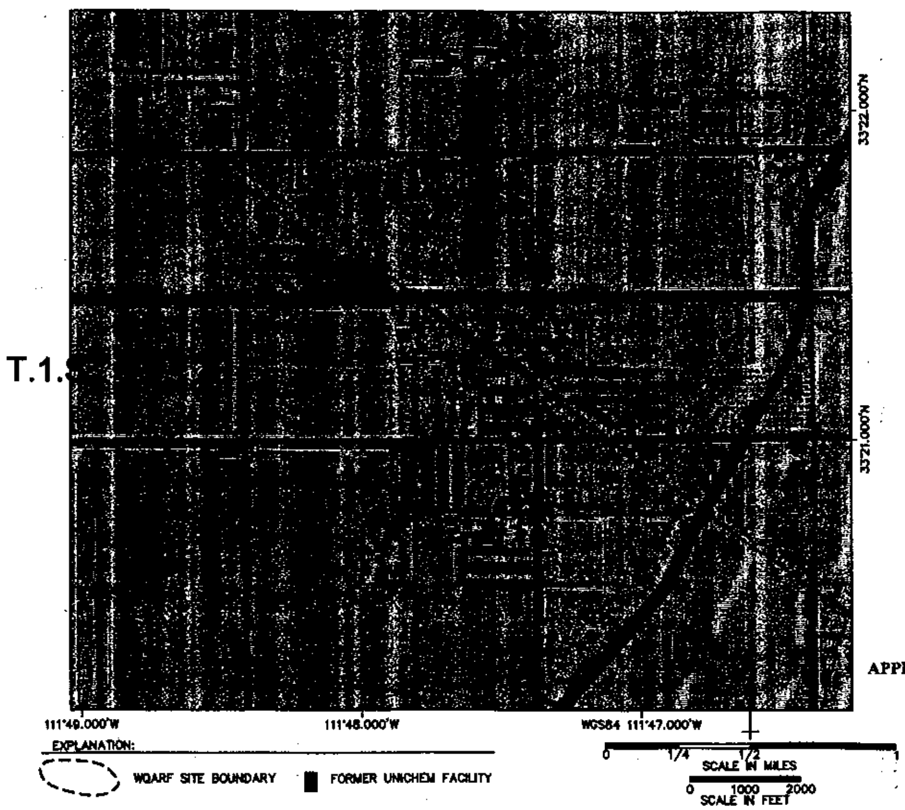
ADEQ COOPER & COMMERCE ERA
ELECTRICAL SPECIFICATIONS

Approved	Date	Revised	Date	Reference	Figure
JWS	03-10-08	-	-	08041E15	E-15

RECORD DRAWINGS

EARLY RESPONSE ACTION

DRAWING INDEX



APPROVED: E/L DATE: 5-6-10
TOWN OF GILBERT ENGINEER

LOCATION MAP - Gilbert, AZ

PROJECT DESCRIPTION

THESE DRAWINGS DEPICT DETAILS FOR INSTALLATION OF PIPING FOR DISCHARGES FROM THE COOPER ROAD AND COMMERCE AVENUE WQARF SITE, LOCATED IN THE SKYLINE STEEL YARD APPROXIMATELY 0.5 MILES NORTH OF ELLIOT ROAD AND 0.25 MILES EAST OF COOPER ROAD. INSTALLATION OF DISCHARGE PIPING WILL COMPLETE CONSTRUCTION OF THE EARLY RESPONSE ACTION (ERA) AT THE SITE, WHICH INCLUDES A GROUNDWATER PUMP AND TREAT SYSTEM AND AN AIR SPARGE, VAPOR EXTRACTION SYSTEM. DISCHARGE PIPING WILL EXTEND FROM A UTILITY VAULT ON THE SOUTH PROPERTY LINE OF THE SKYLINE STEEL YARD, WHERE THE EXISTING TREATED WATER EFFLUENT MAIN TERMINATES. UNDER THE ERA DESIGN SHOWN ON THESE PLANS, TREATED EFFLUENT WILL BE DISCHARGED THROUGH UNDERGROUND PIPING TO THE SRP LATERAL 9.5, EXCEPT DURING SRP'S DRY-UP PERIOD OR OTHER PERIODS AS DICTATED BY SRP. DURING DRY-UP PERIODS, TREATED EFFLUENT WILL BE DISCHARGED THROUGH PIPING INTO THE TOWN OF GILBERT'S SEWER SYSTEM MANHOLE, LOCATED APPROXIMATELY 0.25 MILES EAST OF COOPER ROAD, JUST SOUTH OF LATERAL 9.5. THE ARIZONA DEPARTMENT OF ENVIRONMENTAL QUALITY (ADEQ) WILL OBTAIN DISCHARGE PERMITS FROM THE TOWN OF GILBERT WHEN DISCHARGES TO ITS SEWER SYSTEM ARE REQUIRED.

ADEQ AND/OR ITS CONTRACTORS WILL OPERATE THE COOPER ROAD AND COMMERCE AVENUE WQARF SITE REMEDIAL SYSTEMS UNDER VARIOUS PERMITS AND AGREEMENTS. METERS WILL BE INSTALLED IN THE TREATED EFFLUENT DISCHARGE LINES TO COMPLY WITH REQUIREMENTS OF AN AUTHORIZATION TO DISCHARGE UNDER THE ARIZONA POLLUTANT DISCHARGE ELIMINATION SYSTEM (PERMIT NO. AZ0025801), A DISCHARGE AGREEMENT WITH SRP, AND DISCHARGE PERMITS FROM THE TOWN OF GILBERT.

DRAWINGS PREPARED FOR:

ADEQ Arizona Department of Environmental Quality

DEPARTMENT OF ENVIRONMENTAL QUALITY
COOPER AND COMMERCE WQARF SITE
GILBERT, ARIZONA

RECORD DRAWINGS

GENERAL NOTES

(A) ALL CONSTRUCTION SHALL CONFORM TO CONTRACT DOCUMENTS, INCLUDING MOST RECENT REVISION OF BUILDING AND CONSTRUCTION CODES OF THE TOWN OF GILBERT, ARIZONA, AS APPLICABLE.

(B) CONTRACTOR SHALL, AT HIS EXPENSE, OBTAIN ALL PERMITS NECESSARY TO CONSTRUCT THE EARLY RESPONSE ACTION FACILITIES AS DEPICTED IN THE CONTRACT DOCUMENTS. FURTHER, SUCH PERMITS SHALL BE OBTAINED PRIOR TO COMMENCEMENT OF CONSTRUCTION.

(C) CONTRACTOR SHALL VERIFY LOCATIONS AND ELEVATIONS OF ALL TIE-IN LOCATIONS AND UNDERGROUND UTILITIES. CONTRACTOR SHALL CONTACT ARIZONA BLUE STAKE (1-800-782-5348) FIVE WORKING DAYS PRIOR TO START OF CONSTRUCTION. THE LOCATION AND ELEVATION OF PIPES OR OTHER UNDERGROUND STRUCTURES OR PROPERTY LINES ARE NOT EXACTLY SHOWN ON CONTRACT DOCUMENTS, NOR ARE ALL UNDERGROUND PIPES OR STRUCTURES SHOWN ON CONTRACT DOCUMENTS.

Registered Professional Engineer (Civil) CERTIFICATE NO. 16984 CHRISTOPHER L. JACQUEMIN Date Signed 5-23-12 ARIZONA U.S.A.
Expires 6/3/12

PREPARED BY:

HYDRO GEO CHEM, INC.
6370 E. THOMAS ROAD
SUITE 200
SCOTTSDALE, ARIZONA 85251
(480) 421-1501
http://www.hgcinc.com

EXPIRES 9-30-2010

HYDRO GEO CHEM, INC.	ADEQ COOPER & COMMERCE ERA 4" RECLAIM WATER LINES TO SS MH NO. 2 AND SRP WESTERN CANAL COVER SHEET					
Approved CLJ	Date 3/24/10	Designer DAD	Date 3/24/10	File Name 8330035A	Drawing No. 1A	

ENG-2008-01124

SYMBOLS & ABBREVIATIONS

ABBREVIATIONS

@	AT
AMP	AMPERE
ANSI	AMERICAN NATIONAL STANDARDS INSTITUTE
ASL OR AMSL	ABOVE (MEAN) SEA LEVEL
ASTM	AMERICAN SOCIETY FOR TESTING AND MATERIALS
ATM	ATMOSPHERE
BGS	BELOW GROUND SURFACE
CAP	CAPACITY
℄	CENTERLINE
CLSM	CONTROLLED LOW STRENGTH MATERIAL
CP	CONTROL PANEL
CS	CARBON STEEL
DIA	DIAMETER
DWG	DRAWING
EA	EACH
ELEV OR EL	ELEVATION
EQ	EQUAL (DIMENSION OR SPECIFICATION)
EW	EXTRACTION WELL
EX	EXISTING
F	FAHRENHEIT OR FILTER
FI	FLOW INDICATOR
FIG	FIGURE
FIT	FLOW INDICATOR TRANSMITTER
FIQ	FLOW INDICATOR TOTALIZER
F/MNPT	FEMALE/MALE NATIONAL PIPE TAPER (THREAD)
FT	FEET, FOOT OR FLOW TRANSMITTER
G	GREEN
GAL	GALLON
GALV	GALVANIZED
H	HIGH
HDPE	HIGH DENSITY POLYETHYLENE
HGC	HYDRO GEO CHEM, INC.
HOA	HAND / OFF / AUTO
HP	HORSEPOWER
HS	HAND SWITCH
ID	INSIDE DIMENSION
IN	INCH
IS	CURRENT SWITCH
JS	POWER SWITCH
L	LOW
LB	POUND
LGAC	LIQUID-PHASE GRANULAR ACTIVATED CARBON
LIR	LEVEL INDICATOR RECORDER
LSL	LEVEL SWITCH LOW
M	MOTOR
MH	MANHOLE
MIN, MAX	MINIMUM, MAXIMUM
N	NORTH
NC	NORMALLY CLOSED
NO	NORMALLY OPEN OR NUMBER
NOS	NUMBERS
NTS	NOT TO SCALE
PE	POLYETHYLENE
PI	PRESSURE INDICATOR
PSH	PRESSURE SWITCH HIGH
PSIG	POUNDS PER SQUARE INCH, GAUGE
PT	PRESSURE TRANSMITTER
PV	PRESSURE RELIEF VALVE
PVC	POLY VINYL CHLORIDE
RCRA	RESOURCE CONSERVATION AND RECOVERY ACT
ROW	RIGHT OF WAY
S	SOUTH
SCH	SCHEDULE
SDR	STANDARD DIAMETER RATIO
SRP	SALT RIVER PROJECT
SS	STAINLESS STEEL
TDH	TOTAL DYNAMIC HEAD
THD	THREADED
TI	TEMPERATURE INDICATOR
TYP	TYPICAL
V	VOLT
W	WEST OR WIDTH
XL	UNCLASSIFIED LIGHT
ZS	POSITION SWITCH

VALVES & FITTINGS

NORMALLY OPEN

- BALL VALVE
- GATE VALVE
- GLOBE VALVE
- BUTTERFLY VALVE
- PIPE REDUCER
- FLANGED CONNECTION
- UNION FITTING
- ELBOW DOWN
- ELBOW UP
- TEE DOWN
- FLOW DIRECTION

NORMALLY CLOSED

- BALL VALVE
- GATE VALVE
- PRESSURE / VACUUM RELIEF VALVE
- MONITORING PORT (1/2" BALL VALVE)

P & I D SYMBOLS

- ELECTRICAL INTERCONNECTION
- ELECTRONIC INTERCONNECTION
- FLEXIBLE CONNECTOR
- CAPPED END
- PLUGGED END
- FE 101 FIELD-MOUNTED INSTRUMENT (NEW)
- HS FRONT OF PANEL MOUNTED
- XL 302 INDICATOR LIGHT
- IS 302 REAR OF PANEL MOUNTED
- 301 ELECTRONIC DEVICE OR INSTRUMENT

SYMBOLS

- POWER LINE
- —UGE— UNDERGROUND ELECTRIC
- FENCE
- X / YY DETAIL NUMBER / DRAWING NUMBER

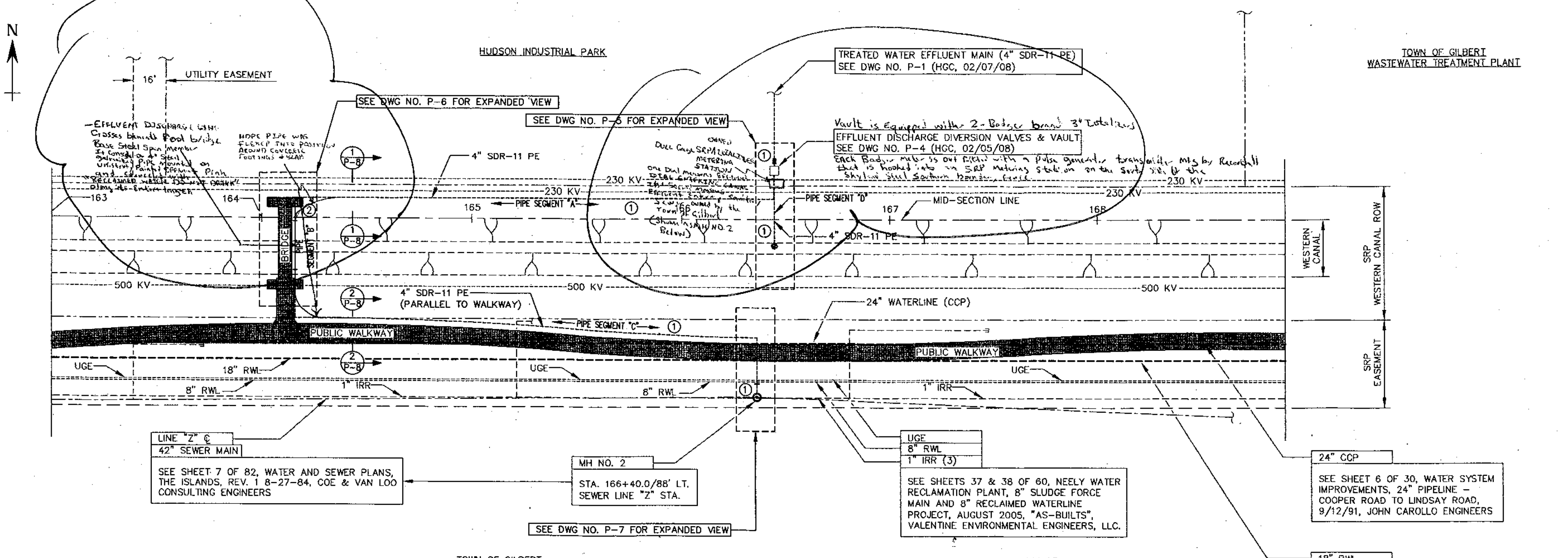
EXPIRES 9-30-2010

HYDRO GEO CHEM, INC.

ADEQ COOPER & COMMERCE ERA
4" RECLAIM WATER LINES TO SS MH NO. 2 AND SRP WESTERN CANAL
SYMBOLS & ABBREVIATIONS

Approved	Date	Designer	Date	File Name	Drawing No.
CLJ	3/24/10	DAD	3/24/10	8330034A	2A

ENG-2008-01124



CONSTRUCTION GENERAL NOTES:

Ⓐ CONTRACTOR SHALL VERIFY ELEVATIONS OF EXISTING UTILITIES TO AN ELEVATION OF SIX FEET BELOW GRADE BEFORE INITIATING ANY OF THE WORK. CONTACT UTILITY OWNER(S) IMMEDIATELY AFTER FIELD VERIFICATION.

Ⓑ PROVIDE SHEETING, SHORING AND SUPPORTS TO FACILITATE PROTECTION AND CONTINUAL OPERATION OF ALL UTILITIES IN WORK AREA. COORDINATE REPLACEMENT OF ANY AND ALL DAMAGED OR DISTURBED UTILITIES WITH AFFECTED UTILITIES AS REQUIRED.

Ⓒ REMOVE AND REPLACE, AS NECESSARY, IN LIKE AND KIND, ALL LANDSCAPING SYSTEMS, CONTROLLERS, DECOMPOSED GRANITE, ETC.

Ⓓ ISOLATE PUBLIC FROM WORK AREA BY ERECTING SUITABLE BARRIERS.

Ⓔ SRP'S WESTERN CANAL MUST BE CLEAR AT END OF EACH DAY'S WORK OR, AT SRP'S REQUEST, DUE TO EMERGENCY SITUATIONS. ACCESS TO SRP ROW AND EASEMENT SHALL BE AVAILABLE TO SRP'S PERSONNEL AT ALL TIMES.

GENERAL NOTE:

Ⓐ EXISTING FEATURES AND CONDITIONS ARE GENERALLY SHOWN IN A LIGHT OR SCREENED COLOR. NEW SCOPES OF WORK ARE GENERALLY SHOWN IN A DARK OR BOLD COLOR AND IN TEXT NOTES.

SAFETY CAUTIONS:

HIGH VOLTAGE OVERHEAD POWER LINES IN VICINITY OF CONSTRUCTION. CONSTRUCTION VEHICLES AND EQUIPMENT SHALL BE GROUNDED.

NOTIFY SRP PRIOR TO CONDUCTING ANY WORK WITHIN WESTERN CANAL, AS POSSIBLE FLOODING MAY OCCUR WHEN SRP DIVERTS WATER INTO CANAL.

CONSTRUCTION KEYNOTES:

① CONTRACTOR SHALL PROVIDE AND INSTALL 4" SDR-11 POLYETHYLENE (PE) RECLAIM WATER LINES FROM COMMON VALVE VAULT TO TOWN OF GILBERT MANHOLE (MH) NO. 2 AND SRP WESTERN CANAL AS SHOWN ON THIS DRAWING, IN ACCORDANCE WITH ASTM STANDARD D-2321, AND AS SPECIFIED IN FOLLOWING MARICOPA ASSOCIATION OF GOVERNMENTS (MAG) STANDARDS, AS APPLICABLE: SECTION 601 (TRENCH EXCAVATION, BACKFILLING AND COMPACTION), SECTION 604 (PLACEMENT OF CONTROLLED LOW STRENGTH MATERIAL), SECTION 616 (RECLAIMED WATER LINE CONSTRUCTION), AND SECTION 220 (RIPRAP CONSTRUCTION).

EACH RECLAIM WATER LINE WILL NOT CONVEY, UNDER PRESSURE, RECLAIM WATER FOR PERMITTED USE. FOR THIS REASON, EACH RECLAIM WATER LINE IS NOT CONSIDERED A PRESSURE OR FORCE SANITARY SEWER SUBJECT TO COMPLIANCE WITH MAG STANDARDS DETAIL 404 FOR SEPARATION AND/OR PROTECTION.

② CONSTRUCT PIPE SEGMENT "B" PRIOR TO PIPE SEGMENTS "A" OR "C" EXTENDING TO PIPE SEGMENT "B", ENABLING PIPE SEGMENT "B" TO BE LEAK TESTED SIMULTANEOUSLY WITH PIPE SEGMENT "A" OR "C".

LEAK TESTING:

BOTH 4" RECLAIM WATER LINES SHALL BE LEAK TESTED AS GENERALLY DESCRIBED BELOW AND AS FURTHER DESCRIBED ON DWG NOS. P-5, P-6 AND P-7A. RECLAIM WATER LINE TO SS MH NO. 2 SHALL BE LEAK TESTED IN THREE SEGMENTS DELINEATED BY PIPE FLANGES, IDENTIFIED AS PIPE SEGMENTS "A", "B" AND "C", AS SHOWN. RECLAIM WATER LINE TO SRP CANAL SHALL BE LEAK TESTED IN ONE SEGMENT AS PIPE SEGMENT "D" AS SHOWN. LEAK TESTING OF EACH PIPE SEGMENT SHALL BE PERFORMED AS LOW PRESSURE HYDROSTATIC TEST USING CLEAN WATER AT COMMON TEST PRESSURE OF 5 PSIG (1.5 TIMES SYSTEM DESIGN PRESSURE APPLIED TO LOW END OF PIPE SEGMENT). DURING AIR DISPLACEMENT BY WATER, VENT AIR FROM HIGH END OF PIPE SEGMENT BY LOOSENING END FLANGE (WITH PIPE ISOLATION BLANK OR BLIND FLANGE). AT TEST PRESSURE, OBSERVE PIPE SEGMENT FOR ANY WATER LEAKAGE. WHERE WATER LEAKAGE IS OBSERVED, REPAIR PIPE SEGMENT, AS APPROPRIATE, AND REPEAT LEAK TEST.

DANIEL A. FOWLER 28426 ARIZONA U.S.A. Expires 9-30-2010

0 25 50
SCALE IN FEET

Registered Professional Engineer (Civil) CERTIFICATE NO. 16984 CHRISTOPHER L. JACQUEMIN Date Signed 5-25-11 ARIZONA U.S.A. Expires 6/30/12

RECORD DRAWING

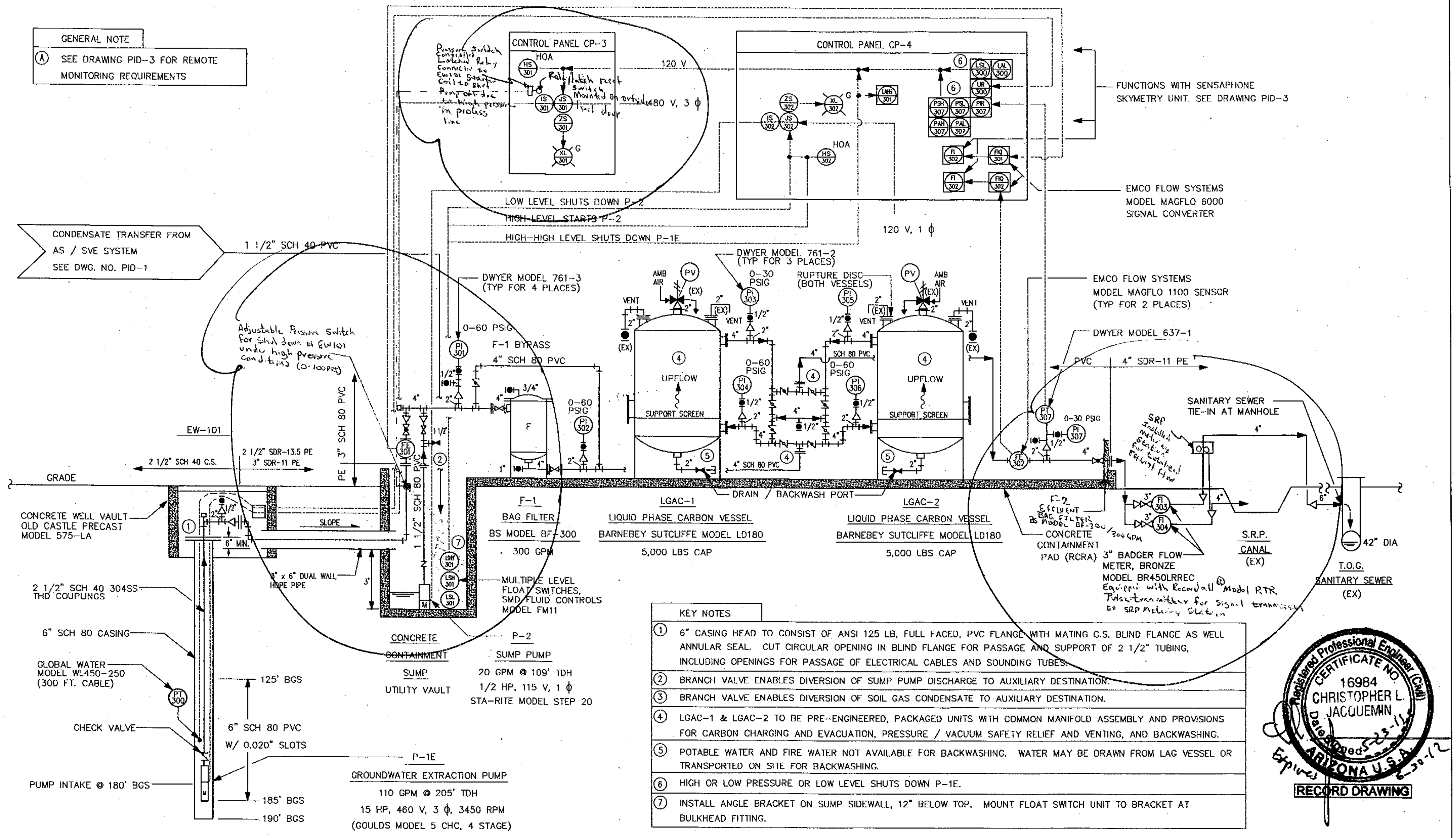
ENG-2008-01124

HYDRO GEO CHEM, INC.

ADEQ COOPER & COMMERCE ERA
4" RECLAIM WATER LINES TO SS MH NO. 2 & SRP WESTERN CANAL
PIPING / TRENCHING PLAN

Approved	Date	Designer	Date	File Name	Drawing No.
CLJ	3/24/10	DAD	3/24/10	8330026A	P-1A

GENERAL NOTE
(A) SEE DRAWING PID-3 FOR REMOTE MONITORING REQUIREMENTS



KEY NOTES
(1) 6" CASING HEAD TO CONSIST OF ANSI 125 LB, FULL FACED, PVC FLANGE WITH MATING C.S. BLIND FLANGE AS WELL ANNULAR SEAL. CUT CIRCULAR OPENING IN BLIND FLANGE FOR PASSAGE AND SUPPORT OF 2 1/2" TUBING, INCLUDING OPENINGS FOR PASSAGE OF ELECTRICAL CABLES AND SOUNDING TUBES.
(2) BRANCH VALVE ENABLES DIVERSION OF SUMP PUMP DISCHARGE TO AUXILIARY DESTINATION.
(3) BRANCH VALVE ENABLES DIVERSION OF SOIL GAS CONDENSATE TO AUXILIARY DESTINATION.
(4) LGAC-1 & LGAC-2 TO BE PRE-ENGINEERED, PACKAGED UNITS WITH COMMON MANIFOLD ASSEMBLY AND PROVISIONS FOR CARBON CHARGING AND EVACUATION, PRESSURE / VACUUM SAFETY RELIEF AND VENTING, AND BACKWASHING.
(5) POTABLE WATER AND FIRE WATER NOT AVAILABLE FOR BACKWASHING. WATER MAY BE DRAWN FROM LAG VESSEL OR TRANSPORTED ON SITE FOR BACKWASHING.
(6) HIGH OR LOW PRESSURE OR LOW LEVEL SHUTS DOWN P-1E.
(7) INSTALL ANGLE BRACKET ON SUMP SIDEWALL, 12" BELOW TOP. MOUNT FLOAT SWITCH UNIT TO BRACKET AT BULKHEAD FITTING.

Registered Professional Engineer (Civil) CERTIFICATE NO. 16984 CHRISTOPHER L. JACQUEMIN Date Signed 5-23-11 ARIZONA U.S.A. Expires 6-30-12

RECORD DRAWING

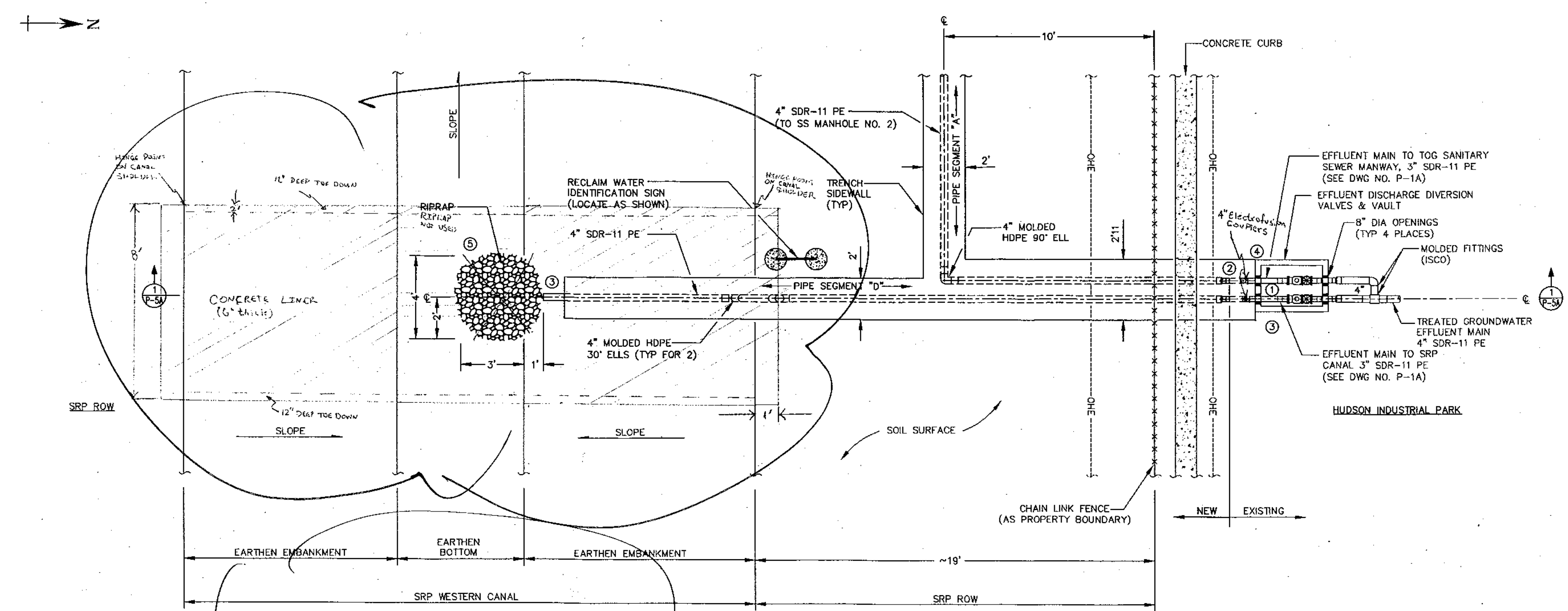
Registered Professional Engineer (Civil) CERTIFICATE NO. 29426 DANIEL A. DOWLER ARIZONA U.S.A. Expires 9-30-2010

HYDRO GEO CHEM, INC.

ADEQ COOPER & COMMERCE ERA
4" RECLAIM WATER LINES TO SS MH NO. 2 & SRP WESTERN CANAL
PROCESS & INSTRUMENTATION DIAGRAM

Approved	Date	Designer	Date	File Name	Drawing No.
CLJ	3/24/10	DAD	3/24/10	8330036A	PID-2A

ENG-2008-01124



NOTE: Treated water outfall Concrete liner has Stenciled on each bank "Reclaimed Water Do Not Drink"

GENERAL NOTE:

Ⓐ WORK THIS DRAWING WITH DWG NOS. P-5A & P-1A.

KEYNOTES:

① TEMPORARILY REMOVE 3" SDR-11 PE PIPE STUBS FROM FLANGED GATE VALVES WITHIN VAULT. INSTALL 3" FLANGED WATER METERS (SUPPLIED BY OWNER) TO DOWNSTREAM END OF GATE VALVES. RECONNECT 3" SDR-11 PE PIPE STUBS TO FLOW METERS.

② CONNECT 4" RECLAIM WATER LINES TO EXISTING 3" SDR-11 PE PIPE STUBS USING 4" x 3" HDPE REDUCERS.

③ PREPARE PIPE SEGMENT "D" FOR LEAK TEST BY INSTALLING SUITABLE CAP WITH TEST PORT ON LOW END OF PIPE SEGMENT WITHIN CANAL AND ISOLATION BLANK BETWEEN FLANGES ON UPSTREAM SIDE OF WATER METER WITHIN VALVE VAULT. UTILIZE TEST PORT OF WATER METER AS AIR VENT PORT. AFTER COMPLETION OF LEAK TEST, REMOVE END CAP AND ISOLATION BLANK.

④ PREPARE PIPE SEGMENT "A" FOR LEAK TEST BY INSTALLING ISOLATION BLANK BETWEEN FLANGES ON UPSTREAM SIDE OF WATER METER AND BLIND FLANGE OR ISOLATION BLANK AT APPROPRIATE SET OF BREAK FLANGES AT PEDESTRIAN BRIDGE CROSSING, DEPENDING ON WHETHER PIPE SEGMENT "B" IS TO BE LEAK TESTED SIMULTANEOUSLY WITH PIPE SEGMENT "A". UTILIZE FLOW TEST PORT OF WATER METER AS TEST PORT. AFTER COMPLETION OF LEAK TEST, REMOVE ISOLATION BLANK(S) AND BLIND FLANGE, IF INSTALLED.

⑤ PROVIDE AND INSTALL RIPRAP IN ACCORDANCE WITH MAG STANDARD SECTION 220.

Registered Professional Engineer (Civil) CERTIFICATE NO. 16984 CHRISTOPHER L. JACQUEMIN Signed 5-23-11 ARIZONA U.S.A. Expires 6-30-11

RECORD DRAWING

0 2.5 5.0
SCALE IN FEET

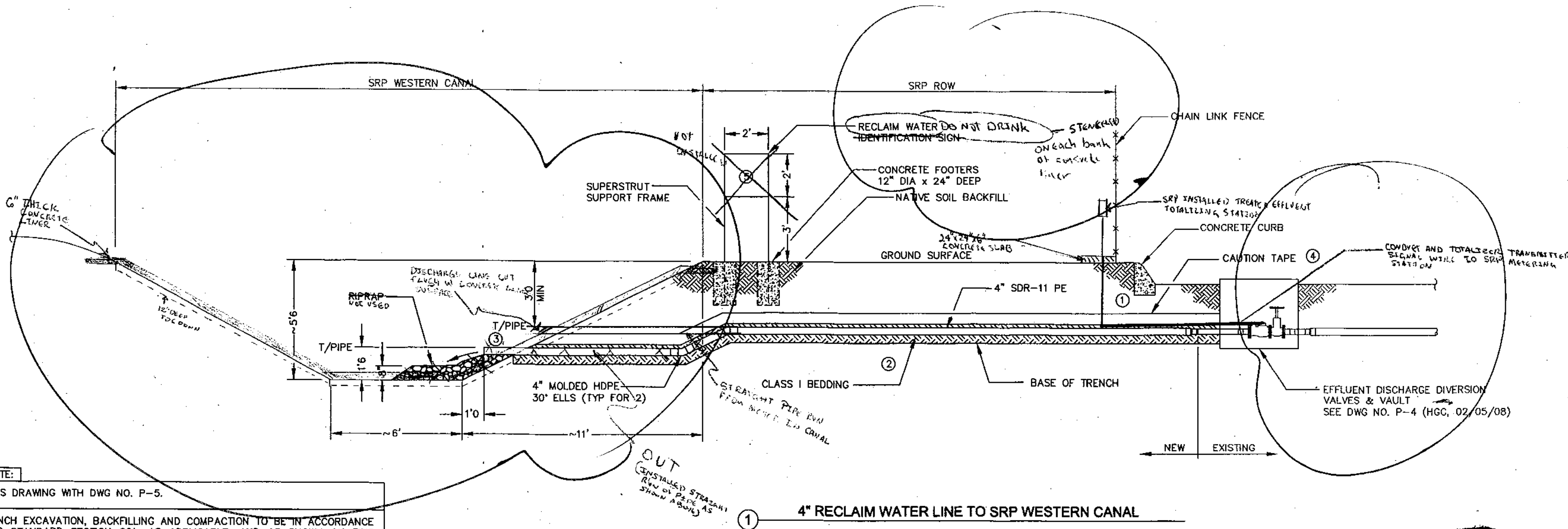
EXPIRES 9-30-2010

HYDRO GEO CHEM, INC.

ADEQ COOPER & COMMERCE ERA
4" RECLAIM WATER LINE TO SRP WESTERN CANAL
PIPING / TRENCHING PLAN

Approved	Date	Designer	Date	File Name	Drawing No.
CLJ	3/24/10	DAD	3/24/10	8330031A	P-5

ENG-2008-01124



① 4" RECLAIM WATER LINE TO SRP WESTERN CANAL

0 2.5 5.0
SCALE IN FEET

GENERAL NOTE:

Ⓐ WORK THIS DRAWING WITH DWG NO. P-5.

Ⓑ PIPE TRENCH EXCAVATION, BACKFILLING AND COMPACTION TO BE IN ACCORDANCE WITH MAG STANDARD SECTION 601, AS APPLICABLE, AND AS SHOWN ON THIS DRAWING.

Ⓒ TRANSFER EXCESS SOIL TO OFF-SITE LOCATION SPECIFIED BY SRP.

KEYNOTES:

① EXCAVATE BENEATH CONCRETE CURB AND CHAIN LINK FENCE.

② PLACE TOP OF CLASS I BEDDING LAYER TWO INCHES ABOVE TOP OF PIPE.

③ APPLY PURPLE FINISH TO EXPOSED SECTION OF PIPE PER MAG STANDARD 616.4.

④ APPLY CAUTION TAPE ALONG ENTIRE PIPE TRENCH ON TOP OF FIRST 6-INCH COURSE OF NATIVE SOIL BACKFILL ABOVE CLASS I BEDDING. CAUTION TAPE TO HAVE FOLLOWING WORDS, "CAUTION: RECLAIM WATER LINE", PER MAG STANDARD 616.4.

⑤ RECLAIM WATER IDENTIFICATION SIGN TO CONSIST OF DURABLE, NON-CORRODING MATERIAL AND HAVE FOLLOWING WORDS, "CAUTION: RECLAIM WATER-DO NOT DRINK", PER MAG STANDARD 616.4, ON BOTH SIDES.

Registered Professional Engineer (Civil) CERTIFICATE NO. 16984 CHRISTOPHER L. JACQUEMIN ARIZONA U.S.A.

RECORD DRAWING

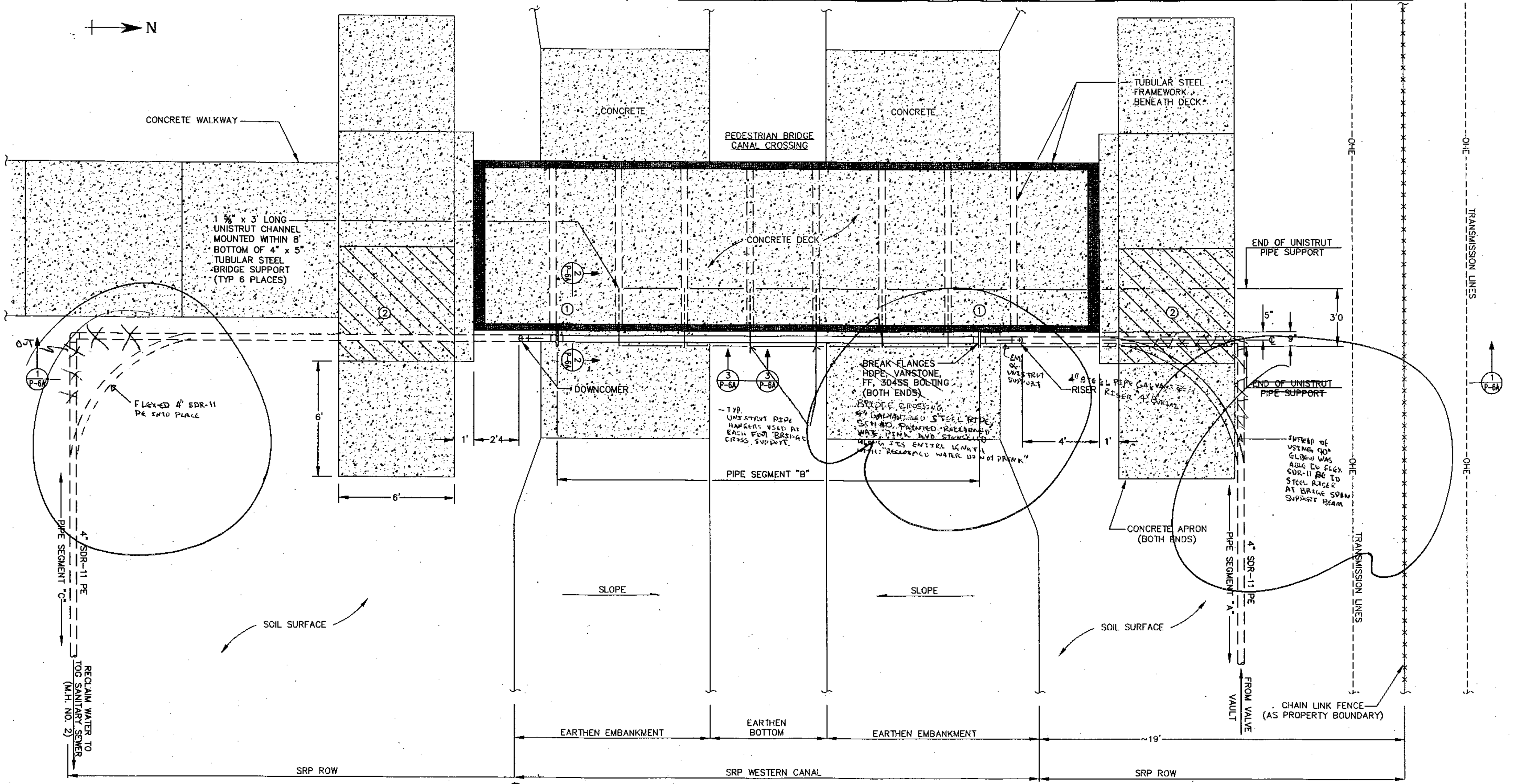
EXPIRES 9-30-2010

HYDRO GEO CHEM, INC.

ADEQ COOPER & COMMERCE ERA
4" RECLAIM WATER LINE TO SRP WESTERN CANAL
PIPING / TRENCHING ELEVATION

Approved	Date	Designer	Date	File Name	Drawing No.
CLJ	3/24/10	DAD	3/24/10	8330032A	P-5A

ENG-2008-01124



RECORD DRAWINGS

GENERAL NOTES:

(A) WORK THIS DRAWING WITH DWG NO. P-6A.

(B) PIPE TRENCH EXCAVATION, BACKFILLING AND COMPACTION TO BE IN ACCORDANCE WITH MAG STANDARD SECTION 601, AS APPLICABLE, AND AS SHOWN ON PIPE TRENCH SECTIONS 1 AND 2, DWG NO. P-8.

KEYNOTES:

(1) PERFORM LEAK TEST OF PIPE SEGMENT "B" SIMULTANEOUSLY WITH LEAK TEST OF PIPE SEGMENT "A" OR "C". PREPARE PIPE SEGMENT "B" FOR LEAK TEST BY INSTALLING BLIND FLANGE ON FREE END. AFTER COMPLETION OF LEAK TEST, REMOVE BLIND FLANGE AND INSTALL ISOLATION BLANK BETWEEN BREAK FLANGES AT SAME LOCATION FOR REMAINING LEAK TEST OF UNTESTED PIPE SEGMENT.

(2) SAW CUT AND REMOVE CONCRETE SECTION FROM EXISTING CONTROL JOINT. REPLACE IN KIND AFTER COMPLETION OF PIPE TRENCH WORK.

Registered Professional Engineer (Civil) CERTIFICATE NO. 16984 CHRISTOPHER L. JACQUEMIN ARIZONA U.S.A.

Expires 6-30-12

EXPIRES 9-30-2010

0 2.5 5.0
SCALE IN FEET

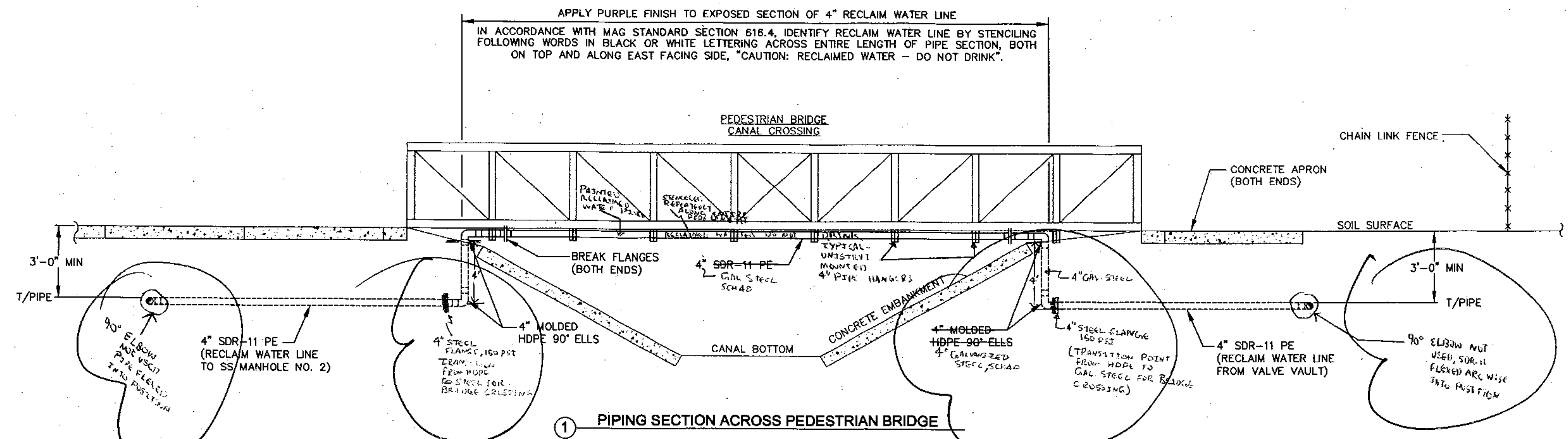
RECORD DRAWING

HYDRO GEO CHEM, INC.

ADEQ COOPER & COMMERCE ERA
4" RECLAIM WATER LINES TO SS MANHOLE NO. 2
EXPANDED PIPING PLAN AT SRP WESTERN CANAL CROSSING

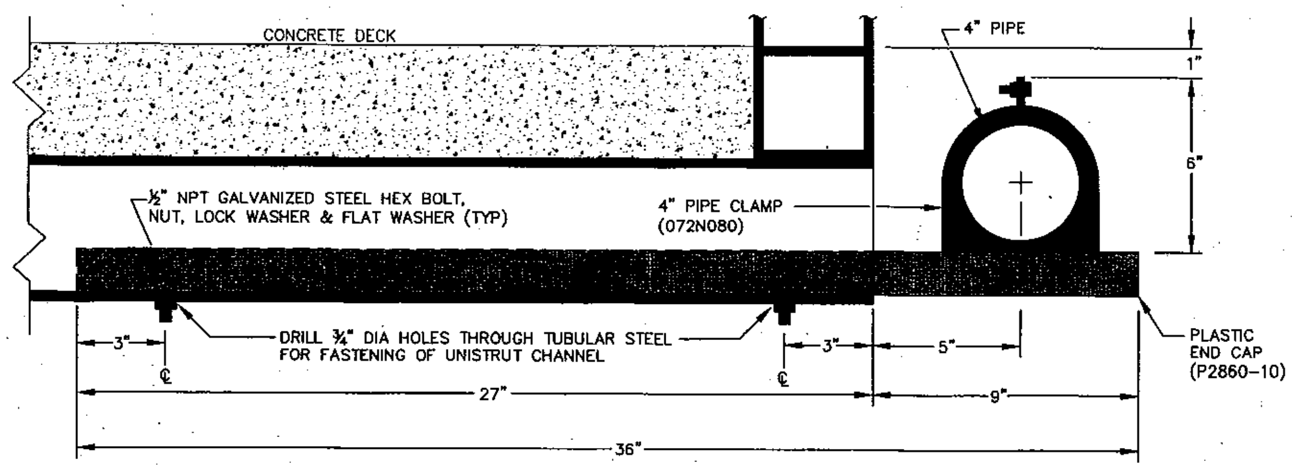
Approved	Date	Designer	Date	File Name	Drawing No.
CLJ	3/24/10	DAD	3/24/10	8330028A	P-6

ENG-2008-01124



(1) PIPING SECTION ACROSS PEDESTRIAN BRIDGE

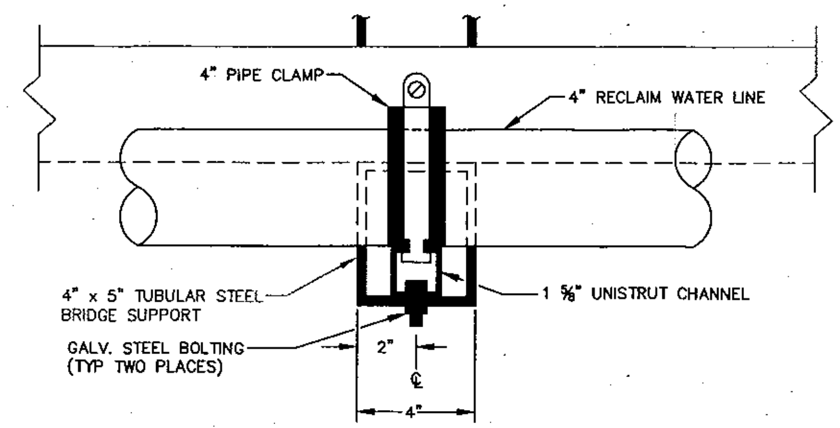
0 2.5 5.0
SCALE IN FEET



RECORD DRAWINGS

(2) TYPICAL PIPE SUPPORT DETAIL AT PEDESTRIAN BRIDGE-SIDE ELEVATION VIEW

0 0.25 0.50
SCALE IN FEET



(3) TYPICAL PIPE SUPPORT DETAIL AT PEDESTRIAN BRIDGE-FRONT ELEVATION VIEW

0 0.25 0.50
SCALE IN FEET

RECORD DRAWING

Registered Professional Engineer (Civil)
CERTIFICATE NO. 16984
CHRISTOPHER L. JACQUEMIN
Date Signed 5-27-11
ARIZONA U.S.A.
Expires 6-30-12

GENERAL NOTE:
(A) WORK THIS DRAWING WITH DWG NO. P-6.

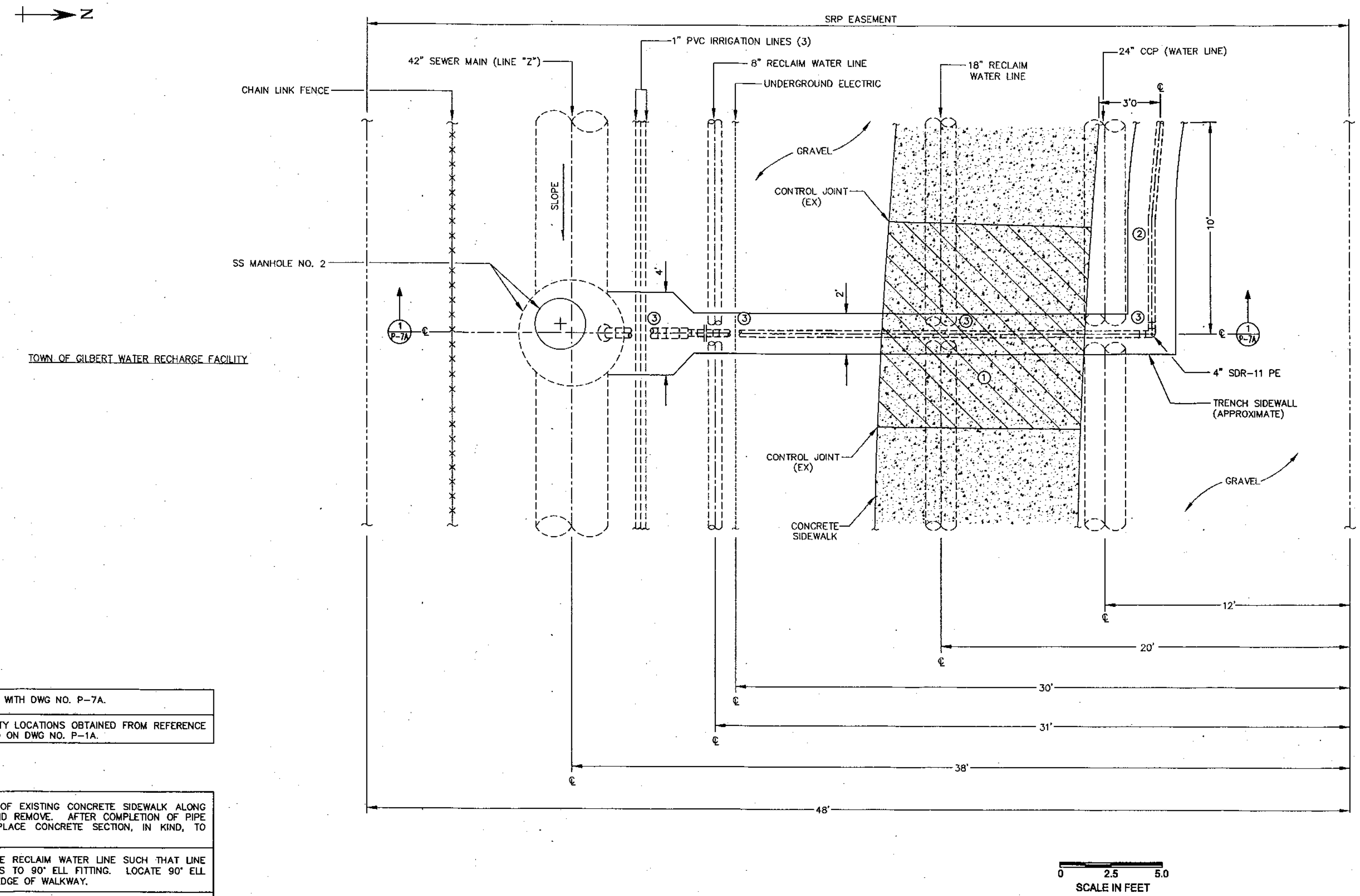
DANIEL A. DOWLER
26426
EXPIRES 9-30-2010

HYDRO GEO CHEM, INC.

ADEQ COOPER & COMMERCE ERA
4" RECLAIM WATER LINE TO SS MANHOLE NO. 2
PIPING SECTIONS AT SRP WESTERN CANAL CROSSING

Approved	Date	Designer	Date	File Name	Drawing No.
CLJ	3/24/10	DAD	3/24/10	8330027A	P-6A

ENG-2008-01124



GENERAL NOTES:

Ⓐ WORK THIS DRAWING WITH DWG NO. P-7A.

Ⓑ UNDERGROUND UTILITY LOCATIONS OBTAINED FROM REFERENCE DRAWINGS IDENTIFIED ON DWG NO. P-1A.

KEYNOTES:

① SAW CUT SECTION OF EXISTING CONCRETE SIDEWALK ALONG CONTROL JOINTS AND REMOVE. AFTER COMPLETION OF PIPE TRENCH WORK, REPLACE CONCRETE SECTION, IN KIND, TO MATCH EXISTING.

② BEND 4" SDR-11 PE RECLAIM WATER LINE SUCH THAT LINE PROPERLY CONNECTS TO 90° ELL FITTING. LOCATE 90° ELL FITTING 3'3" FROM EDGE OF WALKWAY.

③ PRIOR TO TRENCH WORK WITH BACK HOE, SOFT DIG THROUGH UTILITY CORRIDOR TO DEPTH OF SIX FEET BELOW GRADE TO EXPOSE SHALLOW UTILITIES (i.e., IRRIGATION LINES AND ELECTRICAL CONDUIT) AND VERIFY BURIAL DEPTH OF 8" RWL, 18" RWL AND 24" CCP AT GREATER THAN SIX FEET BELOW GRADE. SHOULD ANY UNKNOWN UTILITY BE ENCOUNTERED DURING SOFT DIGGING, IMMEDIATELY CONTACT ARIZONA BLUE STAKE FOR OWNER IDENTIFICATION.

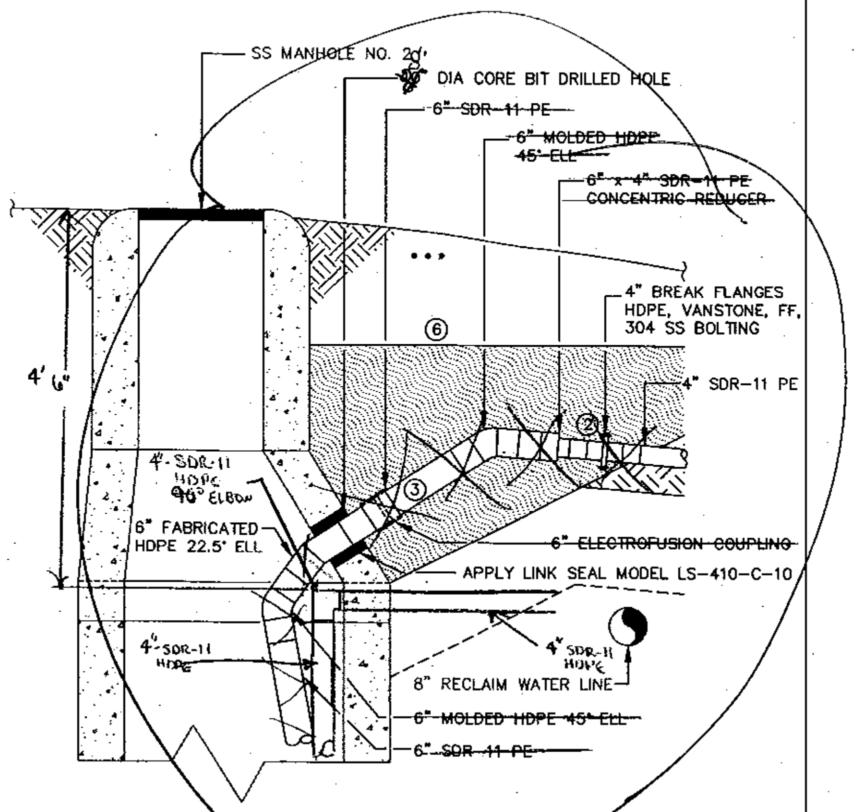
DANIEL A. DOWLER
ARIZONA U.S.A.
EXPIRES 9-30-2010

HYDRO GEO CHEM, INC.

ADEQ COOPER & COMMERCE ERA
4" RECLAIM WATER LINE TO SS MANHOLE NO. 2
EXPANDED PIPING PLAN AT SS MANHOLE NO. 2

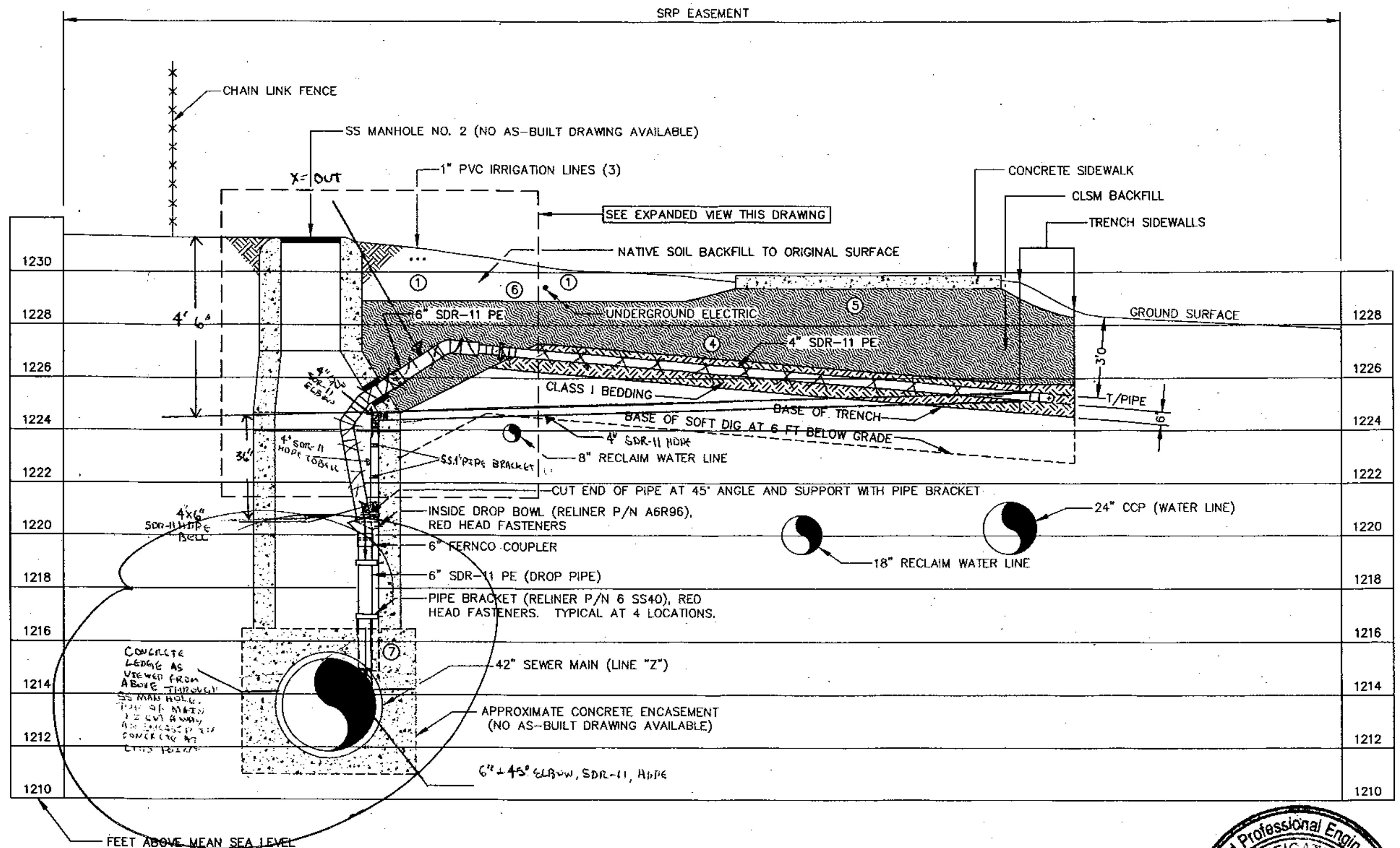
Approved	Date	Designer	Date	File Name	Drawing No.
CLJ	3/24/10	DAD	3/24/10	8330030A	P-7

ENG-2008-01124



EXPANDED VIEW OF SS MANHOLE CONNECTION

0 4.0 8.0
SCALE IN FEET



① UTILITY CORRIDOR & SS SEWER MANHOLE CONNECTION

0 2.5 5.0
SCALE IN FEET

GENERAL NOTES:

Ⓐ WORK THIS DRAWING WITH DWG NO. P-7.

Ⓑ GROUND SURFACE AND UNDERGROUND UTILITY ELEVATIONS APPROXIMATED FROM REFERENCE DRAWINGS IDENTIFIED ON DWG NO. P-1A.

KEYNOTES:

① PRIOR TO COMMENCING TRENCH WORK THROUGH UTILITY CORRIDOR TO SS MANHOLE, NOTIFY TOWN OF GILBERT TO SHUT OFF WATER SUPPLY TO IRRIGATION LINES AND ELECTRICITY WITHIN ELECTRIC LINE. NOTIFY TOWN OF GILBERT WHEN TRENCH WORK IS COMPLETE.

② PREPARE PIPE SEGMENT "C" FOR LEAK TEST BY INSTALLING ISOLATION BLANK BETWEEN APPROPRIATE SET OF BREAK FLANGES AT PEDESTRIAN BRIDGE, DEPENDING ON WHETHER PIPE SEGMENT "B" IS TO BE LEAK TESTED SIMULTANEOUSLY WITH PIPE SEGMENT "C". ALSO, INSTALL BLIND FLANGE WITH TEST PORT ON FLANGED END OF PIPE SEGMENT "C" NEAR SS MH NO. 2. TEMPORARILY LOOSEN ISOLATION BLANK AND BLIND FLANGE TO VENT AIR WHILE FILLING PIPE SEGMENT(S) WITH WATER. AFTER COMPLETION OF LEAK TEST, REMOVE BLIND FLANGE AND ISOLATION BLANK.

③ PRIOR TO INSTALLATION, LEAK TEST 6" DIA PIPE SECTION BY FILLING WITH WATER AND OBSERVING FOR ANY LEAKAGE. PREPARE FOR LEAK TEST BY INSTALLING TEMPORARY BLIND FLANGE ON FLANGED END.

④ TOP OF CLASS I BEDDING LAYER TO BE TWO INCHES ABOVE TOP OF PIPE.

⑤ TOP OF CLSM BACKFILL WITHIN REMOVED SIDEWALK SECTION TO BE FLUSH WITH BASE OF ADJACENT CONCRETE SECTIONS, PROVIDING FIRM BASE FOR REPLACEMENT SIDEWALK.

⑥ APPLY CAUTION TAPE ON CLSM SURFACE ALONG ENTIRE LENGTH OF PIPE TRENCH THROUGH UTILITY CORRIDOR. CAUTION TAPE TO HAVE FOLLOWING WORDS, "CAUTION: RECLAIM WATER LINE", PER MAG STANDARD 616.4.

⑦ IF CONCRETE BENCH INTERFERES WITH DROP PIPE, THEN ROUTE DROP PIPE AROUND AND ALONG SIDE OF BENCH USING TWO 6" MOLDED HDPE 45° ELLS.

Registered Professional Engineer (Civil) CERTIFICATE NO. CHRISTOPHER L. JACQUEMIN Date Signed 5-23-11 ARIZONA U.S.A.
RECORD DRAWING
EXPIRES 6-30-12

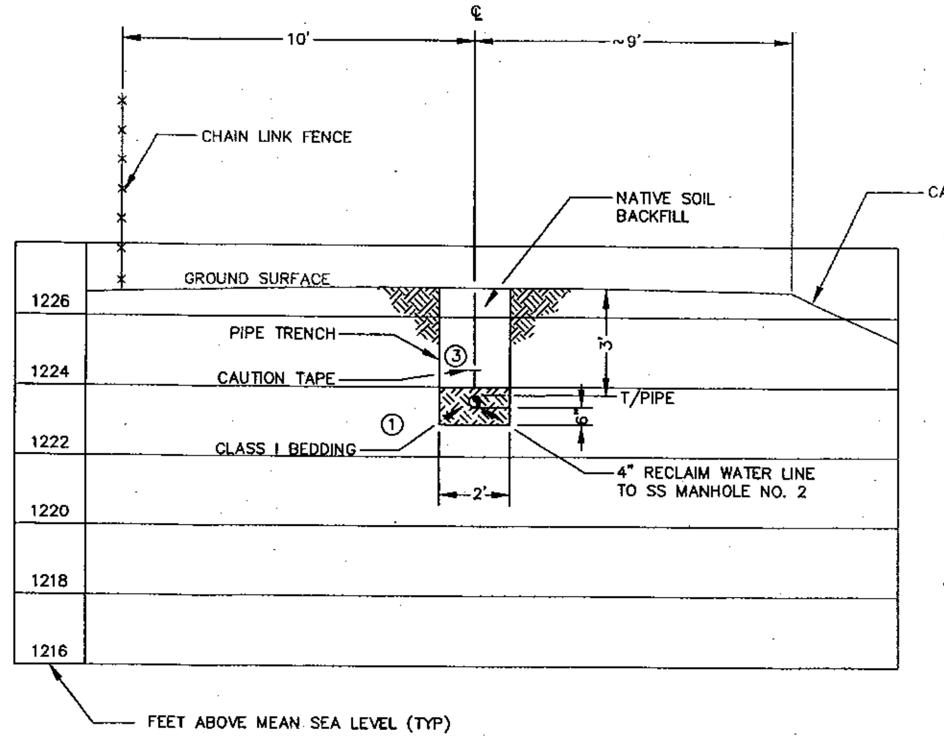
EXPIRES 9-30-2010

ENG-2008-01124

HYDRO GEO CHEM, INC.

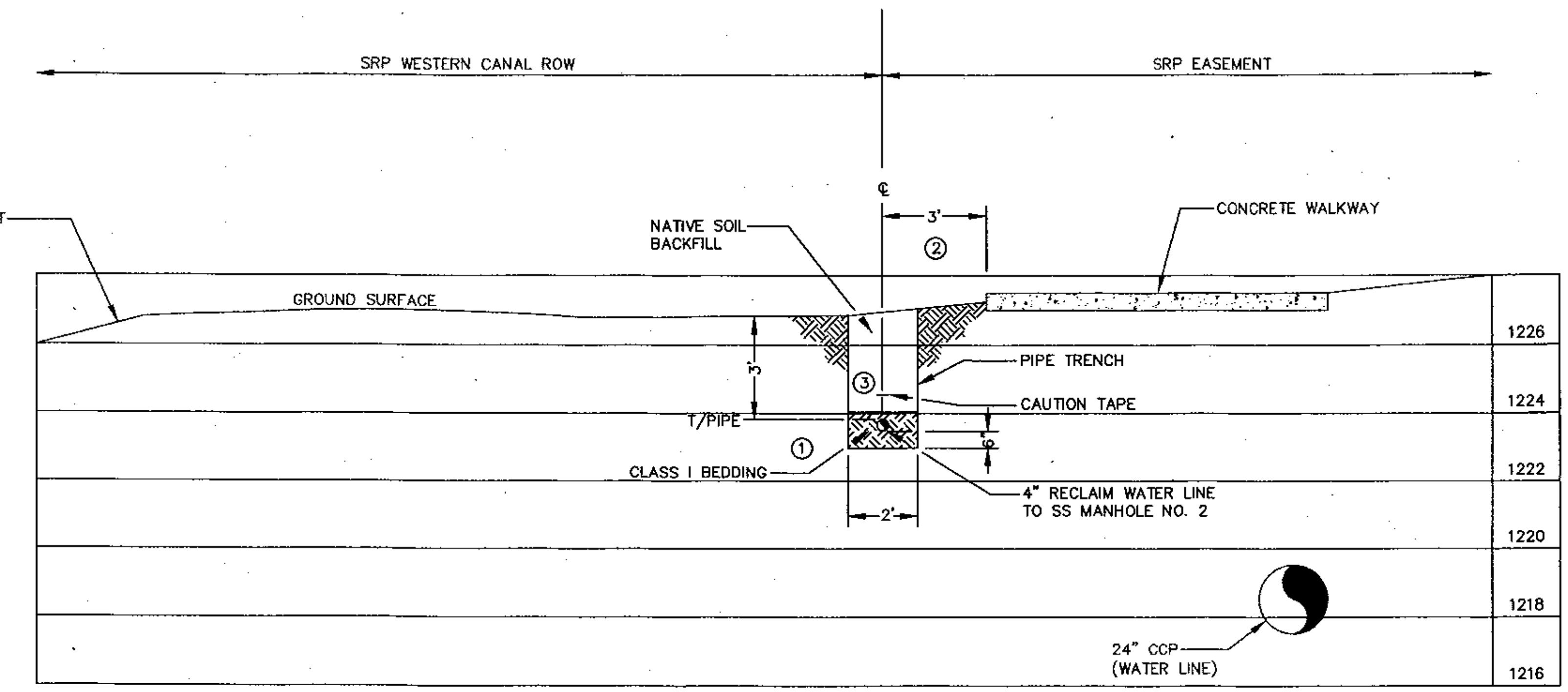
ADEQ COOPER & COMMERCE ERA
4" RECLAIM WATER LINE TO SS MANHOLE NO. 2
SS MANHOLE NO. 2 CONNECTION-ELEVATION AND DETAILS

Approved	Date	Designer	Date	File Name	Drawing No.
CLJ	3/24/10	DAD	3/24/10	8330038A	P-7A



① PIPE TRENCH SECTION - NORTH SIDE OF SRP WESTERN CANAL ROW

0 2.5 5.0
SCALE IN FEET



② PIPE TRENCH SECTION - SOUTH SIDE OF SRP WESTERN CANAL ROW

0 2.5 5.0
SCALE IN FEET

GENERAL NOTES:

Ⓐ WORK THIS DRAWING WITH DWG NO. P-1A.

Ⓑ GROUND SURFACE AND 24" CCP ELEVATIONS APPROXIMATED FROM SHEETS 37 & 38 OF 60, NEELY WATER RECLAMATION PLANT, 8" SLUDGE FORCE MAIN AND 8" RECLAIM WATER LINE PROJECT, AUGUST 2005, "AS-BUILTS", VALENTINE ENVIRONMENTAL ENGINEERS, LLC.

KEYNOTES:

① TOP OF CLASS I BEDDING LAYER TO BE TWO INCHES ABOVE TOP OF PIPE.

② MAINTAIN PIPE PLACEMENT THREE FEET OFFSET FROM EDGE OF CONCRETE WALKWAY.

③ APPLY CAUTION TAPE ALONG ENTIRE PIPE TRENCH ON TOP OF FIRST 6-INCH COURSE OF NATIVE SOIL BACKFILL ABOVE CLASS I BEDDING. CAUTION TAPE TO HAVE FOLLOWING WORDS, "CAUTION: RECLAIM WATER LINE", PER MAG STANDARD 616.4.

Expires 9-30-2010

HYDRO GEO CHEM, INC.

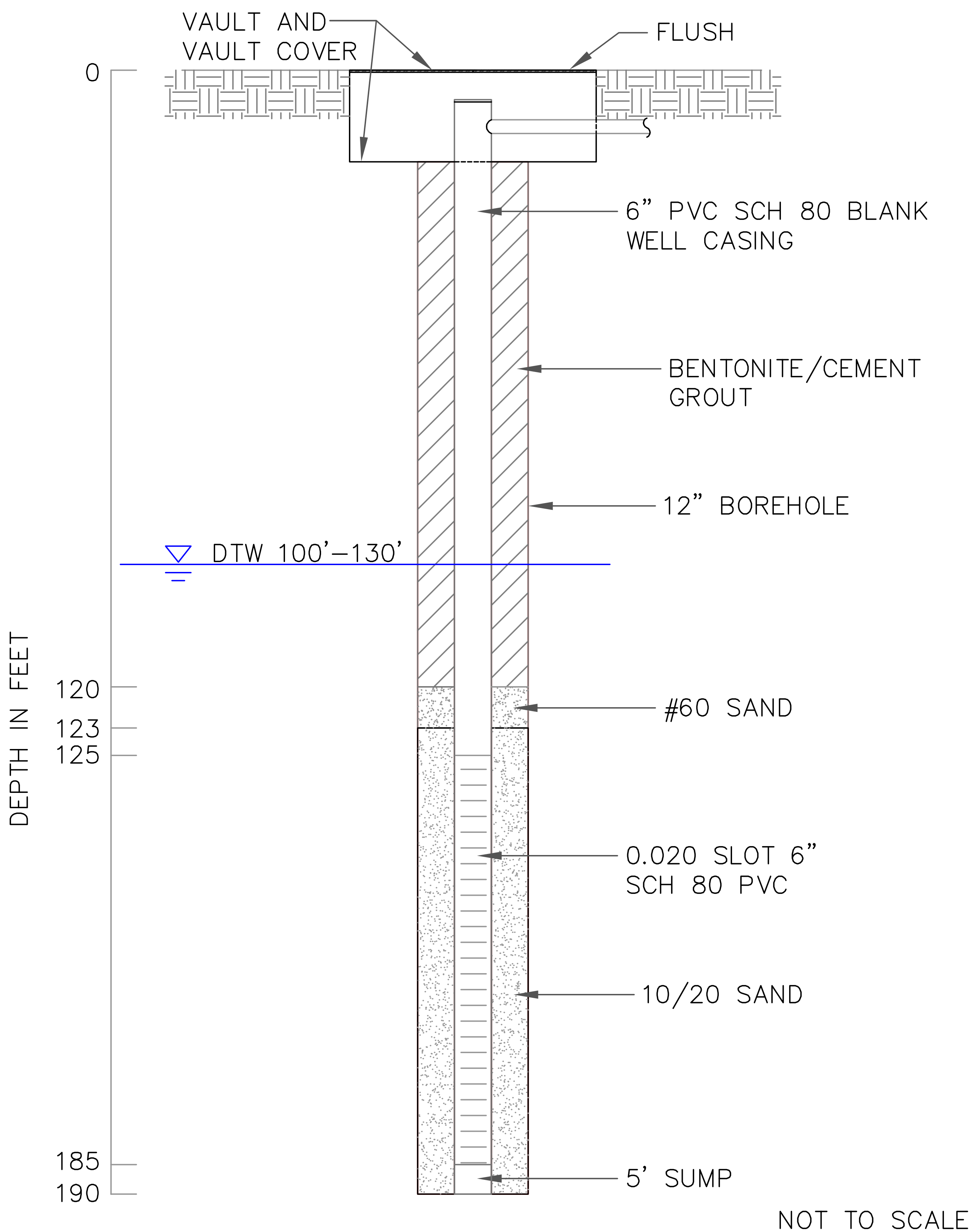
ADEQ COOPER & COMMERCE ERA
4" RECLAIM WATER LINE TO SS MANHOLE NO. 2
PIPE TRENCH SECTIONS

Approved	Date	Designer	Date	File Name	Drawing No.
CLJ	3/24/10	DAD	3/24/10	8330033A	P-8

ENG-2008-01124

APPENDIX C

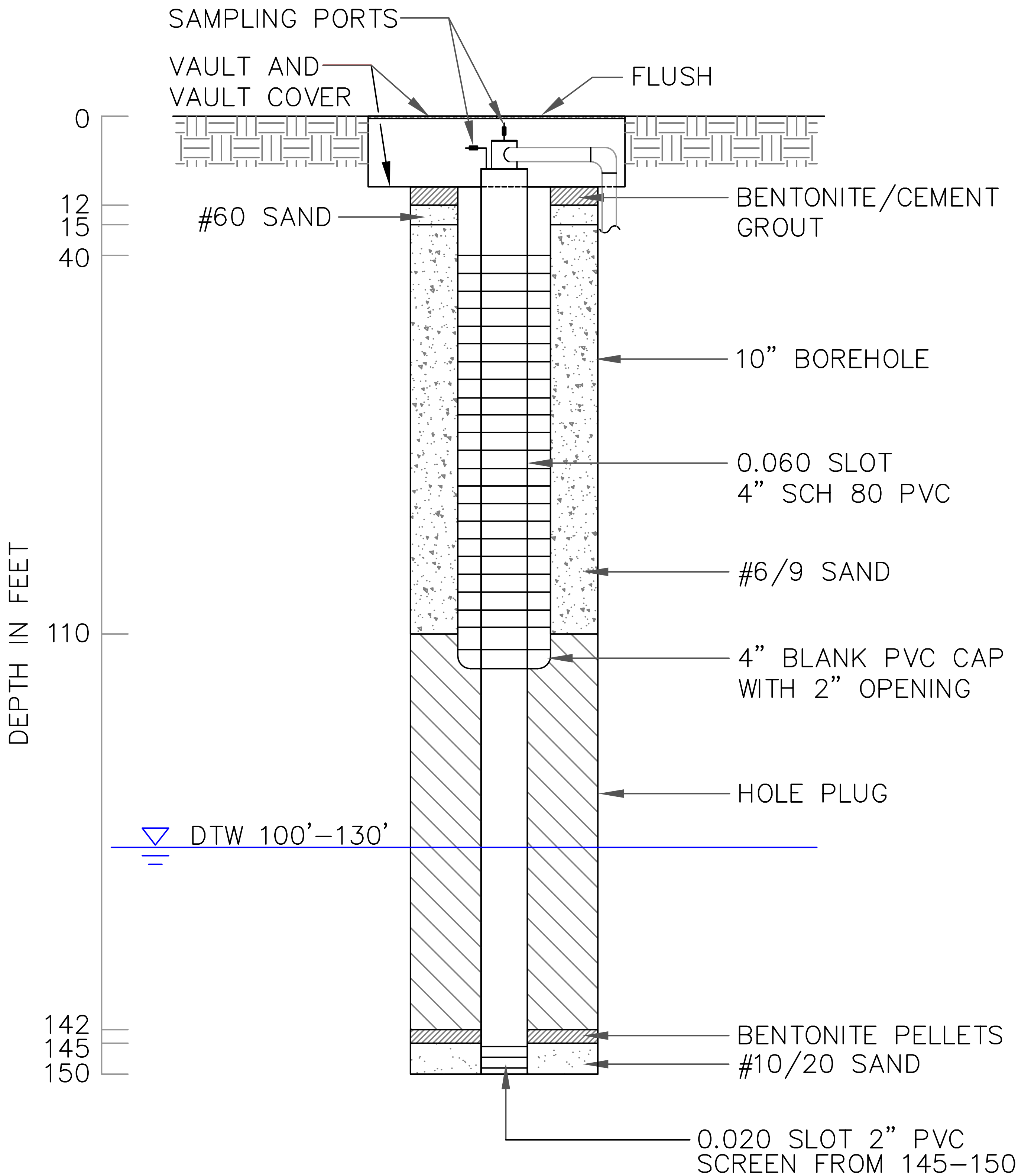
REMEDIAL WELL CONSTRUCTION DIAGRAMS



HYDRO
GEO
CHEM, INC.

GROUNDWATER WELL (EW-101)
ADWR NO. 55-211538

Approved	Date	Author	Date	File Name	Figure
CLJ	4/4/11	JAA	4/4/11	201000208A	1

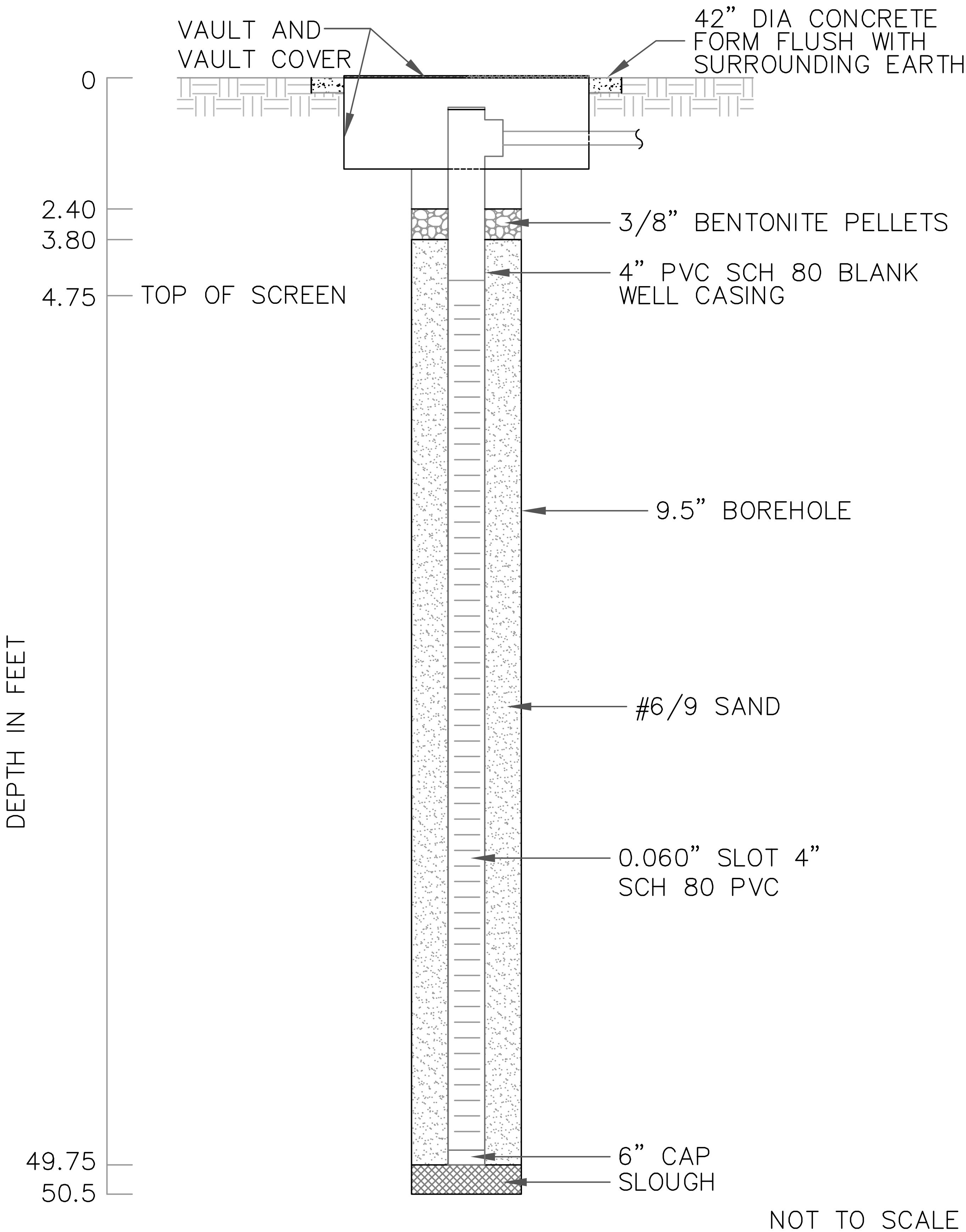


NOT TO SCALE

HYDRO GEO CHEM, INC.

AIR SPARGE / SOIL VAPOR EXTRACTION WELLS
AS/SVE-101 AND AS/SVE-102
ADWR NOs. 55-211536 AND 55-211537

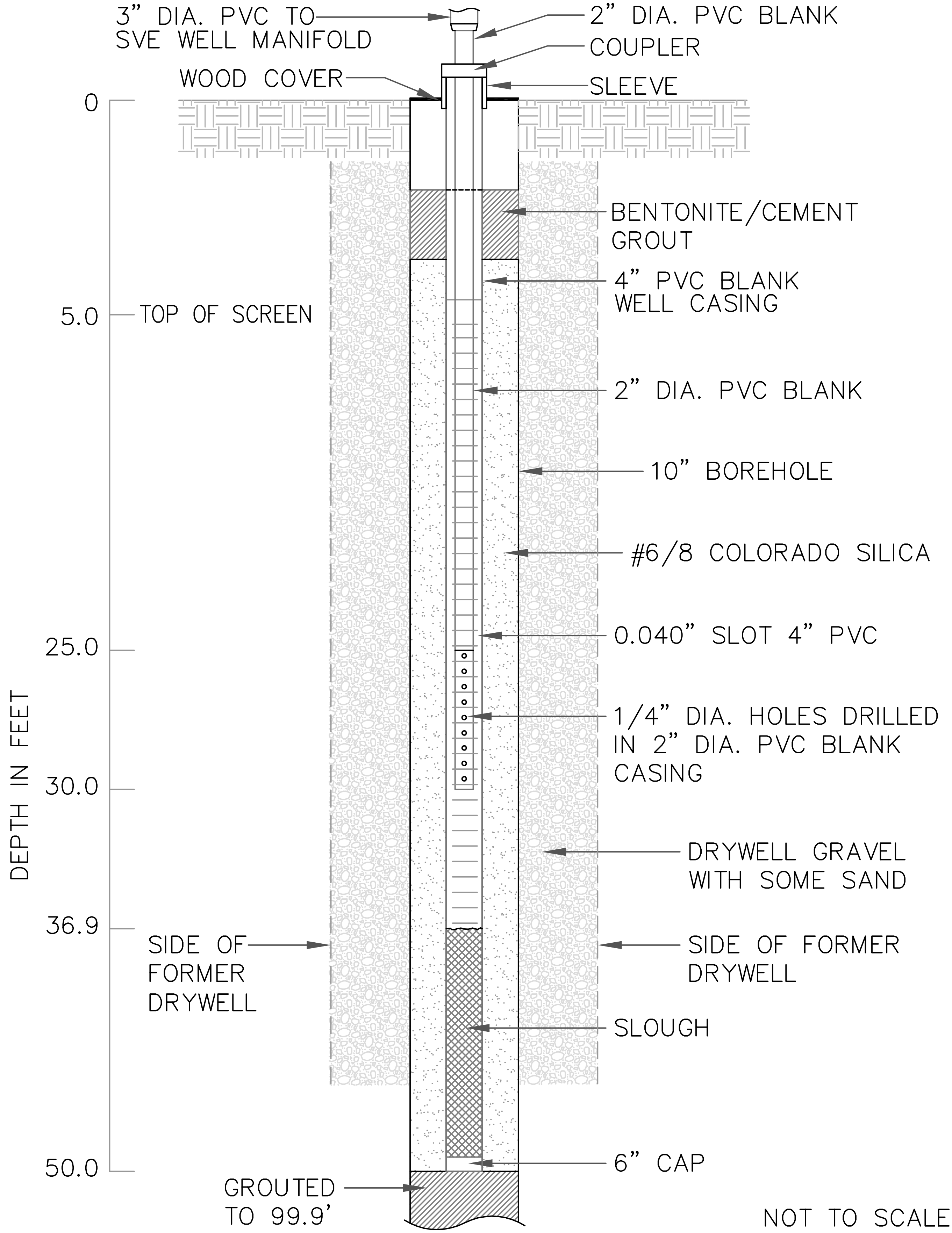
Approved	Date	Author	Date	File Name	Figure
CLJ	5/24/11	JAA	5/24/11	201000209A	2



HYDRO
GEO
CHEM, INC.

SOIL VAPOR EXTRACTION WELL (SVE-105)

Approved	Date	Author	Date	File Name	Figure
CLJ	5/24/11	JAA	5/24/11	2010002010A	3



HYDRO
GEO
CHEM, INC.

SOIL VAPOR EXTRACTION WELL (VP-104)

Approved	Date	Author	Date	File Name	Figure
CLJ	5/24/11	JAA	5/24/11	2010002011A	4

APPENDIX D

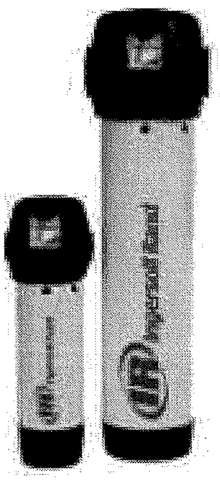
EQUIPMENT INFORMATION AND MAUALS

AIR SPARGE SYSTEM

IRGP216 General Purpose Coalescing/Particulate Filter

Detailed Scope of Supply

All amounts are displayed in US dollars



Technical Information:

Capacity- 216 scfm
Connection Size- 1" NPT
Max Pressure (psig)- 232
Drain Type- Automatic Float - 1/4" ID Tube Connection
Weight- 5.7 lbs
Dimensions- (W x H)- 5.1" x 17.6" **
** Clearance of 5.5" is suggested for element replacement

QTY	Description	Unit Price	Total Price
1	IRGP216 General Purpose Coalescing/Particulate Filter GP - General Purpose Filter designed to remove bulk particles (1 micron and larger) and oil (.5 mg/m3) at rated conditions. Primary purpose is to protect down stream filtration and drying equipment from large contaminants.	$439	$439
1	Differential Pressure Indicator		Included
1	Standard Factory Warranty The Company warrants that the equipment manufactured by it and delivered hereunder will be free of defects in material and workmanship for a period of twelve months from the date of placing the Equipment in operation or eighteen months from the date of shipment from the factory, whichever shall first occur.		Included

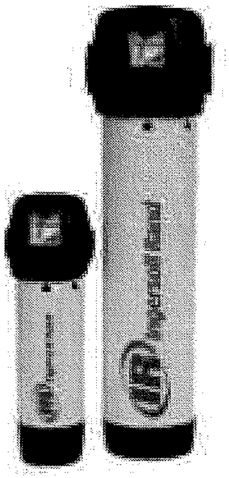
IRGP216 General Purpose Coalescing/Particulate Filter

Total Price $439

IRHE216 High Efficiency Coalescing Filter

Detailed Scope of Supply

All amounts are displayed in US dollars



Technical Information:

Capacity- 216 scfm
Connection Size- 1" NPT
Max Pressure (psig)- 232
Drain Type- Automatic Float - 1/4" ID Tube Connection
Weight- 5.7 lbs
Dimensions- (W x H)- 5.1" x 17.6" **
** Clearance of 5.5" is suggested for element replacement

QTY	Description	Unit Price	Total Price
1	IRHE216 High Efficiency Coalescing Filter	$461	$461
	HE - High Efficiency Filter designed to remove fine particulate (.01 micron and less) and oil (.01 mg/m3) at rated conditions. Primary purpose is to protect downstream air distribution and process equipment. Precede a HE filter with a GP filter to ensure low pressure drop, consistent air quality and avoid excessive, bulk contaminant loading.		
1	Differential Pressure Indicator		Included
1	Standard Factory Warranty		Included
	The Company warrants that the equipment manufactured by it and delivered hereunder will be free of defects in material and workmanship for a period of twelve months from the date of placing the Equipment in operation or eighteen months from the date of shipment from the factory, whichever shall first occur.		

Ingersoll Rand

IRHE216 High Efficiency Coalescing Filter

Total Price $461

Ingersoll-Rand®

Compressed Air Filters

Ingersoll-Rand®

Why Filter Compressed Air?

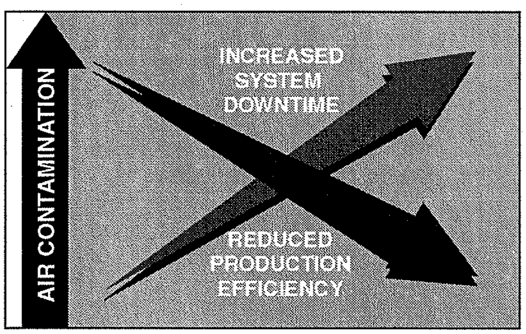
Contamination Reduces Efficiency

The air we breathe contains contamination in the form of water vapour and airborne particles.

During the compression process an air compressor concentrates these contaminants and depending on the design and age will even add to the contamination in the form of oil carry over.

Modern air compressors generally have built in aftercoolers that reduce the discharge temperature of the compressed air and with the help of water separators, remove the bulk of liquid water.

In some applications this may be sufficient, but the remaining dirt and moisture content suspended in aerosol form, can, if not removed, damage the compressed air system and cause product spoilage.



The result - higher overall cost of operation from:

- Increased system downtime
- Reduced production efficiency

These problems can be avoided with the correct selection and application of compressed air filters and dryers from Ingersoll-Rand.

The Air Solutions Group at Ingersoll-Rand has the widest selection of products and application knowledge to protect your investment and your compressed air system.

- Filters
- Refrigeration dryers
- Condensate management
- Desiccant dryers
- Cooling systems
- Piping systems

Benefits

- ✓ Proven to exceed ISO air quality
- ✓ Quickest, simplest maintenance of any filter design
- ✓ Built in safety protection
- ✓ Lowest pressure drop available
- ✓ Corrosion resistant alocrom treatment
- ✓ 10 year housing guarantee

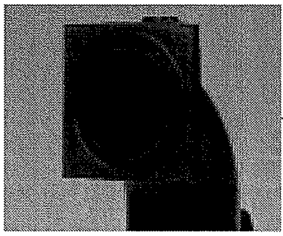
Quality Matters

Ingersoll-Rand ThermoStar Refrigeration Dryers are available in over 20 model sizes to suit all applications. When installed with compressed air filters they will provide clean compressed air to the classes as prescribed in ISO 8573.1.

ISO 8573.1 Quality Classes

QUALITY CLASS	DIRT Particle size in Micron	WATER Pressure Dewpoint °C (ppm. vol.) at 7 bar g	OIL (Including vapour) mg/m³
1	0.1	-70 (0.3)	0.01
2	1	-40 (16)	0.1
3	5	-20 (128)	1.0
4	15	+3 (940)	5
5	40	+7 (1240)	25
6	-	+10 (1500)	-

Ingersoll-Rand. Filters - The 'Class' Solution

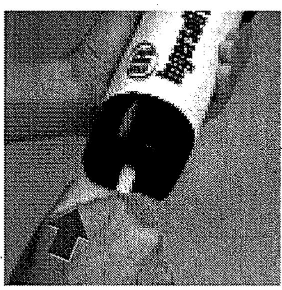


A Perfect Seal Every Time
Moulded seal cannot be lost or mis-aligned.

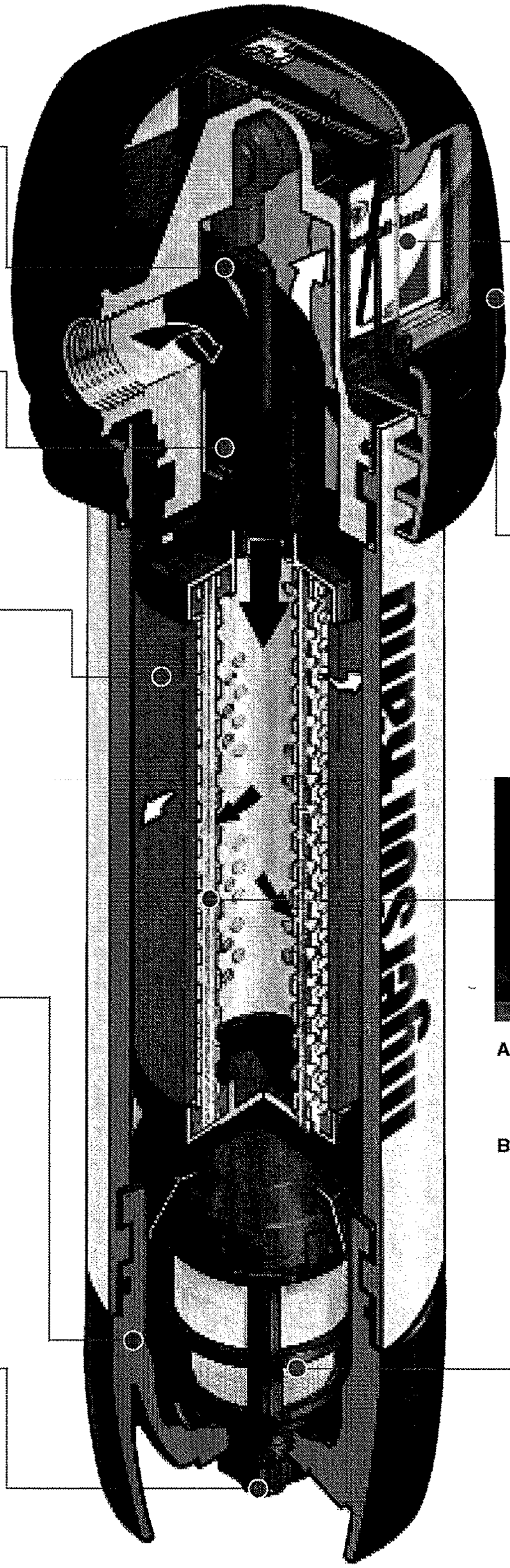
Full Flow Inlet
Gives maximum capacity and lowest pressure drop.

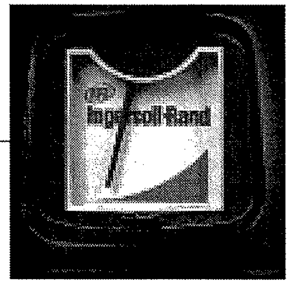
Unique Filter Element
Is available in four filtration grades.

Rapid Maintenance
Lift and twist design is quick and easy.

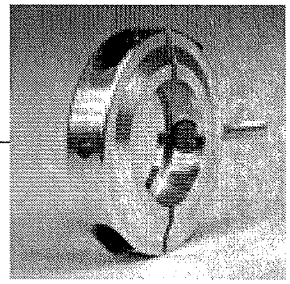


Built in Safety
Simply push for autodrain check and bowl depressurisation.

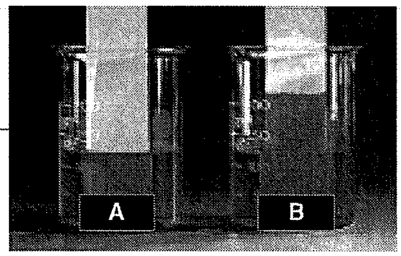




Differential Pressure Indicator
Gives a reminder of filter element life from both sides.

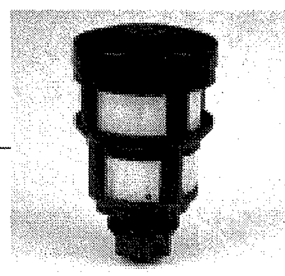


Fixing Clamp
Joins two filters and is a wall mounting bracket in one!



A. Ingersoll-Rand Oleophobic filter media actively repels oil and water to reduce pressure drop and running costs to an absolute minimum.

B. Typical filter media soaks up oil and water increasing pressure drop,reducing efficiency and giving higher running costs.



Self Cleaning Drain Screen
Reduces maintenance and increases reliability.

Technical Specifications

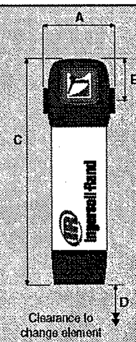
Filter Grade GP, HE AC, DP	Pipe Size NPT	Flow Rates @ 100 psi g (7 bar g)		Dimensions (inches)				Weight lbs.
		cfm	m³/min	A	B	C	D	
(Grade) 19	1/4	19	0.53	3.5	2.0	9.8	4.0	2.2
(Grade) 40	3/8	40	1.12	3.5	2.0	10.4	4.0	2.8
(Grade) 64	1/2	64	1.80	3.5	2.0	11.3	4.0	2.4
(Grade) 123	3/4	123	3.45	5.1	2.6	13.8	5.5	5.0
(Grade) 216	1	216	6.05	5.1	2.6	17.5	5.5	5.7
(Grade) 275	1 1/4	275	7.70	5.1	2.6	19.8	5.5	6.3
(Grade) 350	1 1/2	350	9.80	6.3	3.5	22.8	6.9	10
(Grade) 481	1 1/2	481	13.46	6.3	3.5	27	6.9	14.5
(Grade) 563	2	563	15.76	6.3	3.5	29.5	6.9	15.8
(Grade) 706	2	706	19.76	6.3	3.5	34	6.9	17.4
(Grade) 850	2 1/2	850	23.80	8.2	4.0	37	9.8	31.3
(Grade) 1100	3	1100	30.80	8.2	4.0	40.8	9.8	33.5
(Grade) 1380	3	1380	38.63	8.2	4.0	43.7	9.8	36
	150 lbs. Flg.							
*(Grade) 2100	4	2100	60.0	17.7	7.9	44.8	25.5	210
(Grade) 2750	4	2750	78.0	19.6	9.0	48	25.5	298
(Grade) 4100	6	4100	117	22.8	10.7	50.9	25.5	390
(Grade) 7000	8	7000	195	29.5	14.2	59.8	25.5	812
(Grade) 11000	10	11000	312	29.1	16	66.2	31.5	1135
(Grade) 17000	12	17000	468	39.3	19	70	33.4	1506

Grade GP - General Purpose Protection
Particle removal down to 1 micron including coalesced liquid water and oil, providing a maximum remaining oil aerosol content of 0.5 mg/m³ @ 21°C.

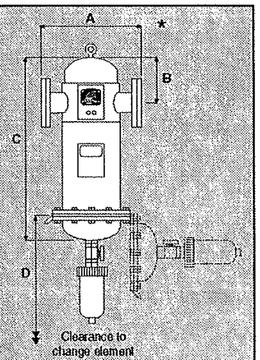
Grade HE - High Efficiency Oil Removal Filtration
Particle removal down to 0.01 micron including water and oil aerosols, providing a maximum remaining oil aerosol content of 0.01 mg/m³ @ 21°C. *(Precede with Grade GP filter).*

Grade AC - Activated Carbon Filtration
Oil vapour and hydrocarbon odour removal, giving a maximum remaining oil content of <0.003 mg/m³ (<0.003 ppm) (excluding methane) @ 21°C. *(Precede Grade AC with Grade HE filter).*

Grade DP - General Purpose Dust Filtration
Dust particle removal down to 1 micron.



1900-1380 CFM



2199-16527 CFM

Operating Limitations

Maximum operating pressure	232 psi g	(16 bar)
Maximum recommended operating temperature (Grade GP/HE/DP)	150°F	(66°C)
Maximum recommended operating temperature (Grade AC)	86°F	(30°C)
Minimum recommended operating temperature	34°F	(1.0°C)

150# FLG. 175 PSI
For flowrates at other pressures, apply the factor shown:

Line Pressure	psi g	15	29	44	73	100	131	160	189	218	232
	bar g	1	2	3	5	7	9	11	13	15	16
Correction Factor		0.38	0.53	0.65	0.85	1.0	1.13	1.25	1.36	1.46	1.51

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Ingersoll-Rand.

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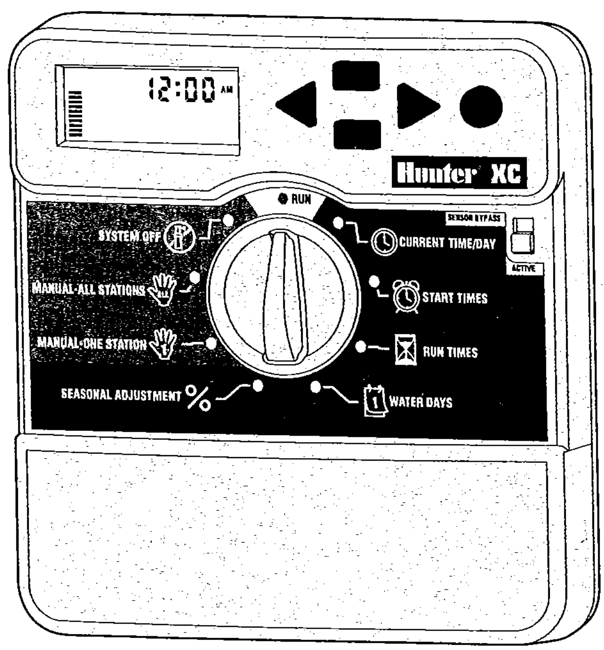
Air Solutions Group
800-D Beaty Street
P.O. Box 1840
Davidson, NC 28036

Form 3198 Printed in USA

XC

Residential Irrigation Controller

Owner's Manual and
Programming Instructions.



Hunter®

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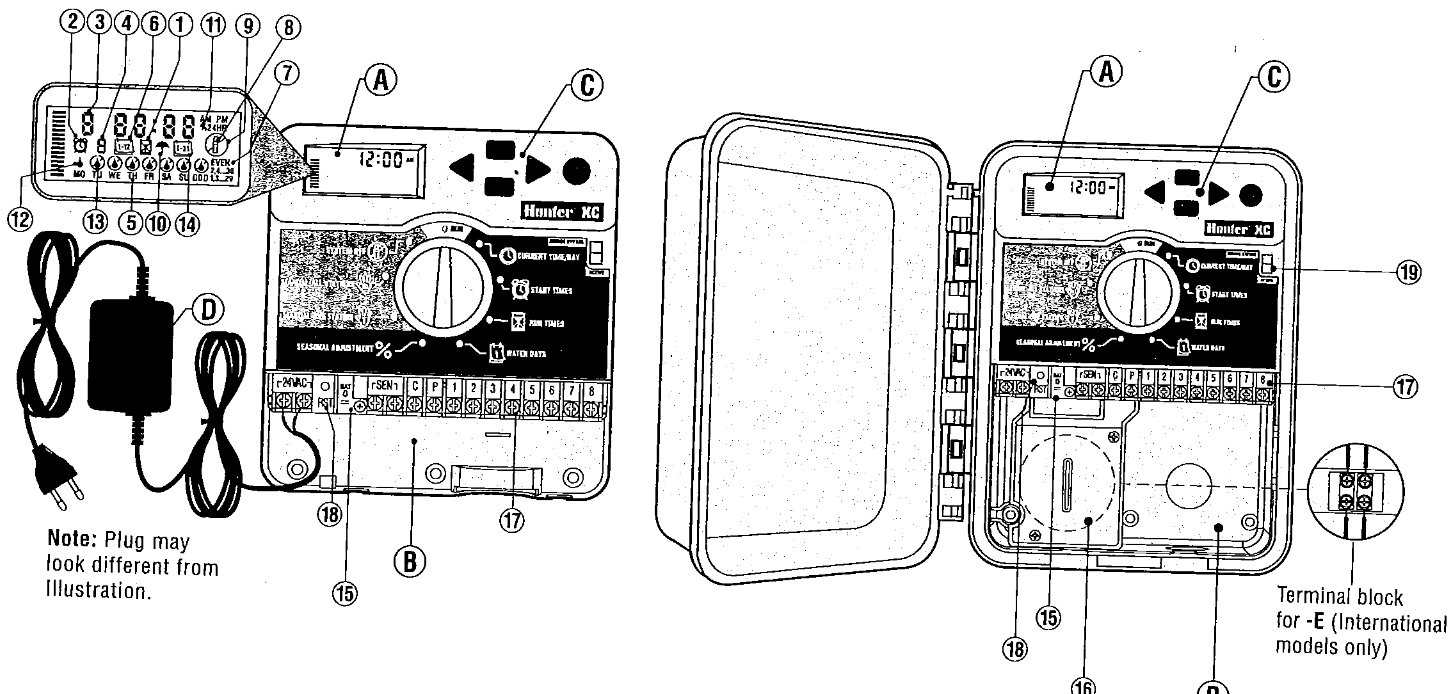
XC COMPONENTS



Note: Plug may look different from Illustration.

Indoor Model

Outdoor Model (Internal Transformer Included)

A – LCD Display

1. Run Times – Allows user to set each valve station run time from 1 minute to 4 hours.
2. Start Times – Allows 1 to 4 start times to be set in each program.
3. **Station Number** – Indicates currently selected station number.
4. **Program Designator** – Identifies program (A, B, or C) in use.
5. **Day of the Week** – Identifies day of the week
6. **Interval Watering** – Identifies month when programming current date.
7. **Odd/Even Watering** – Identifies if Odd or Even watering has been selected.
8. **Flashing Sprinkler** – Indicates that watering is taking place.
9. **System Off** – Allows user to discontinue all programs and watering. Also allows the user to set the programmable "rain off" which stops watering for a period from 1 to 7 days.
10. **Umbrella** – Indicates that the rain sensor is active.
11. % **Seasonal Adjustment** – Allows the user to make run time changes according to the seasons without reprogramming the controller. Bars on the left allow quick visual reference to the seasonal adjustment percentage.
12. **Rain Drop** – Indicates watering will occur on the selected day.
13. **Crossed Rain Drop** – Indicates the watering will NOT occur on the selected day.
14. **Calendar** – Indicates interval watering schedule has been programmed. Icon also appears when programming the current day.

B – Wiring Compartment

15. **Lithium Battery** – The replaceable lithium battery (included) allows the controller to be programmed in the absence of AC power. In addition, the battery will provide power for backup timekeeping in the event of a power outage.
16. **Internal Junction Box** – Junction box in outdoor models for making AC power connections.
17. **Terminal Strip** – Use to attach transformer, sensor, and valve wires from their source to the controller.
18. **Reset Button** – Use to reset the controller.

ENG

C – Control Buttons

Button – Increases the selected item flashing in the display.

Button – Decreases the selected item flashing in the display.

Button – Returns selected flashing display to previous item.

Button – Advances the selected flashing display to the next item.

Button – Selects program A, B or C for different watering zone requirements.

19. **Sensor Bypass Switch.**

Dial Settings

Run – Normal dial position for all controller automatic and manual operation.

Current Time/Day – Allows current day and clock time to be set.

Start Times – Allows 1 to 4 start times to be set in each program.

Run Times – Allows user to set each valve station run time from 1 minute to 4 hours.

Water Days – Allows the user to select interval days to water.

% **Seasonal Adjustment** – Allows user to make run time changes according to the seasons without reprogramming the controller. Bars on the left allow quick visual reference to the seasonal adjustment percentage.

Manual-One Station – Allows user to activate a one-time watering of a single valve.

Manual-All Stations – Allows user to activate a one-time watering of all valve stations or a few selected stations.

System Off – Allows user to discontinue all programs and watering. Also allows the user to set the programmable rain off which stops watering for a period from 1 to 7 days.

D – External Transformer (Indoor Model only)

A plug in transformer is provided to supply AC power to the controller.

MOUNTING THE CONTROLLER TO WALL

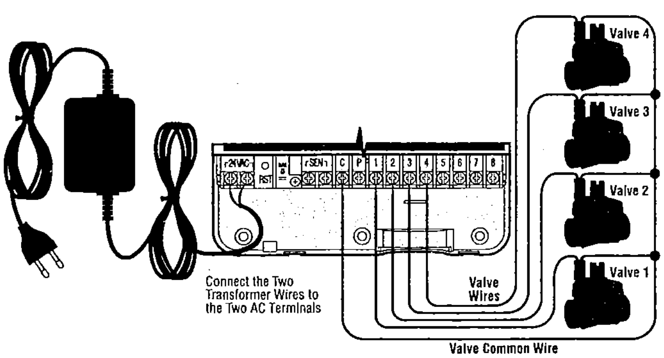
NOTE: The indoor XC is not waterproof or weather resistant, and must be installed indoors or in a protected area.

1. Secure one screw into the wall. Install screw anchors if attaching to drywall or masonry wall.
2. Slide the keyhole on top of the controller over the screw.
3. Secure the controller in place by installing screws in the holes below the terminal strip.

Do not plug transformer into power source until controller is mounted and all valve wiring has been connected.

CONNECTING VALVES AND TRANSFORMER

1. Route valve wires between the control valve location and controller.
2. At valves, attach a common wire to either solenoid wire on all valves. This is most commonly a white colored wire. Attach a separate control wire to the remaining wire of each valve. All wire connections should be done using waterproof connectors.



3. Route the valve wires through the conduit. Attach the conduit through the bottom right side of the controller.
4. Secure the white valve common wire to the C (Common) screw on the terminal strip. Attach each of the individual valve control wires to the appropriate station terminals and tighten their screws.
5. **Indoor Models:** route the transformer cable through the hole on the left side of the controller and connect the wires to the two screws marked 24VAC.

   Outdoor Models: transformer wires are already connected to the AC terminals so all that is required is to connect primary power to the junction box.

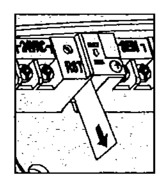
E – High Voltage Wiring (Outdoor Model only)

NOTE: XC outdoor models are water and weather resistant. Connecting the outdoor XC to primary AC power should only be done by a licensed electrician following all local codes. Improper installation could result in shock or fire hazard.

1. Route AC power cable and conduit through the ½" (13mm) conduit opening on the left side bottom of the cabinet.
2. Connect one wire to each of the two wires inside the junction box. Do not connect high voltage to the AC terminals inside the controller. Wire nuts are provided to make these connections. Note: For –E models, connect the wires to the AC terminal block inside the junction box.
3. Replace the junction box cover.

ACTIVATING THE BATTERY

After installing your XC make sure to remove the battery contact insulator to allow the XC to keep time in the event of a power outage.



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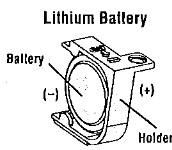
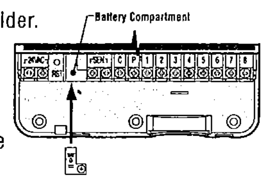
REPLACING THE BATTERY



A high-energy lithium battery is included with your XC controller. The battery allows the user to remotely program the controller without connecting AC power. It is also used to keep the current time and day during power outage conditions. To replace the battery:



1. Remove the screw from the battery holder.
2. Slide the battery holder down to access the battery.
3. Remove and replace the new battery into the battery holder and reinstall the battery holder.

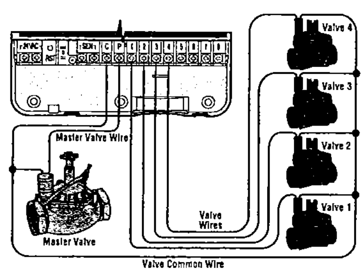
> **NOTE: This positive(+) side of the battery should face the inside of the battery holder.**

Battery type: CR2032 3V

CONNECTING A MASTER VALVE

> **NOTE: Complete this section only if you have a master valve installed in your irrigation system. A master valve is a "normally closed" valve installed at the supply point of the main line that opens only when the controller initiates a watering program.**

1. At the Master Valve, attach the common wire to either solenoid wire of the valve. Attach a separate control wire to the remaining solenoid wire.



2. The common wire should be attached to the **C** terminal inside the controller. The other wire coming from the master valve should be attached to the **P** terminal inside the controller. Tighten each terminal screw.

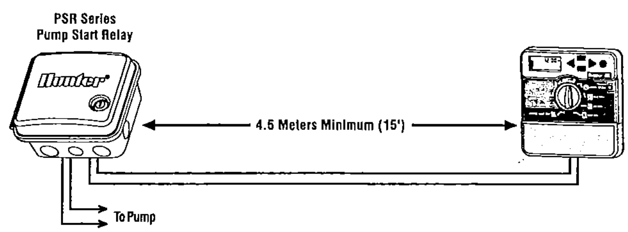
CONNECTING A PUMP START RELAY

> **NOTE: Complete this section only if you have a pump start relay installed. A pump start relay is a device that uses a signal from the controller to actuate a separate electrical circuit to energize a pump to provide water to your system.**

The controller should be mounted at least a 15 ft (4.5 m) away from both the pump start relay and pump to minimize any potential electrical interference.

1. Route a pair of wires from the pump relay into the controller.
2. Connect a common wire to the **C** (Common) terminal inside the controller and connect the remaining wire from the pump start relay to the **P** terminal.

Relay holding current draw must not exceed .30 amps. Do not connect the controller directly to the pump or damage to the controller will result.

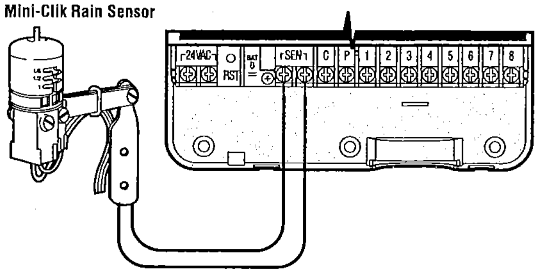


CONNECTING A WEATHER SENSOR

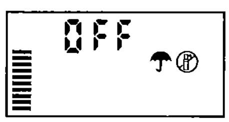
A Hunter weather sensor or other micro-switch type weather sensors can be connected to the XC. The purpose of this sensor is to stop automatic watering when weather conditions dictate.

1. **Remove the metal jumper plate** that is attached across the two SEN terminals inside the controller.
2. Connect one wire to one SEN terminal and the other wire to the other SEN terminal.

Mini-Clik Rain Sensor



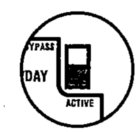
When the weather sensor has deactivated automatic watering, the OFF, ☂, and Ⓟ icons will appear on the display.



Testing the Weather Sensor

The XC provides simplified testing of a rain sensor when the sensor is wired into the sensor circuit. You can manually test proper operation of the rain sensor by running a **MANUAL ALL STATIONS** cycle or by activating the system using the **One Touch MANUAL START** (see page 10). During the Manual cycle, pressing the test button on the Mini-Clik® will interrupt watering.

Manually Bypassing the Weather Sensor



If the rain sensor is interrupting irrigation you can bypass it by using the bypass switch on the front of the controller. Slide the switch to the **SENSOR BYPASS** position to disable the rain sensor from the system to allow for controller operation. You can also bypass the weather sensor for manual operation by using the **MANUAL – ONE STATION** function.

POWER FAILURES

Due to the possibility of power failures, the controller has non-volatile memory. Programmed information will never be lost due to a power outage. The lithium battery will keep the correct time without AC power. Normal watering will resume when AC power is restored.

ENG

WATERING SCHEDULE

HUNTER XC		PROGRAM A							PROGRAM B							PROGRAM C						
DAY OF THE WEEK		MO	TU	WE	TH	FR	SA	SU														
ODD/EVEN OR INTERVAL																						
PROGRAM START TIMES	1																					
	2																					
	3																					
	4																					

STATION	LOCATION	STATION RUN TIME	STATION RUN TIME	STATION RUN TIME
1				
2				
3				
4				
5				
6				
NOTES:				

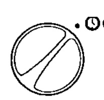
PROGRAMMING THE CONTROLLER

The XC display shows the time and day when the controller is idle. The display changes when the dial is rotated to indicate the specific programming information to enter. When programming, the flashing portion of the display can be changed by pressing the + or – buttons. To change something that is not flashing, press the ◀ or ▶ buttons until the desired field is flashing.

Three programs A, B, and C, each with the ability to have four daily start times, permit plants with different watering requirements to be separated on different day schedules.

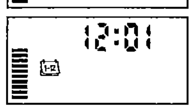
> ⚠ **NOTE: A basic programming rule is that whatever symbol or character is flashing will be the item programmed. For instance, if the hour is flashing when setting the time, the hour can be changed or programmed. For illustration purposes in this manual, flashing characters are in GRAY type.**

Setting the Date and Time



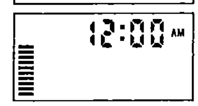
1. Turn the dial to the **CURRENT TIME/DAY** position.
2. The current year will be flashing. Use the + or – buttons to change the year. After setting the year, press the ▶ button to proceed to setting the month.

3. The month and day will be in the display. The month will be flashing and the 1-12 icon will be displayed. Use the + or – buttons to change the month. Press the ▶ button to proceed to setting the day.

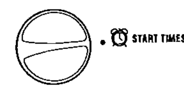


4. The day will be flashing and the 1-31 icon will be displayed. Use the + or – buttons to change the day. Press the ▶ button to proceed to setting the time.

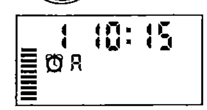
5. The time will be displayed. Use the + and – buttons to select AM, PM, or 24 hour. Press the ▶ button to move to hours. Hours will be flashing. Use the + and – buttons to change the hour shown on the display. Press the ▶ button to move to minute. Minutes will be flashing. Use the + and – buttons to change the minutes shown on the display. The date, day, and time have now been set.



Setting the Program Start Time(s)



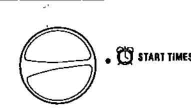
1. Turn the dial to the **START TIMES** position.
2. The factory preset is set on program A. If necessary, you can select program B, or C by pressing the PRG button.
3. Use the + or – button to change the start time. (The start times advance in 15 minute increments).



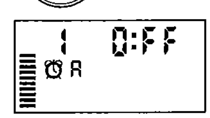
4. Press the ▶ button to add an additional start time, or PRG button for the next program.

> ⚠ **NOTE: One start time will activate all stations sequentially in that program. This eliminates the need to enter each station's start time. Multiple start times in a program can be used for separate morning, afternoon, or evening watering cycles. Start times may be entered in any order. The XC will automatically sort them.**

Eliminating a Program Start Time



With the dial set to **START TIMES** position, push the + or – button until you reach 12:00 AM (Midnight). From here push the – button once to reach the OFF position.

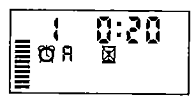


ENG

Setting Station Run Times

1. Turn the dial to **Run Times** position.

2. The display will show the last program selected (A, B, or C), the station number selected, icon, and the station will be flashing. You can switch to another program by pressing the PRG button.



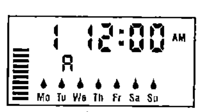
3. Use the + or − button to change the station run time on the display. You can set the run times from 0 to 4 hours.
4. Press the ▶ button to advance to the next station.

Setting Days To Water

1. Turn the dial to the **WATER DAYS** position.

2. The display will show the last program selected (A, B, or C). You can switch to another program by pressing the PRG button.
3. The controller will display the seven days of the week (MO, TU, WE, TH, FR, SA, SU). Each day will have a ♦ icon or a icon above the day. The ♦ icon would represent an "On" water day, while a icon would represent an "Off" watering day.

Selecting Specific Days of the Week to Water

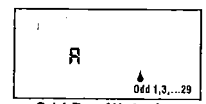


1. With the ♦ cursor on a specific day (the cursor will always start with MO), press the + button to activate a particular day of the week to water. Press the − button to cancel watering for that day. After pressing a button the cursor automatically advances to the next day.
2. Repeat step 1 until all desired days have been selected. The selected days will show a ♦ to indicate their status is ON. The last ♦ is the last day of watering for that program.

Selecting Odd or Even Days to Water

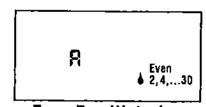
This feature uses numbered day(s) of the month for watering instead of specific days of the week (odd days: 1st, 3rd, 5th, etc.; even days: 2nd, 4th, 6th, etc.).

1. With the ♦ cursor on Su press the ▶ button once. The ♦ icon and odd will be displayed.



Odd Day Watering

2. If odd day watering is desired, turn the dial back to the run position.
3. If even day watering is desired, press the ▶ button once. The ♦ icon and **EVEN** will be displayed. You can move back and forth from **ODD** to **EVEN** by pressing the ◀ and ▶ buttons.

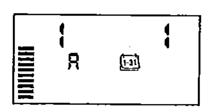


Even Day Watering

NOTE: The 31st of any month and February 29th are always "off" days if Odd watering is selected.

Selecting Interval Watering

With this option you can select interval watering from 1 to 31 days.



1. With the cursor on **EVEN**, press the ▶ button once and the icon will appear and a 1 flashing in the display. Interval watering schedule appears on the display.
2. Press the + or − button to select the number of days between watering days (from 1 to 31 days). This is called the interval.

The controller will water the selected program at the next start time and will then water at the interval programmed.

PROGRAMMING THE CONTROLLER (cont.)

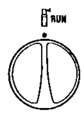
Setting Event Day(s) Off

The XC allows you to program a No Water Day(s). This feature is useful to inhibit watering on specific day(s). For example, if you always mow the lawn on Saturdays, you would designate Saturday as a **No Water Day** so that you are not mowing wet grass.

1. Turn the dial to the **WATER DAYS** position.
2. Enter an interval watering schedule as described on page 8.
3. Press the ▶ button to scroll to the **No Water Days** at the bottom of the display. **MO** will be flashing
4. Use the ▶ button until the cursor is at the day of the week you wish to set as a No Water Day.
5. Press the ■ button to set this day as a no water day. The will illuminate over this day.
6. Repeat steps 4 and 5 until all desired event day(s) are off.

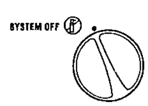
> ⚠ **NOTE: You also have the option in the interval watering schedule to program Odd or Even days off**

Automatic Watering



After programming the XC, set the dial to the **RUN** position to enable automatic execution of all selected watering programs and start times.

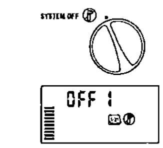
System Off



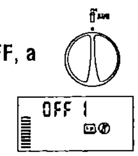
Valves currently watering will be shut off after the dial is turned to the **SYSTEM OFF** position for two seconds. All active programs are discontinued and watering is stopped. To return the controller to normal automatic operation, simply return the dial to the **RUN** position.

Programmable Rain Off

This feature permits the user to stop all programmed waterings for a designated period from 1 to 7 days. At the end of the programmed rain off period, the controller will resume normal automatic operation.



1. Turn the dial to the **SYSTEM OFF** position. Wait for **OFF** to be displayed.
2. Press the ■ button as many times as needed to set the number of days off (up to 7 days).
3. Turn the dial back to the **RUN** position at which **OFF, a number**, the and icons will be displayed.

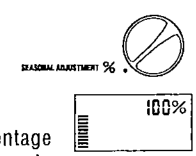


The days off remaining will decrease at midnight each day. When it goes to zero, the display will show normal time of day and normal irrigation will resume at the next scheduled start time.

Seasonal Adjustment %

Seasonal Adjust is used to make global run time changes without re-programming the entire controller. To use the seasonal adjustment feature:

1. Turn the dial to the **SEASONAL ADJUSTMENT** position.
2. The display will now show a flashing number followed by a %, as well as the bar graph which always remains on the display. Press the ■ or ■ button to adjust the percentage of the seasonal adjustment. Each bar on the graph represents 10%. This feature can adjust the controller from 10% to 150% of the original program.



To view the adjusted run times, simply turn the dial to the **RUN TIMES** position, the displayed run time will be updated accordingly as the seasonal adjustment is made.

> ⚠ **NOTE: The controller should always be initially programmed in the 100% position.**

ENG

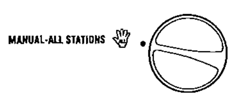
Manually Run a Single Station

1. Turn dial to **MANUAL – ONE STATION** position.

2. Station run time will flash in the display. Use the ▶ button to move to the desired station. You may use the + or − button to select the amount of time for a station to water.
3. Turn the dial clockwise to the **RUN** position to run the station (only the designated station will water, then the controller will return to automatic mode with no change to the previously set program). Also see **One Touch Start and Advance**.

Manually Run All Stations

1. Turn dial to **MANUAL – ALL STATIONS** position.



2. Select program A, B, or C by pressing the PRG button.
3. Station run time will flash in the display. Use the + or − button to select the amount of time for a station to water if different from the run time displayed.
4. Use the ▶ button to move to the next station.
5. Repeat steps 3 and 4 to customize each station.
6. Press the ▶ button until you reach the station at which you would like watering to begin.

Turn the dial clockwise to the **RUN** position (the controller will water the entire program beginning with the station number last left in the display, then return to the automatic mode with no change in the previously set program).

One Touch Manual Start and Advance

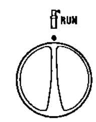
You can also activate all stations to water without using the dial.

1. Hold down the ▶ button for 2 seconds.
2. This feature automatically defaults to program A. You can select program B or C by pressing the PRG button.
3. The station number will be flashing. Press the ▶ button to scroll through the stations and use the + or − button to adjust station run times. (If no buttons are pressed for a few seconds during step 2 or 3, the controller will automatically begin watering).
4. Press the ▶ button scroll to the station you wish to begin with. After a 2 second pause, the program will begin. At any time during the manual cycle, you can use the ◀ or ▶ buttons to navigate from station to station manually.

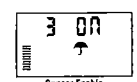
ADVANCED FEATURES

Programmable Sensor Override

The XC allows the user to program the controller so that the sensor disables watering on only desired stations. For example, patio gardens that have pots under overhangs and roofs may not receive water when it rains and will continue to need to be watered during periods of rain. To program sensor override:



1. Turn the dial to the **RUN** position.
2. Press and hold the − button down while turning the dial to **START TIMES** position.
3. Release the − button. At this point, the display will show the station number, ON, and the ☂ icon, will be flashing.

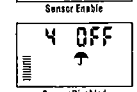


Sensor Enable

4. Press the + or − button to enable or disable the sensor for the station shown.

   ON = Sensor enabled (will suspend irrigation)

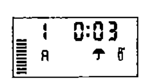
   OFF = Sensor disabled (will allow watering)



Sensor Disabled

5. Use the ◀ or ▶ buttons to scroll to the next station that you would like to program the sensor override.

> **NOTE: The controller default is for the sensor to disable watering on all zones when rain occurs.**



When the XC receives an input from the sensor to disable watering, the display will indicate those stations that have been programmed to override the sensor. A station that is running in the sensor override mode will flash the ☂ and sprinkler icons alternately.

ADVANCED FEATURES (cont.)

Test Program of All Stations

The XC allows the user a simplified method for running a test program. This feature will operate each station in numerical sequence, from the lowest to the highest.

1. With the dial in the **RUN** position, press and hold the PRG button. The station number will be displayed and the time will be flashing.
2. Use the + or – buttons to set the run time from 1 to 15 minutes. The run time needs to be entered only once.
3. After a 2 second pause, the test program will start.

Hunter Quick Check™ Diagnostics

This feature allows you to quickly diagnose wiring problems with your controller. Instead of having to check each field wiring circuit for potential problems, you can use the Hunter Quick Check circuit test procedure. To initiate the Quick Check test procedure:

1. Press the ◀, ▶, +, and – buttons simultaneously. In the standby mode, the LCD will display all segments.
2. Press the + button once to begin the Quick Check procedure. Within seconds, the system searches all stations for detecting any circuit problems. When a field wiring short is detected, an ERR symbol preceded by the station number will momentarily flash on the display. After the Quick Check completes running the circuit diagnostic procedure, the controller returns to the automatic watering mode.

Easy Retrieve™ Program Memory

The XC is capable of saving the preferred watering program into memory for retrieval at a later time. This feature allows for a quick way of resetting the controller to the original programmed watering schedule.

To save the program into the memory

1. With the dial in the **RUN** position, press and hold the + and PRG buttons for 5 seconds. The display will scroll three segments from left to right across the display indicating the program is being saved into memory.
2. Release the + and PRG buttons.

To retrieve a program that was previously saved into memory.

1. With the dial in the **RUN** position, press and hold the – and PRG buttons for 5 seconds. The display will scroll three segments from right to left across the display indicating the program is being saved into memory.
2. Release the – and PRG buttons.

Programmable Delay Between Stations

This feature allows the user to insert a delay between stations between when one station turns off and the next one turns on.

1. Start with the dial in the **RUN** position.
2. Press and hold the – button down while turning the dial to the **RUN TIMES** position.
3. Release the – button. At this point the display will show a delay time for all stations in seconds, which will be flashing.
4. Press the + or – buttons to increase or decrease the delay time between 0 and 4 hours.
5. Return the dial to the **RUN** position.

Clearing the Controller's Memory/Resetting the Controller

If you feel you have misprogrammed the controller, there is a process that will reset the memory to the factory defaults and erase all programs and data that have been entered into the controller.

1. Press and hold down the –, ▶, and PRG buttons.
2. Press and release the reset button in the lower wiring compartment.
3. Wait 2 seconds and release the –, ▶, and PRG buttons. The display should now show 12:00 am. All the memory has been cleared and the controller may now be reprogrammed.

TROUBLESHOOTING GUIDE

PROBLEM	CAUSES	SOLUTIONS
The controller is continuously watering	Too many start times have been programmed.	Only one start time is necessary to activate a program. (refer to Setting Watering Start Times on page 7).
There is no display	Check AC power wiring.	Correct any errors.
The display reads "No AC"	There is no AC power present (the controller is not receiving any power).	Check to see if the transformer is properly installed.
Display reads "Off, "	The rain sensor is interrupting irrigation or the sensor jumper has been removed.	Slide the rain sensor bypass switch to the BYPASS position to bypass the rain sensor circuit, or reinstall the jumper.
Rain sensor will not shut off the system	Defective rain sensor.	Verify operation of rain sensor and proper wiring
	Jumper was not removed when sensor was installed.	Remove jumper from the sensor terminals.
	Stations have been programmed to override the sensor.	Reprogram the sensor override to enable the sensor (see page 10).
Frozen display, or showing incorrect information	Power surge.	Reset the controller per page 11 "Clearing Controller Memory/ Resetting the Controller".
Display shows "ERR" with a number (1-8).	Short in valve wiring circuit, or faulty solenoid on the station number indicated.	Check wire circuit or solenoid for the valve number indicated. Repair short or replace solenoid. Press any button to clear the "ERR" from the display.
Display shows "P ERR"	Faulty pump relay or master valve wiring	Check wiring to relay or master valve solenoid. Press any button to clear the "P ERR" from the display.
	Incompatible or defective relay or solenoid	Check electrical specification for the pump relay. Do not exceed controller's electrical rating. Replace if defective.
	Under sized wire to the pump relay or master valve.	Replace wire with larger gauge wire.

TROUBLESHOOTING GUIDE (cont.)

PROBLEM	CAUSES	SOLUTIONS
Display shows a station is running but the ☂ and icons are flashing	The sensor is interrupting irrigation, however the station has been programmed to override the sensor.	Check the sensor override status (see page 10)
Automatic irrigation does not start at the start time and controller is not in the System Off mode	AM/PM of time of day not set correctly.	Correct AM/PM of time of day
	AM/PM of start time not set correctly.	Correct AM/PM of start time
	Start Time is disabled (set for Off).	See Setting Start Times (pg 7)
	Controller is not receiving AC power	Check AC power connections.

SPECIFICATIONS

Operating Specifications

- Station Run Times: 0 to 4 hours in 1-minute increments.
- 3 Independent Watering Programs.
- Start Times: 4 per day per program for up to 12 daily starts.
- Watering Schedule: 365-day calendar, interval watering, odd/even watering.
- AM/PM, 24-hour clock.
- Simple manual operation.
- Sensor override by station.
- Programmable rain delay (1 to 7 days).
- Seasonal adjustment (10% to 150%).
- Sensor bypass switch.

Electrical Specifications

- Transformer input 120VAC 60 Hz (230VAC 50/60 Hz International Models).
- Transformer Output: 24VAC 1.0 amp.
- Station Output: .56 amps per station.
- Maximum Output: .84 amps (includes master valve).
- Battery: 3V Lithium (included) used for remote programming and backup timekeeping. Use CR2032 3-volt.
- Electronic short circuit protection.
- Non-volatile memory for program data.
- UL Listed.

CERTIFICATE OF CONFORMITY TO EUROPEAN DIRECTIVES

Hunter Industries declares that the irrigation controller Model XC complies with the standards of the European Directives of "electromagnetic compatibility" 87/336/EEC and "low voltage" 73/23/EEC.

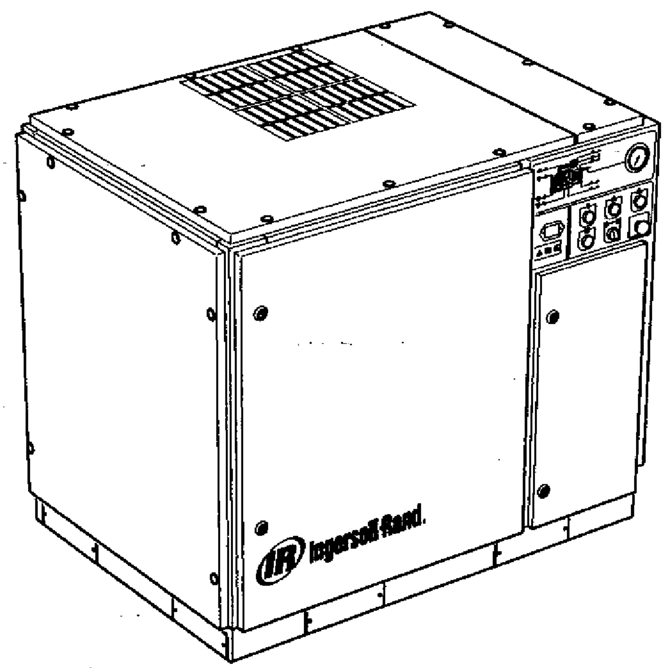
Project Engineer

CE

Ingersoll Rand

SSR UP6 15, UP6 20, UP6 25, UP6 30
60Hz

OPERATION AND MAINTENANCE MANUAL



This manual contains important safety information and must be made available to personnel who operate and maintain this machine.

C.C.N. : 22083729
REV. : C
DATE : JANUARY 2005

AIR COMPRESSOR GROUP
BONDED WARRANTY & REGISTERED START UP

Warranty

The Company warrants that the equipment manufactured by it and delivered hereunder will be free of defects in material and workmanship for a period of twelve months from the date of placing the Equipment in operation or eighteen months from the date of shipment from the factory, whichever shall first occur. The Purchaser shall be obligated to promptly report any failure to conform to this warranty, in writing to the Company in said period, whereupon the Company shall, at its option, correct such nonconformity, by suitable repair to such equipment or, furnish a replacement part F.O.B. point of shipment, provided the Purchaser has stored, installed, maintained and operated such Equipment in accordance with good industry practices and has complied with specific recommendations of the Company. Accessories or equipment furnished by the Company, but manufactured by others, shall carry whatever warranty the manufacturers have conveyed to the Company and which can be passed on to the Purchaser. The Company shall not be liable for any repairs, replacements, or adjustments to the Equipment or any costs of labor performed by the Purchaser or others without Company's prior written approval.

The effects of corrosion, erosion and normal wear and tear are specifically excluded. Performance warranties are limited to those specifically stated within the Company's proposal. Unless responsibility for meeting such performance warranties are limited to specified tests, the Company's obligation shall be to correct in the manner and for the period of time provided above.

THE COMPANY MAKES NO OTHER WARRANTY OR REPRESENTATION OF ANY KIND WHATSOEVER, EXPRESSED OR IMPLIED, EXCEPT THAT OF TITLE, AND ALL IMPLIED WARRANTIES OF MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE, ARE HEREBY DISCLAIMED.

Correction by the Company of nonconformities whether patent or latent, in the manner and for the period of time provided above, shall constitute fulfillment of all liabilities of the Company for such nonconformities whether based on contract, warranty negligence, indemnity, strict liability or otherwise with respect to or arising out of such Equipment.

The purchaser shall not operate Equipment which is considered to be defective, without first notifying the Company in writing of its intention to do so. Any such use of Equipment will be at Purchaser's sole risk and liability.

Note that this is Ingersoll–Rand standard warranty. Any warranty in force at the time of purchase of the compressor or negotiated as part of the purchase order may take precedence over this warranty.

Register on–line at www.air.ingersoll–rand.com/registration.htm

Ingersoll–Rand Air Solutions Group
Global Aftermarket Division
800–B Beaty Street
Davidson, NC 28036

1–800–526–3615

www.air.ingersoll–rand.com

CONTENTS

ABBREVIATIONS & SYMBOLS

####	Contact Ingersoll–Rand for serial number
–>####	Up to Serial No.
####–>	From Serial No.
*	Not illustrated
†	Option
NR	Not required
AR	As required
SM	Sitemaster/Sitepack
HA	High ambient machine
WC	Watercooled machine
AC	Aircooled machine
ERS	Energy recovery system
T.E.F.C.	Totally enclosed fan cooled motor (IP55)
O.D.P.	Open drip proof (motor)

cs	Czech
da	Danish
de	German
el	Greek
en	English
es	Spanish
et	Estonian
fi	Finnish
fr	French
hu	Hungarian
it	Italian
lt	Lithuanian
lv	Latvian, Lettish
mt	Maltese
nl	Dutch
no	Norwegian
pl	Polish
pt	Portuguese
sk	Slovak
sl	Slovenian
sv	Swedish
zh	Chinese

Nothing contained in this document is intended to extend any promise, warranty or representation, expressed or implied, regarding the Ingersoll–Rand products described herein. Any such warranties or other terms and conditions of sale of products shall be in accordance with the standard terms and conditions of sale for such products, which are available upon request.

This manual contains instructions and technical data to cover routine operation and scheduled maintenance tasks by operation and maintenance staff. Major overhauls are outside the scope of this manual and should be referred to an authorised Ingersoll–Rand service department.

The design specification of this machine has been certified as complying with E.C. directives. Any modification to any part is absolutely prohibited and would result in the CE certification and marking being rendered invalid.

All components, accessories, pipes and connectors added to the compressed air system should be:

- of good quality, procured from a reputable manufacturer and, wherever possible, be of a type approved by Ingersoll–Rand.
- clearly rated for a pressure at least equal to the machine maximum allowable working pressure.
- compatible with the compressor lubricant/coolant.
- accompanied with instructions for safe installation, operation and maintenance.

Details of approved equipment are available from Ingersoll–Rand Service departments.

The use of non–genuine spare repair parts other than those included within the Ingersoll–Rand approved parts list may create hazardous conditions over which Ingersoll–Rand has no control. Therefore Ingersoll–Rand does not accept any liabilitity for losses caused by equipment in which non–approved repair parts are installed. Standard warranty conditions may be affected.

Ingersoll–Rand reserves the right to make changes and improvements to products without notice and without incurring any obligation to make such changes or add such improvements to products sold previously.

The intended uses of this machine are outlined below and examples of unapproved usage are also given, however Ingersoll–Rand cannot anticipate every application or work situation that may arise.

IF IN DOUBT CONSULT SUPERVISION.

This machine has been designed and supplied for use only in the following specified conditions and applications:

- Compression of normal ambient air containing no known or detectable additional gases, vapours. or particles
- Operation within the ambient temperature range specified in the *GENERAL INFORMATION* section of this manual.

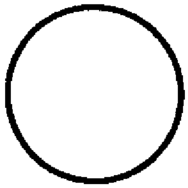
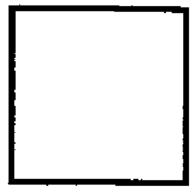
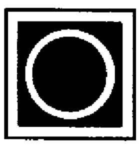
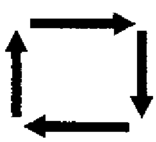
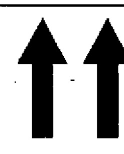
The use of the machine in any of the situation types listed in table 1:–
a) Is not approved by Ingersoll–Rand,
b) May impair the safety of users and other persons, and
c) May prejudice any claims made against Ingersoll–Rand.

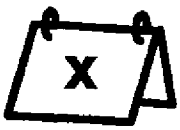
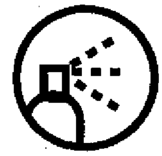
TABLE 1
Use of the machine to produce compressed air for: a) direct human consumption b) indirect human consumption, without suitable filtration and purity checks.
Use of the machine outside the ambient temperature range specified in the *GENERAL INFORMATION SECTION* of this manual.
Use of the machine where there is any actual or foreseeable risk of hazardous levels of flammable gases or vapours. THIS MACHINE IS NOT INTENDED AND MUST NOT BE USED IN POTENTIALLY EXPLOSIVE ATMOSPHERES, INCLUDING SITUATIONS WHERE FLAMMABLE GASES OR VAPOURS MAY BE PRESENT.
Use of the machine fitted with *non Ingersoll–Rand approved components.*
Use of the machine with safety or control components missing or disabled.

The company accepts no responsibility for errors in translation of this manual from the original English version.

ISO SYMBOLS

GRAPHIC FORM AND MEANING OF ISO SYMBOLS

 Prohibition / Mandatory	 Information / Instructions	 Warning
 Use fork lift truck from this side only.	 RESET	 Do not use fork lift truck from this side.
 Emergency stop.	 On (power).	 Off (power).
 AUTOMATIC RESTART	 MAINTENANCE	 MAINTENANCE PROHIBITED
 FRAGILE	 KEEP DRY	 THIS WAY UP
 USE NO HOOKS	 NO SIDE CLAMPS	 HOURS

Use ULTRA–Plus Coolant only Failure to use the specified coolant may result in damage to the machine	 POWER	 INSPECT
 Every X months, if sooner than required by operating hours	 CHANGE / REPLACE	 CLEAN

ANSI SYMBOLS

GRAPHIC FORM AND MEANING OF ANSI SYMBOLS

DANGER

INTAKE AIR. Can contain carbon monoxide or other contaminants. Will cause serious injury or death. Ingersoll–Rand air compressors are not designed, intended or approved for breathing air. Compressed air should not be used for breathing air applications unless treated in accordance with all applicable codes and regulations.

WARNING

HAZARDOUS VOLTAGE. Can cause serious injury or death. Disconnect power and bleed pressure from tank before servicing. Lockout/Tagout machine. Compressor must be connected to properly grounded circuit. See Grounding Instructions in manual. Do not operate compressor in wet conditions. Store indoors.

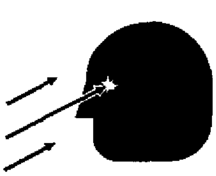
RISK OF FIRE OR EXPLOSION. Electrical arcing from compressor components can ignite flammable liquids and vapors which can result in serious injury. Never operate the compressor near flammable liquids or vapors. If used to spray flammable materials, keep compressor at least 20ft away from the spray area.

HIGH PRESSURE AIR. Rusted tanks can cause explosion and severe injury or death. Receiver under perssure. Operator should relieve tank pressure before performing maintenance. In addition to automatic drain, operate manual drain valve weekly. Manual drain valve located at bottom of the tank.

MOVING PARTS. Can cause serious injury. Do not operate with guards removed. Machine may start automatically. Disconnect power before servicing. Lockout/Tagout machine.

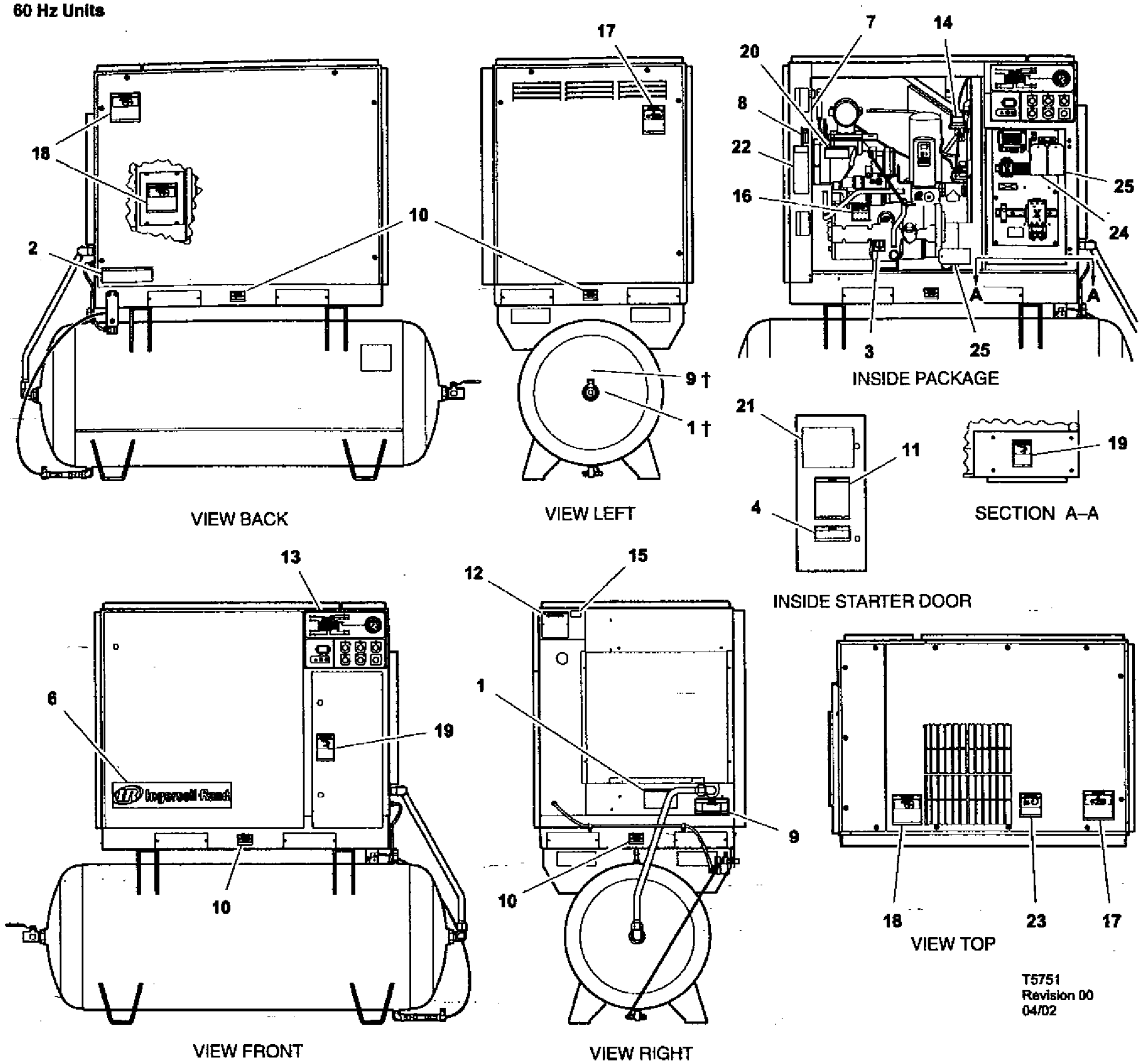
HOT SURFACES. Can cause serious injury. Do not touch. Allow to cool before servicing. Do not touch hot compressor or tubing.

EXPOSED MOVING BELTS AND SHEAVES.
Can cause severe injury or death.
Do not operate without guard in place. Disconnect power before servicing.
Lockout/Tagout machine.



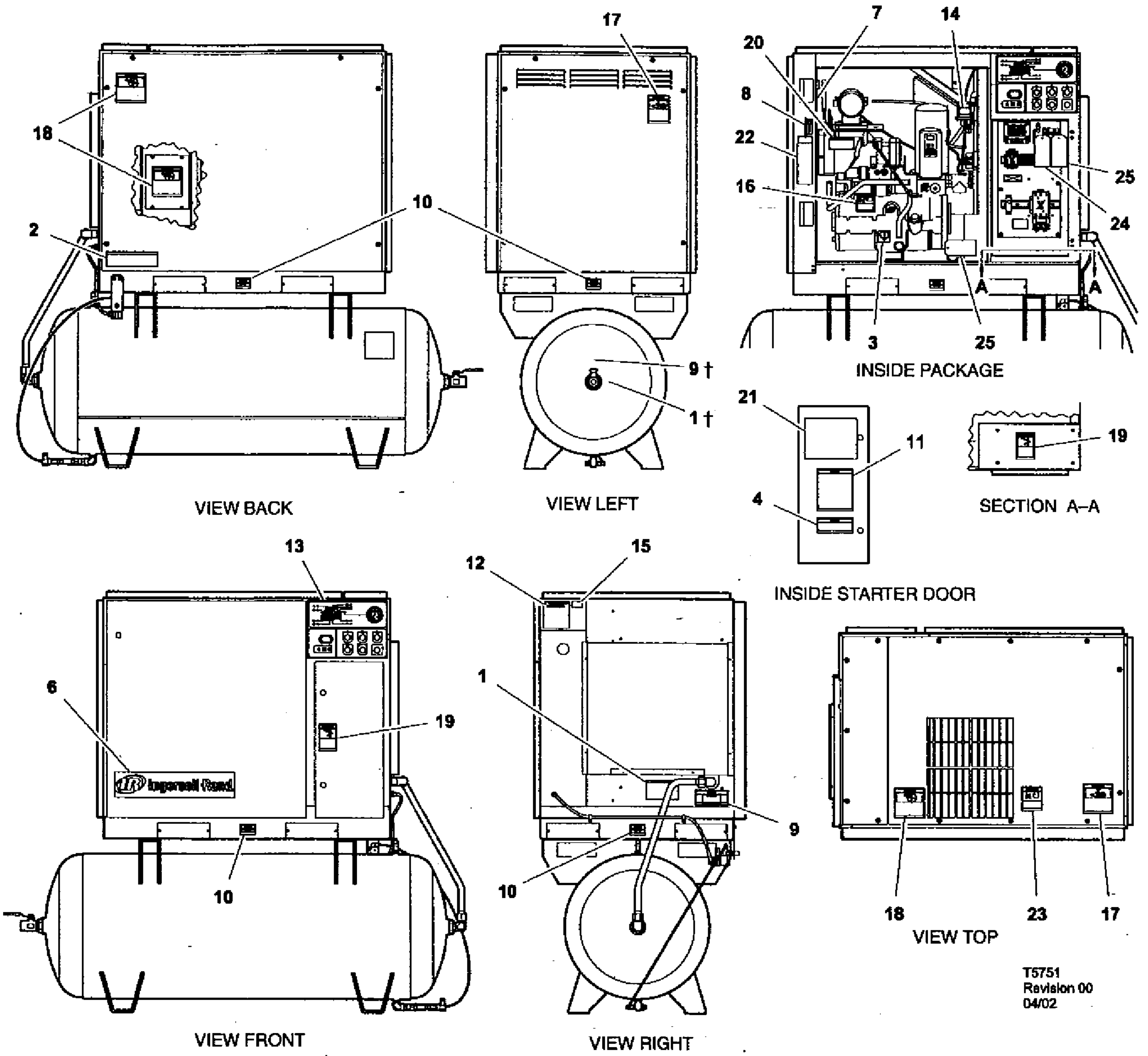
Air flow exhaust may contain flying debris.
Safety protection should be worn at all times.

60 Hz Units



Item	ccn	Qty.	Description	Item	ccn	Qty.	Description
1	32343519	1	Decal, warning contaminated air Located near air discharge port of receiver tank on tank mounted units	9	32343543	1	Decal, notice air discharge Located near air discharge port of receiver tank on tank mounted units
2	32343576	1	Decal, air receiver auto–drain	10	93171262	4	Decal, notice lift here
3	93166460	1	Decal, coolant drain	11	32343493	1	Decal, overload setting IEC starter
4	32343501	1	Decal, dual voltage (if needed)	12	SPEC	1	Specifications, compressor package
5	–			13	32342669	1	Decal, starter box
6	54499306	1	Decal, Ingersoll–Rand signature horizontal 20"	14	32017469	1	Decal, voltage 120/1/60
7	32343063	1	Decal, maintenance parts			†	Optional position
8	30286686	1	Decal, notice rotation				

60 Hz Units



Item	ccn	Qty.	Description	Item	ccn	Qty.	Description
15	32017436	1	Decal, voltage 230/3/60	20	32343584	1	Decal, warning hot surface
	32018475	1	Decal, voltage 200/3/60	21	32343634	1	Decal, wiring schematic DOL 60Hz
	32236481	1	Decal, voltage 380/3/60		32343642	1	Decal, wiring schematic Star Delta 60Hz
	32017444	1	Decal, voltage 460/3/60	22	32343907	1	Decal, lock and tag out
	32177305	1	Decal, voltage 575/3/60	23	32343899	1	Decal, warning flying debris
16	32343527	1	Decal, warning high pressure	24	22115703	1	Tag, rotation 60Hz
17	32343535	1	Decal, warning moving belts	25	32344095	2	Tag, shipping bracket
18	32343550	3	Decal, warning exposed fan				
19	32343568	2	Decal, warning hazardous voltage			†	Optional position

DANGER!
Hazard that **WILL** cause **DEATH, SEVERE INJURY** or substantial property damage if ignored. Instructions must be followed precisely to avoid injury or death.

WARNING!
Hazard that **CAN** cause **DEATH, SEVERE INJURY** or substantial property damage if ignored. Instructions which must be followed precisely to avoid injury or death.

CAUTIONS!
Cautions call attention to instructions which must be followed precisely to avoid damaging the product, process or its surroundings.

NOTES
Notes are used for supplementary information.

BREATHING AIR PRECAUTION
Ingersoll–Rand air compressors are not designed, intended or approved for breathing air. Compressed air should not be used for breathing air applications unless treated in accordance with all applicable codes and regulations.

General Information

Ensure that the operator reads and *understands* the decals and consults the manuals before maintenance or operation.

Ensure that the Operation and Maintenance manual is not removed permanently from the machine.

Ensure that maintenance personnel are adequately trained, competent and have read the Maintenance Manuals.

Do not point air nozzles or sprayers toward anyone.

Compressed air and electricity can be dangerous. Before undertaking any work on the compressor, ensure that the electrical supply has been isolated and the compressor has been relieved of all pressure.

Wear eye protection when operating or servicing compressor.

All persons positioned near to operating machinery should be equipped with hearing protection and given instructions on its use in accordance with workplace safety legislation.

Make sure that all protective covers are in place and that the canopy/doors are closed during operation.

The specification of this machine is such that the machine is not suitable for use in flammable gas risk areas.

Installation of this compressor must be in accordance with recognised electrical codes and any local Health and Safety Codes.

The use of plastic bowls on line filters can be hazardous. Their safety can be affected by either synthetic lubricants, or the additives used in mineral oils. Ingersoll –Rand recommends that only filters with metal bowls should be used on a pressurised system.

Compressed air

Compressed air can be dangerous if incorrectly handled. Before doing any work on the unit, ensure that all pressure is vented from the system and that the machine cannot be started accidentally.

WARNING
Imposing a normal or emergency stop on the compressor will only relieve presure upstream of the minimum pressure valve on top of the separator tank.
If maintenance work is required downstream of this valve, ensure that all pressure is relieved at the process vent point external to the compressor

Ensure that the machine is operating at the rated pressure and that the rated pressure is known to all relevant personnel.

All air pressure equipment installed in or connected to the machine must have safe working pressure ratings of at least the machine rated pressure.

If more than one compressor is connected to one common downstream plant, effective isolation valves must be fitted and controlled by work procedures, so that one machine cannot accidently be pressurised / over pressurised by another.

Compressed air must not be used for a direct feed to any form of breathing apparatus or mask.

The discharged air contains a very small percentage of compressor lubricant and care should be taken to ensure that downstream equipment is compatible.

If the discharged air is to be ultimately released into a confined space, adequate ventilation must be provided.

When using compressed air always use appropriate personal protective equipment.

All pressure containing parts, especially flexible hoses and their couplings, must be regularly inspected, be free from defects and be replaced according to the Manual instructions.

Compressed air can be dangerous if incorrectly handled. Before doing any work on the unit, ensure that all pressure is vented from the system and that the machine cannot be started accidentally.

Avoid bodily contact with compressed air.

All safety valves located in the separator tank must be checked periodically for correct operation.

Do not over–pressurize the receiver tank or similar vessels beyond design limits.

Do not use a receiver tank or similar vessels that fail to meet the design requirements of the compressor. Contact your distributor for assistance.

Do not drill into, weld or otherwise alter the receiver tank or similar vessels.

Materials

The following substances are used in the manufacture of this machine and *may* be hazardous to health if used incorrectly:

. preservative grease
. rust preventative
. compressor coolant

AVOID INGESTION, SKIN CONTACT AND INHALATION OF FUMES

Transport

When loading or transporting machines ensure that the specified lifting and tie down points are used.

Lifting equipment must be properly rated for the weight of the compressor.

Do not work on or walk under the compressor while it is suspended.

Electrical

Keep all parts of the body and any hand–held tools or other conductive objects, away from exposed live parts of the compressor electrical system. Maintain dry footing, stand on insulating surfaces and do not contact any other portion of the compressor when making adjustments or repairs to exposed live parts of the compressor electrical system.

WARNING
Any electrical connections or adjustments should only be made by a suitably qualified electrician

Close and lock all access doors when the compressor is left unattended.

Do not use extinguishers intended for Class A or Class B fires on electrical fires. Use only extinguishers suitable for class *BC* or class *ABC* fires.

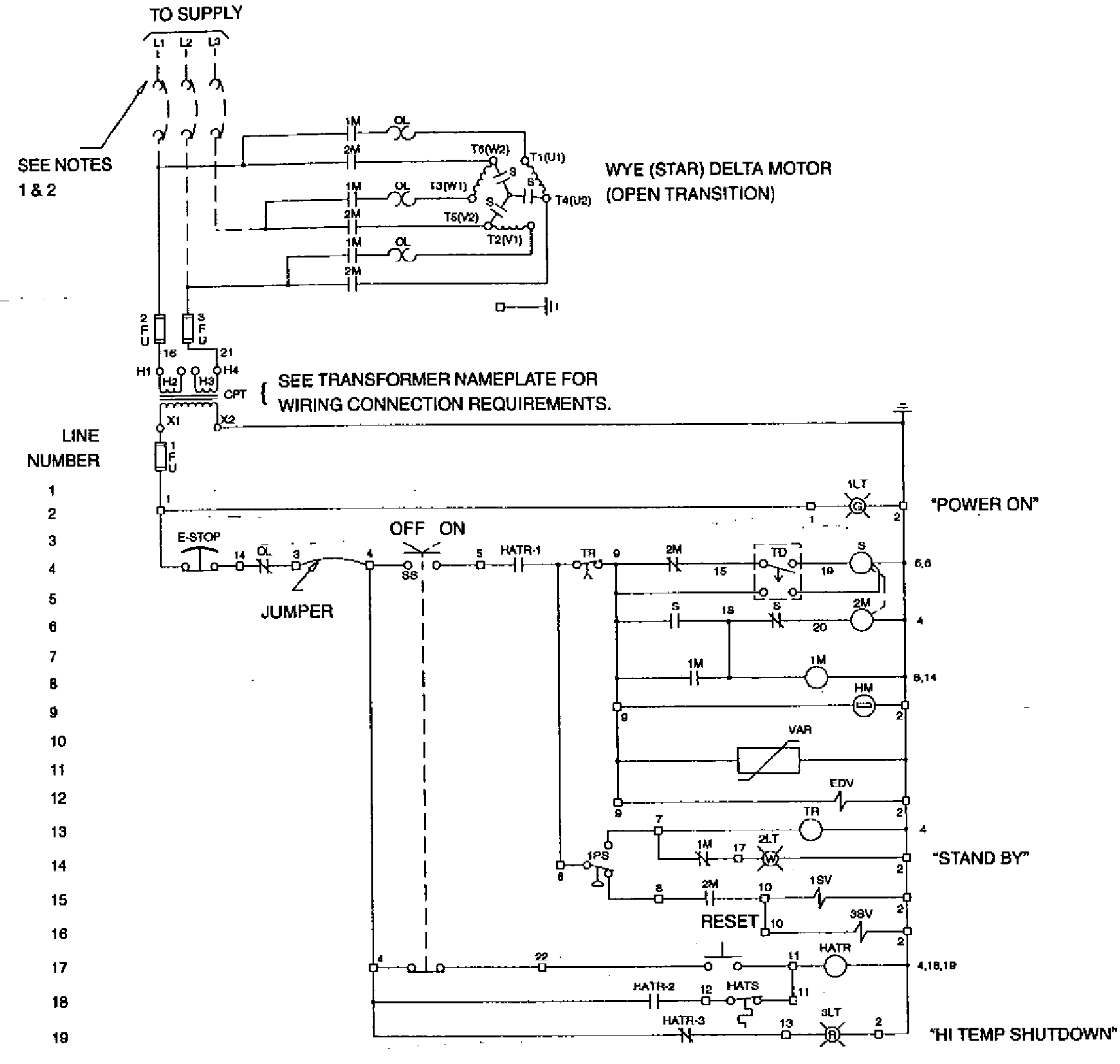
Attempt repairs only in clean, dry, well lighted and ventilated areas.

Connect the compressor only to electrical systems that are compatible with its electrical characteristics and that are within it's rated capacity.

Condensate disposal

As waste water regulations vary by country and region it is the responsibility of the user to establish the limitations and regulations in their particular area. Ingersoll–Rand and its associated distributors are happy to advise and assist in these matters.

For further information, consult Material Data Sheets CPN 88303979 for ULTRA–Plus Coolant.



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Rev. D

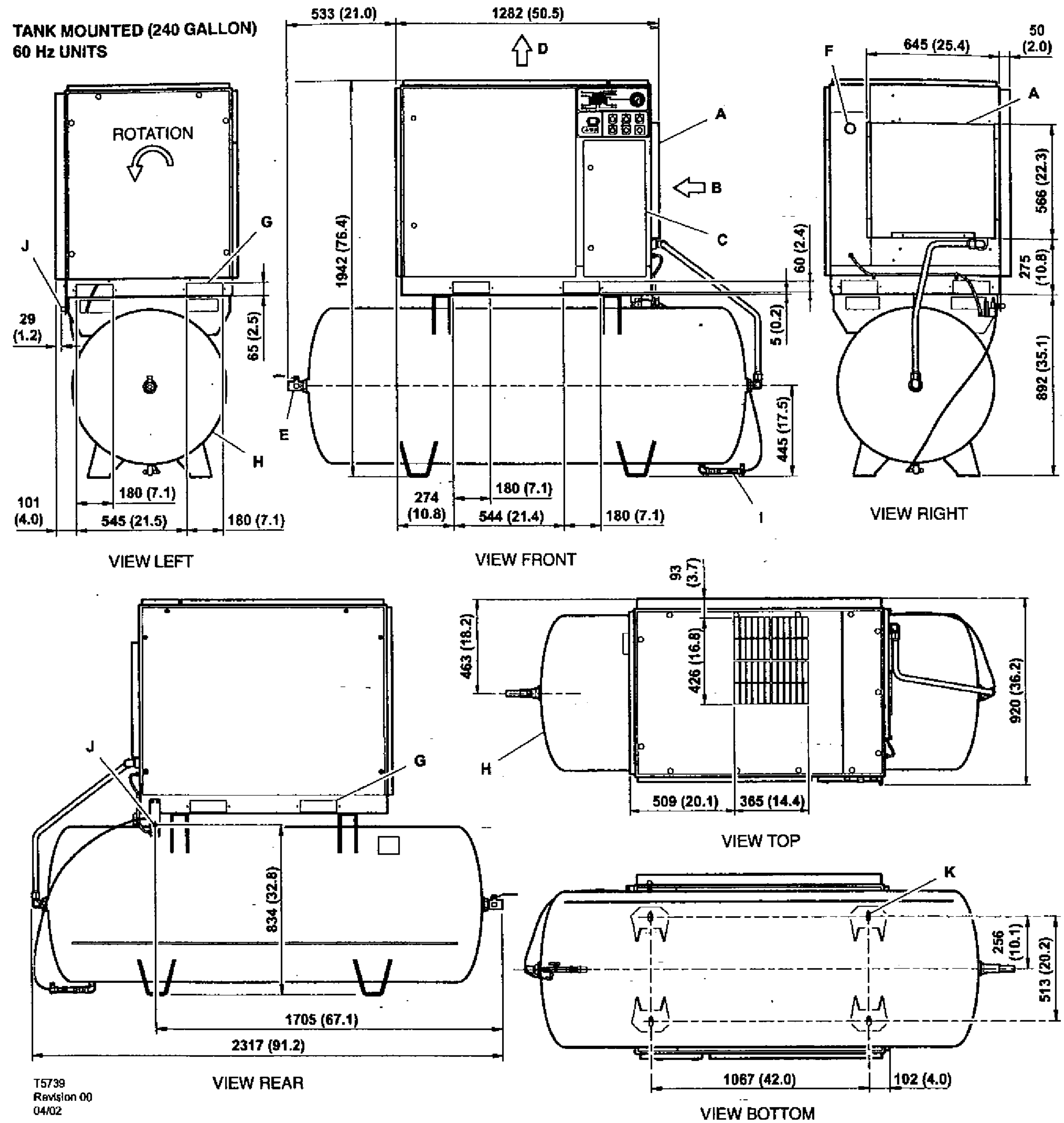
LEGEND

CPT	Transformer, control
EDV	Valve, electric drain
E–STOP	Button, emergency stop
FU	Fuse
HM	Hourmeter
HATR	Relay, high air temperature
HATS	Switch, high air temperature
1M	Contactor (main)
2M	Contactor (delta)
OL	Overload, motor starter
PS	Switch, pressure
SS	Switch, selector
S	Contactor (wye / star)
1SV	Valve, solenoid (Load) N.C.
3SV	Valve, solenoid (Blowdown) N.O.
TD	Relay, Delta starting (10 second)
TR	Relay, auto restart time delay (6 min)
VAR	Varistor
-□-	Terminal points
	L1, L2, L3 Light, transformer type

NOTES

1. Approved fused disconnect or circuit breaker per code requirements must be provided by customer.
2. Dashed lines represent wiring by customer.
3. Sizing of electrical components not supplied by Ingersoll–Rand is the responsibility of the customer and should be done in accordance with the information on the compressor data plate and local electrical codes.
4. Unit will not restart automaticlly after power outage.
5. Circuit shown in normal position de–energized.
6. All wiring to be in accordance with local codes.

TANK MOUNTED (240 GALLON)
60 Hz UNITS



KEY

A	Pre filter
B	Compressor and cooling air intake
C	Starter box
D	Cooling air exhaust
E	1.00" NPT air discharge
F	Customer power inlet
G	Fork lift openings
H	Air receiver (240 gallons)
I	Automatic drain valve
J	0.25 inch condensate drain
K	4 slots 17 (0.7) x 44 (1.8)

See notes – Page 15

NOTES

1. Coolant (lubricant) fill quantity (approximate) 3.4 US gallons (13 liters).

2. Recommended clearance in front of control panel door 42 inches (1067 mm) or minimum as required by the latest national electrical codes (NEC) or applicable local codes.

3. Recommended clearances on left and right sides 36 inches (914mm).

4. Minimum recommended clearance for the rear of the compressor is to be 6 inches (152mm).

5. External piping shall not exert any unresolved moments or forces on the unit. Use pipe size as large or larger at discharge connection.

6. There should be no plastic or pvc piping attached to this unit or used for any lines downstream.

7. Any field installed ducting to and from the compressor cannot add more than 1/2" (12.5mm). water gauge total air resistance.

8. Do not pipe into a common header with a reciprocating compressor, unless the reciprocating compressor utilizes a discharge pulsation damper.

9. Sizing of electrical components not supplied by Ingersoll Rand is the responsibility of the customer and should be done in accordance with the information on the compressor data plate and national and local electrical codes.

NOTE
All dimensions are in millimetres (inches) unless otherwise stated.

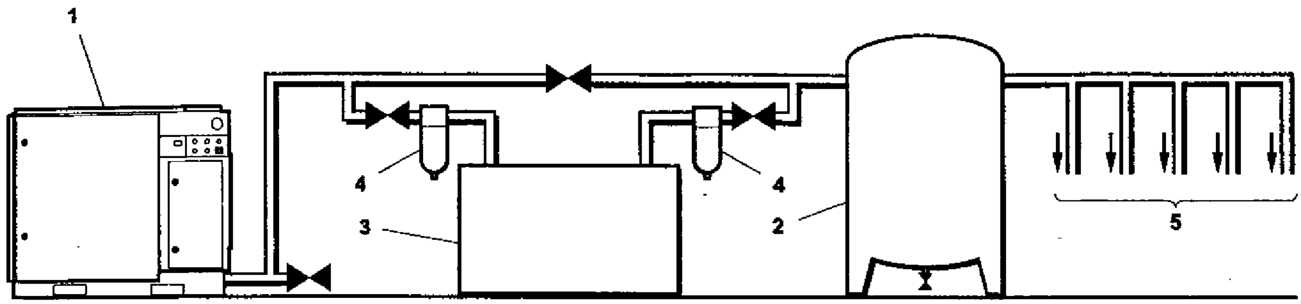
Ensure that the correct fork lift truck slots or marked lifting points are used whenever the machine is lifted or transported.

UNPACKING

The compressor will normally be delivered with a polythene cover. If a knife has to be used to remove this cover ensure that the exterior paintwork of the compressor is not damaged.

Ensure that all transport and packing materials are discarded in a manner prescribed by local codes.

NOTE
Units are shipped with transit locking bolt in place. Prior to running the unit the shipping bolt must be removed and the belt tension checked. Loosen, remove and discard 10mm shipping bolt. For belt tensioning procedure refer to Maintenance section.



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Revision 02
07/04

KEY
1. Compressor
2. Air Receiver
3. Air Dryer
4. Compressed air filters
5. System demand points

NOTE
Items [2] to [5] are optional or may be existing items of plant. Refer to your Ingersoll–Rand distributor / representative for specific recommendations.

LOCATION IN THE PLANT

The compressor can be installed on any level floor capable of supporting it. A dry, well ventilated area where the atmosphere is clean is recommended. A minimum of 150mm (6 inches) should be left at the rear and 1m (3ft) at the sides of the machine for adequate service access and ventilation.

Adequate clearance needs to be allowed around and above the machine to permit safe access for specified maintenance tasks.

Ensure that the machine is positioned securely and on a stable foundation. Any risk of movement should be removed by suitable means, especially to avoid strain on any rigid discharge piping.

CAUTION
Screw type compressors [1] should not be installed in air systems with reciprocating compressors without means of isolation such as a common receiver tank. It is recommended that both types of compressor be piped to a common receiver using individual air lines.

CAUTION
The use of plastic bowls on line filters and other plastic air line components can be hazardous. Their safety can be affected by either synthetic coolants or the additives used in mineral oils. Ingersoll–Rand recommends that only filters with metal bowls should be used on any pressurised system.

CAUTION
Before starting machine remove shipping bolt and discard

CAUTION
The standard compressor unit is not suitable for operation in temperatures liable to cause freezing as Condensate water is liable to be produced in the after cooler and receiver where fitted.

Refer to your Ingersoll–Rand distributor for further information.

DISCHARGE PIPING

Discharge piping should be at least as large as the discharge connection of the compressor. All piping and fittings should be suitably rated for the discharge pressure.

It is essential when installing a new compressor [1], to review the total air system. This is to ensure a safe and effective total system. One item which should be considered is liquid carryover. Installation of air dryers [3] is always good practice since properly selected and installed they can reduce any liquid carryover to zero.

It is good practice to locate an isolation valve close to the compressor and to install line filters [4].

It is a requirement for air dryers covered under Aircare that correctly sized Ingersoll–Rand pre and afterfilters are installed.

60Hz	UP6 15–HA			UP6 20–HA			UP6 25–HA		
COMPRESSOR	125	150	200	125	150	200	125	150	200
Maximum operating pressure PSIG (bar)	125 (8.62)	150 (10.34)	200 (13.79)	125 (8.62)	150 (10.34)	200 (13.79)	125 (8.62)	150 (10.34)	200 (13.79)
Factory set reload pressure PSIG (bar)	115 (7.93)	140 (9.66)	190 (13.10)	115 (7.93)	140 (9.66)	190 (13.10)	115 (7.93)	140 (9.66)	190 (13.10)
Flow rate CFM (m^3/MIN)	65.4 (1.85)	58 (1.64)	45 (1.28)	83 (2.35)	75 (2.12)	58 (1.64)	102 (2.89)	92 (2.61)	75 (2.12)

Airend discharge temperature trip point	228°F (109°C)
Ambient operating temperature min. → max.	35°F(+2°C) → 122°F(+50°C)

MOTOR						
Motor enclosure	ODP	TEFC	ODP	TEFC	ODP	TEFC
Nominal power	15HP		20HP		25HP	
Speed	1765 RPM	1770 RPM	1765 RPM	1770 RPM	1765 RPM	1770 RPM
Frame	256TZ	160 L	284TZ	180 M	286TZ	180 L
Insulation class	F					

COOLING SYSTEM			
Air cooled			
Cooling air flow	1770 ft^3/min	2100 ft^3/min	2100 ft^3/min
Maximum ΔP in air ducts	0.5 inWg (12.7mmH_2O)		
Compressed air outlet ΔT	22°F (12°C)	24°F (13°C)	19°F (10°C)
Cooling air outlet ΔT	21°F (12°C)	26°F (14°C)	29°F (16°C)
GENERAL DATA			
Residual coolant content	3ppm (3 mg/m^3)		
Separator vessel capacity	4.5 gallons (17 liters)		
Coolant capacity	3.4 gallons (13 liters)		
Sound pressure level to CAGI–PNEUROP	68 dB(A)	68 dB(A)	69 dB(A)
Weight – base mount unit	1183 lbs (538 kg)	1203 lbs (547 kg)	1290 lbs (586 kg)
Weight – 120 gallon Receiver mounted	1510 lbs (685 kg)	1530 lbs (694 kg)	1616 lbs (733 kg)
Weight – 240 gallon Receiver mounted	1779 lbs (807 kg)	1799 lbs (816 kg)	1885 lbs (855 kg)

CAUTION

230/460 Dual voltage machines are fitted with a decal to advise the correct voltage as connected from the factory.

There is a decal fitted to the starter door describing the procedure to change the connections for the alternative voltage

Rewiring should only be effected by a competent Electrician.

ELECTRICAL DATA – ALL UNITS SSR UP6–30 / UP6 25–HA										
Standard voltage	**200V**		**230V**		**380V**		**460V**		**575V**	
Drive motor										
Motor enclosure	**ODP**	**TEFC**	**ODP**	**TEFC**	**ODP**	**TEFC**	**ODP**	**TEFC**	**ODP**	**TEFC**
Power	30HP									
Full load current (max) / HA	91.3/80.8A	91.9/79.8A	79.3/70.3A	79.9/69.4A	48.1/42.6A	48.4/42.0A	39.7/35.2A	40.0/34.7A	31.7/28.1A	32.0/27.8A
Starting current DOL (STAR)	500 (216.7)		434 (188.4)		263 (114)		217 (94.2)		169 (75.4)	
Starting time DOL (Star Delta)	3–5 Sec (7–10 Sec)									
Starts per hour (maximum)	6									
ELECTRICAL DATA DOL / Star Delta										
Control voltage	120VAC									
Minimum fuse rating See note 1	150A		125A		80A		60A		50A	
Minimum wire size AWG See note 2	1		2		4		6		8	

1. If a circuit breaker is selected it should only be a magnetic trip type, set above the anticipated starting current of the machine, but below the maximum prospective fault current for the circuit. The circuit breaker or fuseable disconnect must be capable of breaking the prospective fault current at its terminals.

2. PVC/PVC Type Calculated using the following conditions:

i) PVC insulated cable, armoured, copper conductors.
ii) Cable clipped to a wall, in free air.
iii) Ambient temperature of 40°C (104°F) and relative humidity of 40%.
iv) 20m (65ft) cable run.
v) Volt drop limited to –10% during starting, –4% during normal running.
vi) Protected by the circuit breaker listed above.

If there are any deviations from the above, or special regulations apply, the installation must be planned by a competent, qualified engineer.

NOTE
All data applies to standard product only.

ELECTRICAL DATA

- An independent electrical isolator or disconnect should be installed adjacent to the compressor.

Feeder cables/wires should be sized by the customer/electrical contractor to ensure that the circuit is balanced and not overloaded by other electrical equipment. The length of wiring from a suitable electrical feed point is critical as voltage drops may impair the performance of the compressor.

Feeder cables / wires connections to isolator or disconnect should be tight and clean.

The applied voltage must be compatible with the motor and compressor data plate ratings.

The control circuit transformer has different voltage tappings. Ensure that these are set for the specific applied voltage prior to starting.

CAUTION
Never test the insulation resistance of any part of the machines electrical circuits, including the motor without completely disconnecting the electronic controller (where fitted).

CAUTION
Ensure that the motor rotates in the correct direction as indicated by direction arrows, and on drawing.

GENERAL OPERATION

The compressor is an electric motor driven, single stage screw compressor, complete with accessories piped, wired and baseplate mounted. It is a totally self contained air compressor package.

The standard compressor is designed to operate in an ambient range of 35.6°F – 104°F (2°C to 40°C) with a special option package available to operate in ambient temperatures ranges from 35.6°F up to 124°F (2°C up to 50°C). The maximum temperature is applicable to either version up to a maximum elevation of 3280ft (1000m) above sea level. Above this altitude significant reduction in maximum allowable ambient temperature is required.

Compression in the screw type air compressor is created by the meshing of two (male & female) helical rotors.

The air/coolant mixture discharges from the compressor into the separation system. This system removes all but a few PPM of the coolant from the discharge air. The coolant is returned to the cooling system and the air passes through the aftercooler and out of the compressor.

Cooling air is moved through the coolers by the cooling fan and discharged from the machine.

CAUTION
Cooling air is drawn in at the end of the machine package passing through the filter and cooler before being discharged from the top of the machine. Care should be taken to avoid blocking the airflow, or causing any restriction in excess of the maximum backpressure allowed for ducting.
Do not direct the airflow at face or eyes.

The power transmission from the drive motor to the airend male rotor is by pulley and belts. The constant auto tensioning system, using airend mass torque and gas arm, ensures that the belts are always under the correct tension, eliminating the need for adjustment and maximizing the life of the belts.

By cooling the discharge air, much of the water vapour naturally contained in the air is condensed and may be drained from the downstream piping and equipment.

The coolant system consists of a sump, cooler, thermostatic valve and a filter. When the unit is operating, the coolant is pressurized and forced to the compressor bearings.

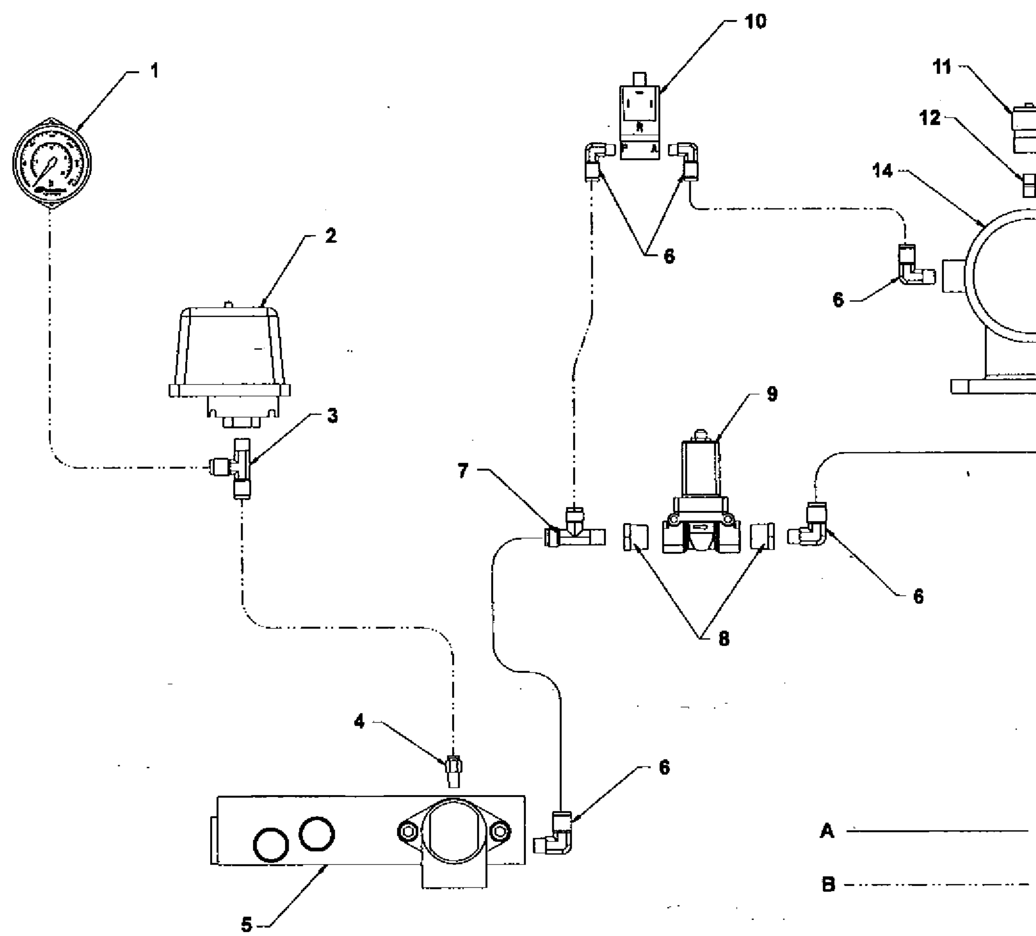
The compressor load control system is automatic **on–off line.** The compressor will operate to maintain a set discharge line pressure and is provided with an auto restart system for use in plants where the air demand varies sufficiently to allow a compressor to shut down and save power. Significant system volume will assist this and is recommended.

WARNING
When the unit stops running as the result of low air demand, normally indicated by auto restart light, it may restart and return to load at any time.

Safety of operation is provided as the compressor will shut down if excessive temperatures or electrical overload conditions should occur.

CAUTION
This unit is not designed or intended to operate when contaminated with silicone. Lubricants, greases or other items containing silicone should not be used on this unit.

ELECTRO–PNEUMATIC CONTROL AND INSTRUMENTATION



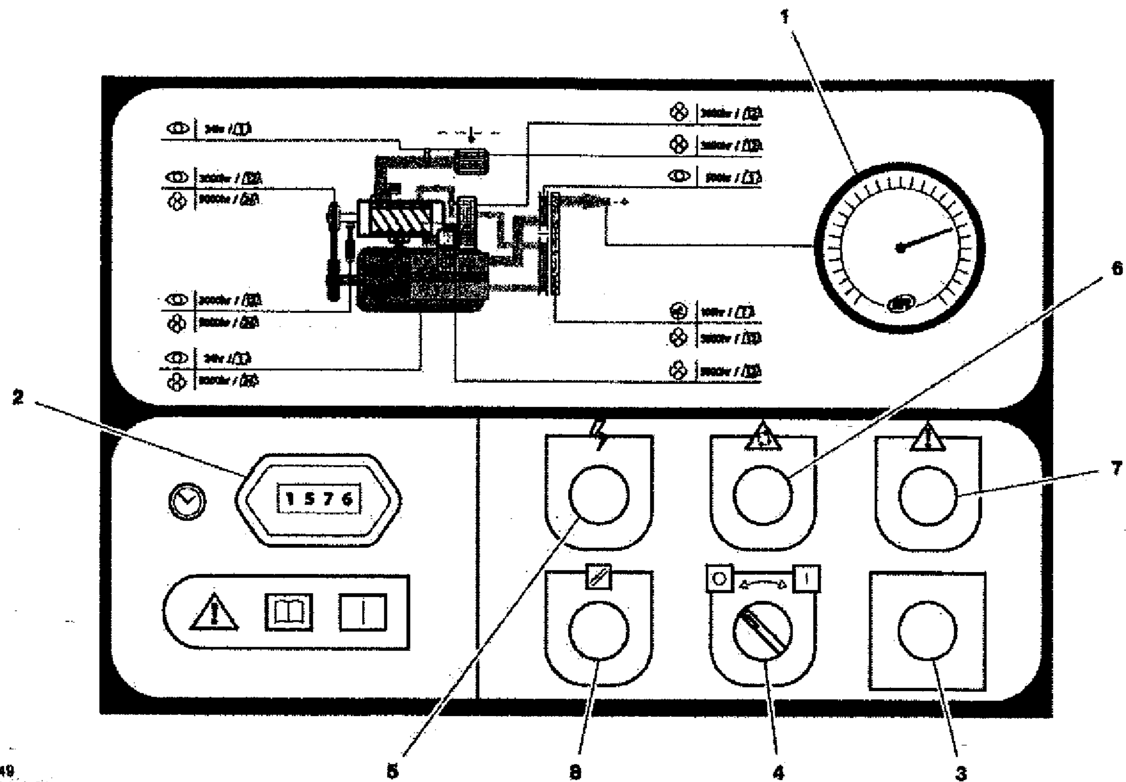
KEY

1. Pressure gauge
2. Pressure switch
3. Tee
4. Connector
5. Combination block
6. Elbow
7. Tee, male run
8. Reducer bushing
9. Valve, solenoid (Blowdown)
10. Valve, solenoid (Load)
11. Indicator air filter
12. Nipple
13. Adaptor
14. Intake valve assembly

NOTES:

A. Tubing 3/8 inch

B. Tubing 1/4 inch



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Revision 00
08/01

1. **PRESSURE GAUGE**
   Indicates the system pressure.

WARNING
DO NOT operate the compressor at discharge pressures exceeding the maximum operating pressure.

2. **HOURMETER**
   Records the total running time of the compressor.

3. **EMERGENCY STOP**
   When depressed will stop the compressor immediately. The 'Power on' indicator will remain illuminated. The emergency stop button must be released before the compressor can be restarted.

4. **START/STOP**
   When switched to the ON position will cause the unit to start and run in a loaded condition if there is a demand for air. If there is no demand, the machine will run unloaded before stopping automatically.
   When switched to the OFF position, will unload and stop the unit if it is running. If the unit is in auto restart it will prevent the unit from re–starting when there is a demand for air.

5. **POWER ON (Green)**
   Indicates the presence of control voltage at the controller.

6. **AUTO RESTART (White)**
   Will illuminate when the machine has shut-down due to low air demand. The machine will restart and load automatically as soon as the demand for air returns.

7. **FAULT / HIGH AIR TEMPERATURE ALARM (Red)**
   Turn off electrical Isolator or disconnect. Investigate cause of fault.

8. **RESET BUTTON**
   Press button to reset the control system following compressor trip.

PRIOR TO STARTING

1. Make visual check of the machine, ensure that all guards secure and that nothing is obstructing the proper ventilation of, or free access to the machine.

2. Check coolant level. Add if necessary.

3. Make sure main discharge valve is open.

4. Turn on electrical isolator or disconnect. The **Power on** (5) indicator will light, indicating that line and control voltages are available.

5. Check direction of rotation at initial start or following interruption in power supply.

WARNING
Make sure that all protective covers are in place. **Cooling air flow exhaust may contain flying debris. Safety Protection should be worn at all times to avoid injury.**

STARTING

1. Push the RESET button (8). The fault indicator (7) will extinguish. Switch the ON/OFF switch (4) to the ON position. The compressor will start and then load automatically.

NORMAL/EMERGENCY STOPPING

1. Switch the ON/OFF switch (4) to the OFF position. The compressor will unload and stop.

2. Press **EMERGENCY STOP** button (3) and the compressor will stop immediately.

3. Turn off electrical isolator or disconnect.

CAUTION
After shutdown never allow unit to stand idle with pressure in receiver/separator system.

SSR UP Series Maintenance Schedule

PERIOD	MAINTENANCE
Each 24 hours operation	Check the coolant level and replenish if necessary.
Visual check of machine for any leaks, dust build up or unusual noise or vibration	Report immediately, contact Ingersoll–Rand authorized distributor for assistance if in doubt
When compressor is receiver mounted	Drain air receiver of condensate, or check that automatic drain is operating
Visual check condition of package pre–filter	Blow clean if needed
If the air filter indicator locks into the red position before the 3000 hour/1 year change out period	Check the Condition of filter. Change the air filter if needed. Dusty environments require more frequent replacement or, optional high dust filter (The indicator sould be checked with unit stopped.)
First 150 hours	Change the coolant filter.
Each month or 100 hours	Remove and clean package pre–filter, replace if needed Check the cooler(s) for build up of foreign matter. Clean if necessary by blowing out with air or by pressure washing.
Each year or 3000 hours	Change the coolant filter. Check scavenge screen for blockage, clean if required. Change the separator cartridge. Change the Air Filter element. Take coolant sample for fluid analysis. Change the package pre–filter. Check the inlet valve flapper, recondition as necessary. Visual Check of Drive Belts and tensioning gas spring.
Pressure vessel inspection frequency may be otherwise defined by local or national legislation.	*Separator vessel and air receiver when fitted.* Fully inspect all external surfaces, and fittings. Report any excessive corrosion, mechanical or impact damage, leakage or other deterioration.
Every two years or 9000 hours	Change drive belt and gas spring. Replace the *Ultra Plus Coolant* at whichever interval occurs first. Check and replace all items included within 3000 hour service Fit the following reconditioning parts as appropriate: Solenoid valves, Inlet valve kit, Minimum Pressure valve kit, Thermostatic Valve Kit
Every 4 years or 18000 hours	Replace all hoses. Strip, clean and re–Grease motor bearings of ODP motors. Replace sealed bearing on IP55 motors. Fit replacement electrical contactor tips.
6 years/18000 hours or as defined by local or national legislation.	*Separator tank.* Remove the cover plate and any necessary fittings. Clean the interior thoroughly and inspect all internal surfaces.

ROUTINE MAINTENANCE

This section refers to the various components which require periodic maintenance and replacement.

. It should be noted that the intervals between service requirement may be significantly reduced as a consequence of poor operating environment. This would include effects of atmospheric contamination and extremes of temperature.

The *SERVICE/MAINTENANCE CHART* indicates the various components' descriptions and the intervals when maintenance has to take place. Oil capacities, etc., can be found in the *GENERAL INFORMATION* section of this manual.

Compressed air can be dangerous if incorrectly handled. Before doing any work on the unit, ensure that all pressure is vented from the system and that the machine cannot be started accidentally.

CAUTION: Before beginning any work on the compressor, open, lock and tag the main electrical disconnect and close the isolation valve on the compressor discharge. Vent pressure from the unit by slowly unscrewing the coolant fill cap one turn. Unscrewing the fill cap opens a vent hole, drilled in the cap, allowing pressure to release to atmosphere. Do not remove the fill cap until all pressure has vented from the unit. Also vent piping by slightly opening the drain valve. When opening the drain valve or the coolant fill cap, stand clear of the valve discharge and wear appropriate eye protection.

Ensure that maintenance personnel are properly trained, competent and have read the Maintenance Manuals.

Prior to attempting any maintenance work, ensure that:–

. all air pressure is fully discharged and isolated from the system. If the automatic blowdown valve is used for this purpose, then allow enough time for it to complete the operation.

. the machine cannot be started accidently or otherwise.

. all residual electrical power sources (mains and battery) are isolated.

Prior to opening or removing panels or covers to work *inside* a machine, ensure that:–

. anyone entering the machine is aware of the reduced level of protection and the additional hazards, including hot surfaces and intermittently moving parts.

. the machine cannot be started accidently or otherwise.

Prior to attempting any maintenance work on a *running* machine, ensure that:–

DANGER
Only properly trained and competent persons should undertake any maintanence tasks with the compressor running or with electrical power connected.

. the work carried out is limited to only those tasks which require the machine to run.

. the work carried out with safety protection devices disabled or removed is limited to only those tasks which require the machine to be running with safety protection devices disabled or removed.

. all hazards present are known (e.g. pressurised components, electrically live components, removed panels, covers and guards, extreme temperatures, inflow and outflow of air, intermittently moving parts, safety valve discharge etc.).

. appropriate personal protective equipment is worn.

. loose clothing, jewellery, long hair etc. is made safe.

. warning signs indicating that *Maintenance Work is in Progress* are posted in a position that can be clearly seen.

Upon completion of maintenance tasks and prior to returning the machine into service, ensure that:–

. the machine is suitably tested.

. all guards and safety protection devices are refitted and correctly working.

. all panels are replaced, canopy and doors closed.

. hazardous materials are effectively contained and disposed of in a manner compliant with local or National environmental protection codes.

WARNING
Do not under any circumstances open any drain valve or remove components from the compressor without first ensuring that the compressor is FULLY SHUT– DOWN, power isolated and all air pressure relieved from the system.

TOP UP COOLANT PROCEDURE

The reservoir is designed to prevent overfill. With warm unit stopped in the normal way, the sight tube level should be within 15mm (0.6in) of the top of the green strip. The level should not drop beyond the bottom of the sight tube when running with a steady load.

CAUTION
Ensure that SSR ULTRA–PLUS coolant is used. Failure to do so will void manufacturers warranty.

COOLANT CHANGE PROCEDURE

It is better to drain the coolant immediately after the compressor has been operating as the liquid will drain more easily and any contaminant will still be in suspension.

1. Stop the machine, electrically isolate and vent all trapped pressure.

2. Place a suitable container close to the drain valve.

3. Slowly remove fill/vent cap.

4. Remove plug from drain valve.

5. Open the drain valve and drain coolant into container.

6. Close the drain valve.

7. Replace plug in drain valve.

8. Refill the machine following the "top up coolant" procedure above. After initial fill, to purge any airlocks, the machine should be run for a few minutes cycling between load and no load, before checking that the level is correct.

9. Replace and tighten oil fill cap.

COOLANT FILTER CHANGE PROCEDURE

1. Stop the machine, electrically isolate and vent all trapped pressure.

2. Loosen filter with the correct tool.

3. Remove the filter from the housing.

4. Place the old filter in a sealed bag and dispose of in a safe way.

5. Clean the mating face of the housing taking care to avoid any particles entering the machine.

6. Remove the new Ingersoll–Rand replacement filter from its protective package.

7. Apply a small amount of lubricant to the filter seal.

8. Screw the new filter down until the seal makes contact with the housing, then hand tighten a further half turn.

9. Start the compressor and check for leaks.

AIR FILTER ELEMENT CHANGE PROCEDURE

1. Stop the machine, electrically isolate and vent all trapped pressure.

2. Unscrew the retaining cap and withdraw the old element.

3. Fit the new element.

4. Replace the retaining cap.

SEPARATOR CARTRIDGE CHANGE PROCEDURE

1. Stop the machine, electrically isolate and vent all trapped pressure.

2. Loosen separator cartridge with the correct tool.

3. Remove the cartridge from the housing; place it in a sealed bag and dispose of it safely.

4. Clean the mating face of the housing.

5. Remove the new Ingersoll–Rand replacement cartridge from its protective package.

6. Apply a small amount of lubricant to the cartridge seal.

7. Screw the new cartridge down until the seal makes contact with the housing, then hand tighten a further half turn.

8. Start the compressor and check for leaks.

> CAUTION
> **This unit is not designed or intended to operate when contaminated with silicone. Lubricants, greases or other items containing silicone should not be used on this unit.**

COOLER CLEANING PROCEDURE

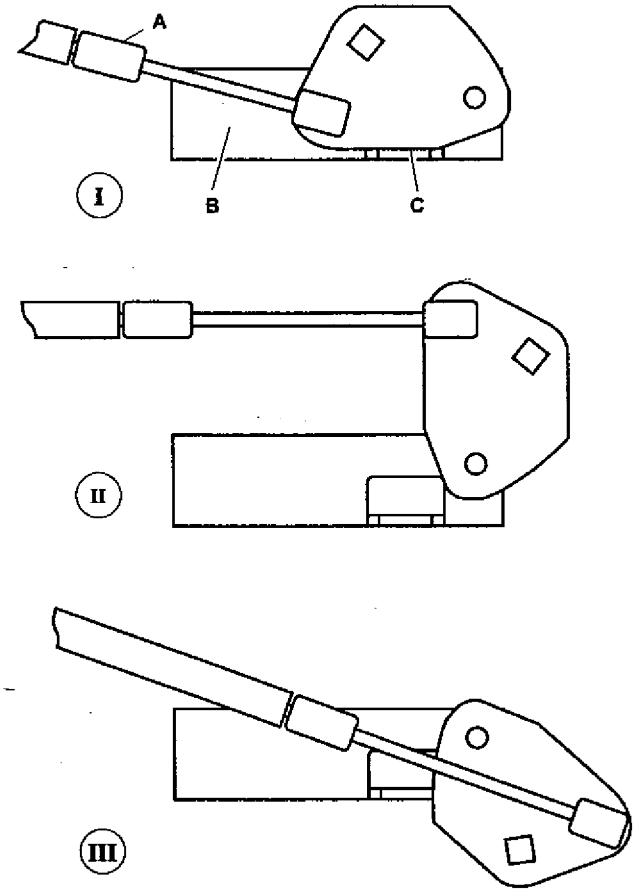
1. Stop the machine, electrically isolate and vent all trapped pressure.

2. Remove the top cover to obtain access to the cooler.

3. Clean the cooler.

4. Rebuild in reverse order.

BELT CHANGE / GAS STRUT CHANGE PROCEDURE



A. Gas strut.

B. Support bracket (part of pivoted assembly).

C. Tension cam.

1. Stop the machine, electrically isolate and vent all trapped pressure.

2. Remove the side cover from the machine.

3. Fit a $^1/_2$" square drive wrench in the tension cam located above the airend (access from front door). Turn clockwise $^1/_4$ turn to Position II to release gas strut tension on the belts.

4. Using a small screwdriver under the spring clip, ease the ball ends off the spherical studs at the ends of the gas strut.

5. Replace the gas strut and the studs at the same time by removing and replacing the studs then pushing the new gas strut firmly onto the studs until it clicks into place.

6. Turn the tension cam clockwise $^1/_4$ turn to Position III to raise and support the airend. Place a block of wood or similar under the separator tank for support.

7. Replace the belts from the left side of the machine.

8. Turn the tension cam counter-clockwise $^1/_2$ turn to Position I to tension the gas strut.

9. Spin the drive to check alignment of the belt ribs on the pulleys (sheaves).

ELECTRIC DRAIN VALVE

PRODUCT DESCRIPTION

The Electric Drain Valve removes condensed water and oil from the air receiver tank. Additional drains may be installed throughout your compressed air system, including aftercoolers, filters, drip legs and dryers.

The Electric Drain Valve operates on a timer which can be set to automatically drain the air receiver tank at operator–determined intervals.

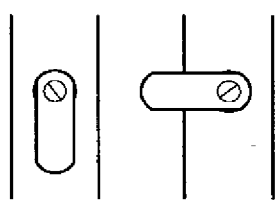
Key features include:

- 100% continuous duty
- NEMA 4 enclosure
- Adjustable time on (0.5 – 10 seconds)
- Adjustable time off (0.5 – 45 minutes)
- Stainless steel operator
- LED to indicate electrical power is on
- LED to indicate valve is open
- Manual override

OPERATION

1. Open the strainer ball valve.

Strainer Ball Valve.



2. Set the "time off" and "time on" knobs. See TIMER SETTINGS (below) for an explanation of the settings.

3. During compressor operation, check for air leaks.

TIMER SETTINGS

The "time off" setting determines the interval between cycles from 30 seconds to 45 minutes. The "time on" setting determines the actual time the compressor drains condensate.

The timer's cycle rate and drain opening time should be adjusted to open just long enough to discharge the condensate. The timer is properly set when it opens and discharges condensate and then vents air for approximately one second before closing. Adjustments may be made depending on mny factors, including humidity and duty cycle.

TROUBLESHOOTING

TROUBLE	CAUSE	ACTION
Valve will not close.	1. Debris in solenoid valve prevents diaphragm from seating.	1. Remove solenoid valve, disassemble, clean and reassemble.
	2. Short in electrical component.	2. Check and replace power cord or timer as needed.
Timer will not activate	1. No electrical supply.	1. Apply power.
	2. Timer malfunction	2. Replace timer.
	3. Clogged port.	3. Clean valve.
	4 Solenoid valve malfunction.	4. Replace solenoid valve.
	5. Clogged strainer.	5. Clean strainer.

MAINTENANCE

Periodically clean the screen inside the valve to keep the drain functioning at maximum capacity. To do this, perform the following steps:

1. Close the strainer ball valve completely to isolate it from the air receiver tank.

2. Press the TEST button on the timer to vent the pressure remaining in the valve. Repeat until all pressure is removed.

CAUTION! High pressure air can cause injury from flying debris. Ensure the strainer ball valve is completely closed and pressure is released from the valve prior to cleaning.

3. Remove the plug from the strainer with a suitable wrench. If you hear air escaping from the cleaning port, STOP IMMEDIATELY and repeat steps I and 2.

4. Remove the stainless steel filter screen and clean it. Remove any debris that may be in the strainer body before replacing the filter screen.

5. Replace plug and tighten with wrench.

6. When putting the Electric Drain Valve back into service, press the TEST button to confirm proper function.

PROBLEM	CAUSE	REMEDY
Compressor fails to start	Mains power or Control voltage not available.	§ Check incoming power supply. § Check the control circuit fuse. § Check the transformer secondary windings for the control voltage.
	Defective Star / Delta timer.	§ Change Star / Delta timer.
Machine shutsdown periodically	High airend temperature.	Top up coolant.
	Motor overload.	§ Set overload to correct value and switch to manual reset.
	Belt stretch protection (when fitted).	Change belt.
	Line voltage variation.	§ Ensure voltage does not drop below 10% on start up and 6% running.
High current draw	Compressor operating above rated pressure.	Set pressure to correct rating for machine.
	Separator cartridge contaminated.	Change air filter, and separator cartridge.
	Low voltage.	§ Ensure voltage does not drop below 10% on start up and 6% running.
	Unbalanced voltage.	Correct incoming supply voltage.
	Damaged airend.	† Change Airend.
Low current draw	Air filter contaminated.	Change air filter.
	Compressor operating unloaded.	Set pressure to correct rating for machine.
	High voltage.	Reduce site voltage to correct operating voltage.
	Defective inlet valve.	† Fit inlet valve service kit.
High discharge pressure	Defective or incorrect pressure switch setting.	Replace or set pressure to correct rating for machine.
	Load solenoid valve defective.	† Fit load solenoid service kit.
	Blowdown valve defective.	† Fit blowdown solenoid service kit.
	Inlet valve malfunction.	† Fit inlet valve service kit.
Low system air pressure	Separator cartridge contaminated.	Fit new Separator cartridge.
	Incorrect pressure switch setting.	Set pressure to correct rating for machine.
	Minimum pressure valve malfunction.	† Fit Minimum pressure valve service kit.
	Load solenoid valve defective.	† Fit load solenoid service kit.
	Blowdown valve defective.	† Fit blowdown solenoid service kit.
	Drive belt slipping.	Fit new belt and tensioner.
	Air system leaks.	† Fix leaks.
	Inlet valve malfunction.	† Fit inlet valve service kit.
	System demand exceeds compressor delivery.	Reduce demand or install additional compressor.

NOTES:

§ Must be carried out by a competent electrician.

† This work is recommended to be carried out only by an Ingersoll–Rand authorized service technician.

PROBLEM	CAUSE		REMEDY
Compressor trips due to over temperature	Compressor operating above rated pressure.		Set pressure to correct rating for machine.
	Package pre–filter blocked.		Clean / replace package pre–filter.
	Cooler blocked.		Clean cooler.
	Missing or incorrectly fitted enclosure panels		Ensure that all enclosure panels are correctly fitted
	Low coolant level.		Top up coolant and check for leaks.
	High ambient temperature.		Re–site compressor.
	Restricted cooling air flow.		Ensure correct air flow to compressor.
Excessive coolant consumption	Separator cartridge leak.		Fit new Separator cartridge.
	Blocked separator cartridge drain.	†	Remove fittings and clean.
	Compressor operating below rated pressure.		Set pressure to correct rating for machine.
	Coolant system leak.	†	Fix leaks.
Excessive noise level	Air system leaks.	†	Fix leaks.
	Airend defective.	†	Change Airend.
	Belts Slipping.		Replace belt and tensioner.
	Motor defective.	†	Replace motor.
	Loose components.	†	Retighten loose items.
Shaft seal leaking	Defective shaft seal.	†	Fit Airend shaft seal kit.
Pressure relief valve opens	Defective switch or incorrect pressure switch setting.		Replace or set pressure to correct rating for machine.
	Minimum pressure valve malfunction.	†	Fit Minimum pressure valve service kit.
	Load solenoid valve defective.	†	Fit load solenoid service kit.
	Blowdown valve defective.	†	Fit blowdown solenoid service kit.
	Inlet valve malfunction.	†	Fit inlet valve service kit.
Black residue on belt guard/cooler box	Drive belt slipping.		Replace belt and tensioner.
	Pulleys misaligned.		Re–align pulleys.
	Worn pulleys.	†	Replace pulleys and belt.
	Gas strut failed.		Replace belt and tensioner.

NOTES:

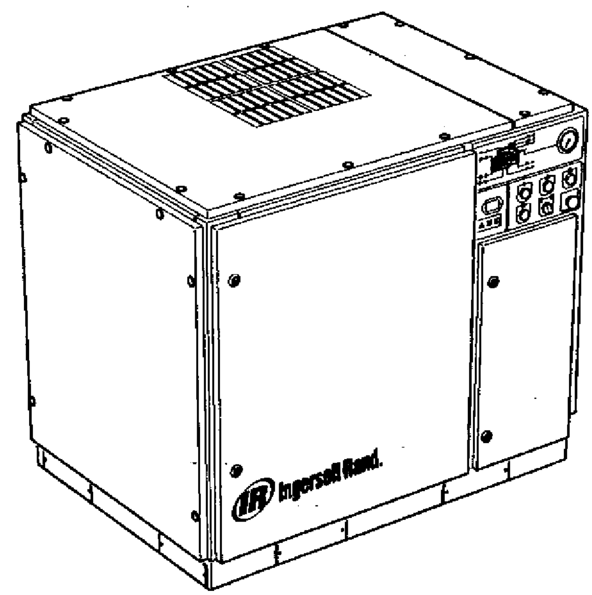
§ Must be carried out by a competent electrician.

† This work is recommended to be carried out only by an Ingersoll–Rand authorized service technician.

Ingersoll Rand

SSR UP6 15, UP6 20, UP6 25, UP6 30
60Hz

OPTIONS MANUAL
Intellisys Option
Dryer Option
High Dust Option
Outdoor Module Option
PORO Option



This manual contains important safety information and must be made available to personnel who operate and maintain this machine.

C.C.N. : 22135917
REV : E
DATE : JANUARY 2005

CONTENTS

ABBREVIATIONS & SYMBOLS

####	Contact Ingersoll–Rand for serial number
–>####	Up to Serial No.
####–>	From Serial No.
*	Not illustrated
†	Option
NR	Not required
AR	As required
SM	Sitemaster/Sitepack
HA	High ambient machine
WC	Watercooled machine
AC	Aircooled machine
ERS	Energy recovery system
T.E.F.C.	Totally enclosed fan cooled motor (IP55)
O.D.P.	Open drip proof (motor)

cs	Czech
da	Danish
de	German
el	Greek
en	English
es	Spanish
et	Estonian
fi	Finnish
fr	French
hu	Hungarian
it	Italian
lt	Lithuanian
lv	Latvian, Lettish
mt	Maltese
nl	Dutch
no	Norwegian
pl	Polish
pt	Portuguese
sk	Slovak
sl	Slovenian
sv	Swedish
zh	Chinese

This manual is provided to cover instructions and technical data for additional options to the standard UP compressor range. It is provided as a SUPPLEMENT to the standard operators and parts manuals and should NOT be used for the operation of the complete machine.

The contents of this manual are considered to be proprietary and confidential to Ingersoll-Rand and should not be reproduced without the prior written permission of Ingersoll-Rand.

Nothing contained in this document is intended to extend any promise, warranty or representation, expressed or implied, regarding the Ingersoll-Rand products described herein. Any such warranties or other terms and conditions of sale of products shall be in accordance with the standard terms and conditions of sale for such products, which are available upon request.

This manual contains instructions and technical data to cover routine operation and scheduled maintenance tasks by operation and maintenance staff. Major overhauls are outside the scope of this manual and should be referred to an authorized Ingersoll-Rand service department.

All components, accessories, pipes and connectors added to the compressed air system should be:

. of good quality, procured from a reputable manufacturer and, wherever possible, be of a type approved by Ingersoll-Rand.

. clearly rated for a pressure at least equal to the machine maximum allowable working pressure.

. compatible with the compressor lubricant/coolant.

. accompanied with instructions for safe installation, operation and maintenance.

Details of approved equipment are available from Ingersoll-Rand Service departments.

The use of non-genuine spare repair parts other than those included within the Ingersoll-Rand approved parts list may create hazardous conditions over which Ingersoll-Rand has no control. Therefore Ingersoll-Rand does not accept any liability for losses caused by equipment in which non-approved repair parts are installed. Standard warranty conditions may be affected.

Ingersoll-Rand reserves the right to make changes and improvements to products without notice and without incurring any obligation to make such changes or add such improvements to products sold previously.

The intended uses of this machine are outlined below and examples of unapproved usage are also given, however Ingersoll-Rand cannot anticipate every application or work situation that may arise.

IF IN DOUBT CONSULT SUPERVISION.

This machine has been designed and supplied for use only in the following specified conditions and applications:

. Compression of normal ambient air containing no known or detectable additional gases, vapors, or particles

. Operation within the ambient temperature range specified in the *GENERAL INFORMATION* section of this manual.

The use of the machine in any of the situation types listed in table 1:–

a) Is not approved by Ingersoll-Rand,

b) May impair the safety of users and other persons, and

c) May prejudice any claims made against Ingersoll-Rand.

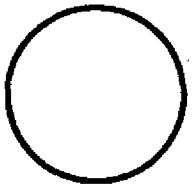
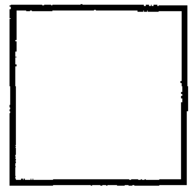
TABLE 1
Use of the machine to produce compressed air for: a) direct human consumption b) indirect human consumption, without suitable filtration and purity checks.
Use of the machine outside the ambient temperature range specified in the *GENERAL INFORMATION SECTION* of this manual.
Use of the machine where there is any actual or foreseeable risk of hazardous levels of flammable gases or vapors. THIS MACHINE IS NOT INTENDED AND MUST NOT BE USED IN POTENTIALLY EXPLOSIVE ATMOSPHERES, INCLUDING SITUATIONS WHERE FLAMMABLE GASES OR VAPOURS MAY BE PRESENT.
Use of the machine fitted with *non Ingersoll-Rand approved components.*
Use of the machine with safety or control components missing or disabled.

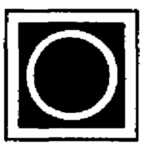
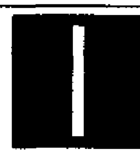
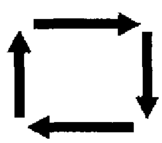
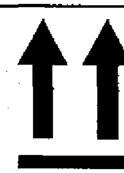
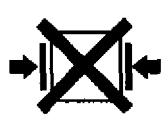
The company accepts no responsibility for errors in translation of this manual from the original English version.

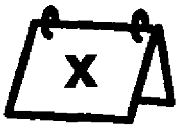
INTELLISYS is a registered trademark of Ingersoll-Rand Company USA.

ISO SYMBOLS

GRAPHIC FORM AND MEANING OF ISO SYMBOLS

		
Prohibition / Mandatory	Information / Instructions	Warning

 Use fork lift truck from this side only.	 RESET	 Do not use fork lift truck from this side.
 Emergency stop.	 On (power).	 Off (power).
 AUTOMATIC RESTART	 MAINTENANCE	 MAINTENANCE PROHIBITED
 FRAGILE	 KEEP DRY	 THIS WAY UP
 USE NO HOOKS	 NO SIDE CLAMPS	 HOURS

Use ULTRA-Plus Coolant only **Failure to use the specified coolant may result in damage to the machine**	 **POWER**	 **INSPECT**
 Every X months, if sooner than required by operating hours	 **CHANGE / REPLACE**	 **CLEAN**
 **MOISTURE**		

ANSI SYMBOLS

GRAPHIC FORM AND MEANING OF ANSI SYMBOLS

⚠ DANGER

INTAKE AIR. Can contain carbon monoxide or other contaminants. Will cause serious injury or death. Ingersoll–Rand air compressors are not designed, intended or approved for breathing air. Compressed air should not be used for breathing air applications unless treated in accordance with all applicable codes and regulations.

⚠ WARNING

HAZARDOUS VOLTAGE. Can cause serious injury or death. Disconnect power and bleed pressure from tank before servicing. Lockout/Tagout machine. Compressor must be connected to properly grounded circuit. See Grounding Instructions in manual. Do not operate compressor in wet conditions. Store indoors.

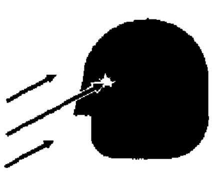
RISK OF FIRE OR EXPLOSION. Electrical arcing from compressor components can ignite flammable liquids and vapors which can result in serious injury. Never operate the compressor near flammable liquids or vapors. If used to spray flammable materials, keep compressor at least 20ft away from the spray area.

HIGH PRESSURE AIR. Rusted tanks can cause explosion and severe injury or death. Receiver under pressure. Operator should relieve tank pressure before performing maintenance. In addition to automatic drain, operate manual drain valve weekly. Manual drain valve located at bottom of the tank.

MOVING PARTS. Can cause serious injury. Do not operate with guards removed. Machine may start automatically. Disconnect power before servicing. Lockout/Tagout machine.

HOT SURFACES. Can cause serious injury. Do not touch. Allow to cool before servicing. Do not touch hot compressor or tubing.

EXPOSED MOVING BELTS AND SHEAVES.
Can cause severe injury or death.
Do not operate without guard in place. Disconnect power before servicing.
Lockout/Tagout machine.



Air flow exhaust may contain flying debris.
Safety protection should be worn at all times.

DANGER!
Hazard that **WILL** cause **DEATH, SEVERE INJURY** or substantial property damage if ignored. Instructions must be followed precisely to avoid injury or death.

WARNING!
Hazard that **CAN** cause **DEATH, SEVERE INJURY** or substantial property damage if ignored. Instructions which must be followed precisely to avoid injury or death.

CAUTIONS!
Cautions call attention to instructions which must be followed precisely to avoid damaging the product, process or its surroundings.

NOTES
Notes are used for supplementary information.

BREATHING AIR PRECAUTION
Ingersoll–Rand air compressors are not designed, intended or approved for breathing air. Compressed air should not be used for breathing air applications unless treated in accordance with all applicable codes and regulations.

General Information

Ensure that the operator reads and *understands* the decals and consults the manuals before maintenance or operation.

Ensure that the Operation and Maintenance manual is not removed permanently from the machine.

Ensure that maintenance personnel are adequately trained, competent and have read the Maintenance Manuals.

Do not point air nozzles or sprayers toward anyone.

Compressed air and electricity can be dangerous. Before undertaking any work on the compressor, ensure that the electrical supply has been isolated and the compressor has been relieved of all pressure.

Wear eye protection when operating or servicing compressor.

All persons positioned near to operating machinery should be equipped with hearing protection and given instructions on its use in accordance with workplace safety legislation.

Make sure that all protective covers are in place and that the canopy/doors are closed during operation.

The specification of this machine is such that the machine is not suitable for use in flammable gas risk areas.

Installation of this compressor must be in accordance with recognized electrical codes and any local Health and Safety Codes.

The use of plastic bowls on line filters can be hazardous. Their safety can be affected by either synthetic lubricants, or the additives used in mineral oils. Ingersoll –Rand recommends that only filters with metal bowls should be used on a pressurized system.

Compressed air

Compressed air can be dangerous if incorrectly handled. Before doing any work on the unit, ensure that all pressure is vented from the system and that the machine cannot be started accidentally.

WARNING
Imposing a normal or emergency stop on the compressor will only relieve pressure upstream of the minimum pressure valve on top of the separator tank.
If maintenance work is required downstream of this valve, ensure that all pressure is relieved at the process vent point external to the compressor

Ensure that the machine is operating at the rated pressure and that the rated pressure is known to all relevant personnel.

All air pressure equipment installed in or connected to the machine must have safe working pressure ratings of at least the machine rated pressure.

If more than one compressor is connected to one common downstream plant, effective isolation valves must be fitted and controlled by work procedures, so that one machine cannot accidently be pressurized / over pressurized by another.

Compressed air must not be used for a direct feed to any form of breathing apparatus or mask.

The discharged air contains a very small percentage of compressor lubricant and care should be taken to ensure that downstream equipment is compatible.

If the discharged air is to be ultimately released into a confined space, adequate ventilation must be provided.

When using compressed air always use appropriate personal protective equipment.

All pressure containing parts, especially flexible hoses and their couplings, must be regularly inspected, be free from defects and be replaced according to the Manual instructions.

Compressed air can be dangerous if incorrectly handled. Before doing any work on the unit, ensure that all pressure is vented from the system and that the machine cannot be started accidentally.

Avoid bodily contact with compressed air.

All safety valves located in the separator tank must be checked periodically for correct operation.

Do not over–pressurize the receiver tank or similar vessels beyond design limits.

Do not use a receiver tank or similar vessels that fail to meet the design requirements of the compressor. Contact your distributor for assistance.

Do not drill into, weld or otherwise alter the receiver tank or similar vessels.

Materials

The following substances are used in the manufacture of this machine and *may* be hazardous to health if used incorrectly:
- preservative grease
- rust preventative
- compressor coolant

AVOID INGESTION, SKIN CONTACT AND INHALATION OF FUMES

Transport

When loading or transporting machines ensure that the specified lifting and tie down points are used.

Lifting equipment must be properly rated for the weight of the compressor.

Do not work on or walk under the compressor while it is suspended.

Electrical

Keep all parts of the body and any hand–held tools or other conductive objects, away from exposed live parts of the compressor electrical system. Maintain dry footing, stand on insulating surfaces and do not contact any other portion of the compressor when making adjustments or repairs to exposed live parts of the compressor electrical system.

WARNING
Any electrical connections or adjustments should only be made by a suitably qualified electrician

Close and lock all access doors when the compressor is left unattended.

Do not use extinguishers intended for Class A or Class B fires on electrical fires. Use only extinguishers suitable for class *BC* or class *ABC* fires.

Attempt repairs only in clean, dry, well lighted and ventilated areas.

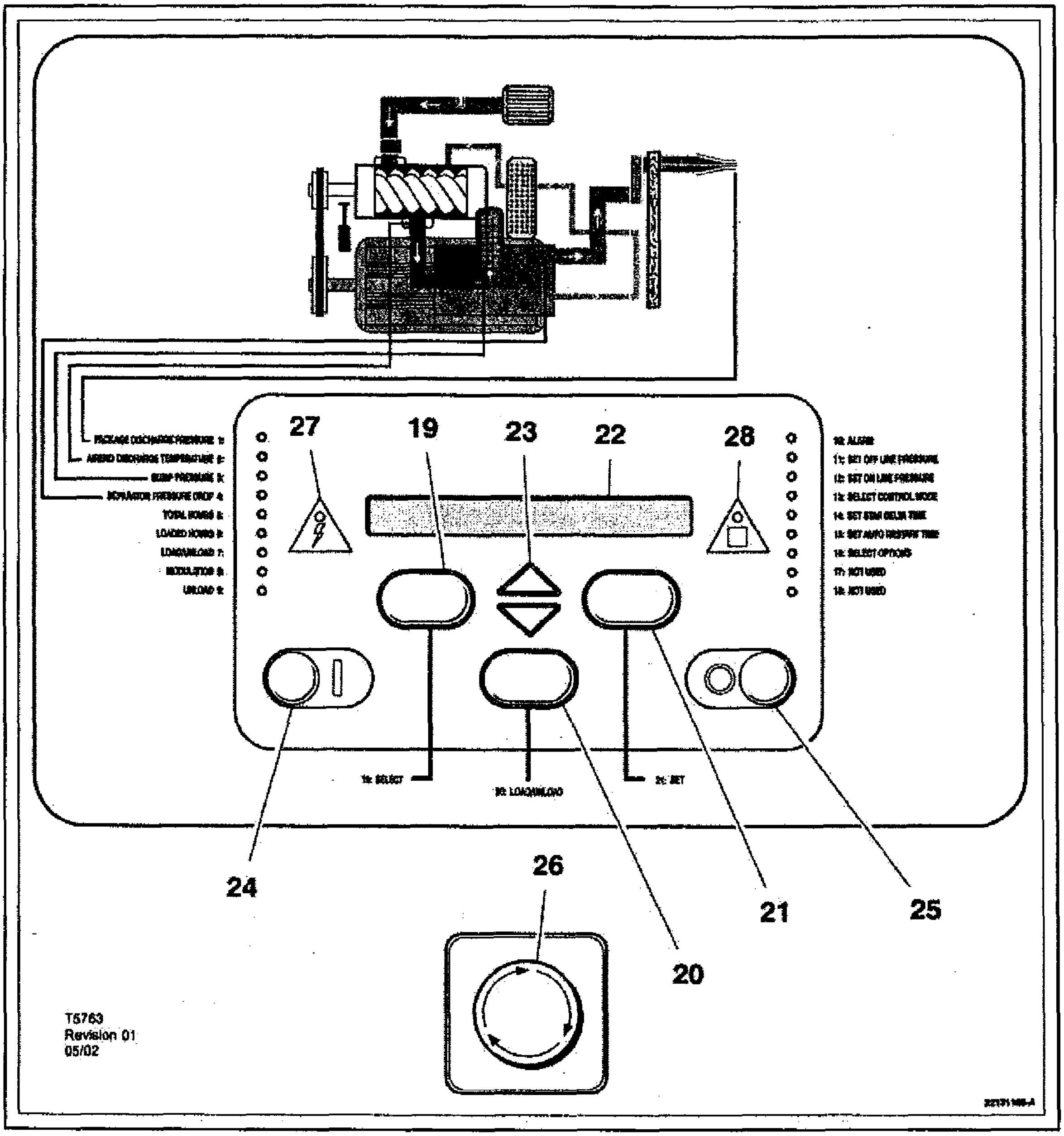
Connect the compressor only to electrical systems that are compatible with its electrical characteristics and that are within it's rated capacity.

Condensate disposal

As waste water regulations vary by country and region it is the responsibility of the user to establish the limitations and regulations in their particular area. Ingersoll–Rand and its associated distributors are happy to advise and assist in these matters.

For further information, consult Material Data Sheets CCN 88303979 for ULTRA–Plus Coolant.

INTELLISYS CONTROL AND INSTRUMENTATION



PRIOR TO STARTING

1. Check coolant level. Add if necessary.

2. Make sure main discharge valve is open.

3. Turn on electrical isolator. The power L.E.D. will illuminate and the display will indicate 'Ready to start'.

WARNING

Make sure that all protective covers are in place.

STARTING

Press 'Start' **[24]**. The compressor will start and then load automatically.

POWER OUT RESTART (Optional)

If this setting is set to ON, the compressor will automatically restart when power is returned to the compressor if it was operating when power was removed.

POWER OUT RESTART TIME

If the power out restart setting is set to ON, this is the number of seconds from the time power is restored until the compressor starts. The power out restart horn will sound during this time.

NORMAL STOPPING

1. Press 'Unloaded Stop'**[25]**. The compressor will unload then stop.

2. Turn off electrical isolator.

EMERGENCY STOP

1. Press 'Emergency stop button' **[26]** and the compressor will stop immediately.

2. Turn off electrical isolator.

INSTRUMENT PANEL FUNCTION

1 PACKAGE DISCHARGE PRESSURE L.E.D.
This will illuminate when the display indicates the package discharge pressure.

2 AIREND DISCHARGE TEMPERATURE L.E.D.
This will illuminate when the display indicates the airend discharge temperature.

3 SUMP PRESSURE L.E.D.
This will illuminate when the display indicates the sump pressure.

4 SEPARATOR PRESSURE DROP L.E.D.
This will illuminate when the display indicates the separator pressure drop.

5 TOTAL HOURS L.E.D.
This will illuminate when the display indicates the total compressor running hours.

6 LOADED HOURS L.E.D.
This will illuminate when the display indicates the total loaded compressor hours.

7 LOAD/UNLOAD L.E.D.
This will illuminate when the compressor is running *onload*.

8 MODULATION L.E.D.
This will illuminate when the compressor is running in *modulation* mode. (Note: capacity modulation will occur only if the appropriate regulation pneumatics are fitted to the compressor).

9 UNLOAD L.E.D.
This will illuminate when the compressor is running in *unload* mode.

10 ALARM L.E.D.
This will flash when a warning condition exists. The warning detected will be displayed and the compressor will continue to run. The warning can be reset by depressing *set* **[21]**.
It will illuminate when an alarm condition has occurred. The compressor will shutdown immediately. The alarm can be reset by depressing *set* **[21]** twice within 3 seconds.

OTHER L.E.D.s
These will illuminate during the *set point routine* to indicate which function is being adjusted.

11 L.E.D.–Set off line pressure.

12 L.E.D.–Set on line pressure.

13 L.E.D.–Select control mode.

14 L.E.D.–Set star delta time.

15 L.E.D.–Set auto restart time.

16 L.E.D.–Select options.

17 L.E.D.–Not used.

18 L.E.D.–Not used.

19 DISPLAY SELECT BUTTON
Press to index through compressor operating conditions. The corresponding L.E.D. will illuminate adjacent to display.
This is used to select alternative status displays (after approximately 5 minutes, the display defaults to the package discharge pressure). Depressing this button in the *set point routine* will cause exit to *checking machine* for 2 seconds, then *ready to start*.

20 LOAD/UNLOAD BUTTON
These are used to manually switch the compressor between a loaded control mode (e.g. *on/off line*) and unloaded running.
See L.E.D.

21 SET BUTTON
Depressing this button when the compressor is stopped will enable entry into the *set point routine*. When in the *set point routine*, depressing this button will cause the controller to move on to the next set point setting, saving the new value if one has been entered.
A warning reset is obtained by depressing this button (while the machine is running). An alarm reset is obtained by depressing this button twice within 3 seconds (the alarm condition will remain if the indicated fault has not been rectified).

22 LIQUID CRYSTAL DISPLAY
This indicates the status of the compressor, set up parameters and warning/alarm messages. When the compressor is running, the display will normally show the package discharge pressure.

23 ARROW KEYS
These are used to index through warning and alarm messages. In the *set point routine*, these buttons are used to increase/decrease set point values and enable/disable some operation conditions.

The arrow keys are also used to select pressure bands 1 (▲) or 2 (▼) during normal operation of the compressor.

24 START BUTTON
This button when depressed will cause the compressor to start and load automatically, provided that the controller detects a demand for air. When pressed in the *display* mode, it will cause exit to *checking machine* for 2 seconds, then *ready to start*.

25 UNLOADED STOP
This button when depressed while the compressor is running, will unload the compressor (if not already unloaded) for 10 seconds and then stop. This is the normal method for stopping the compressor. If the compressor is already stopped, it will execute an L.E.D. check (all the L.E.D.s should illuminate) and display the controller software revision.

26 EMERGENCY STOP
This button when depressed will stop the compressor immediately and display an *emergency stop* alarm message.

27 POWER L.E.D.
This will illuminate when the 8V controller supply is available.

28 AUTOMATIC RESTART L.E.D.
This will illuminate when the machine has shutdown due to low air demand. The compressor will restart and load automatically as soon as the demand for air resumes.

DISPLAY MESSAGES
When the compressor is running normally, the display will indicate the package discharge pressure and illuminate the corresponding L.E.D. **[1]**. An arrow will also appear in the far right of the display indicating pressure band selection. Pressing *display select* **[19]** will change the display value and the corresponding L.E.D. will illuminate. The controller monitors all aspects of the compressor while running and will display warnings or in severe conditions execute an emergency stop and display alarm conditions.

MACHINE CONTROL MODES

CAPACITY CONTROL
The compressor is designed to work with two types of capacity control, to suit the individual plant requirements. These controls are:–
A. On line – Off line. (Fitted as standard)
B. On line – Off line, with Upper Range Modulation. (Optional extra)
Either is available by selection at the control panel.

ON LINE – OFF LINE CONTROL
For applications that require a widely varying air demand, this mode of control will deliver air at full capacity or zero capacity with low receiver pressure.

This mode of operation is controlled by the pressure transducer responding to changes in plant air pressure. This sensor energizes the load solenoid valve which in turn operates the venting valve (blowdown) and the closing of the atmospheric vent opening in the air inlet valve.

The compressor then delivers full capacity air to the plant system. If the air pressure in this system rises to the upper set point of the pressure setting, the load solenoid valve is de–energized allowing the inlet valve to close. At the same time, the venting valve opens allowing the receiver pressure to drop.

The pressure setting has a range of 12 psi (0.83 bar) between its upper and lower set points.The upper set point is set at 3 psi (0.2 bar) above the compressor rated discharge pressure.

UPPER RANGE MODULATION CONTROL (Optional Extra)
For plants having a relatively high and constant air demand, Upper Range Modulation is the recommended mode of control.

Upper range modulation retains the features of On line – Off line control but provides the throttling of the inlet air flow as the line pressure rises to the upper set point of the *off–line* pressure setting.

By bleeding off a small amount from the regulator valve, which energises the Modulate Solenoid Valve, a reduction in the air signal to the pneumatic cylinder on the inlet valve allows the cylinder to 'trim' the inlet valve position as dictated by changing line pressure. Modulation begins when the compressor reaches about 94% of the rated line pressure and is factory set to modulate down to approximately 70% of rated capacity.

If the air demand decreases to a level below the 70% modulated output, the line pressure will increase slightly to the upper limit of the pressure setting, when the compressor then changes to the Off line control position and operates with the receiver vented.

AUTOMATIC START/STOP
For plants that have a widely varying plant air demand, larger air storage capacity, and/or want automatically available stand–by air capacity, Automatic Start–Stop Control Option is available.

During periods of low demand, if the line pressure rises to the off line air pressure set point of the Intellisys®, a timer is energized and begins to time out. The automatic restart time is adjustable in a 2–60 minute range. The timer will continue to operate as long as the plant line pressure remains above the on line set point of the Intellisys®. If the timer continues to operate for as long as its adjusted time setting, a contact in the Intellisys opens to de–energize the compressor starter coils. At the same time, a yellow Automatic Restart light on the Intellisys® panel is lit and the message AUTO RESTART will be displayed to indicate the compressor has shut down automatically and will restart automatically.

The automatic restart will take place when the line pressure drops to the online set point of the Intellisys®.

To operate in the automatic start/stop mode, proceed with the following steps:

1. Press the SET button until the message AUTO S/S OFF is displayed.

2. Push the up or down arrows to select the auto start/stop function (on or off). AUTO S/S OFF in the display indicates auto start/stop is disabled (off). AUTO S/S ON in the display indicates auto start/stop is enabled (on). Press the SET button to store function. The display will flash to acknowledge and then display AUTO S/S 10 MIN.

3. Press the up or down arrows to select the desired automatic restart time (2–60 min. range). The default value is 10 minutes. Press SET button to store the value.The display will flash to acknowledge. Press the DISPLAY SELECT button or wait 30 seconds for the controller to automatically exit the set routine.The display returns to READY TO START.

4. Start the compressor and adjust the isolation valve to allow the unit to slowly reach the offline pressure and unload.The compressor should run for a minimum of 10 min. and unloaded for the pre–set time and then shut down.

5. The compressor should restart automatically when the system air pressure drops below the online air pressure setting.

CONTROLLER WARNING MESSAGES

In the event of a warning, the controller will display a message and the *alarm L.E.D.* **[10]** will flash. The warning message will alternate with the normal display every 4 seconds, the compressor will continue to run but the fault should be rectified as soon as possible. The *arrow keys* **[23]** should be used to index the display for any additional warning messages. A warning message may be reset by depressing *set* **[21]** once.

NOTE:
The warning will recur if the fault has not been rectified. The following warning messages may be displayed:

COOLANT FILTER (OPTIONAL)
The pressure differential across the coolant filter exceeds 15 psi (1 bar)

AIR FILTER
The air filter is dirty or blocked and should be replaced.

SEPARATOR ELEMENT
The separator element is dirty or blocked and should be replaced.

AIREND TEMPERATURE
The airend temperature reaches 97% of the high airend temperature set point (i.e. 223°F (106°C)).

CONTROLLER ALARMS

In the event of an alarm, the controller will execute an emergency stop, the *alarm L.E.D.* **[10]** will illuminate and an alarm message will be displayed. The *arrow keys* **[23]** should be used to index the display for any additional alarm messages. An alarm is reset by depressing *set* **[21]** twice within a 3 second period after the fault has been rectified. The compressor will restart only when all alarm conditions have been rectified. The following alarm messages may be displayed (For fault correction see the Fault Finding section):

STARTER FAULT

The contactor sequence during start or stop is incorrect.

AIREND TEMPERATURE

The airend discharge temperature is above the high temperature set point.

MOTOR OVERLOAD

The motor overload contacts are open. The motor overload must be reset before the controller can be reset.

REVERSE ROTATION

No sump pressure is detected after the first 2 seconds of running. Isolate the machine and reverse the mains supply connections before resuming.

OVER PRESSURE

The line pressure is 15 psi (1 bar) greater than the rated discharge pressure.

TEMPERATURE SENSOR 1

The airend temperature sensor/ connecting cable has failed.

TEMPERATURE SENSOR 2

The separator tank temperature sensor/connecting cable has failed.

PRESSURE SENSOR

Indicates pressure transducer failure / connecting cable fault.

FAILED CALIBRATION

During calibration routine, a 10% of scale error has been detected. Ensure that the separator is completely blowndown and repeat calibration.

CONTROL POWER LOSS

The 48Vac signal is not present at the controller.

REMOTE START FAILURE

Momentary remote start has not disengaged before star–delta transition. This alarm is active only if the remote start/stop is enabled.

REMOTE STOP FAILURE

The momentary remote stop switch has not disengaged when the start signal is received. This alarm is active only if the remote start/stop is enabled.

EMERGENCY STOP

The emergency stop button is engaged.

LOW SUMP PRESSURE

The sump pressure drops below 15 psi (1 bar) during normal operation.

FIELD OPTION/S

Before installation and operation of this option, these instructions should be studied carefully to obtain a clear knowledge of the option and its application to the compressor.

REMOTE START/STOP

The Remote Start/Stop Option allows the operator to control the compressor from a remote mounted start/stop station.Terminal points are provided in connector J1 in the top of the Intellisys® controller; one a connection for a normally closed stop switch (terminals 3 and 4), and one for a normally open, momentary contact start switch (terminals 5 and 6). Refer to the compressor wiring schematic for specific connection points.

For safety, a selection is available in the Intellisys® set–points to disable the remote start and stop function.This allows the compressor to be fully controlled by the Intellisys® and not from the remote start/stop station.

If the remote start switch is momentarily closed, the Intellisys® starts the compressor.The remote stop switch is normally closed. If the remote stop switch opens, the compressor will unload and stop.The compressor cannot restart until the remote stop switch has been reset to a closed position. (EMERGENCY STOP will display on the Intellisys® if the stop switch is not closed).

To operate in the remote start/stop mode, proceed with the following steps:

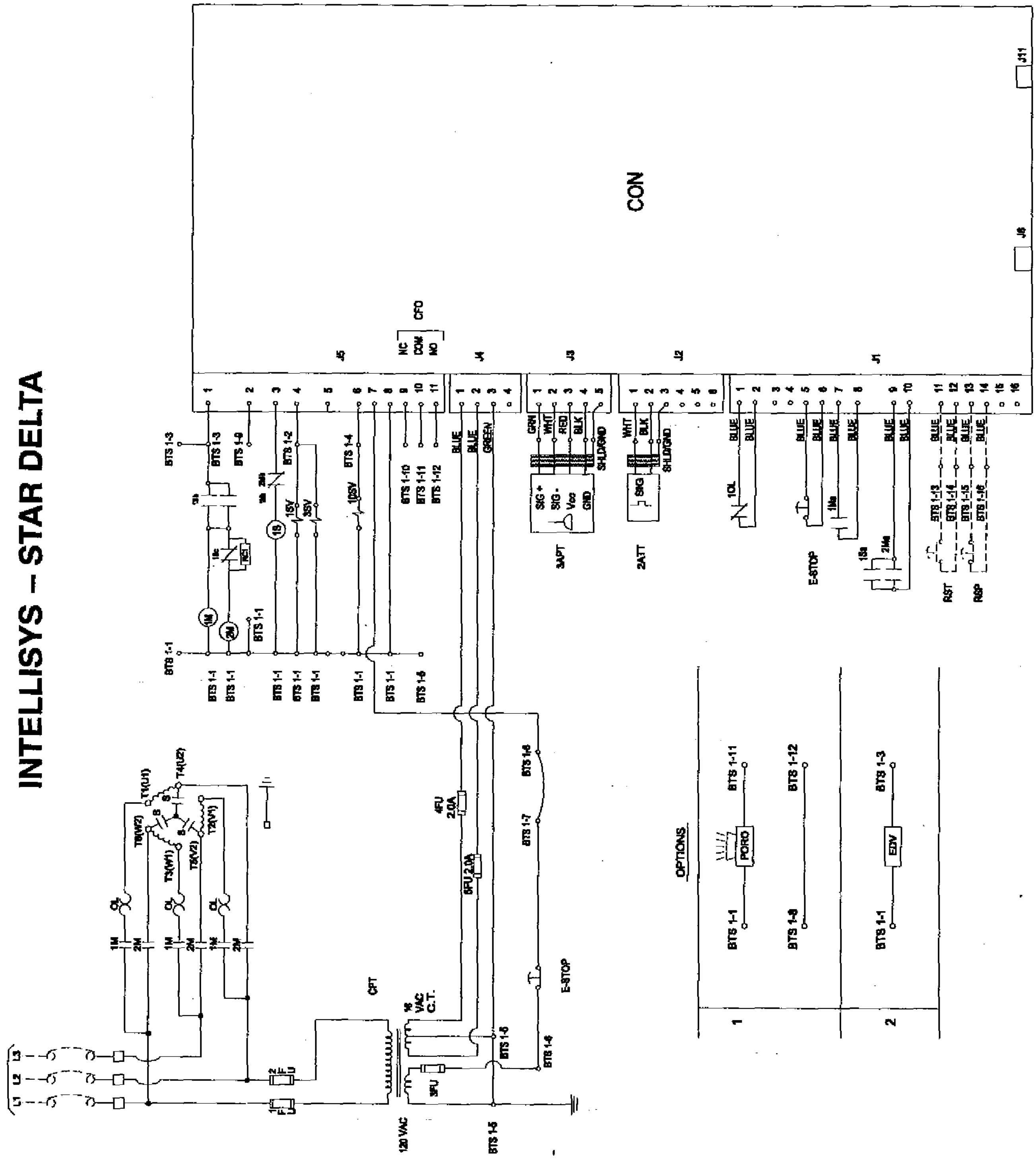
1. Press the SET button until the message REMOTE S/S OFF is displayed.

2. Push the up or down arrows to select the remote start/stop function (on or off). REMOTE S/S OFF in the display indicates remote start/stop is disabled (off). REMOTE S/S ON in the display indicates remote start/stop in enabled (on). Press the SET button to store the function. The display will flash to acknowledge. Press the DISPLAY SELECT button or wait 30 seconds for the controller to automatically exit the set routine.The display returns to READY TO START.

3. Start the compressor with the Start button on the Intellisys control panel.The compressor must be started locally first before the Remote Start/Stop buttons are activated by the Intellisys®.

ELECTRICAL SCHEMATIC – STAR DELTA WITH INTELLISYS CONTROL

INTELLISYS – STAR DELTA



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Revision E

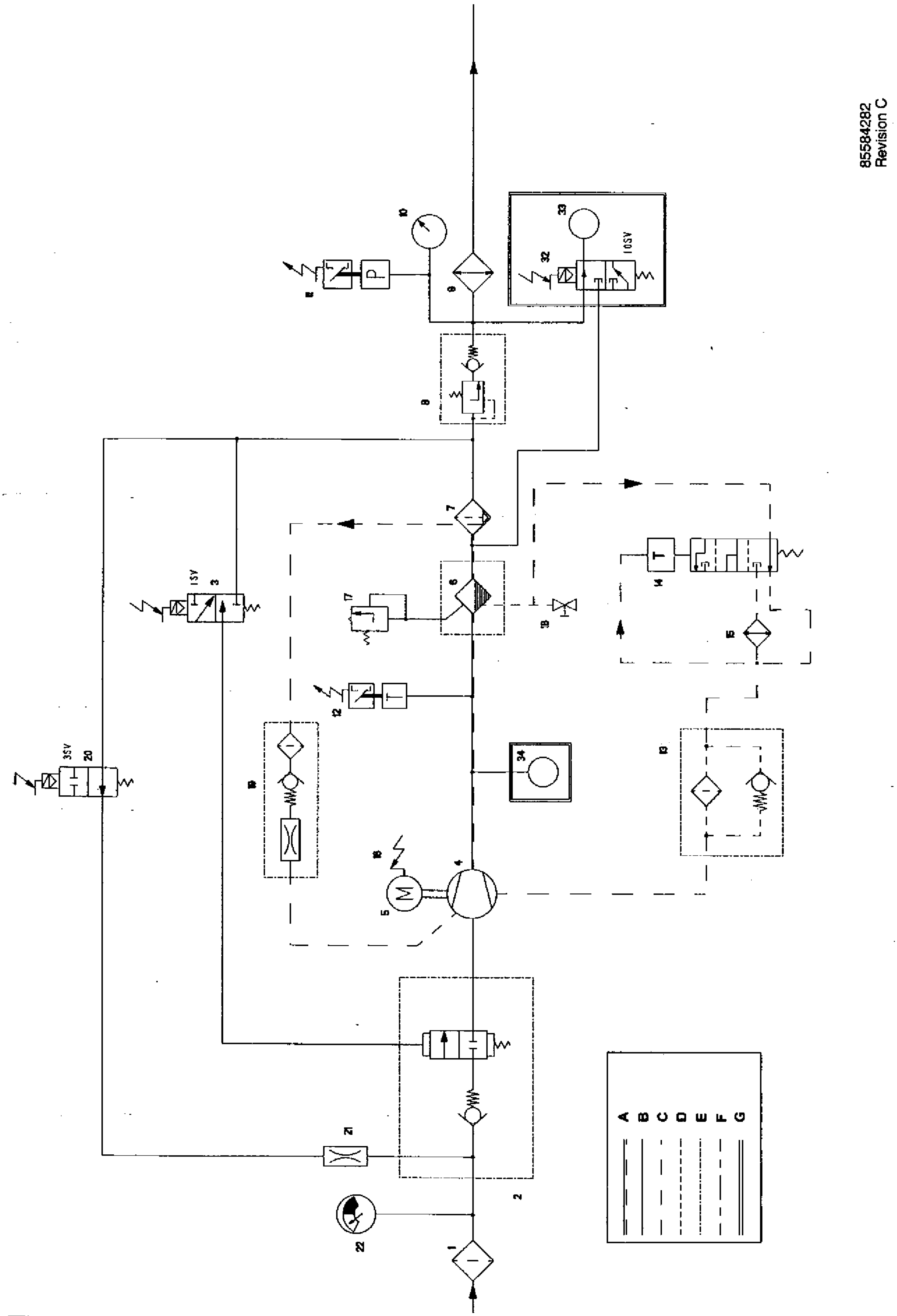
KEY

CON	Controller, INTELLISYS
CPT	Transformer, control
EDV	Valve, electric drain
E–STOP	Button, emergency stop
FU	Fuse
1M	Contactor (main)
2M	Contactor (delta)
OL	Overload, motor starter
1SV	Valve, solenoid (load) N.C
3SV	Valve, solenoid (blowdown) N.O
10SV	Valve, solenoid (line / sump) N.C
RST	Remote start (Optional)
RSP	Remote stop (Optional)
CFO	Common fault output
PORO	Power out restart (Optional)
2ATT	Temperature sensor
3APT	Pressure sensor
1S	Contactor (wye / star)

NOTES

1. Approved fused disconnect or circuit breaker per code requirements must be provided by customer.
2. Dashed lines represent wiring by customer.
3. Sizing of electrical components not supplied by Ingersoll–Rand is the responsibility of the customer and should be done in accordance with the information on the compressor data plate and local electrical codes.
4. Unit will not restart automaticlly after power outage, except with additional PORO option.
5. Circuit shown in normal position de–energized.
6. All wiring to be in accordance with local codes.
7. Blue – 16 Volts AC

PIPING AND INSTRUMENTATION WITH INTELLISYS CONTROL

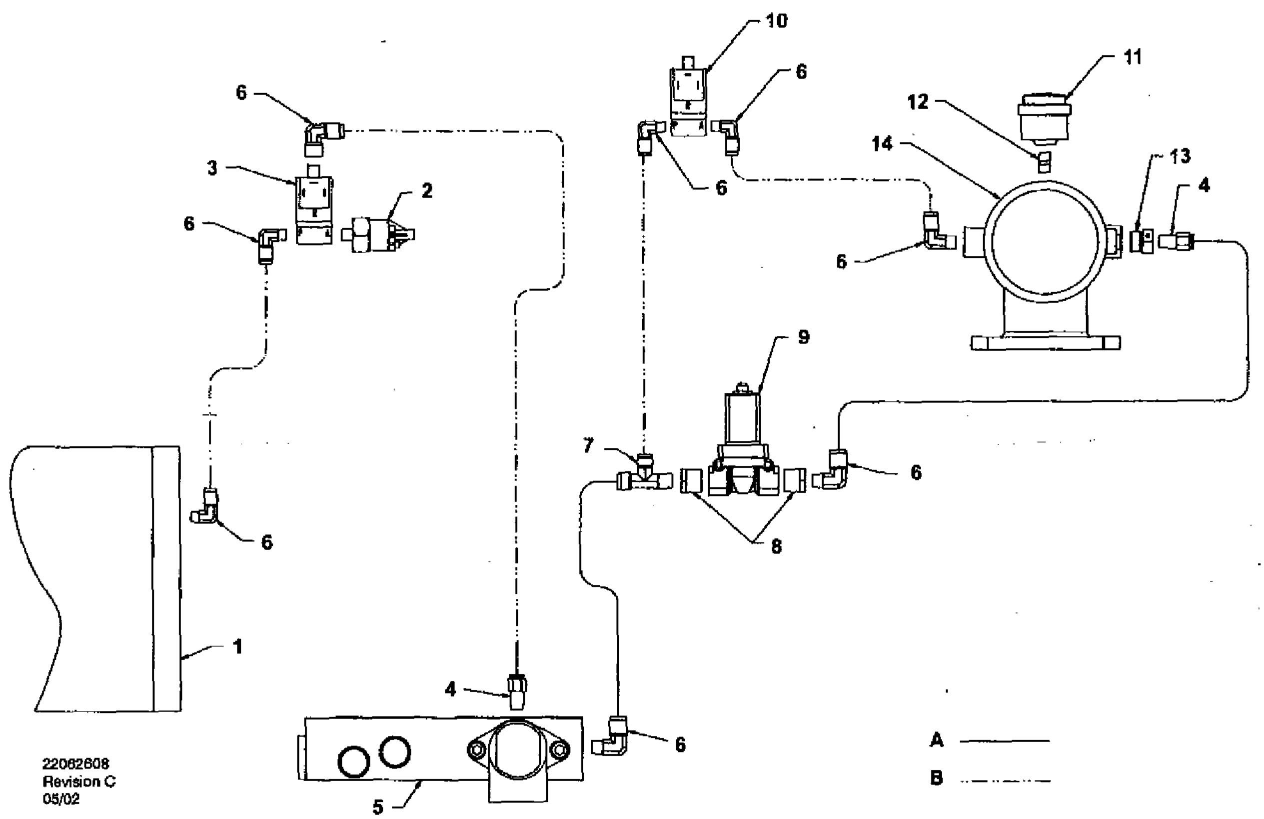


KEY

1. Filter, air
2. Valve, inlet
3. Valve, solenoid (load)
4. Airend assembly
5. Motor
6. Tank, separator, Coarse
7. Separator, Fine
8. Valve, minimum pressure
9. Aftercooler
10. Gauge, pressure
11. Switch, discharge pressure
12. Switch, temperature
13. Filter, coolant
14. Thermostat
15. Cooler
16. Relay, overload Motor
17. Valve, safety
18. Valve, drain
19. Screen, scavenge
20. Valve, solenoid (blowdown)
21. Orifice
22. Indicator, air restriction
32. Valve solenoid (line/sump), Intellisys Option
33. Transducer pressure, Intellisys Option, replaces 10 and 11
34. Sensor temperature, Intellisys Option, replaces 12

A	Air/Coolant
B	Air
C	Coolant
D	Condensate
E	Component boundary
F	Refrigerant
G	Option

INTELLISYS CONTROL AND INSTRUMENTATION DIAGRAM



KEY

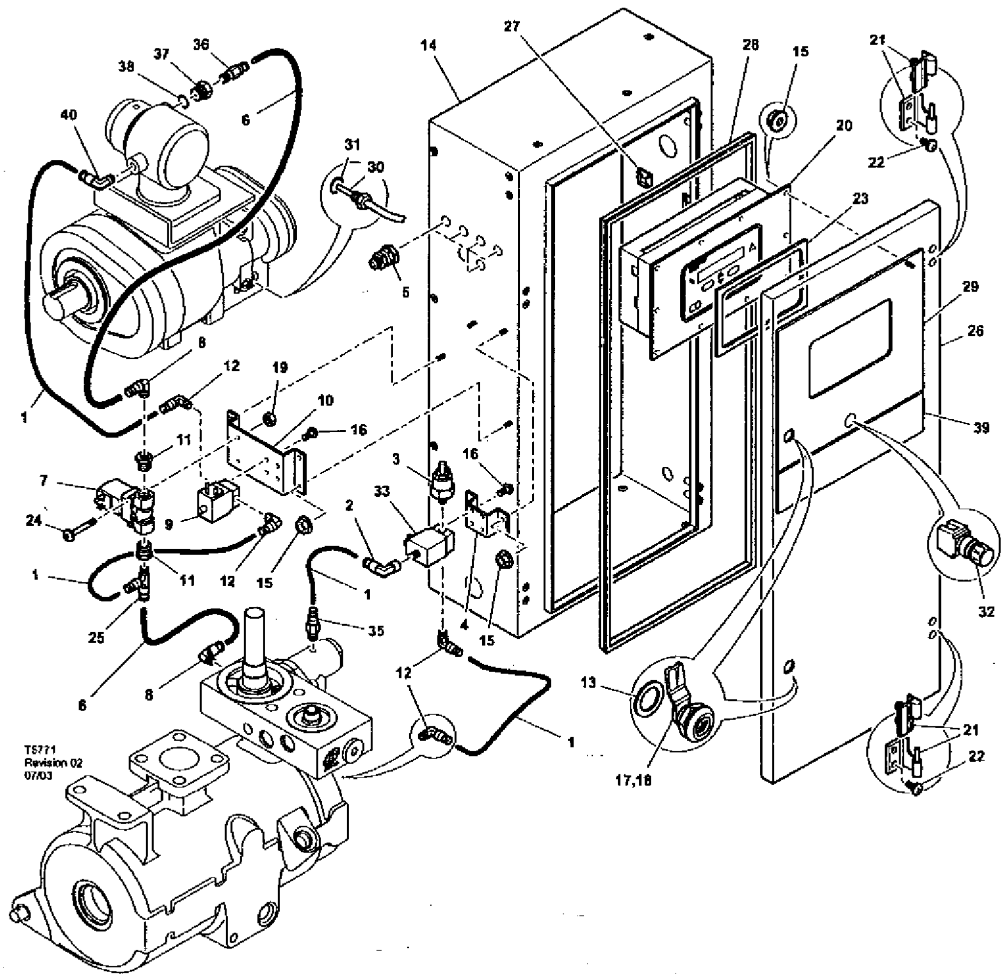
1. Tank, separator
2. Transducer, pressure
3. Valve, solenoid (Line / Sump)
4. Connector
5. Combination block
6. Elbow
7. Tee, male run
8. Reducer bushing
9. Valve, solenoid (Blowdown)
10. Valve, solenoid (Load)
11. Indicator air filter
12. Nipple
13. Adaptor
14. Intake valve assembly

NOTES:

A. Tubing 3/8 inch

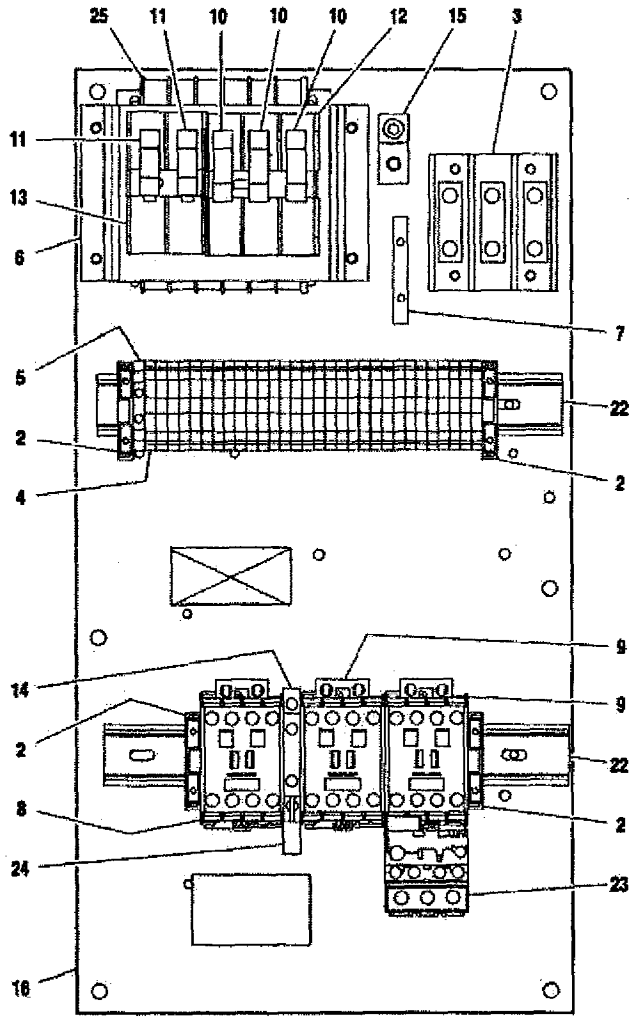
B. Tubing 1/4 inch

INTELLISYS PARTS – INSTRUMENTATION AND ELECTRICAL SYSTEM



Item	ccn	Qty.	Description	Item	ccn	Qty.	Description
1	39124813	AR	Tube (Nylon)	22	96743992	4	Screw
2	39155460	1	Elbow	23	39495874	1	Gasket
3	39853809	1	Transducer	24	96742754	2	Screw
4	22107833	1	Bracket	25	22055909	1	Tee
5	92877018	5	Gland, cable	26	22177190	1	Cabinet door
6	39124821	AR	Tube (Nylon)	27	39133467	3	Mount
7	54654652	1	Valve, solenoid (Blowdown)	28	22177315	1	Gasket, door
8	39155650	2	Elbow	29	22131155	1	Decal, controller
9	54774302	1	Valve, solenoid (Load)	30	22137848	1	Sensor, temperature
10	54755426	1	Bracket	31	39404157	1	'O' Ring
11	95944625	2	Bushing	32	22113344	1	Button, emergency stop
12	39155577	4	Elbow	33	22289797	1	Valve, solenoid (line/sump)
13	93492072	2	Seal	*34	39192000	4	Grommet
14	22177174	1	Cabinet	35	39156393	1	Connector
15	96737564	14	Nut	36	39156419	1	Connector
16	96743182	8	Screw	37	54774997	1	Bush
17	85584340	4	Latch	38	39404165	1	'O' Ring
*18	92829308	1	Key	39	22131148	1	Decal
19	96703756	2	Nut	40	39155478	1	Elbow
20	22128763	1	Controller, INTELLISYS				* Not illustrated
21	22091193	2	Hinge				

INTELLISYS PARTS – C23/16 STAR/DELTA – 60Hz – 440/460V – 20/25hp, 575V – 20/30hp



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Revision D

Item	ccn	Qty.	Description
1	–		
2	39252937	4	Block, end stop
3	39164520	1	Block, terminal
4	39252903	30	Block, terminal
5	39252911	1	Block, terminal ground
6	22114623	1	Bracket
7	32342115	1	Bus, grounding
8	22074413	1	Contactor – C16
9	39252036	2	Contactor – C23
10	22074033	3	Fuse 2.0A 125–250V
11	32342099	2	Fuse 1.5A 600V
12	39479035	1	Fuse, holder
13	39480504	1	Fuse, holder
14	39333257	1	Interlock
15	32342123	1	Lug, power grounding
16	22113351	1	Panel
*17	39191648	1	Plug 11 position
*18	39191655	1	Plug 16 position
*19	39186101	1	Plug 4 position
*20	39191630	1	Plug 5 position
*21	39186093	1	Plug 6 position
22	22056741	2	Rail
23	39255591	1	Relay, overload
24	39203443	1	Suppressor
25	39491519	1	Transformer

* Not illustrated

Ingersoll Rand

Presented to:

Hydro Geo Chem

Prepared by:
Nathan Ellis
Customer Center Manager
3626 East Southern Avenue
Phoenix, AZ 85040
Direct: 602-431-1400
Fax: 602-431-1401

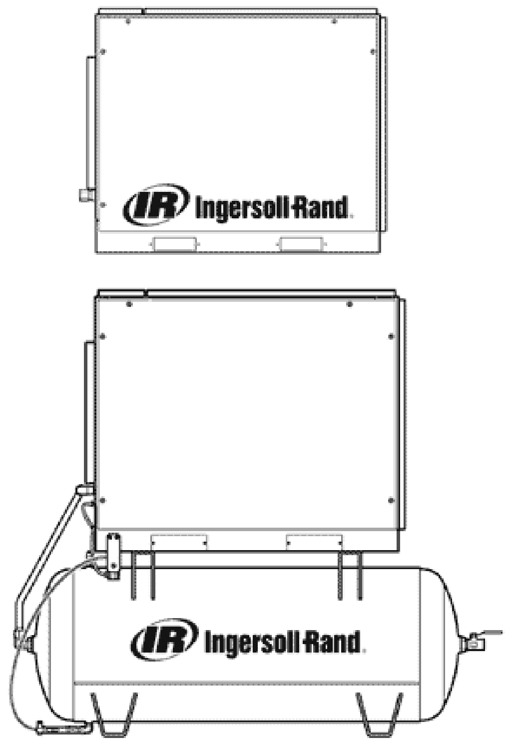
Proposal: 148NDE020108
February 1, 2008

This proposal is valid until Sunday, March 02, 2008. After that date the quote and terms in the proposal may need to be revised.

UP6-25-125 High Ambient

Detailed Scope of Supply

All amounts are displayed in US dollars



Technical Information:
25HP Rotary Screw Compressor
Capacity- 102 cfm @ 125 PSIG
Maximum Operating Pressure- 125 PSIG
Outlet Size- 1.0 " NPT

Dimensions- Length x Width x Height:
52"x 36"x 42.5" Baseplate
67"x 36"x 42.5" Baseplate w/ dryer option
77.5" x 36" x 71" 120-gal Tank Mtd (same w/ dryer)
94" x 36" x 76.5" 240-gal Tank Mtd (same w/ dryer)

Weight:
1203 lb. Baseplate (1451 lb w/ dryer)
1530 lb. 120-gal Tank Mounted (1775 lb w/ dryer)
1799 lb. 240-gal Tank Mounted (2044 lb w/ dryer)

Package Amp Draw Table:
200/3/60- 76.6 Amps 230/3/60- 66.6 Amps
460/3/60- 33.3 Amps 575/3/60- 26.6 Amps
Sound Level- per CAGI-PNEUROP PN2CPTC2
Standard enclosure- 69 dBA
Aftercooler CTD- 18 °F
Fan Air Flow- 1950 cfm
Items as specified below

QTY	Description	Unit Price	Total Price
1	UP6-25-125 High Ambient Fixed Speed Rotary Screw Air Compressor	$9,763	$9,763
1	Nema 4 with Intellisys, Totally Enclosed Fan Cooled Motor and Star-Delta Starter	$1,033	$1,033

UP6-25-125 High Ambient

Qty	Item	Unit Price	Total
1	Ultra Plus Coolant		Included

Ultra-Plus coolant is an advanced synthetic lubricant specifically designed for use in Ingersoll Rand rotary screw air compressors. Ultra-Plus coolant is formulated for a 9,000 hour extended coolant life, or two (2) years, whichever occurs first. It is specifically designed to offer superior lubrication and cooling under the demanding conditions of rotary screw applications and usage. Ultra-Plus coolant offers superior biodegradability and simple condensation separation characteristics. applications and usage. Ultra-Plus coolant offers superior biodegradability and simple condensation separation characteristics.

Qty	Item	Unit Price	Total
1	240 Gallon Receiver	$1,256	$1,256
1	Standard Factory Warranty		Included

The Company warrants that the equipment manufactured by it and delivered hereunder will be free of defects in material and workmanship for a period of twelve months from the date of placing the Equipment in operation or eighteen months from the date of shipment from the factory, whichever shall first occur.

Qty	Item	Unit Price	Total
1	AirCare Advantage - only available from the professionals at Ingersoll Rand		Included

AirCare Advantage is available on all new Ingersoll Rand compressed air equipment. Ingersoll Rand and your local Ingersoll Rand representatives help you maximize your ownership experience. Equipment reliability comes from buying the best Ingersoll Rand equipment and partnering with the best local service team. AirCare Advantage provides options for extending protection on the equipment_s key components. Protect as much as the entire package for up to 10-years or as basic as just the compression airend for as long as you own the unit _ you select the level of protection that matches the demands on your business. Your local Ingersoll Rand representative can help you select the protection that is best for you - AirCare Advantage, only from Ingersoll Rand.

Qty	Item	Unit Price	Total
1	Startup Kit	$82	$82

Each kit contains one (1) replacement oil filter for 150 break-in period and one (1) gallon of Ultra Plus Coolant.

Qty	Item	Unit Price	Total
1	Intellisys Controller		Included

The Intellisys microprocessor utilizes a finger-touch membrane panel providing access to all adjustments and key operating parameters. By automatically warning and/or stopping the compressor, Intellisys then displays the problem eliminating costly troubleshooting and minimizing downtime. Intellisys provides five display standards, four adjustable operating parameters, two fault warnings and eight fault shutdowns.

UP6-25-125 High Ambient

1	Outdoor Modification Enclosure, for Weatherproof Package	$263	$263
1	Modulation Control	$570	$570
1	High Dust Air Filter	$167	$167
1	Moisture Separator	$136	$136
1	Standard Crate		Included

Total Price $13,270

IRGP216 General Purpose Coalescing/Particulate Filter

Detailed Scope of Supply

All amounts are displayed in US dollars

Technical Information:

Capacity- 216 scfm
Connection Size- 1" NPT
Max Pressure (psig)- 232
Drain Type- Automatic Float - 1/4" ID Tube Connection
Weight- 5.7 lbs
Dimensions- (W x H)- 5.1" x 17.6" **
** Clearance of 5.5" is suggested for element replacement

QTY	Description	Unit Price	Total Price
1	IRGP216 General Purpose Coalescing/Particulate Filter GP - General Purpose Filter designed to remove bulk particles (1 micron and larger) and oil (.5 mg/m3) at rated conditions. Primary purpose is to protect down stream filtration and drying equipment from large contaminants.	$439	$439
1	Differential Pressure Indicator		Included
1	Standard Factory Warranty The Company warrants that the equipment manufactured by it and delivered hereunder will be free of defects in material and workmanship for a period of twelve months from the date of placing the Equipment in operation or eighteen months from the date of shipment from the factory, whichever shall first occur.		Included

Ingersoll Rand

IRGP216 General Purpose Coalescing/Particulate Filter

Total Price $439

IRHE216 High Efficiency Coalescing Filter

Detailed Scope of Supply

All amounts are displayed in US dollars

Technical Information:

Capacity- 216 scfm
Connection Size- 1" NPT
Max Pressure (psig)- 232
Drain Type- Automatic Float - 1/4" ID Tube Connection
Weight- 5.7 lbs
Dimensions- (W x H)- 5.1" x 17.6" **
** Clearance of 5.5" is suggested for element replacement

QTY	Description	Unit Price	Total Price
1	IRHE216 High Efficiency Coalescing Filter	$461	$461
	HE - High Efficiency Filter designed to remove fine particulate (.01 micron and less) and oil (.01 mg/m3) at rated conditions. Primary purpose is to protect downstream air distribution and process equipment. Precede a HE filter with a GP filter to ensure low pressure drop, consistent air quality and avoid excessive, bulk contaminant loading.		
1	Differential Pressure Indicator		Included
1	Standard Factory Warranty		Included
	The Company warrants that the equipment manufactured by it and delivered hereunder will be free of defects in material and workmanship for a period of twelve months from the date of placing the Equipment in operation or eighteen months from the date of shipment from the factory, whichever shall first occur.		

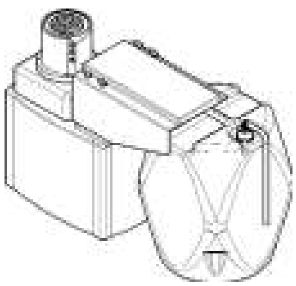
IRHE216 High Efficiency Coalescing Filter

Total Price $461

PolySep 250

Detailed Scope of Supply

All amounts are displayed in US dollars



Technical Information:
Max SCFM: 250
Max HP 60
Air Inlet: 1/4"NPT
Condensate Inlets: Qty (3) 1/2"NPT
Dimensions - (L x W x H) - 45.5"x 19.5"x 37.8"
Adsorption Module: AM250
Items as specified below

QTY	Description	Unit Price	Total Price
1	PS-250 Oil/Water Separator	$1,727	$1,727
	The PolySep helps protect and maintain the environment by efficiently separating oil from the condensate, which allows you to return up to 99.9% of the condensate to sanitary sewers.		
1	Standard Factory Warranty		Included
	The Company warrants that the equipment manufactured by it and delivered hereunder will be free of defects in material and workmanship for a period of twelve months from the date of placing the Equipment in operation or eighteen months from the date of shipment from the factory, whichever shall first occur.		

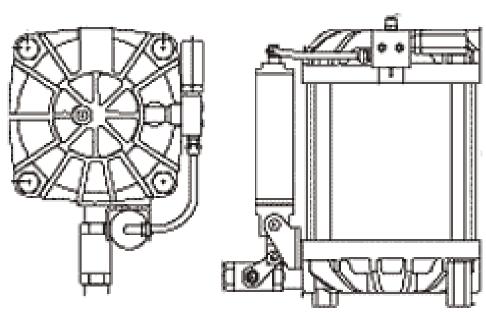
Total Price $1,727

Ingersoll Rand

PNLD II-12 Pneumatic No-Loss Drain

Detailed Scope of Supply

All amounts are displayed in US dollars



Technical Information:

Operating pressure: 0 to 200 PSI
Condensate Capacity: 16 to 52 oz.
Dry Weight: 7 to 13 lbs
Condensate inlet: ½" npt
Condensate discharge: 3/8" to ½" npt
Condensate discharged @ 100 psi: 12 to 44 oz.
Maximum Capacity (SCFM): 5-100,000 CFM
Pilot Air Pressure Range: 0-120 psi
Allowable Fluid Temperature: 34-150 deg F

QTY	Description	Unit Price	Total Price
1	PNLD II-12 Pneumatic No-Loss Drain	$488	$488
	The Pneumatic No-Loss Drain (PNLD) is a heavy-duty industrial drain valve that does not require electricity, pre-setting, or manual intervention. The PNLD only discharges when condensate is present, resulting in lower energy costs by eliminating unnecessary loss of valuable compressed air.		
1	Standard Factory Warranty		Included
	The Company warrants that the equipment manufactured by it and delivered hereunder will be free of defects in material and workmanship for a period of twelve months from the date of placing the Equipment in operation or eighteen months from the date of shipment from the factory, whichever shall first occur.		

PNLD II-12 Pneumatic No-Loss Drain

Total Price $488

Ingersoll Rand

Quote Summary

All amounts are displayed in US dollars

Hydro-Geo 25

Qty	Description	Unit Price	Total Price
1	UP6-25-125 High Ambient	$13,270.00	$13,270.00
1	IRGP216 General Purpose Coalescing/Particulate Filter	$439.00	$439.00
1	IRHE216 High Efficiency Coalescing Filter	$461.00	$461.00
1	PolySep 250	$1,727.00	$1,727.00
2	PNLD II-12 Pneumatic No-Loss Drain	$488.00	$976.00
1	Start Up and Training		$350.00

Total Price $17,223.00

Delivery:	4 Weeks
Payment Terms:	Net 30 Days
FOB:	Shipping Point
Freight Terms:	Prepaid and Add

Pricing and availability are subject to change without notice

AIR SOLUTIONS GROUP
TERMS AND CONDITIONS OF SALE

1. General The Terms and Conditions of Sale outlined herein shall apply to the sale by Ingersoll-Rand Company (hereinafter referred to as Company) of products, equipment, and parts relating thereto (hereinafter referred to as Equipment). It shall be understood that the Company's proceeding with any work shall be in accordance with the terms and conditions outlined herein.

The Company will comply with applicable laws and regulations in effect on the date of the Company's proposal as they may apply to the manufacture of the Equipment. Compliance with any local governmental laws or regulations relating to the location, use or operation of the Equipment, or its use in conjunction with other equipment, shall be the sole responsibility of the Purchaser.

2. Title and Risk of Loss Title and risk of loss or damage to the Equipment shall pass to the Purchaser upon tender of delivery F.O.B. manufacturing facility unless otherwise agreed upon by the parties, except that a security interest in the Equipment shall remain in the Company, regardless of mode of attachment to realty or other property, until full payment has been made therefor, and Purchaser shall adequately insure the Equipment against loss or damage from any cause wherein the Company shall be named as an additional insured.

3. Assignment Neither party shall assign or transfer this contract without the prior written consent of the other party.

4. Delivery and Delays Delivery dates shall be interpreted as estimated and in no event shall dates be construed as falling within the meaning of "time is of the essence."

The Company shall not be liable for any loss or delay due to causes beyond the reasonable control of the Company. In the event of delay in performance due to any such cause, the date of delivery or time for completion will be adjusted to reflect the actual length of time lost by reason of such delay. The Purchaser's receipt of Equipment shall constitute a waiver of any claims for delay.

5. Taxes The price does not include any present or future Federal, State, or local property, license, privilege, sales, use, excise, gross receipts or other like taxes or assessments applicable to this transaction or any services performed hereunder. Such taxes will be itemized separately to Purchaser. The Company will accept a valid exemption certificate from Purchaser. If exemption certificate is not recognized by the governmental taxing authority, Purchaser agrees to promptly reimburse the Company for any taxes which the Company is required to pay.

6. Patents The Company shall defend the Purchaser against any proceeding based upon a claim that the Equipment manufactured by the Company, and furnished under this contract, infringes any patent of the United States of America, providing the Company is promptly notified in writing and given authority, information and assistance for defense of same; and the Company may, at its option, procure for the Purchaser the right to continue to use said Equipment, or modify it so that it becomes non-infringing, or replace the same with non-infringing equipment, or remove said Equipment and refund the purchase price. The Company does not accept any liability whatsoever in respect to patents claiming more than the Equipment furnished hereunder, or claiming methods and processes to be carried out with the aid of said Equipment. The foregoing states the entire liability of the Company with regard to patent infringement.

7. Warranty The Company warrants that the Equipment manufactured by it and delivered hereunder will be free of defects in material and workmanship for a period of twelve months from the date of placing the Equipment in operation or eighteen months from the date of shipment, whichever shall first occur.

The Purchaser shall be obligated to promptly report any failure to conform to this warranty, in writing to the Company within said period, whereupon the Company shall, at its option, correct such nonconformity, by suitable repair to such Equipment or, furnish a replacement part provided the Purchaser has stored, installed, maintained, and operated such Equipment in accordance with good industry practices and has complied with specific recommendations of the Company. Company reserves the right to take possession of or direct Purchaser to return any replaced parts, which shall become Company property. Accessories or equipment furnished by the Company, but manufactured by others, shall carry whatever warranty the manufacturers have conveyed to the Company and which can be passed on to the Purchaser. This warranty shall not apply to any component which Purchaser directs Company to use in or add to the Equipment, and which would not otherwise be used or added by the Company. The Company shall not be liable for any repairs, replacements, or adjustments to the Equipment or any costs of labor performed by the Purchaser or others without the Company's prior written approval.

The effects of corrosion, erosion, and normal wear and tear are specifically excluded. Performance warranties are limited to those specifically stated within the Company's proposal, and the Company's obligation for meeting such performance warranties shall be to correct in the manner and for the period of time provided above.

THE COMPANY MAKES NO OTHER WARRANTY OR REPRESENTATION OF ANY KIND WHATSOEVER, EXPRESSED OR IMPLIED, EXCEPT THAT OF TITLE, AND ALL IMPLIED WARRANTIES OF MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE, ARE HEREBY DISCLAIMED.

Correction by the Company of nonconformities whether patent or latent, in the manner and for the period of time provided above, shall constitute fulfillment of all liabilities of the Company for such nonconformities, with respect to or arising out of such Equipment.

The Purchaser shall not operate Equipment which is considered to be defective, and any such use of Equipment will be at the Purchaser's sole risk and liability.

8. Limitation of Liability The remedies of the Purchaser set forth herein are exclusive, and the total liability of the Company with respect to this contract, whether based on contract, warranty, negligence, indemnity, strict liability or otherwise, shall not exceed the purchase price of the unit of Equipment upon which such liability is based.

The Company and its suppliers shall in no event be liable to the Purchaser, any successors in interest or any beneficiary or assignee of this contract for any consequential, incidental, indirect, special, or punitive damages arising out of this contract or any breach thereof, or any defect in, or failure of, or malfunction of the Equipment hereunder, whether or not such loss or damage is based on contract, warranty, negligence, indemnity, strict liability or otherwise.

9. Nuclear Liability In the event that the Equipment sold hereunder is to be used in a nuclear facility, the Purchaser shall, prior to such use, arrange for insurance or governmental indemnity protecting the Company against liability and hereby releases and agrees to indemnify the Company and its suppliers for any nuclear damage, including loss of use, in any manner arising out of a nuclear incident, whether alleged to be due, in whole or in part to the negligence or otherwise of the Company or its suppliers.

10. Governing Law The rights and obligations of the parties shall be governed by the laws of the State of New Jersey excluding any conflicts of law provisions. The United Nations convention on contracts for the international sale of goods shall not apply to this agreement.

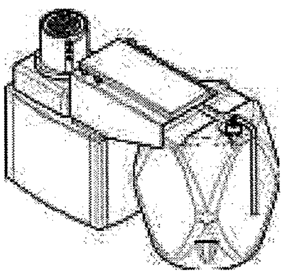
11. Execution The Company shall not be bound by any contract or any modification thereto until approved in writing by an officer of the Company. The contract, when so approved, shall supersede all previous communications, either oral or written.

Ingersoll Rand

PolySep 250

Detailed Scope of Supply

All amounts are displayed in US dollars



Technical Information:
Max SCFM: 250
Max HP 60
Air Inlet: 1/4"NPT
Condensate Inlets: Qty (3) 1/2"NPT
Dimensions - (L x W x H) - 45.5"x 19.5"x 37.8"
Adsorption Module: AM250
Items as specified below

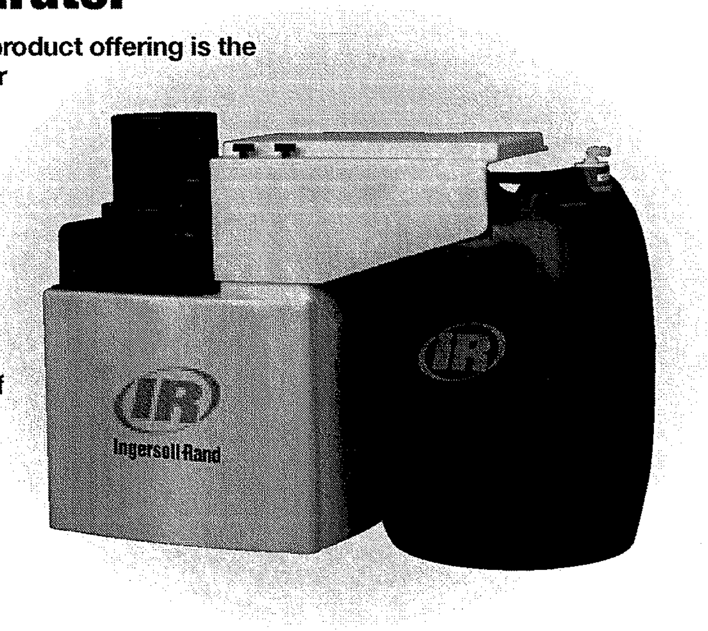
QTY	Description	Unit Price	Total Price
1	PS-250 Oil/Water Separator	$1,727	$1,727
	The PolySep helps protect and maintain the environment by efficiently separating oil from the condensate, which allows you to return up to 99.9% of the condensate to sanitary sewers.		
1	Standard Factory Warranty		Included
	The Company warrants that the equipment manufactured by it and delivered hereunder will be free of defects in material and workmanship for a period of twelve months from the date of placing the Equipment in operation or eighteen months from the date of shipment from the factory, whichever shall first occur.		

Total Price $1,727

Ingersoll-Rand®

PS PolySep Oil/Water Separator

The Ingersoll-Rand PS Polysep Oil/Water Seperator product offering is the most comprehensive environmental solution in the air compressor industry



The Problem with Other Oil/Water Separators

Compressor oils that do not have good separation characteristics, known as emulsions, tend to foul up the carbon filters as well as the pre-adsorption and coalescing medias that are commonly installed in front of the carbon filters. Those filters have to be replaced before their capacity is fully used. This is a result of oil binding off the pore area of the carbon where the condensate first comes in contact with the filter. The jelled oil clogs the filter, which then prevents the volume of condensate from properly flowing through the filter. This premature failure of the carbon filters most often results in the system backing up on the floor.

The IR Environmental Solution

IR PolySep is designed to effectively separate emulsified compressor condensate, as well as oils that have better separation characteristics, without premature element failure and backup spillages. These systems are designed to cover compressor ranges from 5-4500 SCFM, and work effectively with Polyglycols, Mineral Oils, PAOs, Polysol Esters & Diesters.

Benefits

- Non-corrosive materials
- No electricity
- Expandable system
- Permanently absorbs oils
- Only two moving parts
- Valuable for ISO 14001 Certified Companies
- Extended filter life
- Low maintenance cost
- Helps protect and maintain the environment

Technical Specification Guide

Model	CCN#	Max. SCFM	Max. HP	Absorbtion Module Volume (gal.)	Air Line NPT	Condensate Inlet NPT	Oil Outlet NPT	Water Outlet NPT	Replacement Adsorption Modules	Dimensions LxWxH (in.)	Weight (lbs.)
PS-30	38041596	30	7.5	1	N/A	1/2"	3/4"	3/4"	38041604	11.5x11.5x27.5	15
PS-60	42528455	60	15	2	N/A	1/2"	3/4"	3/4"	42528505	11.5x11.5x27.5	25
PS-125	38339040	125	30	5	N/A	1/2"	3/4"	3/4"	38339057	28.5x19.5x30.8	100
PS-250	42528463	250	50	15	1/4"	1/2"	3/4"	3/4"	42528513	44.5x19.5x37.8	140
PS-560	42528471	560	125	30	1/4"	1/2"	3/4"	3/4"	42528521	45.5x19.5x37.8	140
PS-1125	42528489	1125	300	55	1/4"	1/2"	3/4"	3/4"	42528539	45.5x19.5x37.8	140

PolySep Accessories

Flow Divider 22204432

Note: This component balances load between multiple PolySep units, maximizing element life and optimizing operation.

PolySep Installation Kit 38338273

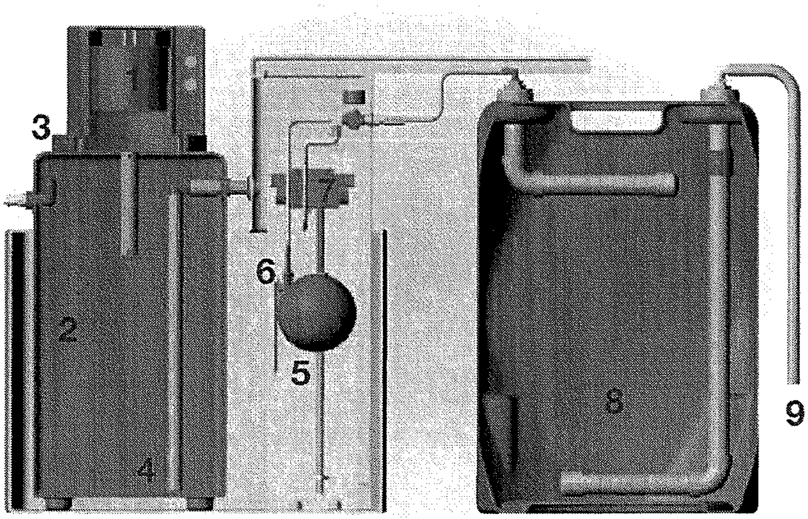
Note: Kit includes (2) 4-Way 1/4" Manifolds, (2) 1/2" x 3/8" Reducing Bushings and (8) 1/4 Plugs.

2.5 Gallon Oil Container 38339081

Note: 2.5 Gallon Oil Container comes standard with PS-125. Needs to be purchased separate with all other models.

IR Ingersoll-Rand®

PS PolySep Oil/Water Separator



1 **Diffuser Chamber**

2 **Main Reservoir**

3 **Oil Weir**

4 **Pick-Up Tube**

5 **Float**

6 **Ball Valve**

7 **Pump**

8 **Filter Module**

9 **Discharge**

Operation

The condensate enters the diffuser chamber (1) when it is depressurized. The oily condensate then enters a main reservoir (2) where gravity separation occurs. Any oil that floats to the surface is skimmed off through an adjustable oil weir (3). The condensate then moves to a separate chamber through a pick-up tube (4). As the condensate accumulates in the next chamber, a float (5) rises with the level of condensate. The float is connected to a ball valve (6) by a lever arm. The increased level of condensate causes the float to rise and open the ball valve. As the valve opens, the air-operated pump (7) is allowed to push the condensate out to the filter module (8). If the level of condensate continues to rise, the float also rises and further opens the ball valve. Cleaned water discharged (9) from the filter module can be disposed of directly into the facility's sanitary sewer. This system assures maximum contact time for the filter module.

The PolySep system only requires compressed air to operate the diaphragm pump and is only used when the level of condensate rises enough to operate the pump. This system is reliable because there are only two moving parts.

The PolySep filter modules are available in three separate sizes. The same delivery system is used for each filter module. Thus, an expanded system may only require a larger filter module. Once spent, there are no messy bags to dispose of. The containers are totally self-contained and easily transported by use of a forklift handle located at the top.

More Than Air. Solutions.

Online solutions: http://www.air.irco.com

Water discharged from the PolySep oil/water separation system is not intended or approved for human consumption. Installation of PolySep oil/water separation system must be in accordance with all local and national regulations. Check with local municipality to determine permissible oil content in effluent. Regular monitoring of outlet water is required to ensure that permitted limits are not being exceeded.

Ingersoll-Rand

Ingersoll-Rand
800-B Beaty St.
Davidson, NC 28036

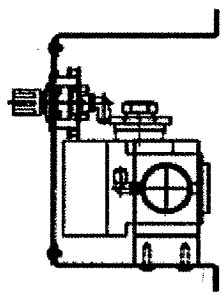
 Form 38430393 Rev. 01 Printed in USA

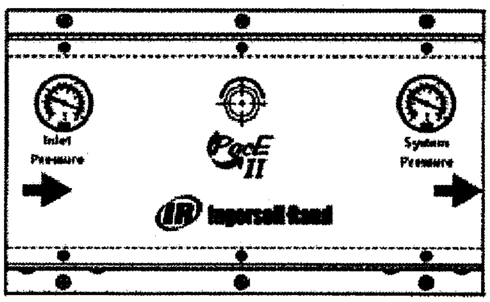
Ingersoll Rand

Pace Air Controller 2" NPT

Detailed Scope of Supply

All amounts are displayed in US dollars





Technical Information:

Connection Size - 2" NPT Female
MAX Flow Rate - 650 scfm
MAX Inlet Pressure- 150 psig
Control Range - 150 psig to 7 psig
Operating Temperature Range - 176F(80C) to -4F(-20C)
Items as specified below

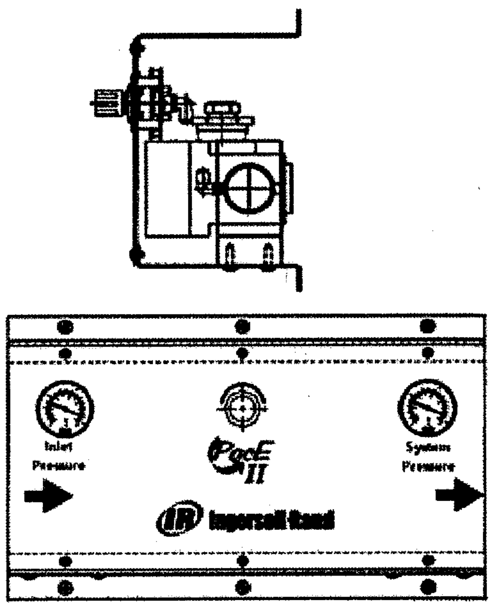
QTY	Description	Unit Price	Total Price
1	Pace Air Controller 2" NPT	$1,899.00	$1,899.00
	The Pace controller increases system efficiency by enabling you to store compressed air at high pressure in your receiver while supplying constant air pressure in the system. The result is reduced losses, lower energy costs, and lower pressure dewpoint.		
1	Standard Factory Warranty		Included
	The Company warrants that the equipment manufactured by it and delivered hereunder will be free of defects in material and workmanship for a period of twelve months from the date of placing the Equipment in operation or eighteen months from the date of shipment from the factory, whichever shall first occur.		

Ingersoll Rand

Pace Air Controller 2" NPT

Detailed Scope of Supply

All amounts are displayed in US dollars



Technical Information:

Connection Size - 2" NPT Female
MAX Flow Rate - 650 scfm
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Control Range - 150 psig to 7 psig
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Items as specified below

QTY	Description	Unit Price	Total Price
1	Pace Air Controller 2" NPT The Pace controller increases system efficiency by enabling you to store compressed air at high pressure in your receiver while supplying constant air pressure in the system. The result is reduced losses, lower energy costs, and lower pressure dewpoint.	$1,899.00	$1,899.00
1	Standard Factory Warranty The Company warrants that the equipment manufactured by it and delivered hereunder will be free of defects in material and workmanship for a period of twelve months from the date of placing the Equipment in operation or eighteen months from the date of shipment from the factory, whichever shall first occur.		Included

Ingersoll Rand

Pace Air Controller 2" NPT

Total Price $1,899.00

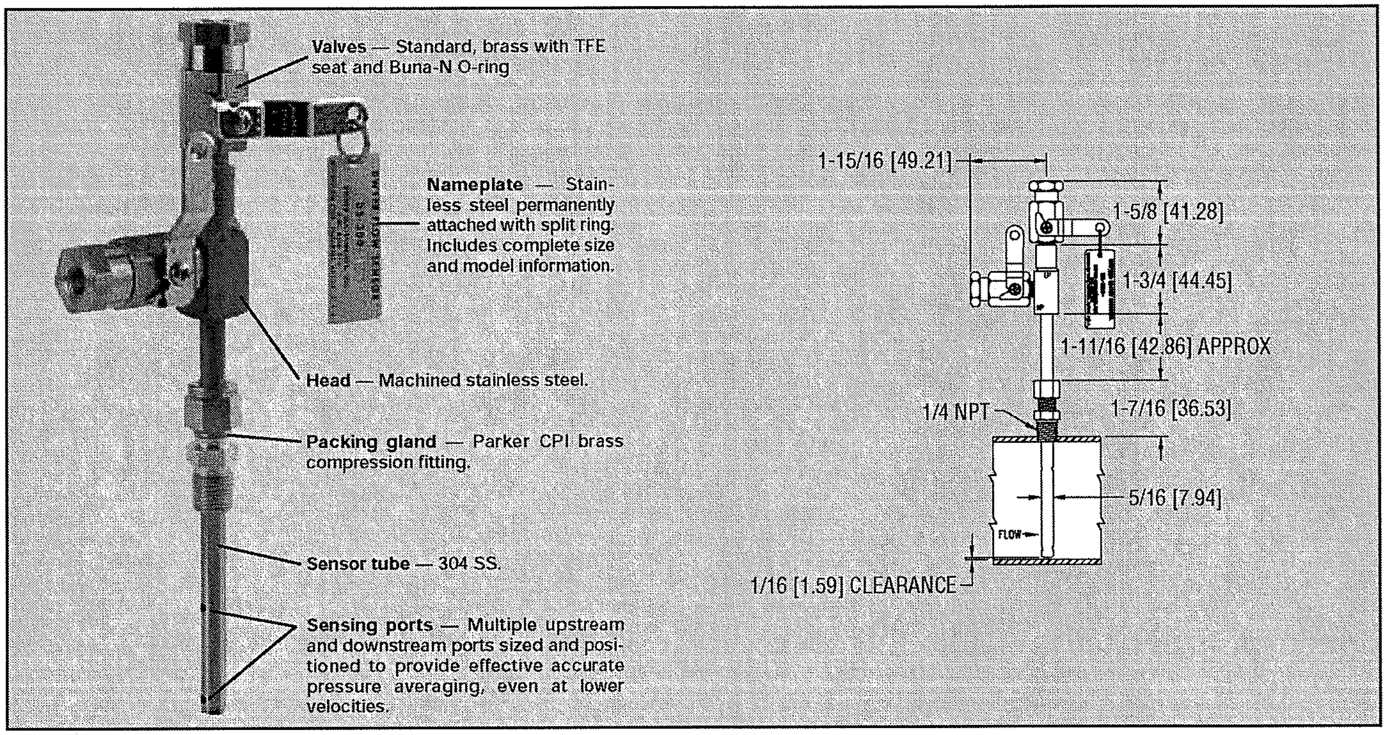
INSTRUMENTATION

FE-201, FE-202, & FE-203

Flow

Series DS In-Line Flow Sensors

Use with the Dwyer® Differential Pressure Gages or Transmitters



In-Line Flow Sensors are averaging Pitot tubes that provide accurate and convenient flow rate sensing for schedule 40 pipe. When purchased with a Dwyer® Capsuhelic® differential pressure gage of appropriate range, the result is a flow indicating system delivered off the shelf at an economical price.
Pitot tubes have been used in flow measurement for years. Conventional pitot tubes sense velocity pressure at only one point in the flowing stream. Therefore, a series of measurements must be taken across the stream to obtain a meaningful average flow rate. The Dwyer® flow sensor eliminates the need for "traversing" the flowing stream because of its multiple sensing points and built-in averaging capability.

The Series DS-300 flow sensors are designed to be inserted in the pipeline through a compression fitting. They are furnished with instrument shut-off valves on both pressure connections. Valves are fitted with ⅛" female NPT connections. Accessories include adapters with ¼" SAE 45° flared ends compatible with hoses supplied with the Model A-471 Portable Capsuhelic® gage kit. Standard valves are rated at 200 psig (13.7 bar) and 200°F (93.3°C). Where valves are not required, they can be omitted at reduced cost. Series DS-300 flow sensors are available for pipe sizes from 1" to 10".

DS-400 Averaging Flow Sensors are quality constructed from extra strong ¾" dia. stainless steel to resist increased forces encountered at higher flow rates with both air and water. This extra strength also allows them to be made in longer insertion lengths up to 24 inches (61 cm). All models include convenient and quick-acting quarter-turn ball valves to isolate the sensor for zeroing. Process connections to the valve assembly are ⅛" female NPT. A pair of ⅛" NPT × ¼" SAE 45° flared adapters are included, compatible with hoses used in the Model A-471 Portable Capsuhelic® Gage Kit. Supplied solid brass mounting adapter has a ¾" dia. compression fitting to lock in required insertion length and a ¾" male NPT thread for mounting in a Threaded Branch Connection.

Select model with suffix which matches pipe size

DS-300-1"
DS-300-1¼"
DS-300-1½"
* **DS-300-2"**
DS-300-2½"
DS-300-3"
DS-300-4"
DS-300-6"
DS-300-8"
DS-300-10"

DS-400-6"
DS-400-8"
DS-400-10"
DS-400-12"
DS-400-14"
DS-400-16"
DS-400-18"
DS-400-20"
DS-400-24"

Options and Accessories

A-160 Thredolet,⅜" NPT, forged steel, 3000 psi
A-161 Brass Bushing, ¼" x ⅜"
(DS-300) To order, add suffix -LVdeduct
Ⓑ Items subject to Schedule B discounts

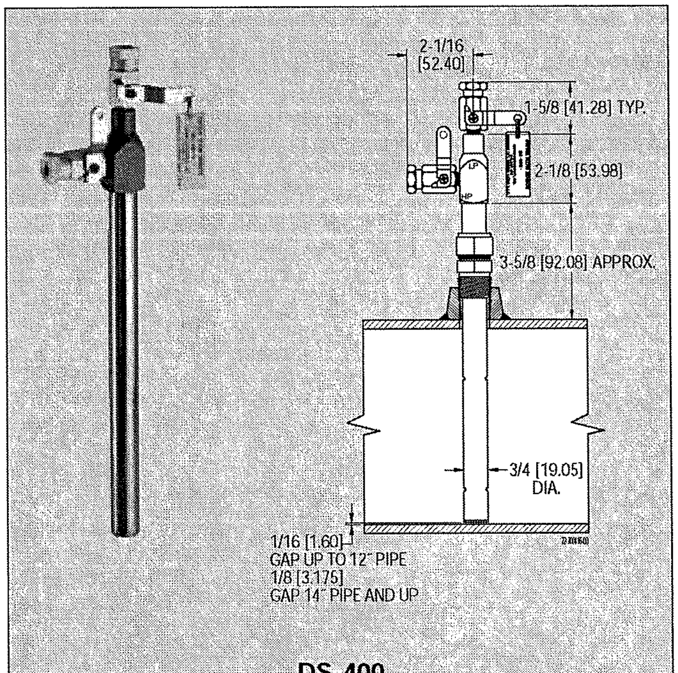
How To Order

Merely determine the pipe size into which the flow sensor will be mounted and designate the size as a suffix to Model DS-300. For example, a flow sensor to be mounted in a 2" pipe would be a Model No. DS-300-2".

For non-critical water and air flow monitoring applications, the chart below can be utilized for ordering a stock Capsuhelic® differential pressure gage for use with the DS-300 flow sensor. Simply locate the maximum flow rate for the media being measured under the appropriate pipe size and read the Capsuhelic® gage range in inches of water column to the left. The DS-300 sensor is supplied with installation and operating instructions, Bulletin F-50. It also includes complete flow conversion information for the three media conditions shown in the chart below. This information enables the user to create a complete differential pressure to flow rate conversion table for the sensor and differential pressure gage employed. Both the Dwyer® Capsuhelic® gage and flow sensor feature excellent repeatability so, once the desired flow rate is determined, deviation from that flow in quantitative measure can be easily determined. You may wish to order the adjustable signal flag option for the Capsuhelic® gage to provide an easily identified reference point for the proper flow.

Capsuhelic® gages with special ranges and/or direct reading scales in appropriate flow units are available on special order for more critical applications. Customer supplied data for the full scale flow (quantity and units) is required along with the differential pressure reading at that full flow figure. Prior to ordering a special Capsuhelic® differential pressure gage for flow read-out, we recommend you request Bulletin F-50 to obtain complete data on converting flow rates of various media to the sensor differential pressure output. With this bulletin and after making a few simple calculations, the exact range gage required can easily be determined.

Large 3/4 Inch Diameter for Extra Strength in Lengths to 24 Inches



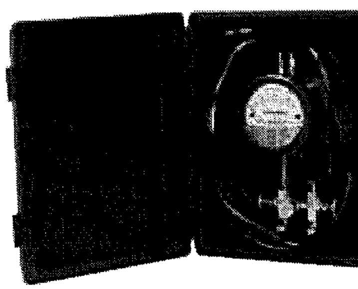
DS-400

GAGE RANGE (IN. W.C.)	MEDIA @ 70°F	FULL RANGE FLOWS BY PIPE SIZE (APPROXIMATE)									
		1"	1¼"	1½"	2"	2½"	3"	4"	6"	8"	10"
2	Water (GPM)	4.8	8.3	11.5	20.5	30	49	86	205	350	560
	Air @ 14.7 PSIA (SCFM)	19.0	33.0	42.0	65.0	113	183	330	760	1340	2130
	Air @ 100 PSIG (SCFM)	50.0	90.5	120.0	210.0	325	510	920	2050	3600	6000
5	Water (GPM)	7.7	14.0	18.0	34.0	47	78	138	320	560	890
	Air @ 14.7 PSIA (SCFM)	30.0	51.0	66.0	118.0	178	289	510	1200	2150	3400
	Air @ 100 PSIG (SCFM)	83.0	142.0	190.0	340.0	610	820	1600	3300	5700	10000
10	Water (GPM)	11.0	19.0	25.5	45.5	67	110	195	450	800	1260
	Air @ 14.7 PSIA (SCFM)	41.0	72.0	93.0	163.0	250	410	725	1690	3040	4860
	Air @ 100 PSIG (SCFM)	120.0	205.0	275.0	470.0	740	1100	2000	4600	8100	15000
25	Water (GPM)	18.0	32.0	40.5	72.0	108	173	310	720	1250	2000
	Air @ 14.7 PSIA (SCFM)	63.0	112.0	155.0	255.0	390	640	1130	2630	4860	7700
	Air @ 100 PSIG (SCFM)	185.0	325.0	430.0	760.0	1200	1800	3300	7200	13000	22000
50	Water (GPM)	25.0	44.0	57.5	100.0	152	247	435	1000	1800	
	Air @ 14.7 PSIA (SCFM)	90.0	161.0	205.0	360.0	560	900	1600	3700	6400	
	Air @ 100 PSIG (SCFM)	260.0	460.0	620.0	1050.0	1700	2600	4600	10000	18500	
100	Water (GPM)	36.5	62.0	82.0	142.0	220	350	620	1500		
	Air @ 14.7 PSIA (SCFM)	135.0	230.0	300.0	505.0	800	1290	2290	5000		
	Air @ 100 PSIG (SCFM)	370.0	660.0	870.0	1500.0	2300	3600	6500	15000		

Model A-471 Portable Kit

The Dwyer® Series 4000 Capsuhelic® differential pressure gage is ideally suited for use as a read-out device with the DS-300 Flow Sensors. The gage may be used on system pressures of up to 500 psig even when the flow sensor differential pressure to be read is less than 0.5" w.c. With accuracy of ±3% of full scale, the Capsuhelic® gage can be used in ambient temperatures from 32 to 200°F (0 to 93.3°C). Zero and range adjustments are made from outside the gage. The standard gage with a die cast aluminum housing can be used with the flow sensor for air or oil applications. For water flow measurements, the optional forged brass housing should be specified. The Capsuhelic® gage may be panel or surface mounted and permanently plumbed to the flow sensor if desired. The optional A-610 pipe mounting bracket allows the gage to be easily attached to any 1¼" - 2" horizontal or vertical pipe.

For portable operation, the A-471 Capsuhelic® Portable Gage Kit is available complete with tough polypropylene carrying case, mounting bracket, 3-way manifold valve, two 10' high pressure hoses, and all necessary fittings. See pages 8 and 9 for complete information on the Capsuhelic® gage.



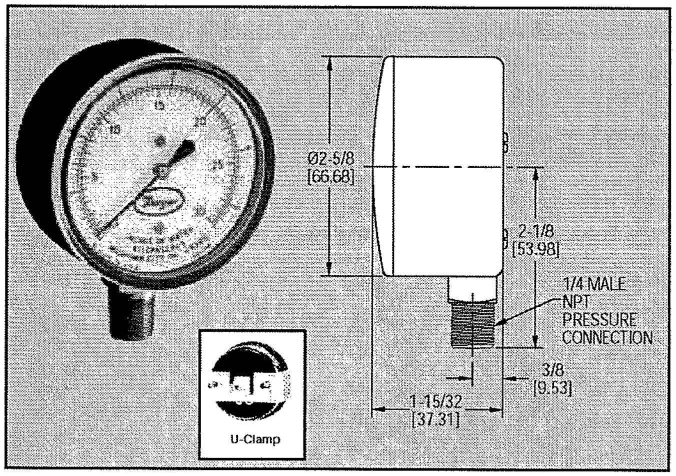
CAPSUHELIC® GAGE SHOWN INSTALLED IN A-471 PORTABLE KIT

PI-103, PI-104, PI-105, & PI-106

Dwyer®

Series 61000 Pressure Gages

Exceptional Value in a 2 1/2" Gage



Series 61000 gages feature an extra sensitive bronze diaphragm for ASME Grade A accuracy in ranges to 100 inches w.c. The gage measures pressure of air, natural gas and other compatible gases and liquids.

SPECIFICATIONS

Service: Compatible gases and liquids.
Wetted Materials: Phosphor bronze diaphragm, brass and polycarbonate.
Housing: Steel with black baked enamel finish.
Dial/Pointer: Aluminum.
Accuracy: 61000, ASME Grade A — 1% middle half of scale, 2% remainder: 61015 only — 1% middle half of scale, 3% remainder.
Pressure Limit: 110% FS.
Temperature Limits: -40 to 160°F (-40 to 71°C).
Size: 2-1/2".
Process Connection: 1/4" male NPT bottom-std. 1/4" male NPT back 61000U.
Weight: 6.5 oz (184 g).

MODELS

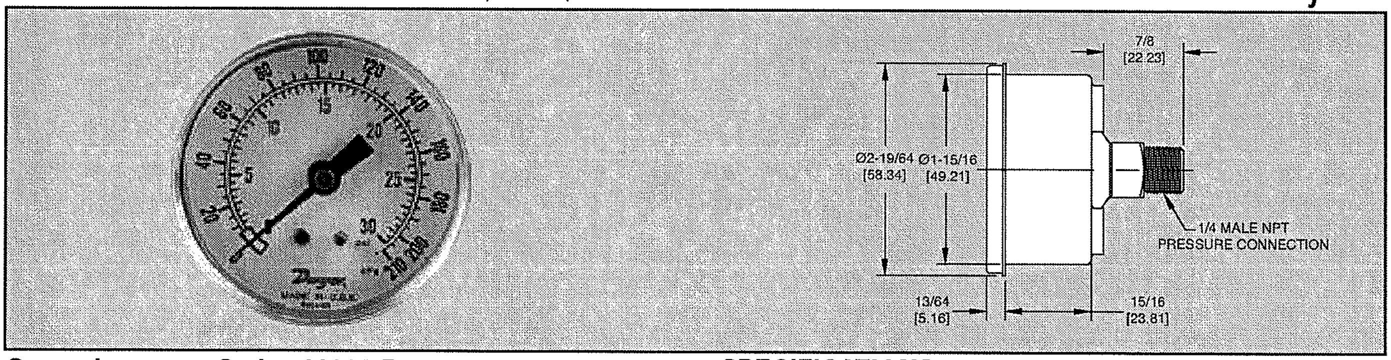
Model Number	Range in. w.c.	Range kPa
61015	0-15	0-4
61030	0-30	0-7.5
61060	0-60	0-15
61100	0-100	0-25

Options — Add options as a suffix. **U**-U-clamp (panel mount)

Dwyer®

Series 66000 Pressure Gage

2" (51 mm) Dual Scale Dial, Center Back Connection, ASME Grade B Accuracy



General purpose Series 66000 Pressure Gages are suitable for use with air, oil, water or compatible gases. The brass internals are housed within a rugged ABS plastic case. The aluminum dial and pointer are protected by an impact resistant polycarbonate window. Accuracy is ±3-2-3% per ASME Grade B. Brass back connection is 1/4" male NPT.

MODELS

Model Numbers	Range psig	Range kPa	
66015	0-15	0-100	
66030	0-30	0-200	
66060	0-60	0-400	
66120	0-120	0-800	

SPECIFICATIONS

Service: Clean, noncorrosive liquids or gases.
Wetted Materials: Brass.
Housing: Black ABS plastic with clear polycarbonate window.
Dial/Pointer: 2" (51 mm) aluminum dial with black enameled pointer.
Accuracy: ±3-2-3% per ASME Grade B.
Pressure Limit: 1.5 x full scale.
Temperature Limits: 14 to 176°F (-10 to 80°C).
Size: 2".
Process Connections: 1/4" male NPT, center back.
Weight: 1 lb (0.5 kg).

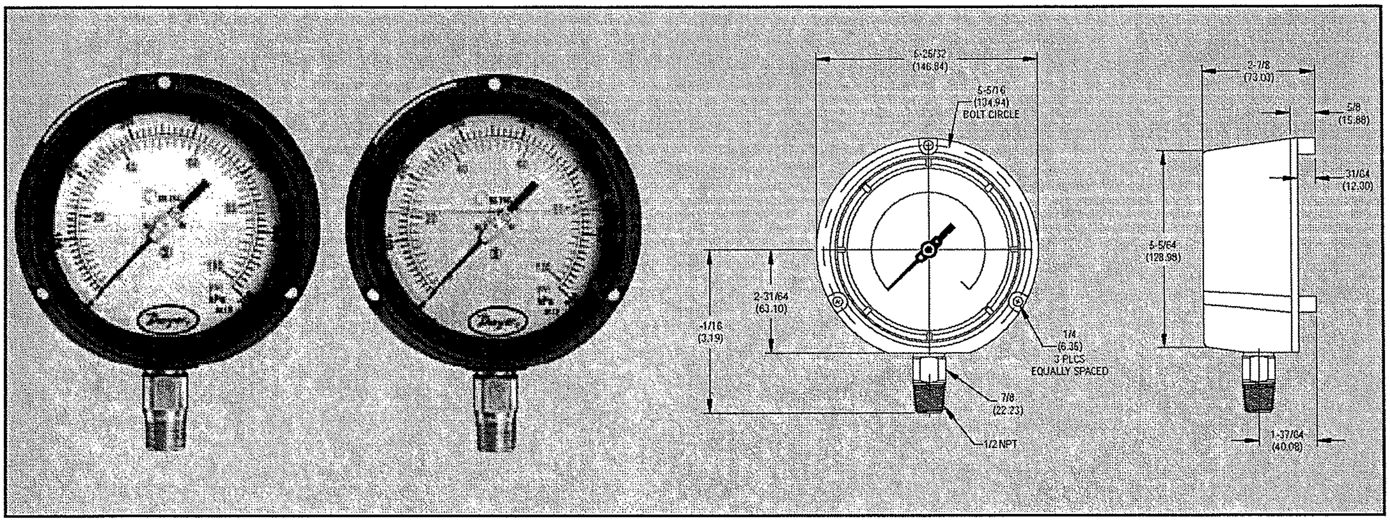
APPLICATIONS

Compressors, water pumps, industrial machinery and regulators.

PI-202

Series 761 & 762 Process Pressure Gages

Liquid-Fillable or Glycerin-Filled



Series 761/762 Process Pressure Gages have a dual English/metric scale with ±0.5% or ±1% full scale accuracy. Series 761 gages may be easily liquid filled in the field without the need for a separate kit. Series 762 gages have a glycerin-filled housing, providing superior performance in applications where vibration, pulsation, mechanical shock and pressure spikes are common. The gages are designed with 316L SS tube and socket for excellent chemical compatibility and are offered in a wide selection of ranges, from full vacuum, compound to 20,000 psi.

APPLICATIONS

Chemical, Refinery, Fertilizer, Petrochemical, Pharmaceutical, Power, Oil, Cement, Sugar, Food and Beverage, Pulp and Paper, and Waste Water.

SPECIFICATIONS

Service: Compatible gases and liquids.
Wetted Materials: 316L SS Bourdon tube & connection.
Housing: Fiberglass reinforced Polypropylene.
Lens: Shatterproof safety glass.
Accuracy: 761: ±0.5% full scale, ASME B40.1, Grade 2A; 762: ±1% full scale, ASME B40.1, Grade 1A.
Pressure Limit: 130% of full scale for ranges 8000 psi or less. 115% of full scale for ranges greater than 8000 psi.
Temperature Limit: Ambient: -4 to 150°F (-20 to 65°C); 761 Process: 300°F max (150°C max); 762 Process: 150°F max (65°C max).
Size: 4-1/2" (115 mm).
Process Connection: 1/2" male NPT.
Enclosure Rating: NEMA 3 (IP55).
Weight: 761: 1.4 lb (650 g); 762: 1.6 lb (750 g).

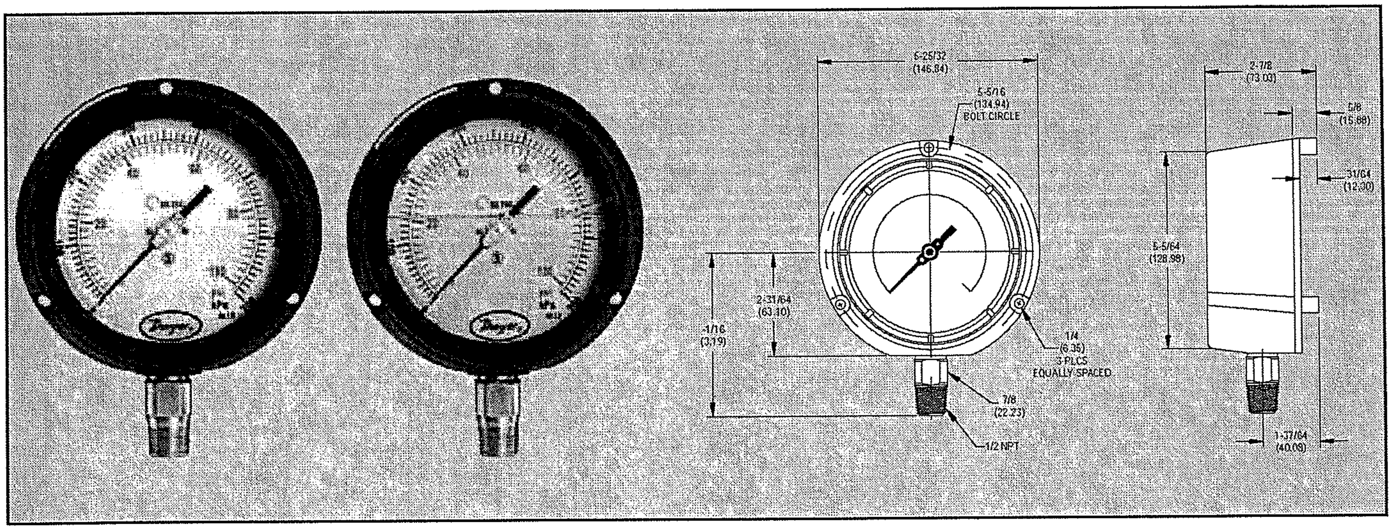
Model Number	Range	Model Number	Range
761-1	0-15 psi (0 to 100 kPa)	**761-15**	0-3000 psi (0 to 20 MPa)
761-2	0-30 psi (0 to 200 kPa)	**761-16**	0-4000 psi (0 to 28 MPa)
761-3	0-60 psi (0 to 400 kPa)	**761-17**	0-5000 psi (0 to 34 MPa)
* **761-4**	0-100 psi (0 to 700 kPa)	**761-18**	0-6000 psi (0 to 40 MPa)
761-5	0-160 psi (0 to 1100 kPa)	**761-19**	0-10000 psi (0 to 70 MPa)
761-6	30" Hg-0 vac (0 to -100 kPa)	**761-20**	0-15000 psi (0 to 100 MPa)
761-7	0-200 psi (0 to 1400 kPa)	**761-21**	0-20000 psi (0 to 140 MPa)
761-8	0-300 psi (0 to 2000 kPa)	**761-22**	30" Hg-0-15 psi (-100 to 100 kPa)
761-9	0-400 psi (0 to 2800 kPa)	**761-23**	30" Hg-0-30 psi (-100 to 200 kPa)
761-10	0-500 psi (0 to 3400 kPa)	**761-24**	30" Hg-0-60 psi (-100 to 400 kPa)
761-11	0-600 psi (0 to 4000 kPa)	**761-25**	30" Hg-0-100 psi (-100 to 700 kPa)
761-12	0-1000 psi (0 to 7000 kPa)	**761-26**	30" Hg-0-150 psi (-100 to 100 kPa)
761-13	0-1500 psi (0 to 10 MPa)	**761-27**	30" Hg-0-200 psi (-100 to 1400 kPa)
761-14	0-2000 psi (0 to 14 MPa)	**761-28**	30" Hg-0-300 psi (-100 to 2000 kPa)

For glycerin fill change series from 761 to 762.

PI-301, PI-302, PI-304, & PI-306

Series 761 & 762 Process Pressure Gages

Liquid-Fillable or Glycerin-Filled



Series 761/762 Process Pressure Gages have a dual English/metric scale with ±0.5% or ±1% full scale accuracy. Series 761 gages may be easily liquid filled in the field without the need for a separate kit. Series 762 gages have a glycerin-filled housing, providing superior performance in applications where vibration, pulsation, mechanical shock and pressure spikes are common. The gages are designed with 316L SS tube and socket for excellent chemical compatibility and are offered in a wide selection of ranges, from full vacuum, compound to 20,000 psi.

APPLICATIONS

Chemical, Refinery, Fertilizer, Petrochemical, Pharmaceutical, Power, Oil, Cement, Sugar, Food and Beverage, Pulp and Paper, and Waste Water.

SPECIFICATIONS

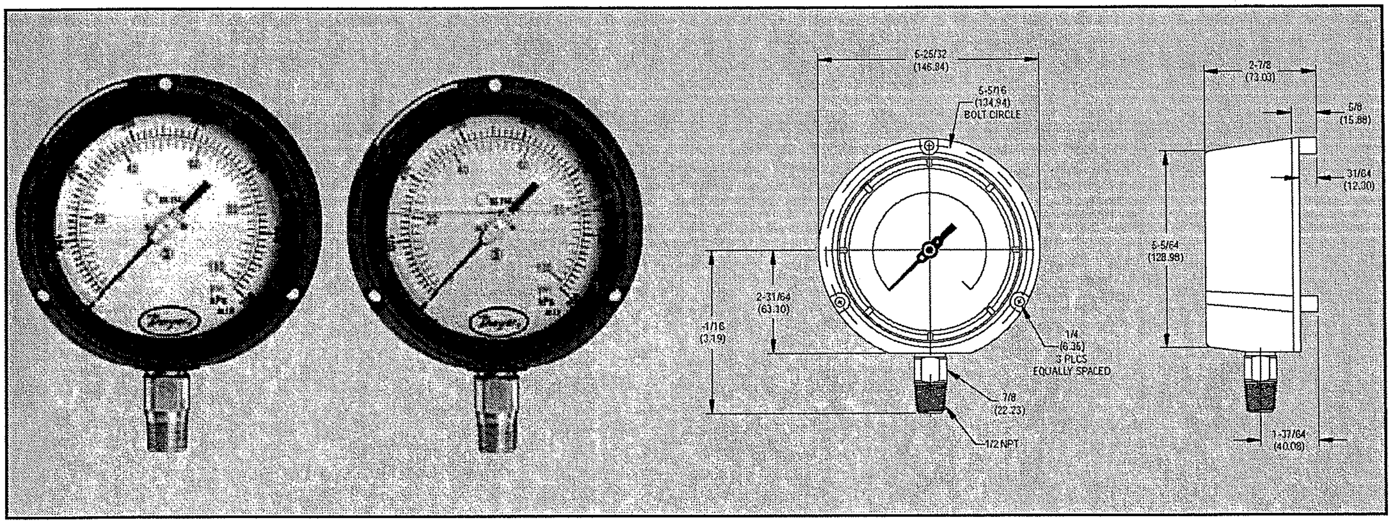
Service: Compatible gases and liquids.
Wetted Materials: 316L SS Bourdon tube & connection.
Housing: Fiberglass reinforced Polypropylene.
Lens: Shatterproof safety glass.
Accuracy: 761: ±0.5% full scale, ASME B40.1, Grade 2A; 762: ±1% full scale, ASME B40.1, Grade 1A.
Pressure Limit: 130% of full scale for ranges 8000 psi or less. 115% of full scale for ranges greater than 8000 psi.
Temperature Limit: Ambient: -4 to 150°F (-20 to 65°C); 761 Process: 300°F max (150°C max); 762 Process: 150°F max (65°C max).
Size: 4-1/2" (115 mm).
Process Connection: 1/2" male NPT.
Enclosure Rating: NEMA 3 (IP55).
Weight: 761: 1.4 lb (650 g); 762: 1.6 lb (750 g).

Model Number	Range	Model Number	Range
761-1	0-15 psi (0 to 100 kPa)	**761-15**	0-3000 psi (0 to 20 MPa)
761-2	0-30 psi (0 to 200 kPa)	**761-16**	0-4000 psi (0 to 28 MPa)
* **761-3**	0-60 psi (0 to 400 kPa)	**761-17**	0-5000 psi (0 to 34 MPa)
761-4	0-100 psi (0 to 700 kPa)	**761-18**	0-6000 psi (0 to 40 MPa)
761-5	0-160 psi (0 to 1100 kPa)	**761-19**	0-10000 psi (0 to 70 MPa)
761-6	30" Hg-0 vac (0 to -100 kPa)	**761-20**	0-15000 psi (0 to 100 MPa)
761-7	0-200 psi (0 to 1400 kPa)	**761-21**	0-20000 psi (0 to 140 MPa)
761-8	0-300 psi (0 to 2000 kPa)	**761-22**	30" Hg-0-15 psi (-100 to 100 kPa)
761-9	0-400 psi (0 to 2800 kPa)	**761-23**	30" Hg-0-30 psi (-100 to 200 kPa)
761-10	0-500 psi (0 to 3400 kPa)	**761-24**	30" Hg-0-60 psi (-100 to 400 kPa)
761-11	0-600 psi (0 to 4000 kPa)	**761-25**	30" Hg-0-100 psi (-100 to 700 kPa)
761-12	0-1000 psi (0 to 7000 kPa)	**761-26**	30" Hg-0-150 psi (-100 to 100 kPa)
761-13	0-1500 psi (0 to 10 MPa)	**761-27**	30" Hg-0-200 psi (-100 to 1400 kPa)
761-14	0-2000 psi (0 to 14 MPa)	**761-28**	30" Hg-0-300 psi (-100 to 2000 kPa)

For glycerin fill change series from 761 to 762.

PI-303, PI-305, & PI-307

Dwyer® Series 761 & 762 Process Pressure Gages
Liquid-Fillable or Glycerin-Filled



Series 761/762 Process Pressure Gages have a dual English/metric scale with ±0.5% or ±1% full scale accuracy. Series 761 gages may be easily liquid filled in the field without the need for a separate kit. Series 762 gages have a glycerin-filled housing, providing superior performance in applications where vibration, pulsation, mechanical shock and pressure spikes are common. The gages are designed with 316L SS tube and socket for excellent chemical compatibility and are offered in a wide selection of ranges, from full vacuum, compound to 20,000 psi.

APPLICATIONS

Chemical, Refinery, Fertilizer, Petrochemical, Pharmaceutical, Power, Oil, Cement, Sugar, Food and Beverage, Pulp and Paper, and Waste Water.

SPECIFICATIONS

Service: Compatible gases and liquids.
Wetted Materials: 316L SS Bourdon tube & connection.
Housing: Fiberglass reinforced Polypropylene.
Lens: Shatterproof safety glass.
Accuracy: 761: ±0.5% full scale, ASME B40.1, Grade 2A; 762: ±1% full scale, ASME B40.1, Grade 1A.
Pressure Limit: 130% of full scale for ranges 8000 psi or less. 115% of full scale for ranges greater than 8000 psi.
Temperature Limit: Ambient: -4 to 150°F (-20 to 65°C); 761 Process: 300°F max (150°C max); 762 Process: 150°F max (65°C max).
Size: 4-1/2″ (115 mm).
Process Connection: 1/2″ male NPT.
Enclosure Rating: NEMA 3 (IP55).
Weight: 761: 1.4 lb (650 g); 762: 1.6 lb (750 g).

Model Number	Range	Model Number	Range
761-1	0-15 psi (0 to 100 kPa)	**761-15**	0-3000 psi (0 to 20 MPa)
761-2	0-30 psi (0 to 200 kPa)	**761-16**	0-4000 psi (0 to 28 MPa)
761-3	0-60 psi (0 to 400 kPa)	**761-17**	0-5000 psi (0 to 34 MPa)
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761-6	30″ Hg-0 vac (0 to -100 kPa)	**761-20**	0-15000 psi (0 to 100 MPa)
761-7	0-200 psi (0 to 1400 kPa)	**761-21**	0-20000 psi (0 to 140 MPa)
761-8	0-300 psi (0 to 2000 kPa)	**761-22**	30″ Hg-0-15 psi (-100 to 100 kPa)
761-9	0-400 psi (0 to 2800 kPa)	**761-23**	30″ Hg-0-30 psi (-100 to 200 kPa)
761-10	0-500 psi (0 to 3400 kPa)	**761-24**	30″ Hg-0-60 psi (-100 to 400 kPa)
761-11	0-600 psi (0 to 4000 kPa)	**761-25**	30″ Hg-0-100 psi (-100 to 700 kPa)
761-12	0-1000 psi (0 to 7000 kPa)	**761-26**	30″ Hg-0-150 psi (-100 to 100 kPa)
761-13	0-1500 psi (0 to 10 MPa)	**761-27**	30″ Hg-0-200 psi (-100 to 1400 kPa)
761-14	0-2000 psi (0 to 14 MPa)	**761-28**	30″ Hg-0-300 psi (-100 to 2000 kPa)

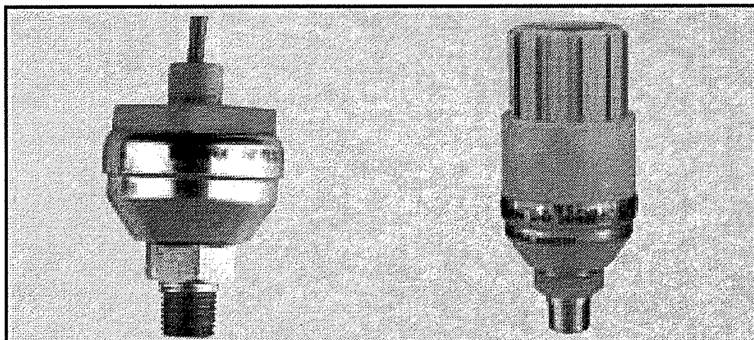
For glycerin fill change series from 761 to 762.

PT-110

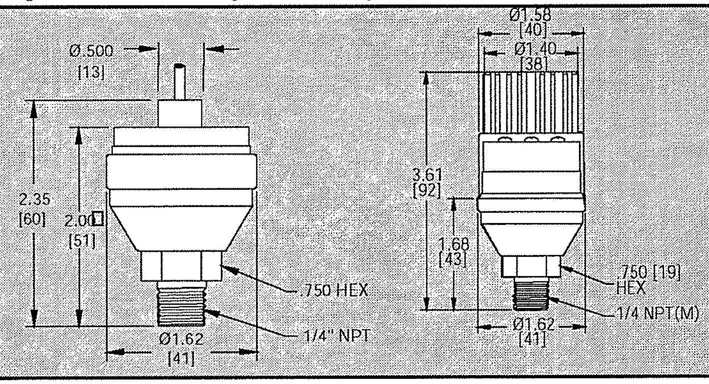
Series 673 Pressure Transmitter

±0.25% Full Span Accuracy, 4-20 mA Signal, Ranges to 1000 psi

CE



NEW CONDUIT VERSION



The low cost Series 673 Pressure Transmitter is a fixed range transmitter designed for harsh environments and suitable for high shock and vibration applications. Constructed of stainless steel, the Series 673 provides a 4 to 20 mA output signal with 0.25% accuracy. Use the Series 673 in industrial OEM equipment, hydraulic systems, HVAC equipment, industrial engines and compressor control.

Model Number*		Range	Model Number*		Range
673-1	673-1C	0-1 psi	673-7	673-7C	100 psi
673-2	673-2C	0-2 psi	673-8	673-8C	200 psi
673-3	673-3C	0-5 psi	673-9	673-9C	500 psi
673-4	673-4C	0-10 psi	673-10	673-10C	1000 psi
673-5	673-5C	0-25 psi	673-13	673-13C	-14.7-30 psig
673-6	673-6C	50 psi	673-14	673-14C	-14.7-100 psig

* The model numbers followed by a "C" represent the conduit version.

SPECIFICATIONS

Service: Liquid, gas, or vapor.

Wetted Materials: 17-4 PH SS.

Accuracy: ±0.25% FS (RSS), (includes non-linearity, hysteresis and non-repeatability).

Temperature Limits:
-40 to 260°F (-40 to 125°C).

Pressure Limits: 2 x maximum range.

Compensated Temperature Range: 4 to 212°F (-20 to 100°C).

Thermal Errors: Zero: ±3.6% FS/100°F(100°C); Span: ±2.7% FS/100°F(100°C).

Supply Voltage: 9-30 VDC.

Output: 4-20 mA, 2-wire.

Zero & Span Adjustment: Fixed.

Response Time: <60 msec.

Loop Resistance: 0 to 800Ω.

Stability: 0.5% FS/year.

Shock: 200 g.

Vibration: 20 g.

Electrical Connections: 2 ft (61 cm) multiconductor cable.

Conduit Connection: 1/4"-18 (22.3 mm) knockout.

Enclosure: Stainless Steel and Valox.

Weight: 2.3 oz (65 g).

Agency Approvals: CE.

PT-300

WL450 All Stainless Level Transmitter

Submersible stainless steel diaphragm water level transmitters

Features

- Rugged 316L stainless steel flush-diaphragm sensor
- Highly stable digital temperature compensation
- 16-bit internal digital error correction
- Durable and environmentally neutral Hytrel® cable
- Custom cable lengths and ranges are available

Description

The WL450 All Stainless Level Transmitter offers standard features and a level of performance that far exceed those of other comparably priced transmitters. The WL450 features a 316L stainless steel diaphragm, digital temperature compensation, and environmentally neutral Hytrel® cable. These assets enable the unit to provide a high level of performance over a long period of time and a wide range of operating conditions. The WL450 is ideally suited for environmental monitoring applications such as test wells, streams, rivers, and reservoirs.

Simple Digital Output

The WL450 includes a RS-485 direct to digital output for a modem or other communications network. This avoids the error and complication involved with analog to digital conversion devices. Please contact Global Water for more details about direct to digital applications.

Standard Units for a Range of Uses

All of our standard WL450 units are set up for 2-wire, 4-20 mA output. They are calibrated for specific ranges in feet of head with an appropriate length of Hytrel® vented cable, including: 0-3' range (25' cable), 0-15' range (25' cable), 0-30' range (50' cable), 0-60' range (100' cable), 0-120' range (150' cable), 0-250' range (300' cable), and 0-500' range (510' of cable).

Customize for Your Application

In addition to the standard WL450 ranges and cable lengths, we can customize your WL450 for a small additional fee. Please contact Global Water regarding this option.

Specifications

Accuracy	Total error band ±0.1% standard
Operating Temperature	14 to 176°F (-10 to 80°C)
Power	10 to 28 VDC
Communication	RS-485
Wetted Materials	316L stainless steel, polyamide, fluorocarbon
Cable	Hytrel®-jacketed, vented and shielded
Dimensions	0.825" dia. x 3.7" long (2 cm dia. x 9 cm long)
Weight	1 lb (0.45 kg)

Ordering & Options

All Stainless Level Transmitters

Order No.	Sensor Range (Ft/Head)	Cable Length	Price
WL450-003	0 to 3'	25'	$579.00
WL450-015	0 to 15'	25'	579.00
WL450-030	0 to 50'	50'	625.00
WL450-060	0 to 100'	100'	710.00
WL450-120	0 to 150'	150'	797.50
WL450-250	0 to 300'	300'	1,060.00
WL450-500	0 to 500'	510'	1,429.00
WL450-CUS	Custom Range	Custom Length	Call Us

Options

Order No.	Description	Price
WL450-EXC	Extra Hytrel® Vented Cable (up to a total of 1000')	$1.75/ft

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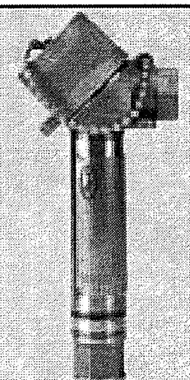
PT-307

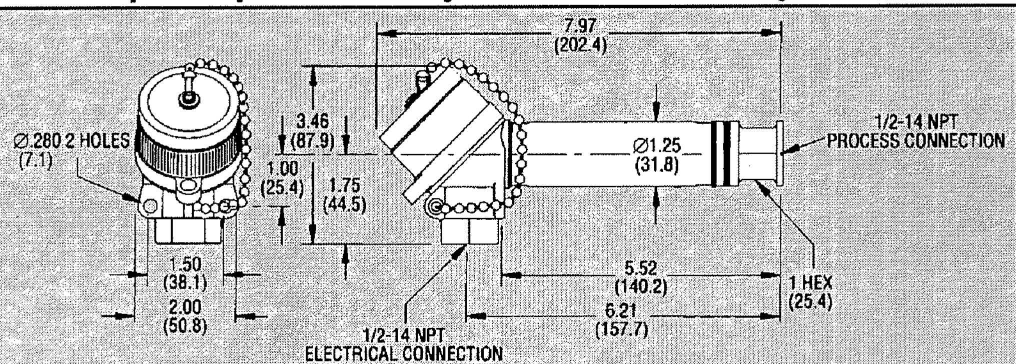
Dwyer®

Series 637 Adjustable Range Pressure Transmitter

CE FM APPROVED

Stainless Steel, Explosion-proof, Accuracy ±0.25%, 4-20 mA Signal





Series 637 Pressure Transmitters are durable and compact with all welded 316 SS construction and exceptional ±0.25% accuracy. Four ranges are offered up to 0-300 psig (0-20 bar). Zero and span are adjustable to ±10% each; range turndown is a full 5:1. Integral junction box simplifies field wiring. Output is 4-20 mA with 12-40 VDC power supply. Units are explosion-proof, intrinsically safe with FM approval and they meet NACE standards for off-shore applications.

Model Number	Stock Range, PSI	Minimum Range, PSI	Stock Range, Bar	Minimum Range, Bar
637-0	0-15	0-3	0-1	0-0.2
✱ 637-1	0-30	0-6	0-2	0-0.4
637-2	0-100	0-20	0-7	0-1.4
637-3	0-300	0-60	0-20	0-4

ACCESSORIES

MTL5041, Intrinsically Safe Galvanic Isolator
MTL7706, Intrinsically Safe Zener Barrier

SPECIFICATIONS

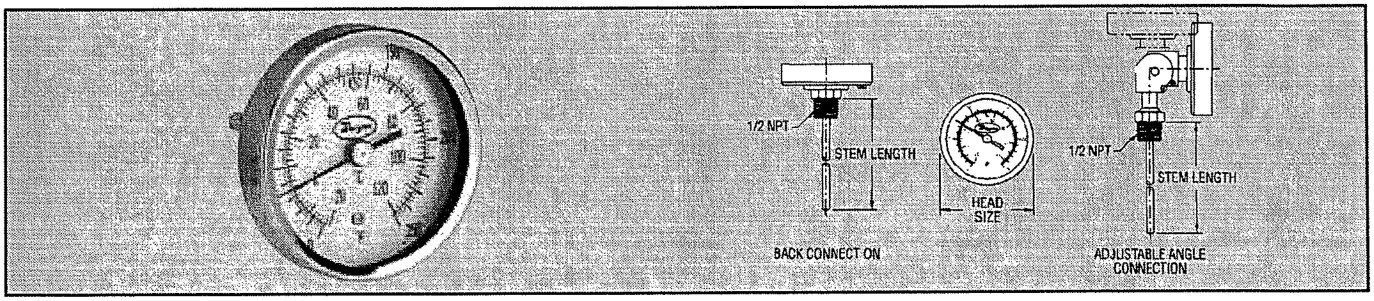
Service: Liquid, gas or vapor.
Wetted Materials: 316 L SS.
Body: 316 SS.
Accuracy: ±0.25% of calibrated span.
Stability: ±0.5% of upper range limit for six months.
Temperature Limits: Process Interface -40 to 212°F (-40 to100°C).
Pressure Limits: 300% full scale.
Compensated Temperature: -20 to 180°F (-29 to 82°C).
Thermal Effect: (includes zero and span) ±.02% upper range /°F (30 to 130°F) ±.032% upper range /°F (-20 to 180°F).
Power Requirements: 12 to 40 VDC with rev. polarity protection.
Output Signal: 4-20 mA DC, max. 30 mA DC (2-wire).
Zero and Span Adjustment: ±10% each.
Loop Resistance: 600 ohms @ 24 VDC; max. ohms = (supply voltage -12) x 50.
Electrical Connection: 1/2" female NPT.
Process Connection: 1/2" female NPT.
Response Time: Time constant of 20 ms.
Weight: 1.67 lb (752 g).
Agency Approvals: CE, explosion-proof for Class I, Div. 1, Groups B, C, D; Dust-ignition proof for Class II, Div. 1, Groups E & G and suitable for Class III, Div. 1; Hazardous Locations.

TI-101 & TI-102

Series BT

Bimetal Thermometers

2", 3" or 5" Dial, Dual Scale, ±1% FS Accuracy, External Reset



Series BT Bimetal Thermometers offer accurate, reliable service even in the toughest environments. These corrosion resistant units are constructed from stainless steel and are hermetically sealed to prevent crystal fogging. The bimetal element directly drives pointer, eliminating gears and linkage. An external reset screw allows field calibration and easy-to-read aluminum dial minimizes parallax error. Choose back connection, lower connection or adjustable angle for easy viewing and installation. Adjustable models can be rotated a full 360° and tilted over a 180° arc. NOTE: When using in pressurized applications, use a suitable thermowell.

SPECIFICATIONS

Wetted Materials: 304 SS.
Accuracy: ±1% full scale.
Response Time: ≤ 40 seconds.
Temperature Limits: Head: 200°F (93°C). Stem: Not to exceed 50% overrange or 1000°F (538°C) or 800°F (427°C) continuously.
Process Connection: 1/4" NPT on 2" dial size; 1/2" NPT on 3" or 5" dial size.
Materials of Construction: 304 SS stem, glass crystal, anodized aluminum dial, Series 300 SS head, bezel, and mounting bushing.
Stem Diameter: 1/4" O.D.
Immersion Depth: Minimum 2" in liquids, 4" in gas.

MODELS

	Dial Size, Stem Length	Temperature Range, °F(°C)	Degree Div., °F(°C)
Back Connection			
BTB22551*	2", 2-½"	0/250	2
BTB2405D	2", 4"	0/250 (-20/120)	2 (2)
BTB2409D	2", 4"	200/1000 (100/550)	10 (5)
*BTB32510D	3", 2½"	0/200 (-20/100)	2 (2)
BTB3255D	3", 2½"	0/250 (20/120)	2 (2)
BTB3257D	3", 2½"	50/550 (10/290)	5 (5)
BTB34010D	3", 4"	0/200 (-20/100)	2 (2)
BTB3405D	3", 4"	0/250 (-20/120)	2 (2)
BTB3407D	3", 4"	50/550 (10/290)	5 (5)
BTB3605D	3", 6"	0/250 (-20/120)	2 (2)

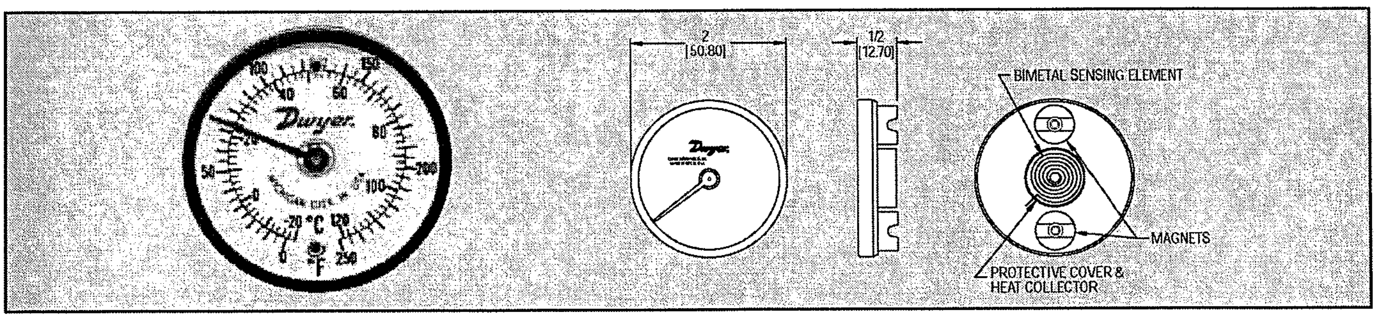
Model Number	Dial Size, Stem Length	Temperature Range, °F(°C)	Degree Div., °F(°C)
Adjustable Angle Connection			
BTA54010D	5", 4"	0/200 (-20/100)	2 (2)
BTA5405D	5", 4"	0/250 (-20/120)	2 (2)
BTA5407D	5", 4"	50/550 (10/290)	5 (5)
BTA56010D	5", 6"	0/200 (-20/100)	2 (2)
BTA5605D	5", 6"	0/250 (-20/120)	2 (2)
BTA5607D	5", 6"	50/550 (10/290)	5 (5)
Lower Connection			
BTC3255D	3", 2.5"	0/250 (-20/120)	2 (2)

Temperature

Series ST

Surface Mount Thermometer

2" Dual Scale Dial, ±2% Full Scale Accuracy



Measure the temperature of boilers, air ducts, motors, bearings, furnaces or other surfaces with Series ST Surface Mount Thermometers. Dual magnet design allows easy mounting on any ferrous surface. Bi-metallic thermal sensing coil provides quick temperature measurement with ±2% full scale accuracy.

SPECIFICATIONS

Accuracy: ±2% full scale.
Sensing Element: Bimetal coil.
Response Time: Approximately one minute.
Mounting: Two Alnico magnets on back.
Materials of Construction: Aluminum with optically clear crystal.
Head Size: 2" (5.08 cm).
Height: 1/2" (1.27 cm).
Weight: 2 oz (56.7 g).

MODELS

Model Number	Range
ST250	0 to 250°F (-20 to 120°C)
ST500	0 to 500°F (-20 to 260°C)
ST750	0 to 750 °F (-20 to 399°C)

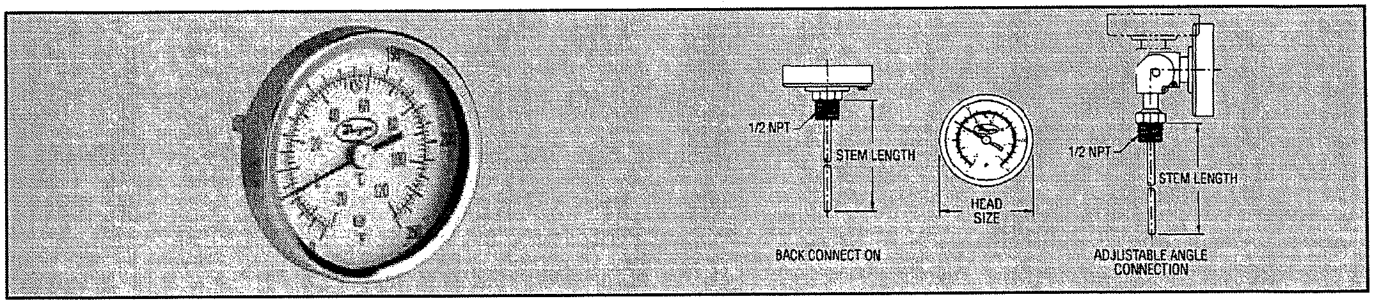
APPLICATIONS

Manifolds, platens, boilers, air ducts, furnaces, engines, motors, bearings, enclosures, cabinets, drums, plumbing, piping, refrigerators, and other ferrous surfaces.

TI-201

Series BT Bimetal Thermometers

2", 3" or 5" Dial, Dual Scale, ±1% FS Accuracy, External Reset



Series BT Bimetal Thermometers offer accurate, reliable service even in the toughest environments. These corrosion resistant units are constructed from stainless steel and are hermetically sealed to prevent crystal fogging. The bimetal element directly drives pointer, eliminating gears and linkage. An external reset screw allows field calibration and easy-to-read aluminum dial minimizes parallax error. Choose back connection, lower connection or adjustable angle for easy viewing and installation. Adjustable models can be rotated a full 360° and tilted over a 180° arc. NOTE: When using in pressurized applications, use a suitable thermowell.

SPECIFICATIONS

Wetted Materials: 304 SS.
Accuracy: ±1% full scale.
Response Time: ≤ 40 seconds.
Temperature Limits: Head: 200°F (93°C). Stem: Not to exceed 50% over-range or 1000°F (538°C) or 800°F (427°C) continuously.
Process Connection: 1/4" NPT on 2" dial size; 1/2" NPT on 3" or 5" dial size.
Materials of Construction: 304 SS stem, glass crystal, anodized aluminum dial, Series 300 SS head, bezel, and mounting bushing.
Stem Diameter: 1/4" O.D.
Immersion Depth: Minimum 2" in liquids, 4" in gas.

MODELS

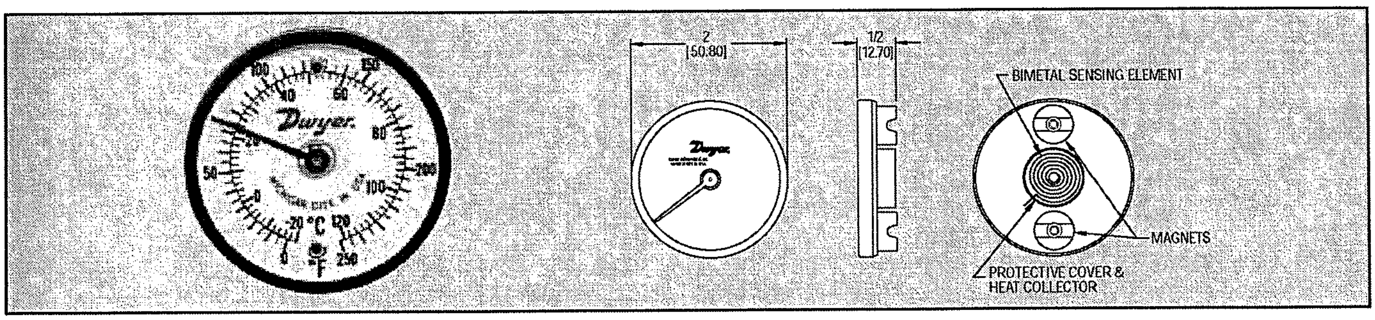
	Dial Size, Stem Length	Temperature Range, °F(°C)	Degree Div., °F(°C)
Back Connection			
BTB22551*	2", 2-½"	0/250	2
BTB2405D	2", 4"	0/250 (-20/120)	2 (2)
BTB2409D	2", 4"	200/1000 (100/550)	10 (5)
* BTB32510D	3", 2½"	0/200 (-20/100)	2 (2)
BTB3255D	3", 2½"	0/250 (20/120)	2 (2)
BTB3257D	3", 2½"	50/550 (10/290)	5 (5)
BTB34010D	3", 4"	0/200 (-20/100)	2 (2)
BTB3405D	3", 4"	0/250 (-20/120)	2 (2)
BTB3407D	3", 4"	50/550 (10/290)	5 (5)
BTB3605D	3", 6"	0/250 (-20/120)	2 (2)

Model Number	Dial Size, Stem Length	Temperature Range, °F(°C)	Degree Div., °F(°C)
Adjustable Angle Connection			
BTA54010D	5", 4"	0/200 (-20/100)	2 (2)
BTA5405D	5", 4"	0/250 (-20/120)	2 (2)
BTA5407D	5", 4"	50/550 (10/290)	5 (5)
BTA56010D	5", 6"	0/200 (-20/100)	2 (2)
BTA5605D	5", 6"	0/250 (-20/120)	2 (2)
BTA5607D	5", 6"	50/550 (10/290)	5 (5)
Lower Connection			
BTC3255D	3", 2.5"	0/250 (-20/120)	2 (2)

Temperature

Series ST Surface Mount Thermometer

2" Dual Scale Dial, ±2% Full Scale Accuracy



Measure the temperature of boilers, air ducts, motors, bearings, furnaces or other surfaces with Series ST Surface Mount Thermometers. Dual magnet design allows easy mounting on any ferrous surface. Bi-metallic thermal sensing coil provides quick temperature measurement with ±2% full scale accuracy.

SPECIFICATIONS

Accuracy: ±2% full scale.
Sensing Element: Bimetal coil.
Response Time: Approximately one minute.
Mounting: Two Alnico magnets on back.
Materials of Construction: Aluminum with optically clear crystal.
Head Size: 2" (5.08 cm).
Height: 1/2" (1.27 cm).
Weight: 2 oz (56.7 g).

MODELS

Model Number	Range
ST250	0 to 250°F (-20 to 120°C)
ST500	0 to 500°F (-20 to 260°C)
ST750	0 to 750 °F (-20 to 399°C)

APPLICATIONS

Manifolds, platens, boilers, air ducts, furnaces, engines, motors, bearings, enclosures, cabinets, drums, plumbing, piping, refrigerators, and other ferrous surfaces.

XV-201, -202, & -203

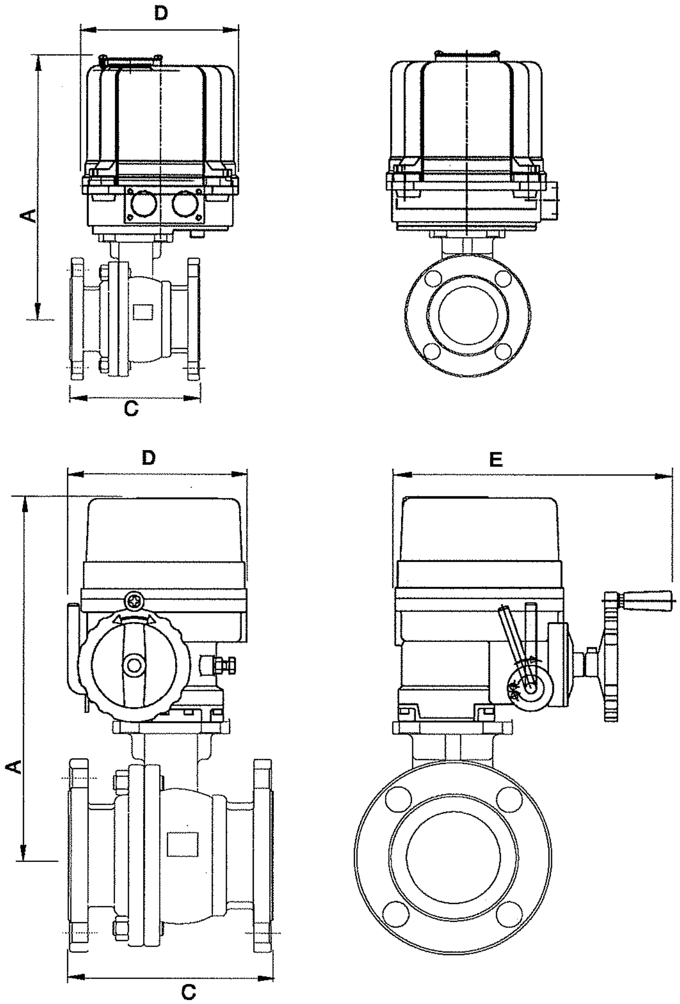
TRIAD VALVE AUTOMATION
www.triadprocess.com
email: sales@triadprocess.com
248.685.9938

9150

TRIAD®

AUTOMATED VALVE ASSEMBLY

SERIES 9150
ELECTRIC BALL VALVE
STAINLESS STEEL FLANGED



TECHNICAL SPECIFICATIONS	
General	150# Flanged Full Port
Body	Stainless Steel
Ball/ Stem	Stainless Steel
Seat	RPTFE
Pressure Rating	ANSI 150#
Voltage	120VAC
Connection	ANSI 150#

SIZE	A	C	D	E	Cv	Actuator	Weight	Assembly #
1/2"	7.03	4.26	4.80	-	30	EW-530	10.20	90050
3/4"	7.21	4.61	4.80	-	60	EW-530	11.22	90051
1"	7.51	5.00	4.80	-	90	EW-530	13.30	90052
1 1/2"	8.71	6.50	4.80	-	250	EW-530	20.68	90053
* 2"	9.00	7.00	4.80	-	480	EW-530	26.60	90054
2 1/2"	13.23	7.50	6.75	10.00	750	EW-880	36.64	90055
3"	13.82	8.00	6.75	10.00	800	EW-880	58.40	90056
4"	16.26	9.00	9.00	13.31	2300	EW-1400	103.40	90057
6"	19.62	15.50	9.81	13.94	3500	EW-4400	209.00	90058

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SVE SYSTEM

BARNEBEY SUTCLIFFE
A WATERLINK COMPANY

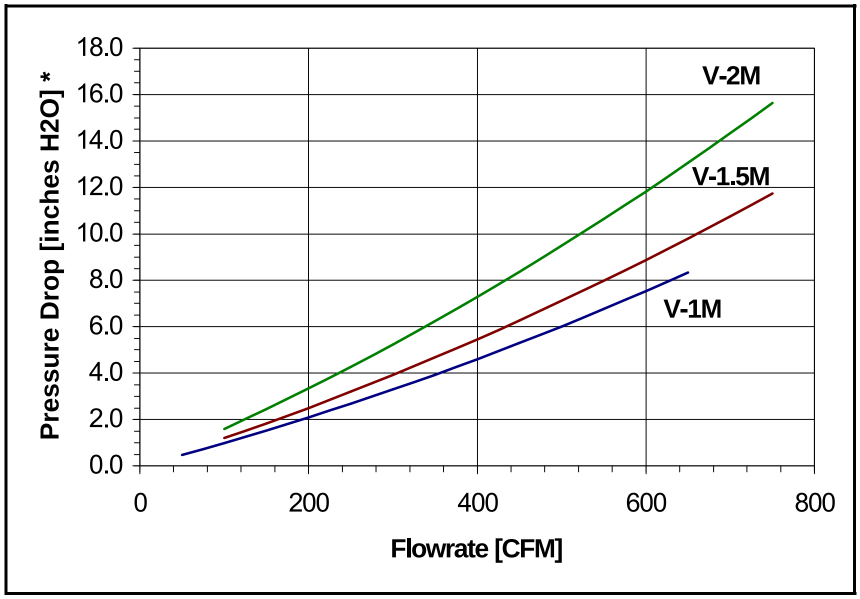
Powerful Solutions for a New Tomorrow

Protect V Series

The Protect V series adsorbers are economical vapor adsorbers designed for operating at a maximum pressure of 15 psi, maximum vacuum of 15” mercury, operating temperature up to 150 °F, and maximum flow rate of 750 cfm. The V series is designed to hold from 500 to 2,000 pounds of activated carbon.

Important Features:

- Durable carbon steel construction
- Low profile design
- Upper & lower open-air plenum area for maximum carbon usage
- Rust-prohibitive exterior epoxy urethane coating
- 16” Round inspection manway
- Condensate drain plug
- Lifting lugs and forklift guides for portability
- ¾” threaded fitting for optional carbon saturation indicator
- All models available to rent



* Estimated pressure drop based on 4x10 mesh carbon.

Model #	GAC		Recommended Maximum Flow Rate, cfm	Weight, lbs. (Empty / Operating)
	$ft.^3$	lbs.**		
V-1M	36	1,000	675	1,005 / 2,005
V-1.5M	54	1,500	750	1,150 / 2,650
V-2M	72	2,000	750	1,150 / 3,150

** Weight estimated from vessel volume.

Corporate Capabilities:

Barnebey Sutcliffe has been manufacturing and servicing adsorption equipment for over 80 years. Some of our other products and services include:

- Wide variety of coal & coconut shell carbons
- Broad range of filtration media
- National network of service centers
- Carbon reactivation (hazardous & non-hazardous)
- Vessel rental
- Spent media exchange
- Technical support
- Custom-engineered systems
- ASME Code certified fabrication facility

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BARNEBEY SUTCLIFFE
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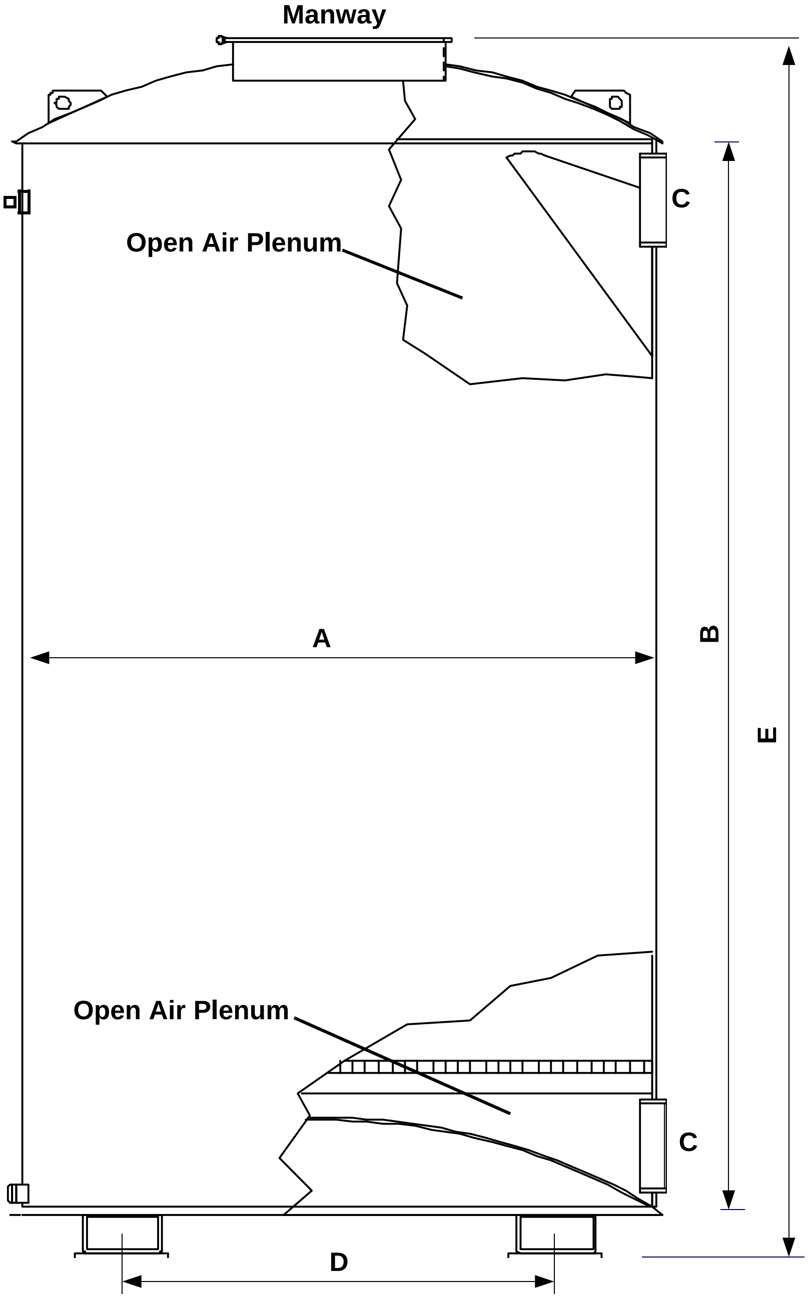
Powerful Solutions for a New Tomorrow



Drawing not to scale.

Available Options:

- Internal linings
- Camloc quick connectors
- Isolation butterfly valves
- Higher operating pressures / vacuums and temperatures
- Stainless steel construction
- Flanged inlet / outlet connections
- Pressure relief valves
- Air release valves
- Pre-piped dual systems
- Custom colors
- Skid mounted SVE systems
- Protect saturation indicator

To discuss your application needs, call us at one of our regional offices or at

1-800-866-2272

www.bscarbons.com

Model	Diameter A	Can Length B	Inlet / Outlet C	Forklift Guides D	Overall Height E
V-1M	45 ½”	72”	6” fpt	33”	84” ±
V-1.5M	48”	84”	6” fpt	33”	96” ±
V-2M	48”	84”	6” fpt	33”	96 ±

Due to the ongoing improvement of our products, we reserve the right to change system specifications and performance criteria without notification. Warning: Some compounds and/or high concentrations can lead to heat buildup in GAC and potential bed fire. Contact BSC for

Introduction

Granular Activated Carbon (GAC), How it Works

Granular activated carbpn removes organic pollutants by a process called adsorption. As the vapor stream passes through the porous granules of activated carbon, molecules of the organic pollutants are attracted to the surface of the pores and are held there by weak physical forces. The phenomenon is somewhat similar to iron filings being held by a weak magnet.

The ability of granular activated carbon to remove large quantities of organic impurities is a function of its highly developed internal pore structure. This unique pore structure is created during the manufacturing process, which involves the crushing and thermal "activation" of select grades of bituminous coal under carefully controlled conditions. As a result of this processing, an extensive network of pores is created inside each carbon granule, providing an enormous internal surface area of 6,000 – 17,000 sq. ft. per gram, depending on the grade the of activated carbon used.

Granular activated carbon's great porosity is responsible for its high capacity for trapping and holding organic molecules. For example, just one pound of carbon granules has an effective total (external and internal) surface area equal to that of a 150-acre farm. A single handful of activated carbon has a total surface area equal to that of a football field. Multiply the surface area of that farm or football field by the amount of carbon inside a water treatment facility, and some idea of the magnitude of activated carbon's adsorptive capacity for organic contaminants may be readily obtained.

After the carbon's capacity for adsorbing organic impurities is used up, the granules will be restored to their original adsorptive capacity through "reactivation." Reactivation is simply the restoration of the carbon's ability to adsorb impurities from water. This restoration of carbon's adsorption capacity is accomplished as the carbon passes through a reactivation kiln at temperatures as high as 1800°F. As the carbon passes through the kiln, the organic impurities are burned from internal surfaces of the individual carbon granules.

More than 90 percent of the original carbon is recovered in the reactivation process. Fresh carbon is added to the treatment system to compensate for the small losses resulting from reactivation and handling of the carbon.

Activated Carbon Design Criteria

The two most important operating conditions for activated carbon treatment systems are flow rate of the contaminated stream and concentration of the adsorbate (contaminant). As a general rule, lower flow rates allow a greater contact time with a unit volume of carbon, thereby improving the ability of the available carbon by allowing time for an adsorbate to migrate through the carbon pore. However, it may be possible to compensate for high flow rates with a smaller particle size. The potential for pressure drop problems must be studied when changing to a smaller particle size.

There are several considerations involved for evaluating a carbon adsorption system. The type of contaminant to be removed is very important (VOC, general odor, specific organics, or all of these). Factors which generally improve the rate of adsorption are lower stream temperature and higher contaminant boiling point (pressure can also have an affect). Finally, adsorption is, for the most part, an equilibrium reaction. Changes in equilibrium conditions, such as increase in temperature or decrease in pressure, can lead to the release of adsorbed contaminants. At bed saturation, when the pores in the carbon granule are fully occupied with contaminants, and a more absorbable contaminant is introduced into the stream, the less absorbable contaminant will be released back into the stream. In such cases, the activated carbon is considered spent and the effluent concentration may be higher than the influent concentration for a particular contaminant.

Operation & Handling Guidelines

GAC Transfer

Loading vapor phase granular or extruded activated carbon is referred to as dry loading. In the process of dry loading an activated carbon bed, attention must be paid to prevent formation of the air pockets that lead to channeling. Channeling is the absence of even flow distribution in the carbon bed, therefore reducing the efficiency and capacity of the bed.

Dry Loading Procedure

1. Make sure that vessel is isolated from process stream and drained.
2. Close all valves and manways on process vessel except top manway.
3. Empty bags or supersacks (1000 lb.) of carbon into vessel.

Dry Removal of Spent GAC

In this procedure, the GAC will be removed through the top manway using a vacuum truck or some other means of vacuum collection.

1. Make sure that vessel is isolated from process stream and drained.
2. Close all valves and manways on process vessel except top manway.
3. Open top manway.
4. By means of vacuum system, start removing spent carbon through top manway.

Be careful not to damage the inside paint/liner, laterals, chairs, or any other internals with the suction hose.

Heat Generation Concerns

Vapor phase adsorption is a condensation reaction, therefore as the activated carbon adsorbs contaminants, heat is being released as a result of the adsorption process. This heat is referred to as the latent heat of vaporization, which is the heat that is given up when a material changes its state from being a vapor to a liquid.

In most cases this heat is dissipated with the vapor stream causing the effluent temperature to be slightly higher than the influent temperature. The higher the flowrate per pound of contaminant adsorbed, the more effective the dissipation of the latent heat. If the flowrate is very slow and the latent heat is generated faster than it is dissipated, the temperature of the GAC bed will continue to rise resulting in damage to the vessel's paint, or in extreme cases, bed fire or process explosion.

If you detect a rising temperature of the GAC bed, or large temperature increases across the bed, a step should be taken to reduce contaminant concentration. This can be accomplished by adding dilution (atmospheric) air or inert gas such as nitrogen to the influent stream. A rising temperature can be detected, in a moderate case, by touching the vessel; in a severe case, by sensing the radiated heat; and in an extreme case, by observing the peeling paint on the vessel.

If the bed temperature is too hot to touch the vessel, immediately isolate the vessel from the process. This will eliminate the addition of latent heat to the bed. Allow the bed to dissipate its heat through the vessel's shell.

Never open the vessel's manway to help cool the bed. Doing such will introduce free oxygen to the already existing heat source and fuel (carbon), resulting in a potential fire or explosion.

Never add water to cool a carbon bed or to extinguish a bed fire. Adding water to a hot carbon bed can result in a reaction that produces hydrogen gas. Hydrogen gas is highly explosive!

Upflow vs. Downflow Operation

Barnebey Sutcliffe Corporation highly recommends operating all vapor phase GAC adsorbers in an upflow configuration, meaning traveling through the GAC bed from the bottom up. This is mainly due to a condensation reaction that may cause some free contaminated liquids to accumulate in the plenum area at the bottom of the adsorber. As this liquid vaporizes, the contaminated vapors still have to travel through the entire GAC bed, therefore the contaminants will be adsorbed.

In case of a downflow operation, the same contaminated liquids that may accumulate due to condensation (once vaporized) go directly to the clean effluent, therefore cause an indication of a breakthrough.

Record Keeping

In many cases, record keeping may be a regulatory issue. When it comes to troubleshooting a process, its history of performance becomes very valuable. Regardless of regulatory requirements, we recommend that the following records will be kept

1. Adsorber model number and specs.
2. GAC specs.
3. Number of adsorbers in operation.
4. Number of hours per day each adsorber is on-line.
5. Number of days each adsorber is on-line.
6. Flowrate information.
7. Influent temperature.
8. Effluent temperature.
9. Analytical report of influent contaminant.
10. Analytical report of effluent contaminant.
11. Analytical report of spent carbon.
12. Date of GAC changeouts, GAC type, and pounds changed.
13. Any unusual behavior, both mechanical and process related.

Routine Maintenance

1. Inspection of the vessel (rust, dents, leaks, etc.).
2. Check for any accumulated condensation. Any accumulated condensation should be drained on a regular basis. Accumulated condensation can cause operational problems and channeling.

Hazards with Certain Process Conditions

Under certain process conditions, activated carbons may show an affinity for atmospheric oxygen or may interact with process streams to generate potentially toxic or hazardous levels of hydrogen sulfide, methane, ethanol, carbon dioxide, and other gases. These effects can become pronounced in a relatively confined space, such as the headspace of an adsorber. Should entry to confined spaces containing activated carbon become necessary, appropriate ventilation and other safety practices for potentially flammable, toxic or oxygen-deficient environments should be followed.

To avoid possible combustion of the carbon, or the material being adsorbed, caution is recommended in contacting activated carbon with strong oxidizing agents, such as chlorine.

Need for Grounding of Carbon Systems

In certain systems, high voltage static electrical charges may accumulate to levels of shock or an ignition hazard. As a precaution against possible ignition or shock, all carbon treatment systems should be adequately grounded.

DANGER!

Wet granular activated carbon adsorbs oxygen, therefore creates an oxygen deficient environment. In a confined space where activated carbon is wetted, a hazardous environment is created. SUCH AN ENVIRONMENT MAY BE FATAL. Do not use a respirator in such an environment. You must use live air equipment.

Investigation of this matter was prompted by an accident, which occurred on a project in which a granular activated carbon system was being installed. Studies conducted in vessels similar to that in which the accident occurred have shown that low oxygen content exists in vessels containing wet carbon. Laboratory experiments conducted since that time also have revealed that commercial activated carbons in a wet or moist condition will lower the oxygen content of an isolated space. Indications are as follows:

1. The phenomenon occurs with wet activated carbon of all common types.
2. The rate of oxygen uptake naturally varies with the degree of exposure of the wet carbon to the air. Thus it is relatively rapid in a drained bed.
3. There is some indication of a limit to carbon's capacity for oxygen; however, the prudent action should be to assume that all carbon, wet or dry will exhibit this oxygen-depleting characteristic.

Therefore, all confined spaces containing activated carbon, should be presumed to be hazardous. Appropriate safety measures should always be taken before entering, as well as when workers are in a confined space. OSHA regulations pertaining to confined space entry and oxygen depleted environments should be strictly adhered to.

Heat Hazard

Latent heat is generated in the process of adsorbing vapor contaminants. If you detect a rising temperature in the GAC bed, increase the flowrate through the bed. This can be accomplished by adding dilution (atmospheric) air or an inert gas, such as nitrogen, to the influent stream. The added follow-through helps displace the heat, that is generated in the adsorption process, out of the vessel.

A rising temperature can be detected in a moderate case, by touching the vessel; in a severe case, by sensing the radiated heat; and in an extreme case, by observing the peeling paint on the vessel.

If the bed temperature is too hot to touch, immediately isolate the vessel from the process. This will eliminate the addition of latent heat to the bed. Allow the bed to dissipate its heat through the vessel's shell.

Never open the vessel's manway to help cool the bed. Doing so will introduce free oxygen to the already existing heat source and fuel (carbon), resulting in an immediate fire or explosion.

Never apply water to cool a carbon bed or to extinguish a bed fire. Adding water to a hot carbon bed can result in a reaction that produces hydrogen gas. Hydrogen gas is highly explosive!

Installation and Startup

It is highly recommended that you read this manual prior to installation in order to familiarize yourself with the considerations regarding the operation of a vapor adsorber.

1. Install vessel on a leveled foundation that can support its working load.
2. Open manway and inspect internal paint/liner for integrity.
3. While manway is open, inspect chair, laterals (if any), and other internal fixtures for integrity.
4. Inspect outer fixtures on vessel for mechanical damage and integrity (valves, relief valve, gauges, etc.).
5. Close all valves and manways.
6. Fill vessel with GAC as described in GAC Transfer Section.
7. Connect the vessel to process piping.
8. Vessel is ready for process flow.

Service & Support

Barnebey Sutcliffe Corporation has full service vacuum and re-bed crews around the nation. Our service centers stock a variety of carbon and other filtration medias. The service crew will bring virgin or reactivated carbon to your site and perform the changeouts per your specifications. To obtain pricing information, or to schedule a changeout, please call (800) 886-2272.

If you have technical questions regarding the type of activated carbon you use, other filtration medias, or if you need spare parts for your system, call the same phone number.

It is always helpful, and speeds up service and support inquiries, if you have the model number and job number of your equipment.

Technical Specifications

	V-1M	V-1.5M	V-2M
Design Conditions			
Service Flowrate	375 CFM	750 CFM	750 CFM
Max. Operating Pressure	15 PSI	15 PSI	15 PSI
Max. Operating Vacuum	15" Hg	15" Hg	15" Hg
Max. Operating Temp.	150°F	150°F	150°F
Specifications			
Vessel O.D.	3'-9½"	4'-0"	4'-0"
Shell Section	6'-0"	7'-0"	7'-0"
Vessel Height	7'-1"	8'-0"	8'-0"
Top Head	3/16" dished	3/16" dished	3/16" dished
Bottom Head	3/16" inverted dish	3/16" inverted dish	3/16" inverted dish
Shell	3/16"	3/16"	3/16"
Cross Section (ID)	11.11 ft^2	12.37 ft^2	12.37 ft^2
Nominal GAC Capacity	1,000 lbs.	1,500 lbs.	2,000 lbs.
Empty Weight	1,005 lbs.	1,150 lbs.	1,150 lbs.
Operating Weight	2,005 lbs.	2,650 lbs.	3,150 lbs.
Air Distribution			
Bottom	Open plenum w/ 20 mesh stainless screen support	¾" PVC SCH 80 cross style, 0.016" slots	open plenum w/ 20 mesh stainless screen support
Top	Open plenum	Open plenum	Open plenum
Nozzles & Connections			
Inlet / Outlet	6" half coupling	2" bulkhead FPT	4" half coupling
Drain	1" full coupling	N/A	¾" half coupling
Top Manway / Lid	16" grooved ring type	16" grooved ring type	16" grooved ring type
Shell Sample Ports	(4x) ¾" full coupling	(4x) ¾" full coupling	(4x) ¾" full czoupling
Paint System			
Internal	Sand blast to SSPC-SP5, epoxy primer 7.0–8.0 mil DFT, epoxy liner 7.0–8.0 DFT		
External	Sand blast to SSPC-SP6, epoxy primer 7.0–8.0 DFT, epoxy urethane 2.0–3.0 DFT		

DL105
Micro PLC User Manual

Manual Number D1–USER–M

WARNING

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To minimize the risk of potential safety problems, you should follow all applicable local and national codes that regulate the installation and operation of your equipment. These codes vary from area to area and usually change with time. It is your responsibility to determine which codes should be followed, and to verify that the equipment, installation, and operation are in compliance with the latest revision of these codes.

At a minimum, you should follow all applicable sections of the National Fire Code, National Electrical Code, and the codes of the National Electrical Manufacturer's Association (NEMA). There may be local regulatory or government offices that can also help determine which codes and standards are necessary for safe installation and operation.

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For additional warranty and safety information, see the Terms and Conditions section of our Desk Reference. If you have any questions concerning the installation or operation of this equipment, or if you need additional information, please call us at 770–844–4200.

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Afin de réduire au minimum le risque d'éventuels problèmes de sécurité, vous devez respecter tous les codes locaux et nationaux applicables régissant l'installation et le fonctionnement de votre équipement. Ces codes diffèrent d'une région à l'autre et, habituellement, évoluent au fil du temps. Il vous incombe de déterminer les codes à respecter et de vous assurer que l'équipement, l'installation et le fonctionnement sont conformes aux exigences de la version la plus récente de ces codes.

Vous devez, à tout le moins, respecter toutes les sections applicables du Code national de prévention des incendies, du Code national de l'électricité et des codes de la National Electrical Manufacturer's Association (NEMA). Des organismes de réglementation ou des services gouvernementaux locaux peuvent également vous aider à déterminer les codes ainsi que les normes à respecter pour assurer une installation et un fonctionnement sûrs.

L'omission de respecter la totalité des codes et des normes applicables peut entraîner des dommages à l'équipement ou causer de graves blessures au personnel. Nous ne garantissons pas que les produits décrits dans cette publication conviennent à votre application particulière et nous n'assumons aucune responsabilité à l'égard de la conception, de l'installation ou du fonctionnement de votre produit.

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Manual Revisions

If you contact us in reference to this manual, remember to include the revision number.

Title: DL105 Micro PLC User Manual
Manual Number: D1–USER–M

Edition/Rev	Date	Description of Changes
Original	9/96	Original Issue
2nd Edition	5/98	Updated
2nd Edition, Rev. A	7/03	Updated with corrections and a new appendix

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1

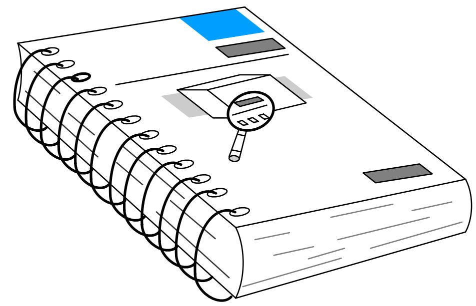
Getting Started

In This Chapter. . . .

Introduction

The Purpose of this Manual

Thank you for purchasing a DL105 Micro PLC. This manual shows you how to install, program, and maintain all the Micro PLCs in the DL105 family. It also helps you understand how to interface them to other devices in a control system.



This manual contains important information for personnel who will install DL105 PLCs, and for the PLC programmer. If you understand PLC systems our manuals will provide all the information you need to get and keep your system up and running.

Where to Begin

If you already understand the DL105 Micro PLC please read Chapter 2, "Installation, Wiring, and Specifications", and proceed on to other chapters as needed. Be sure to keep this manual handy for reference when you run into questions. If you are a new DL105 customer, we suggest you read this manual completely so you can understand the wide variety of features in the DL105 family of products. We believe you will be pleasantly surprised with how much you can accomplish with ***Direct***LOGIC products.

Supplemental Manuals

If you have purchased operator interfaces or ***Direct***SOFT32, you will need to supplement this manual with the manuals that are written for these products.

Technical Support

We realize that even though we strive to be the best, we may have arranged our information in such a way you cannot find what you are looking for. First, check these resources for help in locating the information:

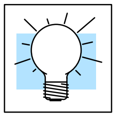
- **Table of Contents** – chapter and section listing of contents, in the front of this manual
- **Appendices** – reference material for key topics, near the end of this manual

You can also check our online resources for the latest product support information:

- **Internet** – the address of our Web site is: **http://www.automationdirect.com**

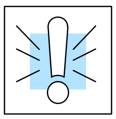
If you still need assistance, please call us at 770–844–4200. Our technical support group is glad to work with you in answering your questions. They are available Monday through Friday from 9:00 A.M. to 6:00 P.M. Eastern Standard Time. If you have a comment or question about any of our products, services, or manuals, please fill out and return the 'Suggestions' card that was shipped with this manual.

Conventions Used



When you see the “light bulb” icon in the left-hand margin, the paragraph to its immediate right will give you a **special tip**.
The word **TIP:** in boldface will mark the beginning of the text.

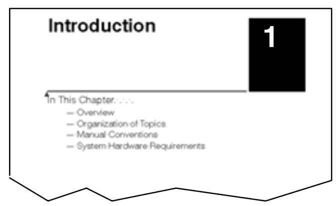
When you see the “notepad” icon in the left-hand margin, the paragraph to its immediate right will be a **special note**.
The word **NOTE:** in boldface will mark the beginning of the text.



When you see the “exclamation mark” icon in the left-hand margin, the paragraph to its immediate right will be a **warning.** This information could prevent injury, loss of property, or even death (in extreme cases).
The word **WARNING:** in boldface will mark the beginning of the text.

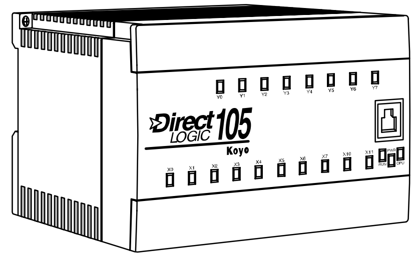
Key Topics for Each Chapter

The beginning of each chapter will list the key topics that can be found in that chapter.



DL105 Micro PLC Components

The DL105 Micro PLC family is a versatile product line that provides a wide variety of features in a very compact footprint. The PLCs are small, yet offer many features usually found in larger, more expensive systems. These include removeable connectors, RS-232C communication port, and +24V auxiliary power supply.



The DL105 Micro PLC Family

The DL105 Micro PLC family includes eight different versions. All have the same appearance and CPU performance. The CPU offers the same instruction set as our popular DL230 CPU, plus several more instructions specifically designed for machine control applications. All DL105 PLCs have an RS–232C communications port, and the AC-powered versions have an auxiliary +24V output. Units with DC inputs have selectable high-speed input features on four input points. Units with DC outputs offer selectable pulse output capability on the first two output points. All DL105 Micro PLCs offer a large amount of program memory, a substantial instruction set and advanced diagnostics. Details of these features and more are covered in Chapter 4, CPU Specifications and Operation. The eight types of DL105 Micro PLCs provide a variety of Input/Output choices, listed in the following table.

DL105 Part Number	Discrete Input Type	Discrete Output Type	External Power	Auxiliary 24V Output	High-Speed Input	Pulse Output
F1–130AR	AC	Relay	94–240 VAC	Yes	No	No
F1–130DR/ F1–130DR–CE*	DC	Relay	94–240 VAC	Yes	Yes	No
F1–130AD	AC	DC	94–240 VAC	Yes	No	Yes
F1–130DD/ F1–130DD–CE*	DC	DC	94–240 VAC	Yes	Yes	Yes
F1–130AA	AC	AC	94–240 VAC	Yes	No	No
F1–130DA	DC	AC	94–240 VAC	Yes	Yes	No
F1–130DR–D	DC	Relay	10–30 VDC	No	Yes	No
F1–130DD–D	DC	DC	10–30 VDC	No	Yes	Yes

* The “–CE” versions look and function the same as the standard versions but are manufactured to comply with CE standards.

Programming Methods

Two programming methods are available: RLL (Relay Ladder Logic) and RLL^{PLUS} Stage programming RLL^{PLUS} combines the added feature of flow chart programming (stage) to the standard RLL language. Both the ***Direct***SOFT32 programming package and the handheld programmer support RLL^{PLUS} as well as standard RLL instructions.

*Direct*SOFT32 Programming for Windows™

The DL105 Micro PLC can be programmed with one of the most advanced programming packages in the industry —***Direct***SOFT32, a Windows-based software package that supports familiar features such as cut-and-paste between applications, point-and-click editing, viewing and editing multiple application programs at the same time, etc.

DirectSOFT32 universally supports the ***Direct***LOGIC CPU families. This means you can use the full version of ***Direct***SOFT32 to program DL105, DL205, DL305, DL405 or any new CPUs we may add to our product line. (Upgrade software may be required for new CPUs as they become available.) With the introduction of the DL105, we are also offering a low-cost DL105-only version of ***Direct***SOFT32 to make it even more affordable for new customers. A separate manual discusses ***Direct***SOFT32 programming software.

Handheld Programmer

All DL105 Micro PLCs have a built-in programming port for use with the handheld programmer (D2–HPP), the same programmer used with the DL205 family. The handheld programmer can be used to create, modify and debug your application program. A separate manual discusses the Handheld Programmer.

I/O Quick Chart Selection

The eight versions of the DL105 have Input/Output circuits which can interface to a wide variety of field devices. In several instances a particular Input or Output circuit can interface to either DC or AC voltages, or both sinking and sourcing circuit arrangements. Check this chart carefully to find the proper DL105 Micro PLC to interface to the field devices in your application.

DL105 Part Number	INPUTS			OUTPUTS		
	I/O type / commons	Sink / Source	Voltage Ranges	I/O type / commons	Sink / Source	Voltage / Current Ratings
F1–130AR	AC / 3	–	80 – 132 VAC 90 – 150 VDC	Relay / 4	Sink or Source	12 – 30 VDC, 7A * 12 – 250 VAC, 7A *
F1–130DR/ F1–130DR–CE***	DC / 3	Sink or Source	10 – 26.4 VDC 21.6 – 26.4 VAC	Relay / 4	Sink or Source	12 – 30 VDC, 7A * 12 – 250 VAC, 7A *
F1–130AD	AC / 3	–	80 – 132 VAC 90 – 150 VDC	DC / 1 **	Sink	5 – 30 VDC, 0.3A (Y0–Y1) 5 – 30 VDC, 0.6A (Y3–Y7)
F1–130DD/ F1–130DD–CE***	DC / 3	Sink or Source	10 – 26.4 VDC 21.6 – 26.4 VAC	DC / 1 **	Sink	5 – 30 VDC, 0.3A (Y0–Y1) 5 – 30 VDC, 0.6A (Y3–Y7)
F1–130AA	AC / 3	–	80 – 132 VAC 90 – 150 VDC	AC / 4	–	20 – 140 VAC, 47 – 63 Hz 1.7A *
F1–130DA	DC / 3	Sink or Source	10 – 26.4 VDC 21.6 – 26.4 VAC	AC / 4	–	20 – 140 VAC, 47 – 63 Hz 1.7A *
F1–130DR–D	DC / 3	Sink or Source	10 – 26.4 VDC 21.6 – 26.4 VAC	Relay / 4	Sink or Source	12 – 30 VDC, 7A * 12 – 250 VAC, 7A *
F1–130DD–D	DC / 3	Sink or Source	10 – 26.4 VDC 21.6 – 26.4 VAC	DC / 1 **	Sink	5 – 30 VDC, 0.3A (Y0–Y1) 5 – 30 VDC, 0.6A (Y3–Y7)

* Subject to temperature derating chart. See Chapter 2 Specifications for your particular DL105 version.
** DC outputs have one electrical common, but it is accessible at three terminals on the output connector.
*** The "–CE" versions look and function the same as the standard versions but are manufactured to comply with CE standards.

Quick Start for PLC Checkout and Programming

If you have experience with PLCs, or if you just want to setup a quick example, this example is for you! This example is not intended to tell you everything you need to start-up your system, warnings and helpful tips are in the rest of the manual. It is only intended to give you a general picture of what you will need to do to get your system powered-up.

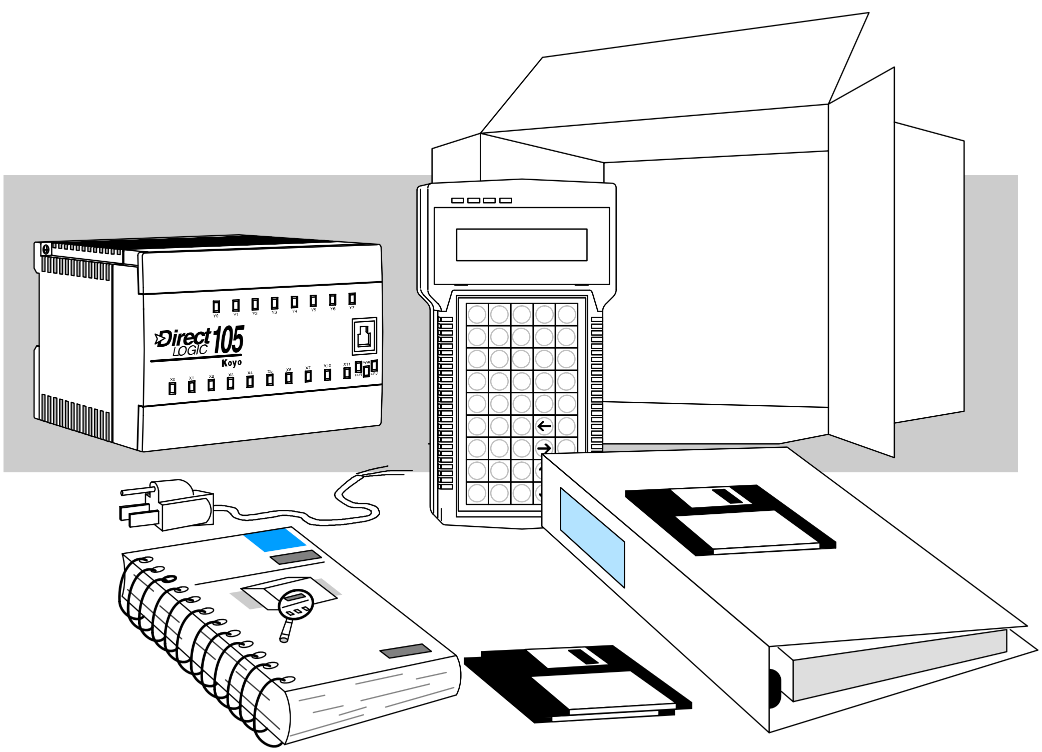
Step 1: Unpack the DL105 Equipment

Unpack the DL105 equipment and verify you have the parts necessary to build this demonstration system. The recommended components are:

- DL105 Micro PLC
- AC power cord for AC-powered units
- F1–04SIM input simulator, or toggle switches (see Step 2 on next page).
- Hook-up wire, 16-20 AWG
- DL105 User Manual (this manual)
- A small screwdriver, regular or #2 Philips type

You will need at least one of the following programming options:

- ***Direct***SOFT32 Programming Software, ***Direct***SOFT32 Manual, and a programming cable (connects the DL105 to a personal computer),or
- D2–HPP Handheld Programmer (comes with programming cable), and the Handheld Programmer Manual

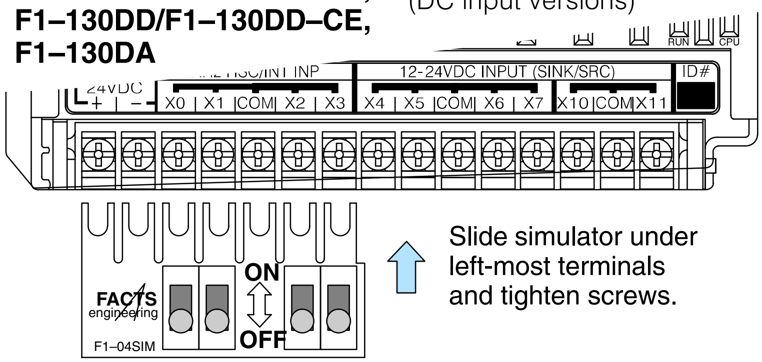


Step 2: Connect Switches to Input Terminals

To finish this quick-start exercise or study other examples in this manual, you'll need to connect some input switches as shown below. For most models, the F1-04SIM Input Simulator is a quick way to install four switches on inputs X0 – X3. DC-powered units will require routing DC power to the simulator as shown. We recommend using one of the models compatible with the input simulator as you learn the DL105.

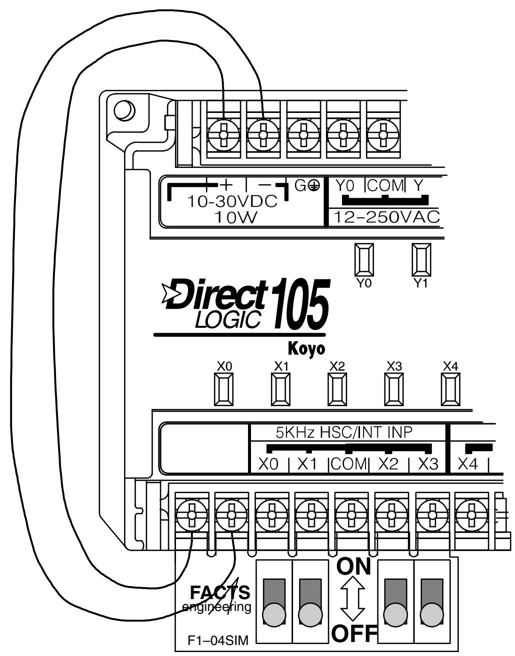
However, you may wire individual toggle switches to AC-powered units as shown, *as long as you follow the instructions in the accompanying WARNING note.*

F1–130DR/F1–130DR–CE, F1–130DD/F1–130DD–CE, F1–130DA (DC input versions)

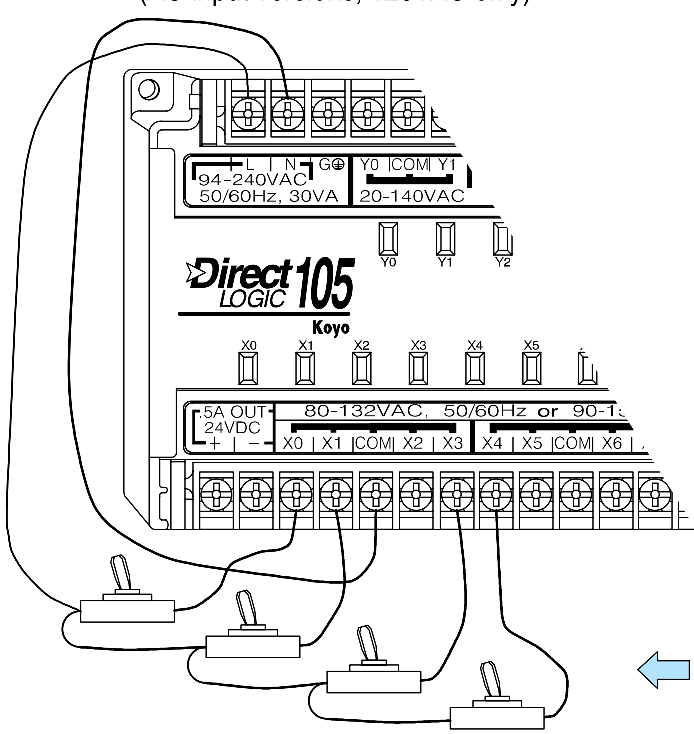


Slide simulator under left-most terminals and tighten screws.

F1–130DR–D, F1–130DD–D
(DC-powered versions)



F1–130AR, F1–130AD, F1–130AA
(AC input versions, 120VAC only)



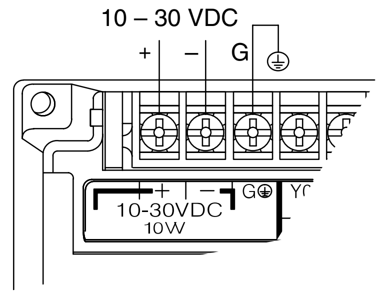
Toggle Switches, UL Listed

WARNING: DO NOT wire the toggle switches as shown to 240VAC-powered units. The discrete inputs will only accept 120VAC nominal. Also, remove power and unplug the DL105 when wiring the switches. Only use UL-approved switches rated for at least 250VAC, 1A. Firmly mount the switches before using.
NEVER use the input simulator on these units with AC-type discrete inputs.

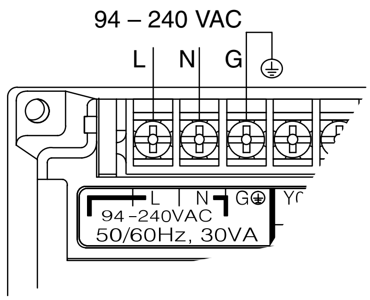
Step 3: Connect the Power Wiring

Connect the power input wiring for the version DL105 you have. Observe all precautions stated earlier in this manual. For more details on wiring, see Chapter 2 on Installation, Wiring, and Specifications. When the wiring is complete, close the connector covers. Do not apply power at this time.

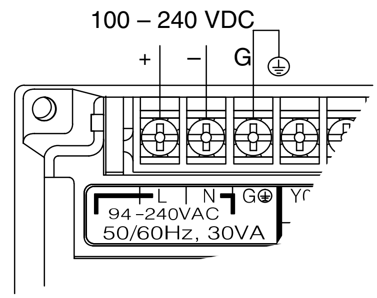
12/24 VDC Power Input



110/220 VAC Power Input

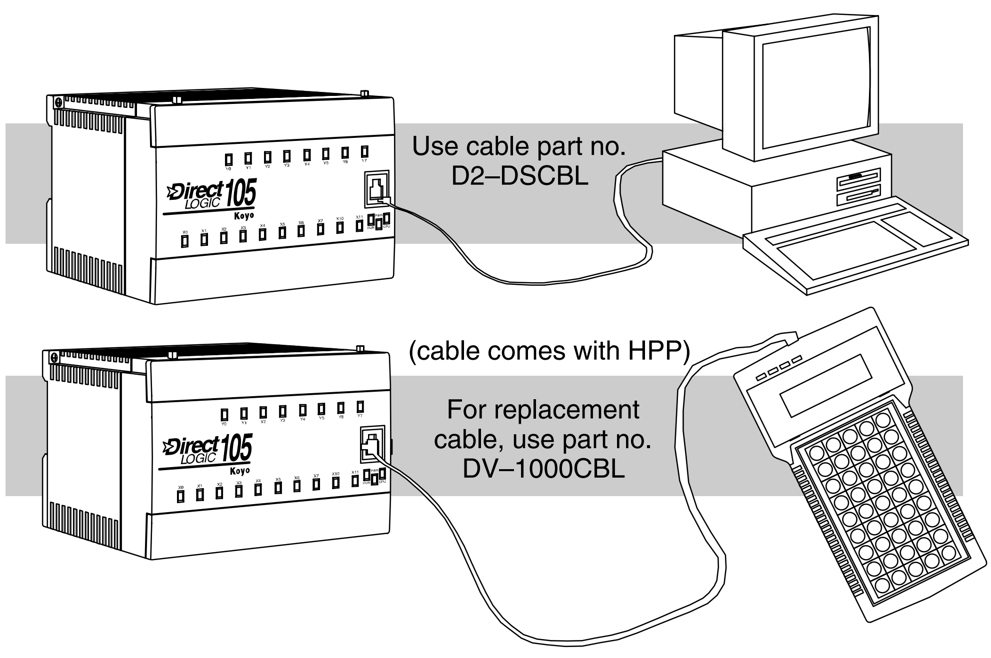


125 VDC Power Input



Step 4: Connect the Programming Device

Most programmers will use ***Direct***SOFT32 programming software, installed on a personal computer. Or, you may need the portability of the Handheld Programmer. Both devices will connect the COM1 port of the DL105 via the appropriate cable.



Step 5: Switch on the System Power

Apply power to the system and ensure the PWR indicator on the DL105 is on. If not, remove power from the system and check all wiring and refer to the troubleshooting section in Chapter 8 for assistance.

Step 6: Initialize Scratchpad Memory

It's a good precaution to always clear the system memory (scratchpad memory) on a new DL105. When a unit has been without power for several days, the system RAM contents may have been corrupted and will require initialization.

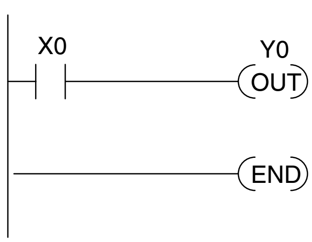
- In ***Direct***SOFT32, select the *PLC* menu, then *Setup*, then *Initialize Scratchpad.* For additional information, see the ***Direct***SOFT32 Manual.
- For the Handheld Programmer, use the AUX key and execute AUX 54. For additional information, see the Handheld Programmer Manual.

Step 7: Enter a Ladder Program

At this point, ***Direct***SOFT32 programmers need to refer to the Quick Start Tutorial in the DirectSOFT32 Manual. There you will learn how to establish a communications link with the DL105 PLC, change CPU modes to Run or Program, and enter a program.

If you are learning how to program with the Handheld Programmer, make sure the CPU is in Program Mode (the RUN LED on the front of the DL105 should be off.) If the RUN LED is on, use the MODE key on the Handheld Programmer to put the PLC in Program Mode. Enter the following keystrokes on the Handheld Programmer.

Equivalent ***DirectSOFT32*** display



CLR, CLR / C 2, E 4, AUX, ENT, ENT, CLR	Clear the Program
NEXT, $ STR, →, A 0, ENT	Move to the first address and enter X0 contact
GX OUT, →, A 0, ENT	Enter output Y0
SHFT, E 4, N TMR, D 3, ENT	Enter the END statement

After entering the simple example program put the PLC in Run mode by using the Mode key on the Handheld Programmer.

The RUN indicator on the PLC will illuminate indicating the CPU has entered the Run mode. If not, repeat this step, ensuring the program is entered properly or refer to the troubleshooting guide in chapter 8.

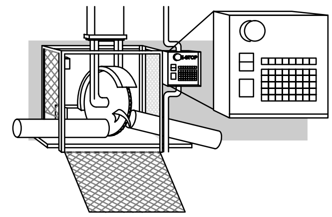
After the CPU enters the run mode, the output status indicator for Y should follow the switch status on input channel X0. When the switch is on, the output will be on.

Getting Started

Steps to Designing a Successful System

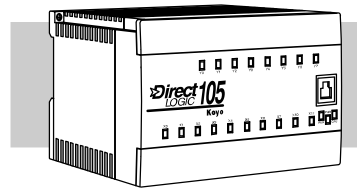
Step 1: Review the Installation Guidelines

Always make safety the first priority in any system design. Chapter 2 provides several guidelines that will help you design a safer, more reliable system. This chapter also includes wiring guidelines for the various versions of the DL105 PLC.



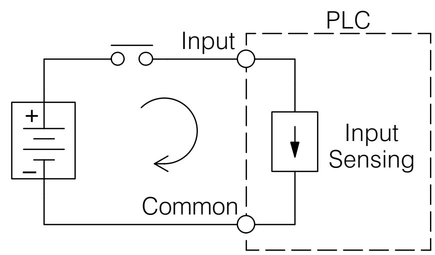
Step 2: Understand the PLC Setup Procedures

The PLC is the heart of your automation system. Make sure you take time to understand the various features and setup requirements.



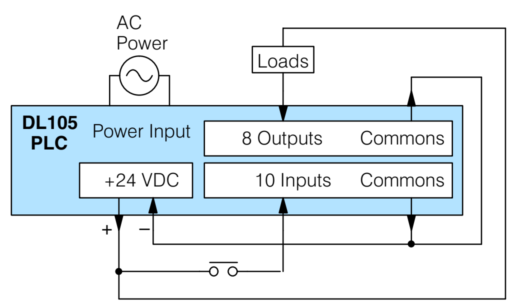
Step 3: Review the I/O Selection Criteria

There are many considerations involved when you select your I/O type and field devices. Take time to understand how the various types of sensors and loads can affect your choice of I/O type.



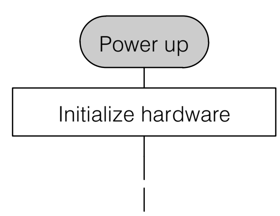
Step 4: Choose a System Wiring Strategy

It is important to understand the various system design options that are available before wiring field devices and field-side power supplies to the Micro PLC.



Step 5: Understand the System Operation

Before you begin to enter a program, it is very helpful to understand how the DL105 system processes information. This involves not only program execution steps, but also involves the various modes of operation and memory layout characteristics.

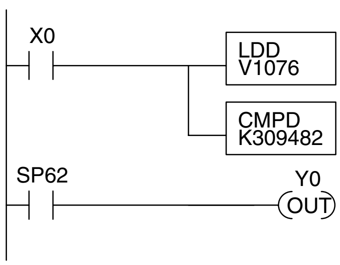


Step 6: Review the Programming Concepts

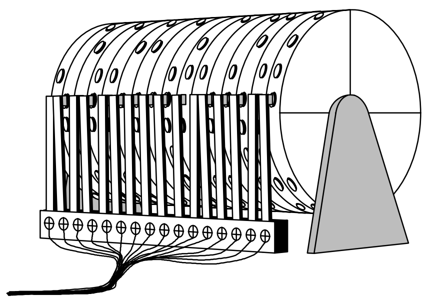
The DL105 PLC instruction set provides for three main approaches to solving the application program, depicted in the figure below.

- RLL diagram-style programming is the best tool for solving boolean logic and general CPU register/accumulator manipulation. It includes dozens of instructions, which will also be needed to augment drums and stages.
- The Timer/Event Drum Sequencer features up to 16 steps and offers both time and/or event-based step transitions. The EDRUM instruction is best for a repetitive process based on a single series of steps.
- Stage programming (also called RLL*Plus*) is based on state-transition diagrams. Stages divide the ladder program into sections which correspond to the states in a flow chart you draw for your process.

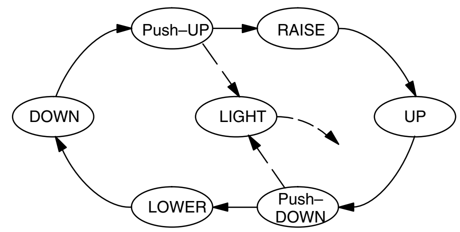
Standard RLL Programming
(see Chapter 5)



Timer/Event Drum Sequencer
(see Chapter 6)



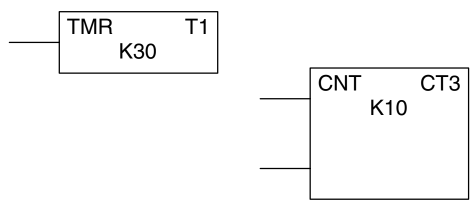
Stage Programming
(see Chapter 7)



After reviewing the programming concepts above, you'll be equipped with a variety of tools to write your application program.

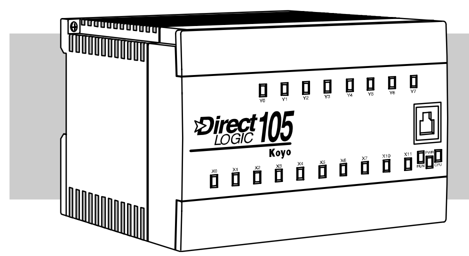
Step 7: Choose the Instructions

Once you have installed the Micro PLC and understand the main programming concepts, you can begin writing your application program. At that time you will begin to use one of the most powerful instruction sets available in a small PLC.



Step 8: Understand the Maintenance and Troubleshooting Procedures

Sometimes equipment failures occur when we least expect it. Switches fail, loads short and need to be replaced, etc. In most cases, the majority of the troubleshooting and maintenance time is spent trying to locate the problem. The DL105 Micro PLC has many built-in features such as error codes that can help you quickly identify problems.



Questions and Answers about DL105 Micro PLCs

Q. What is the instruction set like?

A. The instruction set is very close to our popular DL230 CPU. However, there are significant additions, such as the drum instruction and High-Speed I/O capability.

Q. Do I have to buy the full *Direct*SOFT32 programming package to program the DL105?

A. No. We offer a DL105-specific version of ***Direct***SOFT32 that's very affordable.

Q. Is the DL105 networkable or expandable?

A. No, the DL130 series is stand-alone PLCs. However, our DL205 system is expandable and networkable (with DL240 CPU), yet very compact and affordable.

Q. Does the DL105 have motion control capability?

A. Yes. The High-Speed I/O features offer either encoder inputs with high-speed counting and presets with interrupt, or a pulse/direction output for stepper control. Three types of motion profiles are available, which are explained in Chapter 3.

Q. Are the ladder programs stored in a removable EPROM?

A. The DL105 contains a non-removable EEPROM for program storage, which may be written and erased thousands of times. You may transfer programs to/from ***Direct***SOFT32 on a PC, or the HPP (which does support a removable EEPROM).

Q. Does the DL105 contain fuses for its outputs?

A. There are no output circuit fuses. Therefore, we recommend fusing each channel, or fusing each common. See Chapter 2 for I/O wiring guidelines.

Q. Is the DL105 Micro PLC U.L.® approved?

A. The Micro PLC has been designed to meet the requirements of UL (Underwriters' Laboratories, Inc.), CSA (Canadian Standards Association), and CUL (Canadian Underwriters' Laboratories, Inc.). Approvals are pending the completion of testing.

Q. Does the DL105 Micro PLC comply with European Union (EU) Directives?

A. Currently, the following four versions carry the CE label, indicating compliance with European Union Directives: The F1–130DR–CE and F1–130DD–CE AC powered versions and the F1–130DD–D and F1–130DR–D DC powered versions. See Appendix E for further information on EU Directives.

Q. Which devices can I connect to the Com1 port of the DL105?

A. The port is RS-232C, fixed at 9600 baud, and uses the proprietary K-sequence protocol. The port communicates with the following devices:

- DV-1000 Data Access Unit or Optimation Operator interface panels
- ***Direct***SOFT32 (running on a personal computer)
- D2-HPP handheld programmer
- Other devices which communicate via K-sequence protcol should work with the DL105 Micro PLC. Contact the vendor for details.

Q. Can the DL105 accept 5VDC inputs?

A. No, 5 volts is lower than the DC input ON threshold. However, many TTL logic circuits can drive the inputs if they are wired as open collector (sinking) inputs. See Chapter 2 for I/O wiring guidelines.

2

Installation, Wiring, and Specifications

In This Chapter. . . .

Safety Guidelines

NOTE: Products with CE marks perform their required functions safely and adhere to relevant standards as specified by EC directives provided they are used according to their intended purpose and that the instructions in this manual are adhered to. The protection provided by the equipment may be impaired if this equipment is used in a manner not specified in this manual. A listing of our international affiliates is availble on our Web site: http://www.automationdirect.com.

WARNING: Providing a safe operating environment for personnel and equipment is your responsibility and should be your primary goal during system planning and installation. Automation systems can fail and may result in situations that can cause serious injury to personnel or damage to equipment. Do not rely on the automation system alone to provide a safe operating environment. You should use external electromechanical devices, such as relays or limit switches, that are independent of the PLC application to provide protection for any part of the system that may cause personal injury or damage.
Every automation application is different, so there may be special requirements for your particular application. Make sure you follow all national, state, and local government requirements for the proper installation and use of your equipment.

Plan for Safety

The best way to provide a safe operating environment is to make personnel and equipment safety part of the planning process. You should examine *every* aspect of the system to determine which areas are critical to operator or machine safety. If you are not familiar with PLC system installation practices, or your company does not have established installation guidelines, you should obtain additional information from the following sources.

- NEMA — The National Electrical Manufacturers Association, located in Washington, D.C., publishes many different documents that discuss standards for industrial control systems. You can order these publications directly from NEMA. Some of these include:
  ICS 1, General Standards for Industrial Control and Systems
  ICS 3, Industrial Systems
  ICS 6, Enclosures for Industrial Control Systems
- NEC — The National Electrical Code provides regulations concerning the installation and use of various types of electrical equipment. Copies of the NEC Handbook can often be obtained from your local electrical equipment distributor or your local library.
- Local and State Agencies — many local governments and state governments have additional requirements above and beyond those described in the NEC Handbook. Check with your local Electrical Inspector or Fire Marshall office for information.

Three Levels of Protection

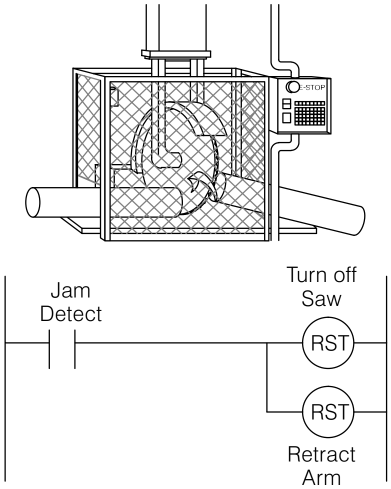
The publications mentioned provide many ideas and requirements for system safety. At a minimum, you should follow these regulations. Also, you should use the following techniques, which provide three levels of system control.

- Orderly system shutdown sequence in the PLC control program
- Mechanical disconnect for output module power
- Emergency stop switch for disconnecting system power

Orderly System Shutdown

The first level of fault detection is ideally the PLC control program, which can identify machine problems. You must analyze your application and identify any shutdown sequences that must be performed. These types of problems are usually things such as jammed parts, etc. that do not pose a risk of personal injury or equipment damage.

WARNING: The control program *must not* be the only form of protection for any problems that may result in a risk of personal injury or equipment damage.



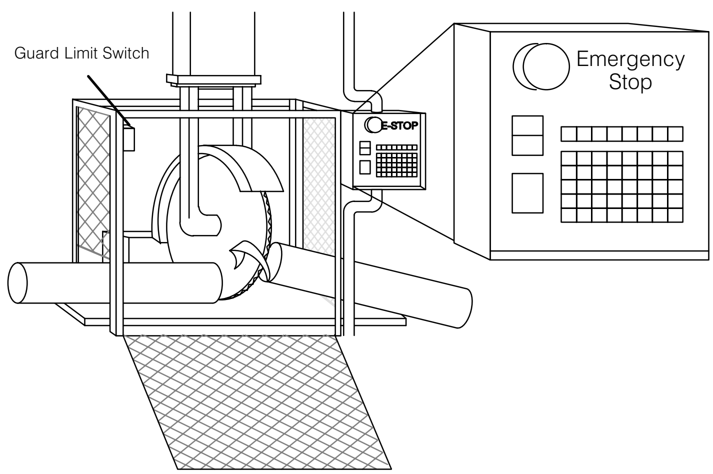
System Power Disconnect

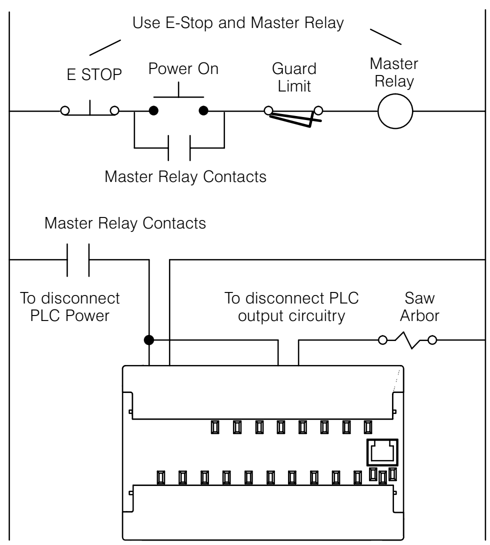
You should also use electromechanical devices, such as master control relays and/or limit switches, to prevent accidental equipment startup at an unexpected time. These devices should be installed in such a manner to prevent *any* machine operations from occurring.

For example, if the machine has a jammed part the PLC control program can turn off the saw blade and retract the arbor. However, since the operator must open the guard to remove the part, you should also include a bypass switch that disconnects *all* system power any time the guard is opened.

Emergency Stop

The machinery must provide a quick *manual* method of disconnecting *all* system power. The disconnect device or switch must be clearly labeled “**Emergency Stop**”.

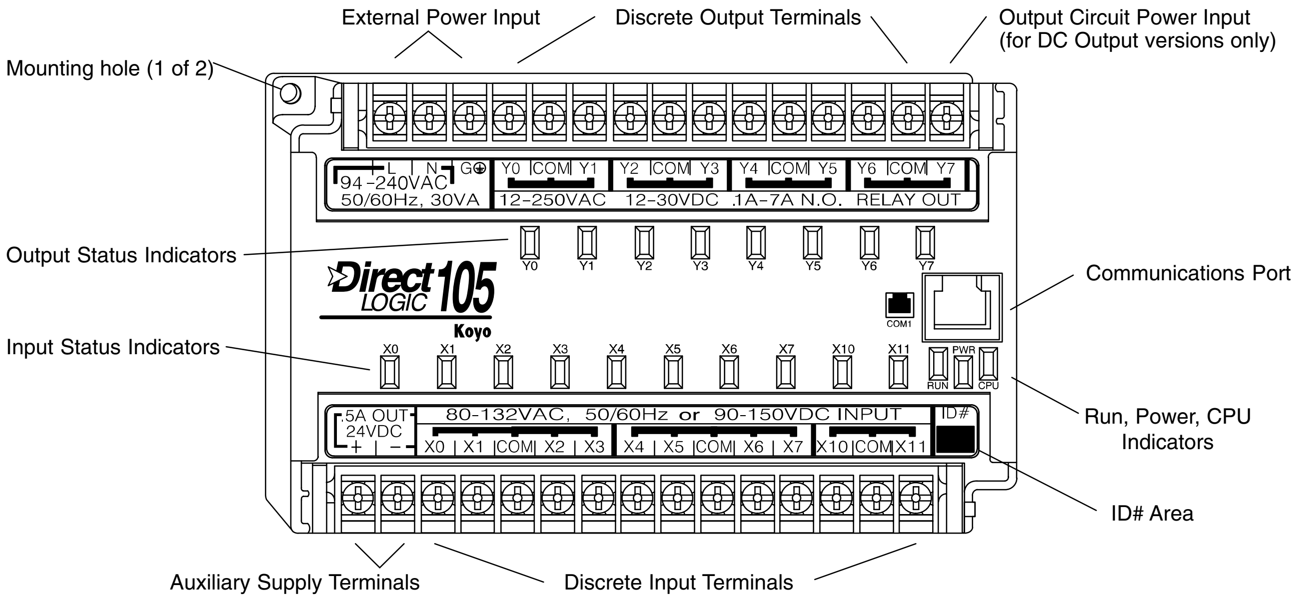




After an Emergency shutdown or any other type of power interruption, there may be requirements that must be met before the PLC control program can be restarted. For example, there may be specific register values that must be established (or maintained from the state prior to the shutdown) before operations can resume. In this case, you may want to use retentive memory locations, or include constants in the control program to ensure a known starting point.

Orientation to DL105 Front Panel

All connections, indicators, and labels on the DL105 Micro PLCs are located on its front panel. Please refer to the drawing below.

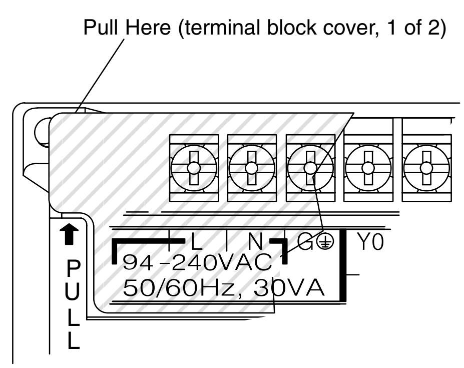


The upper connector accepts external power connections on the left-most terminals. The remainder of the terminals accept wires for the eight output points and their commons. On DC output versions, the end terminal on the right accepts power for the output stage. In many applications the external power to the Micro PLC also powers the loads and output circuit, so this terminal block groups them together.

The lower connector delivers the internal +24VDC auxiliary supply output on the two left-most terminals (AC-powered units only). On DC-powered units, the terminals are not used. The remaining terminals accept wires for the ten discrete inputs and their commons. In many applications the auxiliary +24VDC output also powers the input circuit, so this terminal block groups them together.

Accessing the I/O Terminals

To access the terminals just pull forward on the corner of the terminal cover where it is marked “pull”, as shown to the right. After exposing the connector block, it may be removed from the unit if desired.



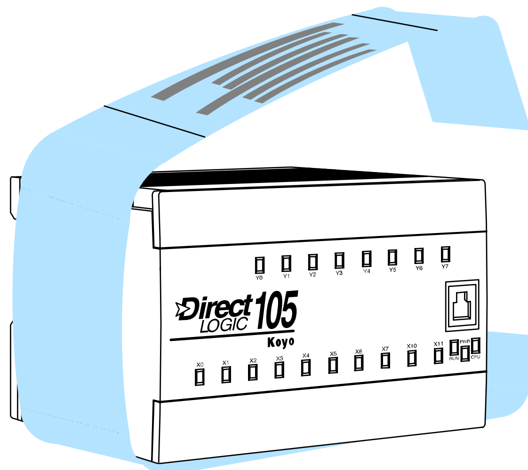
WARNING: For some applications, field device power may still be present on the terminal block even though the Micro PLC is turned off. To minimize the risk of electrical shock, check all field device power *before* you expose or remove either connector. Be sure to leave the covers normally closed.

Protective Sheet for DL105 Vents

Some machine fabrication environments may accidentally cause conductive debris to fall through the DL105 cooling vents and into the unit. All DL105 units come with a protective sheet wrapped around the unit, covering the cooling vents. However, it must be removed before electrical operation. Just unfasten the sheet on the right side of the unit. The instructions are reprinted below for your reference.

CAUTION

1. DO NOT REMOVE THIS PROTECTIVE SHEET until installation and wiring are completed.
2. REMOVE THIS SHEET before operation to enable heat to escape for proper cooling.



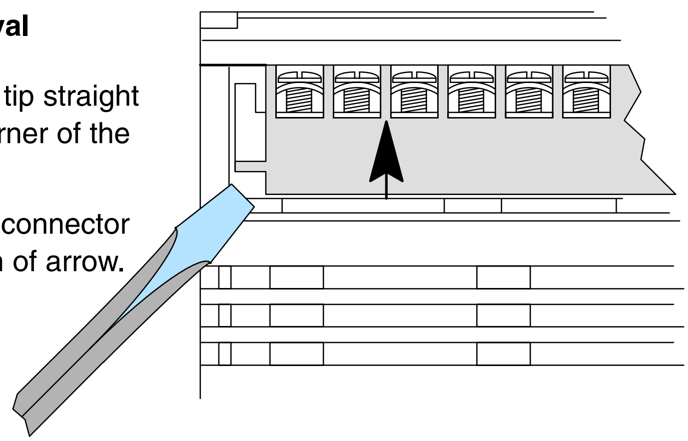
Connector Removal

The input and output terminal block connectors on the DL105 are identical. The connectors are designed for easy removal with just a small screwdriver. The drawing below shows the procedure for removal at one end. You'll need to work at both ends of the connector, so the ends move upwards approximately together.

Connector Removal

1. Insert the screwdriver tip straight into the opening at the corner of the connector as shown.

2. Pry screwdriver tip so connector moves upward in direction of arrow.



The two terminal block connectors on DL105 PLCs have regular screw terminals, which will accept either standard or #2 Philips screwdriver tips. You can insert one 14 AWG wire under a terminal, or two 16 AWG wires (one on each side of the screw). Be careful not to overtighten; maximum torque is 6 inch/ounces.

Spare terminal block connectors and connector covers may be ordered by individual part numbers:

Part Number	Qty Per Package	Description
F1–IOCON	4	DL105 I/O Terminal Block
F1–IOCVR	4	DL105 I/O Terminal Cover

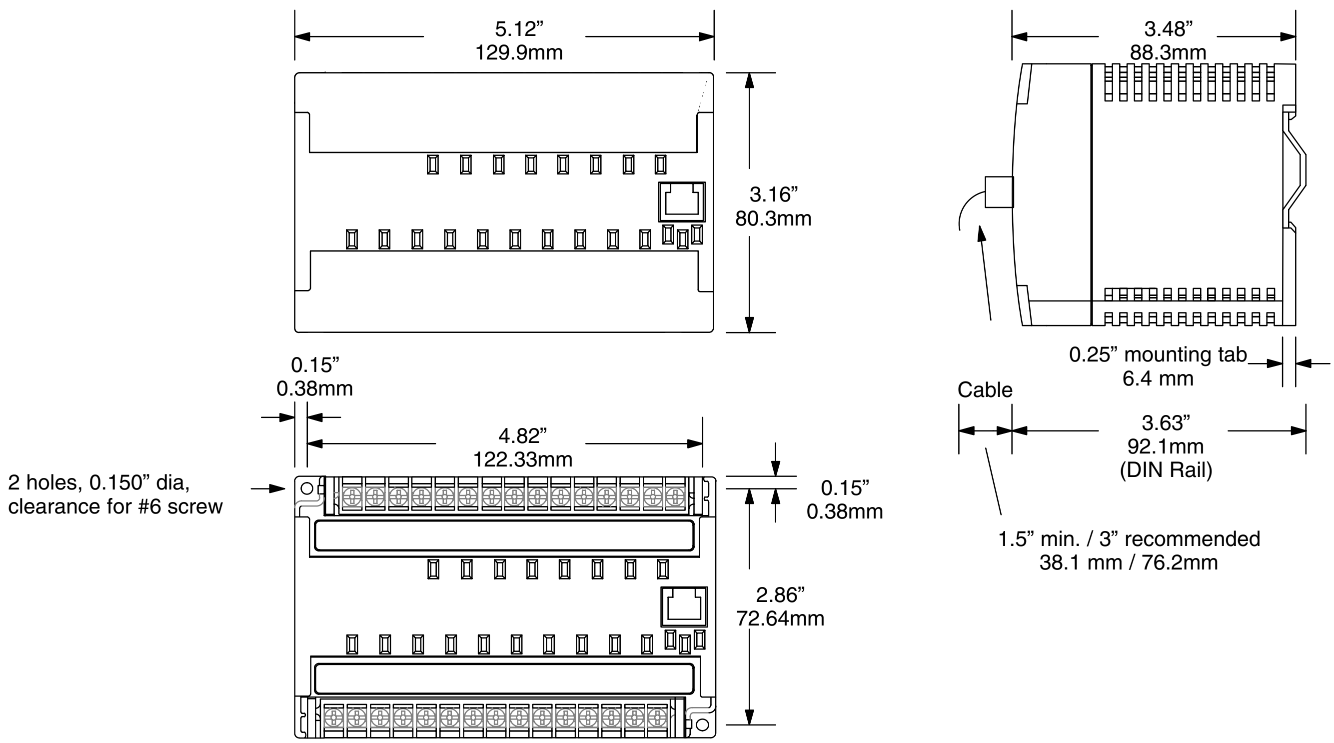
Mounting Guidelines

In addition to the panel layout guidelines, other specifications can affect the definition and installation of a PLC system. Always consider the following:

- Environmental Specifications
- Power Requirements
- Agency Approvals
- Enclosure Selection and Component Dimensions

Unit Dimensions

The following diagram shows the outside dimensions and mounting hole locations for all versions of the DL105. Make sure you follow the installation guidelines to allow proper spacing from other components.



Enclosures

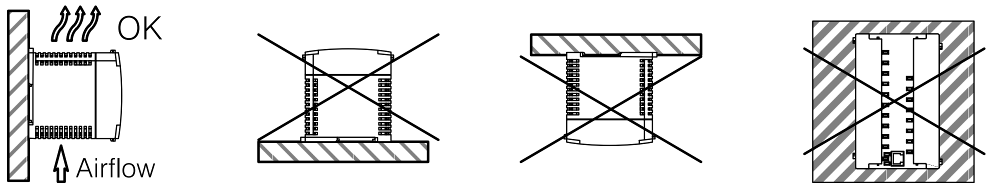
Your selection of a proper enclosure is important to ensure safe and proper operation of your DL105 system. Applications of DL105 systems vary and may require additional features. The minimum considerations for enclosures include:

- Conformance to electrical standards
- Protection from the elements in an industrial environment
- Common ground reference
- Maintenance of specified ambient temperature
- Access to equipment
- Security or restricted access
- Sufficient space for proper installation and maintenance of equipment

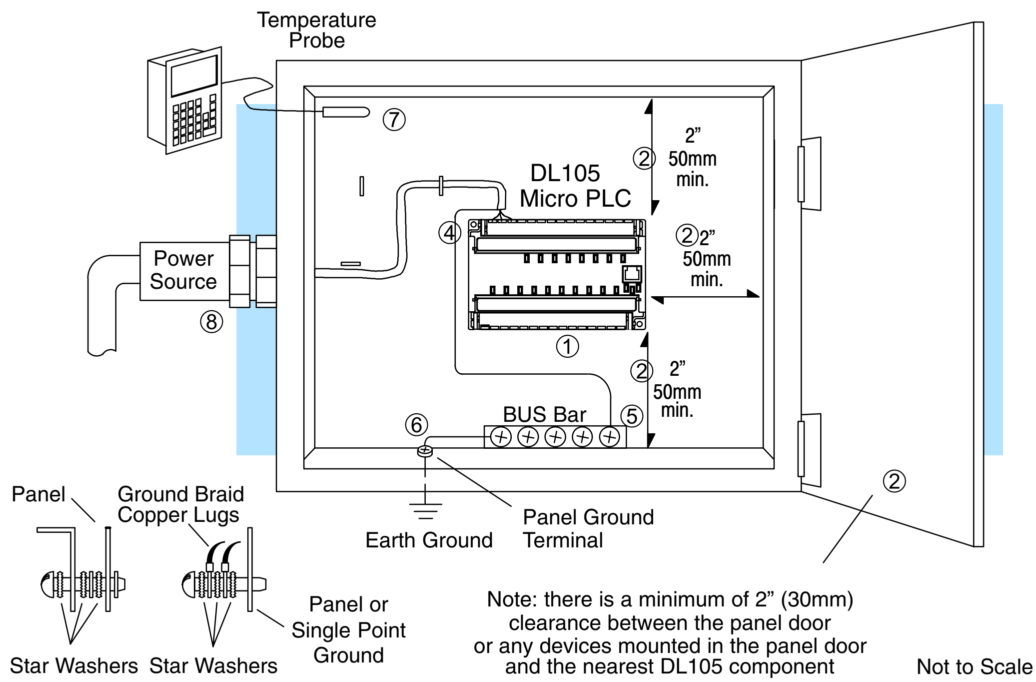
Panel Layout & Clearances

There are many things to consider when designing the panel layout. The following items correspond to the diagram shown. Note: there may be additional requirements, depending on your application and use of other components in the cabinet.

1. Mount the bases horizontally as shown below to provide proper ventilation. You ***cannot*** mount the DL105 units vertically, upside down, or on a flat horizontal surface. If you place more than one unit in a cabinet, there must be a minimum of 7.2” (183mm) between the units.



2. Provide a minimum clearance of 2” (50mm) between the unit and all sides of the cabinet. *Note, remember to allow for any operator panels or other items mounted in the door.*
3. There should also be at least 3” (78mm) of clearance between the unit and any wiring ducts that run parallel to the terminals.



4. The ground terminal on the DL105 base must be connected to a single point ground. Use copper stranded wire to achieve a low impedance. Copper eye lugs should be crimped and soldered to the ends of the stranded wire to ensure good surface contact.
5. There must be a single point ground (i.e. copper bus bar) for all devices in the panel requiring an earth ground return. The single point of ground must be connected to the panel ground termination. The panel ground termination must be connected to earth ground. Minimum wire sizes, color coding, and general safety practices should comply with appropriate electrical codes and standards for your area.

6. A good common ground reference (Earth ground) is essential for proper operation of the DL105. One side of all control and power circuits and the ground lead on flexible shielded cable must be properly connected to Earth ground. There are several methods of providing an adequate common ground reference, including:
   a) Installing a ground rod as close to the panel as possible.
   b) Connection to incoming power system ground.
7. Evaluate any installations where the ambient temperature may approach the lower or upper limits of the specifications. If you suspect the ambient temperature will not be within the operating specification for the DL105 system, measures such as installing a cooling/heating source must be taken to get the ambient temperature within the range of specifications.
8. The DL105 systems are designed to be powered by 110 VAC , 220 VAC, 125 VDC or 24 VDC normally available throughout an industrial environment. Isolation transformers and noise suppression devices are not normally necessary, but may be helpful in eliminating/reducing suspected power problems.

NOTE: If you are using other components in your system, make sure you refer to the appropriate manual to determine how those units can affect mounting dimensions.

Agency Approvals

Some applications require agency approvals for particular components. The DL105 Micro PLC submission status for agency approval is listed below:

- UL (Underwriters' Laboratories, Inc.) pending (Apr., 1998)
- CSA (Canadian Standards Association) pending (Apr., 1998)
- CUL (Canadian Underwriters' Laboratories, Inc.) pending (Apr., 1998)
- CE (European Economic Union) F1–130DD–D, F1–130DR–D, F1–130DR–CE, and F1–130DD–CE carry CE mark

Environmental Specifications

The following table lists the environmental specifications that generally apply to DL105 Micro PLCs. The ranges that vary for the Handheld Programmer are noted at the bottom of this chart. Certain output circuit types may have derating curves, depending on the ambient temperature and the number of outputs ON. Please refer to the appropriate section in this chapter pertaining to your particular DL105.

Specification	Rating
Storage temperature	–4° F to 158° F (–20° C to 70° C)
Ambient operating temperature*	32° F to 140° F (0° C to 60° C)
Ambient humidity**	5% – 95% relative humidity (non–condensing)
Vibration resistance	MIL STD 810C, Method 514.2
Shock resistance	MIL STD 810C, Method 516.2
Noise immunity	NEMA (ICS3–304)
Atmosphere	No corrosive gases

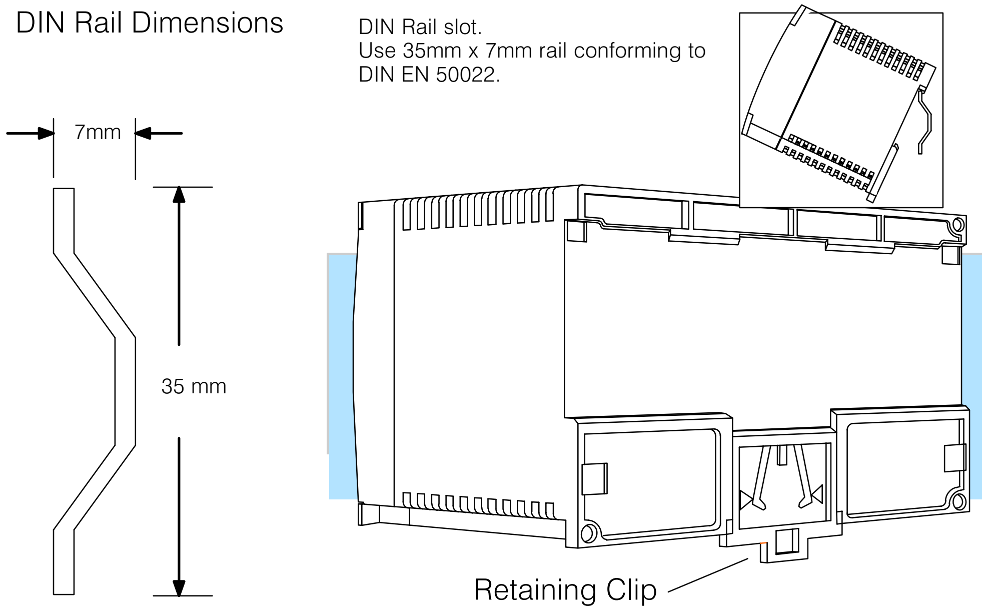
* Operating temperature for the Handheld Programmer and the DV–1000 is 32° to 122° F (0° to 50° C) Storage temperature for the Handheld Programmer and the DV–1000 is –4° to 158° F (–20° to70° C).
**Equipment will operate down to 5% relative humidity. However, static electricity problems occur much more frequently at low humidity levels (below 30%). Make sure you take adequate precautions when you touch the equipment. Consider using ground straps, anti-static floor coverings, etc. if you use the equipment in low-humidity environments.

Using Mounting Rails

DL105 Micro PLCs can also be secured to a cabinet by using mounting rails. We recommend rails that conform to DIN EN standard 50 022. They are approximately 35mm high, with a depth of 7.5mm. If you mount the Micro PLC on a rail, do consider using end brackets on each side of the PLC. The end bracket helps keep the PLC from sliding horizontally along the rail, reducing the possibility of accidentally pulling the wiring loose.

On the bottom of the PLC is a small retaining clip. To secure the PLC to a DIN rail, place it onto the rail and gently push up on the clip to lock it onto the rail.

To remove the PLC, pull down on the retaining clip, lift up on the PLC slightly, then pulling it away from the rail.



NOTE: We provide the following list as a guideline. Local and/or national codes may require the use of a particular type of material. Consult the manufacturer or their authorized representative prior to designing your system.

Vendor	Type	Materials and Lengths
Phoenix Contacts Products P.O. Box 4100 Harrisburg, PA 17111–0100 717–944–1300	NS 35/7,5	Steel, 6.5ft. (2m) (part number 08 01 73 3)
Weidmuller, Inc. 821 Southlake Blvd. Richmond, VA 23236 804–794–2877	TS 35x7.5	Steel, aluminum, copper, PVC Several lengths are available (consult manufacturer for appropriate part number)
Wieland available from Newark Electronics 4108 North Ravenswood Ave. Chicago, Il 60640 312–784–5100	TS 35x27x7.5	Steel, 6.5ft. (2m) (part number 94F2750)

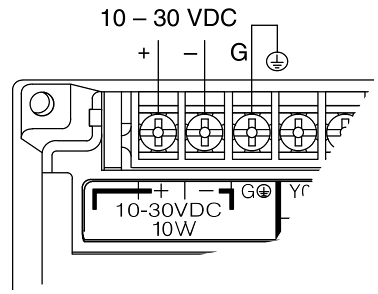
Wiring Guidelines

Power Input Wiring

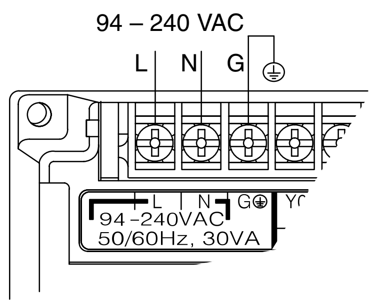
The diagram shows various possible external power connections for DL105 Micro PLCs. The terminals can accept up to 14 AWG wire. You may be able to use larger wiring depending on the wire type, but 14 AWG is the recommended size.

NOTE: You can connect either 115 VAC, 220 VAC, or 125 VDC to AC-powered versions of the DL105. Special wiring or jumpers are not required as with some of the other ***Direct***LOGIC™ products.

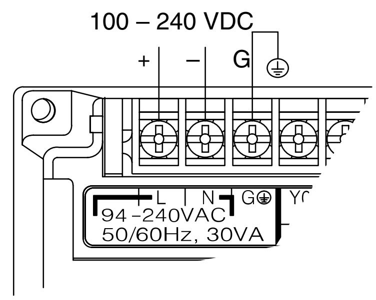
12/24 VDC Power Input



110/220 VAC Power Input



125 VDC Power Input



WARNING: Once the power wiring is connected, secure the terminal block cover in the closed position. When the cover is open there is a risk of electrical shock if you accidentally touch the connection terminals or power wiring.

Fuse Protection for Input Power

There are no internal fuses for the input power circuits, so external circuit protection is needed to ensure the safety of service personnel and the safe operation of the equipment itself. To meet UL/CSA specifications, the input power must be fused.

Depending on the type of input power being used, follow these fuse protection recommendations:

208/240 VAC Operation

When operating the unit from 208/240 VAC, whether the voltage source is a step-down transformer or from two phases, fuse both the line (L) and neutral (N) leads. The recommended fuse size is 0.375A (for example, a Littlefuse 312.375 or equivalent).

110/125 VAC Operation

When operating the unit from 110/125 VAC, it is only necessary to fuse the line (L) lead; it is not necessary to fuse the neutral (N) lead. The recommended fuse size is 0.5A (for example, a Littlefuse 312.500 or equivalent).

125 VDC Operation

Proper fusing techniques are required when operating from 125 VDC. Depending on your ground reference, the hot lead must be fused. A DC failure can maintain an arc for much longer time and distance. Typically, the main bus is fused at a higher level than the branch device, which in this case would be the DL105 unit. This double fusing technique is required when operating from direct current. The recommended fuse size for the branch circuit to the DL105 is 0.5A (for example, a Littlefuse 312.500 or equivalent).

12/24 VDC Operation

When operating at these lower dc voltages, wire gauge size is just as important as proper fusing techniques. Using large conductors minimizes the voltage drop in the conductor. Each DL105 input power terminal can accommodate one 14 AWG or two 16 AWG wires. Each terminal block junction and/or connection creates a voltage drop, so try to keep the number of connections to a minimum. In general, when using 12/24 VDC input power, observe the same double fusing techniques that are used with 125 VDC input power. The recommended fuse size for the branch circuit to the DL105 is 1A (for example, a Littlefuse 312.001 or equivalent).

External Power Source

The power source must be capable of suppling voltage and current complying with individual Micro PLC specifications, according to the following specifications:

Part Numbers	**F1–130AR, F1–130DR / F1–130DR–CE, F1–130AD, F1–130DD / F1–130DD–CE, F1–130AA, F1–130DA**	**F1–130DR–D, F1–130DD–D**
Input Voltage Range	85–132 VAC (110 nominal) 170–264 VAC (220 nominal), 100 – 264 VDC (125 nominal)	10 – 30 VDC (12 to 24VDC) with less than 10% ripple
Maximum Inrush Current	12 A, <1/2 mS	12 A, <1/2 mS
Maximum Power	30 VA (for AC power) 30 W (for DC power)	10W (0.3A @ 30VDC)
Voltage Withstand (dielectric)	1 minute @ 1500 VAC between primary, secondary, field ground	
Insulation Resistance	> 10 MΩ at 500 VDC	
Auxiliary 24 VDC Output	21.6–26.4 VDC Ripple less than 200 mV p-p 500 mA max, isolated.	None

NOTE: The rating between all internal circuits is BASIC INSULATION ONLY.

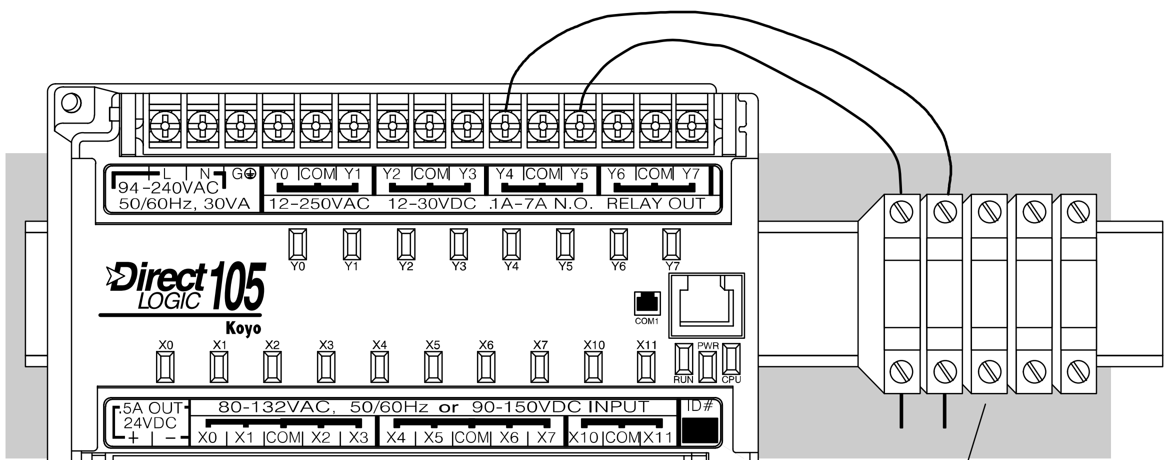
Planning the Wiring Routes

The following guidelines provide general information on how to wire the I/O connections to DL105 Micro PLCs. For specific information on wiring a particular PLC refer to the corresponding specification sheet further in this chapter.

1. Each terminal connection of the DL105 PLC can accept one 14 AWG wire or two 16 AWG size wires. Do not exceed this recommended capacity.
2. Always use a continuous length of wire. Do not splice wires to attain a needed length.
3. Use the shortest possible wire length.
4. Use wire trays for routing where possible.
5. Avoid running wires near high energy wiring.
6. Avoid running input wiring close to output wiring where possible.
7. To minimize voltage drops when wires must run a long distance , consider using multiple wires for the return line.
8. Avoid running DC wiring in close proximity to AC wiring where possible.
9. Avoid creating sharp bends in the wires.

Fuse Protection for Input and Output Circuits

Input and Output circuits on DL105 Micro PLCs do not have internal fuses. However, the +24V Auxiliary Supply is current-limited. In order to protect your Micro PLC, we suggest you add external fuses to your I/O wiring. A fast-blow fuse, with a lower current rating than the I/O bank's common current rating can be wired to each common. Or, a fuse with a rating of slightly less than the maximum current per output point can be added to each output. Refer to the Micro PLC specification sheets further in this chapter to find the maximum current per output point or per output common. Adding the external fuse does not guarantee the prevention of Micro PLC damage, but it will provide added protection.



External Fuses
(shown with DIN Rail, Fuse Blocks)

I/O Point Numbering

All DL105 Micro PLCs have a fixed I/O configuration. It follows the same octal numbering system used on other ***Direct***Logic family PLCs, starting at X0 and Y0. The letter X is always used to indicate inputs and the letter Y is always used for outputs.

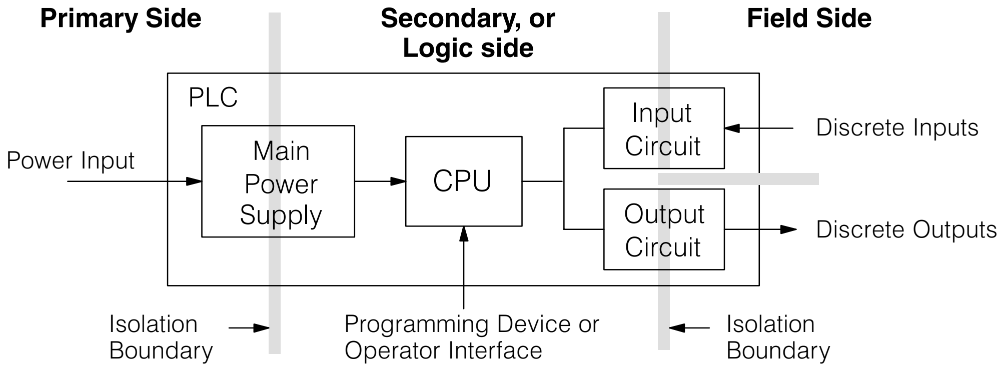
The I/O numbering always starts at zero and does not include the digits 8 or 9. The addresses are typically assigned in groups of 8 or 16, depending on the number of points in an I/O group. For the DL105 the ten inputs use reference numbers X0 – X7 and X10 – X11. The eight output points use references Y0 – Y7.

System Wiring Strategies

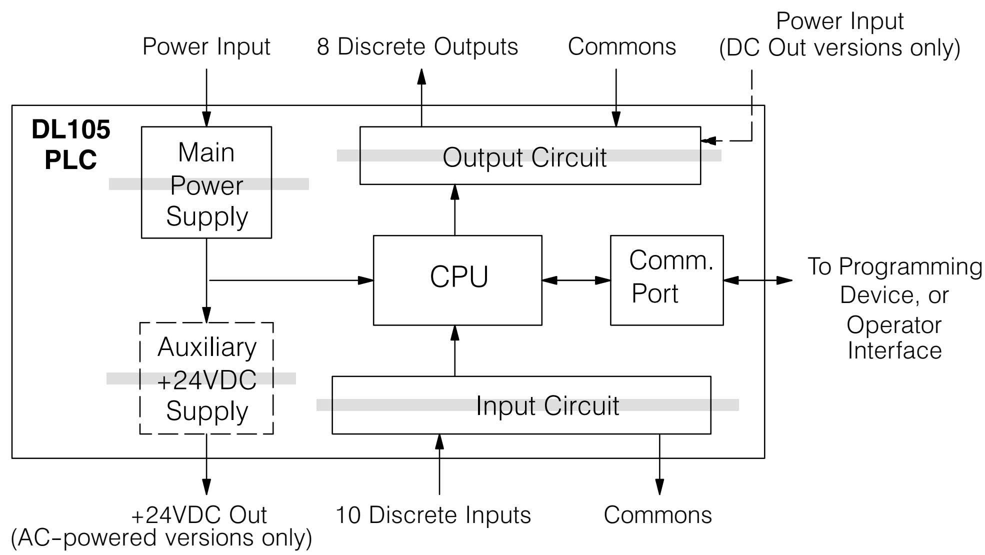
The DL105 Micro PLC is very flexible and will work in many different wiring configurations. By studying this section before actual installation, you can probably find the best wiring strategy for your application . This will help to lower system cost, wiring errors, and avoid safety problems.

PLC Isolation Boundaries

PLC circuitry is divided into three main regions separated by isolation boundaries, shown in the drawing below. Electrical isolation provides safety, so that a fault in one area does not damage another. A transformer in the power supply provides magnetic isolation between the primary and secondary sides. Opto-couplers provide optical isolation in Input and Output circuits. This isolates logic circuitry from the field side, where factory machinery connects. Note that the discrete inputs are isolated from the discrete outputs, because each is isolated from the logic side. Isolation boundaries protect the operator interface (and the operator) from power input faults or field wiring faults. *When wiring a PLC, it is extremely important to avoid making external connections that connect logic side circuits to any other.*



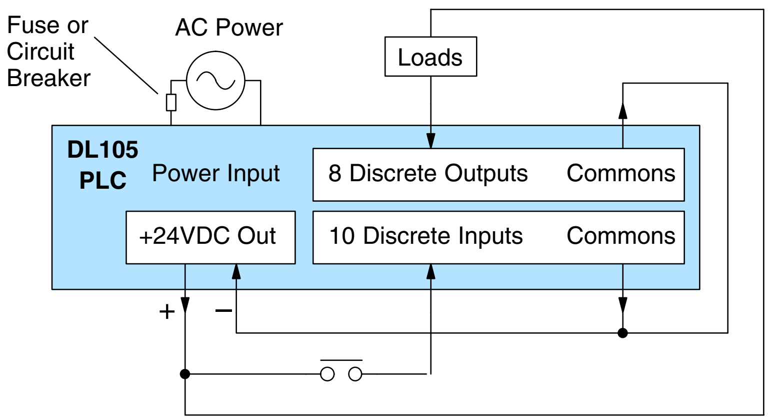
The next figure shows the internal layout of DL105 PLCs, as viewed from the front panel. In addition to the basic circuits covered above, it includes an auxiliary +24VDC power supply with its own isolation boundary. Since the supply output is isolated from the other three circuits, it can power input and/or output circuits!



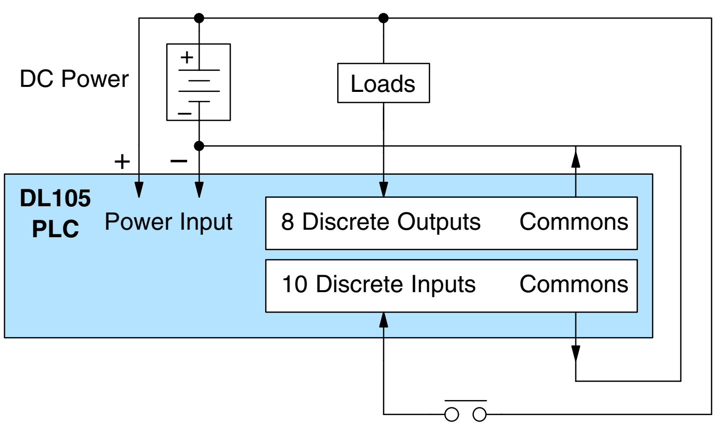
In many cases, using the built-in auxiliary +24VDC supply can result in a cost savings for your control system. It can power combined loads up to 500 mA, which is enough to eliminate the need for an additional power supply in some applications. If you are the system designer for your application, you may be able to select and design in field devices which can use the +24VDC auxiliary supply.

Powering I/O Circuits with the Auxiliary Supply

All AC-powered DL105 Micro PLCs feature the internal auxiliary supply. If input devices AND output loads need +24VDC power, the auxiliary supply can power both circuits as shown in the following diagram.



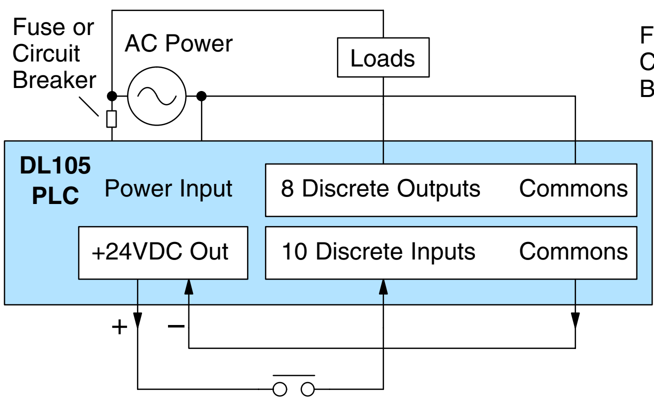
DC-powered DL105 Micro PLCs are designed for application environments in which low-voltage DC power is more readily available than AC. These include a wide range of battery–powered applications, such as remotely-located control, in vehicles, portable machines, etc. For this application type, all input devices and output loads typically use the same DC power source. The F1-130DR-D and F1-130DD-D are compatible with either +12VDC or +24VDC systems. Typical wiring for DC-powered applications is shown in the following diagram.

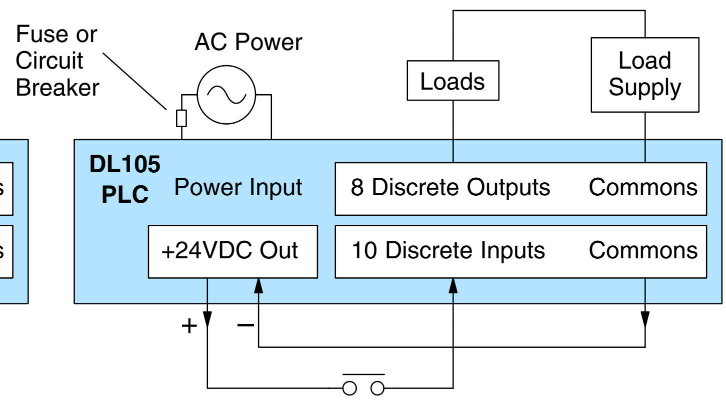


Powering I/O Circuits Using Separate Supplies

In some applications it will be necessary to power the input devices from one power source, and to power output loads from another source. Loads often require high-energy AC power, while input sensors use low-energy DC. If a machine operator is likely to come in close contact with input wiring, then safety reasons also require isolation from high-energy output circuits. It is most convenient if the loads can use the same power source as the Micro PLC, and the input sensors can use the auxiliary supply, as shown to the left in the figure below.

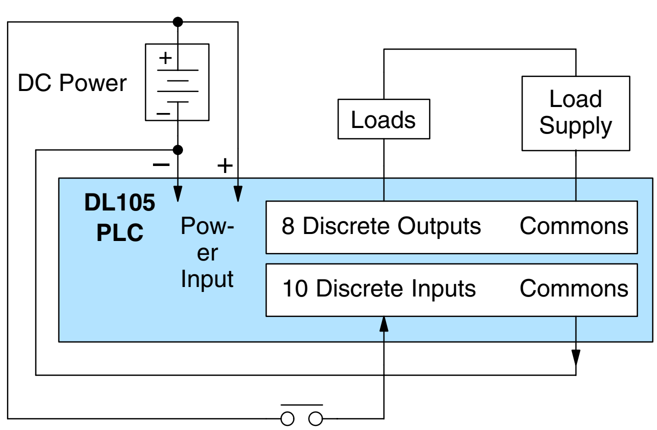
If the loads cannot be powered from the Micro PLC supply, then a separate supply must be used as shown to the right in the figure below.

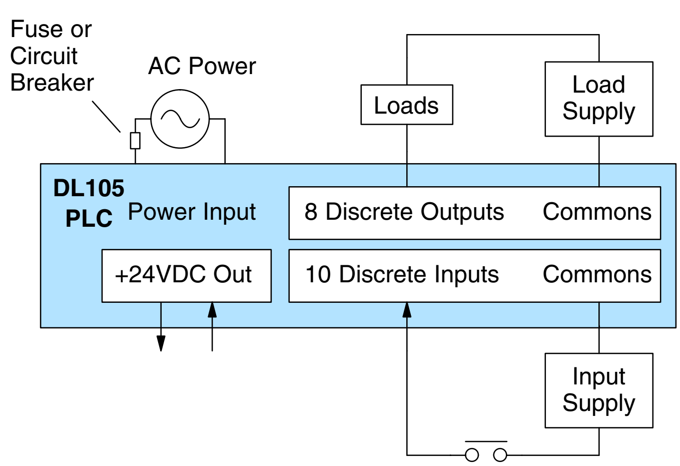




Some applications will use the Micro PLC power source to also power the input circuit. This typically occurs on a DC-powered DL105, as shown in the drawing below to the left. The inputs share the PLC power source supply, while the outputs have their own separate supply.

A worst-case scenario, from a cost and complexity view-point, is an application which requires separate power sources for the PLC, input devices, and output loads. The example wiring diagram below on the right shows how this can work, but also that the auxiliary supply out is an unused resource. For these reasons, you'll probably want to avoid this situation if possible.

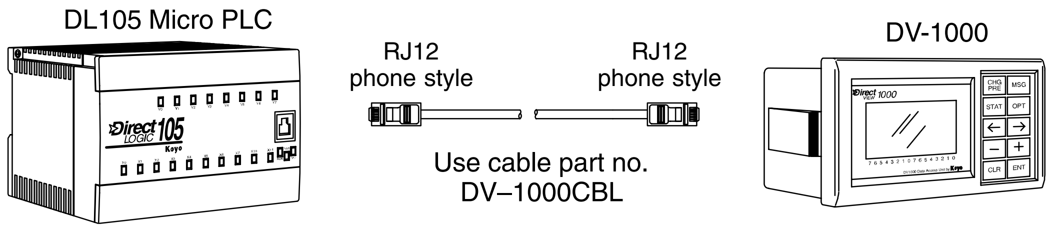




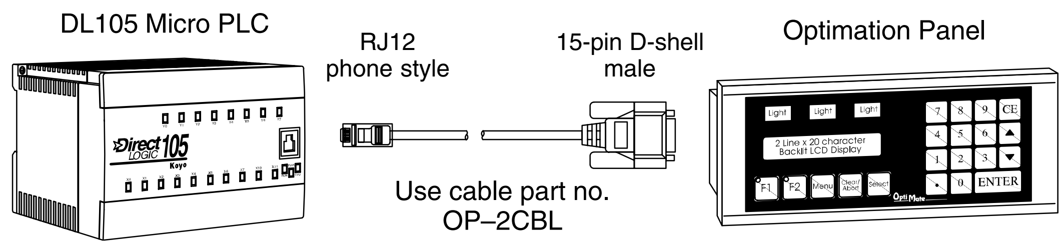
Connecting Operator Interface Devices

Operator interfaces require data and power connections. Operator interfaces with a large CRT usually require separate AC power. However, small operator interface devices like the popular DV-1000 Data Access Unit and the Optimation panels may be powered directly from the DL105 Micro PLC.

Connect the DV-1000 to the DL105 Micro PLC COM1 port using the cable shown below. A single cable contains transmit/receive data wires and +5V power.

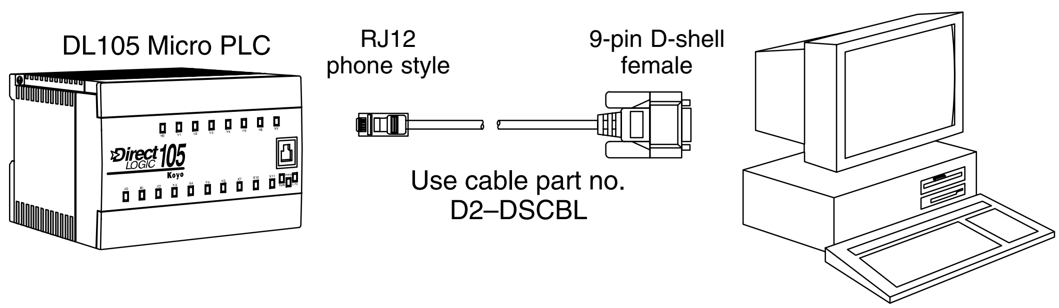


Optimation operator interface panels require separate power and communications connections. Connect the DL105 COM1 port to the 15-pin D-shell connector on the rear of the Optimation panel using the cable shown below. Optimation panels require 8–30VDC power, so use separate wiring to connect the +24VDC supply output on AC-powered DL105 PLCs. Use external +24VDC power for DC-powered DL105s.

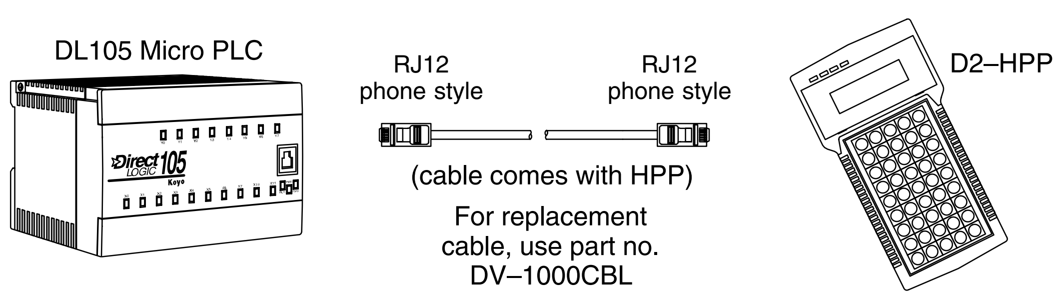


Connecting Programming Devices

DL105 Micro PLCs can be programmed with either a handheld programmer or with ***Direct***SOFT32 on a PC. Connect the DL105 to a PC using the cable shown below.



The D2-HPP Handheld Programmer comes with a communications cable. For a replacement part, use the cable shown below.



Sinking / Sourcing Concepts

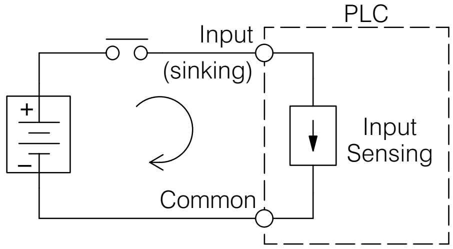
Before going further in our study of wiring strategies, we must have a solid understanding of "*sinking*" and "*sourcing*" concepts. Use of these terms occurs frequently in input or output circuit discussions. It is the goal of this section to make these concepts easy to understand, further ensuring your success in installation. First we give the following short definitions, followed by practical applications.

Sinking = Path to supply **ground (–)**

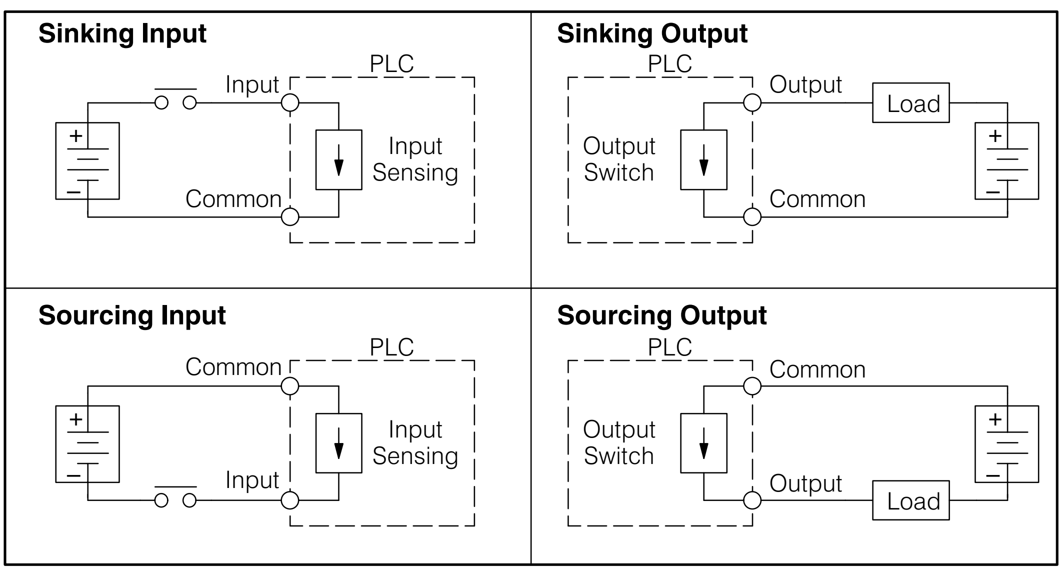
Sourcing = Path to supply **source (+)**

First you will notice that these are only associated with DC circuits and not AC, because of the reference to (+) and (–) polarities. Therefore, *sinking and sourcing terminology only applies to DC input and output circuits.* Input and output points that are either sinking or sourcing can conduct current in only one direction. This means it is possible to connect the external supply and field device to the I/O point with current trying to flow in the wrong direction, and the circuit will not operate. However, we can successfully connect the supply and field device every time by understanding "sourcing" and "sinking".

For example, the figure to the right depicts a "sinking" input. To properly connect the external supply, we just have to connect it so the the input *provides a path to ground (–)*. So, we start at the PLC input terminal, follow through the input sensing circuit, exit at the common terminal, and connect the supply (–) to the common terminal. By adding the switch, between the supply (+) and the input, we have completed the circuit. Current flows in the direction of the arrow when the switch is closed.

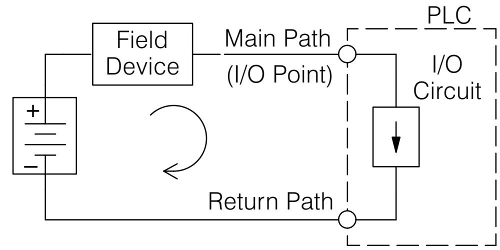


By applying the circuit principle above to the four possible combinations of input/output sinking/sourcing types, we have the four circuits as shown below. DL105 Micro PLCs provide all except the sourcing output I/O circuit types.

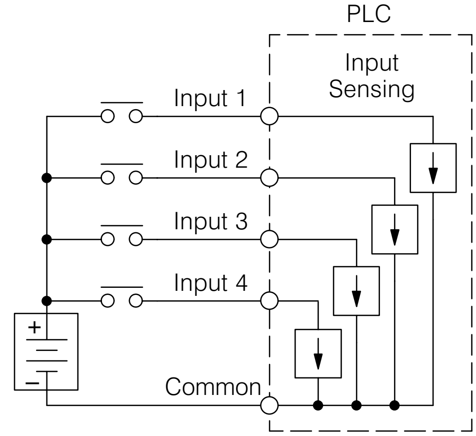


I/O "Common" Terminal Concepts

In order for a PLC I/O circuit to operate, current must enter at one terminal and exit at another. This means at least two terminals are associated with every I/O point. In the figure to the right, the Input or Output terminal is the *main path* for the current. One additional terminal must provide the *return path* to the power supply.

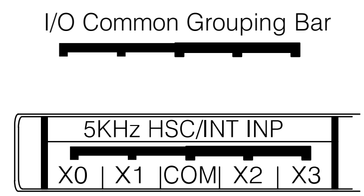


If we had unlimited space and budget for I/O terminals, then every I/O point could have two dedicated terminals just as the figure above shows. However, providing this level of flexibility is not practical or even necessary for most applications. So, most Input or Output point groups on PLCs share the return path among two or more I/O points. The figure to the right shows a group (or *bank*) of 4 input points which share a common return path. In this way, the four inputs require only five terminals instead of eight.

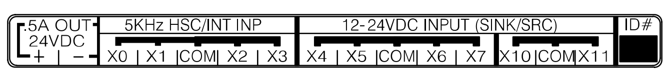


Note: In the circuit above, the current in the common path is 4 times any channel's input current when all inputs are energized. This is especially important in output circuits, where heavier gauge wire is sometimes necessary on commons.

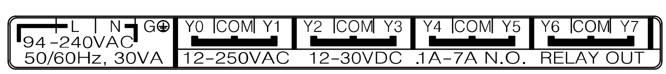
Most DL105 input and output circuits are grouped into banks that share a common return path. The best indication of I/O common grouping is on the wiring label. The I/O common grouping bar, labeled at the right, occurs in the section of wiring label below it. It indicates X0, X1, X2, and X3 share the common terminal located between X1 and X2.



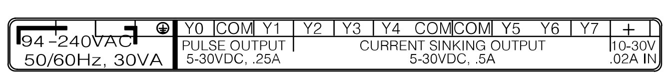
The following complete label shows two banks of four inputs and one bank of two.



The following label for relay outputs shows four banks of two output points each.



The last label below for DC outputs has no common grouping bar. In this unique case, all eight outputs share the same electrical common. The common is available on three terminals, so there is a physical place to connect each point's common wire.

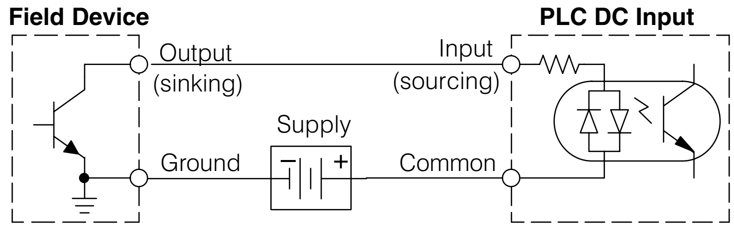


Connecting DC I/O to "Solid State" Field Devices

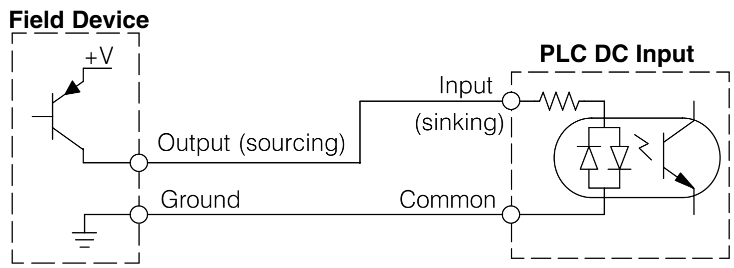
In the previous section on Sourcing and Sinking concepts, we explained that DC I/O circuits sometimes will only allow current to flow one way. This is also true for many of the field devices which have solid-state (transistor) interfaces. In other words, field devices can also be sourcing or sinking. *When connecting two devices in a series DC circuit, one must be wired as sourcing and the other as sinking*.

Solid State Input Sensors

The DL105's DC inputs are flexible in that they detect current flow in either direction, so they can be wired as either sourcing or sinking. In the following circuit, a field device has an open-collector NPN transistor output. It sinks current from the PLC input point, which sources current. The power supply can be the +24 auxiliary supply or another supply (+12 VDC or +24VDC), as long as the input specifications are met.



In the next circuit, a field device has an open-emitter PNP transistor output. It sources current to the PLC input point, which sinks the current back to ground. Since the field device is sourcing current, no additional power supply is required.

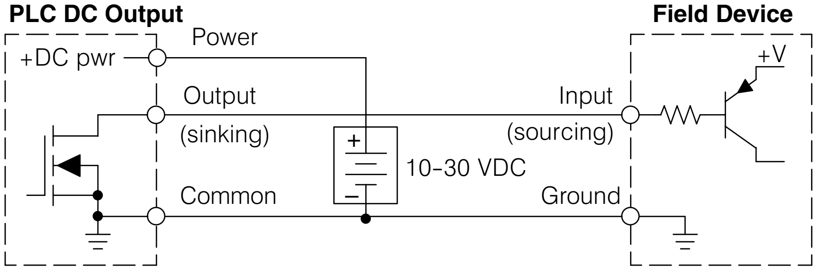


Solid State Output Loads

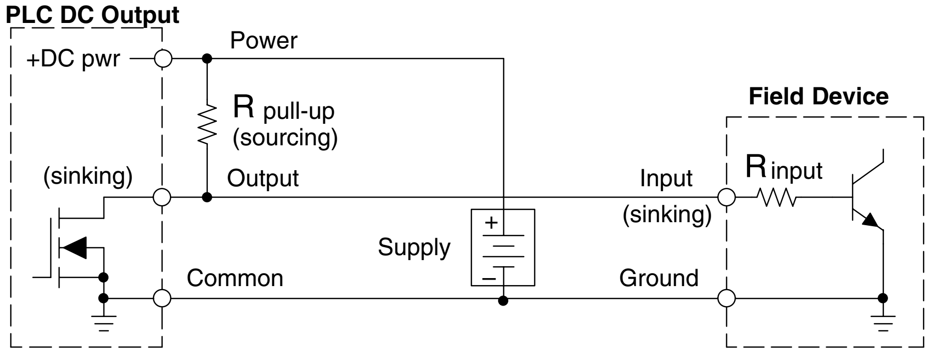
Sometimes an application requires connecting a PLC output point to a solid state input on a device. This type of connection is usually made to carry a low-level signal, not to send DC power to an actuator.

The DL105's DC outputs are sinking-only. This means that each DC output provides a path to ground when it is energized. Also, remember that all eight outputs have the same electrical common, even though there are three common terminal screws. Finally, recall that the DC output circuit requires power (10 – 30 VDC) from an external power source.

In the following circuit, the PLC output point sinks current to the output common when energized. It is connected to a sourcing input of a field device input.



In the next example we connect a PLC DC output point to the sinking input of a field device. This is a bit tricky, because both the PLC output and field device input are sinking type. Since the circuit must have one sourcing and one sinking device, we add sourcing capability to the PLC output by using a pull-up resistor. In the circuit below, we connect $R_{pull\text{-}up}$ from the output to the DC output circuit power input.



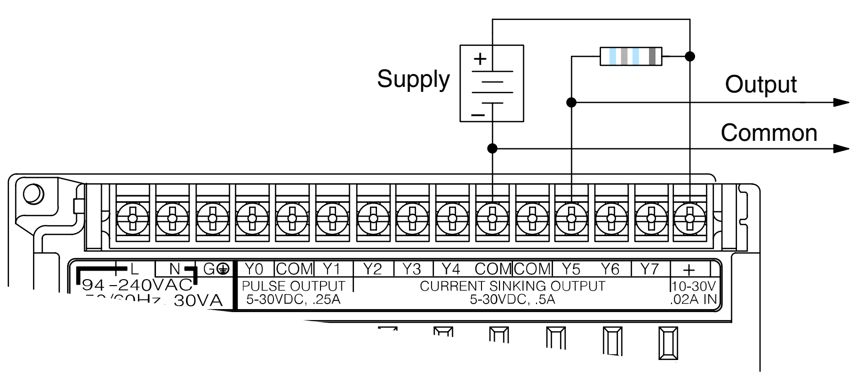
NOTE: DO NOT attempt to drive a heavy load (>25 mA) with this pull-up method.
NOTE 2: Using the pull-up resistor to implement a sourcing output has the effect of inverting the output point logic. In other words, the field device input is energized when the PLC output is OFF, from a ladder logic point-of-view. Your ladder program must comprehend this and generate an inverted output. Or, you may choose to cancel the effect of the inversion elsewhere, such as in the field device.

It is important to choose the correct value of $R_{pull\text{-}up}$. In order to do so, we need to know the nominal input current to the field device (I_{input}) when the input is energized. If this value is not known, it can be calculated as shown (a typical value is 15 mA). Then use I_{input} and the voltage of the external supply to compute $R_{pull\text{-}up}$. Then calculate the power $P_{pull\text{-}up}$ (in watts), in order to size $R_{pull\text{-}up}$ properly.

$$I_{input} = \frac{V_{input\ (turn\text{–}on)}}{R_{input}}$$

$$R_{pull\text{-}up} = \frac{V_{supply} - 0.7}{I_{input}} - R_{input} \qquad P_{pull\text{-}up} = \frac{{V_{supply}}^2}{R_{pullup}}$$

The drawing below shows the actual wiring of the DL105 Micro PLC to the supply and pull-up resistor.



Relay Output Wiring Methods

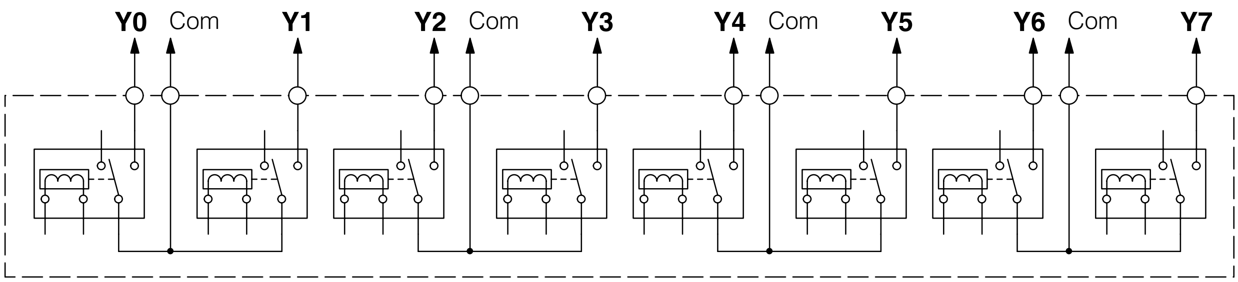
The F1–130AR, F1–130DR/F1–130DR–CE, and F1–130DR–D models feature relay outputs. Relays are best for the following applications:

- Loads that require higher currents than the solid-state DL105 outputs can deliver
- Cost-sensitive applications
- Some output channels need isolation from other outputs (such as when some loads require AC while others require DC)

Some applications in which NOT to use relays:

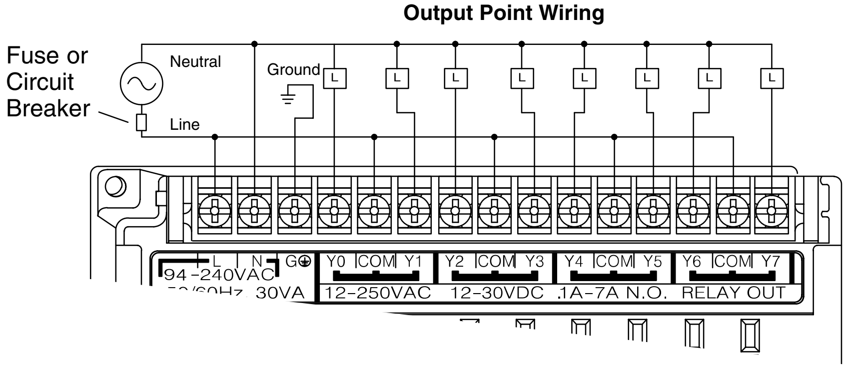
- Loads that require currents under 10 mA
- Loads which must be switched at high speed and duty cycle

Assuming relays are right for your application, we're now ready to explore various ways to wire relay outputs to the loads. Note that there are eight normally-open SPST relays available. They are organized into four pairs with individual commons. The figure below shows the relays and the internal wiring of the PLC. Note that each pair is isolated from the other three relay pairs.



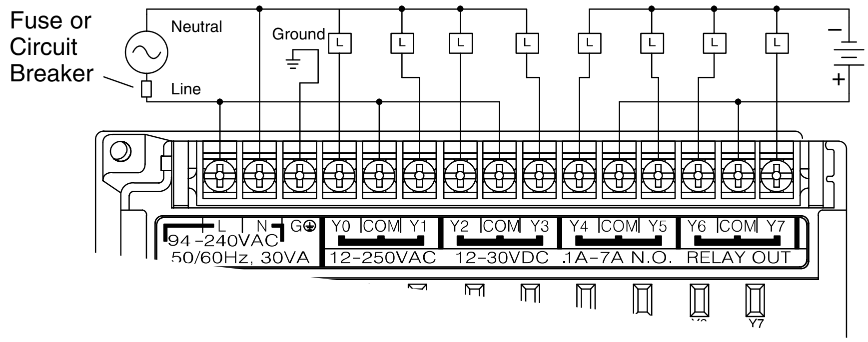
In the circuit below, all loads use the same AC power supply which powers the DL105 PLC. In this example, all commons are connected together.

Output Point Wiring



In the circuit on the following page, loads for Y0 – Y3 use the same AC power supply which powers the DL105 PLC. Loads for Y4 – Y7 use a separate DC supply. In this example, the commons are separated according to which supply powers the associated load.

Output Point Wiring



Surge Suppresion For Inductive Loads

Inductive load devices (devices with a coil) generate transient voltages when de-energized with a relay contact. When a relay contact is closed it “bounces”, which energizes and de-energizes the coil until the “bouncing” stops. The transient voltages generated are much larger in amplitude than the supply voltage, especially with a DC supply voltage.

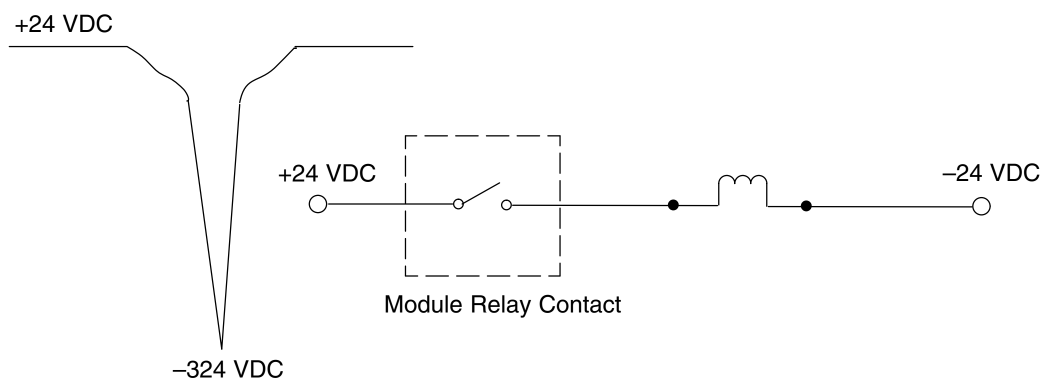
When switching a DC-supplied inductive load the full supply voltage is always present when the relay contact opens (or “bounces”). When switching an AC-supplied inductive load there is one chance in 60 (60 Hz) or 50 (50 Hz) that the relay contact will open (or “bounce”) when the AC sine wave is zero crossing. If the voltage is not zero when the relay contact opens there is energy stored in the inductor that is released when the voltage to the inductor is suddenly removed. This release of energy is the cause of the transient voltages.

When inductive load devices (motors, motor starters, interposing relays, solenoids, valves, etc.) are controlled with relay contacts, it is recommended that a surge suppression device be connected directly across the coil of the field device. If the inductive device has plug-type connectors, the suppression device can be installed on the terminal block of the relay output.

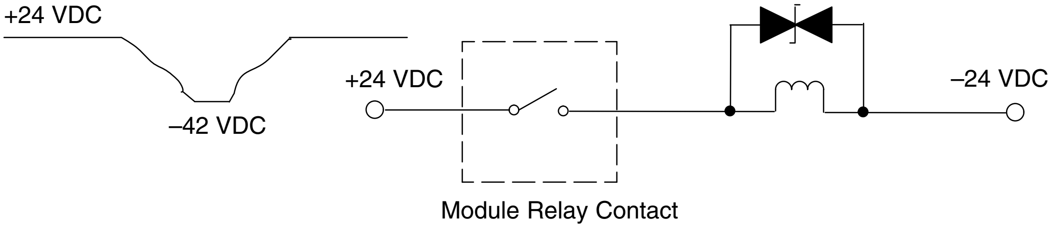
Transient Voltage Suppressors (TVS or transorb) provide the best surge and transient suppression of AC and DC powered coils, providing the fastest response with the smallest overshoot.

Metal Oxide Varistors (MOV) provide the next best surge and transient suppression of AC and DC powered coils.

For example, the waveform in the figure below shows the energy released when opening a contact switching a 24 VDC solenoid. Notice the large voltage spike.



This figure shows the same circuit with a transorb (TVS) across the coil. Notice that the voltage spike is significantly reduced.



Use the following table to help select a TVS or MOV suppressor for your application based on the inductive load voltage.

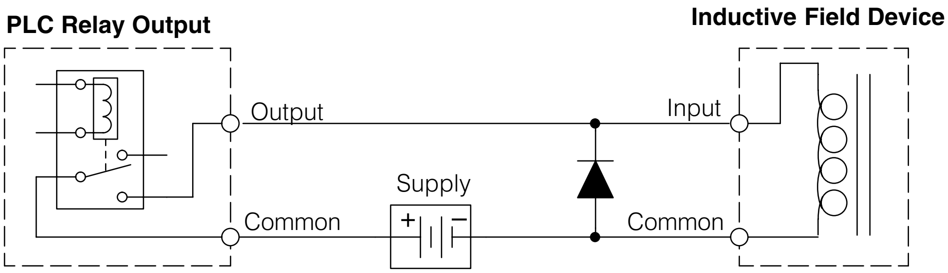
Vendor / Catalog	Type (TVS, MOV, Diode)	Inductive Load Voltage	Part Number
General Instrument Transient Voltage Suppressors, LiteOn Diodes; from DigiKey Catalog; Phone: 1-800-344-4539	TVS TVS TVS Diode	110/120 VAC 220/240 VAC 12/24 VDC or VAC 12/24 VDC or VAC	P6KE180CAGICT–ND P6KE350CA P6K30CAGICT–ND 1N4004CT–ND
Harris Metal Oxide Varistors; from Newark Catalog; Phone: 1-800-463-9275	MOV MOV	110/120 VAC 220/240 VAC	V150LA20C V250LA20C

Prolonging Relay Contact Life

Relay contacts wear according to the amount of relay switching, amount of spark created at the time of open or closure, and presence of airborne contaminants. There are some steps you can take to help prolong the life of relay contacts, such as switching the relay on or off only when it is necessary, and if possible, switching the load on or off at a time when it will draw the least current. Also, take measures to suppress inductive voltage spikes from inductive DC loads such as contactors and solenoids.

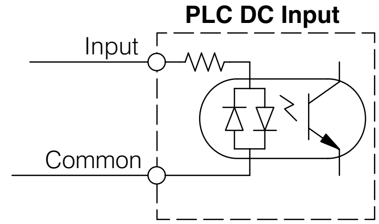
For inductive loads in DC circuits we recommend using a suppression diode as shown in the following diagram (DO NOT use this circuit with an AC power supply). When the load is energized the diode is reverse-biased (high impedance). When the load is turned off, energy stored in its coil is released in the form of a negative-going voltage spike. At this moment the diode is forward-biased (low impedance) and shunts the energy to ground. This protects the relay contacts from the high voltage arc that would occur just as the contacts are opening.

Place the diode as close to the inductive field device as possible. Use a diode with a peak inverse voltage rating (PIV) at least 100 PIV, 3A forward current or larger. Use a fast-recovery type (such as Schottky type). DO NOT use a small-signal diode such as 1N914, 1N941, etc. Be sure the diode is in the circuit correctly before operation. If installed backwards, it short-circuits the supply when the relay energizes.

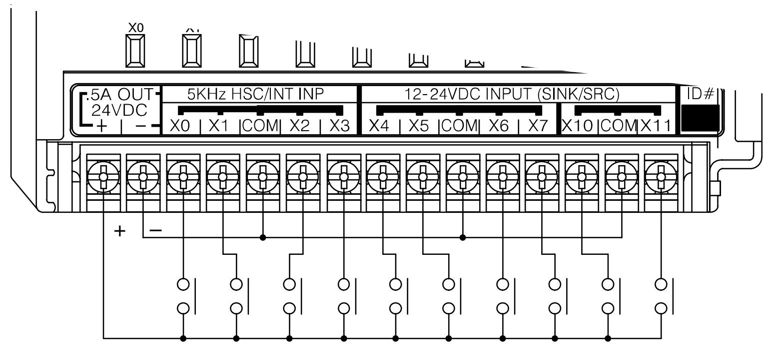


DC Input Wiring Methods

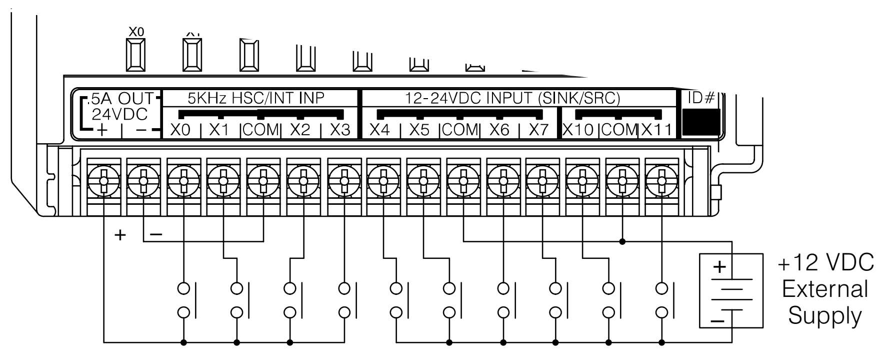
DL105 Micro PLCs with DC inputs are particularly flexible because they can be either sinking or sourcing. The dual diodes (shown to the right) allow current to flow in either direction. The inputs accept either 10 – 26.4 VDC or 21.6 – 26.4 VAC. That's right, either AC or DC voltages will work. The target applications are +12 VDC, +24 VDC, and 24 VAC. You can actually wire part of the inputs as DC sinking, others as DC sourcing, and the rest as AC!



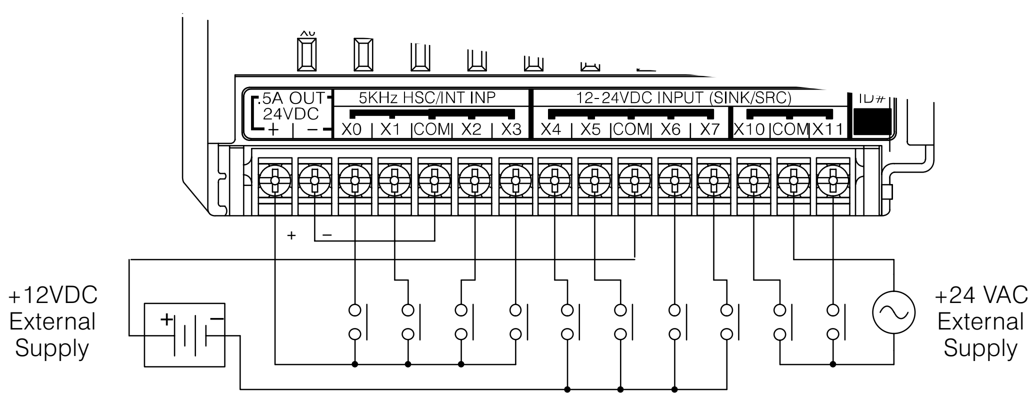
In the first and simplest example below, all commons are connected together and all inputs are sinking.



In the next example, the first four inputs are sinking, and the last six are sourcing.



In the last example, four inputs are sinking DC, four are sourcing DC, and two are AC.



DC Output Wiring Methods

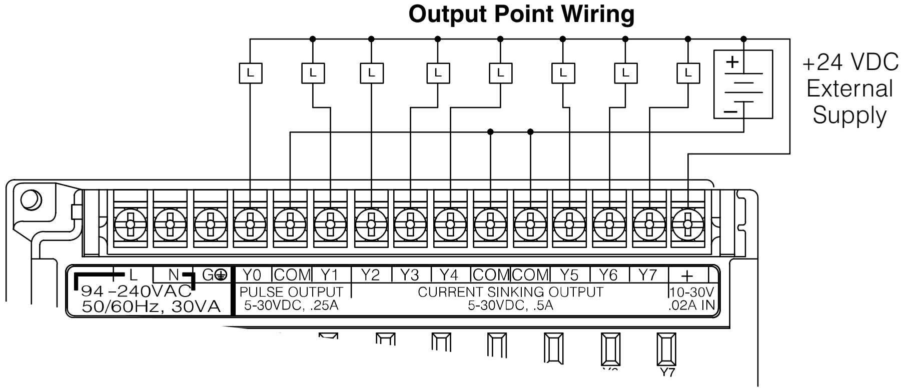
DL105 DC output circuits are high-performance MOSFET switches with low on-resistance and fast switching times. Please note the following characteristics which are unique to the DC output type:

- There is only one electrical common for all eight outputs, even though there are three common terminals. All eight outputs belong to one bank.
- The output switches are current-sinking only. However, you can still use different DC voltages from one load to another.
- The output circuit inside the PLC requires external power. The supply (–) must be connected to a common terminal, and the supply (+) connects the the right-most terminal on the upper connector.

NOTE: Always connect all three common terminals together at the connector with short wires (do not leave some common terminals unconnected).This provides three connections to share the load return current, enhancing reliability.

In the example below, all eight outputs share a common supply. It may be external as shown, or they may use the auxiliary +24VDC supply when available.

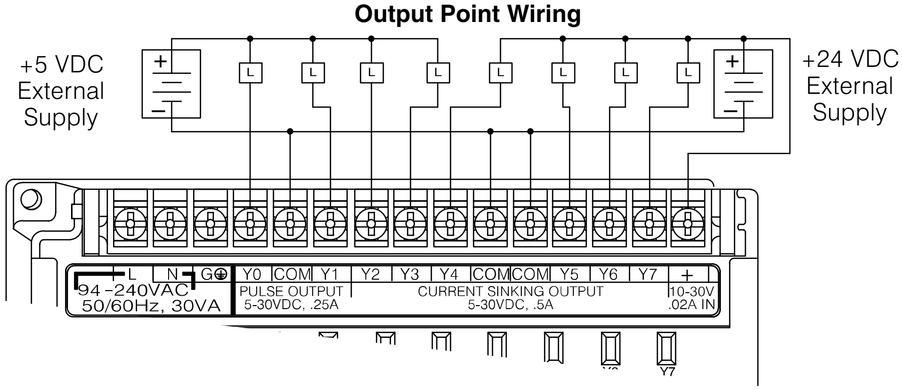
Output Point Wiring



In the next example below, the outputs have "split" supplies. The first four outputs are using a +5 VDC supply, and the last four are using a +24 VDC supply. However, you can split the outputs among any number of supplies, as long as:

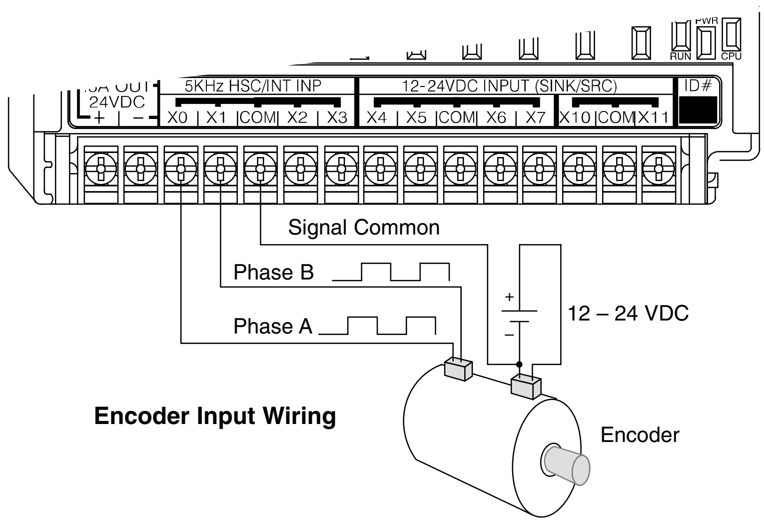
- all supply voltages are within the specified range
- all output points are wired as sinking
- all source (–) terminals are connected together

Output Point Wiring



High-Speed I/O Wiring Methods

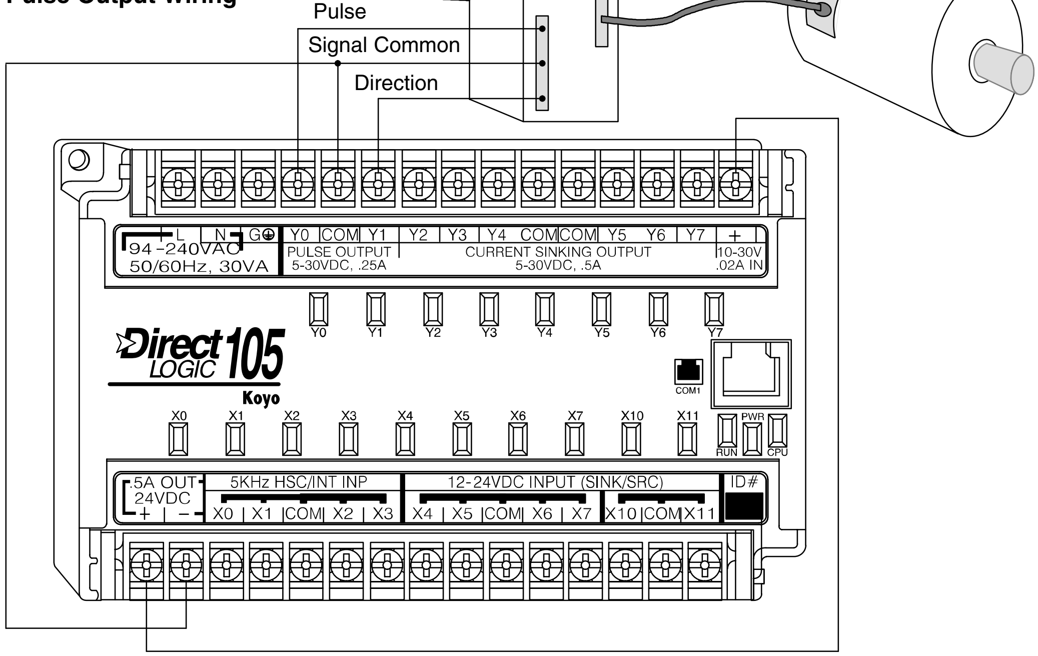
DL105 versions with DC type input or output points contain a dedicated High-Speed I/O circuit (HSIO). The circuit configuration is programmable, and it processes select I/O points independently from the CPU scan. Chapter 4 discusses the programming options for HSIO. While the HSIO circuit has six modes, we show wiring diagrams for two of the most popular modes in this chapter. The high-speed input interfaces to points X0 – X3. Properly configured, the DL105 can count quadrature pulses at up to 5 kHz from an incremental encoder as shown below.



Encoder Input Wiring

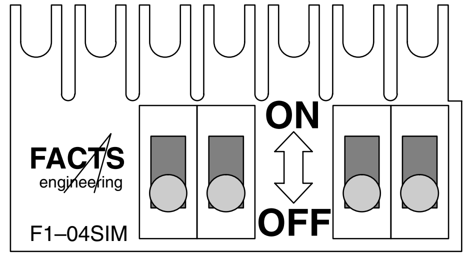
DL105 versions with DC type output points can use the High Speed I/O Pulse Output feature. It can generate high-speed pulses for specialized control such as stepper motor / intelligent drive systems. Outputs Y0 and Y1 can generate pulse and direction signals, or they can generate CCW and CW pulse signals respectively. See Chapter 3 on high-speed input and pulse output options.

Pulse Output Wiring



F1–04SIM Input Simulator Wiring

The F1–04SIM Input Simulator, shown to the right, provides four switches for inputs X0 through X3. The simulator is useful during program development or for debug purposes. It works by using the +24VDC auxiliary supply output, routing the voltage through the switches and into the inputs.



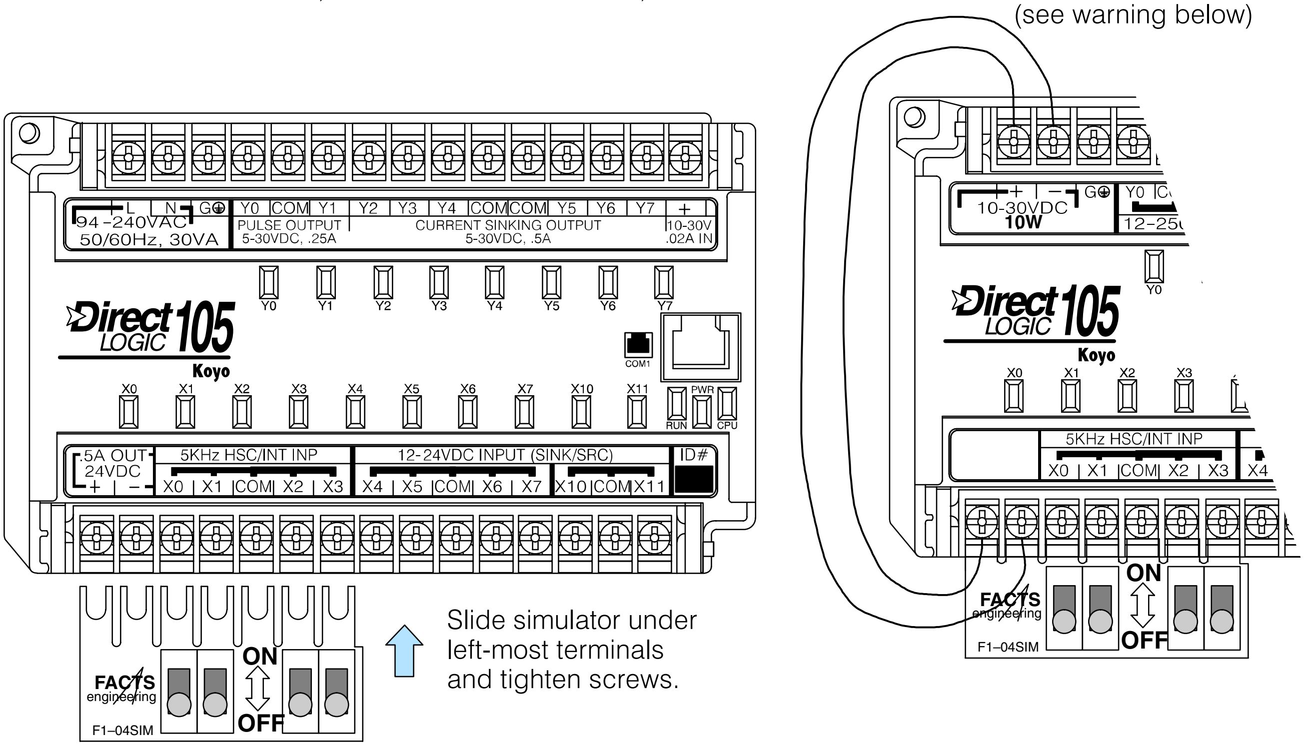
In use, the simulator can quickly provide test inputs to your ladder program. The status of outputs is observable on the front panel LEDs, even without wiring the outputs to any loads.

The Simulator works on all DC input versions of the DL105. DC-powered versions need two wires from the power input to connect to the two left-most terminals on the simulator (wiring shown below), since DC-powered units do not generate +24VDC auxiliary output. Polarity does not matter, since the inputs can be sinking or sourcing.

NOTE: The Input Simulator will not work on DL105 micros with AC type inputs. The +24 VDC auxiliary supply voltage is less than the required input threshold.

F1-130DR/F1-130DR-CE, F1-130DD/F1-130DD-CE, F1-130DA

F1-130DR-D, F1-130DD-D only (see warning below)



NOTE: Never attempt to install more than one simulator on one DL105 PLC.

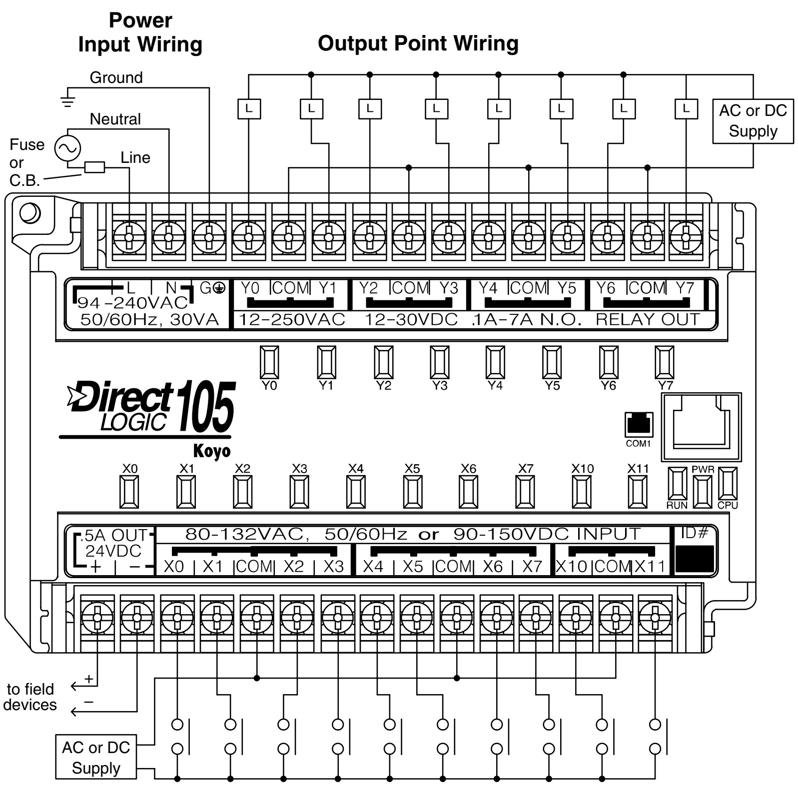
WARNING: DO NOT use the two wires as shown above on AC-powered DL105 PLCs. Doing so will permanently damage the Micro PLC and may result in electrical shock due to the exposed circuit board of the input simulator.

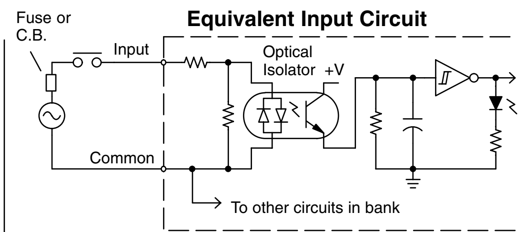
Wiring Diagrams and Specifications

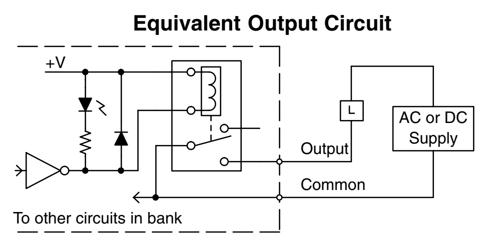
The remainder of this chapter dedicates two to three pages to each of the eight versions of DL105 Micro PLCs. Each section contains a basic wiring diagram, equivalent I/O circuits, and specification tables. Please refer to the section which describes the particular DL105 version used in your application.

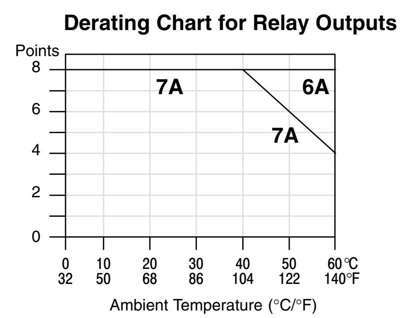
F1–130AR I/O Wiring Diagram

The F1–130AR Micro PLC features ten AC inputs and eight relay contact outputs. The following diagram shows a typical field wiring example. The AC external power connection uses three terminals at the top left as shown.









The ten AC input channels use terminals on the bottom connector. This input type also works for high-voltage DC signals. Inputs are organized into two banks of four, plus one bank of two. Each bank has a common terminal. In the case of DC input signals, the input may be wired in as either the sourcing or sinking type. The wiring example above shows all commons connected together, but separate supplies and common circuits may be used. The equivalent input circuit shows one channel of a typical bank.

The eight relay output channels use terminals on the top connector. Outputs are organized into four banks of two normally-open relay contacts. Each bank has a common terminal. The wiring example above shows all commons connected together, but separate supplies and common circuits may be used. The equivalent output circuit shows one channel of a typical bank. The relay contacts can switch AC or DC voltages.

Auxiliary +24V Power Supply

The F1–130AR has a +24V supply output to power external devices. The output is rated at 0.5 Amperes, and includes short-circuit protection and full isolation from internal CPU circuitry. These features make it ideal for powering sensors, solenoids, and other field devices. In fact, it can be used as the DC supply for loads in the relay output circuits. Be sure the combined load currents do not exceed 0.5 A. Note that on the F1–130AR, the +24V auxiliary output is not high enough to power its input circuits (input ON threshold is 90VDC).

F1–130AR General Specifications

External Power Requirements	100 – 240 +10% –15%
Communication Port	K–Sequence, 9600 baud, 8 data bits, odd parity
Programming cable type	D2–DSCBL
Internal Field Supply Ratings	+24VDC , 0.5A maximum, isolated
Operating Temperature	32 to 140° F (0 to 60° C)
Storage Temperature	–4 to 158° F (–20 to 70° C)
Relative Humidity	5 to 95% (non-condensing)
Environmental air	No corrosive gases permitted
Vibration	MIL STD 810C 514.2
Shock	MIL STD 810C 516.2
Noise Immunity	NEMA ICS3–304
Terminal Type	Removable
Wire Gauge	One AWG14 or two AWG16, AWG24 minimum

AC Input Specifications X0 – X7, X10 – X11

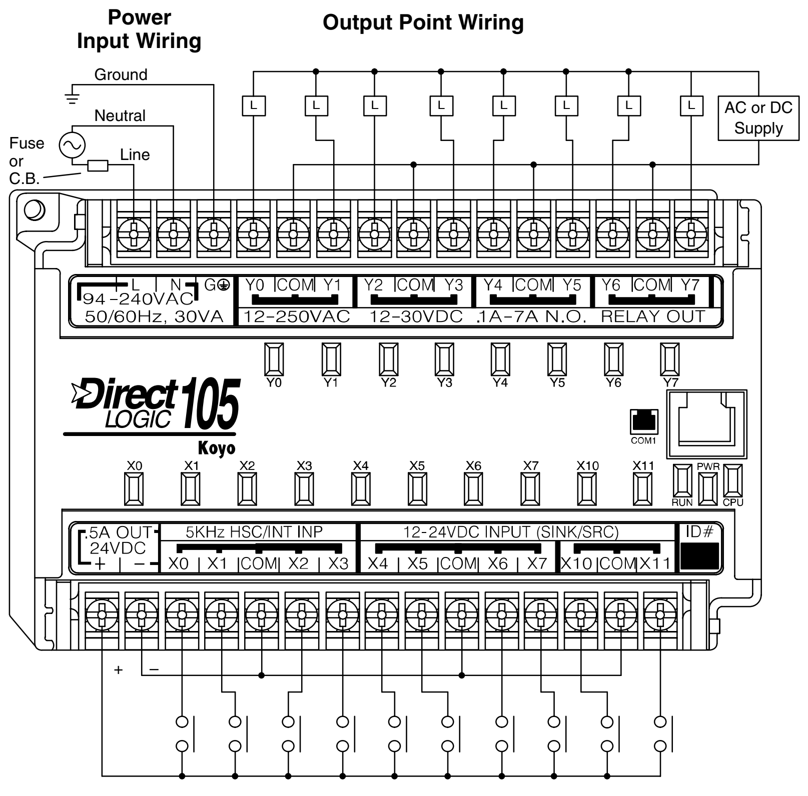
Input Voltage Range for ON condition	80 – 132 VAC, or 90 – 150 VDC
Input Current	6 mA @ 132 VAC 6.8 mA @ 150 VDC
Maximum Voltage	132 VAC, or 150 VDC
ON Current/Voltage	>4 mA @ 80 VAC, or 90 VDC
OFF Current/Voltage	<2 mA @ 45 VAC, or 60 VDC
OFF to ON Response	< 8 mS
ON to OFF Response	<15 mS
Status Indicators	Logic Side
Commons	4 channels / common x 2 banks, 2 channels / common x 1 bank

Relay Output Specifications Y0 – Y7

Operating Voltage	12 – 250 VAC, 12 – 30 VDC @ 7A, 30 – 150 VDC @ 0.5A, resistive
Output Current	7A / point (subject to derating) 14A / common
Maximum Motor Load	1/3 HP
Maximum Voltage	265 VAC, 150 VDC
Minimum Off Resistance	100 meg ohms @ 500 VDC
Smallest Recommended Load	10 mA
OFF to ON Response	15 mS
ON to OFF Response	5 mS
Status Indicators	Logic Side
Commons	2 channels / common x 4 banks
Fuses	None (external recommended)

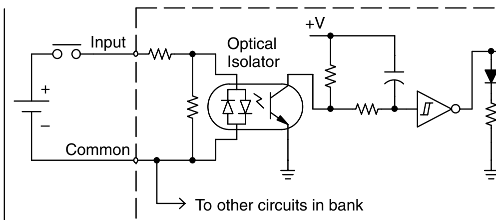
F1–130DR/ F1–130DR–CE I/O Wiring Diagram

These micro PLCs feature ten DC inputs and eight relay contact outputs. The following diagram shows a typical field wiring example. The AC external power connection uses three terminals at the top left as shown.

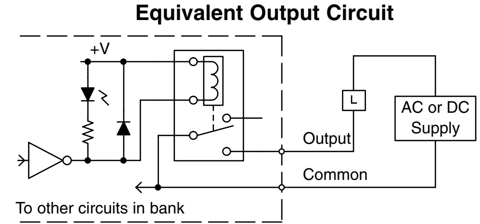


Input Point Wiring

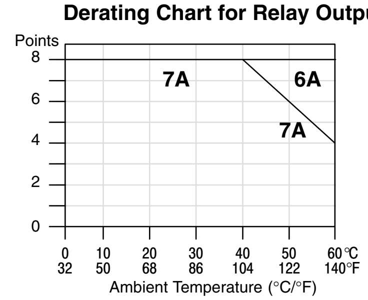
Equivalent Circuit, Standard Inputs (X4 – X11)



Equivalent Output Circuit

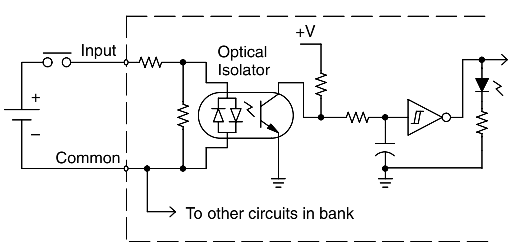


Derating Chart for Relay Outputs



The ten DC input channels use terminals on the bottom connector. Inputs are organized into two banks of four, plus one bank of two. Each bank has an isolated common terminal, and may be wired as either sinking or sourcing inputs. The wiring example above shows all commons connected together, but separate supplies and common circuits may be used. The equivalent circuit for standard inputs is shown above, and the high-speed input circuit is shown to the right.

Equivalent Circuit, High-Speed Inputs (X0 – X3)



The eight output channels use terminals on the top connector. Outputs are organized into four banks of two normally-open relay contacts. Each bank has a common terminal. The wiring example above shows all commons connected together, but separate supplies and common circuits may be used. The equivalent output circuit shows one channel of a typical bank. The relay contacts can switch AC or DC voltages.

Auxiliary +24V Power Supply

These versions have a +24V supply output to power external devices. The output is rated at 0.5 Amperes, and includes short-circuit protection and full isolation from internal CPU circuitry. These features make it ideal for powering sensors, solenoids, and other field devices. In fact, it can be used as the DC supply for switches or sensors in the input circuit, or for loads in the relay output circuits. Be sure the combined load currents do not exceed 0.5 A.

F1–130DR/ F1–130DR–CE General Specifications

External Power Requirements	100 – 240 +10% –15%
Communication Port	K–Sequence, 9600 baud, 8 data bits, odd parity
Programming cable type	D2–DSCBL
Internal Field Supply Ratings	+24VDC , 0.5A maximum, isolated
Operating Temperature	32 to 140° F (0 to 60° C)
Storage Temperature	–4 to 158° F (–20 to 70° C)
Relative Humidity	5 to 95% (non-condensing)
Environmental air	No corrosive gases permitted
Vibration	MIL STD 810C 514.2
Shock	MIL STD 810C 516.2
Noise Immunity	NEMA ICS3–304
Terminal Type	Removable
Wire Gauge	One AWG14 or two AWG16, AWG24 minimum

DC Input Specifications

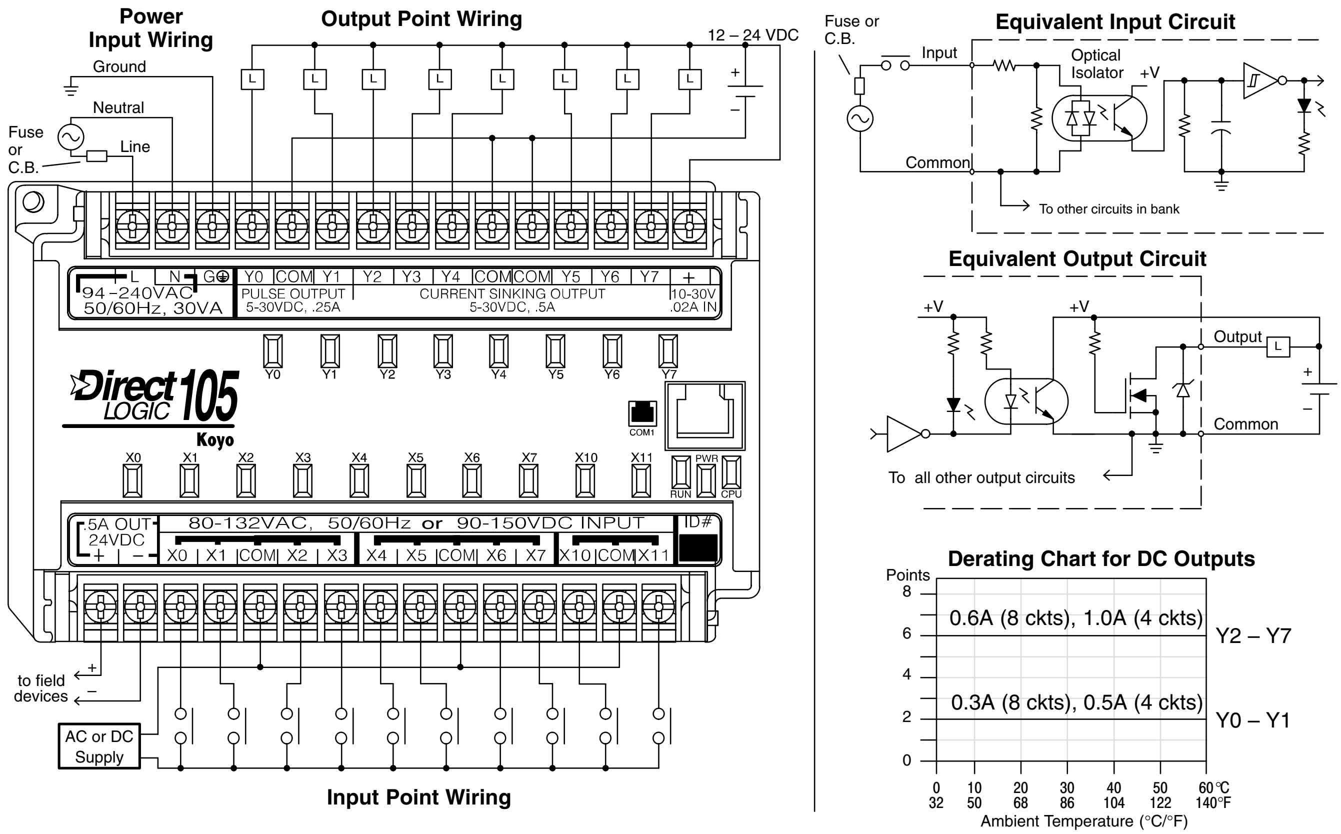
Parameter	High–Speed Inputs, X0 – X3	Standard DC Inputs X4 – X11
Input Voltage Range	10 – 26.4 VDC	10 – 26.4 VDC or 21.6 – 26.4 VAC
Maximum Voltage	30 VDC (5 kHz maximum frequency)	30 VDC
Minimum Pulse Width	100 μs	N/A
ON Voltage Level	> 9.0 VDC	> 9.0 VDC
OFF Voltage Level	< 2.0 VDC	< 2.0 VDC
Input Impedance	2.8 kΩ @ 12 – 24 VDC	2.8 kΩ @ 12 – 24 VDC
Minimum ON Current	>3 mA	>3 mA
Maximum OFF Current	< 0.5 mA	<0.5 mA
OFF to ON Response	<50 μs	2 – 8 mS, 4 mS typical
ON to OFF Response	< 50 μs	2 – 8 mS, 4 mS typical
Status Indicators	Logic side	Logic side
Commons	4 channels / common x 1 bank	4 channels / common x 1 bank, 2 channels / common x 1 bank

Relay Output Specifications

Operating Voltage	12 – 250 VAC, 12 – 30 VDC @ 7A, 30 – 150 VDC @ 0.5A, resistive
Output Current	7A / point (subject to derating) 14A / common
Maximum Motor Load	1/3 HP
Maximum Voltage	265 VAC, 30 VDC
Minimum Off Resistance	100 meg ohms @ 500 VDC
Smallest Recommended Load	10 mA
OFF to ON Response	15 mS
ON to OFF Response	5 mS
Status Indicators	Logic Side
Commons	2 channels / common x 4 banks
Fuses	None (external recommended)

F1–130AD I/O Wiring Diagram

The F1–130AD Micro PLC features ten AC inputs and eight DC outputs. The following diagram shows a typical field wiring example. The AC external power connection uses three terminals at the top left as shown.



The ten AC input channels use terminals on the bottom connector. This input type also works for high-voltage DC signals. Inputs are organized into two banks of four, plus one bank of two. Each bank has an isolated common terminal. In the case of DC input signals, the input may be wired in as either the sourcing or sinking type. The wiring example above shows all commons connected together, but separate supplies and common circuits may be used. The equivalent input circuit shows one channel of a typical bank.

The eight current sinking DC output channels use terminals on the top connector. The three common terminals are internally connected, meaning all outputs actually share the same electrical common. The wiring example above shows all commons connected together, because it is best to share the common current among the three terminal connections. Note the requirement for external power on the end (right-most) terminal. The equivalent output circuit shows one channel of the bank of eight.

Auxiliary +24V Power Supply

The F1–130AD has a +24V supply output to power external devices. The output is rated at 0.5 Amperes, and includes short-circuit protection and full isolation from internal CPU circuitry. These features make it ideal for powering sensors, solenoids, and other field devices. In fact, it can be used as the supply for loads in the DC output circuits. Since the outputs are the sinking type, you'll need to connect +24V to the output commons. Be sure the combined load currents do not exceed 0.5 A. Note that on the F1–130AD, the +24V auxiliary output is not high enough to power its input circuits (input ON threshold is 90VDC).

F1–130AD General Specifications

External Power Requirements	100 – 240 + 10% –15%
Communication Port	K–Sequence, 9600 baud, 8 data bits, odd parity
Programming cable type	D2–DSCBL
Internal Field Supply Ratings	+24VDC , 0.5A maximum, isolated
Operating Temperature	32 to 140° F (0 to 60° C)
Storage Temperature	–4 to 158° F (–20 to 70° C)
Relative Humidity	5 to 95% (non-condensing)
Environmental air	No corrosive gases permitted
Vibration	MIL STD 810C 514.2
Shock	MIL STD 810C 516.2
Noise Immunity	NEMA ICS3–304
Terminal Type	Removable
Wire Gauge	One AWG14 or two AWG16, AWG24 minimum

AC Input Specifications

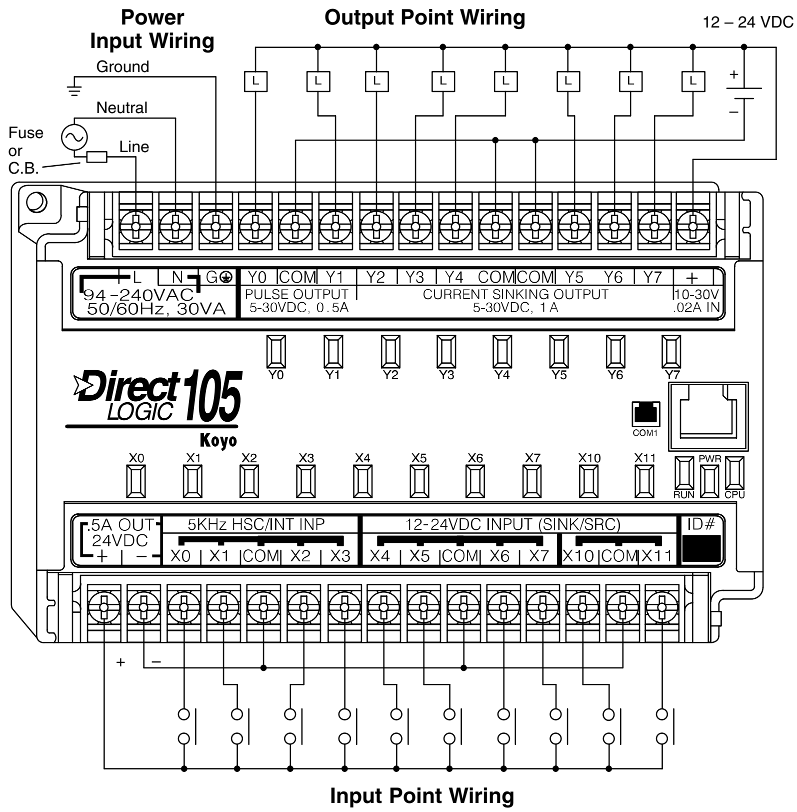
Input Voltage Range for ON condition	80 – 132 VAC, or 90 – 150 VDC
Input Current	6 mA @ 132 VAC 6.8 mA @ 150 VDC
Maximum Voltage	132 VAC, or 150 VDC
ON Current/Voltage	>4 mA @ 80 VAC, or 90 VDC
OFF Current/Voltage	<2 mA @ 45 VAC, or 60 VDC
OFF to ON Response	< 8 mS
ON to OFF Response	<15 mS
Status Indicators	Logic Side
Commons	4 channels / common x 2 banks, 2 channels / common x 1 bank

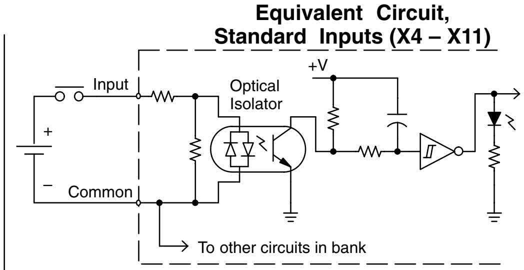
DC Output Specifications

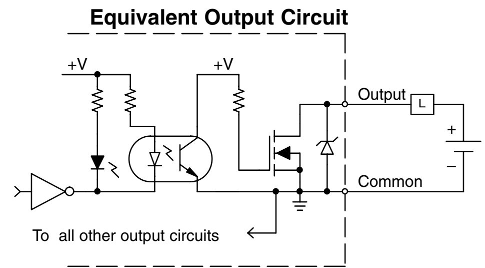
Parameter	Pulse Outputs, Y0 – Y1	Standard Outputs, Y2 – Y7
Operating Voltage	5 – 30 VDC	5 – 30 VDC
Peak Voltage	60 VDC (7 kHz maximum frequency)	60 VDC
On Voltage Drop	0.4 VDC @ 0.25A	0.4 VDC @ 0.5A
Max Current (resistive)	0.5 A / point (subject to derating)	1.0 A / point (subject to derating)
Max leakage current	15 μA @ 30 VDC	15 μA @ 30 VDC
Max inrush current	1.5 A for 10 mS, 0.5 A for 100 mS	3 A for 10 mS, 1 A for 100 mS
Extenal DC power required	10 – 30 VDC @30 mA, plus load current	10 – 30 VDC @30 mA, plus load current
OFF to ON Response	<10 μS	3.5 μS
ON to OFF Response	<70 μS	110 μS
Status Indicators	Logic Side	Logic Side
Commons	Internally connected	Internally connected
Fuses	None	None

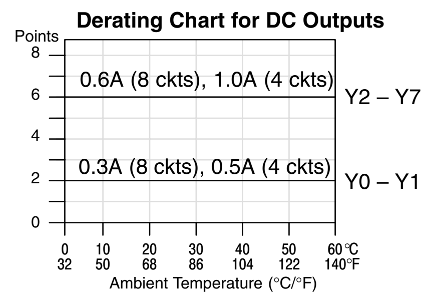
F1–130DD/ F1–130DD–CE I/O Wiring Diagram

These micro PLCs feature ten DC inputs and eight DC outputs. The following diagram shows a typical field wiring example. The AC external power connection uses three terminals at the top left as shown.

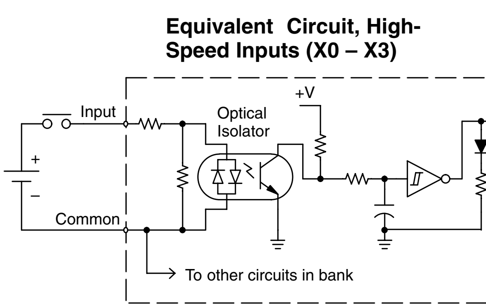








The ten DC input channels use terminals on the bottom connector. Inputs are organized into two banks of four, plus one bank of two. Each bank has an isolated common terminal, and may be wired as either sinking or sourcing inputs. The wiring example above shows all commons connected together, but separate supplies and common circuits may be used. The equivalent circuit for standard inputs is shown above, and the high-speed input circuit is shown to the right.



The eight current sinking DC output channels use terminals on the top connector. Outputs are organized as one bank of sinking outputs. The three common terminals are internally connected, so all outputs actually share the same electrical common. The wiring example above shows all commons connected together, because it is best to share the common current among the three terminal connections. The equivalent output circuit shows one channel of the bank of eight.

Auxiliary +24V Power Supply

These versions have a +24V supply output to power external devices. The output is rated at 0.5 Amperes, and includes short-circuit protection and full isolation from internal circuitry. These features make it ideal for powering sensors, solenoids, and other field devices. In fact, it can be used as the DC supply for switches or sensors in the input circuit, or for loads in the DC output circuits (up to 0.5 A).

F1–130DD/ F130–DD–CE General Specifications

External Power Requirements	100 – 240 +10% –15%
Communication Port	K–Sequence, 9600 baud, 8 data bits, odd parity
Programming cable type	D2–DSCBL
Internal Field Supply Ratings	+24VDC , 0.5A maximum, isolated
Operating Temperature	32 to 140° F (0 to 60° C)
Storage Temperature	–4 to 158° F (–20 to 70° C)
Relative Humidity	5 to 95% (non-condensing)
Environmental air	No corrosive gases permitted
Vibration	MIL STD 810C 514.2
Shock	MIL STD 810C 516.2
Noise Immunity	NEMA ICS3–304
Terminal Type	Removable
Wire Gauge	One AWG14 or two AWG16, AWG24 minimum

DC Input Specifications

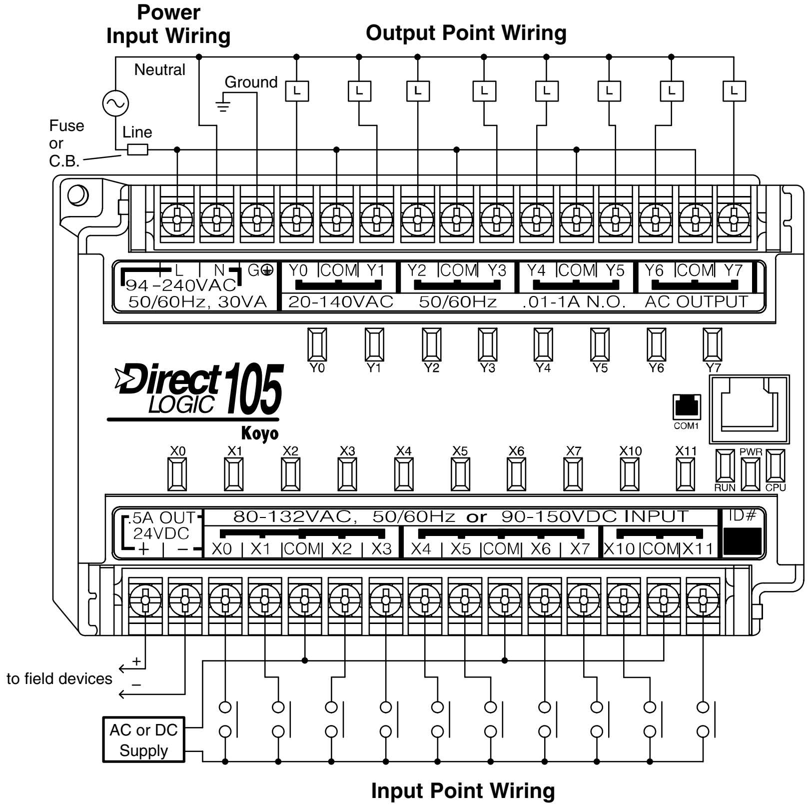
Parameter	High–Speed Inputs, X0 – X3	Standard DC Inputs X4 – X11
Input Voltage Range	10 – 26.4 VDC	10 – 26.4 VDC or 21.6 – 26.4 VAC
Maximum Voltage	30 VDC (5 kHz maximum frequency)	30 VDC
Minimum Pulse Width	100 μs	N/A
ON Voltage Level	> 9.0 VDC	> 9.0 VDC
OFF Voltage Level	< 2.0 VDC	< 2.0 VDC
Input Impedance	2.8 kΩ @ 12 – 24 VDC	2.8 kΩ @ 12 – 24 VDC
Minimum ON Current	>3 mA	>3 mA
Maximum OFF Current	< 0.5 mA	<0.5 mA
OFF to ON Response	<50 μS	2 – 8 mS, 4 mS typical
ON to OFF Response	< 50 μS	2 – 8 mS, 4 mS typical
Status Indicators	Logic side	Logic side
Commons	4 channels / common x 1 bank	4 channels / common x 1 bank, 2 channels / common x 1 bank

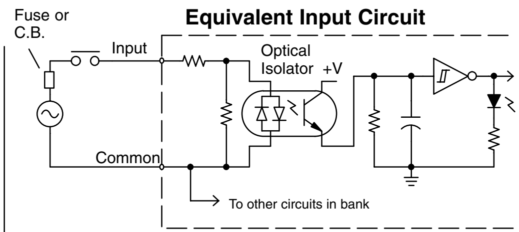
DC Output Specifications

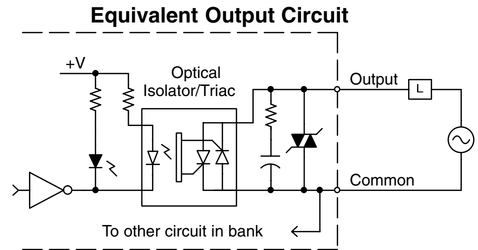
Parameter	Pulse Outputs, Y0 – Y1	Standard Outputs, Y2 – Y7
Operating Voltage	5 – 30 VDC	5 – 30 VDC
Peak Voltage	60 VDC (7 kHz maximum frequency)	60 VDC
On Voltage Drop	0.4 VDC @ 0.25A	0.4 VDC @ 0.5A
Max Current (resistive)	0.5 A / point (subject to derating)	1.0 A / point (subject to derating)
Max leakage current	15 μA @ 30 VDC	15 μA @ 30 VDC
Max inrush current	1.5 A for 10 mS, 0.5 A for 100 mS	3 A for 10 mS, 1 A for 100 mS
External DC power required	10 – 30 VDC @30 mA, plus load current	10 – 30 VDC @30 mA, plus load current
OFF to ON Response	<10 μs	3.5 μs
ON to OFF Response	<70 μs	110 μs
Status Indicators	Logic Side	Logic Side
Commons	Internally connected	Internally connected
Fuses	None	None

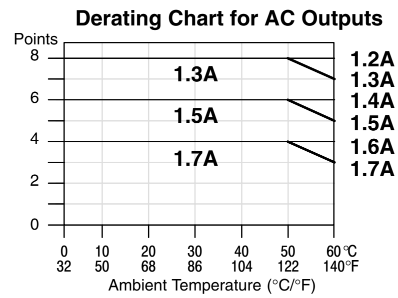
F1–130AA I/O Wiring Diagram

The F1–130AA Micro PLC features ten AC inputs and eight AC outputs. The following diagram shows a typical field wiring example. The AC external power connection uses three terminals at the top left as shown.









The ten AC input channels use terminals on the bottom connector. This input type also works for high-voltage DC signals. Inputs are organized into two banks of four, plus one bank of two. Each bank has an isolated common terminal. In the case of DC input signals, the input may be wired in as either the sourcing or sinking type. The wiring example above shows all commons connected together, but separate supplies and common circuits may be used. The equivalent input circuit shows one channel of a typical bank.

The eight output channels use terminals on the top connector. Outputs are organized into four banks of two triac switches. Each bank has a common terminal. The wiring example above shows all commons connected together, but separate supplies and common circuits may be used. The equivalent output circuit shows one channel of a typical bank.

Auxiliary +24V Power Supply

The F1–130AA has a +24V supply output to power external devices. The output is rated at 0.5 Amperes, and includes short-circuit protection and full isolation from internal CPU circuitry. These features make it ideal for powering sensors, solenoids, and other field devices. Note that on the F1–130AA, the +24V auxiliary output cannot directly power its input and output circuits(input ON threshold is 90VDC, outputs require AC only).

F1–130AA General Specifications

External Power Requirements	100 – 240 +10% –15%
Communication Port	K–Sequence, 9600 baud, 8 data bits, odd parity
Programming cable type	D2–DSCBL
Internal Field Supply Ratings	+24VDC , 0.5A maximum, isolated
Operating Temperature	32 to 140° F (0 to 60° C)
Storage Temperature	–4 to 158° F (–20 to 70° C)
Relative Humidity	5 to 95% (non-condensing)
Environmental air	No corrosive gases permitted
Vibration	MIL STD 810C 514.2
Shock	MIL STD 810C 516.2
Noise Immunity	NEMA ICS3–304
Terminal Type	Removable
Wire Gauge	One AWG14 or two AWG16, AWG24 minimum

AC Input Specifications

Input Voltage Range for ON condition	80 – 132 VAC, or 90 – 150 VDC
Input Current	6 mA @ 132 VAC 6.8 mA @ 150 VDC
Maximum Voltage	132 VAC, or 150 VDC
ON Current/Voltage	>4 mA @ 80 VAC, or 90 VDC
OFF Current/Voltage	<2 mA @ 45 VAC, or 60 VDC
OFF to ON Response	< 8 mS
ON to OFF Response	<15 mS
Status Indicators	Logic Side
Commons	4 channels / common x 2 banks, 2 channels / common x 1 bank

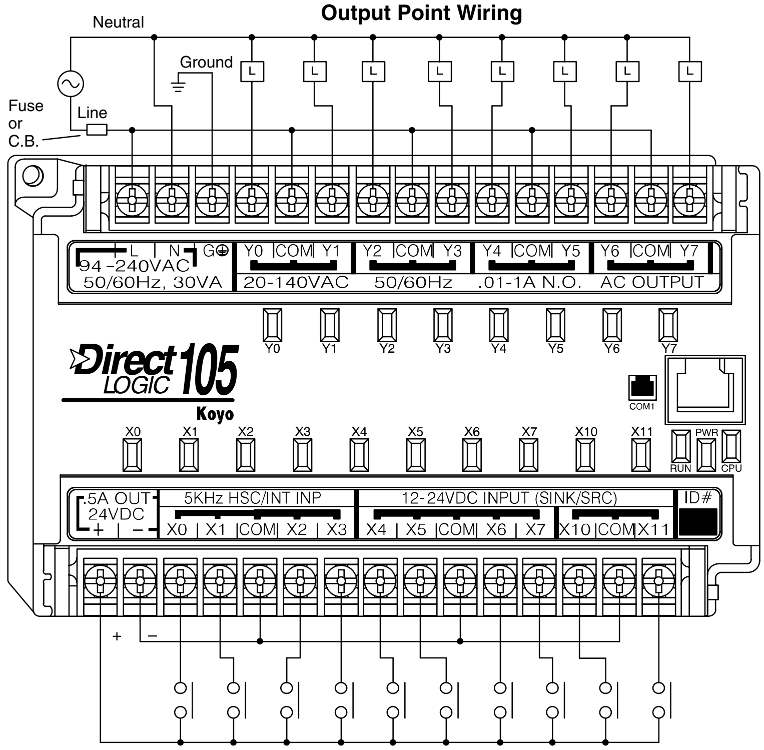
AC Output Specifications

Operating Voltage	20 – 140 VAC, 47 – 63 Hz
Peak Voltage	400 VAC
On Voltage Drop	1.3 VAC @ 2 A
Max Current	1.7 A / point, subject to derating
Max leakage current	1 mA @ 400 VAC
Max inrush current	30 A for 10 mS, 15 A for 100 mS
Minimum Load	10 mA
OFF to ON Response	8.33 mS @ 60 Hz, zero-crossing, 10 mS @ 50 Hz, zero-crossing
ON to OFF Response	8.33 mS @ 60 Hz, zero-crossing, 10 mS @ 50 Hz, zero-crossing
Status Indicators	Logic Side
Commons	2 channels / common x 4 banks
Fuses	None (external recommended)

F1–130DA I/O Wiring Diagram

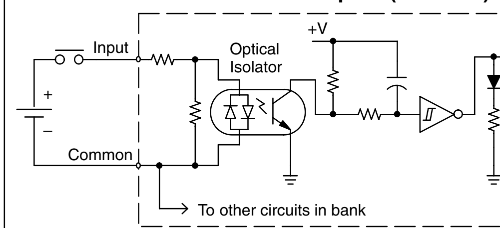
The F1–130DA Micro PLC features ten DC inputs and eight AC outputs. The following diagram shows a typical field wiring example. The AC external power connection uses three terminals at the top left as shown.

Output Point Wiring

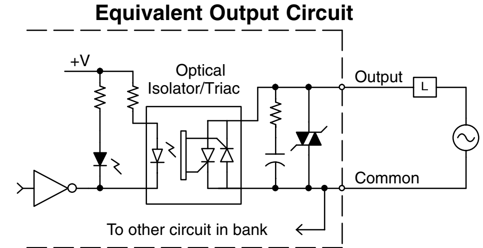


Input Point Wiring

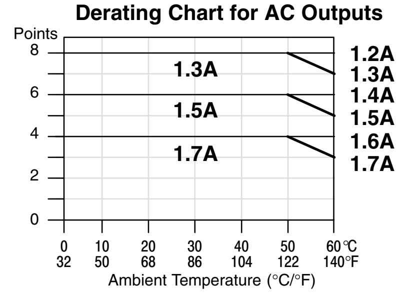
Equivalent Circuit, Standard Inputs (X4 – X11)



Equivalent Output Circuit

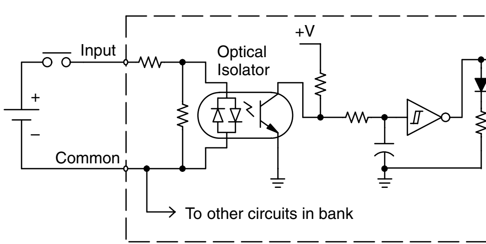


Derating Chart for AC Outputs



The ten DC input channels use terminals on the bottom connector. Inputs are organized into two banks of four, plus one bank of two. Each bank has an isolated common terminal, and may be wired as sinking or sourcing inputs. The wiring example above shows all commons connected together, but separate supplies and common circuits may be used. The equivalent circuit for standard inputs is shown above, and the high-speed input circuit is shown to the right.

Equivalent Circuit, High-Speed Inputs (X0 – X3)



The eight output channels use terminals on the top connector. Outputs are organized into four banks of two triac switches. Each bank has a common terminal. The wiring example above shows all commons connected together, but separate supplies and common circuits may be used. The equivalent output circuit shows one channel of a typical bank.

Auxiliary +24V Power Supply

The F1–130DA has a +24V supply output to power external devices. The output is rated at 0.5 Amperes, and includes short-circuit protection and full isolation from internal CPU circuitry. These features make it ideal for powering sensors, solenoids, and other field devices. In fact, it can be used as the DC supply for switches or sensors in the input circuit. Note that on the F1–130DA, the +24V output cannot power its output circuits, because they require AC voltages.

F1–130DA General Specifications

External Power Requirements	100 – 240 +10% –15%
Communication Port	K–Sequence, 9600 baud, 8 data bits, odd parity
Programming cable type	D2–DSCBL
Internal Field Supply Ratings	+24VDC , 0.5A maximum, isolated
Operating Temperature	32 to 140° F (0 to 60° C)
Storage Temperature	–4 to 158° F (–20 to 70° C)
Relative Humidity	5 to 95% (non-condensing)
Environmental air	No corrosive gases permitted
Vibration	MIL STD 810C 514.2
Shock	MIL STD 810C 516.2
Noise Immunity	NEMA ICS3–304
Terminal Type	Removable
Wire Gauge	One AWG14 or two AWG16, AWG24 minimum

DC Input Specifications

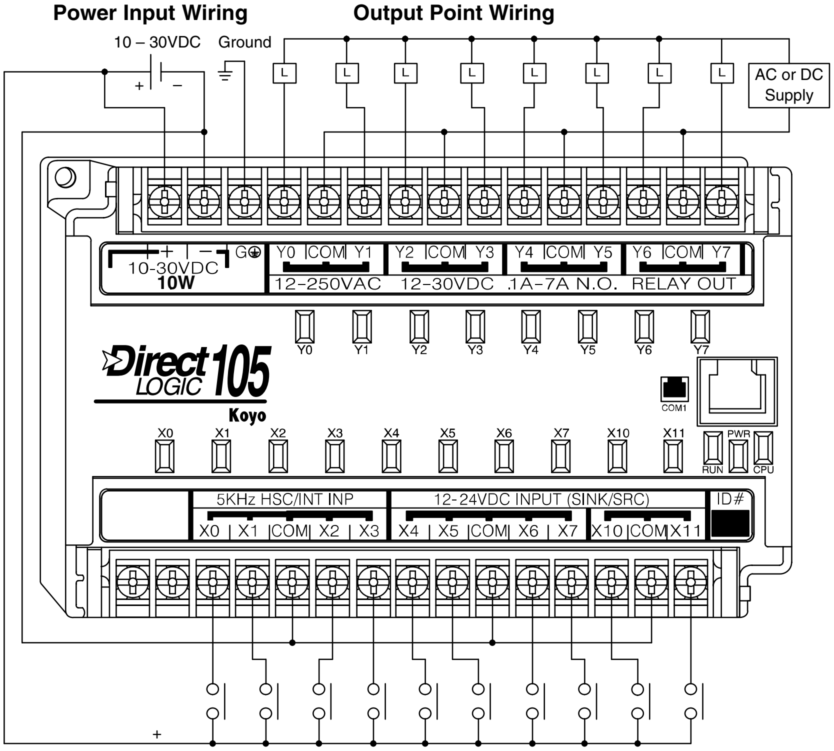
Parameter	**High–Speed Inputs, X0 – X3**	**Standard DC Inputs X4 – X11**
Input Voltage Range	10 – 26.4 VDC	10 – 26.4 VDC or 21.6 – 26.4 VAC
Maximum Voltage	30 VDC (5 kHz maximum frequency)	30 VDC
Minimum Pulse Width	100 µS	N/A
ON Voltage Level	> 9.0 VDC	> 9.0 VDC
OFF Voltage Level	< 2.0 VDC	< 2.0 VDC
Input Impedance	2.8 kΩ @ 12 – 24 VDC	2.8 kΩ @ 12 – 24 VDC
Minimum ON Current	>3 mA	>3 mA
Maximum OFF Current	< 0.5 mA	<0.5 mA
OFF to ON Response	<50 µS	2 – 8 mS, 4 mS typical
ON to OFF Response	< 50 µS	2 – 8 mS, 4 mS typical
Status Indicators	Logic side	Logic side
Commons	4 channels / common x 1 bank	4 channels / common x 1 bank, 2 channels / common x 1 bank

AC Output Specifications

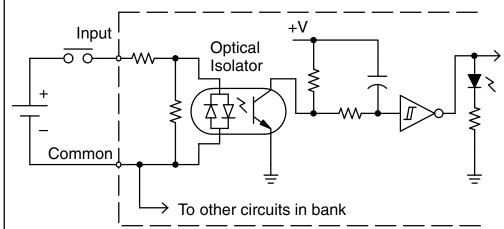
Operating Voltage	20 – 140 VAC, 47 – 63 Hz
Peak Voltage	400 VAC
On Voltage Drop	1.3 VAC @ 2 A
Max Current	1.7 A / point, subject to derating
Max leakage current	1 mA @ 400 VAC
Max inrush current	30 A for 10 mS, 15 A for 100 mS
Minimum Load	10 mA
OFF to ON Response	8.33 mS @ 60 Hz, zero-crossing, 10 mS @ 50 Hz, zero-crossing
ON to OFF Response	8.33 mS @ 60 Hz, zero-crossing, 10 mS @ 50 Hz, zero-crossing
Status Indicators	Logic Side
Commons	2 channels / common x 4 banks
Fuses	None (external recommended)

F1–130DR–D I/O Wiring Diagram

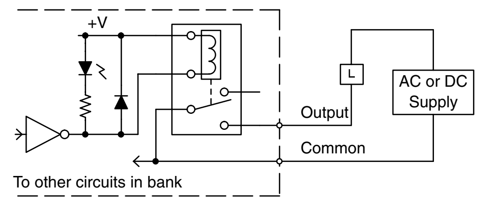
The F1–130DR–D Micro PLC features ten DC inputs and eight relay outputs. The following diagram shows a typical field wiring example. The DC external power connection uses three terminals at the top left as shown.



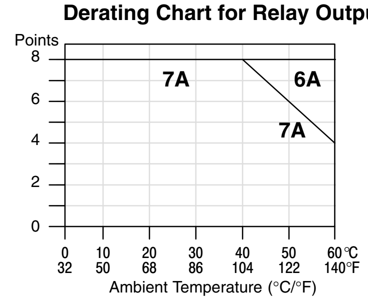
Equivalent Circuit, Standard Inputs (X4 – X11)



Equivalent Output Circuit

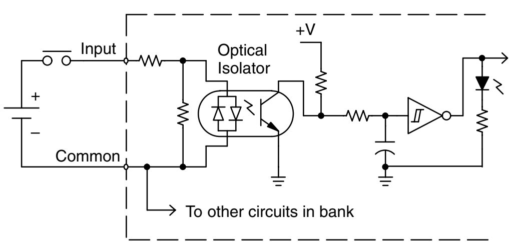


Derating Chart for Relay Outputs



The ten DC input channels use terminals on the bottom connector. Inputs are organized into two banks of four, plus one bank of two. Each bank has an isolated common terminal, and may be wired as sinking or sourcing inputs. The wiring example above shows all commons connected together, but separate supplies and common circuits may be used. The equivalent circuit for standard inputs is shown above, and the high-speed input circuit is shown to the right.

Equivalent Circuit, High-Speed Inputs (X0 – X3)



The eight output channels use terminals on the top connector. Outputs are organized into four banks of two normally-open relay contacts. Each bank has a common terminal. The wiring example above shows all commons connected together, but separate supplies and common circuits may be used. The equivalent output circuit shows one channel of a typical bank. The relay contacts can switch AC or DC voltages.

No Auxiliary +24V Power Supply

The F1–130DR–D does not include a +24V output, as do most other DL105 PLCs. Since this unit requires +24V as the main supply input, it it usually most economical to use the same supply to power suitable field devices. In the wiring diagram above, the external power source for the unit also powers the input circuitry. The same external supply can power both input and output circuits, because they are both isolated from the internal logic circuitry.

F1–130DR–D General Specifications

External Power Requirements	10–30VDC, 1.5A
Communication Port	K–Sequence, 9600 baud, 8 data bits, odd parity
Programming cable type	D2–DSCBL
Operating Temperature	32 to 140° F (0 to 60° C)
Storage Temperature	–4 to 158° F (–20 to 70° C)
Relative Humidity	5 to 95% (non-condensing)
Environmental air	No corrosive gases permitted
Vibration	MIL STD 810C 514.2
Shock	MIL STD 810C 516.2
Noise Immunity	NEMA ICS3–304
Terminal Type	Removable
Wire Gauge	One AWG14 or two AWG16, AWG24 minimum

DC Input Specifications

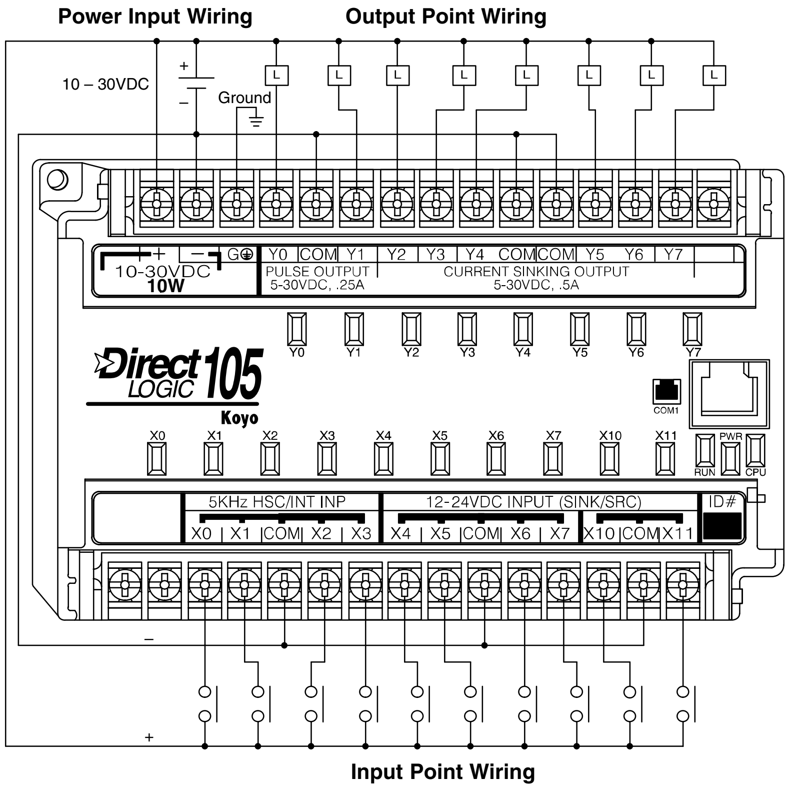
Parameter	High–Speed Inputs, X0 – X3	Standard DC Inputs X4 – X11
Input Voltage Range	10 – 26.4 VDC	10 – 26.4 VDC or 21.6 – 26.4 VAC
Maximum Voltage	30 VDC (5 kHz maximum frequency)	30 VDC
Minimum Pulse Width	100 μs	N/A
ON Voltage Level	> 9.0 VDC	> 9.0 VDC
OFF Voltage Level	< 2.0 VDC	< 2.0 VDC
Input Impedance	2.8 kΩ @ 12 – 24 VDC	2.8 kΩ @ 12 – 24 VDC
Minimum ON Current	>3 mA	>3 mA
Maximum OFF Current	< 0.5 mA	<0.5 mA
OFF to ON Response	<50 μS	2 – 8 mS, 4 mS typical
ON to OFF Response	< 50 μS	2 – 8 mS, 4 mS typical
Status Indicators	Logic side	Logic side
Commons	4 channels / common x 1 bank	4 channels / common x 1 bank, 2 channels / common x 1 bank

Relay Output Specifications

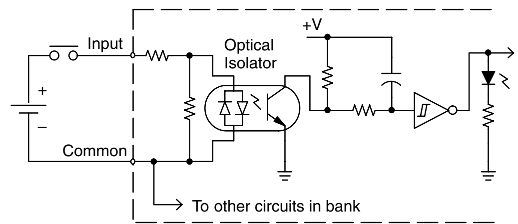
Operating Voltage	12 – 250 VAC, 12 – 30 VDC @ 7A, 30 – 150 VDC @ 0.5A, resistive
Output Current	7A / point (subject to derating) 14A / common
Maximum Motor Load	1/3 HP
Maximum Voltage	265 VAC, 150 VDC
Minimum Off Resistance	100 meg ohms @ 500 VDC
Smallest Recommended Load	10 mA
OFF to ON Response	15 ms
ON to OFF Response	5 ms
Status Indicators	Logic Side
Commons	2 channels / common x 4 banks
Fuses	None (external recommended)

F1–130DD–D I/O Wiring Diagram

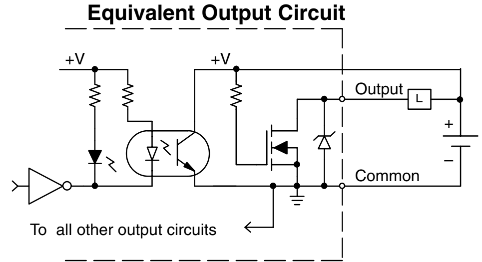
The F1–130DD–D Micro PLC features ten DC inputs and eight DC outputs. The following diagram shows a typical field wiring example. The DC external power connection uses three terminals at the top left as shown.



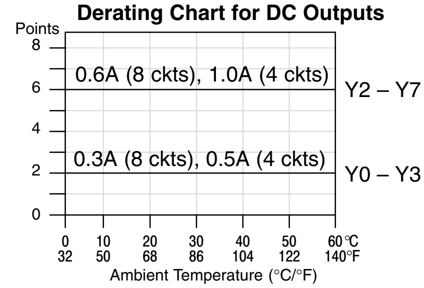
Equivalent Circuit, Standard Inputs (X4 – X11)



Equivalent Output Circuit

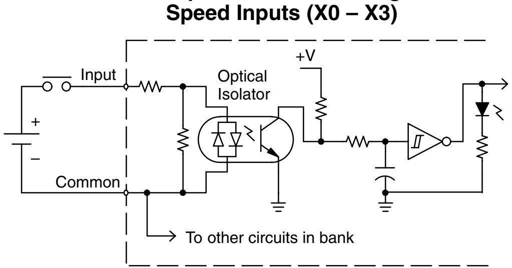


Derating Chart for DC Outputs



The ten DC input channels use terminals on the bottom connector. Inputs are organized into two banks of four, plus one bank of two. Each bank has an isolated common terminal, and can be wired as either sinking or sourcing inputs. The wiring example above shows all commons connected together, but separate supplies and common circuits may be used. The equivalent circuit for standard inputs is shown above, and the high-speed input circuit is shown to the right.

Equivalent Circuit, High-Speed Inputs (X0 – X3)



The eight current-sinking DC output channels use terminals on the top connector. Outputs are organized as one bank of eight. The three common terminals are internally connected, meaning all outputs actually share the same electrical common. The wiring example above shows all commons connected together, because it is best to share the common current among the three terminal connections. The equivalent output circuit shows one channel of the bank of eight.

No Auxiliary +24V Power Supply

The F1–130DR–D does not include a +24V output, as do most other DL105 PLCs. Since this unit requires +24V as the main supply input, it it usually most economical to use the same supply to power suitable field devices. In the wiring diagram above, the external power source for the unit also powers the input and output circuitry. The same external supply can power both input and output circuits, because they are both isolated from the internal logic circuitry.

F1–130DD–D General Specifications

External Power Requirements	10–30VDC, 1.5A
Communication Port	K–Sequence, 9600 baud, 8 data bits, odd parity
Programming cable type	D2–DSCBL
Operating Temperature	32 to 140° F (0 to 60° C)
Storage Temperature	–4 to 158° F (–20 to 70° C)
Relative Humidity	5 to 95% (non-condensing)
Environmental air	No corrosive gases permitted
Vibration	MIL STD 810C 514.2
Shock	MIL STD 810C 516.2
Noise Immunity	NEMA ICS3–304
Terminal Type	Removable
Wire Gauge	One AWG14 or two AWG16, AWG24 minimum

DC Input Specifications

Parameter	High–Speed Inputs, X0 – X3	Standard DC Inputs X4 – X11
Input Voltage Range	10 – 26.4 VDC	10 – 26.4 VDC or 21.6 – 26.4 VAC
Maximum Voltage	30 VDC (5 kHz maximum frequency)	30 VDC
Minimum Pulse Width	100 μs	N/A
ON Voltage Level	> 9.0 VDC	> 9.0 VDC
OFF Voltage Level	< 2.0 VDC	< 2.0 VDC
Input Impedance	2.8 kΩ @ 12 – 24 VDC	2.8 kΩ @ 12 – 24 VDC
Minimum ON Current	>3 mA	>3 mA
Maximum OFF Current	< 0.5 mA	<0.5 mA
OFF to ON Response	<50 μS	2 – 8 mS, 4 mS typical
ON to OFF Response	< 50 μS	2 – 8 mS, 4 mS typical
Status Indicators	Logic side	Logic side
Commons	4 channels / common x 1 bank	4 channels / common x 1 bank, 2 channels / common x 1 bank

DC Output Specifications

Parameter	Pulse Outputs, Y0 – Y1	Standard Outputs, Y2 – Y7
Operating Voltage	5 – 30 VDC	5 – 30 VDC
Peak Voltage	60 VDC (7 kHz maximum frequency)	60 VDC
On Voltage Drop	0.4 VDC @ 0.25A	0.4 VDC @ 0.5A
Max Current (resistive)	0.5 A / point (subject to derating)	1.0 A / point (subject to derating)
Max leakage current	15 μA @ 30 VDC	15 μA @ 30 VDC
Max inrush current	1.5 A for 10 mS, 0.5 A for 100 mS	3 A for 10 mS, 1 A for 100 mS
Extenal DC power required	10 – 30 VDC @30 mA, plus load current	10 – 30 VDC @30 mA, plus load current
OFF to ON Response	<10 μs	3.5 μs
ON to OFF Response	<70 μs	110 μs
Status Indicators	Logic Side	Logic Side
Commons	Internally connected	Internally connected
Fuses	None	None

Glossary of Specification Terms

Discrete Input	One of ten input connections to the PLC which converts an electrical signal from a field device to a binary status (off or on), which is read by the internal CPU each PLC scan.
Discrete Output	One of eight output connections from the PLC which converts an internal ladder program result (0 or 1) to turn On or Off an output switching device. This enables the program to turn on and off large field loads.
I/O Common	A connection in the input or output terminals which is shared by multiple I/O circuits. It usually is in the return path to the power supply of the I/O circuit.
Input Voltage Range	The operating voltage range of the input circuit.
Maximum Voltage	Maximum voltage allowed for the input circuit.
ON Voltage Level	The minimum voltage level at which the input point will turn ON.
OFF Voltage Level	The maximum voltage level at which the input point will turn OFF
Input Impedance	Input impedance can be used to calculate input current for a particular operating voltage.
Input Current	Typical operating current for an active (ON) input.
Minimum ON Current	The minimum current for the input circuit to operate reliably in the ON state.
Maximum OFF Current	The maximum current for the input circuit to operate reliably in the OFF state.
OFF to ON Response	The time the module requires to process an OFF to ON state transition.
ON to OFF Response	The time the module requires to process an ON to OFF state transition.
Terminal Type	Indicates whether the terminal type is a removable or non-removable connector or a fixed terminal.
Status Indicators	The LEDs that indicate the ON/OFF status of an input or output point. All LEDs on DL105 Micro PLCs are electrically located on the logic side of the input or output circuit.

3

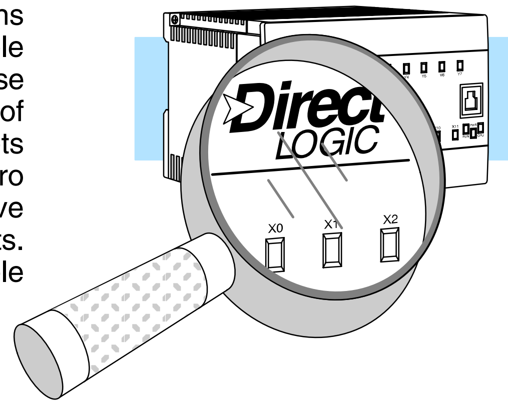
High-Speed Input and Pulse Output Features

In This Chapter. . . .

Introduction

Built-in Motion Control Solution

Many machine control applications require various types of simple high-speed monitoring and control. These applications usually involve some type of motion control, or high-speed interrupts for time-critical events. The DL105 Micro PLC solves this traditionally expensive problem with built-in CPU enhancements. Let's take a closer look at the available high-speed I/O features.



The available **high-speed input features** are:

- High Speed Counter (5 kHz max.) with up to 24 counter presets and built-in interrupt subroutine, counts up only, with reset
- Quadrature encoder inputs to measure counts and clockwise or counter clockwise direction (5 kHz max.), counts up or down, with reset
- High-speed interrupt input for immediate response to critical or time-sensitive tasks
- Pulse catch feature to monitor one input point, having a pulse width as small as 100μS (0.1ms)
- Programmable discrete filtering (both on and off delay up to 99ms) to ensure input signal integrity (this is the default mode for inputs X0–X3)

The available **pulse output features** are:

- Single-axis programmable pulse output (7 kHz max.) with three profile types, including trapezoidal moves, registration, and velocity control

Availability of HSIO Features

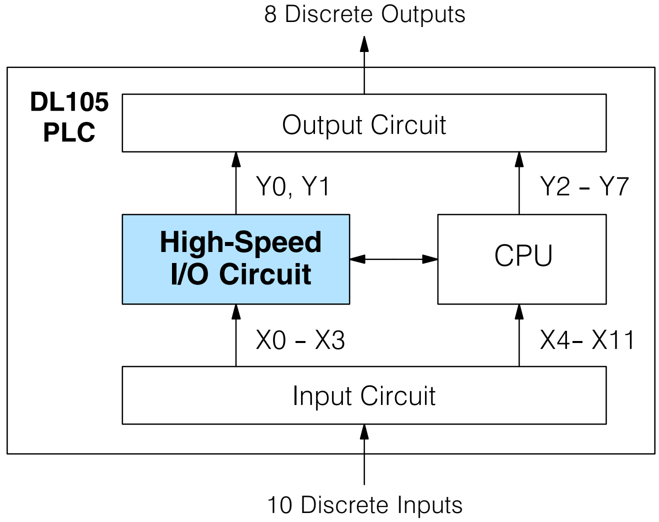
IMPORTANT: Please note the following restrictions on availability of features:

- High-speed input options are available only on DL105s with DC inputs.
- Pulse output options are available only on DL105s with DC outputs.
- Only one HSIO feature may be in use at one time. You cannot use a high–speed input feature and the pulse output at the same time.

DL105 Part Number	Discrete Input Type	Discrete Output Type	High-Speed Input	Pulse Output
F1–130AR	AC	Relay	No	No
F1–130DR	**DC**	Relay	**Yes**	No
F1–130AD	AC	**DC**	No	**Yes**
F1–130DD	**DC**	**DC**	**Yes**	**Yes**
F1–130AA	AC	AC	No	No
F1–130DA	**DC**	AC	**Yes**	No
F1–130DR–D	**DC**	Relay	**Yes**	No
F1–130DD–D	**DC**	**DC**	**Yes**	**Yes**

Dedicated High-Speed I/O Circuit

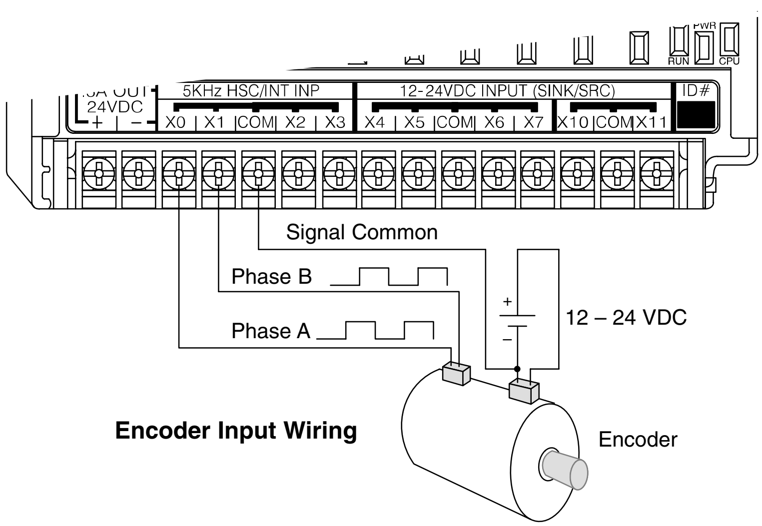
The internal CPU's main task is to execute the ladder program and read/write all I/O points during each scan. In order to service high-speed I/O events, the DL105 includes a special circuit which is dedicated to a portion of the I/O points. Refer to the DL105 block diagram in the figure below.



The high-speed I/O circuit (HSIO) is dedicated to the first four inputs (X0 – X3) and the first two outputs (Y0 – Y1). We might think of this as a "CPU helper". In the default operation (called "Mode 60") the HSIO circuit just passes through the I/O signals to or from the CPU, so that all ten inputs behave equally and all eight outputs behave equally. When the CPU is configured in any other HSIO Mode, the HSIO circuit imposes a specialized function on the portion of inputs and outputs shown. The HSIO circuit *operates independently of the CPU program scan*. This provides accurate measurement and capturing of high-speed I/O activity while the CPU is busy with ladder program execution.

Wiring Diagrams for Each HSIO Mode

After choosing the appropriate HSIO mode for your application, you'll need to refer to the section in this chapter for that specific mode. Each section includes wiring diagram(s) to help you connect the High-Speed I/O points correctly to field devices. An example of the quadrature counter mode diagram is shown below.



Encoder Input Wiring

Choosing the HSIO Operating Mode

Understanding the Six Modes

The High-Speed I/O circuit operates in one of 6 basic modes as listed in the table below. The number in the left column is the mode number (later, we'll use these numbers to configure the PLC). Choose one of the following modes according to the primary function you want from the dedicated High-Speed I/O circuit. You can simply use all ten inputs and eight outputs as regular I/O points with Mode 60.

Mode Number	Mode Name	Mode Features
10	High-Speed Counter	5 kHz counter with 24 presets and reset input, counts up only, causes interrupt on preset
20	Quadrature Counter	Channel A / Channel B 5 kHz quadrature input, counts up and down
30	Pulse Output	Stepper control – pulse and direction signals, programmable motion profile
40	High-Speed Interrupt	Generates an interrupt based on input transition or time
50	Pulse Catch	Captures narrow pulses on a selected input
60	Discrete/Filtered Input	Rejects narrow pulses on selected inputs

In choosing one of the six high-speed I/O modes, the I/O points listed in the table below operate only as the function listed. If an input point is not specifically used to support a particular mode, it usually operates as a filtered input by default. Similarly, output points operate normally unless Pulse Output mode is selected.

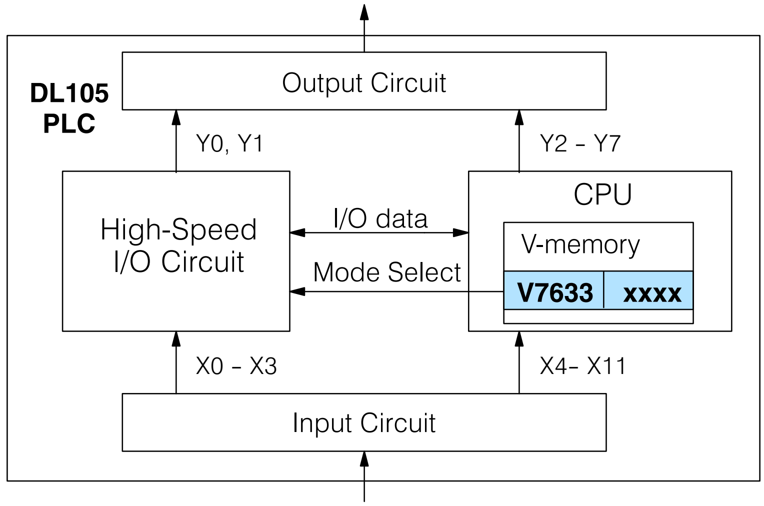
Physical I/O Point Usage						
	DC Input Points				DC Output Points	
Mode	**X0**	**X1**	**X2**	**X3**	**Y0**	**Y1**
High-Speed Counter	Counter clock	Filtered Input	Filtered Input or Reset Cnt	Filtered Input	Regular Output	Regular Output
Quadrature Counter	Phase A Input	Phase B Input	FIltered Input or Reset Cnt	Filtered Input	Regular Output	Regular Output
High-Speed Interrupt	Interrupt Input, or Filtered Input	Filtered Input	Filtered Input	Filtered Input	Regular Output	Regular Output
Pulse Catch	Pulse Input	Filtered Input	Filtered Input	Filtered Input	Regular Output	Regular Output
Pulse Output	Not available	Filtered Input	Filtered Input, or Interrupt to trigger pulse output	Filtered Input	Pulse or CW Pulse	Direction or CCW Pulse
Filtered Input	Filtered Input	Filtered Input	Filtered Input	Filtered Input	Regular Output	Regular Output

Default Mode

Mode 60 (Filtered Inputs) is the default mode. The DL105 is initialized to this mode at the factory, and any time you clear V-memory scratchpad. In the default condition, X0–X3 are filtered inputs (10 mS delay) and Y0–Y1 are standard outputs.

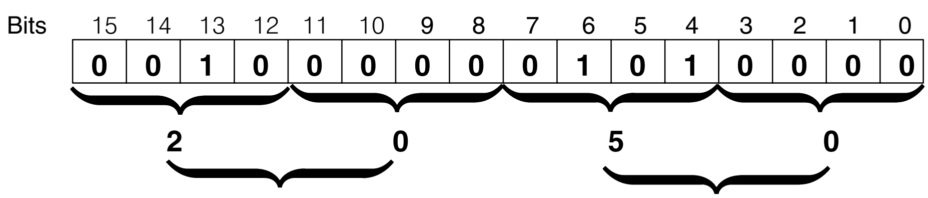
Configuring the HSIO Mode

If you have chosen a mode suited to the high-speed I/O needs of your application, we're ready to proceed to configure the PLC to operate accordingly. In the block diagram below, notice the V-memory detail in the expanded CPU block. V-memory location **V7633** determines the functional mode of the high-speed I/O circuit. *This is the most important V-memory configuration value for HSIO functions!*



The contents of V7633 is a 16-bit word, to be entered in binary–coded decimal. The figure below defines what each 4-bit BCD digit of the word represents.

Memory Location V7633



Miscellaneous Setup (BCD)

00 = Power Up in Previous Mode
20 = Power Up in Run Mode Always

HSIO Mode Setup (BCD)

00 = Not Used
10 = High-Speed Counting Mode
20 = Quadrature Counting Mode
30 = Pulse Output Train
40 = High-Speed Interrupts
50 = Pulse Catching
60 = Discrete Filtered Inputs (default)

Bits 0 – 7 define the mode number 00, 10.. 60 previously referenced in this chapter. The example data "2050" shown selects Mode 50 – Pulse Catch (BCD = 50) and Power Up in Run Mode (BCD=20). Together they form the 4-digit BCD number 2050.

Configuring Inputs X0 – X3

In addition to configuring V7633 for the HSIO mode, you'll need to program the next four locations in certain modes according to the desired function of input points X0 – X3. Other memory locations may require configuring, depending on the HSIO mode (see the corresponding section for particular HSIO modes).

V-memory

Mode	V7633	xxxx
X0	V7634	xxxx
X1	V7635	xxxx
X2	V7636	xxxx
X3	V7637	xxxx

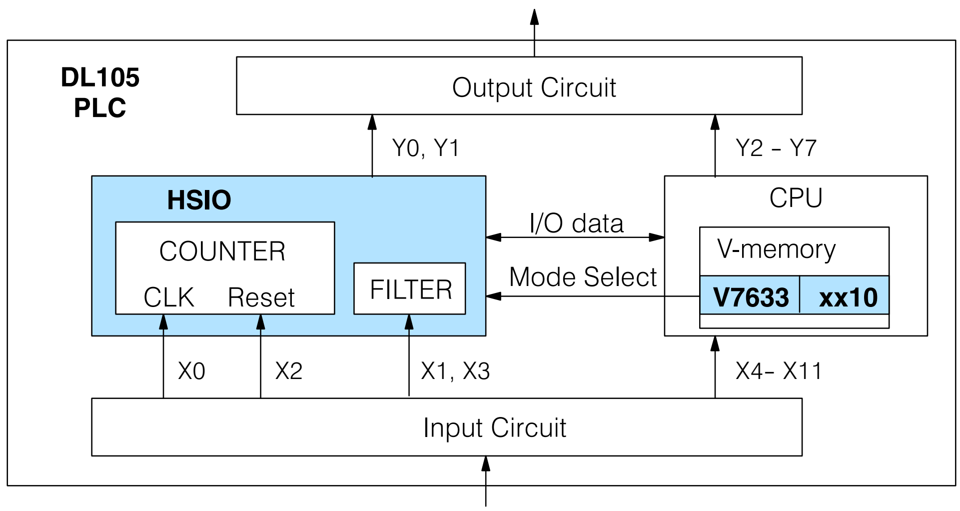
Mode 10: High-Speed Counter

Purpose

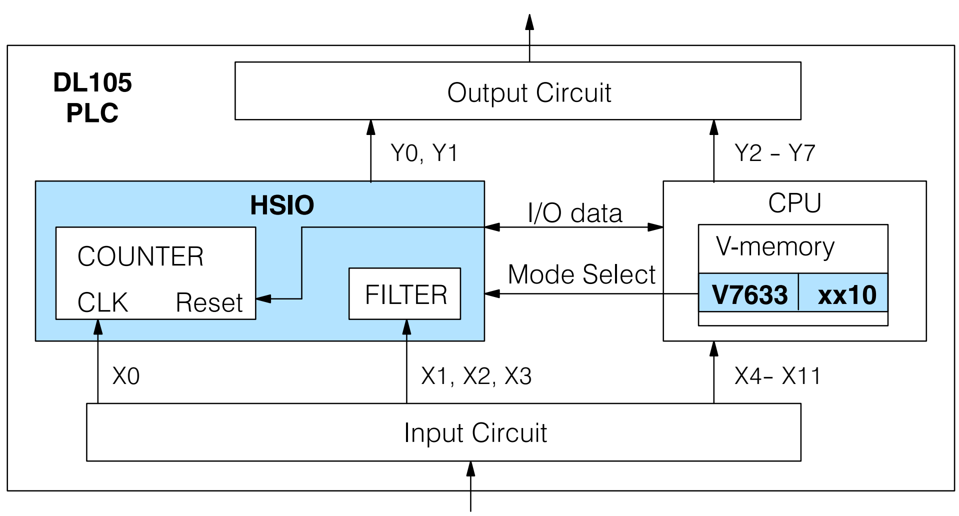
The HSIO circuit contains one high-speed counter. A single pulse train from an external source (X0) clocks the counter on each signal leading edge. The counter counts only upwards, from 0 to 99999999. The counter compares the current count with up to 24 preset values, which you define. The purpose of the presets is to quickly cause an action upon arrival at specific counts, making it ideal for such applications as cut-to-length. It uses counter registers CT76 and CT77 in the CPU.

Functional Block Diagram

Refer to the block diagram below. When the lower byte of HSIO Mode register V7633 contains a BCD “10”, the high-speed up counter in the HSIO circuit is enabled. X0 automatically becomes the “clock” input for the high-speed counter, incrementing it upon each off-to-on transition. The external reset input on X2 is the default configuration for Mode 10. Inputs X1 and X3 are filtered inputs, available to the ladder program.



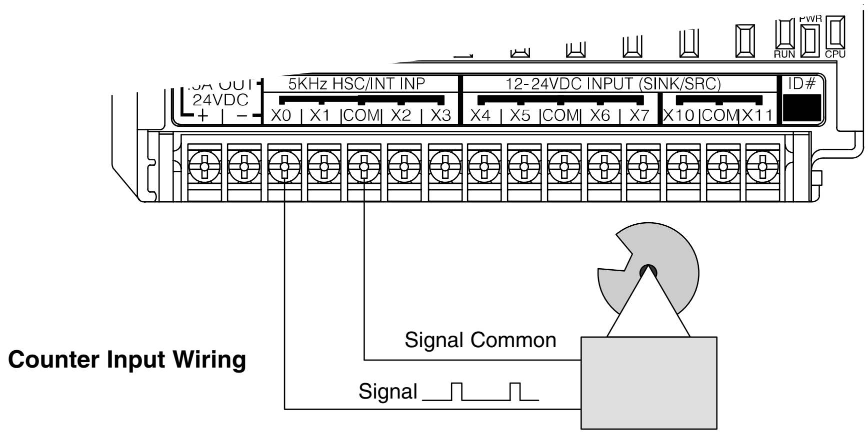
Instead of using X2 as a dedicated reset input, you can configure X2 as a normal filtered input. In this way, the counter reset must be generated in ladder logic.



Next, we will discuss how to program the high-speed counter and its presets.

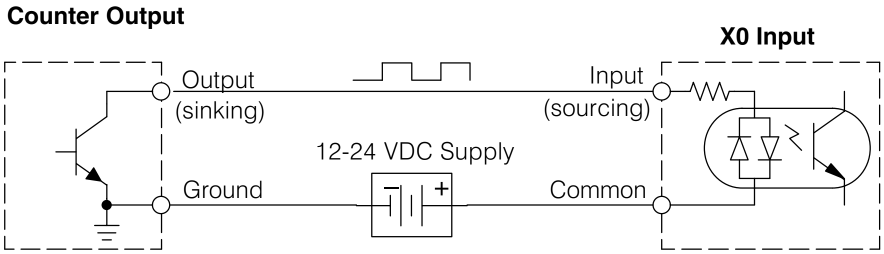
Wiring Diagram

A general wiring diagram for counters/encoders to the DL105 in HSIO Mode 10 is shown below. Many types of pulse-generating devices may be used, such as proximity switches, single-channel encoders, magnetic or optical sensors, etc. Devices with sinking outputs (NPN open collector) are probably the best choice for interfacing. If the counter sources to the inputs, it must output 12 to 24 VDC. Note that devices with 5V sourcing outputs will not work with DL105 inputs.

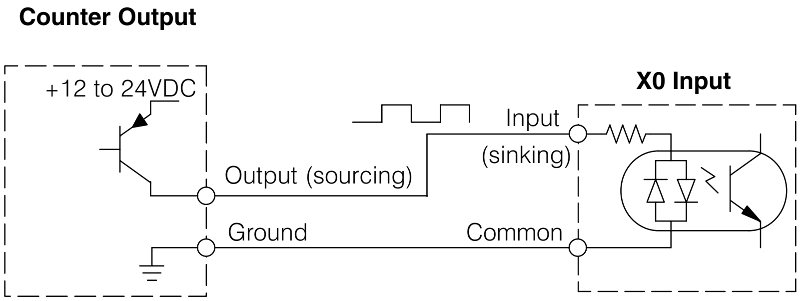


Interfacing to Counter Outputs

The DL105's DC inputs are flexible in that they detect current flow in either direction, so they can be wired to a counter with either sourcing or sinking outputs. In the following circuit, a counter has open-collector NPN transistor outputs. It sinks current from the PLC input point, which sources current. The power supply can be the +24VDC auxiliary supply or another supply (+12VDC or +24VDC), as long as the input specifications are met.

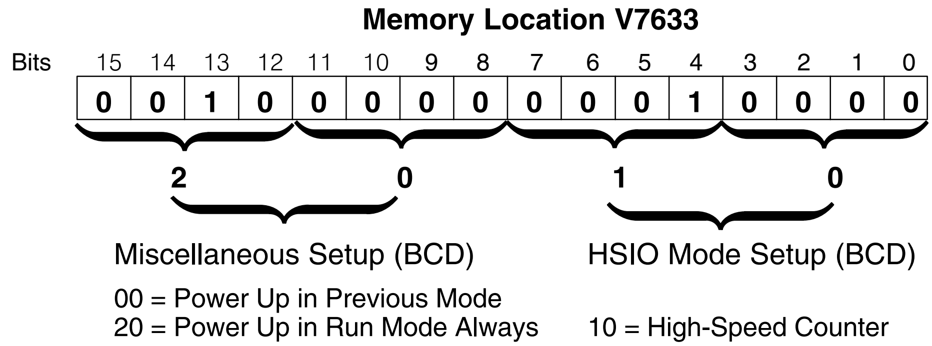


In the next circuit, an encoder has open-emitter PNP transistor outputs. It sources current to the PLC input point, which sinks the current back to ground. Since the encoder sources current, no additional power supply is required. However, note that the encoder output must be 12 to 24 volts (5V encoder outputs will not work).



Setup for Mode 10

Recall that V7633 is the HSIO Mode Select register. Refer to the diagram below. Use BCD 10 in the lower byte to select High-Speed Counter Mode. Use BCD 00 or 20 in the upper byte as required. Combine the two bytes into a data word “xx10”, for writing to V7633.



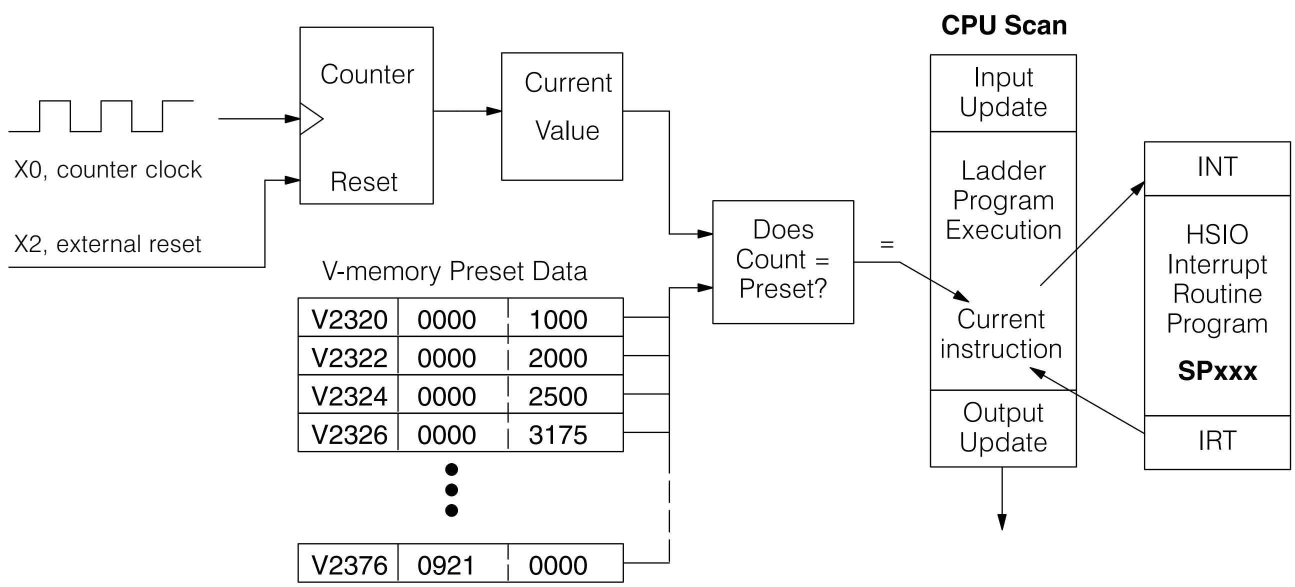
Choose the most convenient method of programming V7633 from the following:

- Include load and out instructions in your ladder program
- ***Direct***SOFT32’s memory editor
- Use the Handheld Programmer D2–HPP

We recommend using the first method above so that the HSIO setup becomes an integral part of your application program. An example program later in this section shows how to to this.

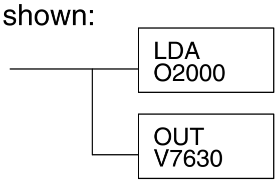
Presets and Special Relays

The goal of counting is to do a special action when the count reaches a preset value. Refer to the figure below. The counter features 24 presets, which you can program. A preset is a number you derive and store so that the counter will constantly compare the current count with the preset. When the two are equal, a special relay contact is energized and program execution jumps to the interrupt routine. We recommend using the special relay(s) in the interrupt service routine to cause any immediate action you desire. After the interrupt service routine is complete, the CPU returns to the ladder program, resuming program execution from the point of interruption. The compare function is ready for the next preset event.



Preset Data Starting Location

V7630 is a pointer location which points to the beginning of the Preset Data Table. The default starting location for the Preset Data Table is V2320 (default after initializing scratchpad V-memory). However, you may change this by programming a different value in V7630. Use the LDA and OUT instructions as shown:



Load the octal address, convert to hex, leave result in accumulator.

Output this address to V7630, the location of the pointer to the Preset data.

Preset Table Pointer

V7630	**2000**

Preset Data

V2000	0000	1000
V2002	0000	2000
V2004	0000	2500
V2006	0000	3175
• • •		
V2076	0000	0000

Using Fewer than 24 Presets

When using fewer than 24 preset registers, the HSIO looks for “0000 FFFF” (use LDD Kffff) in the next preset location to indicate the last preset has been reached. The example to the right uses four presets. The 0000 FFFF in V2331-V2330 indicates the previous preset was the last.

Preset Data

V2320	0000	1000
V2322	0000	2000
V2324	0000	2500
V2326	0000	3175
V2330	0000	FFFF

NOTE: Each successive preset must be greater than the previous preset value. If a preset value is less than a lower-numbered preset value, the CPU cannot compare for that value, since the counter can only count upwards.

Equal Relay Numbers

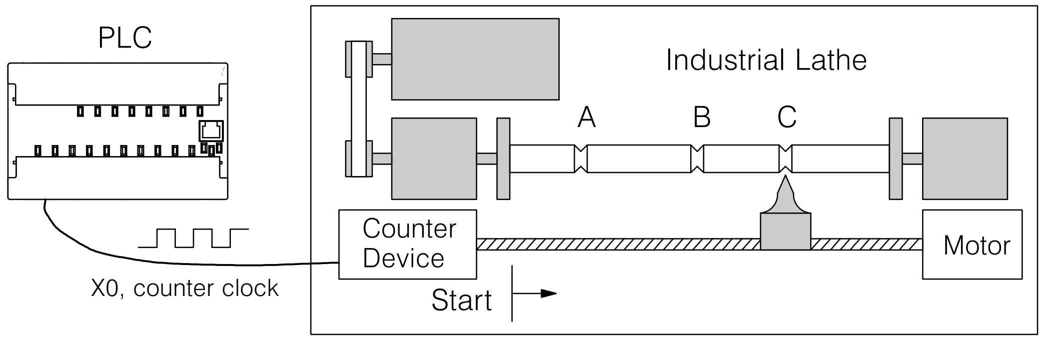
The following table lists all 24 preset register default locations. Each occupies two 16-bit V-memory registers. The corresponding special relay contact number is in the next column. We might also call these “equal” relay contacts, because they are true (closed) when the present high-speed counter value is equal to the preset value. Each contact remains closed until the counter value equals the next preset value.

Preset	Preset V-memory Register	Special Relay Number	Preset	Preset V-memory Register	Special Relay Number
1	V2321 / V2320	SP540	13	V2351 / V2350	SP554
2	V2323 / V2322	SP541	14	V2353 / V2352	SP555
3	V2325 / V2324	SP542	15	V2355 / V2354	SP556
4	V2327 / V2326	SP543	16	V2357 / V2356	SP557
5	V2331 / V2330	SP544	17	V2361 / V2360	SP560
6	V2333 / V2332	SP545	18	V2363 / V2362	SP561
7	V2335 / V2334	SP546	19	V2365 / V2364	SP562
8	V2337 / V2336	SP547	20	V2367 / V2366	SP563
9	V2341 / V2340	SP550	21	V2371 / V2370	SP564
10	V2343 / V2342	SP551	22	V2373 / V2372	SP565
11	V2345 / V2344	SP552	23	V2375 / V2374	SP566
12	V2347 / V2346	SP553	24	V2377 / V2376	SP567

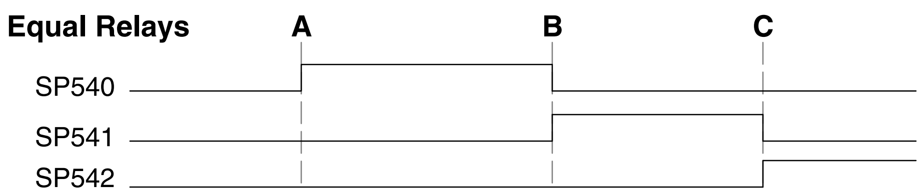
Calculating Your Preset Values

The preset values occupy two data words each. They can range in value from 0000 0000 to 9999 9999, just like the high-speed counter value. All twenty-four values are *absolute* values, meaning that each one is an offset from the counter zero value.

The preset values must be individually derived for each application. In the industrial lathe diagram below, the PLC monitors the position of the lead screw by counting pulses. At points A, B, and C along the linear travel, the cutter head pushes into the work material and cuts a groove.



The timing diagram below shows the duration of each equal relay contact closure. Each contact remains on until the next one closes. All go off when the counter resets.



NOTE: Each successive preset must have a greater value than the previous preset value. In the industrial lathe example, B>A and C>B.

X Input Configuration

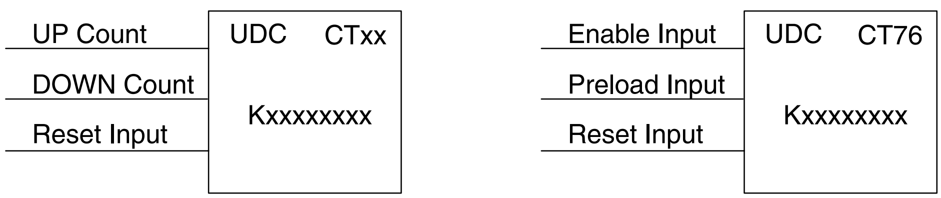
The configurable discrete input options for High-Speed Counter Mode are listed in the table below. Input X0 is dedicated for the counter clock input. Inputs X1 and X3 can only be filtered inputs. The section on Mode 60 operation at the end of this chapter describes programming the filter time constants. Input X2 can be configured as the counter reset, with or without the interrupt option. The interrupt option allows the reset input (X2) to cause an interrupt like presets do, but there is no SP relay contact closure (instead, X2 will be on during the interrupt routine, for 1 scan). Or finally, X2 may be left simply as a filtered input like X1 and X3.

Input	Configuration Register	Function	Hex Code Required
X0	V7634	Counter Clock	0001
X1	V7635	Filtered Input	xx06 (xx = filter time)
X2	V7636	Counter Reset (no interrupt)	0007
		Counter Reset (with interrupt)	0107
		FIltered Input	xx06 (xx = filter time)
X3	V7637	FIltered Input	xx06 (xx = filter time)

Writing Your Control Program

You may recall that the counter instruction is a standard instruction in the DL105 instruction set. Refer to the figure below. The mnemonic for the counter is **UDC** (up-down counter).The DL105 can have up to 64 counters, labeled CT0 through CT77. The high speed counter in the HSIO circuit is accessed in ladder logic by using UDC CT76. It uses counter registers CT76 and CT77 exclusively when the HSIO mode 10 is active (otherwise, CT76 and CT77 are available for standard counter use). The HSIO counter needs two registers because it is a double-word counter. It has three inputs as shown. The first input (Enable) allows counting when active. The middle input (Preload) allows you to change the current count. The bottom signal is the reset. The preload input must be off while the counter is counting.

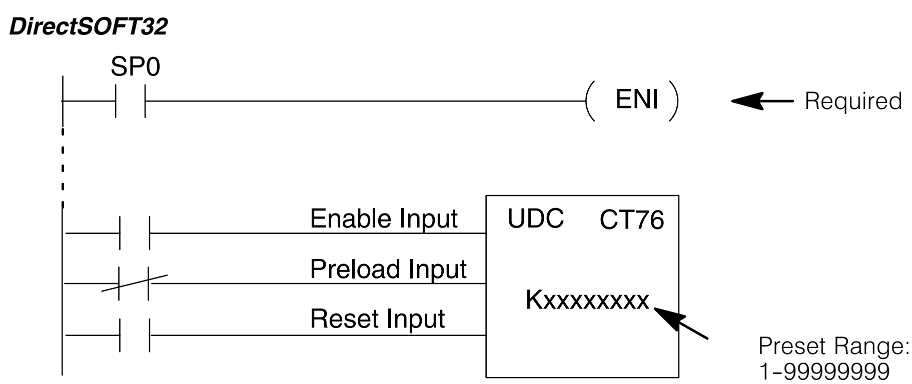
Standard Counter Function | **HSIO Counter Function**



Standard Counter Function:
- Counts UP and DOWN
- Preload counter by write to value
- Reset input is internal only

HSIO Counter Function:
- Counts UP only
- Can use Preload input to change count
- Reset may be internal or external

The next figure shows how the HSIO counter will appear in a ladder program. Note that the Enable Interrupt (ENI) command must execute before the counter value reaches the first preset value. We do this at powerup by using the first scan relay. When using the counter but not the presets and interrupt, we can omit the ENI.

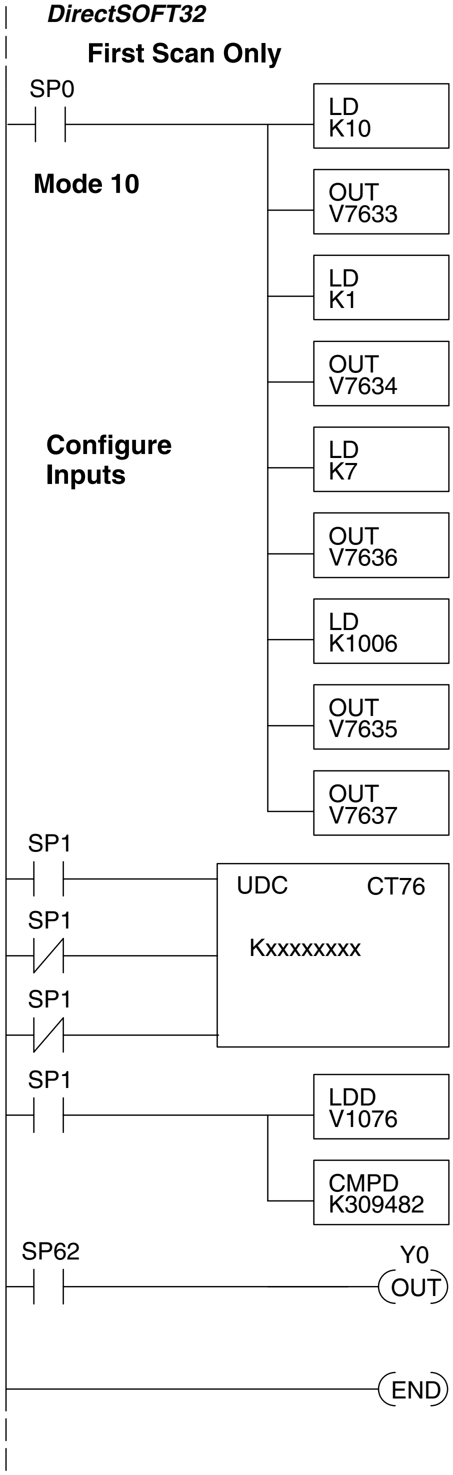


When the enable input is energized, the high-speed counter will respond to pulses on X0 and increment the counter at CT76 – CT77. The reset input contact behaves in a logical OR fashion with the physical reset input X2 (when selected). So,the high speed counter can receive a reset form either the contact(s) on the reset rung in the ladder, OR the external reset X2 if you have configured X2 as an external reset.

Program Example: Counter Without Preset

The following example is the simplest way to use the high-speed counter, which does not use the presets and special relays in the interrupt routine. The program configures the HSIO circuit for Mode 10 operation, so X0 is automatically the counter clock input. It uses the Compare-double (CMPD) instruction to cause action at certain count values. Note that this allows you to have more than 24 “presets”.Then it configures X2 to be the external reset of the counter.

Program Example Cont'd



Load constant K10 into the accumulator. This selects Mode 10 as the HSIO mode.

Output the constant K10 to V7633, the location of HSIO Mode select register.

Load the constant required to configure X0 as the counter clock.

Output the constant K1 to V7634, the location of the setup parameter for X0.

Load the constant required to configure X2 as an external reset without interrupt.

Output the constant K7 to V7636, the location of the setup parameter for X2.

Load the constant required to configure inputs as filtered inputs.

Output the constant K1006 to V7635, the location of setup parameter for X1.

Output the constant K1006 to V7637, the location of setup parameter for X3.

CT76 is the HSIO counter. The first rung's SP1 always enables the counter. The preload contact in the middle is always off. The third rung's Reset input is always off, because we will use the external reset.

Load the current count of the HSIO counter in V1076 and V1077 into the accumulator

Use the Compare-double instruction to compare the double word in the accumulator to the constant K309482

The execution of the above CMPD instruction turns on special relay contact SP62 if the current count is greater than the comparison number (K309482).

END coil marks the end of the main program.

The compare double instruction above uses the current count of the HSIO counter to turn on Y0. This technique can make more than 24 comparisons, but it is scan-time dependent. However, use the 24 built-in presets with the interrupt routine if your application needs a very fast response time, as shown in the next example.

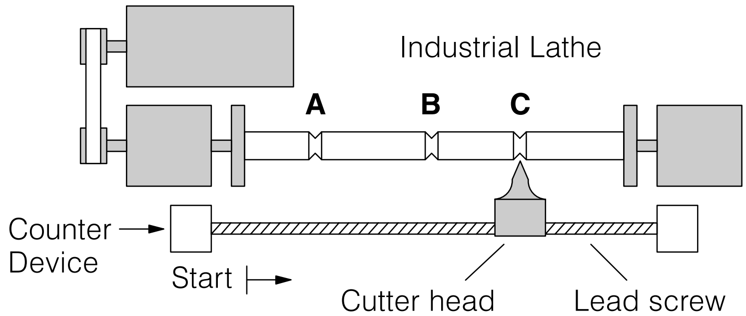
Counter With Presets Program Example

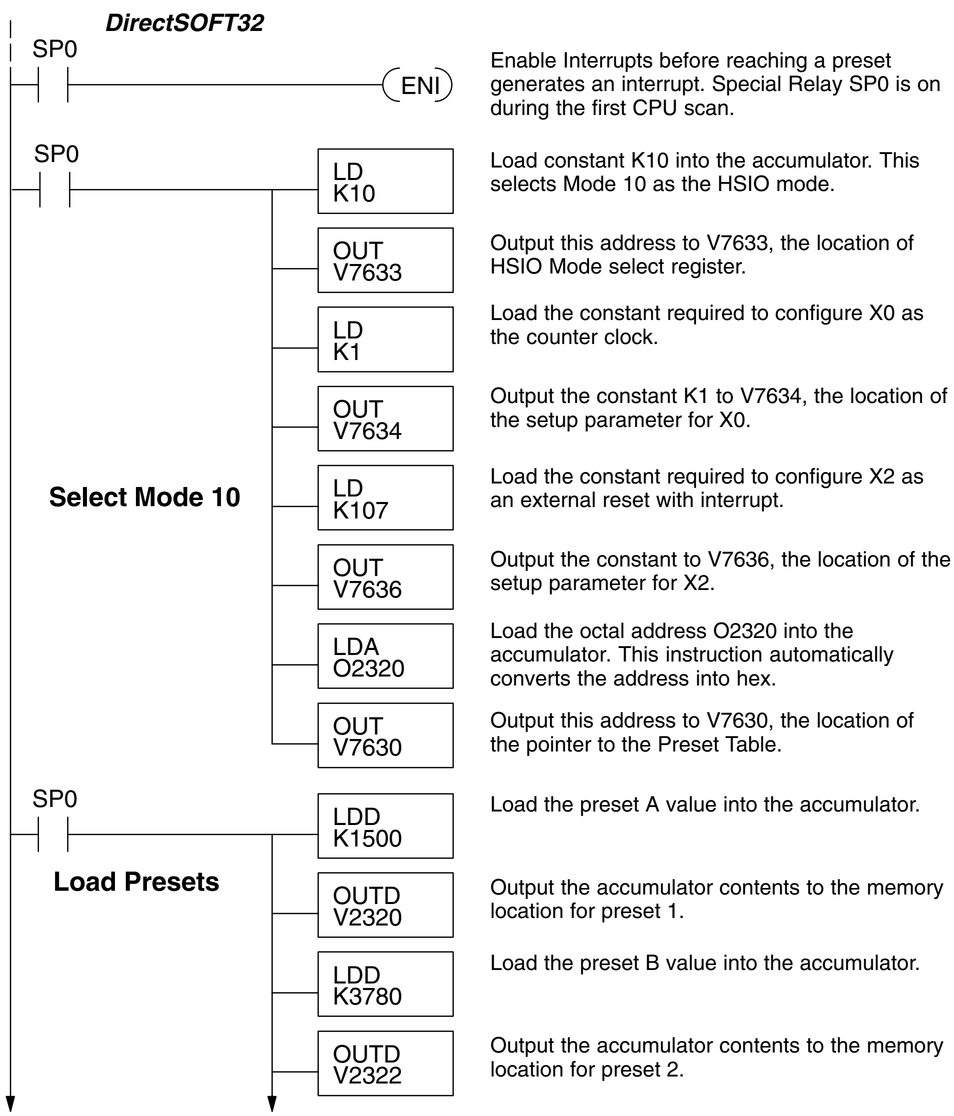
The following example shows how to program the HSIO circuit to trigger on three preset values. You may recall the industrial lathe example from the beginning of this chapter. This example program shows how to control the lathe cutter head to make three grooves in the work-piece at precise positions. When the lead screw turns, the counter device generates pulses which the DL105 can count. The three preset variables A, B, and C represent the positions (number of pulses) corresponding to each of the three grooves.

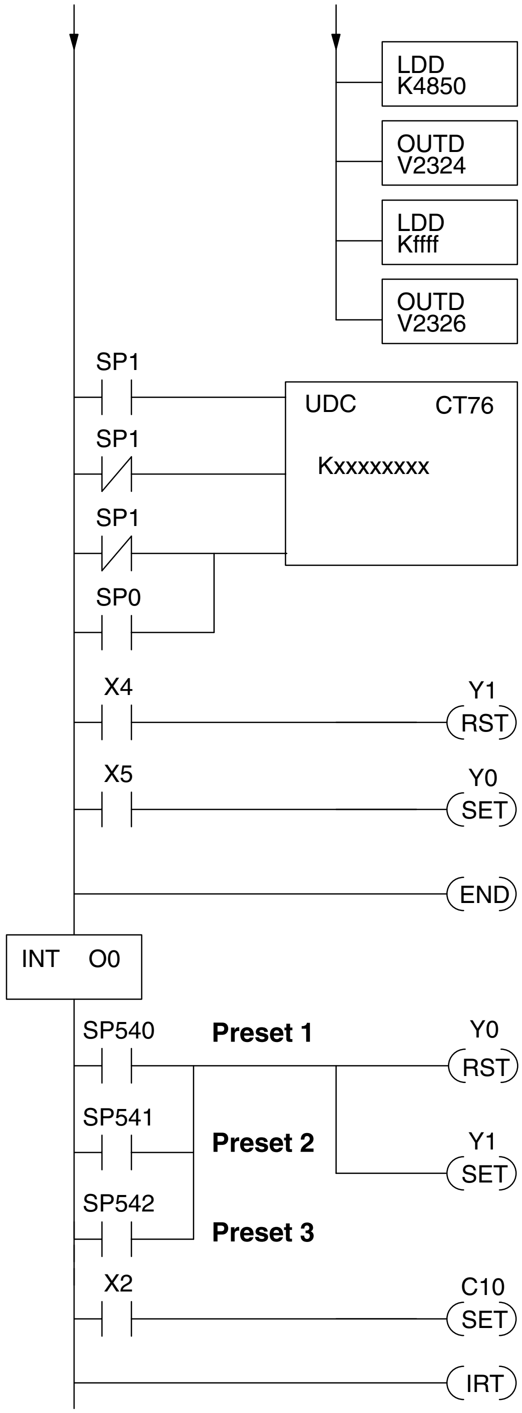
Preset Data

A	V2320	0000	1500
B	V2322	0000	3780
C	V2324	0000	4850
	V2326	0000	FFFF

I/O Assignments
X4 – Cutter head extended
X5 – Cutter head retracted
Y0 – Lead screw motor
Y1 – Cutter head solenoid







Load the preset C value into the accumulator.

Output the accumulator contents to the memory location for preset 3.

Load the constant Kffff into the accumulator. This value represents the end of the preset list.

Output the accumulator contents to the memory location for preset 4 (end of preset marker).

CT76 is the HSIO counter. The first rung's SP1 always enables the counter. The preload contact in the middle is off (unused in this example).

The third rung's Reset input is normally off, because we will use the external reset. You can optionally reset the counter value on each powerup using the SP0 contact.

Input X4 energizes when the groove has finished cutting. So, we retract the cutter head.

Turn lead screw on again, after cutter head has retracted.

END coil marks the end of the main program.

The INT label marks the beginning of the interrupt service routine program.

Inside the interrupt service routine, we turn OFF the lead screw motor immediately.

These special "equal" relays turn on individually as the corresponding preset is reached. In this application, each results in the cutting of a groove (Y1), so they are logically ORed together.

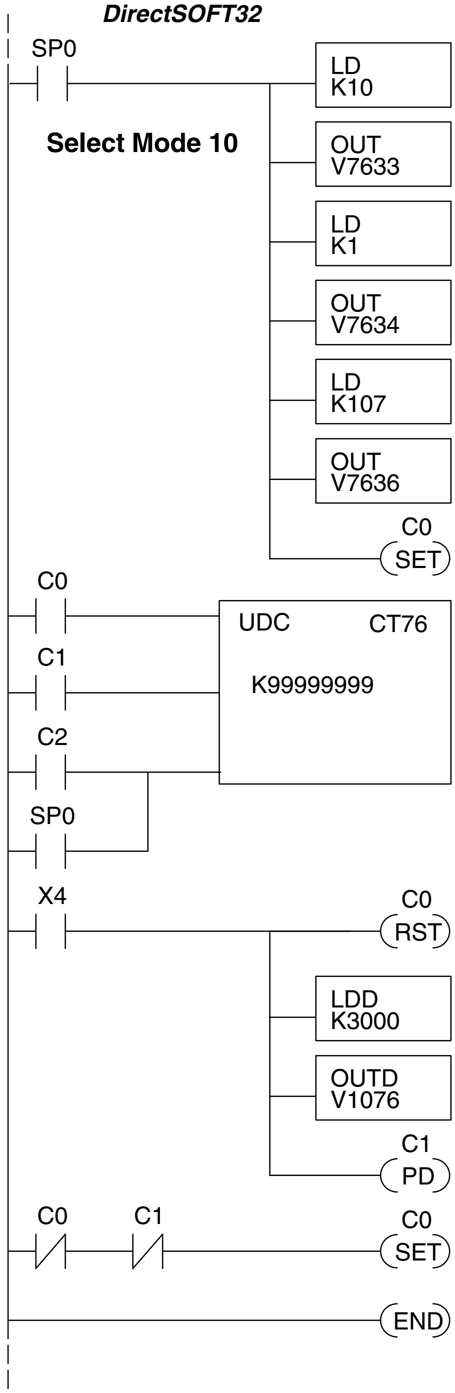
Input X2 will be energized inside the interrupt routine if X2 external interrupt was the source.

Return from the interrupt service routine.

Some applications will require a different type of action at each preset. It is possible for the interrupt routine to distinguish one preset event from another, by turning on a unique output for each equal relay contact SPxxx. We can determine the source of the interrupt by examining the equal relay contacts individually, as well as X2. The X2 contact will be on (inside the interrupt routine only) if the interrupt was caused by the external reset, X2 input.

Counter With Preload Program Example

The following example shows how you can preload the current count with another value. When the preload command input (X4 in this example) is energized, we disable the counter from counting with C0. Then we write the value K3000 to the count register (V1076-V1077). By pulsing C1 on, we preload the current count of the counter with K3000. When the preload command (X4) is turned off, the counter resumes counting any pulses, but now starting from K3000.



Load constant K10 into the accumulator. This selects Mode 10 as the HSIO mode.

Output this address to V7633, the location of HSIO Mode select register.

Load the constant required to configure X0 as the counter clock.

Output the constant K1 to V7634, the location of the setup parameter for X0.

Load the constant required to configure X2 as an external reset with interrupt.

Output the constant to V7636, the location of the setup parameter for X2.

Set C0 on at powerup to enable counting.

CT76 is the HSIO counter. The first rung’s C0 contact enables the counter. The preload contact in the middle is off until the logic near the end of this program turns it on.

The third rung’s Reset input is normally off, because we will use the external reset. You can optionally reset the counter value on each powerup using the SP0 contact.

When the preload request is made, the user turns on X4. First we disable counting by resetting C0, the counter’s enable input.

Load the BCD value K3000 into the accumulator.

Output the constant to V1076/V1077, the location of the accumulated count for CT76.

Generate a preload counter input pulse, which causes the counter to preload from V1076-V1077.

Enable the counter by setting C0, when the preolad pulse on C1 has occurred (C1 is off).

END coil marks the end of the main program.

Troubleshooting Guide for Mode 10

If you're having trouble with Mode 10 operation, please study the following symptoms and possible causes. The most common problems are listed below.

Symptom: The counter does not count.

Possible causes:

1. **Field sensor and wiring** – Verify that the encoder, proximity switch,or counter actually turns on and illuminates the status LED for X0. The problem could be due to sinking-sourcing wiring problem, etc. Remember to check the signal ground connection. Also verify that the pulse on-time is long enough for the PLC to recognize it.
2. **Configuration** – make sure all of the configuration parameters are correct. V7633 must be set to 10, and V7634 must be set to 1 to enable the HSIO counter mode.
3. **Stuck in reset** – check the input status of the reset input, X2. If X2 is on, the counter will not count because it is being held in reset.
4. **Ladder program** – make sure you are using counter CT76 in your program. The top input is the enable signal for the counter. It must be on before the counter will count. The middle input is the preload input and must be off for the counter to count. The bottom input is the counter reset, and must be off during counting.

Symptom: The counter counts but the presets do not function.

Possible causes:

1. **Configuration** – Ensure the preset values are correct. The presets are 32-bit BCD values having a range of 0 to 99999999. Make sure you write all 32 bits to the reserved locations by using the LDD and OUTD instructions. Use only even–numbered addresses, from V2320 to V2376. If using less than 24 presets, be sure to place “0000FFFF” in the location after the last preset used.
2. **Interrupt routine** – Only use Interrupt #0. Make sure the interrupt has been enabled by executing an ENI instruction prior to needing the interrupt. The interrupt routine must be placed after the main program, using the INT label and ending with an interrupt return IRT.
3. **Special relays** – Check the special relay numbers in your program. Use SP540 for Preset 1, SP541 for Preset 2, etc. Remember that only one special equal relay contact is on at a time. When the counter value reaches the next preset, the SP contact which is on now goes off and the next one turns on.

Symptom: The counter counts up but will not reset.

Possible causes:

1. Check the LED status indicator for X2 to make sure it is active when you want a reset. Or, if you are using an internal reset, use the status mode of ***Direct***SOFT32 to monitor the reset input to the counter.

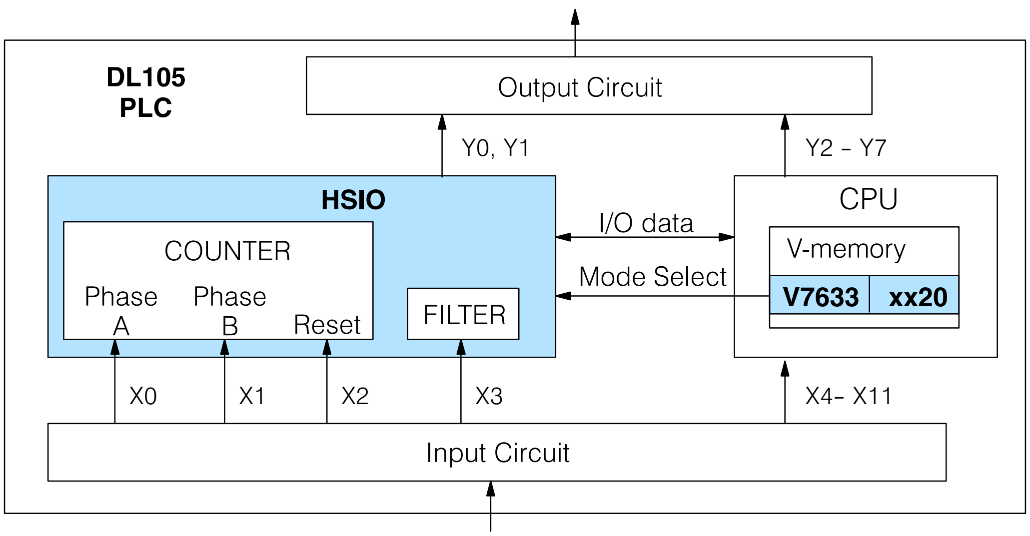
Mode 20: Quadrature Counter

Purpose

The counter in the HSIO circuit can count two quadrature signal pulses instead of a single pulse train (mode 10 operation). Quadrature signals are commonly generated from incremental encoders, which may be rotary or linear. The quadrature counter has a range from 0 to 99999999, and can count at up to a 5 kHz rate, using CT76 and CT77. Unlike Mode 10 operation, the quadrature counter can count UP or DOWN, but *does not feature automated preset values or "interrupt on external reset" capability.* However, you have the standard ladder instruction preset of CT76.

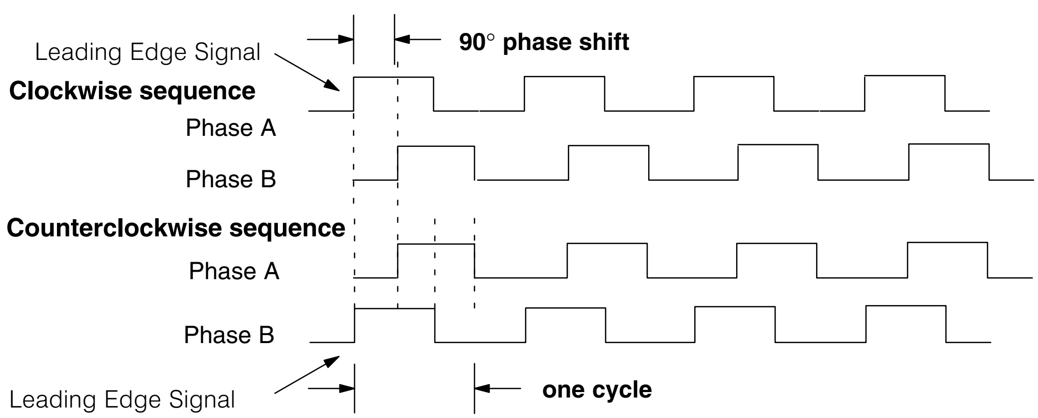
Functional Block Diagram

The diagram below shows HSIO functionality in Mode 20. When the lower byte of HSIO Mode register V7633 contains a BCD "20", the quadrature counter in the HSIO circuit is enabled. Input X0 is dedicated to the Phase A quadrature signal, and input X1 receives Phase B signal. X2 is dedicated to reset the counter to zero value when energized. X3 can only be a regular filtered input in Mode 20.



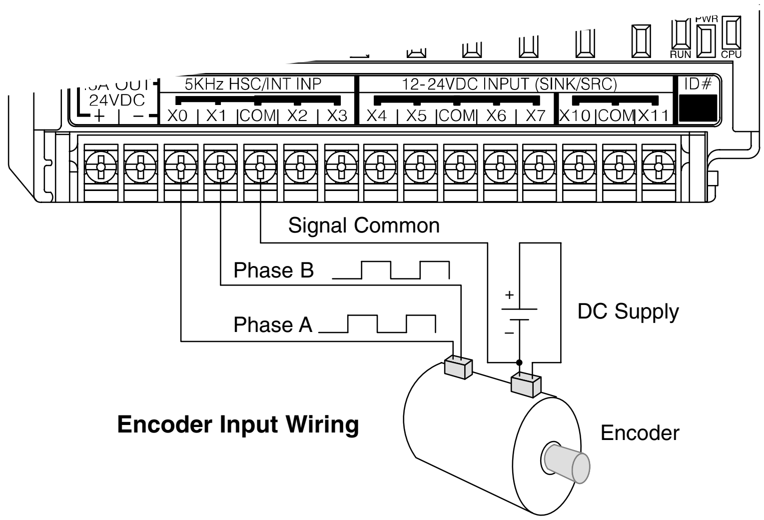
Quadrature Encoder Signals

Quadrature encoder signals contain position and direction information, while their frequency represents speed of motion. Phase A and B signals shown below are phase-shifted 90 degrees, thus the quadrature name. When the rising edge of Phase A precedes Phase B's leading edge (indicates clockwise motion by convention), the HSIO counter counts UP. If Phase B's rising edge precedes Phase A's rising edge (indicates counter-clockwise motion), the counter counts DOWN.



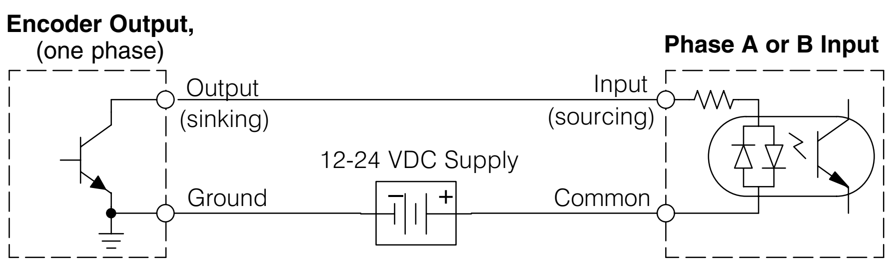
Wiring Diagram

A general wiring diagram for encoders to the DL105 in HSIO Mode 20 is shown below. Encoders with sinking outputs (NPN open collector) are probably the best choice for interfacing. If the encoder sources to the inputs, it must output 12 to 24 VDC. Note that encoders with 5V sourcing outputs will not work with DL105 inputs.

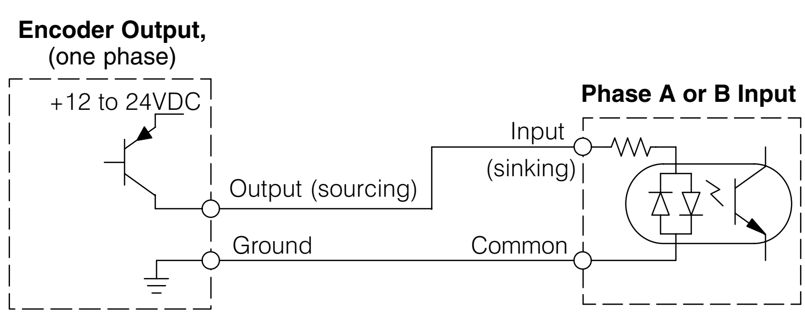


Interfacing to Encoder Outputs

The DL105's DC inputs are flexible in that they detect current flow in either direction, so they can be wired to an encoder with either sourcing or sinking outputs. In the following circuit, an encoder has open-collector NPN transistor outputs. It sinks current from the PLC input point, which sources current. The power supply can be the +24VDC auxiliary supply or another supply (+12VDC or +24VDC), as long as the input specifications are met.

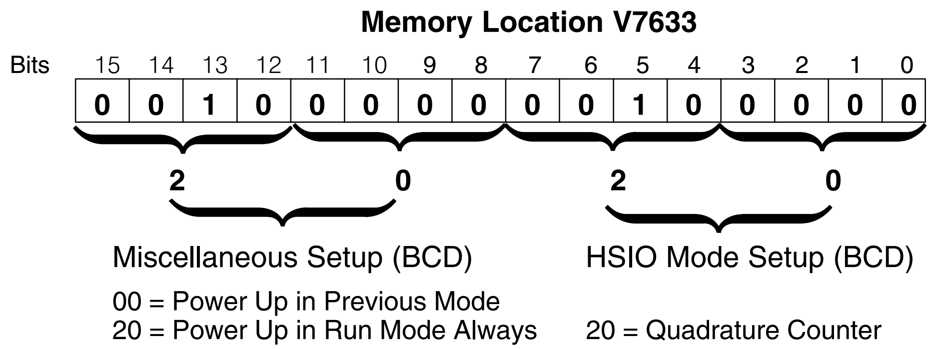


In the next circuit, an encoder has open-emitter PNP transistor outputs. It sources current to the PLC input point, which sinks the current back to ground. Since the encoder sources current, no additional power supply is required. However, note that the encoder output must be 12 to 24 volts (5V encoder outputs will not work).



Setup for Mode 20

Recall that V7633 is the HSIO Mode Select register. Refer to the diagram below. Use BCD 20 in the lower byte to select High-Speed Counter Mode. Use BCD 00 or 20 in the upper byte as required. Combine the two bytes into a data word “xx20”, for writing to V7633.



Choose the most convenient method of programming V7633 from the following:

- Include load and out instructions in your ladder program
- ***Direct***SOFT32’s memory editor
- Use the Handheld Programmer D2–HPP

We recommend using the first method above so that the HSIO setup becomes an integral part of your application program. An example program later in this section shows how to to this.

X Input Configuration

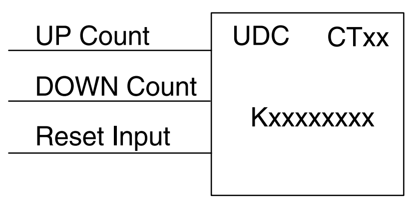
The configurable discrete input options for High-Speed Counter Mode are listed in the table below. Input X0 is dedicated for Phase A, and input X1 is for Phase B. Input X2 is the reset input to the quadrature counter, but it does not cause an interrupt. Input X3 can only be a filtered input. The section on Mode 60 operation at the end of this chapter describes programming the filter time constants.

Input	Configuration Register	Function	Hex Code Required
X0	V7634	Phase A	0012
X1	V7635	Phase B	0000
X2	V7636	Counter Reset (no interrupt)	0007
X3	V7637	Filtered Input	xx06 (xx = filter time)

Writing Your Control Program

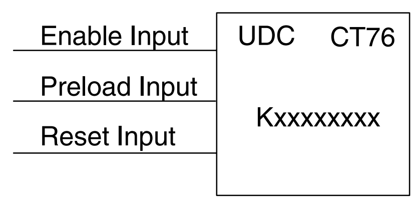
You may recall that the Up-Down counter instruction is standard in the DL105 instruction set. Refer to the figure below. The mnemonic for the counter is **UDC** (up-down counter).The DL105 can have up to 64 counters, labeled CT0 through CT77. The quadrature counter in the HSIO circuit is accessed in ladder logic by using UDC CT76. It uses counter registers CT76 and CT77 exclusively when the HSIO mode 20 is active (otherwise, CT76 and CT77 are available for standard counter use). The HSIO counter needs two registers because it is a double-word counter. It also has three inputs as shown, but they are redefined. The first input is the enable signal, the middle is a preload (write), and the bottom is the reset. The enable input must be on before the counter will count. The preload input allows you to write a new value to the current count. The enable input must be off during a preload.

Standard Counter Function



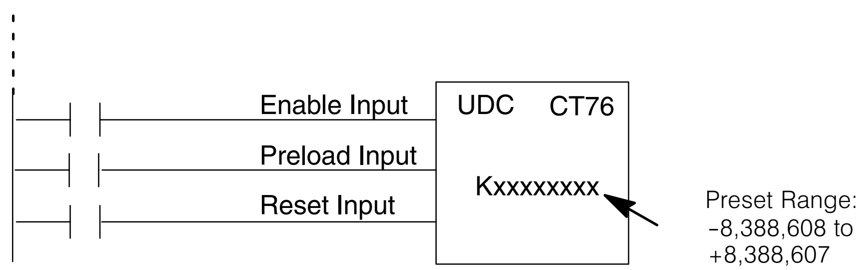
- Counts UP and DOWN
- Preload counter by write to value
- Reset input is internal only

HSIO Counter Function



- Counts UP and DOWN (from X0, X1)
- Can use Preload input to change count
- Reset may be internal or external

The next figure shows the how the HSIO quadrature counter will appear in a ladder program.

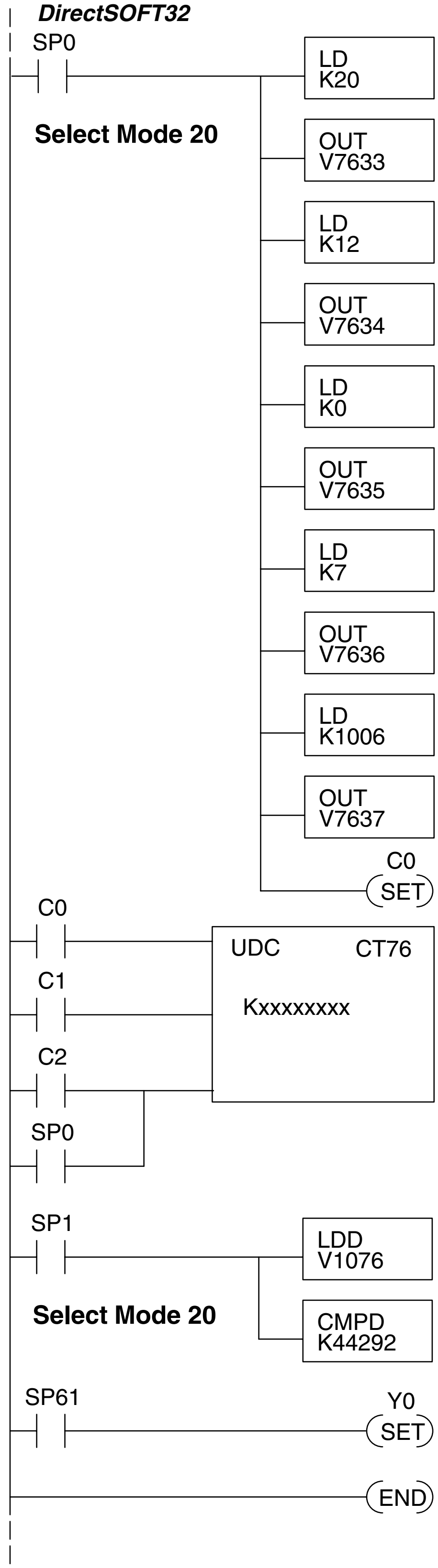


When the enable input is energized, the counter will respond to quadrature pulses on X0 and X1, incrementing or decrementing the counter at CT76 – CT77. The reset input contact behaves in a logical OR fashion with the physical reset input X2. This means the quadrature counter can receive a reset from either the contact(s) on the reset rung in the ladder, OR the external reset X2.

Quadrature Counter w/Preload Program Example

Since presets are not available in quadrature counting, this mode is best suited for simple counting and measuring. The example program on the following page shows how to configure the quadrature counter. The program configures the HSIO circuit for Mode 20 operation, so X0 is Phase A and X1 is Phase B clock inputs.

Program Example Cont'd



Load constant K20 into the accumulator. This selects Mode 20 as the HSIO mode.

Output this address to V7633, the location of the HSIO Mode select register.

Load the constant required to configure X0 as Phase A input.

Output the constant to V7634, the location of the setup register for X0.

Load the constant required to configure X1 as Phase B input.

Output the constant to V7635, the location of the setup register for X1.

Load the constant required to configure X2 as an external reset.

Output the constant to V7636, the location of the setup register for X2.

Load the constant required to configure X3 as a filtered discrete input with a 10 mS time constant.

Output the constant to V7637, the location of the setup register for X3.

Set C0 on at powerup to enable counting.

CT76 is the HSIO quadrature counter. The first rung's SP1 always enables the counter. The preload contact in the middle is controlled by the logic below this counter instruction.

The third rung's Reset input is normally off, because we will use the external reset. You can optionally reset the counter value on each powerup using the SP0 contact.

Load the current value of the counter into the accumulator on each scan.

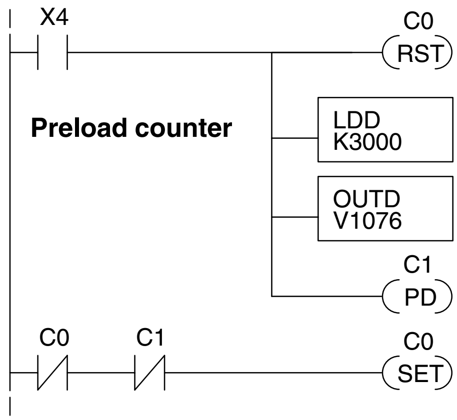
Compare the value in the accumulator with the constant K44292. If they are equal, the SP61 contact will be turned on.

Set Y1 to ON when the counter reaches our comparison value.

END coil marks the end of the main program..

To preload the counter, just add the following example rungs to the program above.

Counter Preload Program Example



When the preload request is made, the user turns on X4. First we disable counting by resetting C0, the counter's enable input.

Load the BCD value K3000 into the accumulator.

Output the constant to V1076/V1077, the location of the accumulated pulse count.

Generate a preload counter input pulse, which causes the counter to preload from V1076-V1077.

Enable the counter by setting C0, when the preolad pulse on C1 has occurred (C1 is off).

Troubleshooting Guide for Mode 20

If you're having trouble with Mode 20 operation, please study the following symptoms and possible causes. The most common problems are listed below.

Symptom: The counter does not count.

Possible causes:

1. **Field sensor and wiring** – Verify that the encoder or other field device inputs actually turn on and illuminates the status LEDs for X0 and X1. A standard incremental encoder will visibly, alternately turn on the LEDs for X0 and X1 when rotating slowly (1 RPM). Or, the problem could be due to a sinking-sourcing wiring problem, etc. Remember to check the signal ground connection. Also verify that the pulse on-time, duty cycle, voltage level, and frequency are within the input specifications.
2. **Configuration** – make sure all of the configuration parameters are correct. V7633 must be set to 20, and V7634 must be set to "0012" to enable the Phase A input, and V7635 must be set to "0000" to enable the Phase B input.
3. **Stuck in reset** – check the input status of the reset input, X2. If X2 is on, the counter will not count because it is being held in reset.
4. **Ladder program** – make sure you are using counter CT76 in your program. The top input is the enable signal for the counter. It must be on before the counter will count. The middle input is the preload input and must be off for the counter to count. The bottom input is the counter reset, and must be off during counting.

Symptom: The counter counts in the wrong direction (up instead of down, and visa-versa).

Possible causes:

1. **Channel A and B assignment** – It's possible that Channel A and B assignments of the encoder wires is backwards from the desired rotation/counting orientation. Just swap the X0 and X1 inputs, and the counting direction will be reversed.

Symptom: The counter counts up and down but will not reset.

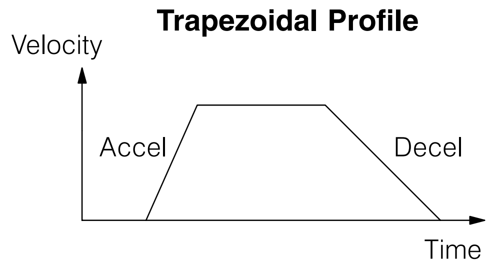
Possible causes:

1. Check the LED status indicator for X2 to make sure it is active when you want a reset. Also verify the configuration register V7636 for X2 is set to 7. Or, if you are using an internal reset, use the status mode of ***Direct***SOFT32 to monitor the reset input to the counter.

Mode 30: Pulse Output

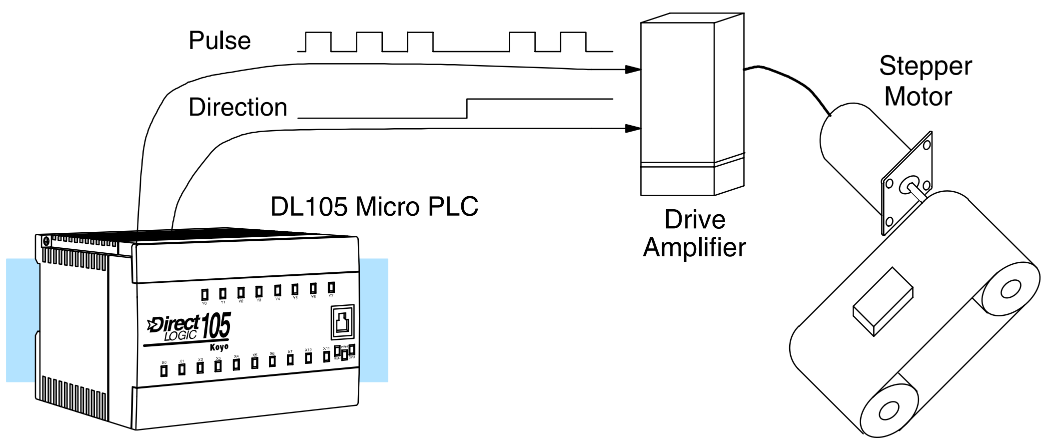
Purpose

The HSIO circuit in Mode 30 generates output pulse trains suitable for open-loop control of a single-axis motion positioning system. It generates pulse (stepper increment) and direction signals which you can connect to motor drive systems and perform various types of motion control. Using Mode 30 Pulse Output, you can select from three profile types:

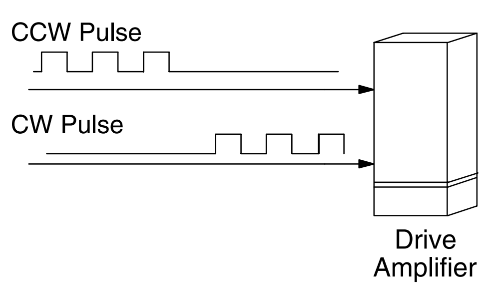


- **Trapezoidal** – Accel Slope to Target Velocity to Decel Slope
- **Registration** – Velocity to Position Control on Interrupt (also used for home search moves)
- **Velocity Control** – Speed and Direction only

The HSIO circuit becomes a high-speed pulse generator (up to 7 kHz) in Mode 30. By programming acceleration and deceleration values, position and velocity target values, the HSIO function automatically calculates the entire motion profile. The figure below shows the DL105 generating pulse and direction signals to the drive amplifier of a stepper positioning system. The pulses accomplish the profile independently and without interruption to ladder program execution in the CPU.



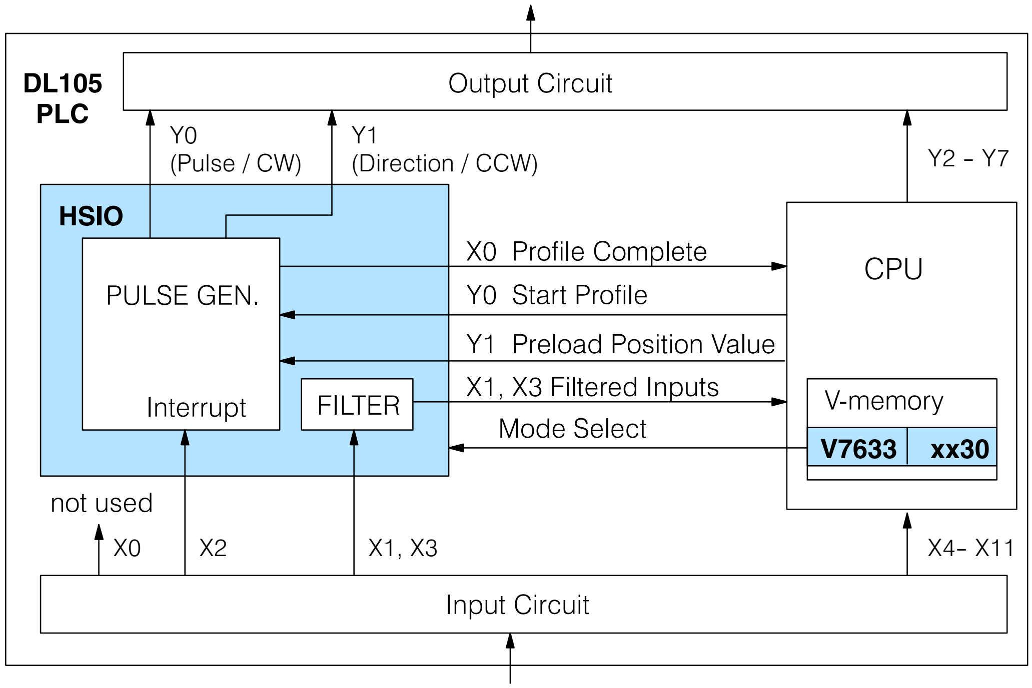
In the figure above, the DL105 generates pulse and direction signals. Each pulse represents the smallest increment of motion to the positioning system (such as one step or micro-step to a stepper system). Alternatively, the HSIO Pulse Output Mode may be configured to deliver counter clock-wise (CCW) and clock-wise (CW) pulse signals as shown to the right.



NOTE: The pulse output is designed for open loop stepper motor systems. This, plus its minimum velocity of 40 pps make it unsuitable for servo motor control.

Functional Block Diagram

The diagram below shows HSIO functionality in Mode 30. When the lower byte of HSIO Mode register V7633 contains a BCD "30", the pulse output capability in the HSIO circuit is enabled. The pulse outputs use Y0 and Y1 terminals on the output connector. Remember that the outputs can only be DC type to operate.



IMPORTANT NOTE: In Pulse Output Mode, X0, Y0, and Y1 references are redefined or are used differently in two ways. *Physical* references refer to terminal screws, while *logical* references refer to I/O references in the ladder program. Please read the items below to understand this very crucial point.

Notice the I/O point assignment and usage in the above diagram:

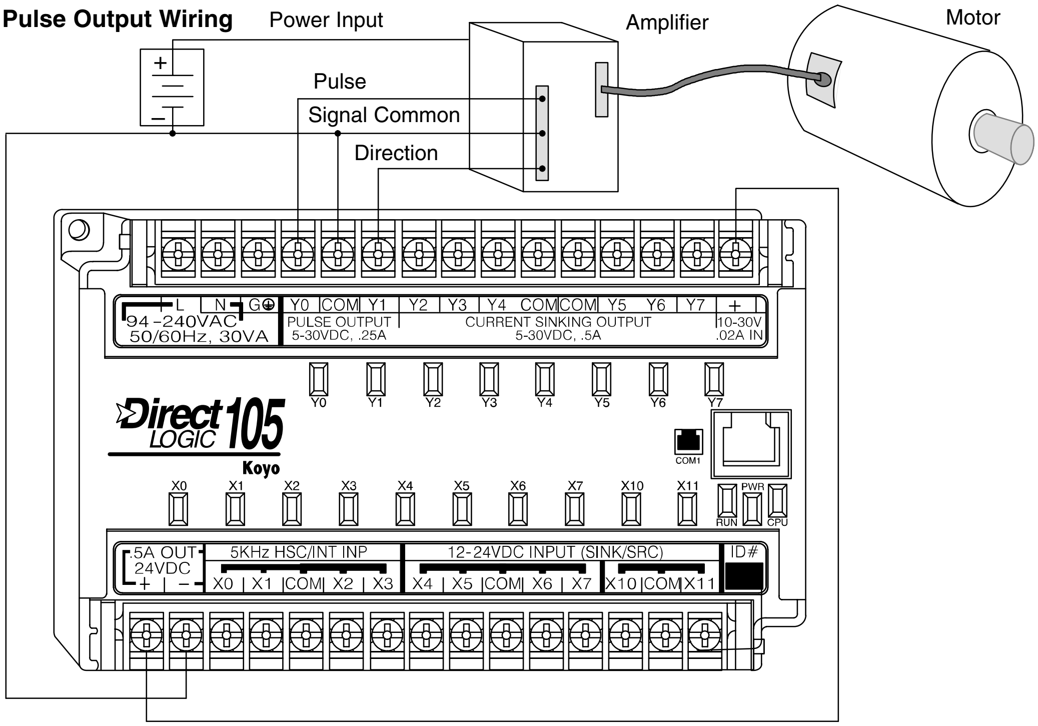
- Physical input X0 is not used, so the terminal screw will not be wired. However, the HSIO function uses logical reference X0 for "Profile Complete" contact, which is available for ladder program use.
- X1 and X3 can only be filtered inputs in Pulse Output Mode, and they are available as input contacts to the ladder program.
- X2 behaves as an external interrupt to the pulse generator for registration profiles. In other profile modes, it can be used as a filtered input just like X1 and X3 (registration mode configuration shown above).
- References "Y0" and "Y1" are used in two different ways. At the output connector, Y0 and Y1 terminals deliver the pulses to the motion system. The ladder program uses logical references Y0 and Y1 to initiate "Start Profile" and "Load Position Value" HSIO functions in Mode 30.

Hopefully, the above discussion will explain why some I/O reference names have dual meanings in Pulse Output Mode. **Please read the remainder of this section with care**, to avoid confusion about which actual I/O function is being discussed.

Wiring Diagram

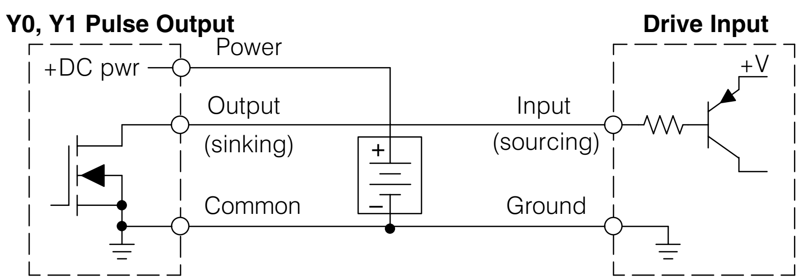
The generalized wiring diagram below shows pulse outputs Y0 and Y1 connected to the drive amplifier inputs of a motion control system.

Pulse Output Wiring

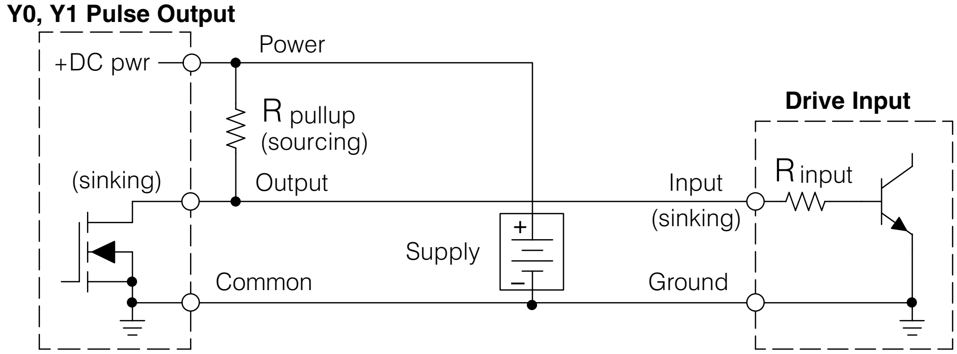


Interfacing to Drive Inputs

The pulse signals from Y0 and Y1 outputs will typically go to drive input circuits as shown above. Remember that the DL105's DC outputs are sinking-only. It will be helpful to locate equivalent circuit schematics of the drive amplifier. The following diagram shows how to interface to a sourcing drive input circuit.



The following circuit shows how to interface to a sinking drive input using a pullup resistor. Please refer to Chapter 2 to learn how to calculate and install R_{pullup}.



Motion Profile Specifications

The motion control profiles generated in Pulse Output Mode have the following specifications:

Parameter	Specification
Profiles	Trapezoidal – Accel Slope / Target Velocity / Decel Slope
	Registration – Velocity to Position Control on Interrupt
	Velocity Control – Speed and Direction only
Position Range	–88388608 to 88388607
Positioning	Absolute / relative command
Velocity Range	40 Hz to 7 kHz
V-memory registers	V2320 to V2325 (Profile Parameter Table)
Current Position	CT76 and CT77 (V1076 and V1077)

Physical I/O Configuration

The configurable discrete I/O options for Pulse Output Mode are listed in the table below. Physical input X0 is not available, because the CPU uses logical X0 contact to sense “profile complete”. Therefore, V7634 is put to another use: selecting pulse/direction or CCW/CW modes for the pulse outputs. Inputs X1 and X3 can only be filtered inputs. Input X2 is dedicated as the external interrupt for use in registration mode.

Physical Input	Configuration Register	Function	Hex Code Required
–	V7634	Y0 = Pulse Y1 = Direction	0103
		Y0 = CW Pulse Y1 = CCW Pulse	0003
X1	V7635	Filtered Input	xx06 (xx = filter time)
X2	V7636	External Interrupt	1006
X3	V7637	Filtered Input	xx06 (xx = filter time)

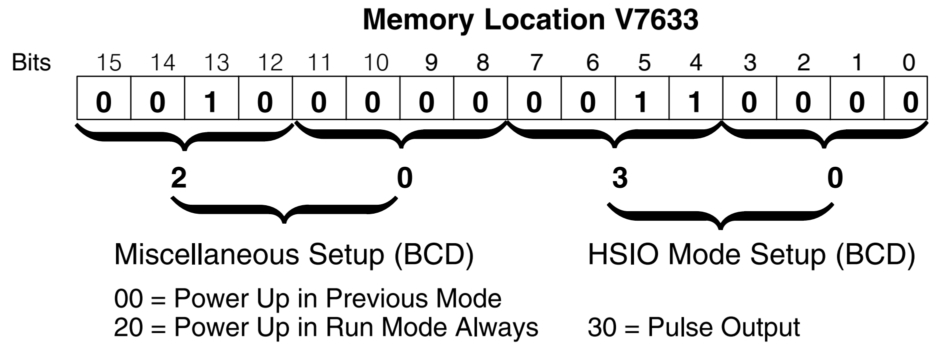
Logical I/O Functions

The following logical I/O references define functions that allow the HSIO to communicate with the ladder program.

Logical I/O	Function
X0	Profile Complete – the HSIO turns on X0 to the CPU when the profile completes. Goes back off when Start Profile (Y0) turns on.
Y0	Start Profile – the ladder program turns on Y0 to start motion. If turned off before the move completes, motion stops. Turning it on again will start another profile, unless the current position equals the target position.
Y1	Preload Position Value – if motion is stopped and Start Profile is off, you can load a new value in CT76/CT77, and turn on Y1. At that transition, the value in CT76/CT77 becomes the current position.

Setup for Mode 30

Recall that V7633 is the HSIO Mode Select register. Refer to the diagram below. Use BCD 30 in the lower byte to select Pulse Output Mode. Use BCD 00 or 20 in the upper byte as required. Combine the two bytes into a data word “xx30”, for writing to V7633.



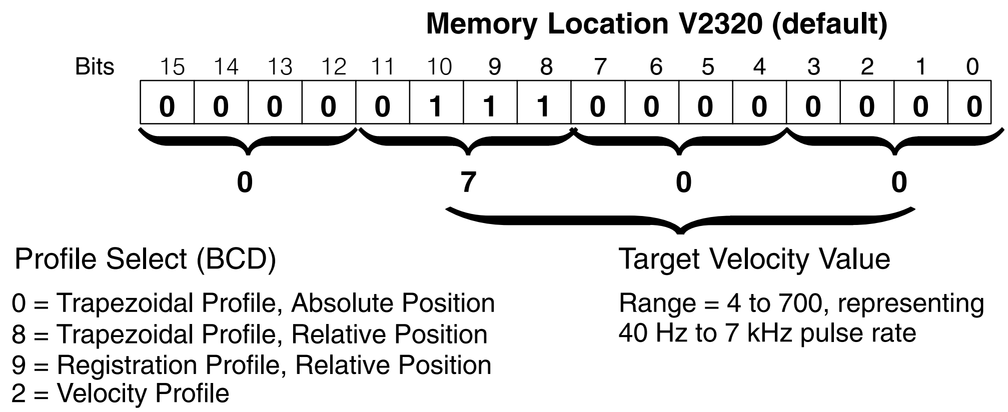
Choose the most convenient method of programming V7633 from the following:

- Include load and out instructions in your ladder program
- ***DirectSOFT32***’s memory editor
- Use the Handheld Programmer D2–HPP

We recommend using the first method above so that the HSIO setup becomes an integral part of your application program. An example program later in this section shows how to to this.

Profile / Velocity Select Register

The first location in the Profile Parameter Table stores two key pieces of information. The upper four bits (12–15) select the type of profile required. The lower 12 bits (0–11) select the Target Velocity.



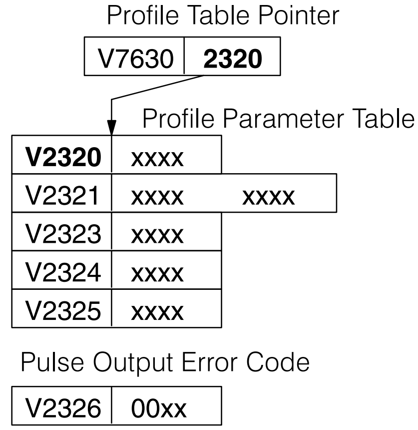
The ladder program must program this location before initiating any of the three profiles. The LD and OUT instruction will write all 16 bits, so be sure to fully specify the full four-digit BCD value for the Position / Velocity Select Register each time.

The absolute and relative selection determines how the HSIO circuit will interpret your specified target position. Absolute position targets are referenced to zero. Relative position targets are referenced to the current position (previous target position). You may choose whichever reference method that is most convenient for your application.

Profile Parameter Table

V7630 is a pointer location which points to the beginning of the Profile Parameter Table. The default starting location for the profile parameter table is V2320. However, you may change this by programming a different value in V7630. Remember to use the LDA (load address) instruction, converting octal into hex.

The HSIO uses the next V-memory register past the bottom of the profile parameter table to indicate profile errors. See the error table at the end of this section for error code definitions.



Trapezoidal Profile

V-Memory	Function	Range	Units
V2320, bits 12–15	Trapezoidal Profile	0=absolute, 8=relative	–
V2320, bits 0–11	Target Velocity Value	4 to 700	x 10 pps
V2321/ 2322	Target Position Value	–88388608 to 88388607	Pulses
V2323	Starting Velocity	4 to 100	x 10 pps
V2324	Acceleration Time	1 to 100	x 100 mS
V2325	Deceleration Time	1 to 100	x 100 mS
V2326	Error Code	(see end of section)	–

Registration Profile

V-Memory	Function	Range	Units
V2320, bits 12–15	Registration Profile	9=relative	–
V2320, bits 0–11	Target Velocity Value	4 to 700	x 10 pps
V2321/ 2322	Target Position Value	–88388608 to 88388607	Pulses
V2323	Starting Velocity	4 to 100	x 10 pps
V2324	Acceleration Time	1 to 100	x 100 mS
V2325	Deceleration Time	1 to 100	x 100 mS
V2326	Error Code	(see end of section)	–

Velocity Profile

V-Memory	Function	Range	Units
V2320	Velocity Profile	2000 only	–
V2321/ 2322	Direction Select	80000000=CCW, 0=CW	Pulses
V2323	Velocity	4 to 700	x 10 pps
V2326	Error Code	(see end of section)	–

Choosing the Profile Type

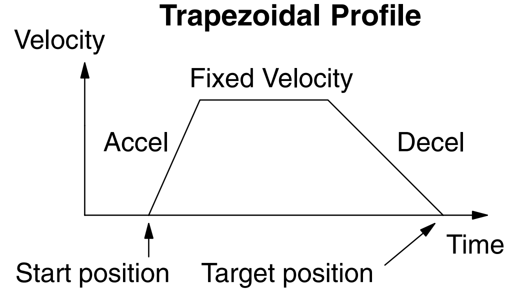
Pulse Output Mode generates three types of motion profiles. Most applications use one type for most moves. However, each move can be different if required.

- Trapezoidal – Accel Slope to Target Velocity to Decel Slope
- Registration – Velocity to Position Control on Interrupt
- Velocity Control – Speed and Direction only

Trapezoidal Profile Defined

The trapezoidal profile is the most common positioning profile. It moves the load to a pre-defined target position by creating a move profile. The acceleration slope is applied at the starting position. The deceleration slope is applied backwards from the target position. The remainder of the move in the middle is spent traveling at a defined velocity.

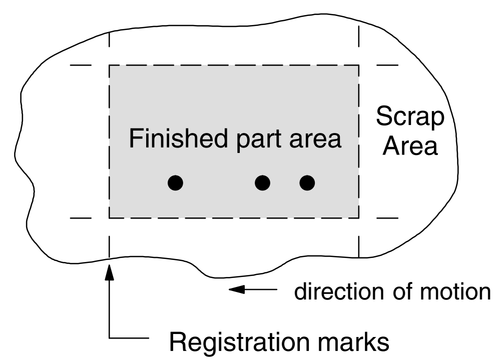
Trapezoidal Profile



Trapezoidal profiles are best for simple point-to-point moves, when the distance between the starting and ending positions of the move is known in advance.

Registration and Home Search Profiles Defined

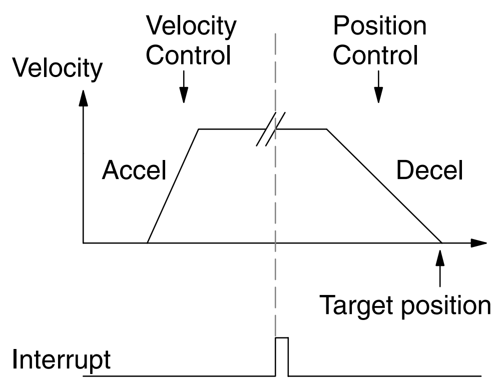
Registration profiles solve a class of motion control problems. In some applications, product material in work moves past a work tool such as a drill station. Shown to the right, registration marks on the scrap area of the work-piece allow a machine tool to register its position relative to the rectangle, to drill properly.



Home search moves allow open-loop motion systems to re-calibrate (preload) the current position value at powerup.

Registration profiles are a combination of velocity and position control modes. The move begins by accelerating to a programmed velocity. The velocity is sustained and the move is of indefinite duration. When an external interrupt signal occurs (due to registration sensing), the profile switches from velocity to position control. The move ends by continuing motion a pre-defined distance past the interrupt point (such as a drill hole location). The deceleration ramp is applied in advance of the target position.

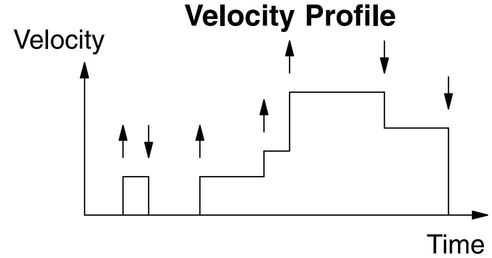
Registration Profile



Velocity Profile Defined

The velocity profile controls only the direction and speed of motion. There is no target position specified, so the move can be of indefinite length. Only the first velocity value needs to be defined. The remaining velocity values can be created while motion in in progress. Arrows in the profile shown indicate velocity changes.

Velocity Profile

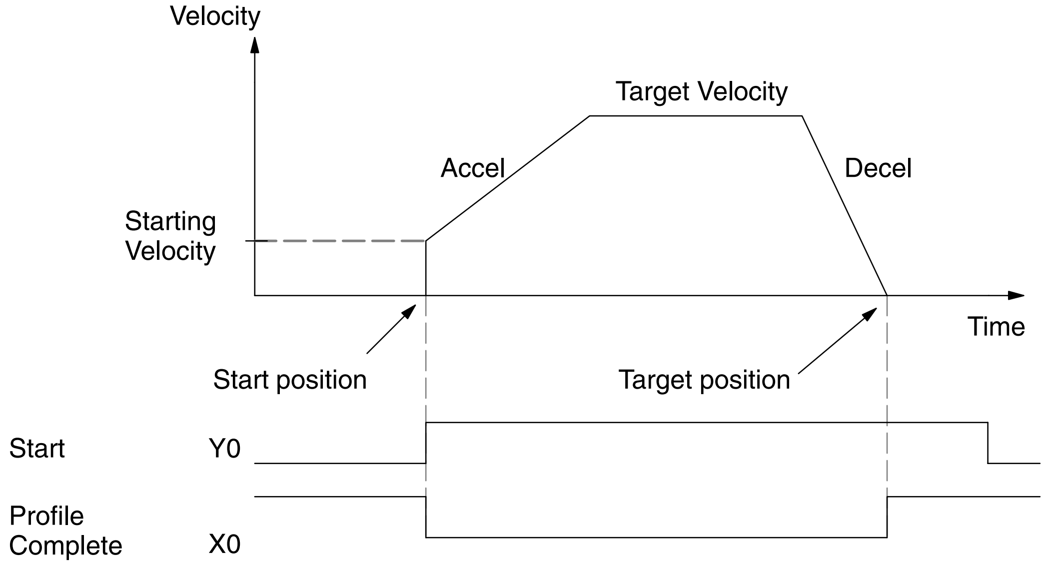


Trapezoidal Profile Operation

Trapezoidal Profile Applications

The trapezoidal profile is best suited for simple point-to-point moves, when the target position is known in advance. Starting velocities must be within the rage of 40 pps to 1 kpps. The remainder of the profile parameters are in the profile parameter table.

Trapezoidal Profile



The time line of signal traces below the profile indicates the order of events.

The HSIO uses logical output Y0 as the Start input to the HSIO, which starts the profile. Immediately the HSIO turns off the Profile Complete signal (logical X0), so the ladder program can monitor the progress of the move. Typically a ladder program will monitor this bit so it knows when to initiate the next profile move.

If you are familiar with motion control, you'll notice that we do not have to specify the direction of the move. The HSIO function examines the target position relative to the current position, and automatically outputs the correct direction information to the motor drive.

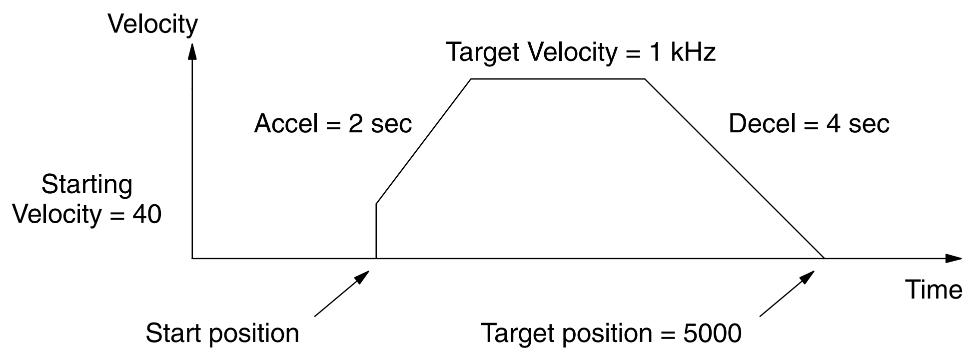
Notice that the motion accelerates immediately to the starting velocity. This segment is useful in stepper systems so we can jump past low speed areas when low-torque problems or a resonant point in the motor might cause a stall. (When a stepper motor stalls, we have lost the position of the load in open-loop positioning systems). However, is is preferable not to make the starting velocity too large, because the stepper motor will also “slip” some pulses due to the inertia of the system.

When you need to change the current position value, use logical Y1 output coil to load a new value into the HSIO counter. If the ladder program loads a new value in CT76/CT77 (V1076/V1077), then energizing Y1 will copy that value into the HSIO circuit counter. This must occur before the profile begins, because the HSIO ignores Y1 during motion.

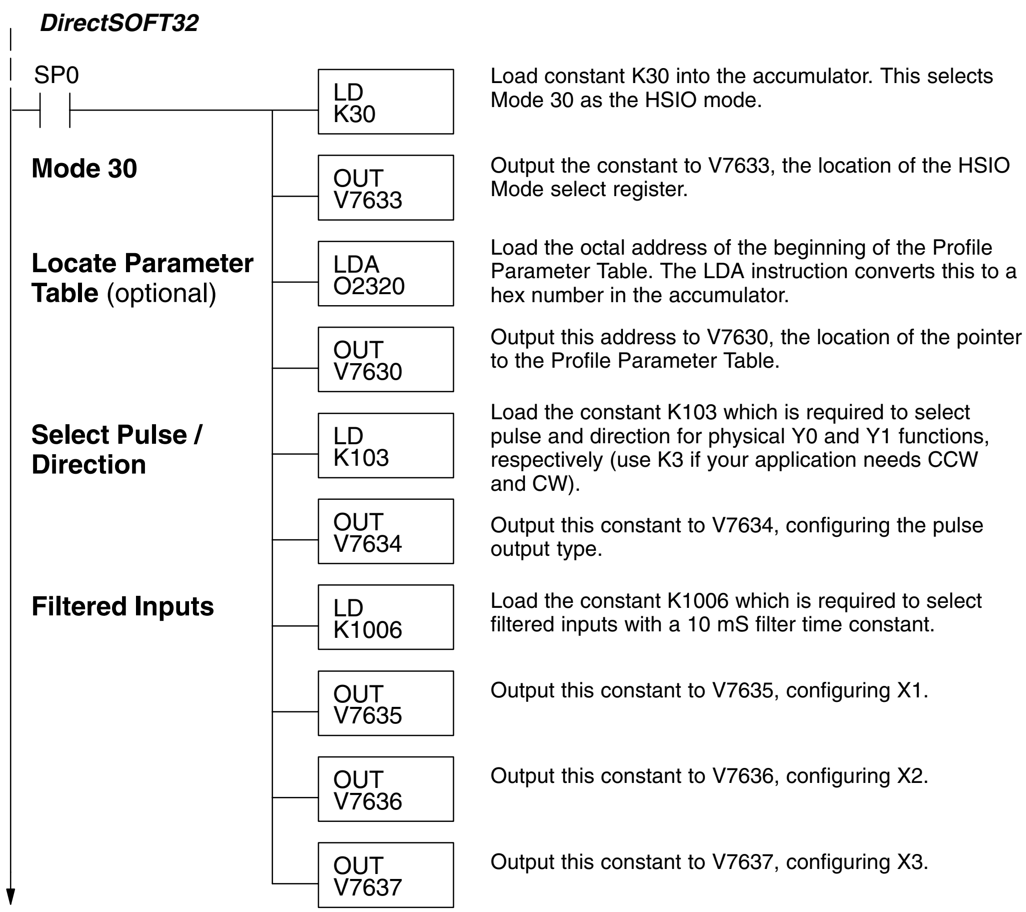
Trapezoidal Profile Program Example

The trapezoidal profile we want to perform is drawn and labeled in the following figure. It consists of a non-zero starting velocity, and moderate target velocity.

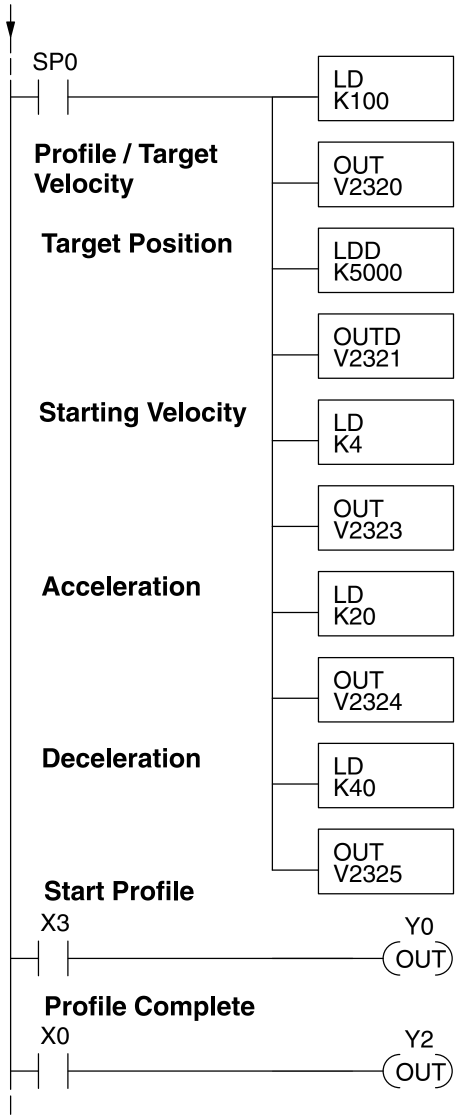
Trapezoidal Profile



The following program will realize the profile drawn above, when executed. The beginning of the program contains all the necessary setup parameters for Pulse Output Mode 30. We only have to do this once in the program, so we use first-scan contact SP0 to trigger the setup.



Program Example Cont'd



Load the constant K100 which is required to select Trapzoidal Profile, absolute positioning, and a target velocity of 1 kHz.

Output this constant to V2320, the location of the Profile Select / Starting Velocity setup register.

Load the constant K5000 which selects a target position of 5000 pulses. Don't forget to use double word size (8-digit BCD position value).

Output this constant to V2321 and V2322, the location of the Target Position double-word register.

Load the constant K4 which is required to select a starting velocity of 40 Hz (4 x 10 pps).

Output this constant to V2323, the location of the starting velocity parameter register.

Load the constant K20 which is required to select an acceleration time of 2 seconds (20 x 100 mS).

Output this constant to V2324, the location of the acceleration parameter register.

Load the constant K40 which is required to select a deceleration time of 4 seconds (40 x 100 mS).

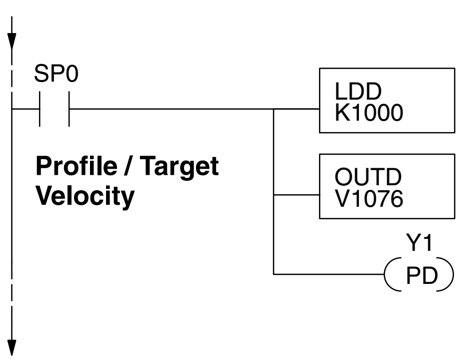
Output this constant to V2325, the location of the deceleration parameter register.

We use a spare filtered input to allow the operator to start the profile. When the operator turns X3 ON, then OFF, logical output Y0 starts the profile.

X0 is the logical output of the HSIO to indicate the move is complete. We use Y2 to energize an annunciator that the profile has finished.

Preload Position Value

At any time you can write (preload) a new position into the current position value. This often done after a home search (see the registration example programs).



Load the constant K1000 as the new current position value.

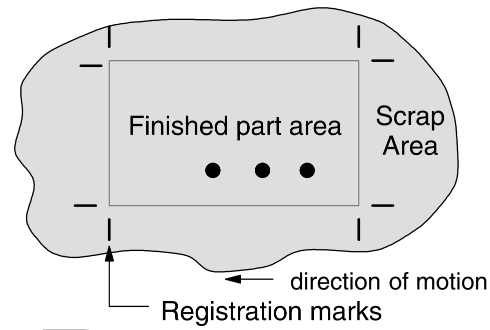
Output this constant to V1076/V1077 (CTA76/CTA77). the location of the current position value.

Turn on Y1 for 1 scan. The off-to-on transition causes the HSIO to preload the current position with the value in

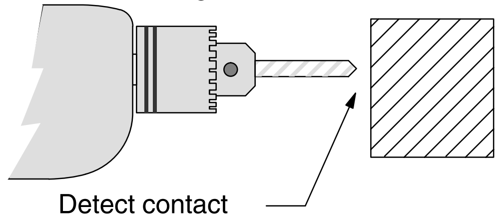
Registration Profile Operation

Registration Applications

1. In a typical application shown to the right, product material in work moves past a work tool such as a drill. Registration marks on the scrap area of the work-piece allow a machine tool to register its position relative to the rectangle, to drill properly.



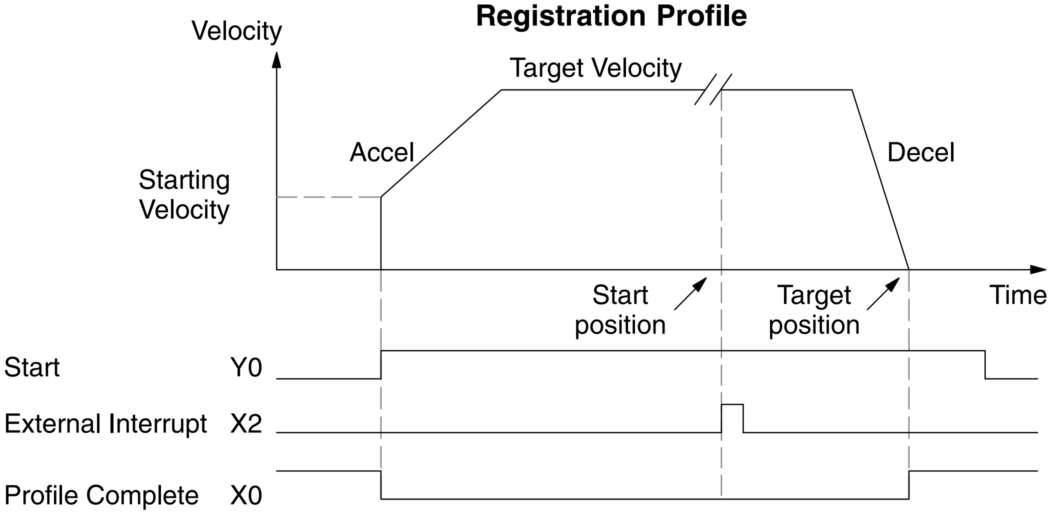
2. In other examples of registration, the work piece is stationary and the tool moves. A drill bit may approach the surface of a part in work, preparing to drill a hole of precise depth. However, the drill bit length gradually decreases due to tool wear. A method to overcome this is to detect the moment of contact with the part surface on each drill, moving the bit into the part a constant distance after contact.



3. The home search move allows a motion system to calibrate its position on startup. In this case, the positioning system makes an indefinite move and waits for the load to pass by a home limit switch. This creates an interrupt at the moment when the load is in a known position. We then stop motion and preload the position value with a number which equates to the physical “home position”.

The registration profile begins with only velocity control. When an interrupt pulse occurs on physical input X2, the starting position is declared to be the present count (current load position). The velocity control switches to position control, moving the load to the target position. Note that the minimum starting velocity is 40 pps. This instantaneous velocity accommodates stepper motors that can stall at low speeds.

Registration Profile

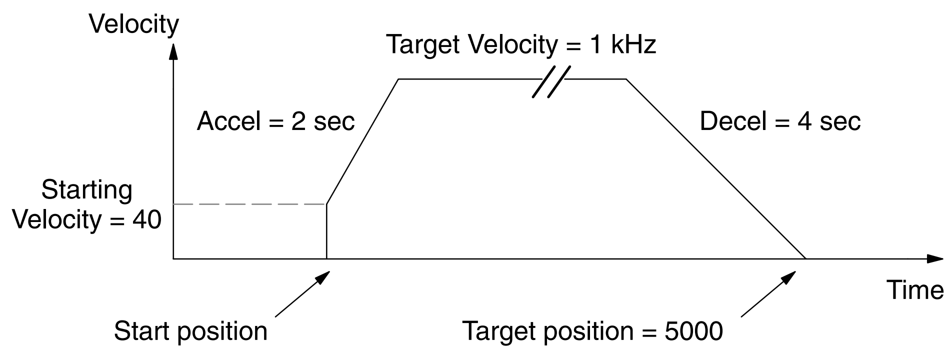


The time line of signal traces below the profile indicates the order of events. The CPU uses logical output Y0 to start the profile. Immediately the HSIO turns off the Profile Complete signal (logical X0), so the ladder program can monitor the move’s completion by sensing the signal’s on state.

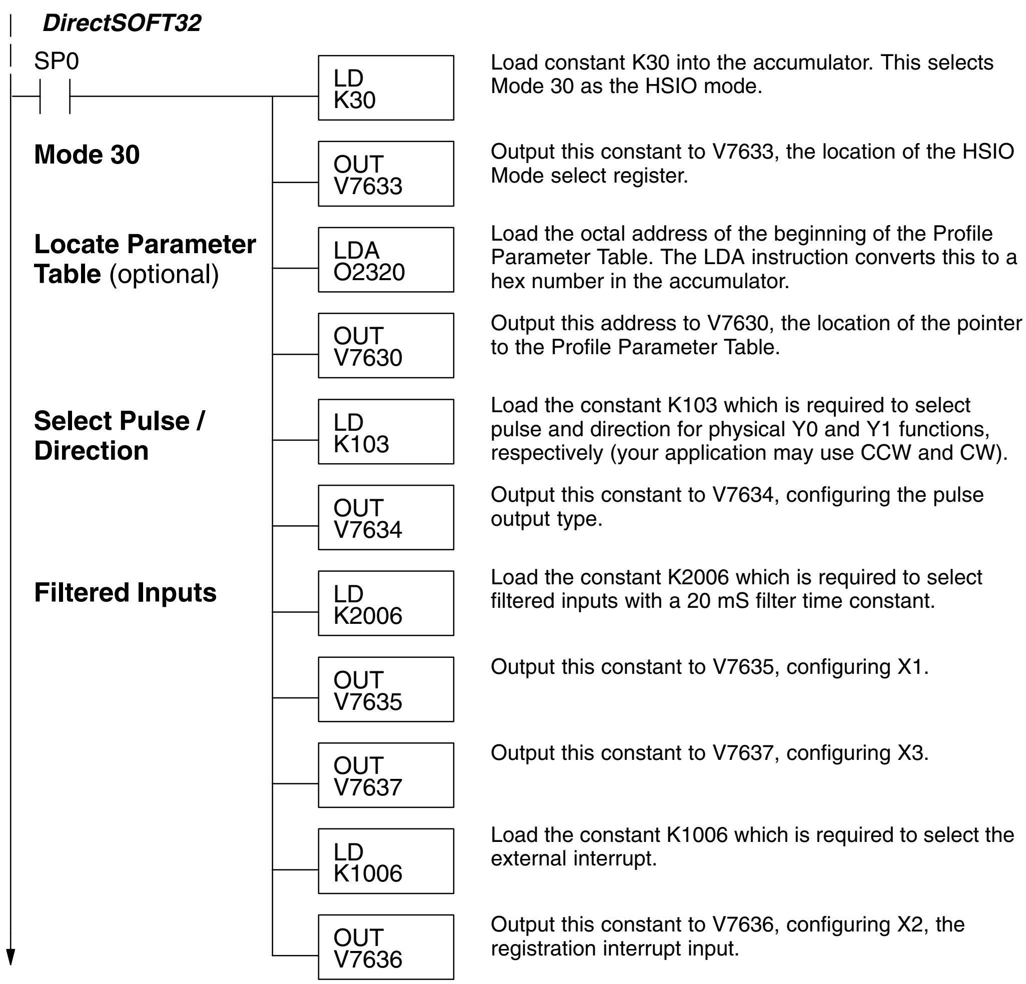
Registration Profile Program Example

The registration profile we want to perform is drawn and labeled in the following figure. It consists of a non-zero starting velocity, and moderate target velocity.

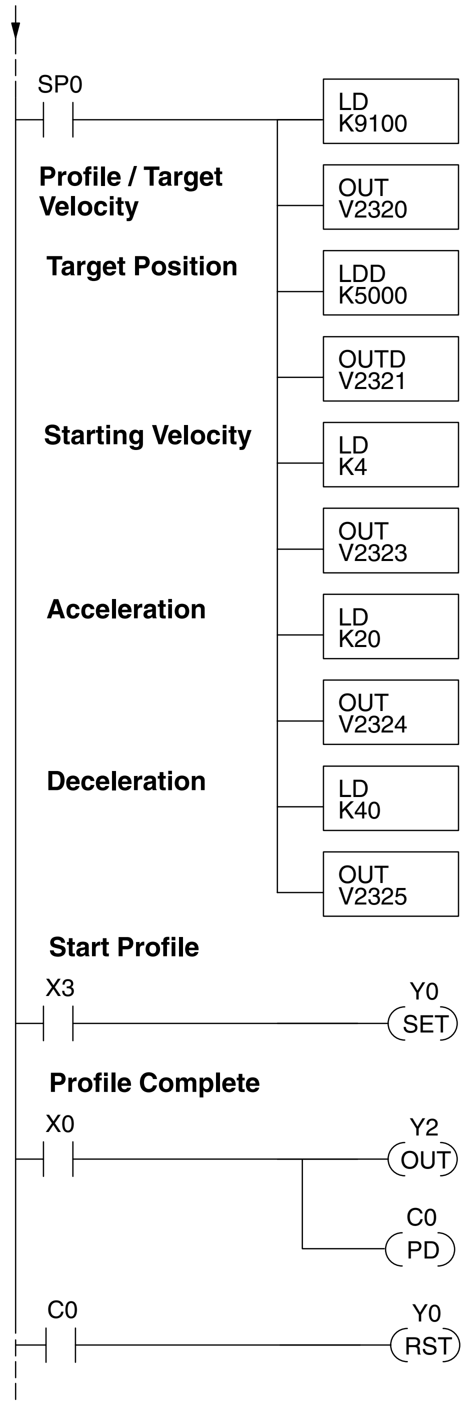
Registration Profile



The following program will realize the profile drawn above, when executed. The first program rung contains all the necessary setup parameters. We only have to do this once in the program, so we use first-scan contact SP0 to trigger the setup.



Program Example Cont'd



Load the constant K9100 which is required to select Registration Profile, relative positioning, and a target velocity of 1 kHz (9xxx times 10 pps).

Output this constant to V2320, the location of the Profile Select / Starting Velocity setup register.

Load the constant K5000 which selects a target position of 5000 pulses. Don't forget to use double word size (8-digit BCD position value).

Output this constant to V2321 and V2322, the location of the Target Position double-word register.

Load the constant K4 which is required to select a starting velocity of 40 Hz (4 x 10 pps).

Output this constant to V2323, the location of the starting velocity parameter register.

Load the constant K20 which is required to select an acceleration time of 2 seconds (20 x 100 mS).

Output this constant to V2324, the location of the acceleration parameter register.

Load the constant K40 which is required to select a deceleration time of 4 seconds (40 x 100 mS).

Output this constant to V2325, the location of the deceleration parameter register.

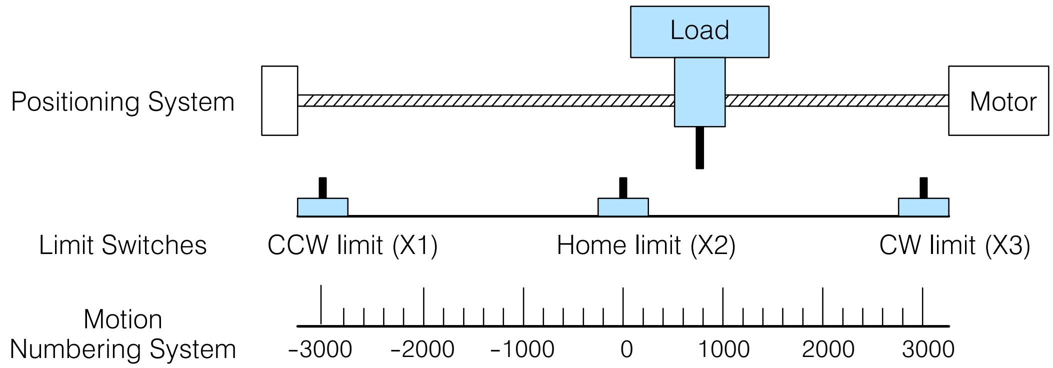
We use a spare filtered input to allow the operator to start the profile. X3 is a momentary Start switch. When the operator turns X3 ON, logical output Y0 starts the profile.

X0 is the logical output of the HSIO to indicate the move is complete. We use Y2 to energize an annunciator that the profile has finished. This won't occur until after the interrupt from X2 has occurred and the profile is complete.

The profile will begin when the start input (X3) is given. Then the motion begins an indefinite move, which lasts until an external interrupt on X2 occurs. Then the motion continues on for 5000 more pulses before stopping.

Home Search Program Example

One of the more challenging aspects of motion control is the establishment of actual position at powerup. This is especially true for open-loop systems which do not have a position feedback device. However, a simple limit switch located at an exact location on the positioning mechanism can provide “position feedback” at one point. For most stepper control systems, this method is a good and economical solution.

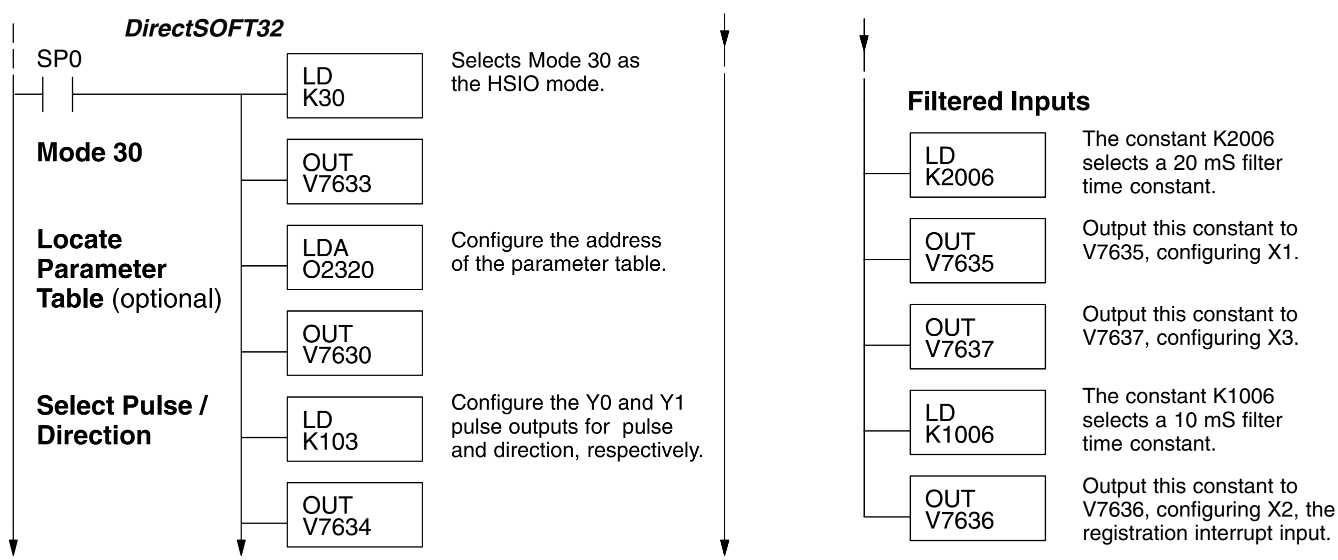


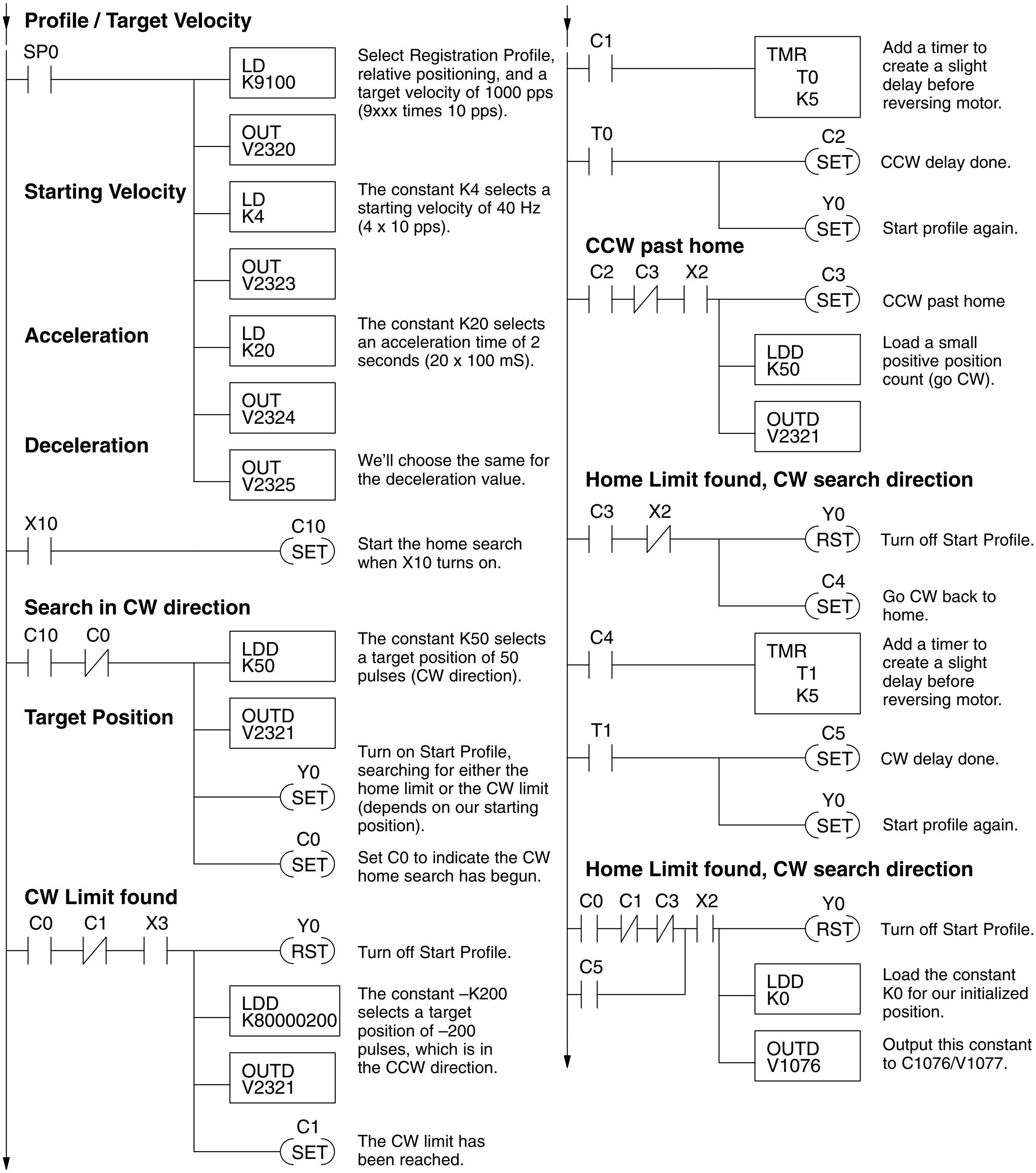
In the drawing above, the load moves left or right depending on the CCW/CW direction of motor rotation. The PLC ladder program senses the CCW and CW limit switches to stop the motor, before the load moves out-of-bounds and damages the machine. The home limit switch is used at powerup to establish the actual position. The numbering system is arbitrary, depending on a machine’s engineering units.

At powerup, we do not know whether the load is located to the left or to the right of the home limit switch. Therefore, we will initiate a *home search profile*, using the registration mode. The home limit switch is wired to X2, causing the interrupt. We choose an arbitrary initial search direction, moving in the CW (left-to-right) direction.

- If the home limit switch closes first, then we stop and initialize the position (this value is typically “0”, but it may be different if preferred).
- However, if the CW limit switch closes first, we must reverse the motor and move until the home limit switch closes, stopping just past it.

In the latter case, we repeat the first move, because we always need to make the final approach to the home limit switch *from the same direction*, so that the final *physical* position is the same in either case!





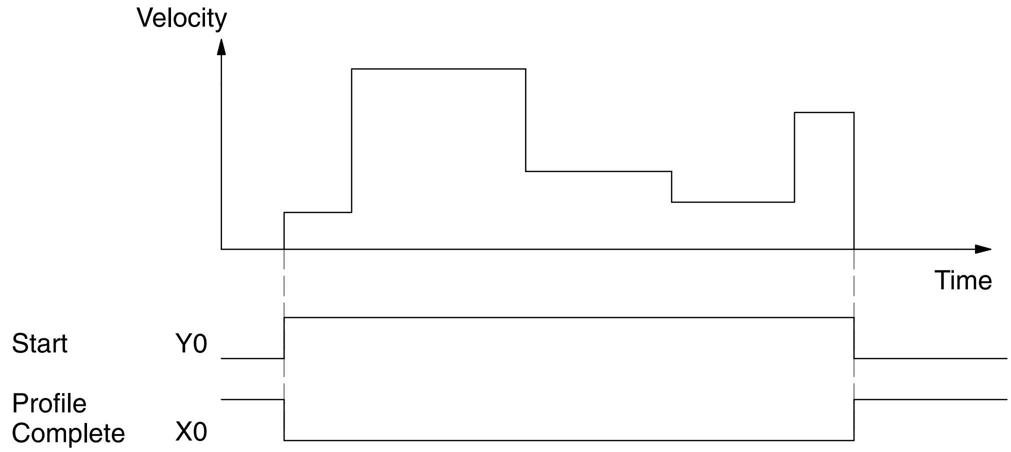
The home search profile will execute specific parts of the program, based on the order of detection of the limit switches. Ladder logic sets C0 to initiate a home search in the CW direction. If the CW limit is encountered, the program searches for home in the CCW direction, passes it slightly, and does the final CW search for home. After reaching home, the last ladder rung preloads the current position to "0".

Velocity Profile Operation

Velocity Profile Applications

The velocity profile is best suited for applications which involve motion but do not require moves to specific points. Conveyor speed control is a typical example.

Velocity Profile



The time line of signal traces below the profile indicates the order of events. Assuming the velocity is set greater than zero, motion begins when the Start input (Y0) energizes. Since there is no end position target, the profile is considered in progress as long as the Start input remains active. The profile complete logical input to ladder logic (X0) correlates directly to the Start input status when velocity profiles are in use.

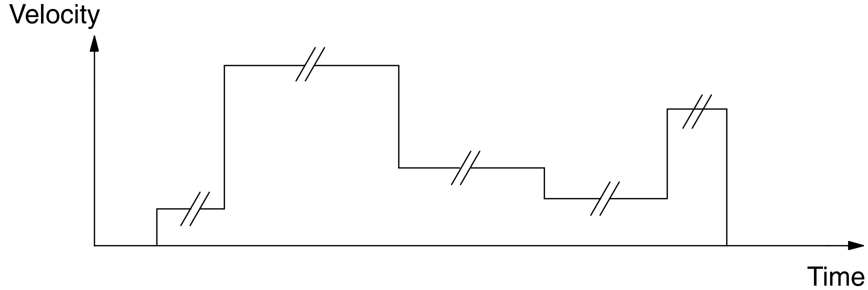
While the Start input is active, the ladder program can command a velocity change by writing a new value to the velocity register (V2323 by default). The full speed range of 40 Hz to 7 kHz is available. Notice from the drawing that there are no acceleration or deceleration ramps between velocity updates. This is how velocity profiling works with the HSIO. However, the ladder program can command more gradual velocity changes by incrementing or decrementing the velocity value more slowly. A counter or timer can be useful in creating your own acceleration/deceleration ramps. Unless the load must do a very complex move, it is easier to let the HSIO function generate the accel/decel ramps by selecting the trapezoidal or registration profiles instead.

Unlike the trapezoidal and registration profiles, you must specify the desired direction of travel with velocity profiles. Load the direction select register (V2321/V2322 by default) with 8000 0000 hex for CCW direction, or 0 for CW direction.

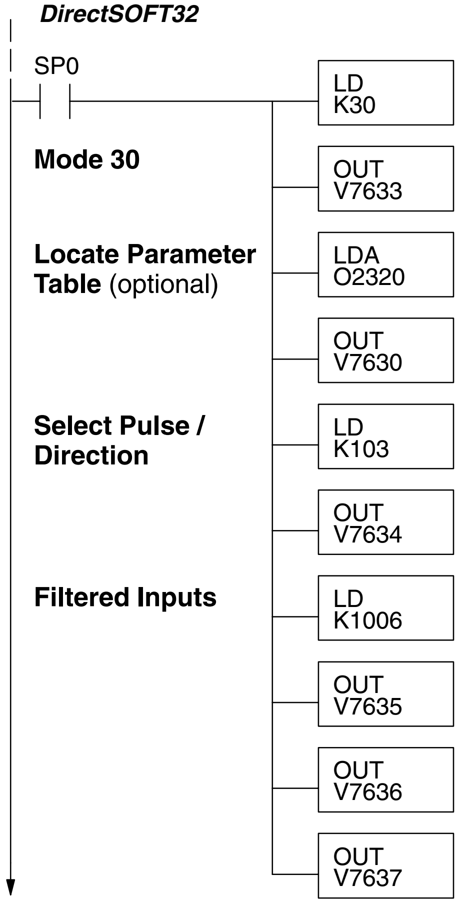
Velocity Profile Program Example

The velocity profile we want to perform is drawn and labeled in the following figure. Each velocity segment is of indefinite length. The velocity only changes when ladder logic (or other device writing to V-memory) updates the velocity parameter.

Velocity Profile



The following program uses dedicated discrete inputs to load in new velocity values. This is a fun program to try, because you can create an infinite variety of profiles with just two or three input switches. The intent is to turn on only one of X1, X2, or X3 at a time. The beginning of the program contains all the necessary setup parameters for Pulse Output Mode 30. We only have to do this once in the program, so we use first-scan contact SP0 to trigger the setup.



Load constant K30 into the accumulator. This selects Mode 30 as the HSIO mode.

Output this constant to V7633, the location of the HSIO Mode select register.

Load the octal address of the beginning of the Profile Parameter Table. The LDA instruction converts this to hex number in the accumulator.

Output this address to V7630, the location of the pointer to the Profile Parameter Table.

Load the constant K103 which is required to select pulse and direction for physical Y0 and Y1 functions, respectively (your application may use CCW and CW).

Output this constant to V7634, configuring the pulse output type.

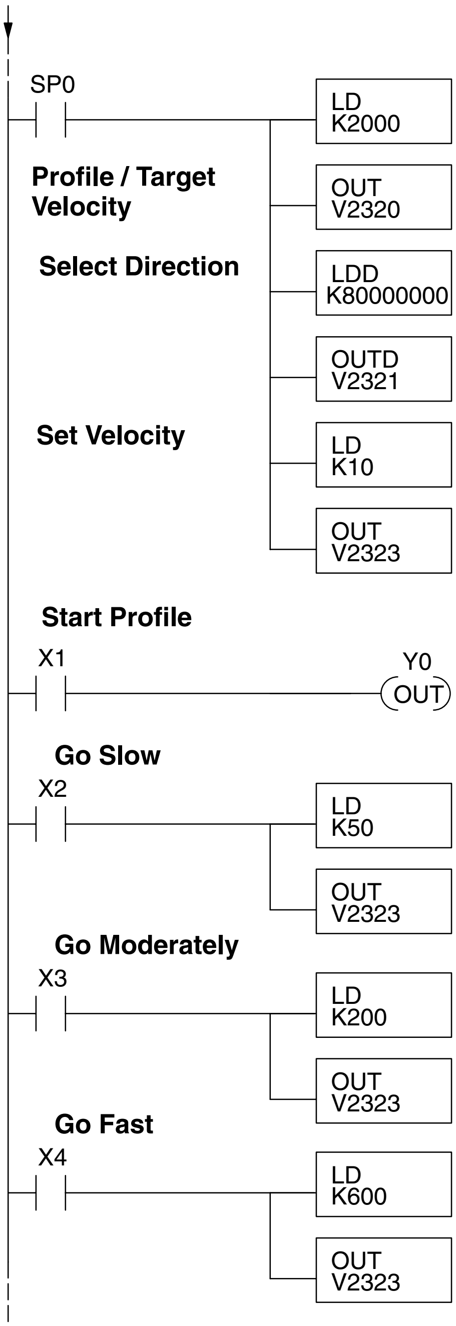
Load the constant K1006 which is required to select filtered inputs with a 10 mS filter time constant.

Output this constant to V7635, configuring X1.

Output this constant to V7636, configuring X2.

Output this constant to V7637, configuring X3.

Program Example Cont'd



Load the constant K2000 which is required to select Velocity Profile. This data word contains no velocity information in the case of velocity mode.

Output this constant to V2320, the location of the Profile Select setup register.

Load the constant K80000000 which selects CCW direction for Velocity Profiles. Don't forget to use double word size (8-digit BCD position value).

Output this constant to V2321 and V2322, the location of the Target Position double-word register.

Load the constant K10 which is required to select an initial velocity of 100 pps (uses x10 multiplier).

Output this constant to V2323, the location of the velocity parameter register. After the program is running, we can write here again, using discrete input switches.

We use a spare filtered input to allow the operator to start the profile. When the operator turns X1 ON and leaves it on, logical output Y0 starts the profile.

Load the constant K50 which is required to select a velocity of 500 pps when the operator closes X2.

Output this constant to V2323, the location of the velocity parameter register. The speed will change immediately.

Load the constant K200 which is required to select a velocity of 2000 pps when the operator closes X3.

Output this constant to V2323, the location of the velocity parameter register. The speed will change immediately.

Load the constant K600 which is required to select a velocity of 6000 pps when the operator closes X4.

Output this constant to V2323, the location of the velocity parameter register. The speed will change immediately.

Pulse Output Error Codes

The Profile Parameter Table starting at V2320 (default location) defines the profile. Certain numbers will result in a error when the HSIO attempts to use the parameters to execute a move profile. When an error occurs, the HSIO writes an error code in V2326.

Error Code	Error Description
0000	No error
0010	Requested profile type code is invalid (must use 0, 1, 2, 8, or 9)
0020	Target Velocity is not in BCD
0021	Target Velocity is specified to be less than 40 pps
0022	Target Velocity is specified to be greater than 7,000 pps
0030	Target Position value is not in BCD
0040	Starting Velocity is not in BCD
0041	Starting Velocity is specified to be less than 40 pps
0042	Starting Velocity is specified to be greater than 1,000 pps
0050	Acceleration Time is not in BCD
0051	Acceleration Time is zero
0052	Acceleration Time is greater than 10 seconds
0010	Deceleration Time is not in BCD
0010	Deceleration Time is zero
0010	Deceleration Time is greater than 10 seconds

Most errors can be corrected by rechecking the Profile Parameter Table values. The error is automatically cleared at powerup and at Program-to-Run Mode transitions.

Troubleshooting Guide for Mode 30

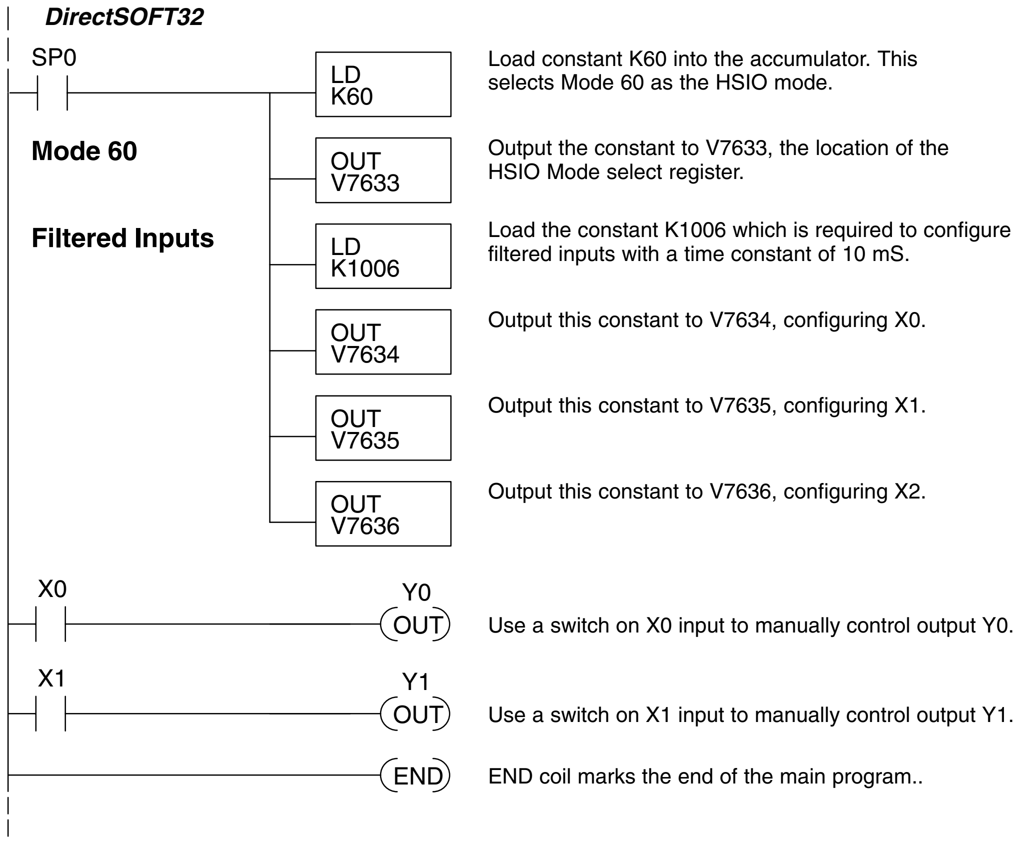
If you're having trouble with Mode 30 operation, please study the following symptoms and possible causes. The most common problems are listed below:

Symptom: The stepper motor does not rotate.

Possible causes:

1. **Configuration** – Verify that the HSIO actually generates pulses on outputs Y0 and Y1. Watch the status LEDs for Y0 and Y1 when you start a motion profile. If the LEDs flicker on and off or are steadily on, the configuration is probably correct.
2. **Programming error** – If there are no pulses on Y0 or Y1 you may have a programming error. Check the contents of V2326 for an error code that may be generated when the PLC attempts to do the move profile. Error code descriptions are given above.

3. **Wiring** – Verify the wiring to the stepper motor is correct. Remember the signal ground connection from the PLC to the motion system is required.
4. **Motion system** – Verify that the drive is powered and enabled. To verify the motion system is working, you can use Mode 60 operation (normal PLC inputs/outputs) as shown in the test program below. With it, you can manually control Y0 and Y1 with X0 and X1, respectively. Using an input simulator is ideal for this type of manual debugging. With the switches you can single-step the motor in either direction. If the motor will not move with this simple control, Mode 30 operation will not be possible until the problem with the motor drive system or wiring is corrected.



5. **Memory Error** – HSIO configuration parameters are stored in the CPU system memory. Corrupted data in this memory area can sometimes interfere with proper HSIO operation. If all other corrective actions fail, initializing the scratchpad memory may solve the problem. With ***Direct***SOFT32, select the *PLC* menu, then *Setup*, then *Initialize Scratchpad*.

Symptom: The motor turns in the wrong direction.

Possible causes:

1. **Wiring** – If you have selected CW and CCW type operation, just swap the wires on Y0 and Y1 outputs.
2. **Direction control** – If you have selected Pulse and Direction type operation, just change the direction bit to the opposite state.

Mode 40: High-Speed Interrupts

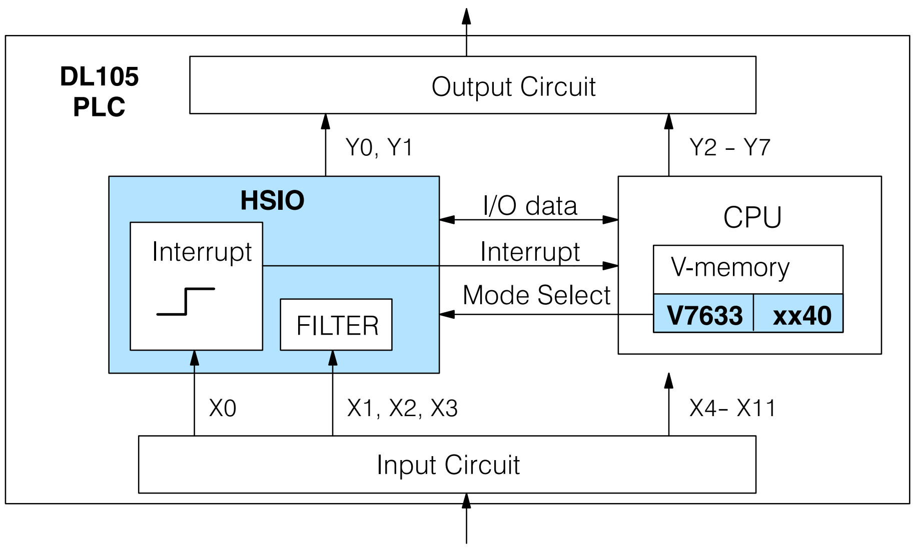
Purpose

The HSIO Mode 40 provides a high-speed interrupt to the ladder program. This capability is provided for your choice of the following application scenarios:

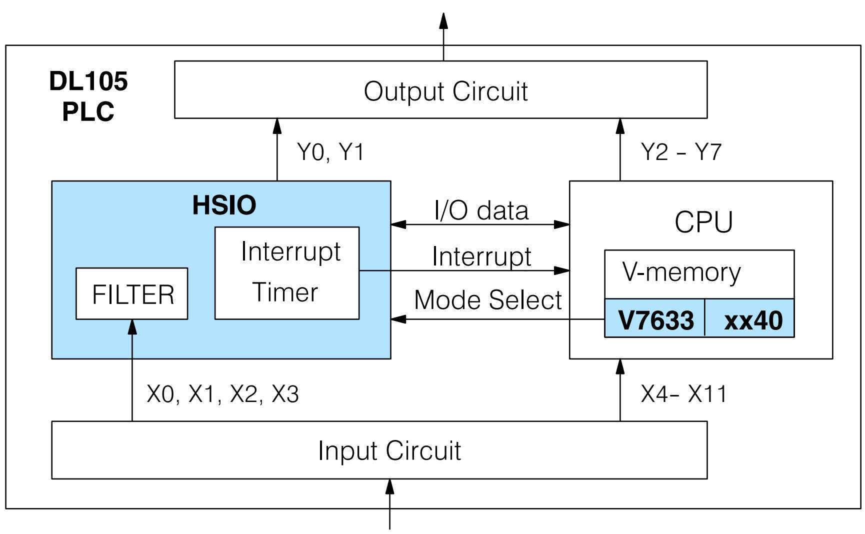
- An external event needs to trigger an interrupt subroutine in the CPU. Using immediate I/O instructions in the subroutine is typical.
- An interrupt routine needs to occur on a timed basis which is different from the CPU scan time (either faster or slower). The timed interrupt is programmable, from 5 to 999 mS.

Functional Block Diagram

The HSIO circuit creates the high-speed interrupt to the CPU. The following diagram shows the external interrupt option, which uses X0. In this configuration, X1, X2, and X3 are all normal filtered inputs.



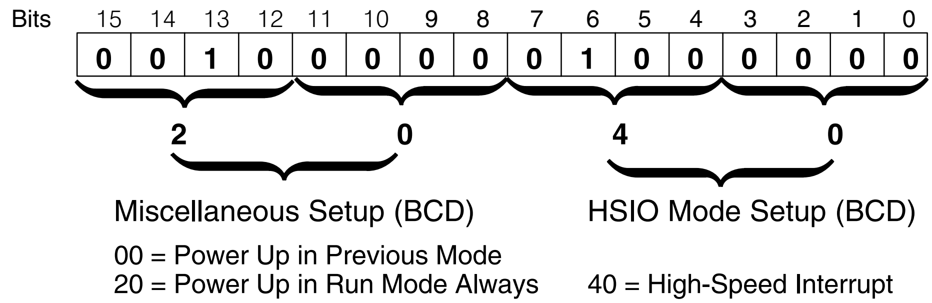
Alternately, you may configure the HSIO circuit to generate interrupts based on a timer, as shown below. In this configuration, inputs X0 through X3 are filtered inputs.



Setup for Mode 40

Recall that V7633 is the HSIO Mode Select register. Refer to the diagram below. Use BCD 40 in the lower byte to select High-Speed Interrupt Mode. Use BCD 00 or 20 in the upper byte as required. Combine the two bytes into a data word “xx40”, for writing to V7633.

Memory Location V7633



Choose the most convenient method of programming V7633 from the following:

- Include load and out instructions in your ladder program
- ***Direct***SOFT32’s memory editor
- Use the Handheld Programmer D2–HPP

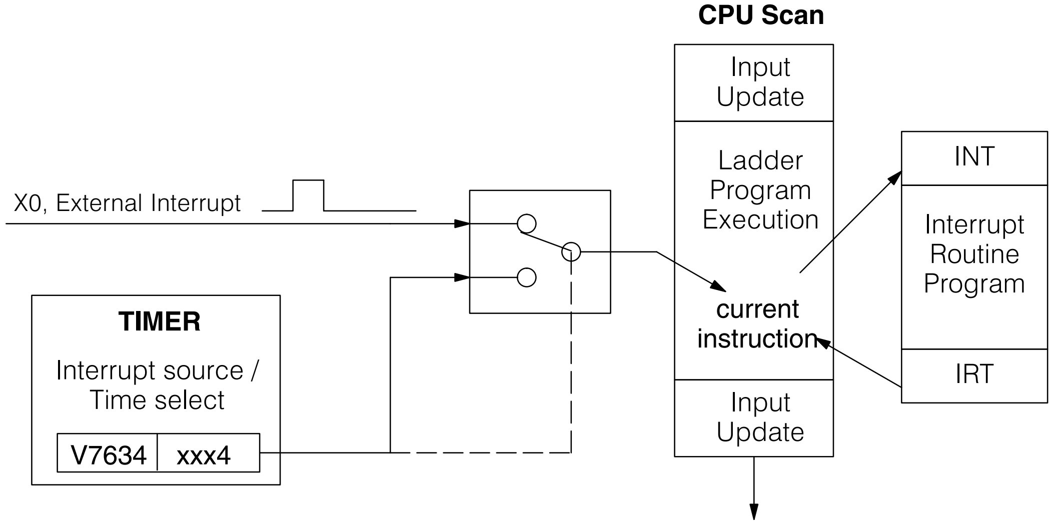
We recommend using the first method above so that the HSIO setup becomes an integral part of your application program. An example program later in this section shows how to to this.

Interrupts and the Ladder Program

Refer to the drawing below. The source of the interrupt may be external (X0), or the HSIO timer function. The setup parameter in V7634 serves a dual purpose:,

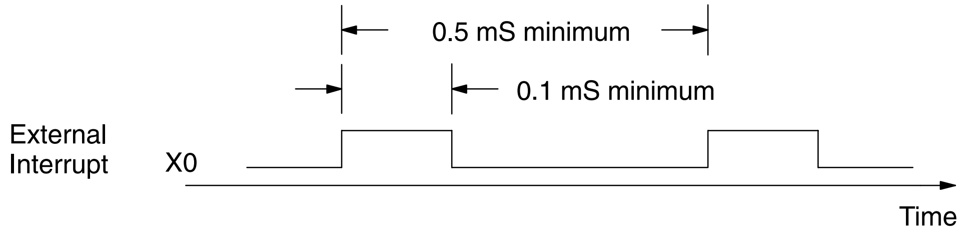
- It selects between the two interrupt sources, external (X0) or an internal timer.
- In the case of the timer interrupt, it programs the interrupt timebase between 5 and 999 mS.

The resulting interrupt uses label INT 0 in the ladder program. Be sure to include the Enable Interrupt (ENI) instruction at the beginning of your program. Otherwise, the interrupt routine will not be executed.



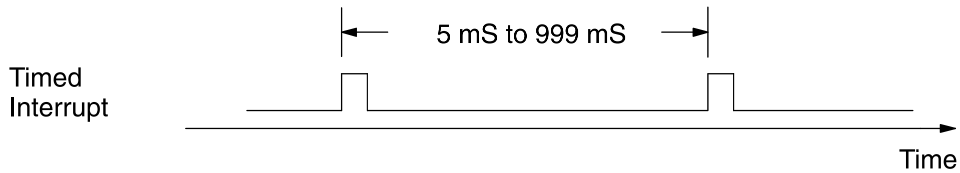
External Interrupt Timing Parameters

Signal pulses at X0 must meet certain timing criteria to guarantee an interrupt will result. Refer to the timing diagram below. The input characteristics of X0 are fixed (it is not a programmable filtered input). The minimum pulse width is 0.1 mS. There must be some delay before the next interrupt pulse arrives, such that the interrupt period cannot be smaller than 0.5 mS.



Timed Interrupt Parameters

When the timed interrupt is selected, the HSIO generates the interrupt to ladder logic. There is no interrupt “pulse width” in this case, but the interrupt period can be adjusted from 5 to 999 mS.



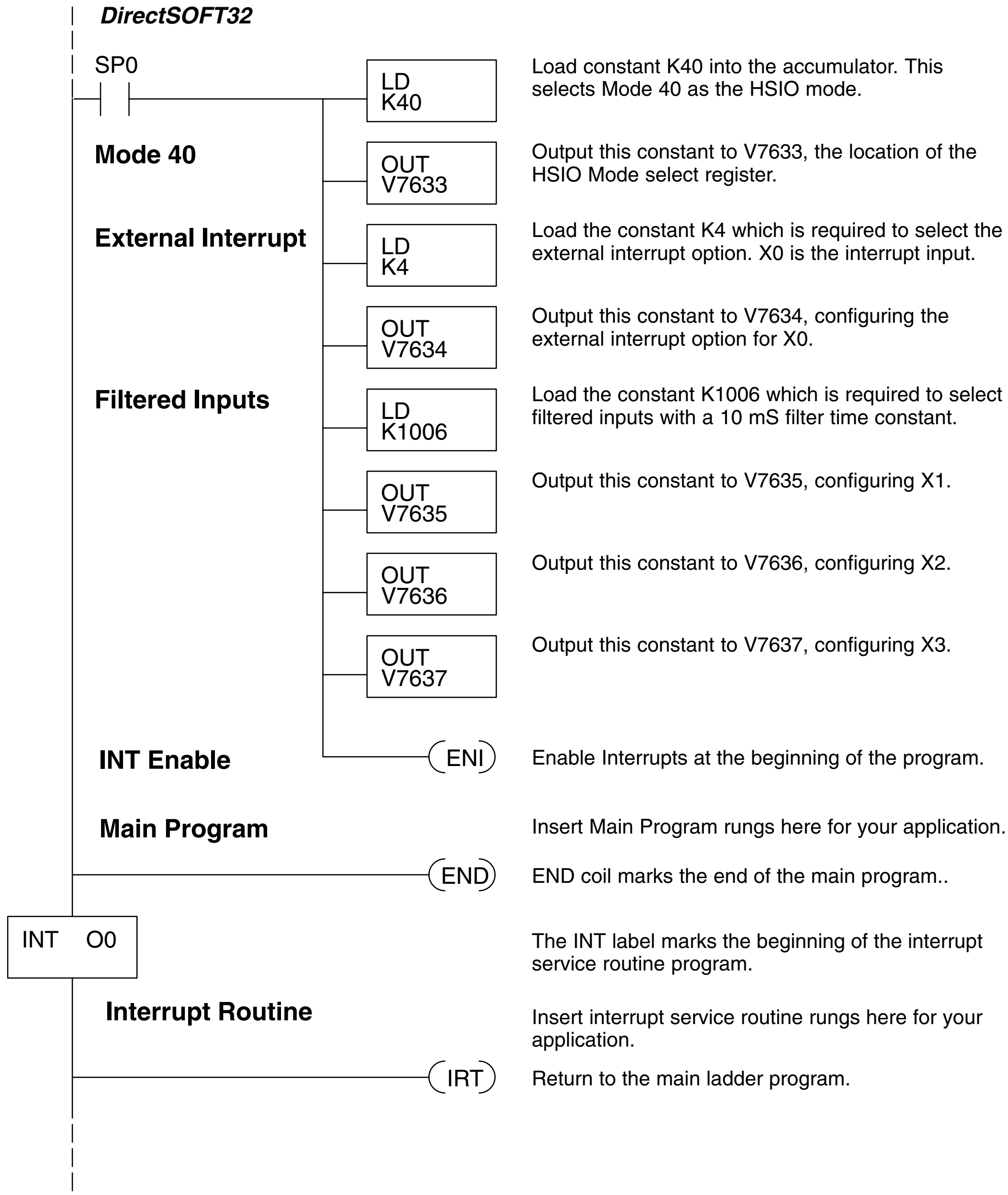
X Input / Timed INT Configuration

The configurable discrete input options for High-Speed Interrupt Mode are listed in the table below. Input X0 is the external interrupt when “0004” is in V7634. If you need a timed interrupt instead, then V7634 contains the interrupt time period, and input X0 becomes a filtered input (uses X1’s filter time constant by default). Inputs X1, X2, and X3 can only be filtered inputs, having individual configuration registers and filter time constants. However, X0 will have the same filter time constant as X1 when the timed interrupt is selected.

Input	Configuration Register	Function	Hex Code Required
X0	V7634	External Interrupt	0004
	Uses X1’s code in V7635	Filtered Input (when timed interrupt is in use)	0054 to 9994, which is the timed INT timebase
X1	V7635	Filtered Input	xx06 (xx = filter time)
X2	V7636	Filtered Input	xx06 (xx = filter time)
X3	V7637	Filtered Input	xx06 (xx = filter time)

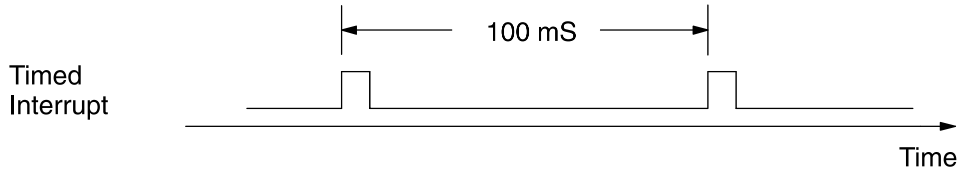
External Interrupt Program Example

The following program selects Mode 40, then selects the external interrupt option. Inputs X1, X2, and X3 are all configured as filtered inputs with a 10 mS time constant. The program is otherwise generic, and may be adapted to your application.

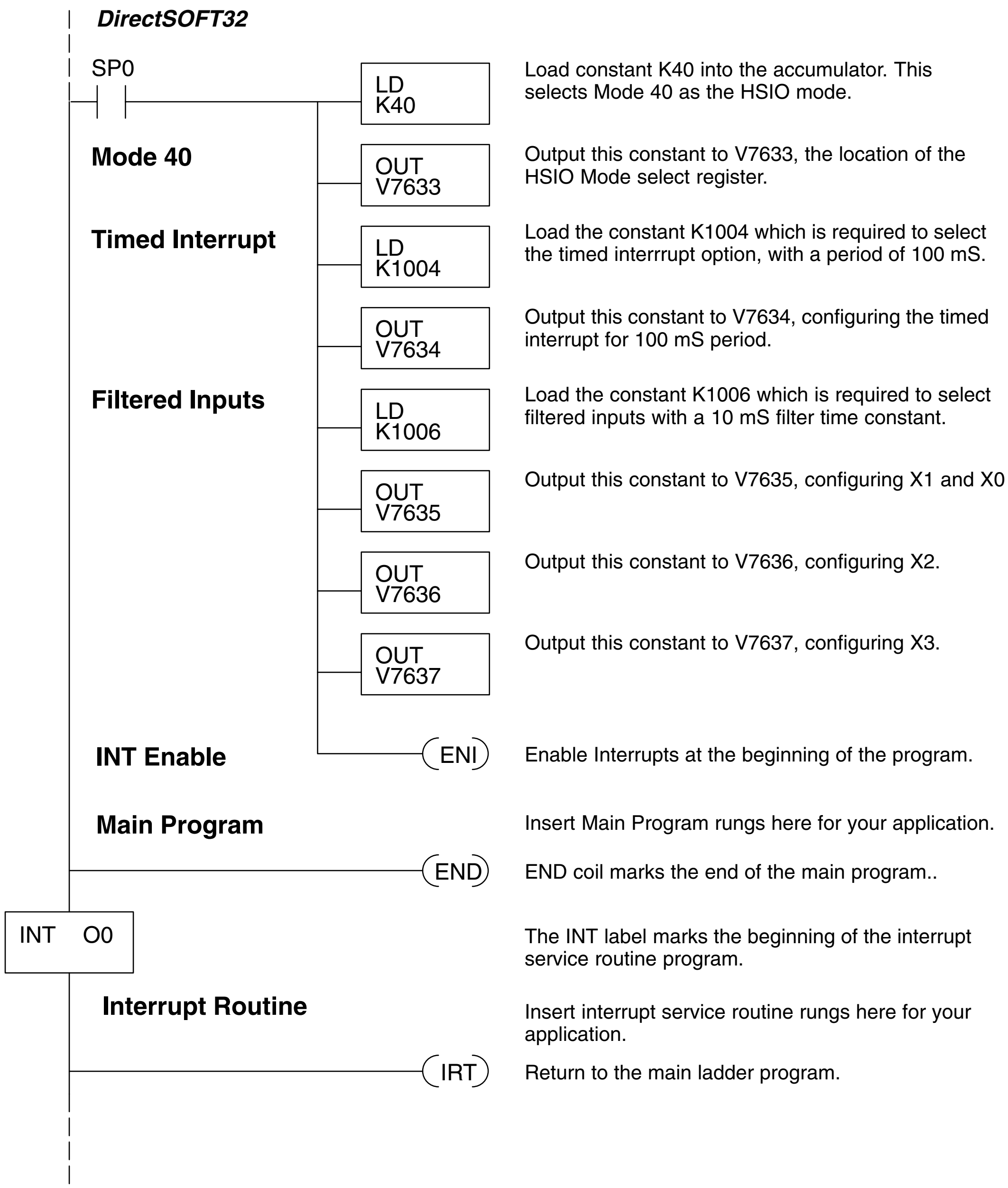


Timed Interrupt Program Example

The following program selects Mode 40, then selects the timed interrupt option, with an interrupt period of 100 mS.



Inputs X0, X1, X2, and X3 are all configured as filtered inputs with a 10 mS time constant. Note that X0 uses the time constant from X1. The program is otherwise generic, and may be adapted to your application.



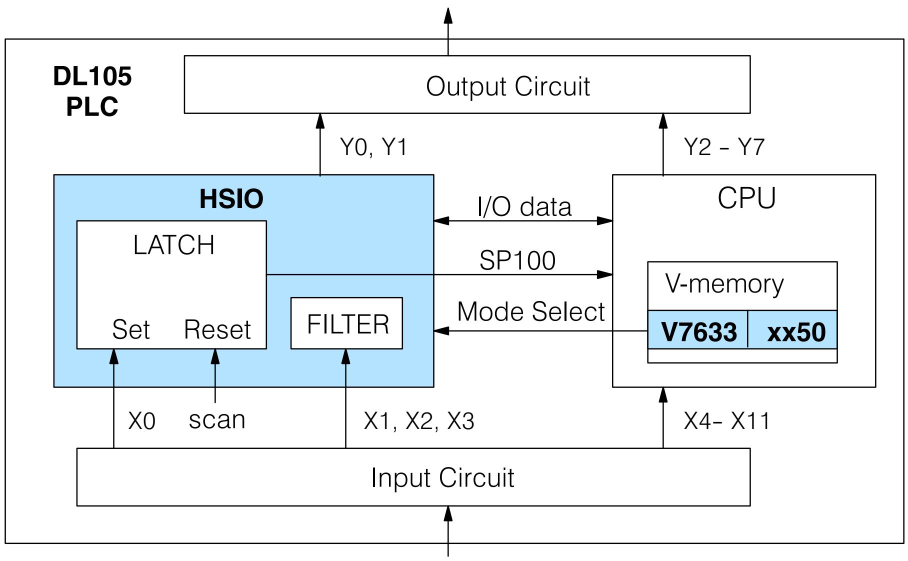
Mode 50: Pulse Catch Input

Purpose

The HSIO circuit has a pulse-catch mode of operation. It monitors the signal on input X0, preserving the occurrence of a narrow pulse. The purpose of the pulse catch mode is to enable the ladder program to "see" an input pulse which is shorter in duration than the current scan time. The HSIO circuit latches the input event on input X0 for one scan, and presents it to ladder logic through special relay SP100 contact. This contact automatically goes off after one scan. *Note that the ladder program cannot read the status of X0 directly.*

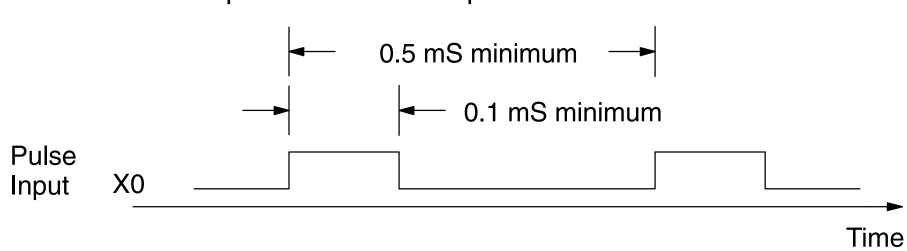
Functional Block Diagram

Refer to the block diagram below. When the lower byte of HSIO Mode register V7633 contains a BCD "50", the pulse catch mode in the HSIO circuit is enabled. X0 automatically becomes the pulse catch input, which sets the latch on each rising edge. The HSIO resets the latch at the end of the next CPU scan. The latch output is available to the ladder program through the special relay contact SP100. Inputs X1, X2, and X3 are available as filtered discrete inputs.



Pulse Catch Timing Parameters

Signal pulses at X0 must meet certain timing criteria to guarantee a pulse capture will result. Refer to the timing diagram below. The input characteristics of X0 are fixed (it is not a programmable filtered input). The minimum pulse width is 0.1 mS. There must be some delay before the next pulse arrives, such that the pulse period cannot be smaller than 0.5 mS. If the pulse period is smaller than 0.5 mS, the next pulse will be considered part of the current pulse.

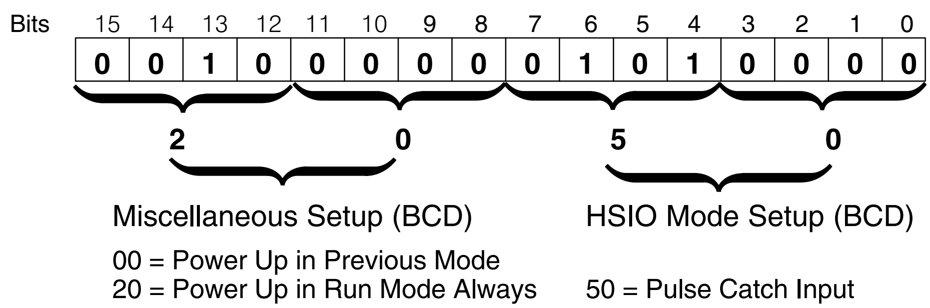


Note that the pulse catch and filtered input functions are opposite in nature. The pulse catch feature on X0 seeks to *capture* narrow pulses, while the filter input feature on X1, X2, and X3 seeks to *reject* narrow pulses.

Setup for Mode 50

Recall that V7633 is the HSIO Mode Select register. Refer to the diagram below. Use BCD 50 in the lower byte to select High-Speed Counter Mode. Use BCD 00 or 20 in the upper byte as required. Combine the two bytes into a data word “xx50”, for writing to V7633.

Memory Location V7633



Choose the most convenient method of programming V7633 from the following:

- Include load and out instructions in your ladder program
- ***Direct***SOFT32’s memory editor
- Use the Handheld Programmer D2–HPP

We recommend using the first method above so that the HSIO setup becomes an integral part of your application program. An example program later in this section shows how to to this.

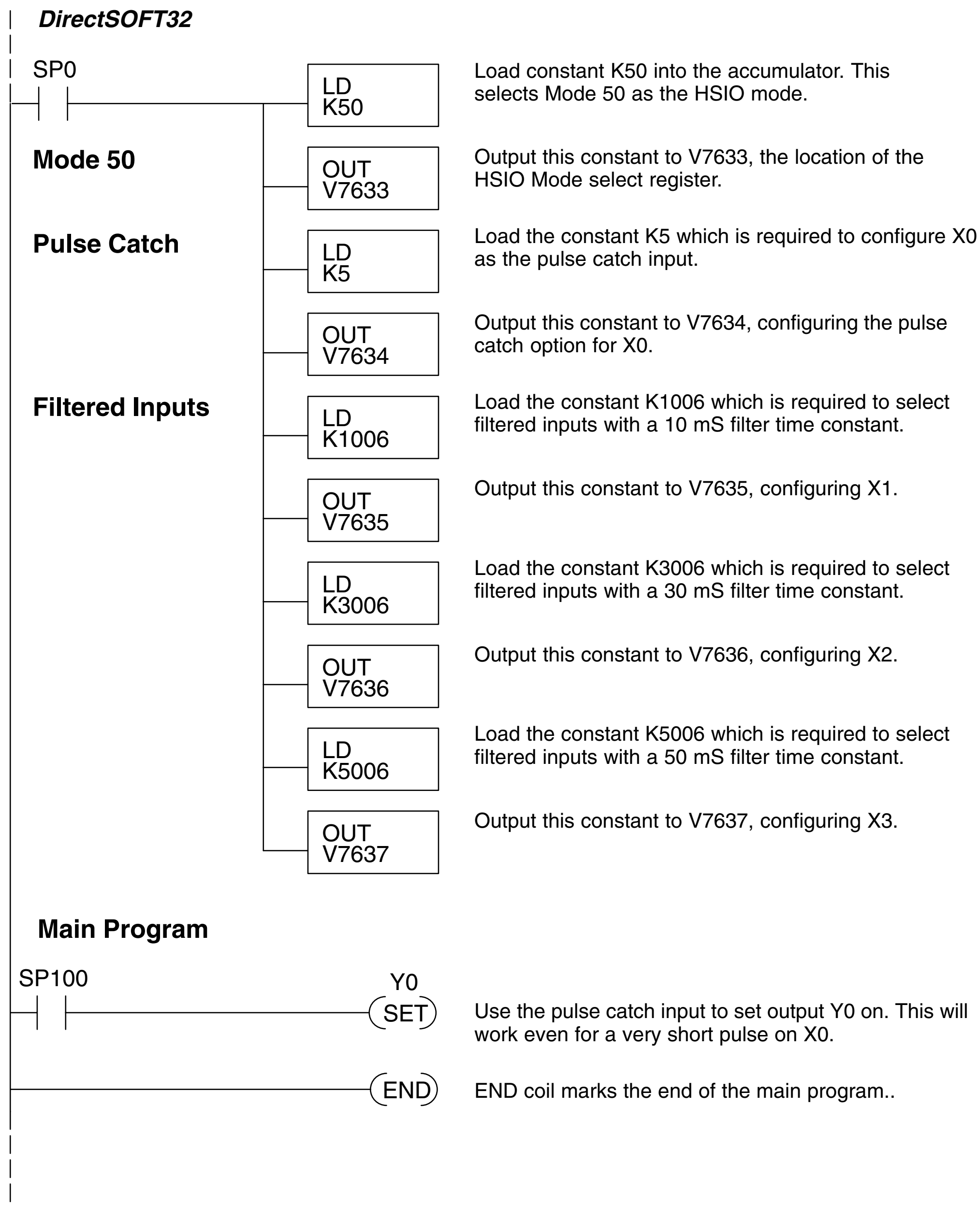
X Input Configuration

The configurable discrete input options for Pulse Catch Mode are listed in the table below. Input X0 is the pulse input, and must have “0005” loaded into it configuration register V7634. Inputs X1, X2, and X3 can only be filtered inputs. Each input has its own configuration register and filter time constant.

Input	Configuration Register	Function	Hex Code Required
X0	V7634	Pulse Catch Input	0005
X1	V7635	Filtered Input	xx06 (xx = filter time)
X2	V7636	Filtered Input	xx06 (xx = filter time)
X3	V7637	Filtered Input	xx06 (xx = filter time)

Pulse Catch Program Example

The following program selects Mode 50, then programs the pulse catch code for X0. Inputs X1, X2, and X3 are all configured as filtered inputs with 10, 30, and 50 mS time constants respectively. The program is otherwise generic, and may be adapted to your application.



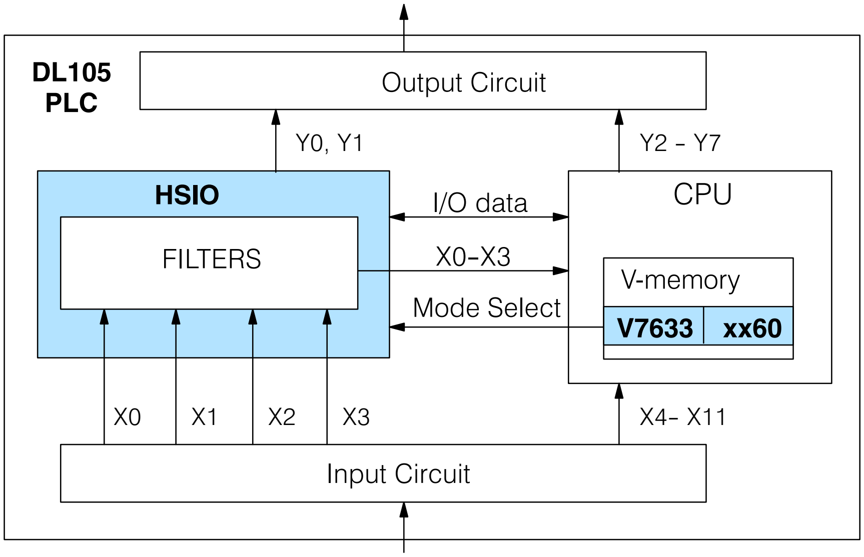
Mode 60: Discrete Inputs with Filter

Purpose

The last mode we will discuss for the HSIO circuit is Mode 60, Discrete Inputs with Filter. The purpose of this mode is to allow the input circuit to reject narrow pulses and accept wide ones, as viewed from the ladder program. This is useful in especially noisy environments or other applications where pulse width is important. In all other modes in this chapter, X0 to X3 usually support the mode functions as special inputs. Only spare inputs operate as filtered inputs by default. Now in Mode 60, all four inputs X0 through X3 function only as discrete filtered inputs.

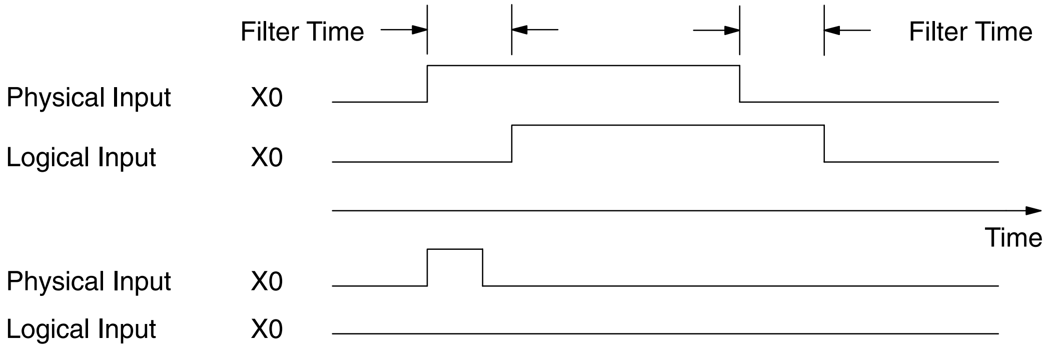
Functional Block Diagram

Refer to the block diagram below. When the lower byte of HSIO Mode register V7633 contains a BCD “60”, the input filter in the HSIO circuit is enabled. Each input X0 through X3 has its own filter time constant. The filter circuit assigns the outputs of the filters as logical references X0 through X3.



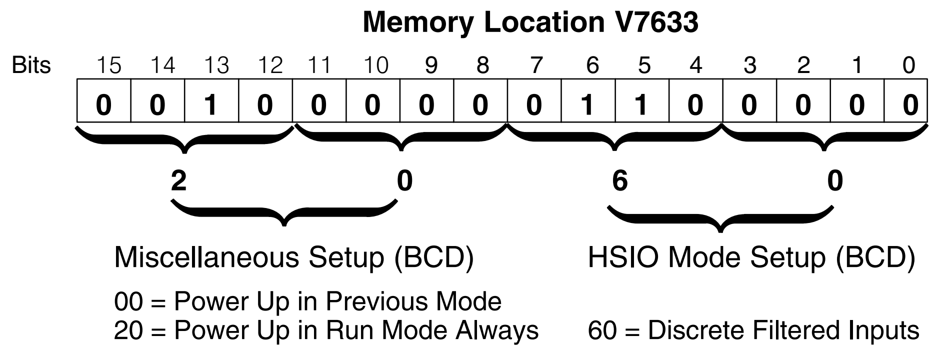
Input Filter Timing Parameters

Signal pulses at inputs X0 – X3 are filtered by using a delay time. In the figure below, the input pulse on the top line is longer than the filter time. The resultant logical input to ladder is phase-shifted (delayed) by the filter time on both rising and falling edges. In the bottom waveforms, the physical input pulse width is smaller than the filter time. In this case, the logical input to the ladder program remains in the OFF state (input pulse was filtered out).



Setup for Mode 60

Recall that V7633 is the HSIO Mode Select register. Refer to the diagram below. Use BCD 60 in the lower byte to select High-Speed Counter Mode. Use BCD 00 or 20 in the upper byte as required. Combine the two bytes into a data word “xx60”, for writing to V7633.



Choose the most convenient method of programming V7633 from the following:

- Include load and out instructions in your ladder program
- ***DirectSOFT32***’s memory editor
- Use the Handheld Programmer D2–HPP

We recommend using the first method above so that the HSIO setup becomes an integral part of your application program. An example program later in this section shows how to to this.

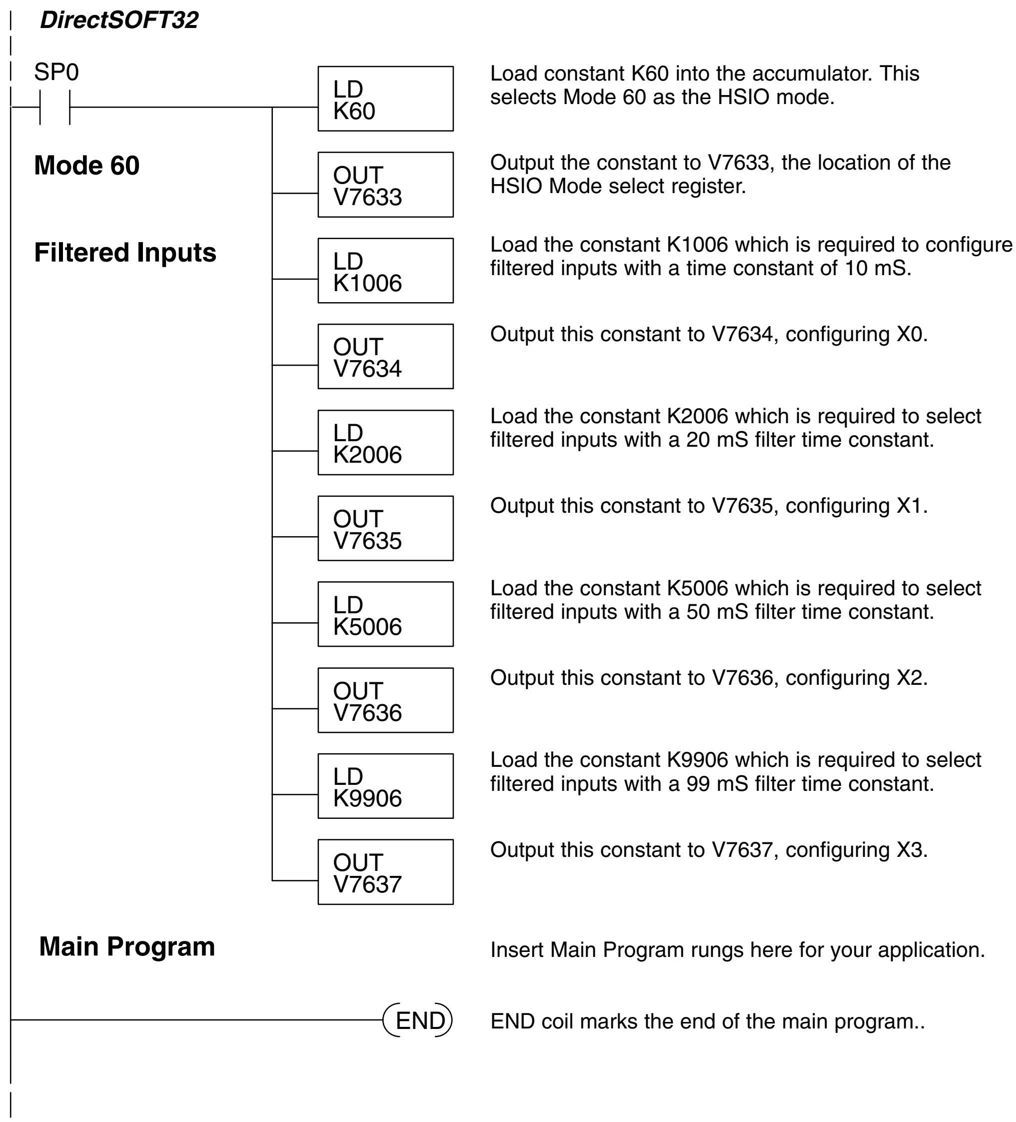
X Input Configuration

The configurable discrete input options for Discrete Filtered Inputs Mode are listed in the table below. The filter time constant (delay) is programmable from 10 to 99 mS. The code for this selection occupies the upper byte of the configuration register in BCD. We combine this number with the required “06” in the lower byte to get “xx06”, where xx = 10 to 99. Input X0, X1, X2, and X3 can only be filtered inputs. Each input has its own configuration register and filter time constant.

Input	Configuration Register	Function	Hex Code Required
X0	V7634	Filtered Input	xx06 (xx = filter delay time)
X1	V7635	Filtered Input	xx06 (xx = filter delay time)
X2	V7636	Filtered Input	xx06 (xx = filter delay time)
X3	V7637	Filtered Input	xx06 (xx = filter delay time)

Filtered Inputs Program Example

The following program selects Mode 60, then programs the filter delay time constants for inputs X0, X1, X2, and X3. Each filter time constant is different, for illustration purposes. The program is otherwise generic, and may be adapted to your application.



4

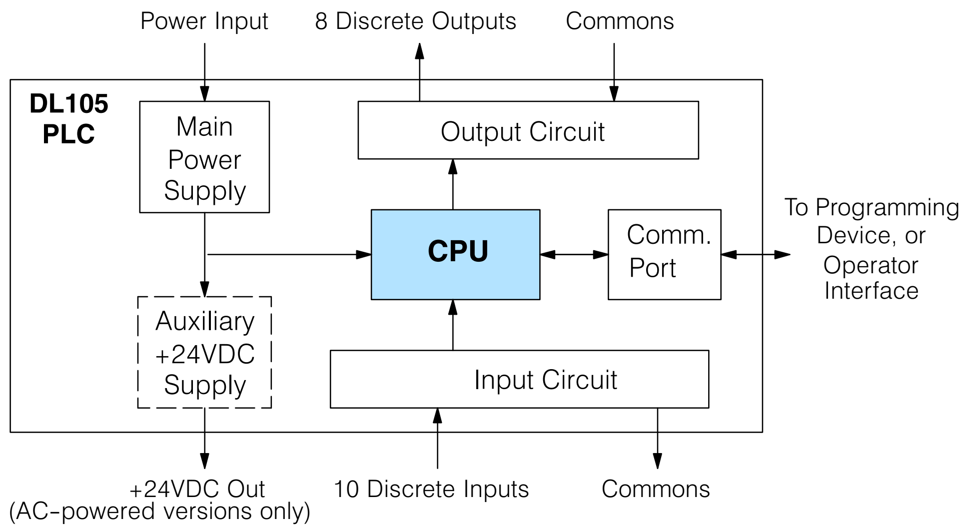
CPU Specifications and Operation

In This Chapter. . . .

Introduction

The Central Processing Unit (CPU) is the heart of the Micro PLC. Almost all PLC operations are controlled by the CPU, so it is important that it is set up correctly. This chapter provides the information needed to understand:

- Steps required to set up the CPU
- Operation of ladder program, organization of Variable Memory



NOTE: The High-Speed I/O function (HSIO) consists of dedicated but configurable hardware in the DL105. It is not considered part of the CPU, because it does not execute the ladder program. For more on HSIO operation, see Chapter 3.

DL105 CPU Features

The DL105 Micro PLC which has 2.4K words of memory comprised of 2.0K of ladder memory and 384 words of V-memory (data registers). Program storage is in the FLASH memory which is a part of the CPU board in the PLC. In addition, there is RAM with the CPU which will store system parameters, V-memory, and other data which is not in the application program. The RAM is backed up by a “super-capacitor”, storing the data for several days in the event of a power outage. The capacitor automatically charges during powered operation of the PLC.

The DL105 supports fixed I/O which includes ten discrete input points and eight output points. No provision for expansion beyond these eighteen I/O points are available in the F1–130 model PLCs.

Over 90 different instructions are available for program development as well as extensive internal diagnostics that can be monitored from the application program or from an operator interface. Chapter 5 provides a detailed description of the instructions.

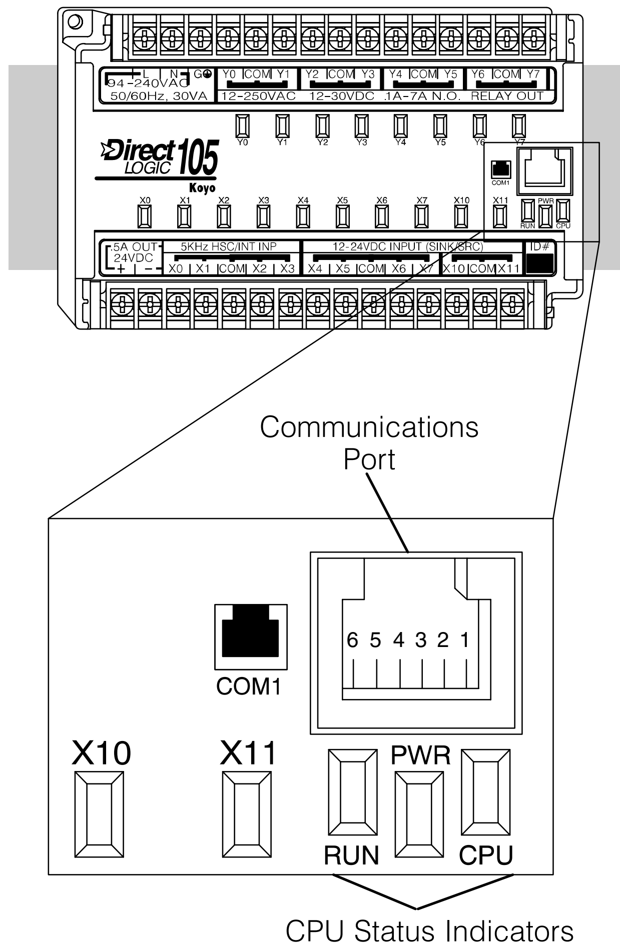
The DL105 provides one built-in RS232C communication port, so you can easily connect a handheld programmer or a personal computer without needing any additional hardware.

CPU Specifications

Feature	DL105
Total Program memory (words)	2.4K
Ladder memory (words)	2048
Total V-memory (words) (See Appendix E)	384
User V-memory (words)	256
Non-volatile V Memory (words)	128
Contact execution (boolean)	3.3 μS
Typical scan (boolean)	4 – 6 mS
RLL Ladder style Programming	Yes
RLL and RLL*PLUS* Programming	Yes
Run Time Edits	Yes
Variable / fixed scan	Variable
Handheld programmer	Yes
DirectSOFT32 programming for Windows™	Yes
Built-in communication ports (RS232C)	Yes
EEPROM or FLASH	Standard on CPU
Local Discrete I/O points available	18
Local Analog input / output channels maximum	None
High-Speed I/O (quad., pulse out, interrupt, pulse catch, etc.)	Yes
I/O Point Density	10 inputs, 8 outputs
Number of instructions available (see Chapter 5 for details)	91
Control relays	256
Special relays (system defined)	112
Stages in RLL*PLUS*	256
Timers	64
Counters	64
Immediate I/O	Yes
Interrupt input (external / timed)	Yes
Subroutines	No
For/Next Loops	No
Math	Integer
Drum Sequencer Instruction	Yes
Time of Day Clock/Calendar	No
Internal diagnostics	Yes
Password security	Yes
System error log	No
User error log	No
Battery backup	No (uses super-cap.)

CPU Hardware Setup

CPU Status Indicators		
RUN	ON OFF	CPU is in RUN mode CPU is in Program mode
CPU	ON OFF	CPU internal diagnostics has detected an error. CPU is OK.
PWR	ON OFF	CPU power good CPU power failure



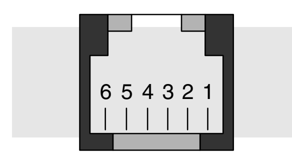
Communication Port	
Com 1	Connects to HPP, ***Direct***SOFT32, operator interfaces, etc. 6-pin, RS232C 9600 Baud Odd parity Station address fixed (1) 8 data bits 1 start, 1 stop bit Asynchronous, Half-duplex, DTE K sequence protocol

Communication Port Pinout Diagrams

Cables are available that allow you to quickly and easily connect a Handheld Programmer or a personal computer to the DL105 PLCs. However, if you need to build your own cables, use the pinout diagrams shown. The DL105 PLCs require an RJ-12 phone plug to fit the built-in jacks.

The Micro PLC has one built-in RS232C communication port. The port is generally used for programming either with the Handheld Programmer or ***Direct***SOFT32, and has a fixed station address of 1. The baud rate is fixed at 9600 baud. This port supports the K–sequence protocol, which is a proprietary protocol.

NOTE: The 5V pins are rated at 200mA maximum, primarilly for use with some operator interface units.



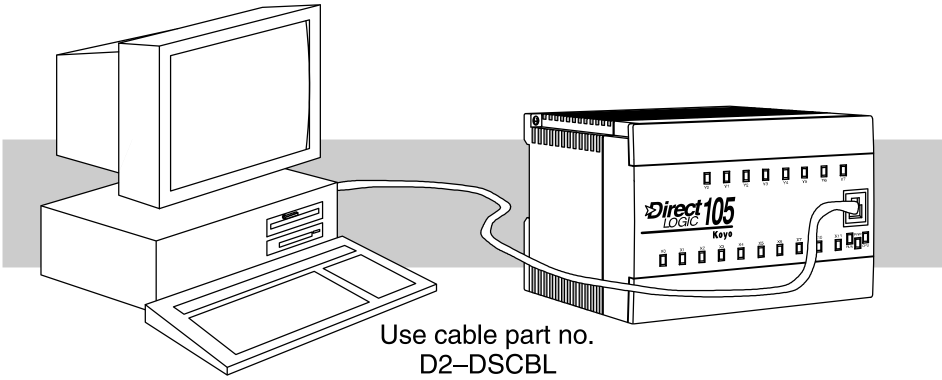
Phone Jack Connector

Port Pinouts

Pin	Signal Definition
1	0 V
2	5 V
3	RS232C Data in
4	RS232C Data out
5	5 V
6	0 V

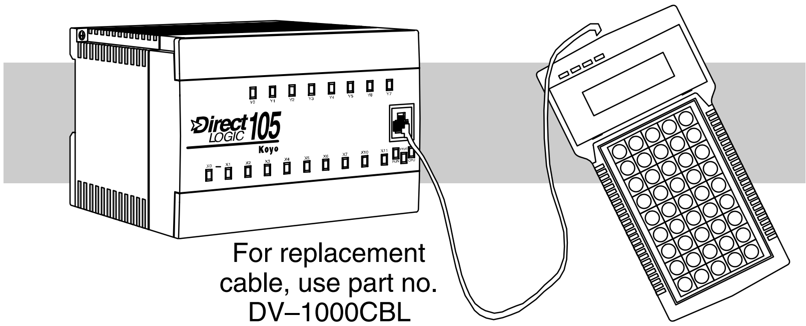
Connecting the Programming Devices

If you're using a Personal Computer with the ***Direct***SOFT32 programming package, you can connect the computer to the DL105's programming port. For an engineering office environment (typical during program development), this is the preferred method of programming.



Use cable part no. D2–DSCBL

The Handheld programmer is connected to the CPU with a handheld programmer cable. This device is ideal for maintaining existing installations or making small program changes. The handheld programmer is shipped with a cable, which is approximately 6.5 feet (200 cm) long.



For replacement cable, use part no. DV–1000CBL

CPU Setup Information

Even if you have years of experience using PLCs, there are a few things you need to do before you can start entering programs. This section includes some basic things, such as changing the CPU mode, but it also includes some things that you may never have to use. Here's a brief list of the items that are discussed.

- Using Auxiliary Functions
- Selecting and Changing the CPU Modes
- Clearing the program (and other memory areas)
- How to initialize system memory
- Setting retentive memory ranges

The following paragraphs provide the setup information necessary to get the CPU ready for programming. They include setup instructions for either type of programming device you are using. The D2–HPP Handheld Programmer Manual provides the Handheld keystrokes required to perform all of these operations. The ***Direct***SOFT32 Manual provides a description of the menus and keystrokes required to perform the setup procedures via ***Direct***SOFT32.

CPU Modes

There are two possible operating modes available with DL105 Micro PLCs.

- RUN — executes program and updates I/O points.
- PROGRAM — allows program changes. The CPU halts execution of the ladder program and all output points are turned off.

Mode of Operation at Power-up

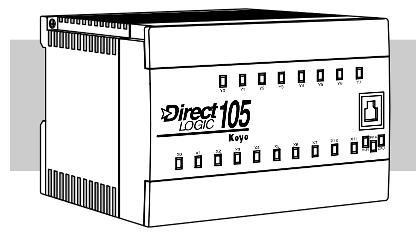
The DL105 operates as follows when the power is connected.

1. The DL105 CPU will normally power-up in the mode that it was in just prior to the power interruption. For example, if the CPU was in Program Mode when the power was disconnected, the CPU will power-up in Program Mode (see warning note below).
2. You can configure the DL105 to always power-up in the Run Mode. You can set bit 13 in V7633 (nonvolatile memory) to enable this feature; we'll show you how to set the bit later in this chapter.

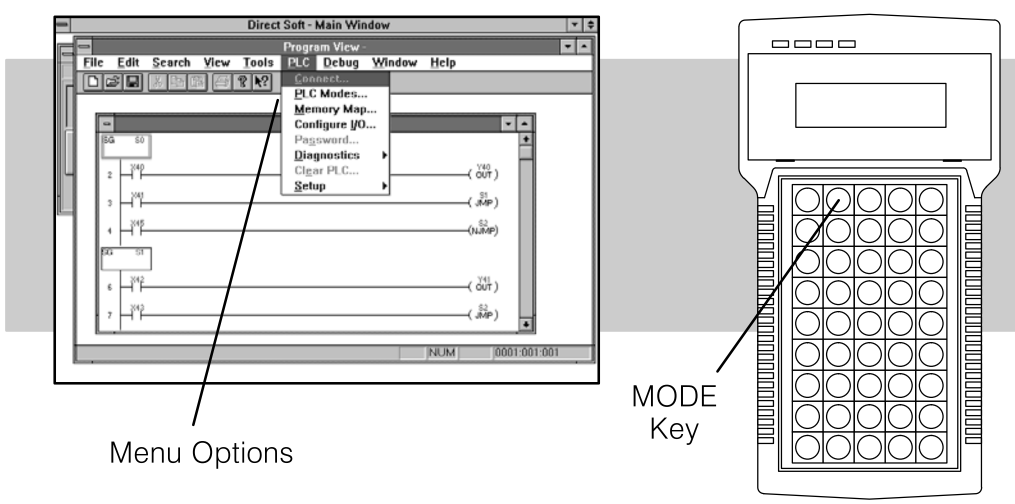
WARNING: If bit 13 in memory location V7633 is *not set*, once the super capacitor has discharged the system memory may not retain the previous mode of operation. When this occurs, the PLC can power-up in either Run or Program Mode. There is no way to determine which mode will be entered. Failure to adhere to this warning greatly increases the risk of unexpected equipment startup.

Changing Modes in the DL105 PLC

The DL105 Micro PLC does not have an external switch to switch CPU operating modes. You have to use a programming device, such as the handheld programmer or ***Direct***SOFT32, to change the operating mode.



You can use either ***Direct***SOFT32 or the Handheld Programmer to change the CPU mode of operation. With ***Direct***SOFT32 you use a menu option in the PLC menu. With the Handheld Programmer, you use the MODE key.

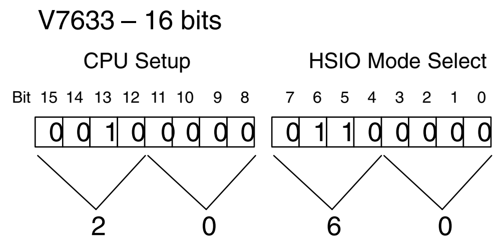


Setting Bits in V7633

You can use the Handheld Programmer or ***Direct***SOFT32 to set the proper bits in V7633.

Since you cannot access the bits individually, you have to enter a constant that will result in the appropriate bit being set. The first two digits of the constant are used to select the CPU options. The second two digits are used with the High-Speed I/O function to select various options. If you're using High Speed I/O functions, make sure you also enter the appropriate code for the feature selected If you want the HSIO inputs and outputs to default to regular I/O point operation, just enter 60 as the last two digits of the code. This configures all I/O points to operate only as standard discrete I/O.

The diagram shows how the upper and lower bytes of V7633 are used. For example, if you entered 2060 into V7633, the powerup-in-run option is selected, and the discrete filtered inputs are selected.



Codes:
00: Default
20: Power-up in Run

Codes:
10: Up Counter
20: Quadrature
30: Pulse output (High Speed)
40: Interrupt (High Speed)
50: Pulse catch (High Speed)
60: Discrete Filtered Input (default)

The following keystrokes show how you can enter the codes into V7633 with the D2–HPP Handheld Programmer.

Select V7633 for Monitoring

CLR | CLR | SHFT

V AND | H 7 | G 6 | D 3 | D 3 | STAT

```
V 7634  V7633
  0001   0000
```

Enter the Code

SHFT | K JMP | C 2 | A 0 | G 6 | A 0 | ENT

```
V 7634  V7633
K2060
```

Since the changes take affect immediately, you may receive an error message. For example, if you select Power-up in Run Mode and the CPU does not yet contain a program, an error will occur.

Auxiliary Functions Many CPU setup tasks involve the use of Auxiliary (AUX) Functions. The AUX Functions perform many different operations, ranging from clearing ladder memory, displaying the scan time, copying programs to EEPROM in the handheld programmer, etc. They are divided into categories that affect different system parameters. Appendix A provides a description of the AUX functions.

You can access the AUX Functions from ***Direct***SOFT32 or from the D2–HPP Handheld Programmer. The manuals for those products provide step-by-step procedures for accessing the AUX Functions. Some of these AUX Functions are designed specifically for the Handheld Programmer setup, so they will not be needed (or available) with the ***Direct***SOFT32 package. The following table shows a list of the Auxiliary functions for the Handheld Programmer.

AUX 2* — RLL Operations		**AUX 6* — Handheld Programmer Configuration**	
21	Check Program	61	Show Revision Numbers
22	Change Reference	62	Beeper On / Off
23	Clear Ladder Range	65	Run Self Diagnostics
24	Clear All Ladders	**AUX 7* — EEPROM Operations**	
AUX 3* — V-Memory Operations		71	Copy CPU memory to HPP EEPROM
31	Clear V Memory	72	Write HPP EEPROM to CPU
AUX 4* — I/O Configuration		73	Compare CPU to HPP EEPROM
41	Show I/O Configuration	74	Blank Check (HPP EEPROM)
AUX 5* — CPU Configuration		75	Erase HPP EEPROM
51	Modify Program Name	76	Show EEPROM Type (CPU and HPP)
53	Display Scan Time	**AUX 8* — Password Operations**	
54	Initialize Scratchpad	81	Modify Password
55	Set Watchdog Timer	82	Unlock CPU
57	Set Retentive Ranges	83	Lock CPU
58	Test Operations		
5B	HSIO Configuration		

Clearing an Existing Program

Before you enter a new program, be sure to always clear ladder memory. You can use AUX Function 24 to clear the complete program.

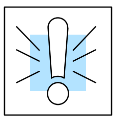
You can also use other AUX functions to clear other memory areas.

- AUX 23 — Clear Ladder Range
- AUX 24 — Clear all Ladders
- AUX 31 — Clear V Memory

Initializing System Memory

The DL105 Micro PLC maintain system parameters in a memory area often referred to as the “scratchpad”. In some cases, you may make changes to the system setup that will be stored in system memory. For example, if you specify a range of Control Relays (CRs) as retentive, these changes are stored in system memory.

AUX 54 resets the system memory to the default values.



WARNING: You may never have to use this feature unless you want to clear any setup information that is stored in system memory. Usually, you’ll only need to initialize the system memory if you are changing programs and the old program required a special system setup. You can usually load in new programs without ever initializing system memory.

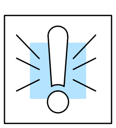
Remember, this AUX function will reset all system memory. If you have set special parameters such as retentive ranges, etc. they will be erased when AUX 54 is used. Make sure you that you have considered all ramifications of this operation before you select it.

Setting Retentive Memory Ranges

The DL105 PLCs provide certain ranges of retentive memory by default. The default ranges are suitable for many applications, but you can change them if your application requires additional retentive ranges or no retentive ranges at all. (see Appendix E) The default settings are:

Memory Area	DL105	
	Default Range	**Available Range**
Control Relays	C300 – C377	C0 – C377
V Memory	V2000 – V2377	V0 – V2377
Timers	None by default	T0 – T77
Counters	CT0 – CT77	CT0 – CT77
Stages	None by default	S0 – S377

You can use AUX 57 (see Appendix A) to set the retentive ranges. You can also use ***Direct***SOFT32 menus to select the retentive ranges.



WARNING: The DL105 PLCs do not have battery back-up. The super capacitor will retain the values in the event of a power loss, but only for a short period of time, depending on conditions. If the retentive ranges are important for your application, make sure you program critical parameters into EEPROM locations.

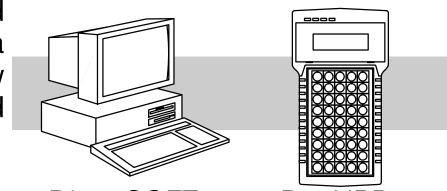
Using a Password

The DL105 PLCs allow you to use a password to help minimize the risk of unauthorized program and/or data changes. Once you enter a password you can “lock” the PLC against access. Once the CPU is locked you must enter the password before you can use a programming device to change any system parameters.

You can select an 8-digit numeric password. The Micro PLCs are shipped from the factory with a password of 00000000. All zeros removes the password protection. If a password has been entered into the CPU you cannot just enter all zeros to remove it. Once you enter the correct password, you can change the password to all zeros to remove the password protection.

WARNING: Make sure you remember your password. If you forget your password you will not be able to access the CPU. The Micro PLC must be returned to the factory to have the password removed.

You can use the D2–HPP Handheld Programmer or ***Direct***SOFT32 to enter a password. The following diagram shows how you can enter a password with the Handheld Programmer.



Select AUX 81

CLR CLR I 8 B 1 AUX ENT

PASSWORD
00000000

Enter the new 8-digit password

X X • • • X ENT

PASSWORD
XXXXXXXX

Press CLR to clear the display

There are three ways to lock the CPU once the password has been entered.

1. If the CPU power is disconnected, the CPU will be automatically locked against access.
2. If you enter the password with ***Direct***SOFT32, the CPU will be automatically locked against access when you exit ***Direct***SOFT32.
3. Use AUX 83 to lock the CPU.

When you use ***Direct***SOFT32, you will be prompted for a password if the CPU has been locked. If you use the Handheld Programmer, you have to use AUX 82 to unlock the CPU. Once you enter AUX 82, you will be prompted to enter the password.

CPU Operation

Achieving the proper control for your equipment or process requires a good understanding of how DL105 CPUs control all aspects of system operation. There are four main areas to understand before you create your application program:

- CPU Operating System — the CPU manages all aspects of system control. A quick overview of all the steps is provided in the next section.
- CPU Operating Modes — The two primary modes of operation are Program Mode and Run Mode.
- CPU Timing — The two important areas we discuss are the I/O response time and the CPU scan time.
- CPU Memory Map — DL105 CPUs offer a wide variety of resources, such as timers, counters, inputs, etc. The memory map section shows the organization and availability of these data types.

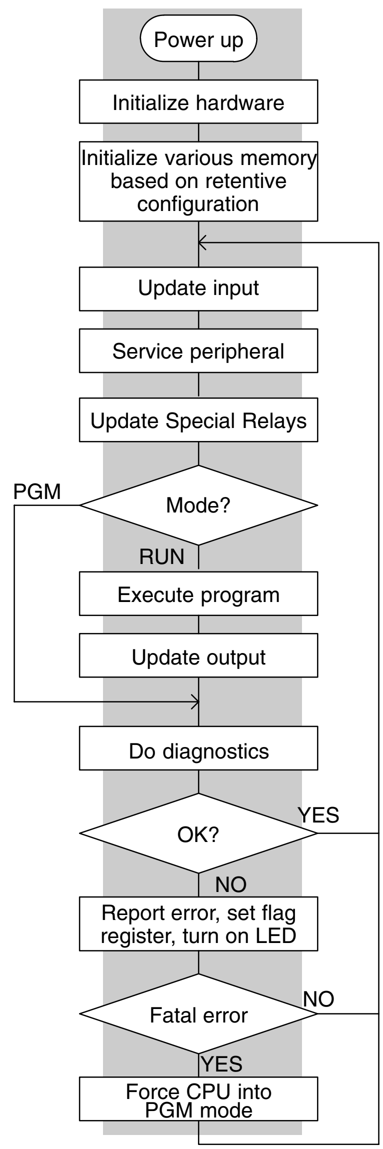
CPU Operating System

At powerup, the CPU initializes the internal electronic hardware. Memory initialization starts with examining the retentive memory settings. In general, the contents of retentive memory is preserved, and non-retentive memory is initialized to zero (unless otherwise specified).

After the one-time powerup tasks, the CPU begins the cyclical scan activity. The flowchart to the right shows how the tasks differ, based on the CPU mode and the existence of any errors. The *"scan time"* is defined as the average time around the task loop. Note that the CPU is always reading the inputs, even during program mode. This allows programming tools to monitor input status at any time.

The outputs are only updated in Run mode. In program mode, they are in the off state.

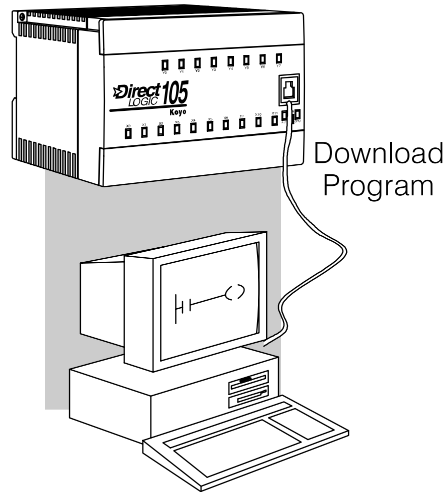
Error detection has two levels. Non-fatal errors are reported, but the CPU remains in its current mode. If a fatal error occurs, the CPU is forced into program mode and the outputs go off.



Program Mode

In Program Mode, the CPU does not execute the application program or update the output points. The primary use for Program Mode is to enter or change an application program. You also use program mode to set up the CPU parameters, such as HSIO features, retentive memory areas, etc.

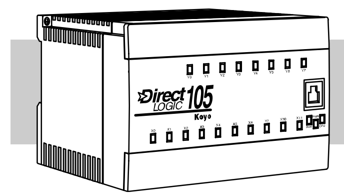
You can use a programming device, such as ***Direct***SOFT32 or the D2–HPP Handheld Programmer to place the CPU in Program Mode.



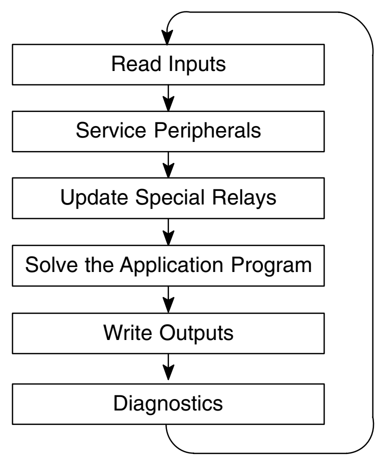
Run Mode

In Run Mode, the CPU executes the application program and updates the I/O system. You can perform many operations during Run Mode. Some of these include:

- Monitor and change I/O point status
- Update timer/counter preset values
- Update Variable memory locations



Normal Run mode scan



Run Mode operation can be divided into several key areas. For the vast majority of applications, some of these execution segments are more important than others. For example, you need to understand how the CPU updates the I/O points, handles forcing operations, and solves the application program. The remaining segments are not that important for most applications.

You can use ***Direct***SOFT32 or the D2–HPP Handheld Programmer to place the CPU in Run Mode.

You can also edit the program during Run Mode. The Run Mode Edits are not “bumpless” to the outputs. Instead, the CPU maintains the outputs in their last state while it accepts the new program information. If an error is found in the new program, then the CPU will turn all the outputs off and enter the Program Mode. This feature is discussed in more detail in Chapter 8.

WARNING: Only authorized personnel fully familiar with all aspects of the application should make changes to the program. Changes during Run Mode become effective immediately. Make sure you thoroughly consider the impact of any changes to minimize the risk of personal injury or damage to equipment.

Read Inputs

The CPU reads the status of all inputs, then stores it in the image register. Input image register locations are designated with an X followed by a memory location. Image register data is used by the CPU when it solves the application program.

Of course, an input may change *after* the CPU has just read the inputs. Generally, the CPU scan time is measured in milliseconds. If you have an application that cannot wait until the next I/O update, you can use Immediate Instructions. These do not use the status of the input image register to solve the application program. The Immediate instructions immediately read the input status directly from the I/O modules. However, this lengthens the program scan since the CPU has to read the I/O point status again. A complete list of the Immediate instructions is included in Chapter 5.

Service Peripherals and Force I/O

After the CPU reads the inputs from the input modules, it reads any attached peripheral devices. This is primarily a communications service for any attached devices. For example, it would read a programming device to see if any input, output, or other memory type status needs to be modified.

Forced I/O— temporarily changes the status of a discrete bit. For example, you may want to force an input on, even though it is really off. This allows you to change the point status that was stored in the image register. This value will be valid until the image register location is written to during the next scan. This is primarily useful during testing situations when you just need to force a bit on to trigger another event.

Forced Inputs — The CPU reads the status of X inputs during the Read Inputs portion of the scan. When the CPU services the programming device, it logs any request to force an X input on. If the input is used in the application program, the ladder X contact is considered closed (on). Since an X input is a real-world input point, the CPU will change the status when it reads the inputs on the next scan.

Forced Outputs— Outputs which are not used in the program can be forced on and off for troubleshooting and maintenance purposes. You can temporarily allow the forcing of any output by inserting an END coil instruction at the beginning of the ladder program. Then you can use ***Direct***SOFT32 or a HPP to force outputs on and off.

The DL105 PLCs only retain the forced value for one scan. There is an exception to this rule. For example, if the point address is greater than X11 or Y7 or it is not used in the ladder program, then the point will maintain the forced status.

WARNING: Only authorized personnel fully familiar with all aspects of the application should make changes to the program. Make sure you thoroughly consider the impact of any changes to minimize the risk of personal injury or damage to equipment.

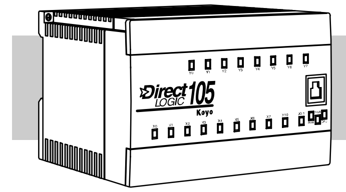
Update Special Relays and Special Registers

There are certain V-memory locations that contain Special Relays and other dedicated register information. This portion of the execution cycle makes sure these locations get updated on every scan. Also, there are several different Special Relays, such as diagnostic relays, etc., that are also updated during this segment.

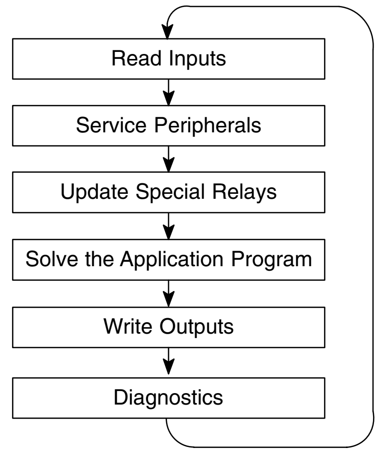
Solve Application Program

The CPU evaluates each instruction in the application program during this segment of the scan cycle. The instructions define the relationship between the input conditions and the desired output response. The CPU uses the output image register area to store the status of the desired action for the outputs. Output image register locations are designated with a Y followed by a memory location. The actual outputs are updated during the write outputs segment of the scan cycle. There are immediate output instructions available that will update the output points immediately instead of waiting until the write output segment. A complete list of the Immediate instructions is provided in Chapter 5.

The internal control relays (C), the stages (S), and the variable memory (V) are also updated in this segment.



Normal Run mode scan



You may recall that you can force various types of points in the system. (This was discussed earlier in this chapter.) If any I/O points or memory data have been forced, the output image register also contains this information.

Write Outputs

Once the application program has solved the instruction logic and constructed the output image register, the CPU writes the contents of the output image register to the corresponding output points. Remember, the CPU also made sure that any forcing operation changes were stored in the output image register, so the forced points get updated with the status specified earlier.

Diagnostics

During this part of the scan, the CPU performs all system diagnostics and other tasks such as calculating the scan time and resetting the watchdog timer. There are many different error conditions that are automatically detected and reported by the DL105 PLCs. Appendix B contains a listing of the various error codes.

Probably one of the more important things that occurs during this segment is the scan time calculation and watchdog timer control. The DL105 CPU has a “watchdog” timer that stores the maximum time allowed for the CPU to complete the solve application segment of the scan cycle. If this time is exceeded the CPU will enter the Program Mode and turn off all outputs. The default value set from the factory is 200 ms. An error is automatically reported. For example, the Handheld Programmer would display the following message “E003 S/W TIMEOUT” when the scan overrun occurs.

You can use AUX 53 to view the minimum, maximum, and current scan time. Use AUX 55 to increase or decrease the watchdog timer value.

I/O Response Time

Is Timing Important for Your Application?

I/O response time is the amount of time required for the control system to sense a change in an input point and update a corresponding output point. In the majority of applications, the CPU performs this task in such a short period of time that you may never have to concern yourself with the aspects of system timing. However, some applications do require extremely fast update times. In these cases, you may need to know how to to determine the amount of time spent during the various segments of operation.

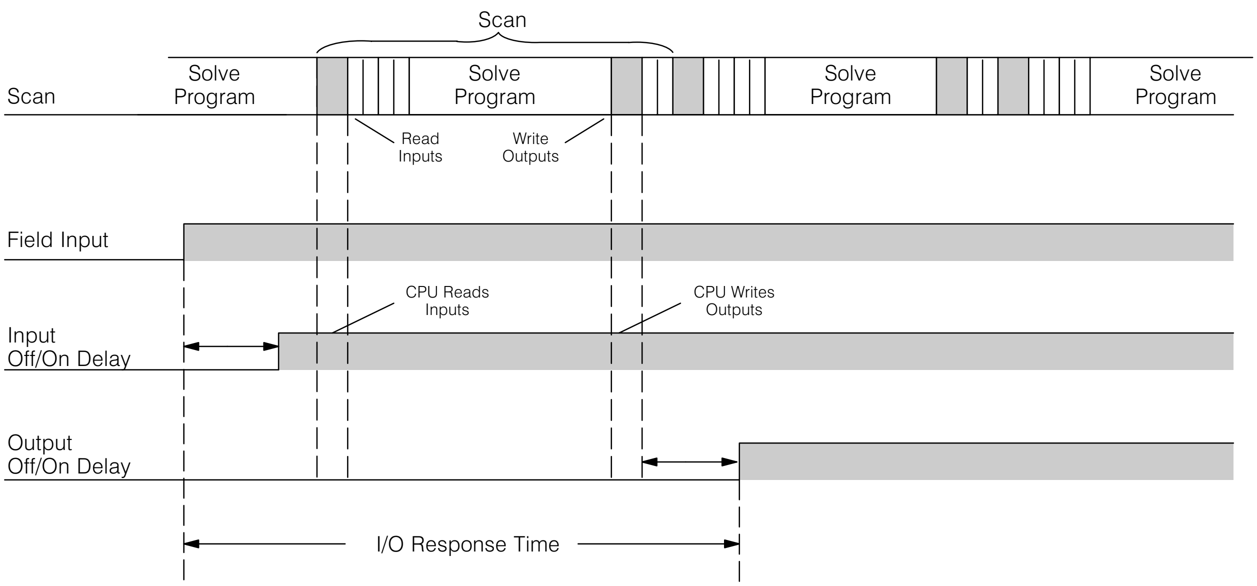
There are four things that can affect the I/O response time.

- The point in the scan cycle when the field input changes states
- Input Off to On delay time
- CPU scan time
- Output Off to On delay time

The next paragraphs show how these items interact to affect the response time.

Normal Minimum I/O Response

The I/O response time is shortest when the input changes just before the Read Inputs portion of the execution cycle. In this case the input status is read, the application program is solved, and the output point gets updated. The following diagram shows an example of the timing for this situation.

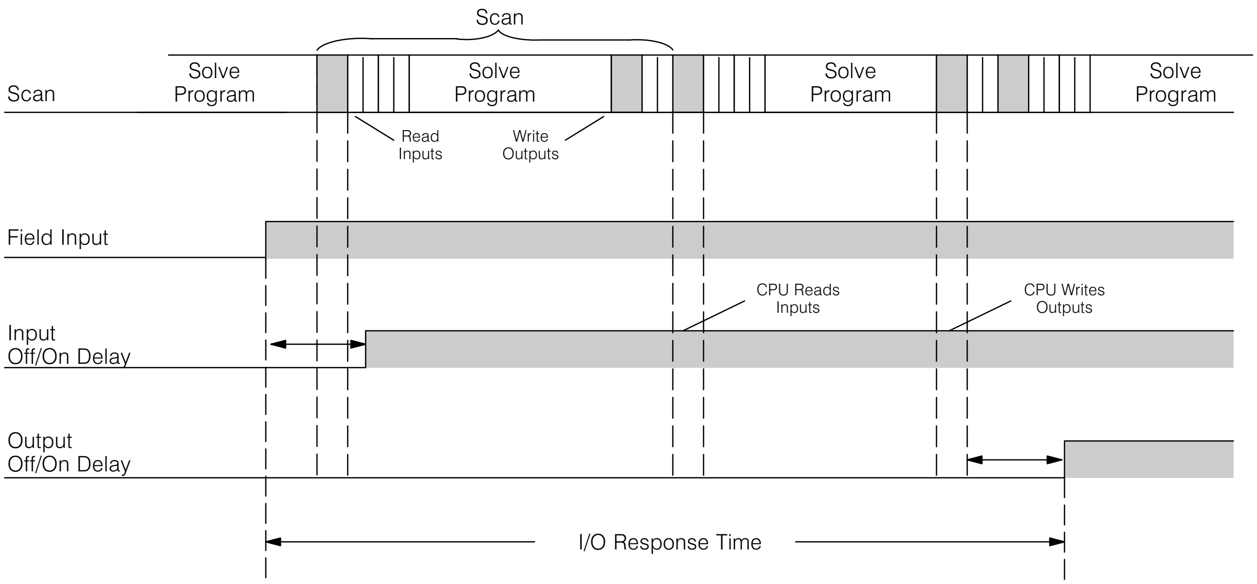


In this case, you can calculate the response time by simply adding the following items:

Input Delay + Scan Time + Output Delay = Response Time

Normal Maximum I/O Response

The I/O response time is longest when the input changes just after the Read Inputs portion of the execution cycle. In this case the new input status does not get read until the following scan. The following diagram shows an example of the timing for this situation.



In this case, you can calculate the response time by simply adding the following items:

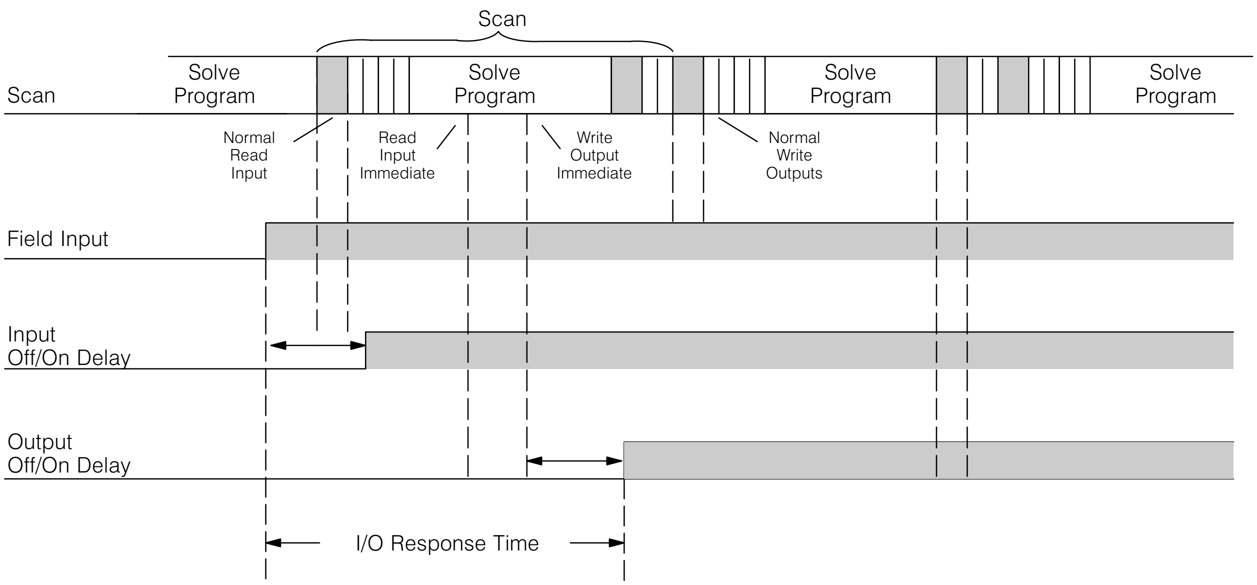
Input Delay +(2 x Scan Time) + Output Delay = Response Time

Improving Response Time

There are a few things you can do the help improve throughput.

- You can choose instructions with faster execution times
- You can use immediate I/O instructions (which update the I/O points during the program execution)
- You can use the HSIO Mode 50 Pulse Catch features designed to operate in high-speed environments. See the Chapter 3 for details on using this feature.

Of these three things the Immediate I/O instructions are probably the most important and most useful. The following example shows how an immediate input instruction and immediate output instruction would affect the response time.



In this case, you can calculate the response time by simply adding the following items.

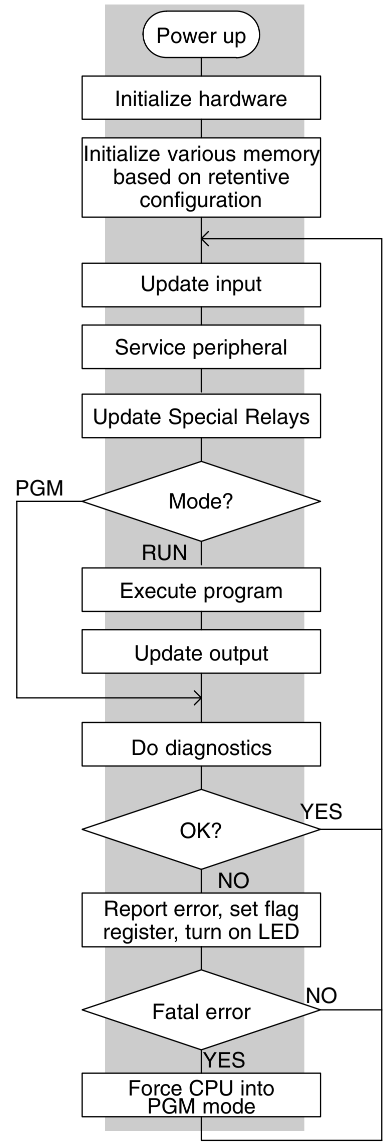
Input Delay + Instruction Execution Time + Output Delay = Response Time

The instruction execution time would be calculated by adding the time for the immediate input instruction, the immediate output instruction, and any other instructions in between the two.

NOTE: Even though the immediate instruction reads the most current status from I/O, it only uses the results to solve that one instruction. It does not use the new status to update the image register. Therefore, any regular instructions that follow will still use the image register values. Any immediate instructions that follow will access the I/O again to update the status.

CPU Scan Time Considerations

The scan time covers all the cyclical tasks that are performed by the operating system. You can use ***Direct***SOFT32 or the Handheld Programmer to display the minimum, maximum, and current scan times that have occurred since the previous Program Mode to Run Mode transition. This information can be very important when evaluating the performance of a system.



As we've shown previously there are several segments that make up the scan cycle. Each of these segments requires a certain amount of time to complete. Of all the segments, the following are the most important.

- Input Update
- Peripheral Service
- Program Execution
- Output Update
- Timed Interrupt Execution

The only one you really have the most control over is the amount of time it takes to execute the application program. This is because different instructions take different amounts of time to execute. So, if you think you need a faster scan, then you can try to choose faster instructions.

Your choice of I/O type and peripheral devices can also affect the scan time. However, these things are usually dictated by the application.

The following paragraphs provide some general information on how much time some of the segments can require.

Reading Inputs

The time required during each scan to read the input status is 40 μS. Don't confuse this with the I/O response time that was discussed earlier.

Writing Outputs

The time required to write the output status is 629 μS. Don't confuse this with the I/O response time that was discussed earlier.

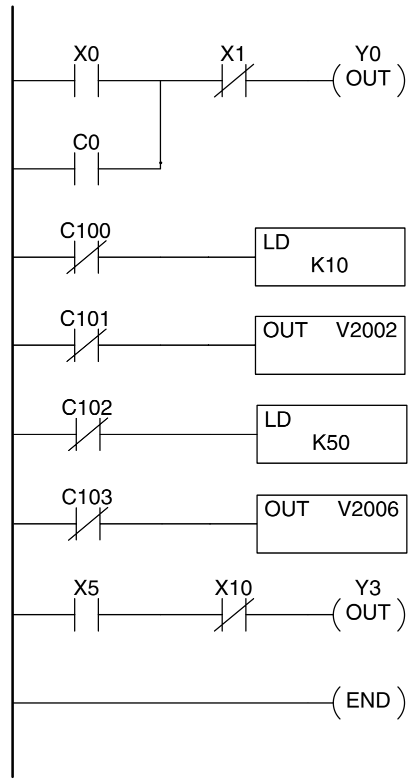
Application Program Execution

The CPU processes the program from address 0 to the END instruction. The CPU executes the program left to right and top to bottom. As each rung is evaluated the appropriate image register or memory location is updated. The time required to solve the application program depends on the type and number of instructions used, and the amount of execution overhead.

Just add the execution times for all the instructions in your program to determine to total execution time. Appendix C provides a complete list of the instruction execution times for the DL105 Micro PLC. For example, the execution time for running the program shown below is calculated as follows:

Instruction	Time
STR X0	3.3 µs
OR C0	2.7 µs
ANDN X1	2.7 µs
OUT Y0	3.4 µs
STRN C100	3.9 µs
LD K10	62 µs
STRN C101	3.9 µs
OUT V2002	60 µs
STRN C102	3.9 µs
LD K50	62 µs
STRN C103	3.9 µs
OUT V2006	60 µs
STR X5	3.3 µs
ANDN X10	2.7 µs
OUT Y3	3.4 µs
END	27 µs
TOTAL	308.1 µs

Overhead	DL105
Minimum	0.86 mS
Maximum	3.85 ms



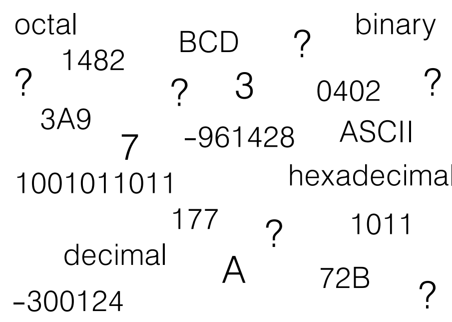
The program above takes only 308.1 µs to execute during each scan. The total scan time is the sum of the program execution plus the overhead as shown above. "Overhead" includes all other housekeeping and diagnostic tasks. The scan time will vary slightly from one scan to the next, because of fluctuation in overhead tasks.

NOTE: You can move words to EEPROM from within the application program. This can add up to 10ms per 32 word boundary.

Program Control Instructions — the DL105 PLCs have an interrupt routine feature that changes the way a program executes. Since this instruction interrupts normal program flow, it will have an effect on the program execution time. For example, a timed interrupt routine with a 10 mS period interrupts the main program execution (before the END statement) every 10 mS, so the CPU can execute the interrupt routine. Chapter 5 provides detailed information on interrupts.

PLC Numbering Systems

If you are a new PLC user or are using ***Direct***LOGIC PLCs for the first time, please take a moment to study how our PLCs use numbers. You'll find that each PLC manufacturer has their own conventions on the use of numbers in their PLCs. We want to take just a moment to familiarize you with how numbers are used in ***Direct***LOGIC PLCs. The information you learn here applies to all our PLCs!

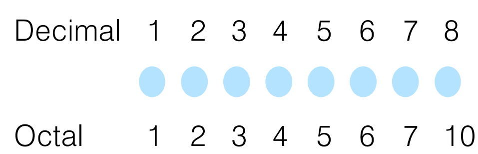


As any good computer does, PLCs store and manipulate numbers in binary form: just ones and zeros. So why do we have to deal with numbers in so many different forms? Numbers have meaning, and some *representations* are more convenient than others for particular purposes. Sometimes we use numbers to represent a size or amount of something. Other numbers refer to locations or addresses, or to time. In science we attach engineering units to numbers to give a particular meaning.

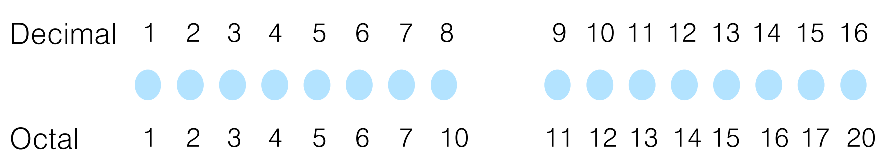
PLC Resources

PLCs offer a fixed amount of resources, depending on the model and configuration. We use the word "resources" to include variable memory (V-memory), I/O points, timers, counters, etc. Most modular PLCs allow you to add I/O points in groups of eight. In fact, all the resources of our PLCs are counted in octal. It's easier for computers to count in groups of eight than ten, because eight is an even power of 2.

Octal means simply counting in groups of eight things at a time. In the figure to the right, there are eight circles. The quantity in decimal is "8", but in octal it is "10" (8 and 9 are not valid in octal). In octal, "10" means 1 group of 8 plus 0 (no individuals).

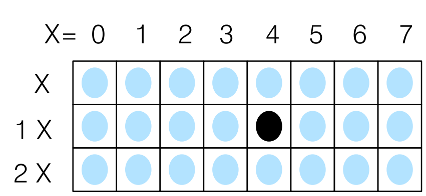


In the figure below, we have two groups of eight circles. Counting in octal we have "20" items, meaning 2 groups of eight, plus 0 individuals Don't say "twenty", say "two–zero octal". This makes a clear distinction between number systems.



After *counting* PLC resources, it's time to *access* PLC resources (there's a difference). The CPU instruction set accesses resources of the PLC using octal addresses. Octal addresses are the same as octal quantities, except they start counting at zero. The number zero is significant to a computer, so we don't skip it.

Our circles are in an array of square containers to the right. To access a resource, our PLC instruction will address its location using the octal references shown. If these were counters, "CT14" would access the black circle location.



V–Memory

Variable memory (called “V-memory”) stores data for the ladder program and for configuration settings (see Appendix E). V-memory locations and V-memory addresses are the same thing, and are numbered in octal. For example, V2073 is a valid location, while V1983 is not valid (“9” and “8” are not valid octal digits).

Each V-memory location is one data word wide, meaning 16 bits. For configuration registers, our manuals will show each bit of a V-memory word. The least significant bit (LSB) will be on the right, and the most significant bit (MSB) on the left. We use the word “significant”, referring to the relative binary weighting of the bits.

V-memory address (octal)	V-memory data (binary) MSB															LSB
V2017	0	1	0	0	1	1	1	0	0	0	1	0	1	0	0	1

V-memory data is 16-bit binary, but we rarely program the data registers one bit at a time. We use instructions or viewing tools that let us work with decimal, octal, and hexadecimal numbers. All these are converted and stored as binary for us.

A frequently-asked question is “How do I tell if a number is octal, BCD, or hex”? The answer is that we usually cannot tell just by looking at the data... but it does not really matter. What matters is: the source or mechanism which writes data into a V-memory location and the thing which later reads it must both use the same data type (i.e., octal, hex, binary, or whatever). The V-memory location is just a storage box... that’s all. It does not convert or move the data on its own.

Binary-Coded Decimal Numbers

Since humans naturally count in decimal (10 fingers, 10 toes), we prefer to enter and view PLC data in decimal as well. However, computers are more efficient in using pure binary numbers. A compromise solution between the two is Binary-Coded Decimal (BCD) representation. A BCD digit ranges from 0 to 9, and is stored as four binary bits (a nibble). This permits each V-memory location to store four BCD digits, with a range of decimal numbers from 0000 to 9999.

BCD number	4	9	3	6
V-memory storage	0 1 0 0	1 0 0 1	0 0 1 1	0 1 1 0

In a pure binary sense, a 16-bit word can represent numbers from 0 to 65535. In storing BCD numbers, the range is reduced to only 0 to 9999. Many math instructions use Binary-Coded Decimal (BCD) data, and ***Direct***SOFT32 and the handheld programmer allow us to enter and view data in BCD.

Hexadecimal Numbers

Hexadecimal numbers are similar to BCD numbers, except they utilize all possible binary values in each 4-bit digit. They are base-16 numbers so we need 16 different digits. To extend our decimal digits 0 through 9, we use A through F as shown.

Decimal	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Hexadecimal	0	1	2	3	4	5	6	7	8	9	A	B	C	D	E	F

A 4-digit hexadecimal number can represent all 65536 values in a V-memory word. The range is from 0000 to FFFF (hex). PLCs often need this full range for sensor data, etc. Hexadecimal is just a convenient way for humans to view full binary data.

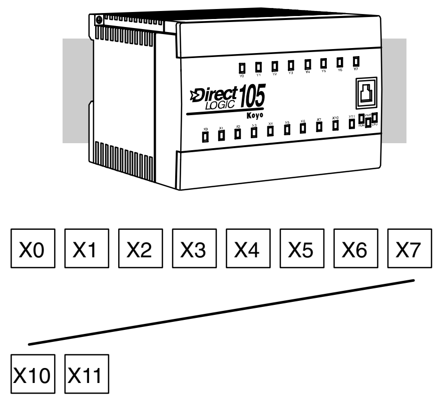
Hexadecimal number	A	7	F	4
V-memory storage	1 0 1 0	0 1 1 1	1 1 1 1	0 1 0 0

Memory Map

With any PLC system, you generally have many different types of information to process. This includes input device status, output device status, various timing elements, parts counts, etc. It is important to understand how the system represents and stores the various types of data. For example, you need to know how the system identifies input points, output points, data words, etc. The following paragraphs discuss the various memory types used in DL105 Micro PLCs. A memory map overview for the CPU follows the memory descriptions.

Octal Numbering System

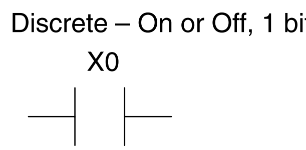
All memory locations and resources are numbered in Octal (base 8). For example, the diagram shows how the octal numbering system works for the discrete input points. Notice the octal system does not contain any numbers with the digits 8 or 9.

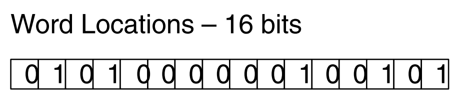


Discrete and Word Locations

As you examine the different memory types, you'll notice two types of memory in the DL105, discrete and word memory. Discrete memory is one bit that can be either a 1 or a 0. Word memory is referred to as V memory (variable) and is a 16-bit location normally used to manipulate data/numbers, store data/numbers, etc.

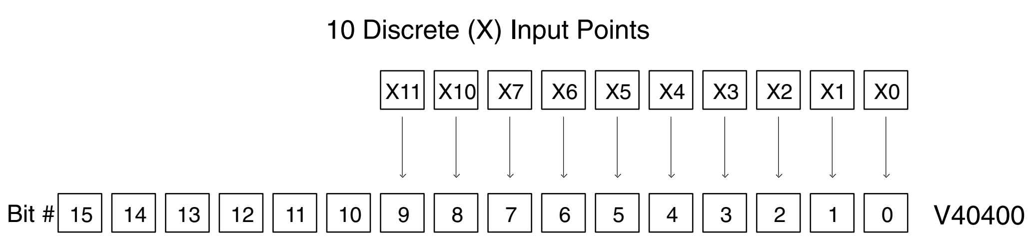
Some information is automatically stored in V memory. For example, the timer current values are stored in V memory.





V Memory Locations for Discrete Memory Areas

The discrete memory area is for inputs, outputs, control relays, special relays, stages, timer status bits and counter status bits. However, you can also access the bit data types as a V-memory word. Each V-memory location contains 16 consecutive discrete locations. For example, the following diagram shows how the X input points are mapped into V-memory locations.



These discrete memory areas and their corresponding V memory ranges are listed in the memory area table for DL105 Micro PLCs on the following pages.

Input Points (X Data Type)

The discrete input points are noted by an X data type. There are 10 discrete input points available with DL105 CPUs. In this example, the output point Y0 will be turned on when input X0 energizes.

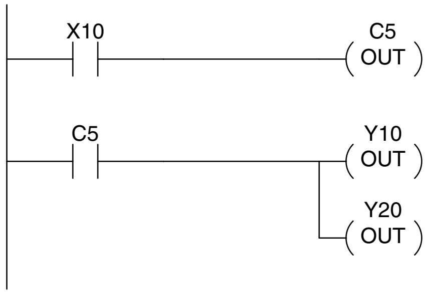
Output Points (Y Data Type)

The discrete output points are noted by a Y data type. There are 128 discrete output points available with DL105 CPUs. In this example, output point Y1 will be turned on when input X1 energizes.

Control Relays (C Data Type)

Control relays are discrete bits normally used to control the user program. The control relays do not represent a real world device, that is, they cannot be physically tied to switches, output coils, etc. They are internal to the CPU. Because of this, control relays can be programmed as discrete inputs or discrete outputs. These locations are used in programming the discrete memory locations (C) or the corresponding word location which contains 16 consecutive discrete locations.

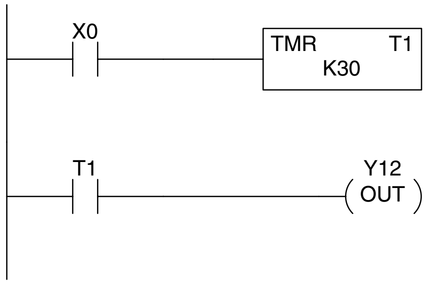
In this example, memory location C5 will energize when input X10 turns on. The second rung shows a simple example of how to use a control relay as an input.



Timers and Timer Status Bits (T Data type)

Timer status bits reflect the relationship between the current value and the preset value of a specified timer. The timer status bit will be on when the current value is equal or greater than the preset value of a corresponding timer.

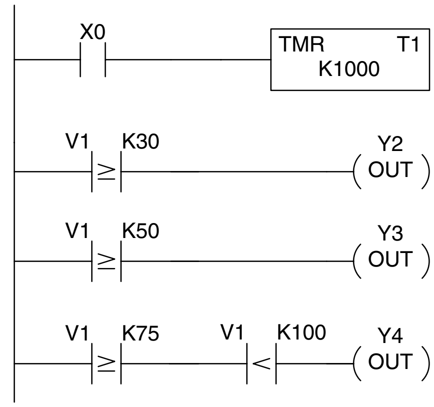
When input X0 turns on, timer T1 will start. When the timer reaches the preset of 3 seconds (K of 30) timer status contact T1 turns on. When T1 turns on, output Y12 turns on. Turning off X0 resets the timer.



Timer Current Values (V Data Type)

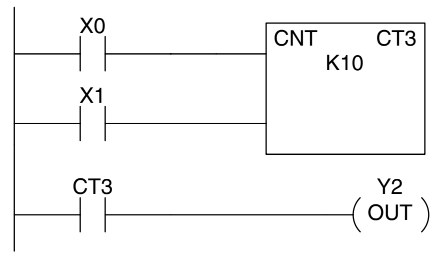
As mentioned earlier, some information is automatically stored in V memory. This is true for the current values associated with timers. For example, V0 holds the current value for Timer 0, V1 holds the current value for Timer 1, etc.

The primary reason for this is programming flexibility. The example shows how you can use relational contacts to monitor several time intervals from a single timer.



Counters and Counter Status Bits (CT Data type)

Counter status bits that reflect the relationship between the current value and the preset value of a specified counter. The counter status bit will be on when the current value is equal to or greater than the preset value of a corresponding counter.

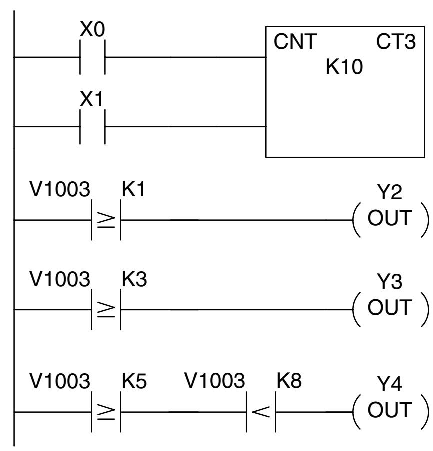


Each time contact X0 transitions from off to on, the counter increments by one. (If X1 comes on, the counter is reset to zero.) When the counter reaches the preset of 10 counts (K of 10) counter status contact CT3 turns on. When CT3 turns on, output Y12 turns on.

Counter Current Values (V Data Type)

Just like the timers, the counter current values are also automatically stored in V memory. For example, V1000 holds the current value for Counter CT0, V1001 holds the current value for Counter CT1, etc.

The primary reason for this is programming flexibility. The example shows how you can use relational contacts to monitor the counter values.

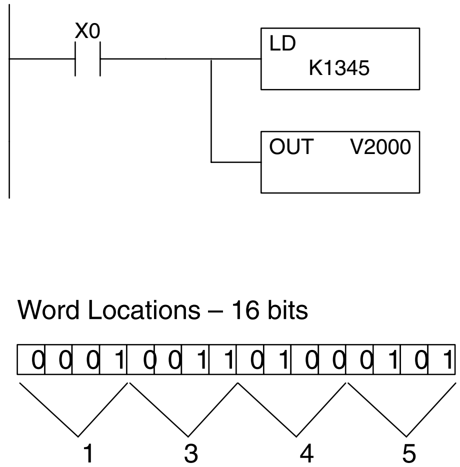


Word Memory (V Data Type)

Word memory is referred to as V memory (variable) and is a 16-bit location normally used to manipulate data/numbers, store data/numbers, etc. (see Appendix E).

Some information is automatically stored in V memory. For example, the timer current values are stored in V memory.

The example shows how a four-digit BCD constant is loaded into the accumulator and then stored in a V-memory location.

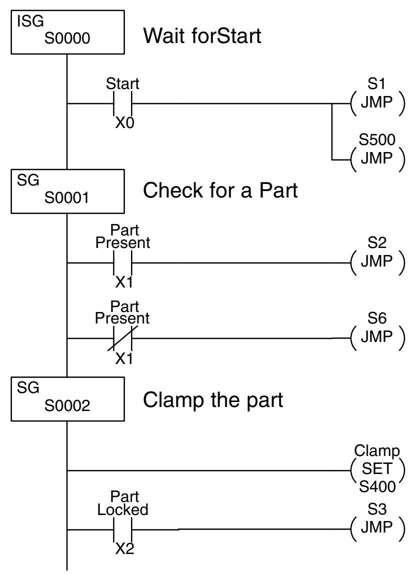


Stages (S Data type)

Stages are used in RLL^{PLUS} Stage programs to create a structured program, similar to a flowchart. Each program stage denotes a program segment. When the program segment, or stage, is active, the logic within that segment is executed. If the stage is off, or inactive, the logic is not executed and the CPU skips to the next active stage. (See Chapter 7 for a more detailed description of RLL^{PLUS} Stage programming.)

Each stage also has a discrete status bit that can be used as an input to indicate whether the stage is active or inactive. If the stage is active, then the status bit is on. If the stage is inactive, then the status bit is off. This status bit can also be turned on or off by other instructions, such as the SET or RESET instructions. This allows you to easily control stages throughout the program.

Ladder Representation



Special Relays (SP Data Type)

Special relays are discrete memory locations with pre-defined functionality. There are many different types of special relays. For example, some aid in program development, others provide system operating status information, etc. Appendix D provides a complete listing of the special relays.

In this example, control relay C10 will energize for 50 ms and de-energize for 50 ms because SP5 is a pre–defined relay that will be on for 50 ms and off for 50 ms.

SP4: 1 second clock
SP5: 100 ms clock
SP6: 50 ms clock

DL105 System V-memory

System Parameters and Default Data Locations (V Data Type)

The DL105 PLCs reserve several V-memory locations for storing system parameters or certain types of system data. These memory locations store things like the error codes, High-Speed I/O data, and other types of system setup information.

System V-memory	Description of Contents	Default Values / Ranges
V2320–V2377	The default location for multiple preset values for the High-Speed Counter	N/A
V7620–V7627	Locations for DV–1000 operator interface parameters	
V7620	Sets the V-memory location that contains the value.	V0 – V2377
V7621	Sets the V-memory location that contains the message.	V0 – V2377
V7622	Sets the total number (1 – 16) of V-memory locations to be displayed.	1 – 16
V7623	Sets the V-memory location that contains the numbers to be displayed.	V0 – V2377
V7624	Sets the V-memory location that contains the character code to be displayed.	V0 – V2377
V7625	Contains the function number that can be assigned to each key.	V-memory location for X, Y, or C points used.
V7626	Powerup operational mode.	0, 1, 2, 12, 3
V7627	Change preset value.	0000 to 9999
V7630	Starting location for the multi–step presets for channel 1. The default value is 2320, which indicates the first value should be obtained from V2320. Since there are 24 presets available, the default range is V2320 – V2377. You can change the starting point if necessary.	Default: V2320 Range: V0 – V2320
V7631–V7632	Not used	N/A
V7633	Sets the desired function code for the high speed counter, interrupt, pulse catch, pulse train, and input filter. Location is also used for setting the power-up in Run Mode option.	Default: 0060 Lower Byte Range: Range: 10 – Counter 20 – Quadrature 30 – Pulse Out 40 – Interrupt 50 – Pulse Catch 60 – Filtered discrete In. Upper Byte Range: Bits 8 – 12, 14,15: Unused Bit 13: Power-up in Run
V7634	X0 Setup Register for High-Speed I/O functions	Default: 1006
V7635	X1 Setup Register for High-Speed I/O functions	Default: 1006
V7636	X2 Setup Register for High-Speed I/O functions	Default: 1006
V7637	X3 Setup Register for High-Speed I/O functions	Default: 1006

System V-memory	Description of Contents	Default Values / Ranges
V7640–V7647	Not used	N/A
V7751	Fault Message Error Code — stores the 4-digit code used with the FAULT instruction when the instruction is executed.	N/A
V7752–V7754	Not used	N/A
V7755	Error code — stores the fatal error code.	
V7756	Error code — stores the major error code.	
V7757	Error code — stores the minor error code.	
V7760–V7762	Not used	
V7763	Program address where syntax error exists	N/A
V7764	Syntax error code	N/A
V7765	Scan — stores the total number of scan cycles that have occurred since the last Program Mode to Run Mode transition.	N/A
V7666–V7774	Not used	N/A
V7775	Scan — stores the current scan time (milliseconds).	N/A
V7776	Scan — stores the minimum scan time that has occurred since the last Program Mode to Run Mode transition (milliseconds).	N/A
V7777	Scan — stores the maximum scan time that has occurred since the last Program Mode to Run Mode transition (milliseconds).	N/A

DL105 Memory Map

Memory Type	Discrete Memory Reference (octal)	Word Memory Reference (octal)	Qty. Decimal	Symbol
Input Points (See note 1)	X0 – X177	V40400 – V40407	128	X0
Output Points (See note 1)	Y0 – Y177	V40500 – V40507	128	Y0
Control Relays	C0 – C377	V40600 – V40617	256	C0 C0
Special Relays	SP0 – SP117 SP540 – SP577	V41200 – V41204 V41226 – V41227	112	SP0
Timers	T0 – T77		64	TMR T0 K100
Timer Current Values	None	V0 – V77	64	V0 K100 ≥
Timer Status Bits	T0 – T77	V41100 – V41103	64	T0
Counters	CT0 – CT77		64	CNT CT0 K10
Counter Current Values	None	V1000 – V1077	64	V1000 K100 ≥
Counter Status Bits	CT0 – CT77	V41140 – V41143	64	CT0
Data Words (See Appendix E)	None	V2000 – V2377	256	None specific, used with many instructions
Data Words Non–volatile (See Appendix E)	None	V4000 – V4177	128	None specific, used with many instructions
Stages	S0 – S377	V41000 – V41017	256	SG S 001 S0
System parameters	None	V7620 – V7647 V7750–V7777	48	None specific, used for various purposes

1 – The DL105 systems are limited to 10 discrete inputs and 8 discrete outputs with the present available hardware, but 128 point addresses exist.

X Input Bit Map

This table provides a listing of individual Input points associated with each V-memory address bit for the DL105’s ten physical inputs. Actual available references are X0 to X177 (V40400 – V40407).

MSB							DL105 Input (X) Points								LSB	Address
17	16	15	14	13	12	11	10	7	6	5	4	3	2	1	0	
–	–	–	–	–	–	011	010	007	006	005	004	003	002	001	000	V40400

Y Output Bit Map

This table provides a listing of individual output points associated with each V-memory address bit for the DL105’s eight physical outputs. Actual available references are Y0 to Y177 (V40500 – V40507).

MSB							DL105 Output (Y) Points								LSB	Address
17	16	15	14	13	12	11	10	7	6	5	4	3	2	1	0	
–	–	–	–	–	–	–	–	007	006	005	004	003	002	001	000	V40500

Control Relay Bit Map

This table provides a listing of the individual control relays associated with each V-memory address bit.

MSB							DL105 Control Relays (C)								LSB	Address
17	16	15	14	13	12	11	10	7	6	5	4	3	2	1	0	
017	016	015	014	013	012	011	010	007	006	005	004	003	002	001	000	V40600
037	036	035	034	033	032	031	030	027	026	025	024	023	022	021	020	V40601
057	056	055	054	053	052	051	050	047	046	045	044	043	042	041	040	V40602
077	076	075	074	073	072	071	070	067	066	065	064	063	062	061	060	V40603
117	116	115	114	113	112	111	110	107	106	105	104	103	102	101	100	V40604
137	136	135	134	133	132	131	130	127	126	125	124	123	122	121	120	V40605
157	156	155	154	153	152	151	150	147	146	145	144	143	142	141	140	V40606
177	176	175	174	173	172	171	170	167	166	165	164	163	162	161	160	V40607
217	216	215	214	213	212	211	210	207	206	205	204	203	202	201	200	V40610
237	236	235	234	233	232	231	230	227	226	225	224	223	222	221	220	V40611
257	256	255	254	253	252	251	250	247	246	245	244	243	242	241	240	V40612
277	276	275	274	273	272	271	270	267	266	265	264	263	262	261	260	V40613
317	316	315	314	313	312	311	310	307	306	305	304	303	302	301	300	V40614
337	336	335	334	333	332	331	330	327	326	325	324	323	322	321	320	V40615
357	356	355	354	353	352	351	350	347	346	345	344	343	342	341	340	V40616
377	376	375	374	373	372	371	370	367	366	365	364	363	362	361	360	V40617

Stage Control / Status Bit Map

This table provides a listing of individual Stage™ control bits associated with each V-memory address bit.

MSB							DL105 Stage (S) Control Bits								LSB	Address
17	16	15	14	13	12	11	10	7	6	5	4	3	2	1	0	
017	016	015	014	013	012	011	010	007	006	005	004	003	002	001	000	V41000
037	036	035	034	033	032	031	030	027	026	025	024	023	022	021	020	V41001
057	056	055	054	053	052	051	050	047	046	045	044	043	042	041	040	V41002
077	076	075	074	073	072	071	070	067	066	065	064	063	062	061	060	V41003
117	116	115	114	113	112	111	110	107	106	105	104	103	102	101	100	V41004
137	136	135	134	133	132	131	130	127	126	125	124	123	122	121	120	V41005
157	156	155	154	153	152	151	150	147	146	145	144	143	142	141	140	V41006
177	176	175	174	173	172	171	170	167	166	165	164	163	162	161	160	V41007
217	216	215	214	213	212	211	210	207	206	205	204	203	202	201	200	V41010
237	236	235	234	233	232	231	230	227	226	225	224	223	222	221	220	V41011
257	256	255	254	253	252	251	250	247	246	245	244	243	242	241	240	V41012
277	276	275	274	273	272	271	270	267	266	265	264	263	262	261	260	V41013
317	316	315	314	313	312	311	310	307	306	305	304	303	302	301	300	V41014
337	336	335	334	333	332	331	330	327	326	325	324	323	322	321	320	V41015
357	356	355	354	353	352	351	350	347	346	345	344	343	342	341	340	V41016
377	376	375	374	373	372	371	370	367	366	365	364	363	362	361	360	V41017

Timer Status Bit Map

This table provides a listing of individual timer contacts associated with each V-memory address bit.

MSB							DL105 Timer (T) Contacts								LSB	Address
17	16	15	14	13	12	11	10	7	6	5	4	3	2	1	0	
017	016	015	014	013	012	011	010	007	006	005	004	003	002	001	000	V41100
037	036	035	034	033	032	031	030	027	026	025	024	023	022	021	020	V41101
057	056	055	054	053	052	051	050	047	046	045	044	043	042	041	040	V41102
077	076	075	074	073	072	071	070	067	066	065	064	063	062	061	060	V41103

Counter Status Bit Map

This table provides a listing of individual counter contacts associated with each V-memory address bit.

MSB							DL105 Counter (CT) Contacts								LSB	Address
17	16	15	14	13	12	11	10	7	6	5	4	3	2	1	0	
017	016	015	014	013	012	011	010	007	006	005	004	003	002	001	000	V41140
037	036	035	034	033	032	031	030	027	026	025	024	023	022	021	020	V41141
057	056	055	054	053	052	051	050	047	046	045	044	043	042	041	040	V41142
077	076	075	074	073	072	071	070	067	066	065	064	063	062	061	060	V41143

5

Standard RLL Instructions

In This Chapter. . . .

Introduction

DL105 Micro PLCs offer a wide variety of instructions to perform many different types of operations. This chapter shows you how to use each standard Relay Ladder Logic (RLL) instruction. In addition to these instructions, you may also need to refer to the Drum instruction in Chapter 6, or the Stage programming instructions in Chapter 7.

There are two ways to quickly find the instruction you need.

- If you know the instruction category (Boolean, Comparative Boolean, etc.) just use the title at the top of the page to find the pages that discuss the instructions in that category.
- If you know the individual instruction name, use the following table to find the page(s) that discusses the instruction.

Instruction	Page
ACON	5–83
ADD	5–59
ADDD	5–11
AND	5–10, 5–21, 5–51
AND STR	5–11
ANDD	5–52
ANDE	5–18
ANDI	5–23
ANDN	5–10, 5–21
ANDNE	5–18
ANDNI	5–23
BCD	5–71
BIN	5–70
CMP	5–57
CMPD	5–58
CNT	5–32
DECB	5–65
DECO	5–69
DISI	5–79
DIV	5–64
DLBL	5–83
EDRUM	6–2, 6–12
ENCO	5–68
END	5–76
ENI	5–79
FAULT	5–82
INCB	5–65
INT	5–79

Instruction	Page
INV	5–72
IRT	5–79
ISG	7–20
JMP	7–20
LD	5–44
LDA	5–47
LDD	5–45
LDF	5–46
LDLBL	5–74
MLR	5–77
MLS	5–77
MOV	5–73
MOVMC	5–74
MUL	5–63
NCON	5–83
NOP	5–76
OR	5–9, 5–20, 5–53
OR OUT	5–13
OR OUTI	5–24
OR STR	5–11
ORD	5–54
ORE	5–17
ORI	5–22
ORN	5–9, 5–20
ORNE	5–17
ORNI	5–22
OUT	5–13, 5–48
OUTD	5–48
OUTF	5–49

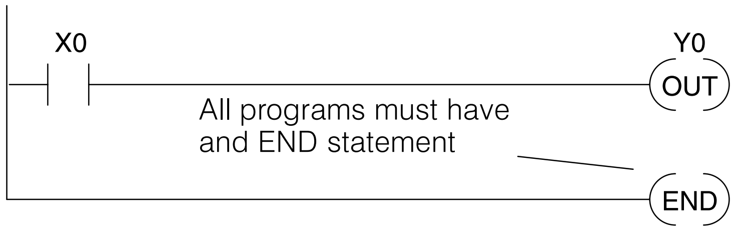
Instruction	Page
PAUSE	5–15
PD	5–14
POP	5–49
RST	5–14
RSTI	5–25
SET	5–14
SETI	5–25
SG	7–19
SGCNT	5–34
SHFL	5–66
SHFR	5–67
SR	5–38
STOP	5–76
STR	5–8, 5–19
STRE	5–16
STRI	5–22
STRN	5–8, 5–19
STRNE	5–16
STRNI	5–22
SUB	5–61
SUBD	5–62
TMR	5–27
TMRF	5–27
TMRA	5–29
TMRAF	5–29
UDC	5–36
XOR	5–55
XORD	5–56

Using Boolean Instructions

Do you ever wonder why so many PLC manufacturers always quote the scan time for a 1K boolean program? Simple. Most all programs utilize many boolean instructions. These are typically very simple instructions designed to join input and output contacts in various series and parallel combinations. Since the ***Direct***SOFT32 software allows you to use graphic symbols to build the program, you don't absolutely *have* to know the mnemonics of the instructions. However, it may helpful at some point, especially if you ever have to troubleshoot the program with a Handheld Programmer.The following paragraphs show how these instructions are used to build simple ladder programs.

END Statement

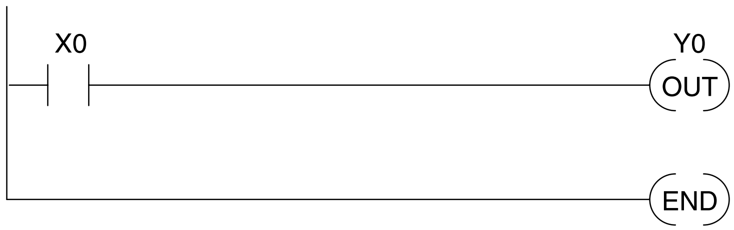
All DL105 programs require an END statement as the last instruction. This tells the CPU that this is the end of the program. Normally, any instructions placed after the END statement will not be executed. There are exceptions to this such as interrupt routines, etc. Chapter 5 discusses the instruction set in detail.



Simple Rungs

You use a contact to start rungs that contain both contacts and coils. The boolean instruction that does this is called a Store or, STR instruction. The output point is represented by the Output or, OUT instruction. The following example shows how to enter a single contact and a single output coil.

DirectSOFT32 Example



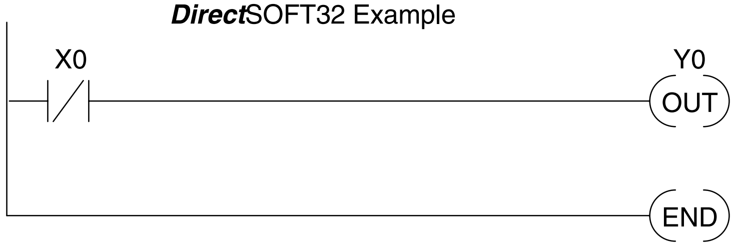
Handheld Mnemonics

STR X0
OUT Y0
END

Normally Closed Contact

Normally closed contacts are also very common. This is accomplished with the Store Not or, STRN instruction. The following example shows a simple rung with a normally closed contact.

DirectSOFT32 Example



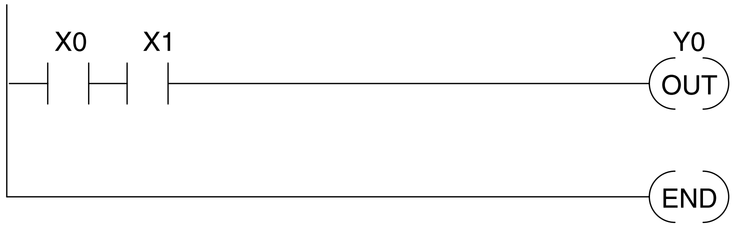
Handheld Mnemonics

STRN X0
OUT Y0
END

Standard RLL Instructions

Contacts in Series Use the AND instruction to join two or more contacts in series. The following example shows two contacts in series and a single output coil. The instructions used would be STR X0, AND X1, followed by OUT Y0.

DirectSOFT32 Example

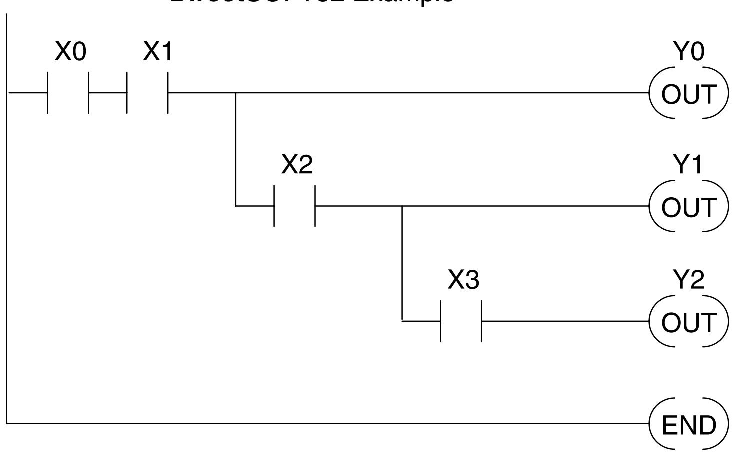


Handheld Mnemonics

STR X0
AND X1
OUT Y0
END

Midline Outputs Sometimes it is necessary to use midline outputs to get additional outputs that are conditional on other contacts. The following example shows how you can use the AND instruction to continue a rung with more conditional outputs.

DirectSOFT32 Example

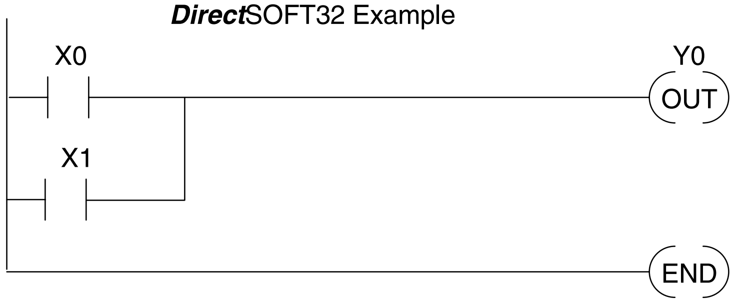


Handheld Mnemonics

STR X0
AND X1
OUT Y0
AND X2
OUT Y1
AND X3
OUT Y2
END

Parallel Elements You also have to join contacts in parallel. The OR instruction allows you to do this. The following example shows two contacts in parallel and a single output coil. The instructions would be STR X0, OR X1, followed by OUT Y0.

DirectSOFT32 Example



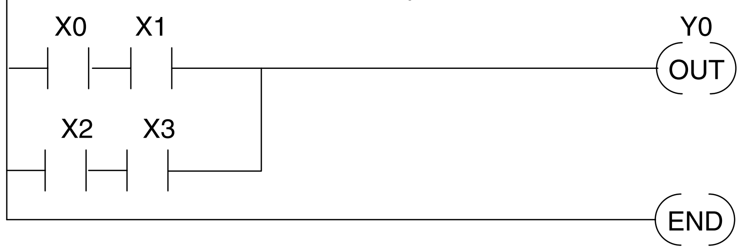
Handheld Mnemonics

STR X0
OR X1
OUT Y0
END

Joining Series Branches in Parallel

Quite often it is necessary to join several groups of series elements in parallel. The Or Store (ORSTR) instruction allows this operation. The following example shows a simple network consisting of series elements joined in parallel.

DirectSOFT32 Example



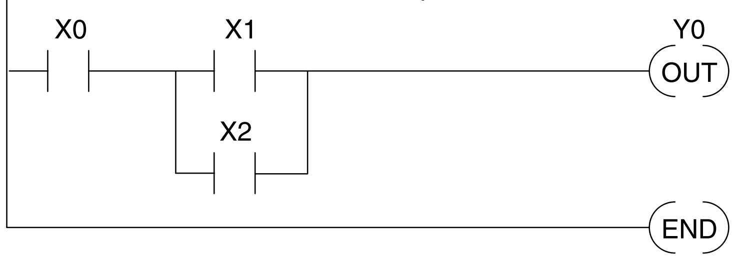
Handheld Mnemonics

STR X0
AND X1
STR X2
AND X3
ORSTR
OUT Y0
END

Joining Parallel Branches in Series

You can also join one or more parallel branches in series. The And Store (ANDSTR) instruction allows this operation. The following example shows a simple network with contact branches in series with parallel contacts.

DirectSOFT32 Example

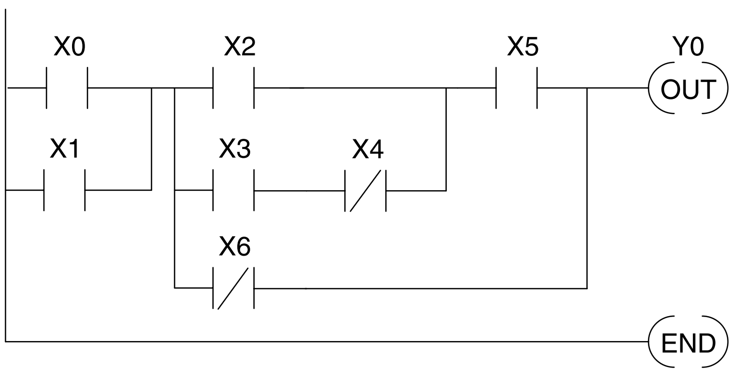


Handheld Mnemonics

STR X0
STR X1
OR X2
ANDSTR
OUT Y0
END

Combination Networks

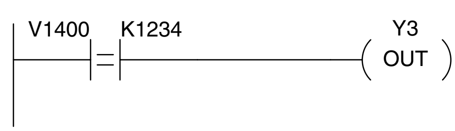
You can combine the various types of series and parallel branches to solve most any application problem. The following example shows a simple combination network.



Comparative Boolean

Some PLC manufacturers make it really difficult to do a simple comparison of two numbers. Some of them require you to move the data all over the place before you can actually perform the comparison. The DL105 Micro PLCs provide Comparative Boolean instructions that allow you to quickly and easily solve this problem. The Comparative Boolean provides evaluation of two 4-digit values using boolean contacts. The valid evaluations are: equal to, not equal to, equal to or greater than, and less than.

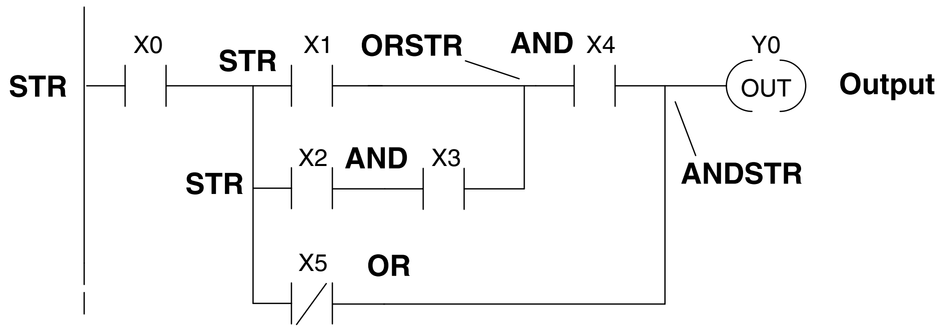
In the following example when the value in V-memory location V1400 is equal to the constant value 1234, Y3 will energize.



Boolean Stack

There are limits to how many elements you can include in a rung. This is because the DL105 PLCs use an 8-level boolean stack to evaluate the various logic elements. The boolean stack is a temporary storage area that solves the logic for the rung. Each time the program encounters a STR instruction, the instruction is placed on the top of the stack. Any other STR instructions already on the boolean stack are pushed down a level. The ANDSTR, and ORSTR instructions combine levels of the boolean stack when they are encountered. An error will occur during program compilation if the CPU encounters a rung that uses more than the eight levels of the boolean stack.

The following example shows how the boolean stack is used to solve boolean logic.



STR X0

1	STR X0
2	
3	
4	
5	
6	
7	
8	

STR X1

1	STR X1
2	STR X0
3	
4	
5	
6	
7	
8	

STR X2

1	STR X2
2	STR X1
3	STR X0
4	
5	
6	
7	
8	

AND X3

1	X2 AND X3
2	STR X1
3	STR X0
4	
5	
6	
7	
8	

ORSTR

1	X1 OR (X2 AND X3)
2	STR X0
3	
:	
8	

AND X4

1	X4 AND [X1 OR (X2 AND X3)]
2	STR X0
3	
:	
8	

ORNOT X5

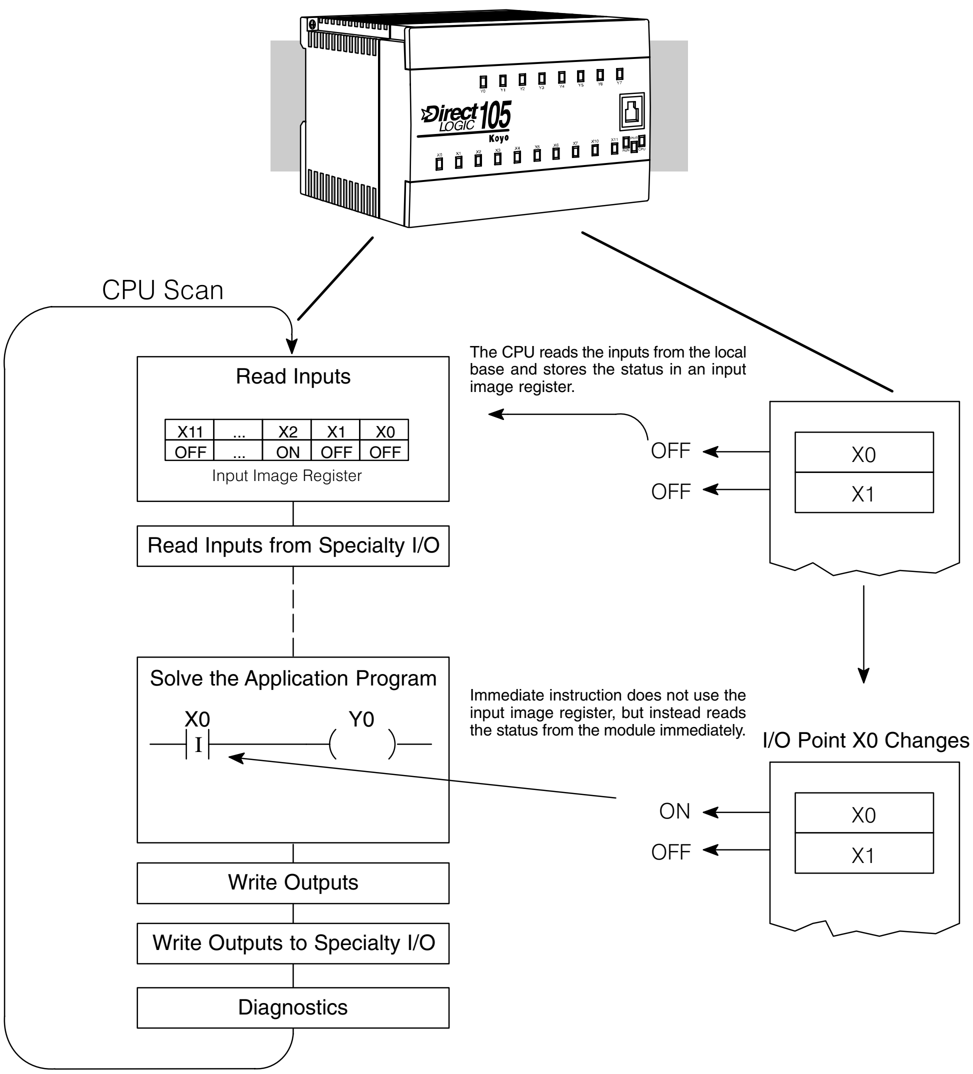
1	NOT X5 OR X4 AND [X1 OR (X2 AND X3)]
2	STR X0
3	
:	
8	

ANDSTR

1	X0 AND (NOT X5 OR X4) AND [X1 OR (X2 AND X3)]
2	
3	
:	
8	

Immediate Boolean The DL105 Micro PLCs usually can complete an operation cycle in a matter of milliseconds. However, in some applications you may not be able to wait a few milliseconds until the next I/O update occurs. The DL105 PLCs offer Immediate input and outputs which are special boolean instructions that allow reading directly from inputs and writing directly to outputs during the program execution portion of the CPU cycle. You may recall that this is normally done during the input or output update portion of the CPU cycle. The immediate instructions take longer to execute because the program execution is interrupted while the CPU reads or writes the I/O point. This function is not normally done until the read inputs or the write outputs portion of the CPU cycle.

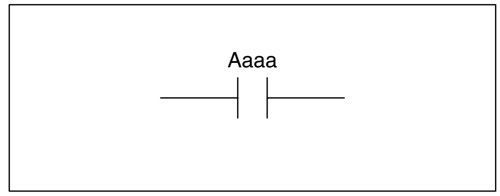
NOTE: Even though the immediate input instruction reads the most current status from the input point, it only uses the results to solve that one instruction. It does not use the new status to update the image register. Therefore, any regular instructions that follow will still use the image register values. Any immediate instructions that follow will access the I/O again to update the status. The immediate output instruction will write the status to the I/O and update the image register.



Boolean Instructions

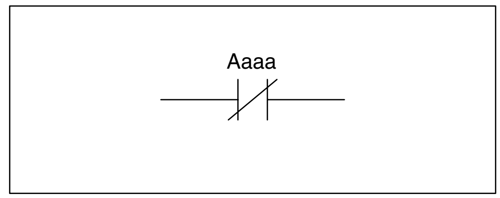
Store (STR)

The Store instruction begins a new rung or an additional branch in a rung with a normally open contact. Status of the contact will be the same state as the associated image register point or memory location.



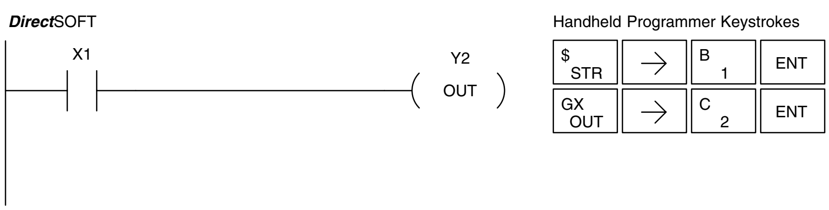
Store Not (STRN)

The Store Not instruction begins a new rung or an additional branch in a rung with a normally closed contact. Status of the contact will be opposite the state of the associated image register point or memory location.

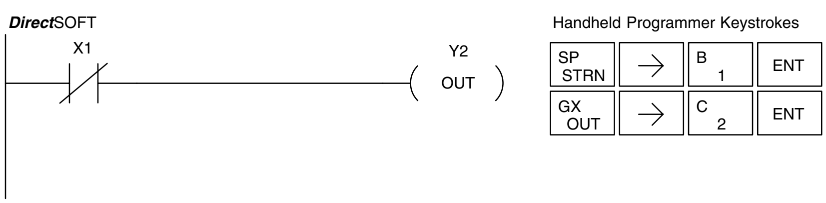


Operand Data Type		DL130 Range
	A	aaa
Inputs	X	0–11
Outputs	Y	0–7
Control Relays	C	0–377
Stage	S	0–377
Timer	T	0–77
Counter	CT	0–77
Special Relay	SP	0–117, 540–577

In the following Store example, when input X1 is on, output Y2 will energize.

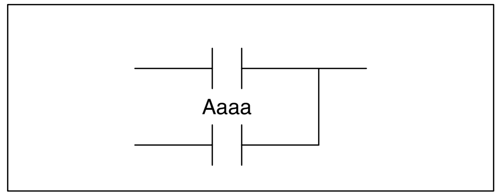


In the following Store Not example, when input X1 is off output Y2 will energize.



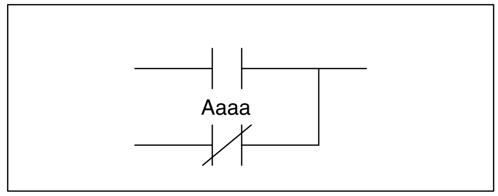
Or (OR)

The Or instruction logically ors a normally open contact in parallel with another contact in a rung. The status of the contact will be the same state as the associated image register point or memory location.



Or Not (ORN)

The Or Not instruction logically ors a normally closed contact in parallel with another contact in a rung. The status of the contact will be opposite the state of the associated image register point or memory location.



Operand Data Type		DL130 Range
	A	aaa
Inputs	X	0–11
Outputs	Y	0–7
Control Relays	C	0–377
Stage	S	0–377
Timer	T	0–77
Counter	CT	0–77
Special Relay	SP	0–117, 540–577

In the following Or example, when input X1 or X2 is on, output Y5 will energize.

***Direct*SOFT**

Handheld Programmer Keystrokes

$ STR	→	B 1	ENT
Q OR	→	C 2	ENT
GX OUT	→	F 5	ENT

In the following Or Not example, when input X1 is on or X2 is off, output Y5 will energize.

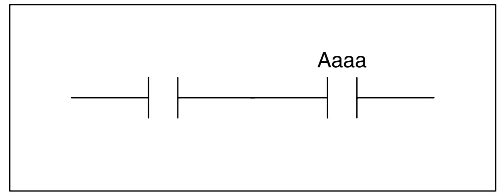
***Direct*SOFT**

Handheld Programmer Keystrokes

$ STR	→	B 1	ENT
R ORN	→	C 2	ENT
GX OUT	→	F 5	ENT

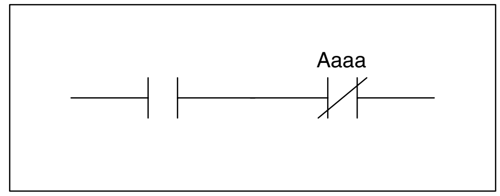
And (AND)

The And instruction logically ands a normally open contact in series with another contact in a rung. The status of the contact will be the same state as the associated image register point or memory location.



And Not (ANDN)

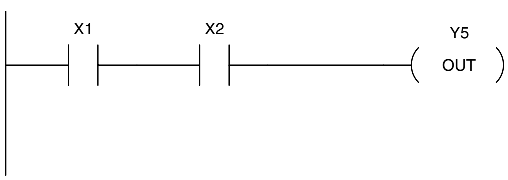
The And Not instruction logically ands a normally closed contact in series with another contact in a rung. The status of the contact will be opposite the state of the associated image register point or memory location.



Operand Data Type		DL130 Range
	A	aaa
Inputs	X	0–11
Outputs	Y	0–7
Control Relays	C	0–377
Stage	S	0–377
Timer	T	0–77
Counter	CT	0–77
Special Relay	SP	0–117, 540–577

In the following And example, when input X1 and X2 are on output Y5 will energize.

***Direct*SOFT**

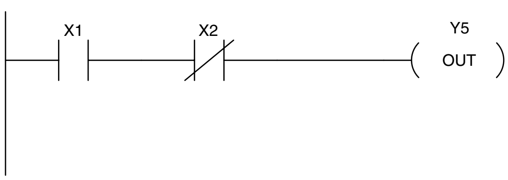


Handheld Programmer Keystrokes

$ STR	→	B 1	ENT
V AND	→	C 2	ENT
GX OUT	→	F 5	ENT

In the following And Not example, when input X1 is on and X2 is off output Y5 will energize.

***Direct*SOFT**

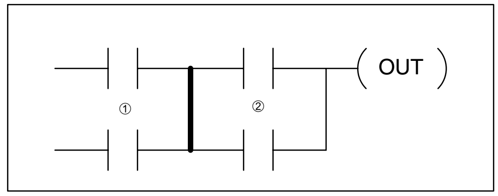


Handheld Programmer Keystrokes

$ STR	→	B 1	ENT
W ANDN	→	C 2	ENT
GX OUT	→	F 5	ENT

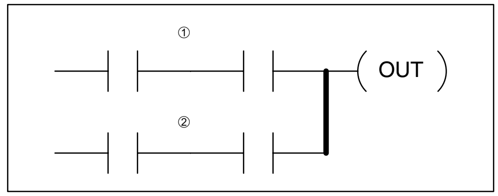
And Store (AND STR)

The And Store instruction logically ands two branches of a rung in series. Both branches must begin with the Store instruction.



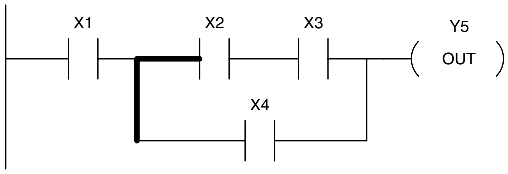
Or Store (OR STR)

The Or Store instruction logically ors two branches of a rung in parallel. Both branches must begin with the Store instruction.



In the following And Store example, the branch consisting of contacts X2, X3, and X4 have been anded with the branch consisting of contact X1.

Direct**SOFT**

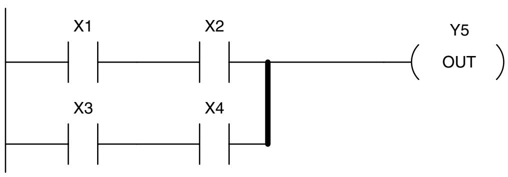


Handheld Programmer Keystrokes

$ STR	→	B 1	ENT
$ STR	→	C 2	ENT
V AND	→	D 3	ENT
Q OR	→	E 4	ENT
L ANDST	ENT		
GX OUT	→	F 5	ENT

In the following Or Store example, the branch consisting of X1 and X2 have been ored with the branch consisting of X3 and X4.

Direct**SOFT**

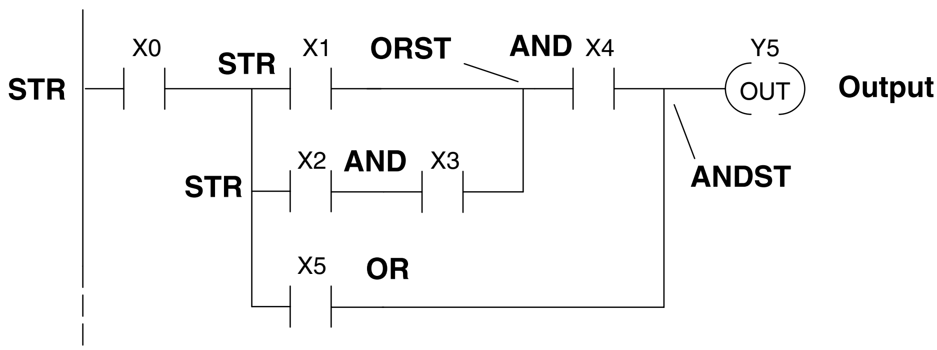


Handheld Programmer Keystrokes

$ STR	→	B 1	ENT
V AND	→	C 2	ENT
$ STR	→	D 3	ENT
V AND	→	E 4	ENT
M ORST	ENT		
GX OUT	→	F 5	ENT

There are limits to what you can enter with boolean instructions. This is because the DL105 internal CPU uses an 8-level stack to evaluate the various logic elements. The stack is a temporary storage area that helps solve the logic for the rung. Each time you enter a STR instruction, the instruction is placed on the top of the stack. Any other instructions on the stack are pushed down a level. The And Store and Or Store instructions combine levels of the stack when they are encountered. Since the stack is only eight levels, an error will occur if the CPU encounters a rung that uses more than the eight levels of the stack.

The following example shows how the stack is used to solve boolean logic.



STR X0

1	STR X0
2	
3	
4	
5	
6	
7	
8	

STR X1

1	STR X1
2	STR X0
3	
4	
5	
6	
7	
8	

STR X2

1	STR X2
2	STR X1
3	STR X0
4	
5	
6	
7	
8	

AND X3

1	X2 AND X3
2	STR X1
3	STR X0
4	
5	
6	
7	
8	

ORST

1	X1 OR (X2 AND X3)
2	STR X0
3	
:	
8	

AND X4

1	X4 AND [X1 OR (X2 AND X3)]
2	STR X0
3	
:	
8	

OR X5

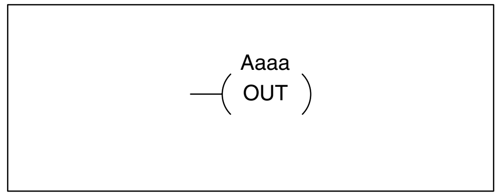
1	X5 OR [X4 AND [X1 OR (X2 AND X3)]]
2	STR X0
3	
:	
8	

ANDST

1	X0 AND [(X5 OR [X4) AND [X1 OR (X2 AND X3)]]]
2	
3	
:	
8	

Out (OUT)

The Out instruction reflects the status of the rung (on/off) and outputs the discrete (on/off) state to the specified image register point or memory location.



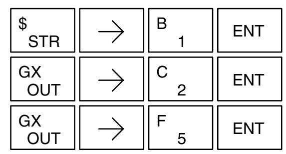
Multiple Out instructions referencing the same discrete location should not be used since only the last Out instruction in the program will control the physical output point. Instead, use the next instruction, the Or Out.

Operand Data Type		DL130 Range
	A	**aaa**
Inputs	X	0–11
Outputs	Y	0–7
Control Relays	C	0–377

In the following Out example, when input X1 is on, output Y2 and Y5 will energize.

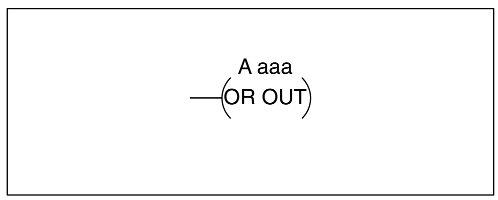
***Direct*SOFT**

Handheld Programmer Keystrokes



Or Out (OR OUT)

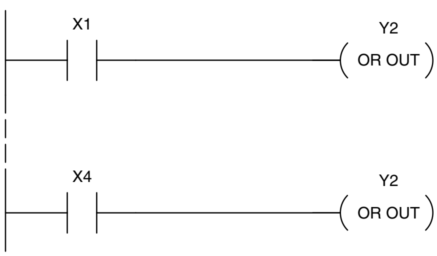
The Or Out instruction allows more than one rung of discrete logic to control a single output. Multiple Or Out instructions referencing the same output coil may be used, since *all* contacts controlling the output are logically ORed together. If the status of *any* rung is on, the output will also be on.



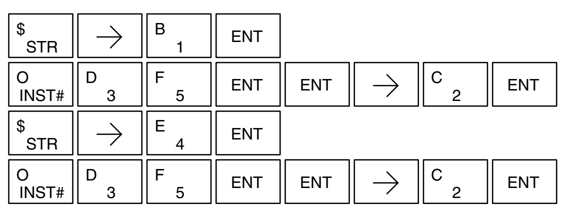
Operand Data Type		DL130 Range
	A	**aaa**
Inputs	X	0–177
Outputs	Y	0–177
Control Relays	C	0–377

In the following example, when X1 or X4 is on, Y2 will energize.

***Direct*SOFT**

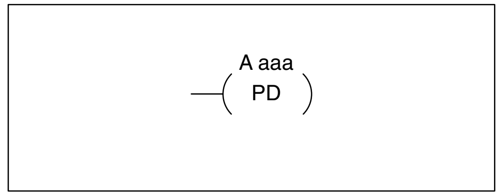


Handheld Programmer Keystrokes



Positive Differential (PD)

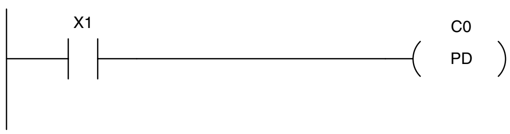
The Positive Differential instruction is typically known as a one shot. When the input logic produces an off to on transition, the output will energize for one CPU scan.



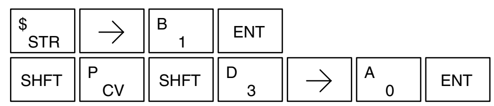
Operand Data Type		DL130 Range
	A	**aaa**
Inputs	X	0–11
Outputs	Y	0–7
Control Relays	C	0–377

In the following example, every time X1 makes an off to on transition, C0 will energize for one scan.

***Direct*SOFT**

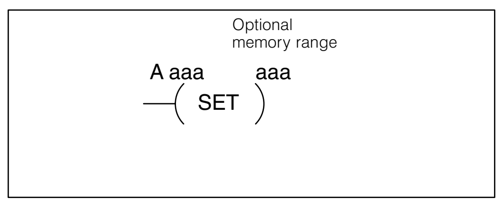


Handheld Programmer Keystrokes



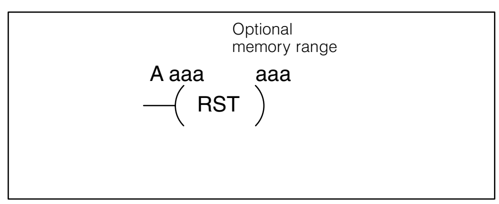
Set (SET)

The Set instruction sets or turns on an image register point/memory location or a consecutive range of image register points/memory locations. Once the point/location is set it will remain on until it is reset using the Reset instruction. It is not necessary for the input controlling the Set instruction to remain on.



Reset (RST)

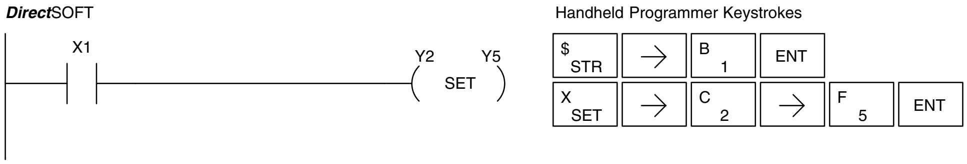
The Reset instruction resets or turns off an image register point/memory location or a range of image registers points/memory locations. Once the point/location is reset it is not necessary for the input to remain on.



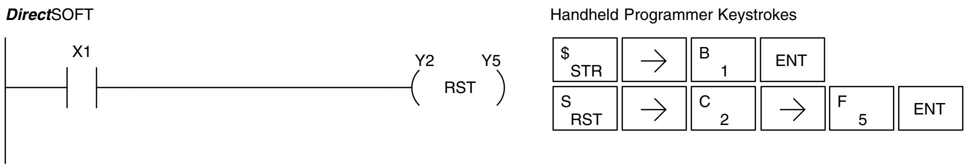
Operand Data Type		DL105 Range
	A	**aaa**
Inputs	X	0–11
Outputs	Y	0–7
Control Relays	C	0–377
Stage	S	0–377
Timer	T	0–77
Counter	CT	0–77

Set, Reset Instr. Continued

In the following example when X1 is on, Y2 through Y5 will energize.

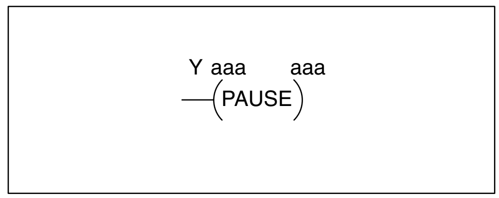


In the following example when X1 is on, Y2 through Y5 will be reset or de–energized.



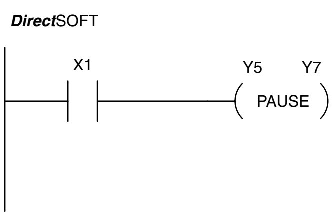
Pause (PAUSE)

The Pause instruction disables the output update on a range of outputs. The ladder program will continue to run and update the image register. However, the outputs in the range specified in the Pause instruction will be turned off at the output points.



Operand Data Type	DL130 Range
	aaa
Outputs Y	0–7

In the following example, when X1 is ON, Y5–Y7 will be turned OFF. The execution of the ladder program will not be affected.



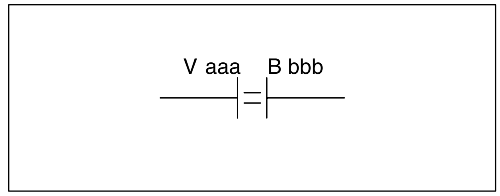
Since the D2–HPP Handheld Programmer does not have a specific Pause key, you can use the corresponding instruction number for entry (#960), or type each letter of the command.

In some cases, you may want certain output points in the specified pause range to operate normally. In that case, use Aux 58 to over-ride the Pause instruction.

Comparative Boolean

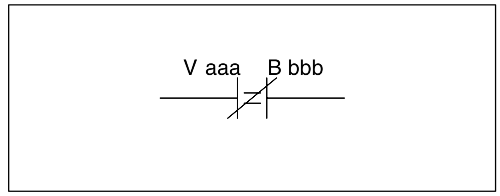
Store If Equal (STRE)

The Store If Equal instruction begins a new rung or additional branch in a rung with a normally open comparative contact. The contact will be on when Vaaa =Bbbb .



Store If Not Equal (STRNE)

The Store If Not Equal instruction begins a new rung or additional branch in a rung with a normally closed comparative contact. The contact will be on when Vaaa $\neq$ Bbbb.

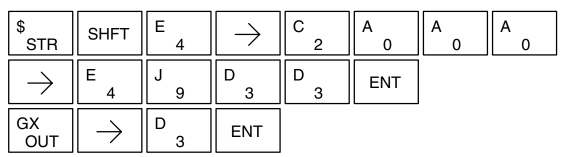


Operand Data Type		DL130 Range	
	B	aaa	bbb
V memory	V	All (See page 4–28)	All (See page 4–28)
Constant	K	—	0–FFFF

In the following example, when the value in V memory location V2000 = 4933 , Y3 will energize.

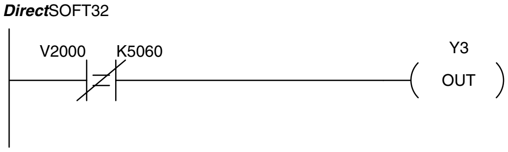
***Direct*SOFT32**

Handheld Programmer Keystrokes

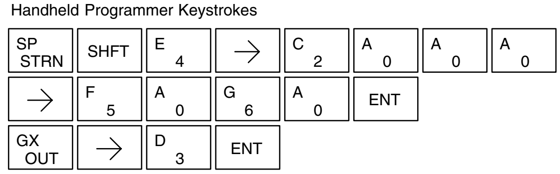


In the following example, when the value in V memory location V2000 $\neq$ 5060, Y3 will energize.

***Direct*SOFT32**

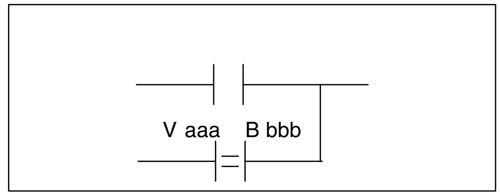


Handheld Programmer Keystrokes



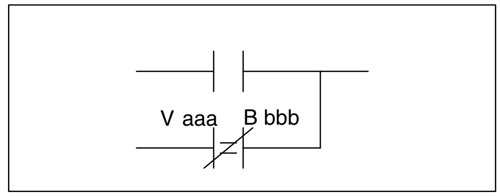
Or If Equal (ORE)

The Or If Equal instruction connects a normally open comparative contact in parallel with another contact. The contact will be on when Vaaa = Bbbb.



Or If Not Equal (ORNE)

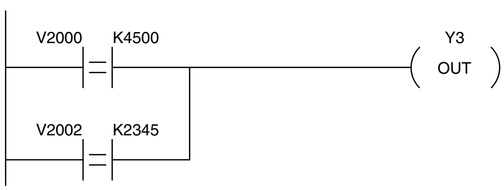
The Or If Not Equal instruction connects a normally closed comparative contact in parallel with another contact. The contact will be on when Vaaa ≠ Bbbb.



Operand Data Type		DL130 Range	
	B	aaa	bbb
V memory	V	All (See page 4–28)	All (See page 4–28)
Constant	K	—	0–FFFF

In the following example, when the value in V memory location V2000 = 4500 or V2002 = 2345 , Y3 will energize.

***Direct*SOFT32**

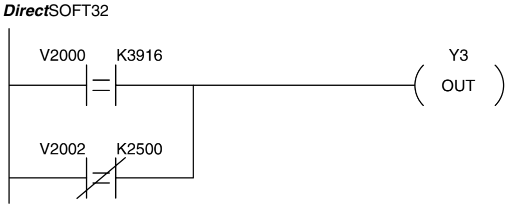


Handheld Programmer Keystrokes

$ STR	SHFT	E 4	→	C 2	A 0	A 0	A 0	→
E 4	F 5	A 0	A 0	ENT				
Q OR	SHFT	E 4	→	C 2	A 0	A 0	C 2	→
C 2	D 3	E 4	F 5	ENT				
GX OUT	→	D 3	ENT					

In the following example, when the value in V memory location V2000 = 3916 or V2002 ≠ 2500, Y3 will energize.

***Direct*SOFT32**

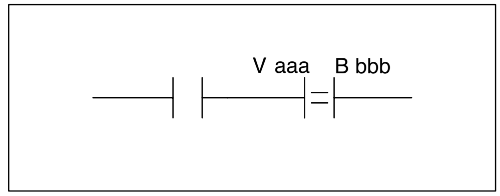


Handheld Programmer Keystrokes

$ STR	SHFT	E 4	→	C 2	A 0	A 0	A 0	→
D 3	J 9	B 1	G 6	ENT				
R ORN	SHFT	E 4	→	C 2	A 0	A 0	C 2	→
C 2	F 5	A 0	A 0	ENT				
GX OUT	→	D 3	ENT					

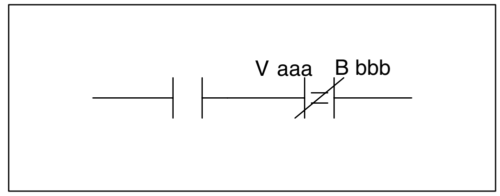
And If Equal (ANDE)

The And If Equal instruction connects a normally open comparative contact in series with another contact. The contact will be on when Vaaa = Bbbb.



And If Not Equal (ANDNE)

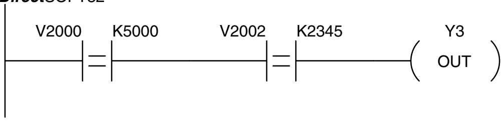
The And If Not Equal instruction connects a normally closed comparative contact in series with another contact. The contact will be on when Vaaa ≠ Bbbb



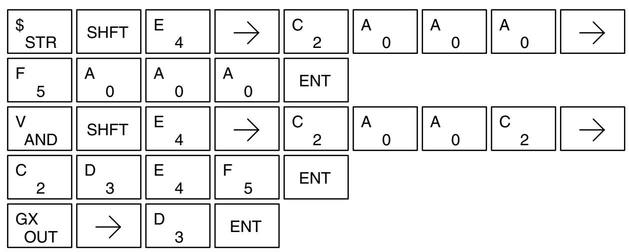
Operand Data Type		DL130 Range	
	A/B	aaa	bbb
V memory	V	All (See page 4–28)	All (See page 4–28)
Constant	K	—	0–FFFF

In the following example, when the value in V memory location V2000 = 5000 and V2002 = 2345, Y3 will energize.

***Direct*SOFT32**

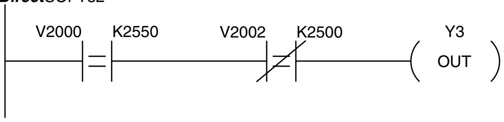


Handheld Programmer Keystrokes

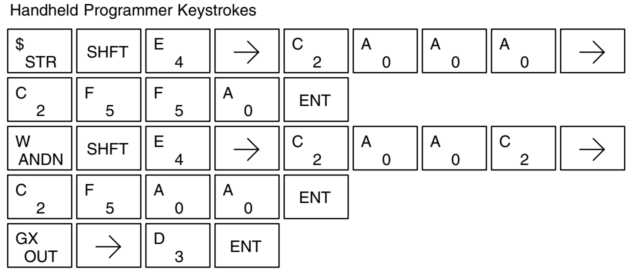


In the following example, when the value in V memory location V2000 = 2550 and V2002 ≠ 2500, Y3 will energize.

***Direct*SOFT32**

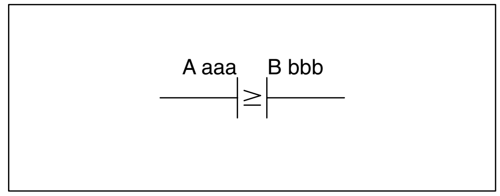


Handheld Programmer Keystrokes



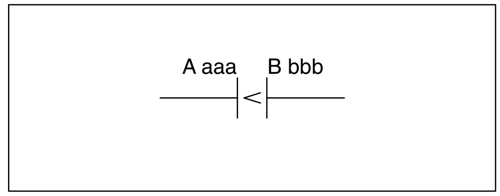
Store (STR)

The Comparative Store instruction begins a new rung or additional branch in a rung with a normally open comparative contact. The contact will be on when Aaaa $\geq$ Bbbb.



Store Not (STRN)

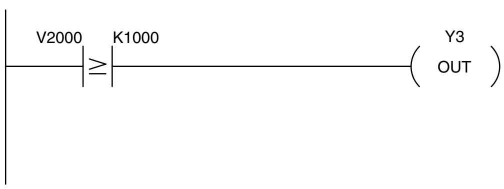
The Comparative Store Not instruction begins a new rung or additional branch in a rung with a normally closed comparative contact. The contact will be on when Aaaa < Bbbb.



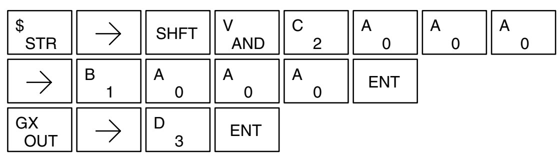
Operand Data Type	A/B	DL130 Range aaa	bbb
V memory	V	All (See page 4–28)	All (See page 4–28)
Constant	K	—	0–FFFF
Timer	T	0–77	
Counter	CT	0–77	

In the following example, when the value in V memory location V2000 $\geq$ 1000, Y3 will energize.

***Direct*SOFT32**

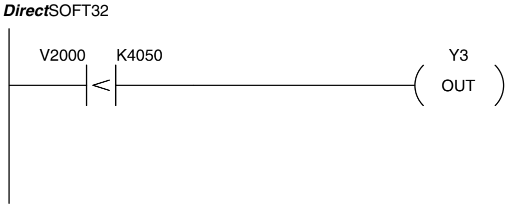


Handheld Programmer Keystrokes

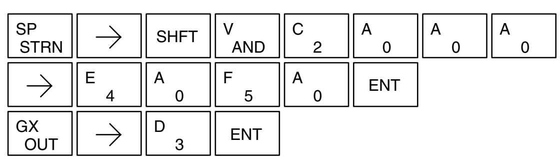


In the following example, when the value in V memory location V2000 < 4050, Y3 will energize.

***Direct*SOFT32**

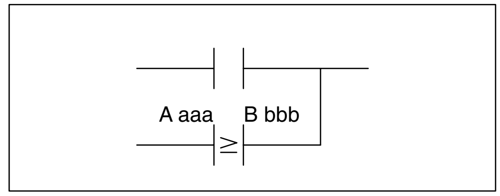


Handheld Programmer Keystrokes



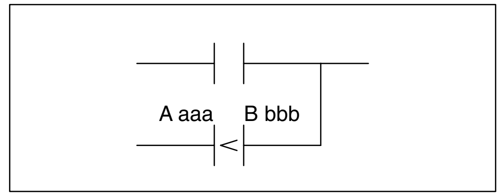
Or (OR)

The Comparative Or instruction connects a normally open comparative contact in parallel with another contact. The contact will be on when Aaaa $\geq$ Bbbb.



Or Not (ORN)

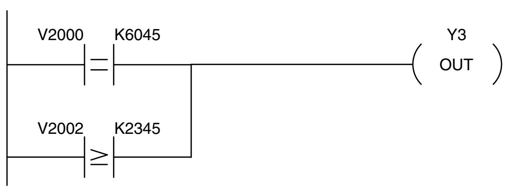
The Comparative Or Not instruction connects a normally open comparative contact in parallel with another contact. The contact will be on when Aaaa < Bbbb.



Operand Data Type		DL130 Range	
	A/B	aaa	bbb
V memory	V	All (See page 4–28)	All (See page 4–28)
Constant	K	—	0–FFFF
Timer	T	0–77	
Counter	CT	0–77	

In the following example, when the value in V memory location V2000 = 6045 or V2002 $\geq$ 2345, Y3 will energize.

***Direct*SOFT32**

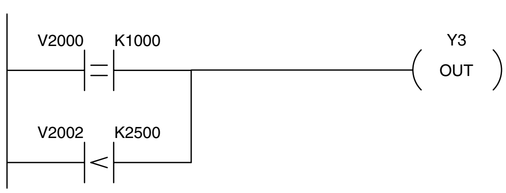


Handheld Programmer Keystrokes

$ STR	SHFT	E 4	→	C 2	A 0	A 0	A 0	→
G 6	A 0	E 4	F 5	ENT				
Q OR	→	SHFT	V AND	C 2	A 0	A 0	C 2	→
C 2	D 3	E 4	F 5	ENT				
GX OUT	→	D 3	ENT					

In the following example when the value in V memory location V2000 = 1000 or V2002 < 2500, Y3 will energize.

***Direct*SOFT32**

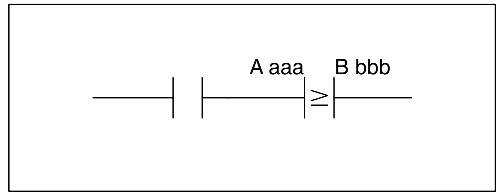


Handheld Programmer Keystrokes

$ STR	SHFT	E 4	→	C 2	A 0	A 0	A 0	→
B 1	A 0	A 0	A 0	ENT				
R ORN	→	SHFT	V AND	C 2	A 0	A 0	C 2	→
C 2	F 5	A 0	A 0	ENT				
GX OUT	→	D 3	ENT					

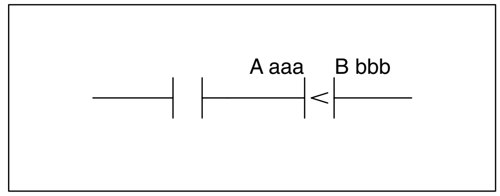
And (AND)

The Comparative And instruction connects a normally open comparative contact in series with another contact. The contact will be on when Aaaa $\geq$ Bbbb.



And Not (ANDN)

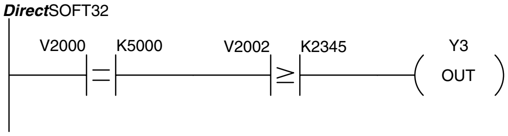
The Comparative And Not instruction connects a normally open comparative contact in parallel with another contact. The contact will be on when Aaaa < Bbbb.



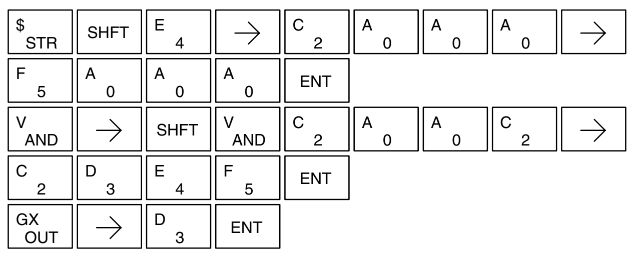
Operand Data Type		DL130 Range	
	A/B	aaa	bbb
V memory	V	All (See page 4–28)	All (See page 4–28)
Constant	K	—	0–FFFF
Timer	T	0–77	
Counter	CT	0–77	

In the following example, when the value in V memory location V2000 = 5000, and V2002 $\geq$ 2345, Y3 will energize.

*Direct*SOFT32

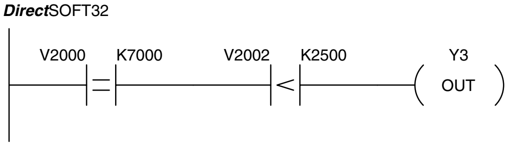


Handheld Programmer Keystrokes

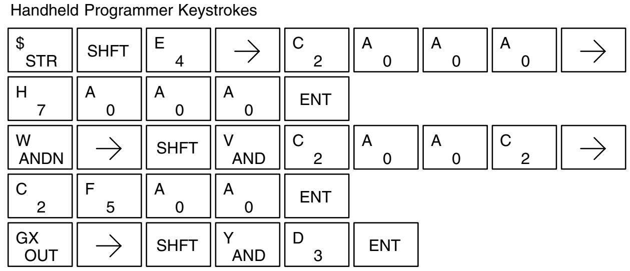


In the following example, when the value in V memory location V2000 = 7000 and V2002 < 2500, Y3 will energize.

*Direct*SOFT32



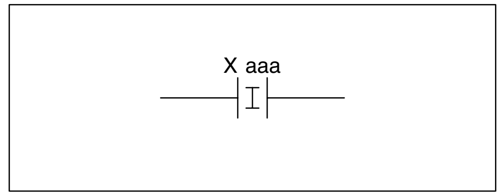
Handheld Programmer Keystrokes



Immediate Instructions

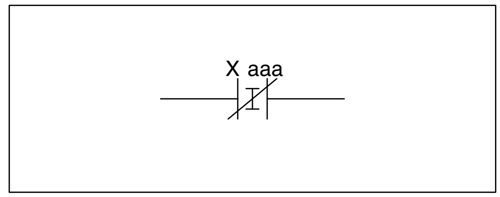
Store Immediate (STRI)

The Store Immediate instruction begins a new rung or additional branch in a rung. The status of the contact will be the same as the status of the associated input point *at the time the instruction is executed*. The image register is not updated.



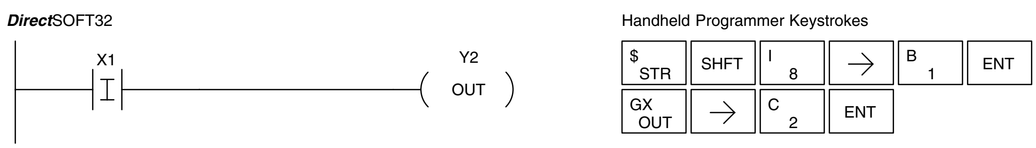
Store Not Immediate (STRNI)

The Store Not Immediate instruction begins a new rung or additional branch in a rung. The status of the contact will be opposite the status of the associated input point *at the time the instruction is executed*. The image register is not updated.

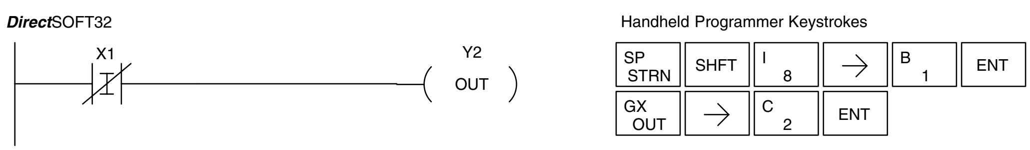


Operand Data Type		DL130 Range
		aaa
Inputs	X	0–11

In the following example, when X1 is on, Y2 will energize.

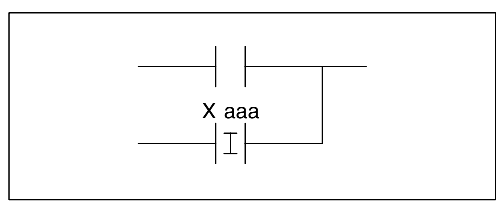


In the following example when X1 is off, Y2 will energize.



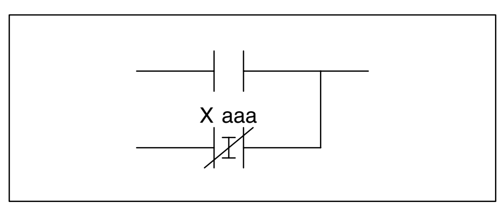
Or Immediate (ORI)

The Or Immediate connects two contacts in parallel. The status of the contact will be the same as the status of the associated input point *at the time the instruction is executed*. The image register is not updated.



Or Not Immediate (ORNI)

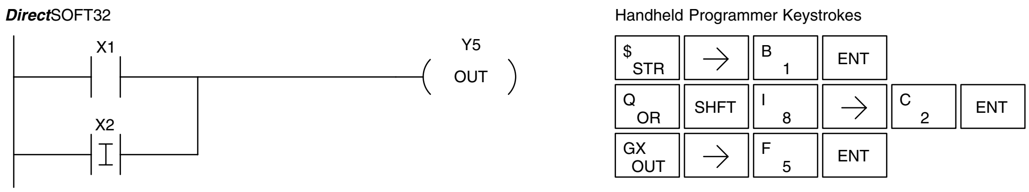
The Or Not Immediate connects two contacts in parallel. The status of the contact will be opposite the status of the associated input point *at the time the instruction is executed*. The image register is not updated.



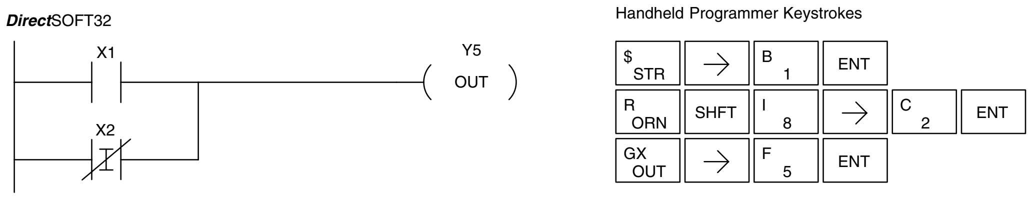
OR Immediate Instructions Cont'd

Operand Data Type		DL130 Range
		aaa
Inputs	X	0–177

In the following example, when X1 or X2 is on, Y5 will energize.

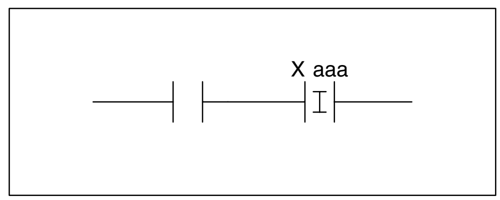


In the following example, when X1 is on or X2 is off, Y5 will energize.



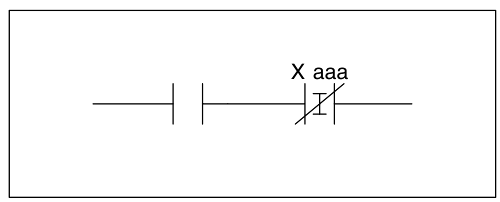
And Immediate (ANDI)

The And Immediate connects two contacts in series. The status of the contact will be the same as the status of the associated input point *at the time the instruction is executed*. The image register is not updated.



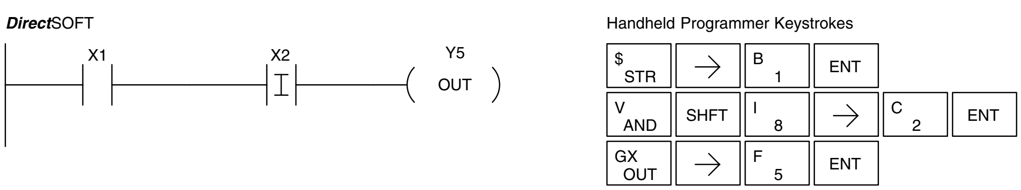
And Not Immediate (ANDNI)

The And Not Immediate connects two contacts in series. The status of the contact will be opposite the status of the associated input point *at the time the instruction is executed*. The image register is not updated.

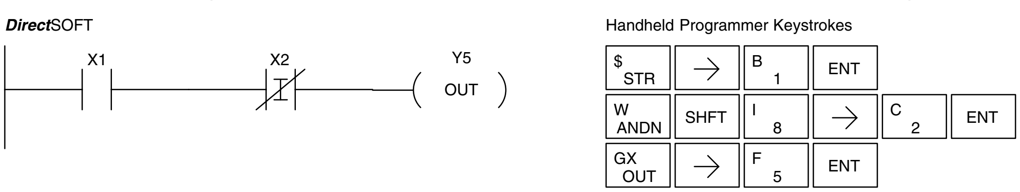


Operand Data Type		DL130 Range
		aaa
Inputs	X	0–11

In the following example, when X1 and X2 are on, Y5 will energize.

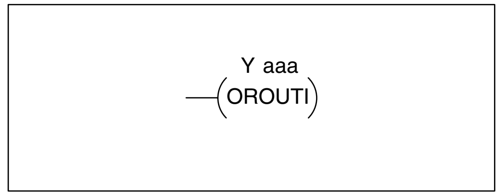


In the following example, when X1 is on and X2 are off, Y5 will energize.



Or Out Immediate (OROUTI)

The Or Out Immediate instruction has been designed to use more than 1 rung of discrete logic to control a single output. Multiple Or Out Immediate instructions referencing the same output coil may be used, since all contacts controlling the output are ored together. If the status of *any* rung is on *at the time the instruction is executed*, the output will also be on.

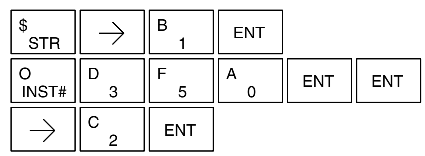


Operand Data Type		DL130 Range
		aaa
Outputs	Y	0–177

In the following example, when X1 is on, output point Y2 on the output module will turn on. For instruction entry on the Handheld Programmer, you can use the instruction number (#350) as shown, or type each letter of the command.

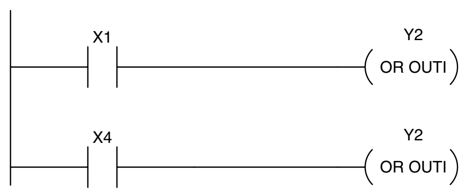
***Direct*SOFT32**

Handheld Programmer Keystrokes

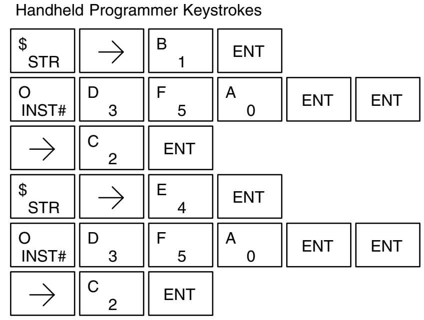


In the following example, when X1 or X4 is on, Y2 will energize.

***Direct*SOFT32**

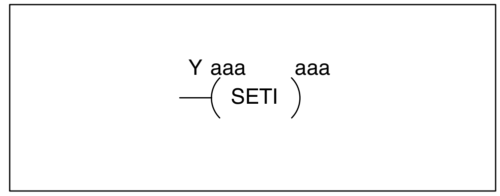


Handheld Programmer Keystrokes



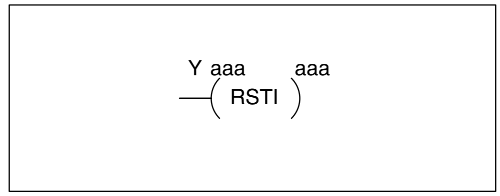
Set Immediate (SETI)

The Set Immediate instruction immediately sets, or turns on an output or a range of outputs in the image register and the corresponding output point(s) *at the time the instruction is executed*. Once the outputs are set it is not necessary for the input to remain on. The Reset Immediate instruction can be used to reset the outputs.



Reset Immediate (RSTI)

The Reset Immediate instruction immediately resets, or turns off an output or a range of outputs in the image register and the output point(s) *at the time the instruction is executed*. Once the outputs are reset it is not necessary for the input to remain on.

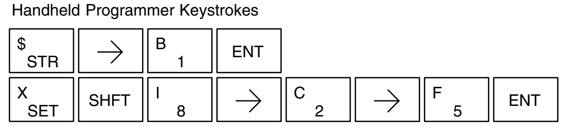


Operand Data Type		DL130 Range
		aaa
Outputs	Y	0–177

In the following example, when X1 is on, Y2 through Y5 will be set on in the image register and on the corresponding output points.

DirectSOFT32

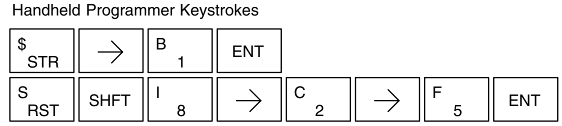
Handheld Programmer Keystrokes



In the following example, when X1 is on, Y5 through Y22 will be reset (off) in the image register and on the corresponding output module(s).

DirectSOFT32

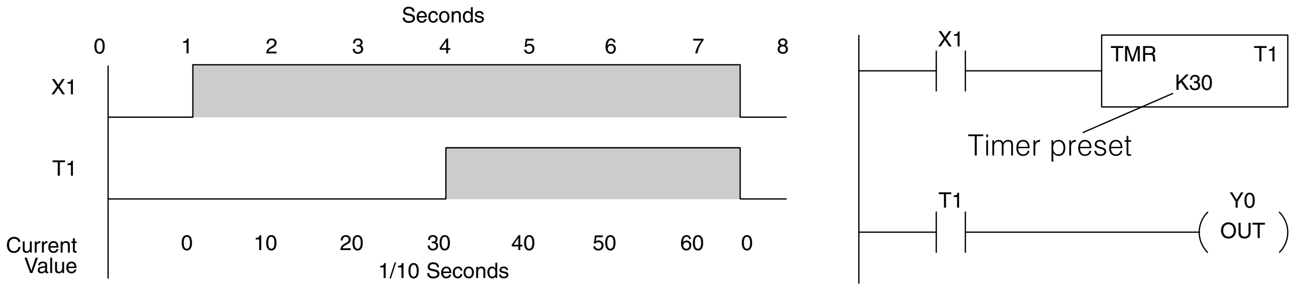
Handheld Programmer Keystrokes



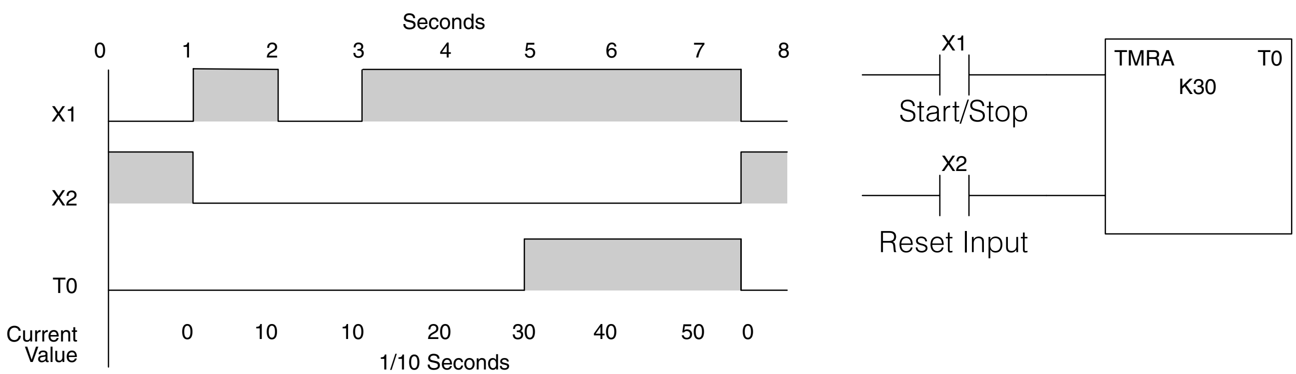
Timer, Counter and Shift Register Instructions

Using Timers

Timers are used to time an event for a desired length of time. The single input timer will time as long as the input is on. When the input changes from on to off the timer current value is reset to 0. There is a tenth of a second and a hundredth of a second timer available with a maximum time of 999.9 and 99.99 seconds respectively. There is a discrete bit associated with each timer to indicate that the current value is equal to or greater than the preset value. The timing diagram below shows the relationship between the timer input, associated discrete bit, current value, and timer preset.

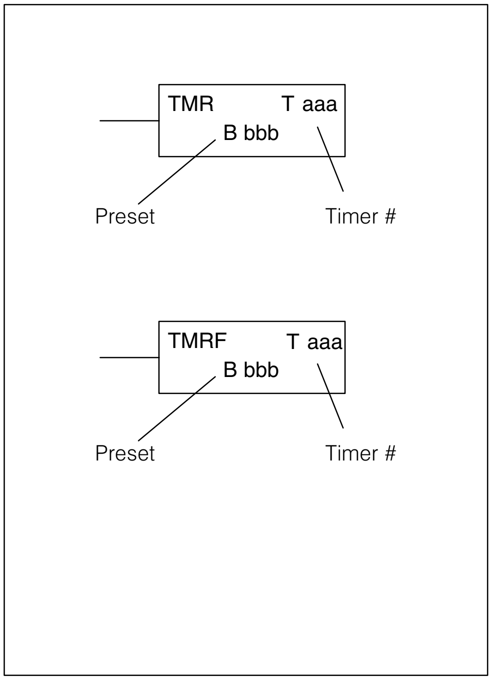


There are those applications that need an accumulating timer, meaning it has the ability to time, stop, and then resume from where it previously stopped. The accumulating timer works similarly to the regular timer, but two inputs are required. The start/stop input starts and stops the timer. When the timer stops, the elapsed time is maintained. When the timer starts again, the timing continues from the elapsed time. When the reset input is turned on, the elapsed time is cleared and the timer will start at 0 when it is restarted. There is a tenth of a second and a hundredth of a second timer available with a maximum time of 9999999.9 and 999999.99 seconds respectively. The timing diagram below shows the relationship between the timer input, timer reset, associated discrete bit, current value, and timer preset.



Timer (TMR) and Timer Fast (TMRF)

The Timer instruction is a 0.1 second single input timer that times to a maximum of 999.9 seconds. The Timer Fast instruction is a 0.01 second single input timer that times up to a maximum of 99.99 seconds. These timers will be enabled if the input logic is true (on) and will be reset to 0 if the input logic is false (off).



The timer discrete status bit and the current value are not specified in the timer instruction.

Instruction Specifications

Timer Reference (Taaa): Specifies the timer number.

Preset Value (Bbbb): Constant value (K) or a V memory location.

Current Value: Timer current values are accessed by referencing the associated V or T memory location*. For example, the timer current value for T3 physically resides in V-memory location V3.

Discrete Status Bit: The discrete status bit is referenced by the associated T memory location. Operating as a "timer done bit", it will be on if the current value is equal to or greater than the preset value. For example, the discrete status bit for Timer 2 is TA2.

NOTE: Timer preset constants (K) may be changed by using a handheld programmer, even when the CPU is in Run Mode. Therefore, a V-memory preset is required only if the ladder program must change the preset.

Operand Data Type		DL130 Range	
	A/B	aaa	bbb
Timers	T	0–77	—
V memory for preset values	V	—	2000–2377 4000–4177
Constants (preset only)	K	—	0–9999
Timer discrete status bits	T/V	0–77 or V41100–41103	
Timer current values	V /T*	0–77	

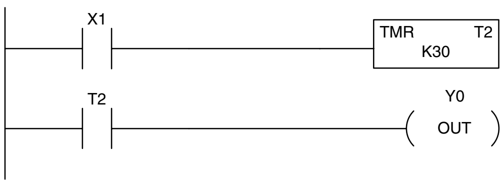
NOTE: * With the HPP, both the Timer discrete status bits and current value are accessed with the same data reference. ***Direct***SOFT32 uses separate references, such as "T2" for discrete status bit for Timer T2, and "TA2" for the current value of Timer T2.

You can perform functions when the timer reaches the specified preset using the discrete status bit. Or, use comparative contacts to perform functions at different time intervals, based on one timer. The examples on the following page show these two methods of programming timers.

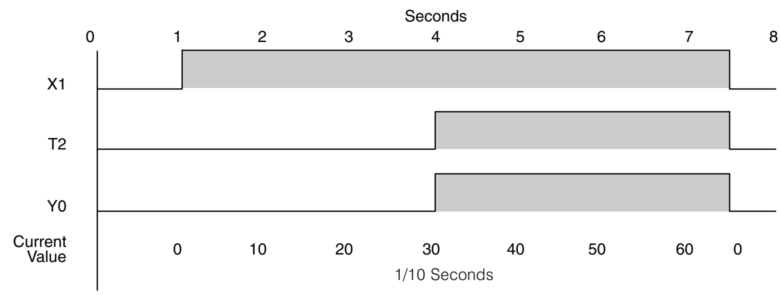
Timer Example Using Discrete Status Bits

In the following example, a single input timer is used with a preset of 3 seconds. The timer discrete status bit (T2) will turn on when the timer has timed for 3 seconds. The timer is reset when X1 turns off, turning the discrete status bit off and resetting the timer current value to 0.

***Direct*SOFT**



Timing Diagram



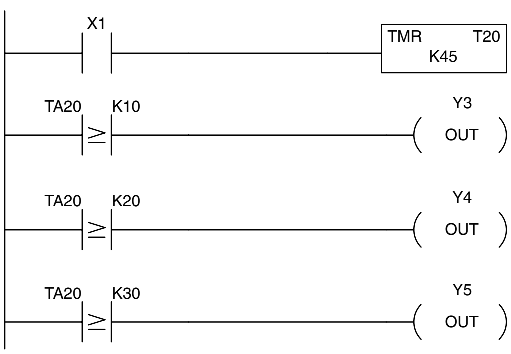
Handheld Programmer Keystrokes

$ STR	→	B 1	ENT			
N TMR	→	C 2	→	D 3	A 0	ENT
$ STR	→	SHFT	T MLR	C 2	ENT	
GX OUT	→	A 0	ENT			

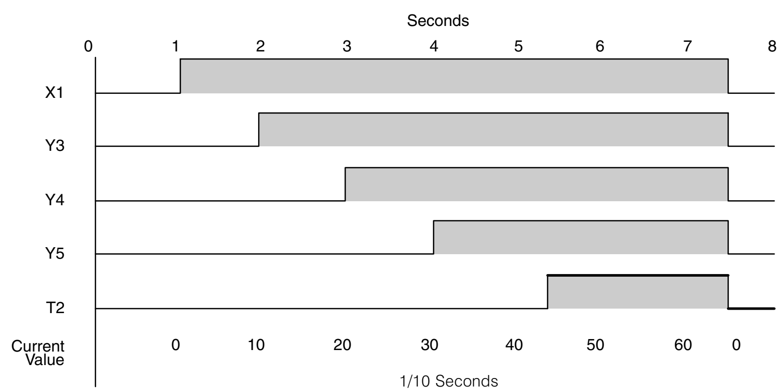
Timer Example Using Comparative Contacts

In the following example, a single input timer is used with a preset of 4.5 seconds. Comparative contacts are used to energize Y3, Y4, and Y5 at one second intervals respectively. When X1 is turned off the timer will be reset to 0 and the comparative contacts will turn off Y3, Y4, and Y5.

***Direct*SOFT**



Timing Diagram



Handheld Programmer Keystrokes

$ STR	→	B 1	ENT						
N TMR	→	C 2	A 0	→	E 4	F 5	ENT		
$ STR	→	SHFT	T MLR	C 2	A 0	→	B 1	A 0	ENT
GX OUT	→	D 3	ENT						
$ STR	→	SHFT	T MLR	C 2	A 0	→	C 2	A 0	ENT
GX OUT	→	E 4	ENT						
$ STR	→	SHFT	T MLR	C 2	A 0	→	D 3	A 0	ENT
GX OUT	→	F 5	ENT						

Accumulating Timer (TMRA)

Accumulating Fast Timer (TMRAF)

The Accumulating Timer is a 0.1 second two input timer that will time to a maximum of 9999999.9. The Accumulating Fast Timer is a 0.01 second two-input timer that will time to a maximum of 999999.99. *Each one uses two timer registers in V-memory.* These timers have two inputs, an enable and a reset. The timer starts timing when the enable is on and stops when the enable is off (without resetting the count). The reset will reset the timer when on and allow the timer to time when off.

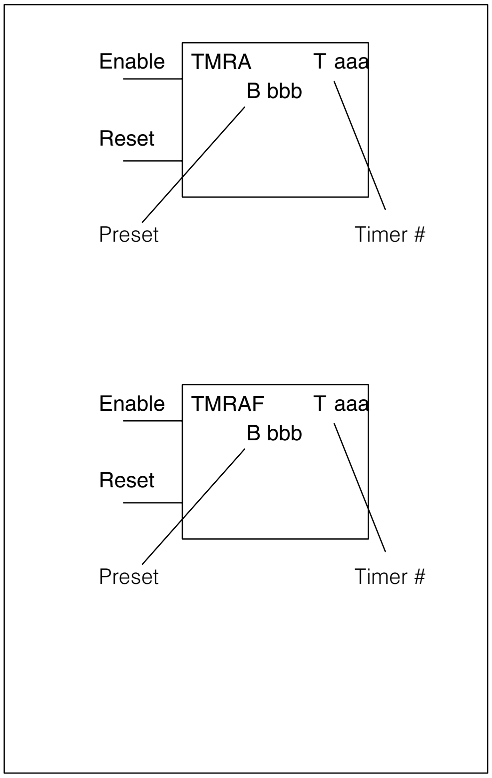
Instruction Specifications

Timer Reference (Taaa): Specifies the timer number.

Preset Value (Bbbb): Constant value (K) or a V memory location.

Current Value: Timer current values are accessed by referencing the associated V or T memory location*. For example, the timer current value for T3 resides in V-memory location V3.

Discrete Status Bit: The discrete status bit is accessed by referencing the associated T memory location. Operating as a “timer done bit”, it will be on if the current value is equal to or greater than the preset value. For example the discrete status bit for timer 2 would be T2.



The timer discrete status bit and the current value are not specified in the timer instruction.

NOTE: The accumulating type timer uses **two consecutive V-memory locations** for the 8-digit value, and therefore two consecutive timer locations. For example, if TMR 1 is used, the next available timer number is TMR 3.

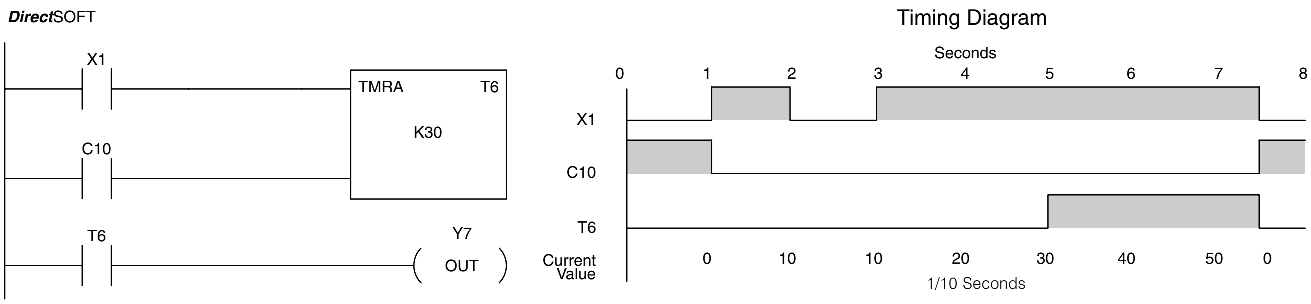
Operand Data Type		DL130 Range	
	A/B	aaa	bbb
Timers	T	0–77	—
V memory for preset values	V	—	2000–2376 4000–4176
Constants (preset only)	K	—	0–99999999
Timer discrete status bits	T/V	0–77 or V41100–41103	
Timer current values	V /T*	0–77	

NOTE: * With the HPP, both the Timer discrete status bits and current value are accessed with the same data reference. ***Direct***SOFT32 uses separate references, such as T2 for discrete status bit for Timer T2, and TA2 for the current value of Timer T2.

The following examples show two methods of programming timers. One performs functions when the timer reaches the preset value using the discrete status bit, or use comparative contacts to perform functions at different time intervals.

Accumulating Timer Example using Discrete Status Bits

In the following example, a two input timer (accumulating timer) is used with a preset of 3 seconds. The timer discrete status bit (T6) will turn on when the timer has timed for 3 seconds. Notice in this example that the timer times for 1 second , stops for one second, then resumes timing. The timer will reset when C10 turns on, turning the discrete status bit off and resetting the timer current value to 0.



Handheld Programmer Keystrokes

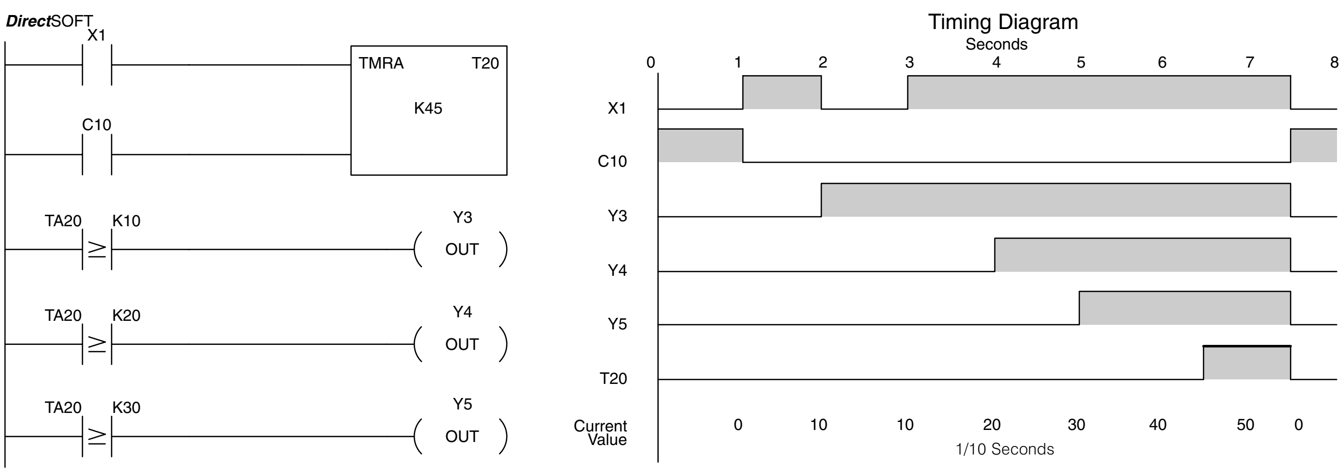
$ STR	→	B 1	ENT			
$ STR	→	SHFT	C 2	B 1	A 0	ENT
N TMR	SHFT	A 0	→	G 6	→	

Handheld Programmer Keystrokes (cont)

D 3	A 0	ENT			
$ STR	→	SHFT	T MLR	G 6	ENT
GX OUT	→	B 1	A 0	ENT	

Accumulator Timer Example Using Comparative Contacts

In the following example, a single input timer is used with a preset of 4.5 seconds. Comparative contacts are used to energized Y3, Y4, and Y5 at one second intervals respectively. The comparative contacts will turn off when the timer is reset.



Handheld Programmer Keystrokes

$ STR	→	B 1	ENT						
$ STR	→	SHFT	C 2	B 1	A 0	ENT			
N TMR	SHFT	A 0	→	C 2	A 0	→	E 4	F 5	ENT
$ STR	→	SHFT	T MLR	C 2	A 0	→	B 1	A 0	ENT
GX OUT	→	D 3	ENT						
$ STR	→	SHFT	T MLR	C 2	A 0	→	C 2	A 0	ENT

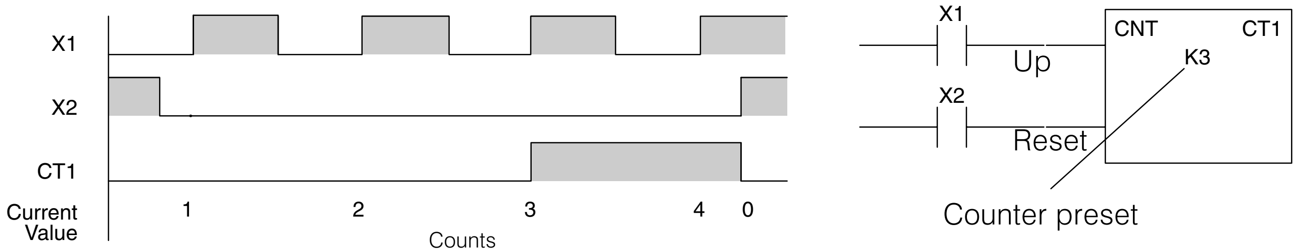
Handheld Programmer Keystrokes (cont)

GX OUT	→	E 4	ENT			
$ STR	→	SHFT	T MLR	C 2	A 0	→
D 3	A 0	ENT				
GX OUT	→	F 5	ENT			

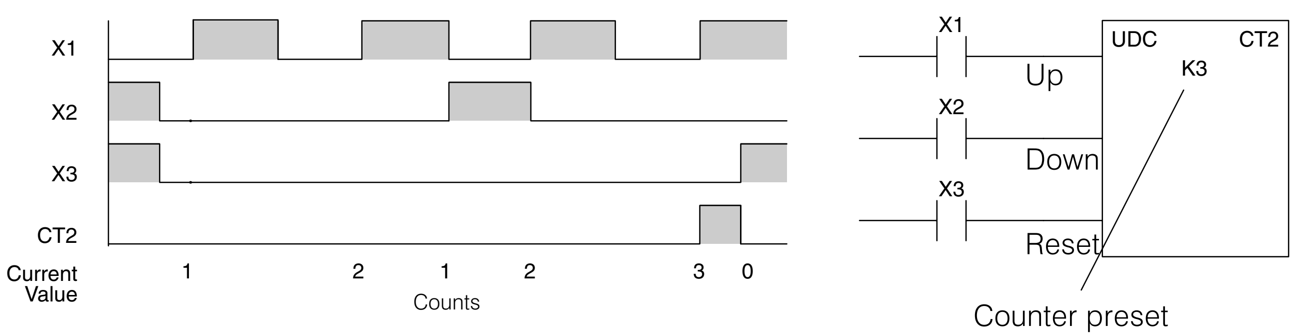
Using Counters

Counters are used to count events . The counters available are up counters, up/down counters, and stage counters (used with RLL*PLUS* programming).

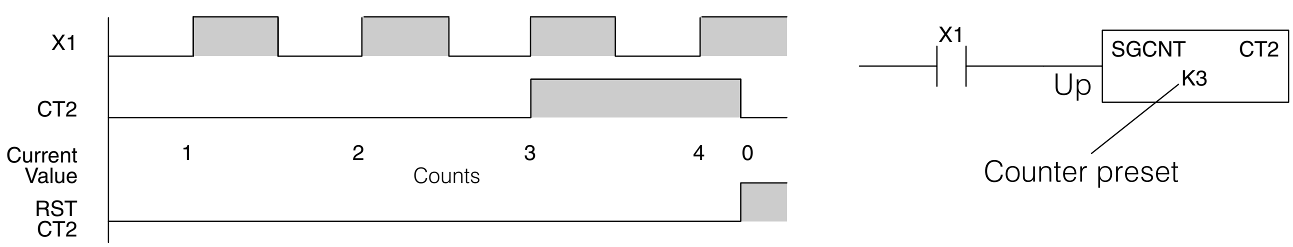
The up counter has two inputs, a count input and a reset input. The maximum count value is 9999. The timing diagram below shows the relationship between the counter input, counter reset, associated discrete bit, current value, and counter preset.



The up down counter has three inputs, a count up input, count down input and reset input. The maximum count value is 99999999. The timing diagram below shows the relationship between the counter input, counter reset, associated discrete bit, current value, and counter preset.

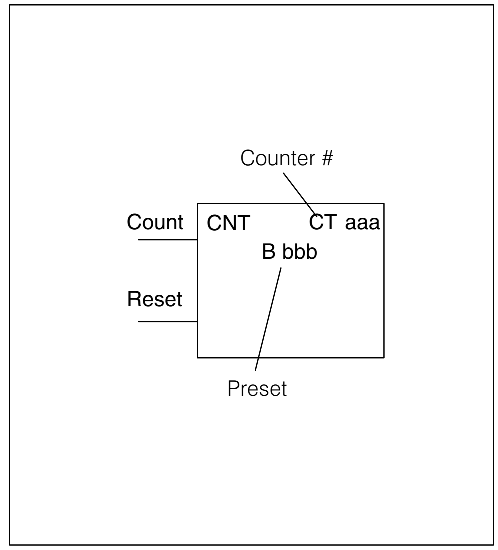


The stage counter has a count input and is reset by the RST instruction. This instruction is useful when programming using the RLL*PLUS* structured programming. The maximum count value is 9999. The timing diagram below shows the relationship between the counter input, associated discrete bit, current value, counter preset and reset instruction.



Counter (CNT)

The Counter is a two input counter that increments when the count input logic transitions from off to on. When the counter reset input is on the counter resets to 0. When the current value equals the preset value, the counter status bit comes on and the counter continues to count up to a maximum count of 9999. The maximum value will be held until the counter is reset.



The counter discrete status bit and the current value are not specified in the counter instruction.

Instruction Specifications

Counter Reference (CTaaa): Specifies the counter number.

Preset Value (Bbbb): Constant value (K) or a V memory location.

Current Values: Counter current values are accessed by referencing the associated V or CT memory locations*. The V-memory location is the counter location + 1000. For example, the counter current value for CT3 resides in V memory location V1003.

Discrete Status Bit: The discrete status bit is accessed by referencing the associated CT memory location. It will be on if the value is equal to or greater than the preset value. For example the discrete status bit for counter 2 would be CT2.

NOTE: Counter preset constants (K) may be changed by using a programming device, even when the CPU is in Run Mode. Therefore, a V-memory preset is required only if the ladder program must change the preset.

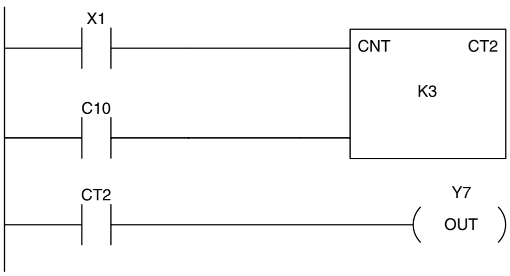
Operand Data Type		DL130 Range	
	A/B	aaa	bbb
Counters	CT	0–77	—
V memory (preset only)	V	—	2000–2377 4000–4177
Constants (preset only)	K	—	0–9999
Counter discrete status bits	CT/V	0–77 or V41140–41143	
Counter current values	V/CT*	1000–1077	

NOTE: * With the HPP, both the Counter discrete status bits and current value are accessed with the same data reference. ***Direct***SOFT32 uses separate references, such as “CT2” for discrete status bit for Counter CT2, and “CTA2” for the current value of Counter CT2.

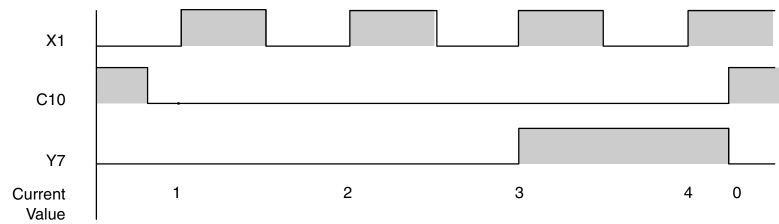
Counter Example Using Discrete Status Bits

In the following example, when X1 makes an off to on transition, counter CT2 will increment by one. When the current value reaches the preset value of 3, the counter status bit CT2 will turn on and energize Y7. When the reset C10 turns on, the counter status bit will turn off and the current value will be 0. The current value for counter CT2 will be held in V memory location V1002.

***Direct*SOFT**



Counting diagram



Handheld Programmer Keystrokes

$ STR	→	B 1	ENT			
$ STR	→	SHFT	C 2	B 1	A 0	ENT
GY CNT	→	C 2	→	D 3	ENT	

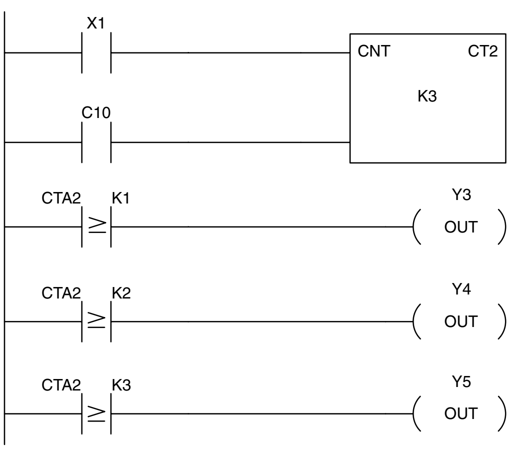
Handheld Programmer Keystrokes (cont)

$ STR	→	SHFT	C 2	SHFT	T MLR	C 2	ENT
GX OUT	→	B 1	A 0	ENT			

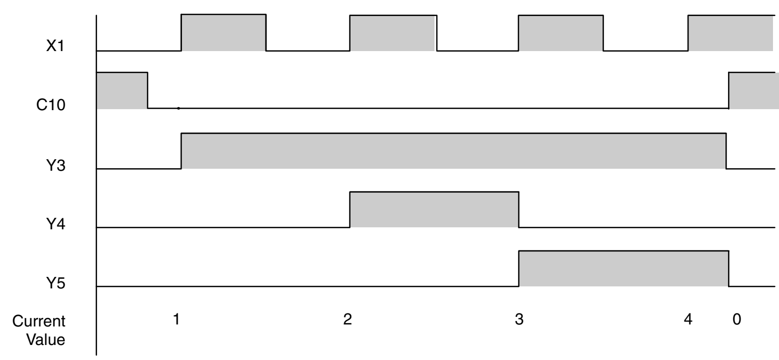
Counter Example Using Comparative Contacts

In the following example, when X1 makes an off to on transition, counter CT2 will increment by one. Comparative contacts are used to energize Y3, Y4, and Y5 at different counts. When the reset C10 turns on, the counter status bit will turn off and the counter current value will be 0, and the comparative contacts will turn off.

***Direct*SOFT**



Counting diagram



Handheld Programmer Keystrokes

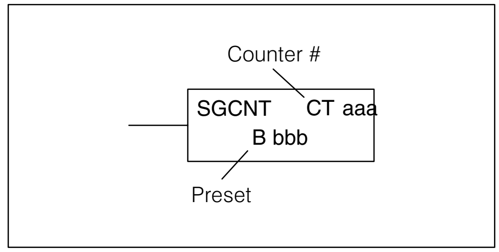
$ STR	→	B 1	ENT			
$ STR	→	SHFT	C 2	B 1	A 0	ENT
GY CNT	→	C 2	→	D 3	ENT	
$ STR	→	SHFT	C 2	SHFT	T MLR	C 2
→	B 1	ENT				
GX OUT	→	D 3	ENT			

Handheld Programmer Keystrokes (cont)

$ STR	→	SHFT	C 2	SHFT	T MLR	C 2
→	C 2	ENT				
GX OUT	→	E 4	ENT			
$ STR	→	SHFT	C 2	SHFT	T MLR	C 2
→	D 3	ENT				
GX OUT	→	F 5	ENT			

Stage Counter (SGCNT)

The Stage Counter is a single input counter that increments when the input logic transitions from off to on. This counter differs from other counters since it will hold its current value until reset using the RST instruction. The Stage Counter is designed for use in RLL*PLUS* programs but can be used in relay ladder logic programs. When the current value equals the preset value, the counter status bit turns on and the counter continues to count up to a maximum count of 9999. The maximum value will be held until the counter is reset.



The counter discrete status bit and the current value are not specified in the counter instruction.

Instruction Specifications

Counter Reference (CTaaa): Specifies the counter number.

Preset Value (Bbbb): Constant value (K) or a V memory location.

Current Values: Counter current values are accessed by referencing the associated V or CT memory locations*. The V-memory location is the counter location + 1000. For example, the counter current value for CT3 resides in V memory location V1003.

Discrete Status Bit: The discrete status bit is accessed by referencing the associated CT memory location. It will be on if the value is equal to or greater than the preset value. For example the discrete status bit for counter 2 would be CT2.

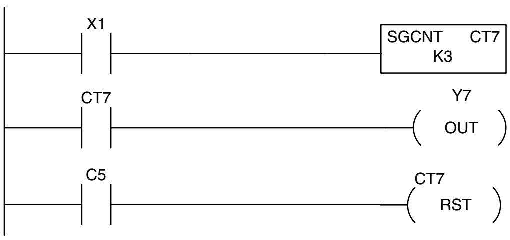
Operand Data Type		DL130 Range	
	A/B	aaa	bbb
Counters	CT	0–77	—
V memory (preset only)	V	—	2000–2377
Constants (preset only)	K	—	0–9999
Counter discrete status bits	CT/V	0–77 or V41140–41143	
Counter current values	V/CT*	1000–1077	

NOTE: * With the HPP, both the Counter discrete status bits and current value are accessed with the same data reference. ***Direct***SOFT32 uses separate references, such as “CT2” for discrete status bit for Counter CT2, and “CTA2” for the current value of Counter CT2.

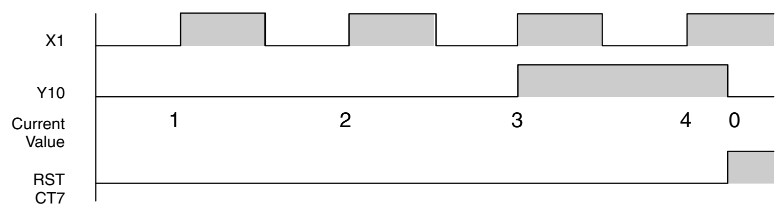
Stage Counter Example Using Discrete Status Bits

In the following example, when X1 makes an off to on transition, stage counter CT7 will increment by one. When the current value reaches 3, the counter status bit CT7 will turn on and energize Y7. The counter status bit CT7 will remain on until the counter is reset using the RST instruction. When the counter is reset, the counter status bit will turn off and the counter current value will be 0. The current value for counter CT7 will be held in V memory location V1007.

*Direct*SOFT



Counting diagram



Handheld Programmer Keystrokes

$ STR	→	B 1	ENT				
SHFT	S RST	SHFT	G 6	SHFT	GY CNT	→	
H 7	→	D 3	ENT				
$ STR	→	SHFT	C 2	SHFT	T MLR	H 7	ENT

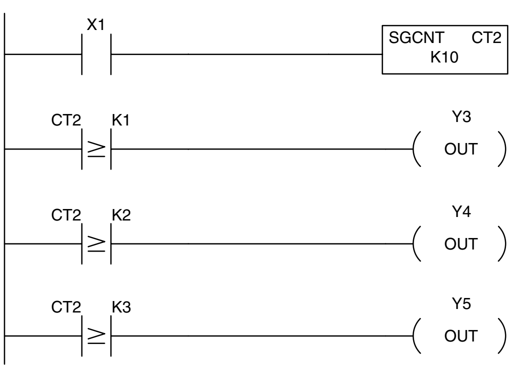
Handheld Programmer Keystrokes (cont)

GX OUT	→	B 1	A 0	ENT			
$ STR	→	SHFT	C 2	F 5	ENT		
S RST	→	SHFT	C 2	SHFT	T MLR	H 7	ENT

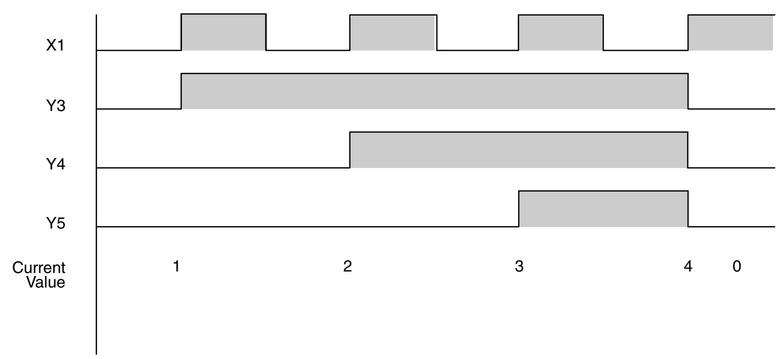
Stage Counter Example Using Comparative Contacts

In the following example, when X1 makes an off to on transition, counter CT2 will increment by one. Comparative contacts are used to energize Y3, Y4, and Y5 at different counts. Although this is not shown in the example, when the counter is reset using the Reset instruction, the counter status bit will turn off and the current value will be 0. The current value for counter CT2 will be held in V memory location V1002.

*Direct*SOFT



Counting diagram



Handheld Programmer Keystrokes

$ STR	→	B 1	ENT			
SHFT	S RST	G 6	SHFT	GY CNT	→	
C 2	→	B 1	A 0	ENT		
$ STR	→	SHFT	C 2	SHFT	T MLR	C 2
→	B 1	ENT				
GX OUT	→	D 3	ENT			

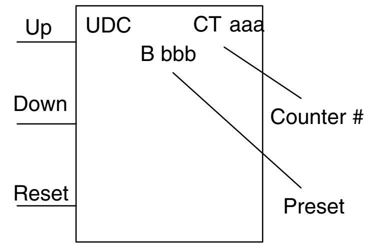
Handheld Programmer Keystrokes (cont)

$ STR	→	SHFT	C 2	SHFT	T MLR	C 2
→	C 2	ENT				
GX OUT	→	E 4	ENT			
$ STR	→	SHFT	C 2	SHFT	T MLR	C 2
→	D 3	ENT				
GX OUT	→	F 5	ENT			

Standard RLL Instructions

Up Down Counter (UDC)

This Up/Down Counter counts up on each off to on transition of the Up input and counts down on each off to on transition of the Down input. The counter is reset to 0 when the Reset input is on. The count range is 0–99999999. The count input not being used must be off in order for the active count input to function.



Caution: The UDC uses two V memory locations for the 8 digit current value. This means that the UDC uses two consecutive counter locations. If UDC CT1 is used in the program, the next available counter is CT3.

The counter discrete status bit and the current value are not specified in the counter instruction.

Instruction Specification

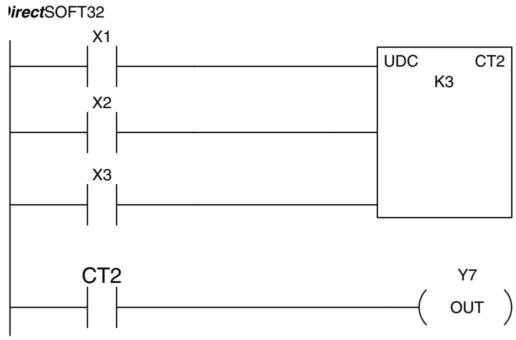
Counter Reference (CTaaa): Specifies the counter number.
Preset Value (Bbbb): Constant value (K) or two consecutive V memory locations.
Current Values: Current count is a double word value accessed by referencing the associated V or CT memory locations*. The V-memory location is the counter location + 1000. For example, the counter current value for CT5 resides in V memory location V1005 and V1006.
Discrete Status Bit: The discrete status bit is accessed by referencing the associated CT memory location. Operating as a “counter done bit” it will be on if the value is equal to or greater than the preset value. For example the discrete status bit for counter 2 would be CT2.

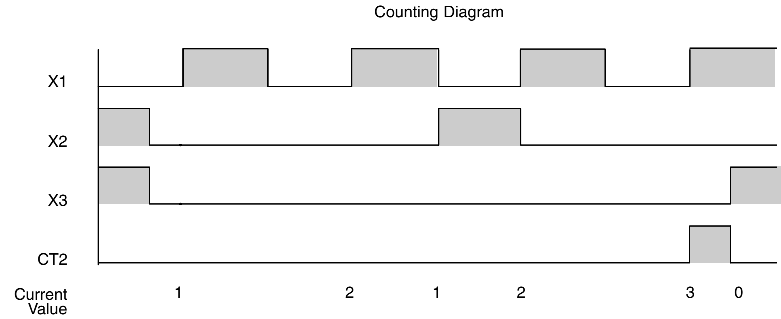
Operand Data Type		DL130 Range	
	A/B	aaa	bbb
Counters	CT	0–77	—
V memory (preset only)	V	—	2000–2377 4000–4177
Constants (preset only)	K	—	0–99999999
Counter discrete status bits	CT/V	0–77 or V41140–41143	
Counter current values	V/CT*	1000–1077	

NOTE: * With the HPP, both the Counter discrete status bits and current value are accessed with the same data reference. ***Direct***SOFT32 uses separate references, such as “CT2” for discrete status bit for Counter CT2, and “CTA2” for the current value of Counter CT2.

Up / Down Counter Example Using Discrete Status Bits

In the following example if X2 and X3 are off ,when X1 toggles from off to on the counter will increment by one. If X1 and X3 are off the counter will decrement by one when X2 toggles from off to on. When the count value reaches the preset value of 3, the counter status bit will turn on. When the reset X3 turns on, the counter status bit will turn off and the current value will be 0.





Handheld Programmer Keystrokes

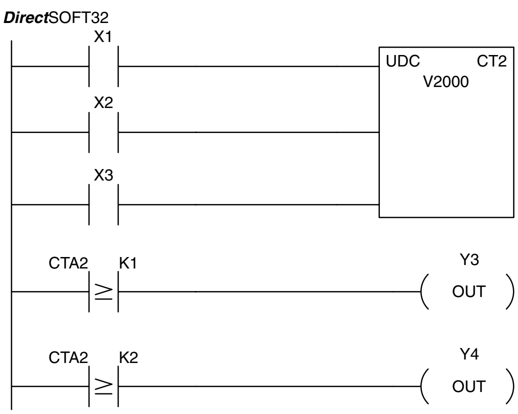
$ STR	→	B 1	ENT		
$ STR	→	C 2	ENT		
$ STR	→	D 3	ENT		
SHFT	U ISG	D 3	C 2	→	C 2

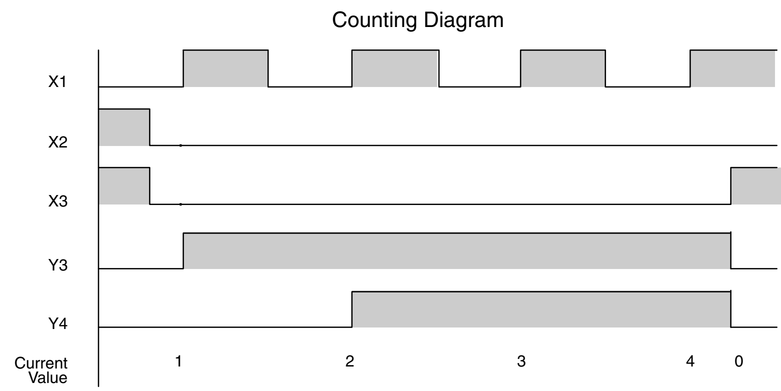
Handheld Programmer Keystrokes (cont)

→	D 3	ENT					
$ STR	→	SHFT	C 2	SHFT	T MLR	C 2	ENT
GX OUT	→	B 1	A 0	ENT			

Up / Down Counter Example Using Comparative Contacts

In the following example, when X1 makes an off to on transition, counter CT2 will increment by one. Comparative contacts are used to energize Y3 and Y4 at different counts. When the reset (X3) turns on, the counter status bit will turn off, the current value will be 0, and the comparative contacts will turn off.





Handheld Programmer Keystrokes

$ STR	→	B 1	ENT			
$ STR	→	C 2	ENT			
$ STR	→	D 3	ENT			
SHFT	U ISG	D 3	C 2	→	C 2	→
SHFT	V AND	C 2	A 0	A 0	A 0	ENT
$ STR	→	SHFT	C 2	SHFT	T MLR	C 2

Handheld Programmer Keystrokes (cont)

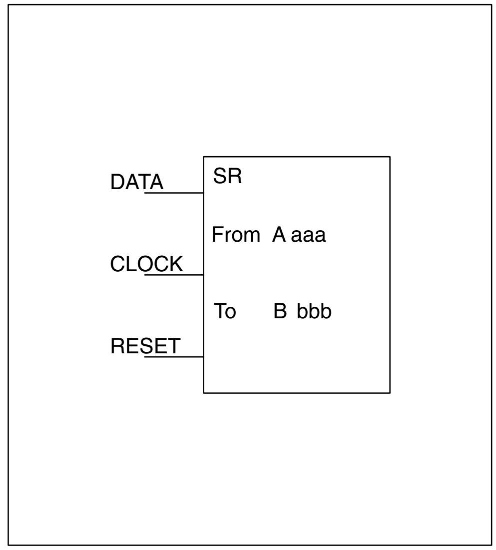
→	B 1	ENT				
GX OUT	→	D 3	ENT			
$ STR	→	SHFT	C 2	SHFT	T MLR	C 2
→	C 2	ENT				
GX OUT	→	E 4	ENT			

Shift Register (SR)

The Shift Register instruction shifts data through a predefined number of control relays. The control ranges in the shift register block must start at the beginning of an 8 bit boundary use 8-bit blocks.

The Shift Register has three contacts.

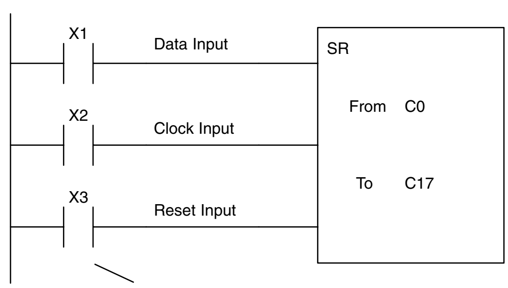
- Data — determines the value (1 or 0) that will enter the register
- Clock — shifts the bits one position on each low to high transition
- Reset —resets the Shift Register to all zeros.



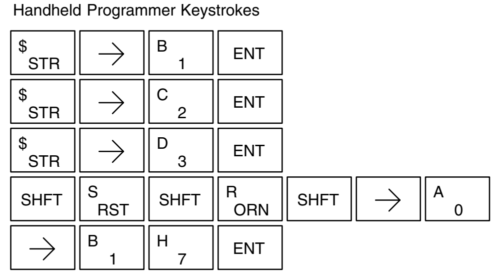
With each off to on transition of the clock input, the bits which make up the shift register block are shifted by one bit position and the status of the data input is placed into the starting bit position in the shift register. The direction of the shift depends on the entry in the From and To fields. From C0 to C17 would define a block of sixteen bits to be shifted from left to right. From C17 to C0 would define a block of sixteen bits, to be shifted from right to left. The maximum size of the shift register block depends on the number of available control relays. The minimum block size is 8 control relays.

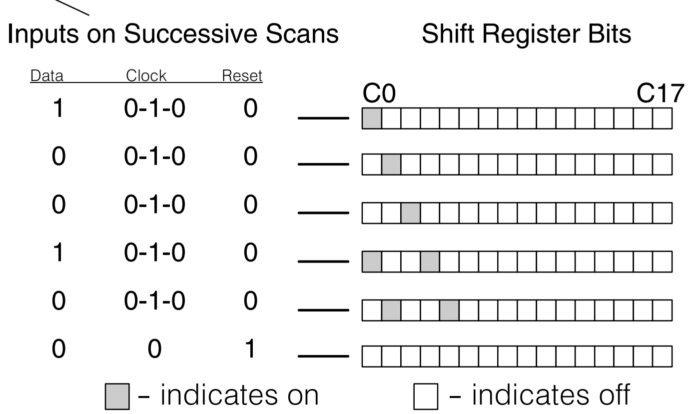
Operand Data Type		DL130 Range	
	A/B	aaa	bbb
Control Relay	C	0–377	0–377

*Direct*SOFT32



Handheld Programmer Keystrokes





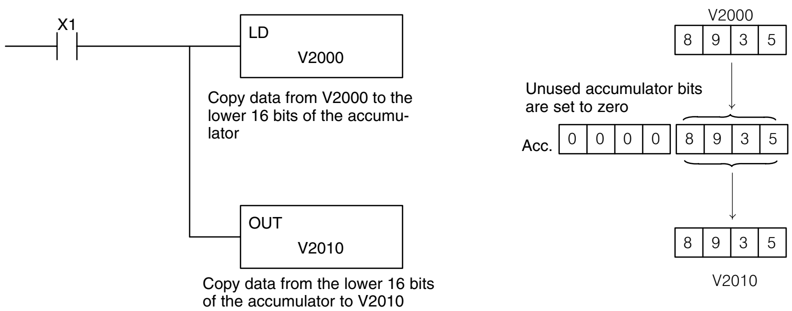
Accumulator / Stack Load and Output Data Instructions

Using the Accumulator

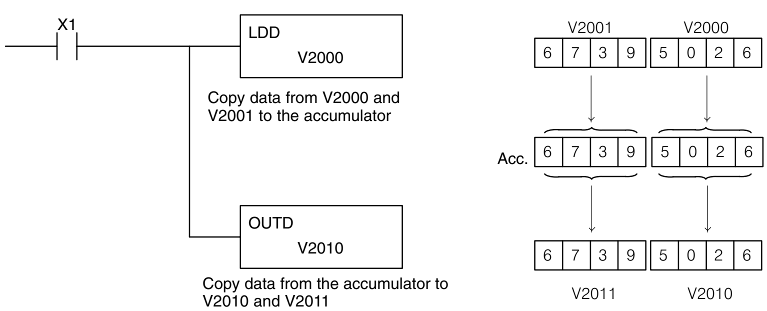
The accumulator in the DL105 internal CPUs is a 32 bit register which is used as a temporary storage location for data that is being copied or manipulated in some manor. For example, you have to use the accumulator to perform math operations such as add, subtract, multiply, etc. Since there are 32 bits, you can use up to an 8-digit BCD number. The accumulator is reset to 0 at the end of every CPU scan.

Copying Data to the Accumulator

The Load and Out instructions and their variations are used to copy data from a V-memory location to the accumulator, or, to copy data from the accumulator to V memory. The following example copies data from V-memory location V2000 to V-memory location V2010.

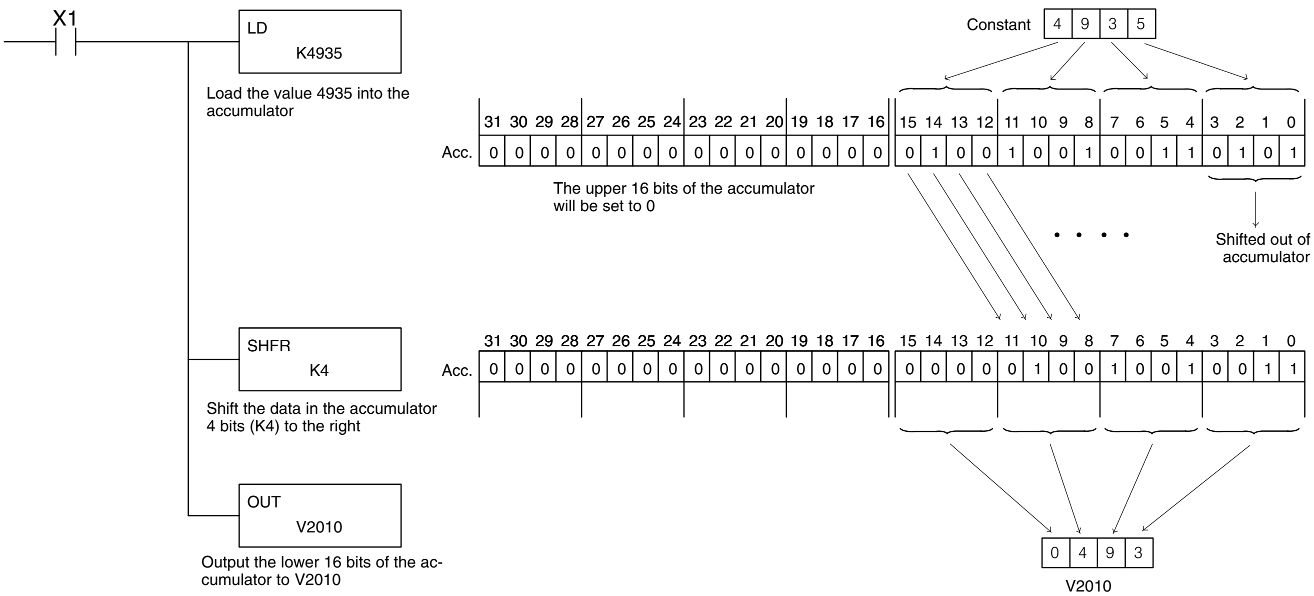


Since the accumulator is 32 bits and V memory locations are 16 bits the Load Double and Out Double (or variations thereof) use two consecutive V-memory locations or 8 digit BCD constants to copy data either to the accumulator from a V-memory address or from a V-memory address to the accumulator. For example if you wanted to copy data from V2000 and V2001 to V2010 and V2011 the most efficient way to perform this function would be as follows:



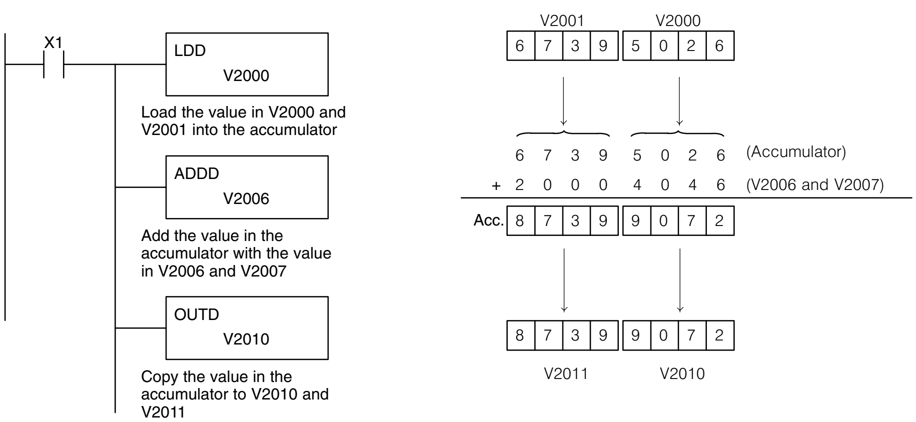
Changing the Accumulator Data

Instructions that manipulate data also use the accumulator. The result of the manipulated data resides in the accumulator. The data that was being manipulated is cleared from the accumulator. The following example loads the constant value 4935 into the accumulator, shifts the data right 4 bits, and outputs the result to V2010.



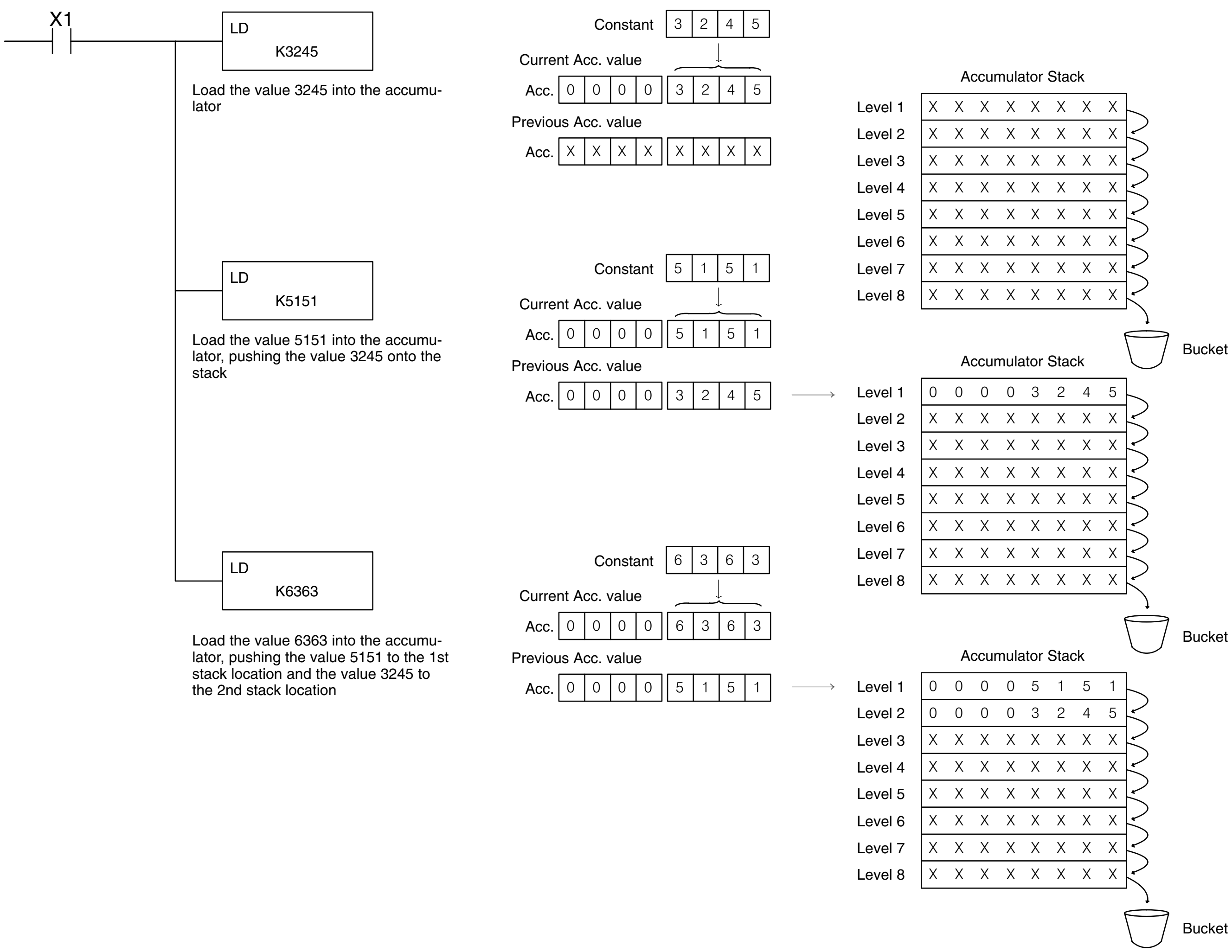
Some of the data manipulation instructions use 32 bits. They use two consecutive V memory locations or an 8 digit BCD constant to manipulate data in the accumulator.

In the following example, when X1 is on, the value in V2000 and V2001 will be loaded into the accumulator using the Load Double instruction. The value in the accumulator is added with the value in V2006 and V2007 using the Add Double instruction. The value in the accumulator is copied to V2010 and V2011 using the Out Double instruction.

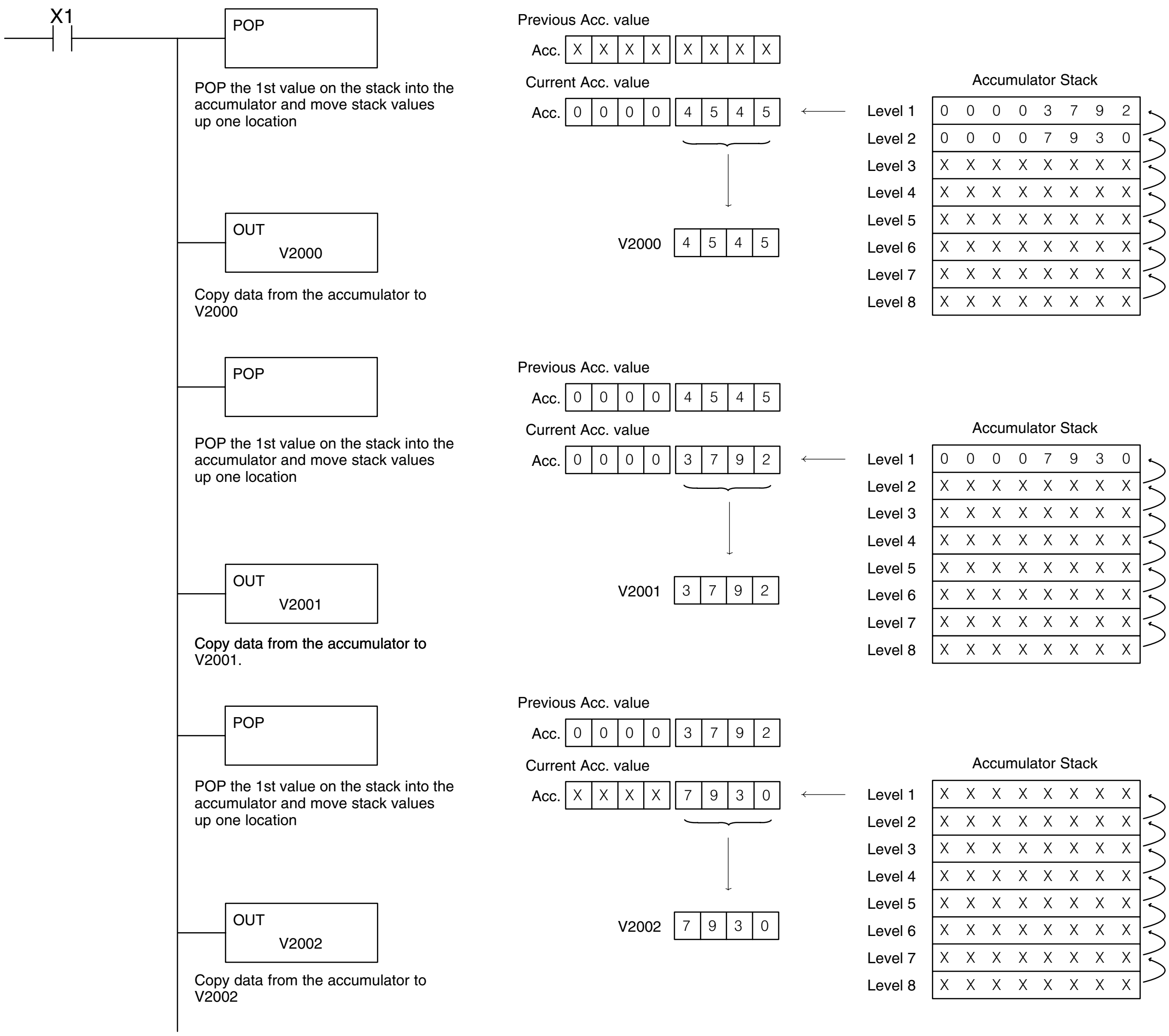


Using the Accumulator Stack

The accumulator stack is used for instructions that require more than one parameter to execute a function or for user defined functionality. The accumulator stack is used when more than one Load instruction is executed without the use of an Out instruction. The first load instruction in the scan places a value into the accumulator. Every Load instruction thereafter without the use of an Out instruction places a value into the accumulator and the value that was in the accumulator is placed onto the accumulator stack. The Out instruction nullifies the previous load instruction and does not place the value that was in the accumulator onto the accumulator stack when the next load instruction is executed. Every time a value is placed onto the accumulator stack the other values in the stack are pushed down one location. The accumulator is eight levels deep (eight 32 bit registers). If there is a value in the eighth location when a new value is placed onto the stack, the value in the eighth location is pushed off the stack and cannot be recovered.



The POP instruction rotates values upward through the stack into the accumulator. When a POP is executed the value which was in the accumulator is cleared and the value that was on top of the stack is in the accumulator. The values in the stack are shifted up one position in the stack.

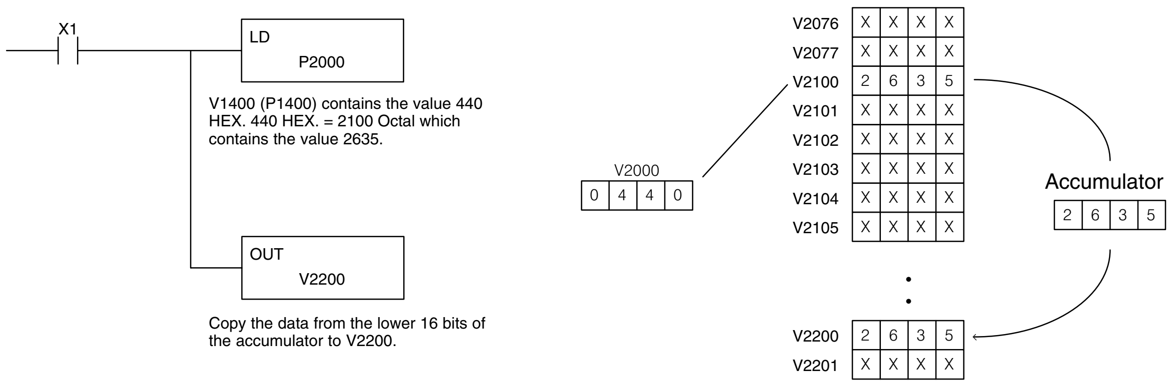


Using Pointers

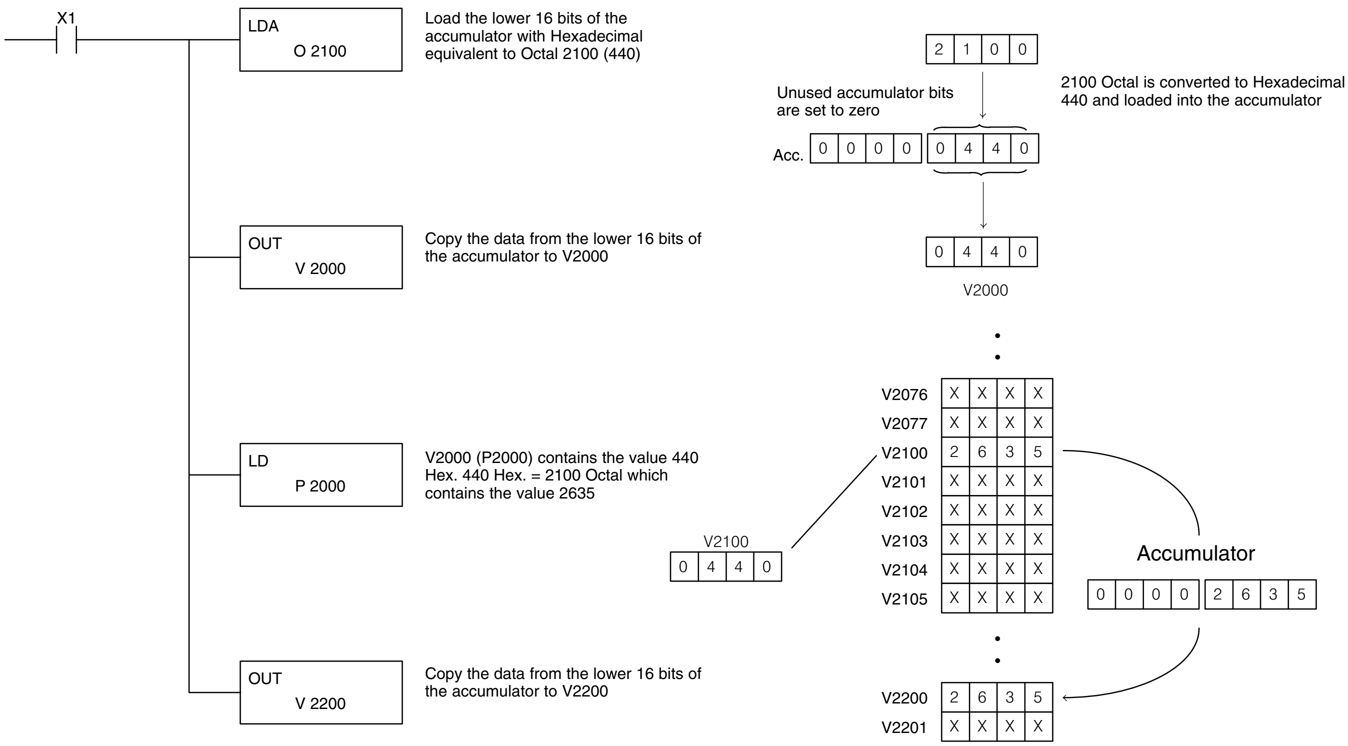
Many of the DL105 series instructions will allow V-memory pointers as a operand (commonly known as indirect addressing). Pointers allow instructions to obtain data from V-memory locations referenced by the pointer value.

NOTE: DL105 V-memory addressing is in octal. However, the pointers reference a V-memory location with values viewed as HEX. Use the Load Address (LDA) instruction to move an address into the pointer location. This instruction performs the Octal to Hexadecimal conversion automatically.

In the following simple example we are using a pointer operand in a Load instruction. V-memory location 2000 is being used as the pointer location. V2000 contains the value 440 which the CPU views as the Hex equivalent of the Octal address V-memory location V2100. The CPU will copy the data from V2100 which in this example contains the value 2635 into the lower word of the accumulator.



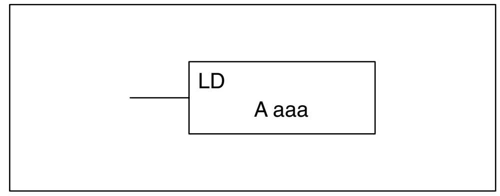
The following example is identical to the one above with one exception. The LDA (Load Address) instruction automatically converts the Octal address to Hex.



Standard RLL Instructions

Load (LD)

The Load instruction is a 16 bit instruction that loads the value (Aaaa), which is either a V memory location or a 4 digit constant, into the lower 16 bits of the accumulator. The upper 16 bits of the accumulator are set to 0.

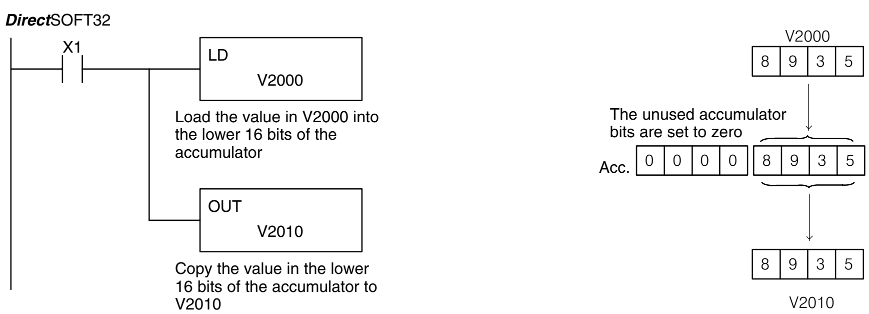


Operand Data Type		DL130 Range
	A	aaa
V memory	V	All (See page 4–28)
Pointer	P	All V mem. (See page 4–28)
Constant	K	0–FFFF

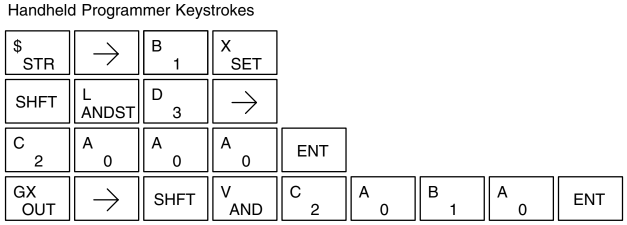
Discrete Bit Flags	Description
SP76	on when the value loaded into the accumulator by any instruction is zero.

NOTE: Two consecutive Load instructions will place the value of the first load instruction onto the accumulator stack.

In the following example, when X1 is on, the value in V2000 will be loaded into the accumulator and output to V2010.

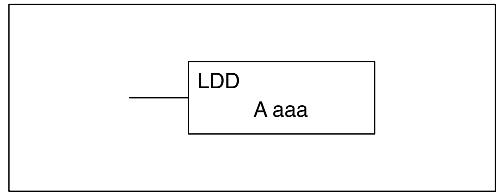


Handheld Programmer Keystrokes



Load Double (LDD)

The Load Double instruction is a 32 bit instruction that loads the value (Aaaa), which is either two consecutive V memory locations or an 8 digit constant value, into the accumulator.

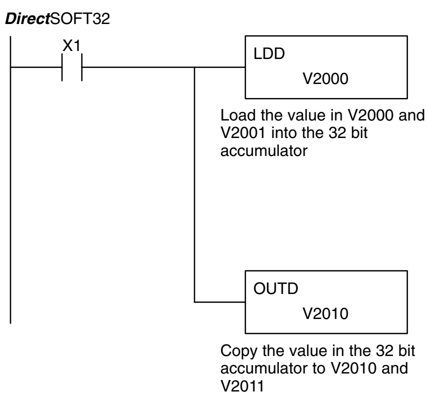


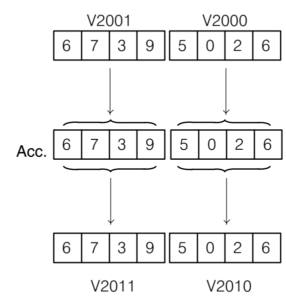
Operand Data Type		DL230 Range
	A	aaa
V memory	V	All (See page 4–28)
Pointer	P	All V mem. (See page 4–28)
Constant	K	0–FFFFFFFF

Discrete Bit Flags	Description
SP76	on when the value loaded into the accumulator by any instruction is zero.

NOTE: Two consecutive Load instructions will place the value of the first load instruction onto the accumulator stack.

In the following example, when X1 is on, the 32 bit value in V2000 and V2001 will be loaded into the accumulator and output to V2010 and V2011.



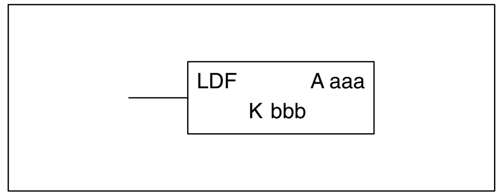


Handheld Programmer Keystrokes

$ STR	→	B 1	ENT	
SHFT	L ANDST	D 3	D 3	→
C 2	A 0	A 0	A 0	ENT
GX OUT	SHFT	D 3	→	
C 2	A 0	B 1	A 0	ENT

Load Formatted (LDF)

The Load Formatted instruction loads 1–32 consecutive bits from discrete memory locations into the accumulator. The instruction requires a starting location (Aaaa) and the number of bits (Kbbb) to be loaded. Unused accumulator bit locations are set to zero.

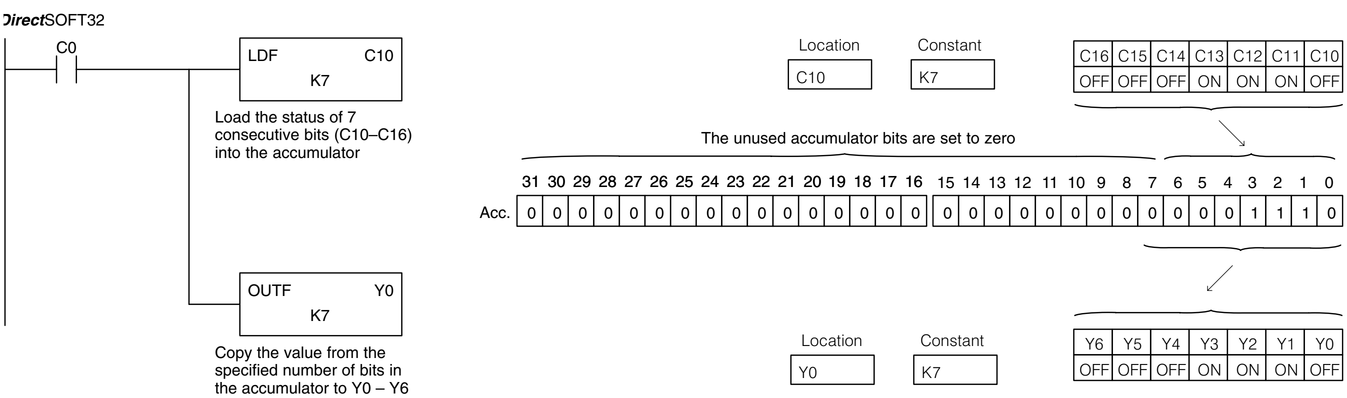


Operand Data Type		DL130 Range	
	A	aaa	bbb
Inputs	X	0–11	—
Outputs	Y	0–7	—
Control Relays	C	0–377	—
Stage Bits	S	0–377	—
Timer Bits	T	0–77	—
Counter Bits	CT	0–77	—
Special Relays	SP	0–117 540–577	—
Constant	K	—	1–32

Discrete Bit Flags	Description
SP76	on when the value loaded into the accumulator by any instruction is zero.

NOTE: Two consecutive Load instructions will place the value of the first load instruction onto the accumulator stack.

In the following example, when C0 is on, the binary pattern of C10–C16 (7 bits) will be loaded into the accumulator using the Load Formatted instruction. The lower 7 bits of the accumulator are output to Y0–Y6 using the Out Formatted instruction.

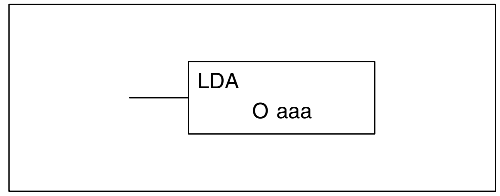


Handheld Programmer Keystrokes

$ STR	→	SHFT	C 2	A 0	ENT	
SHFT	L ANDST	D 3	F 5	→		
SHFT	C 2	B 1	A 0	→	H 7	ENT
GX OUT	SHFT	F 5	→			
A 0	→	H 7	ENT			

Load Address (LDA)

The Load Address instruction is a 16 bit instruction. It converts any octal value or address to the HEX equivalent value and loads the HEX value into the accumulator. This instruction is useful when an address parameter is required since all addresses for the DL105 system are in octal.

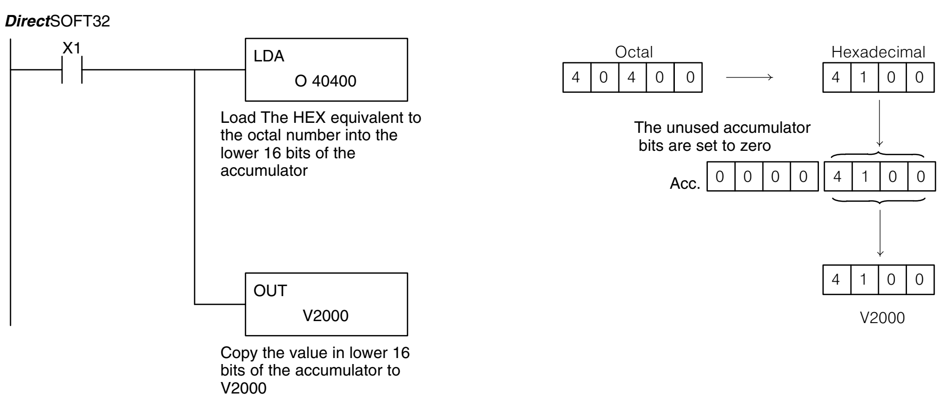


Operand Data Type		DL130 Range
		aaa
Octal Address	O	All V mem. (See page 4–28)

Discrete Bit Flags	Description
SP76	on when the value loaded into the accumulator by any instruction is zero.

NOTE: Two consecutive Load instructions will place the value of the first load instruction onto the accumulator stack.

In the following example when X1 is on, the octal number 40400 will be converted to a HEX 4100 and loaded into the accumulator using the Load Address instruction. The value in the lower 16 bits of the accumulator is copied to V2000 using the Out instruction.



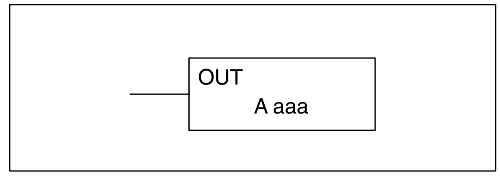
Handheld Programmer Keystrokes

$ STR	→	B 1	ENT					
SHFT	L ANDST	D 3	A 0	→				
E 4	A 0	E 4	A 0	A 0	ENT			
GX OUT	→	SHFT	V AND	C 2	A 0	A 0	A 0	ENT

Out (OUT)

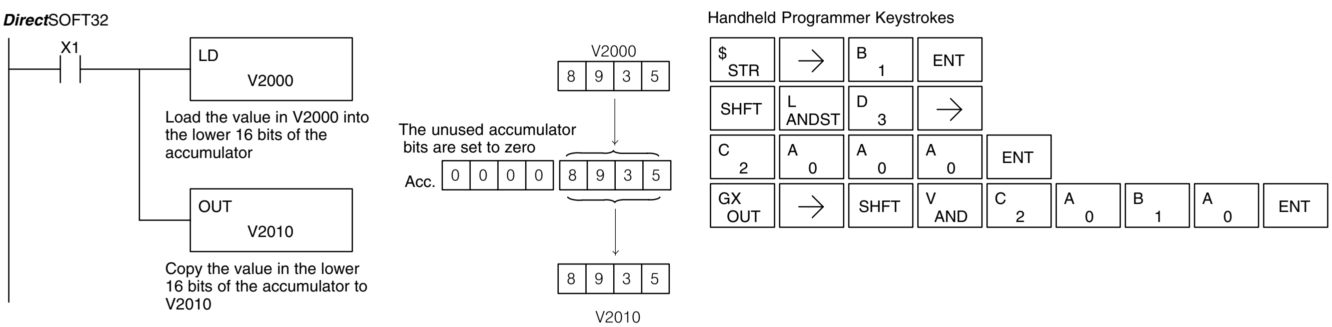
The Out instruction is a 16 bit instruction that copies the value in the lower 16 bits of the accumulator to a specified V memory location (Aaaa).

Note: See Appendix E



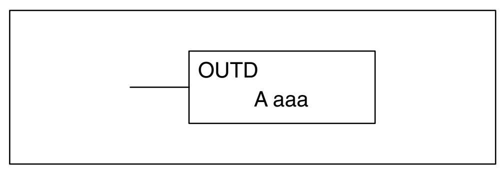
Operand Data Type		DL130 Range
	A	aaa
V memory	V	All (See page 4–28)
Pointer	P	All V mem. (See page 4–28)

In the following example, when X1 is on, the value in V2000 will be loaded into the lower 16 bits of the accumulator using the Load instruction. The value in the lower 16 bits of the accumulator are copied to V2010 using the Out instruction.



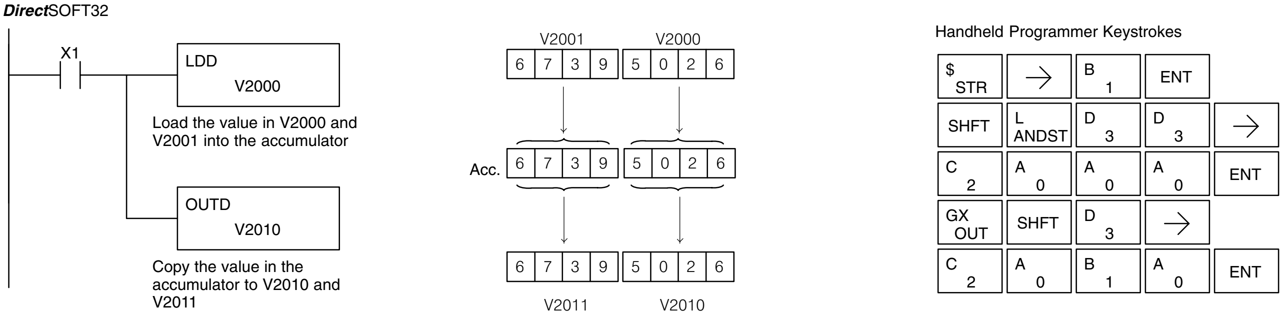
Out Double (OUTD)

The Out Double instruction is a 32 bit instruction that copies the value in the accumulator to two consecutive V memory locations at a specified starting location (Aaaa). Note: See Appendix E



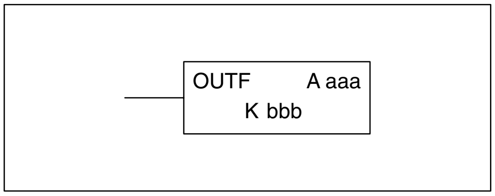
Operand Data Type		DL130 Range
	A	aaa
V memory	V	All (See page 4–28)
Pointer	P	All V mem. (See page 4–28)

In the following example, when X1 is on, the 32 bit value in V2000 and V2001 will be loaded into the accumulator using the Load Double instruction. The value in the accumulator is output to V2010 and V2011 using the Out Double instruction.



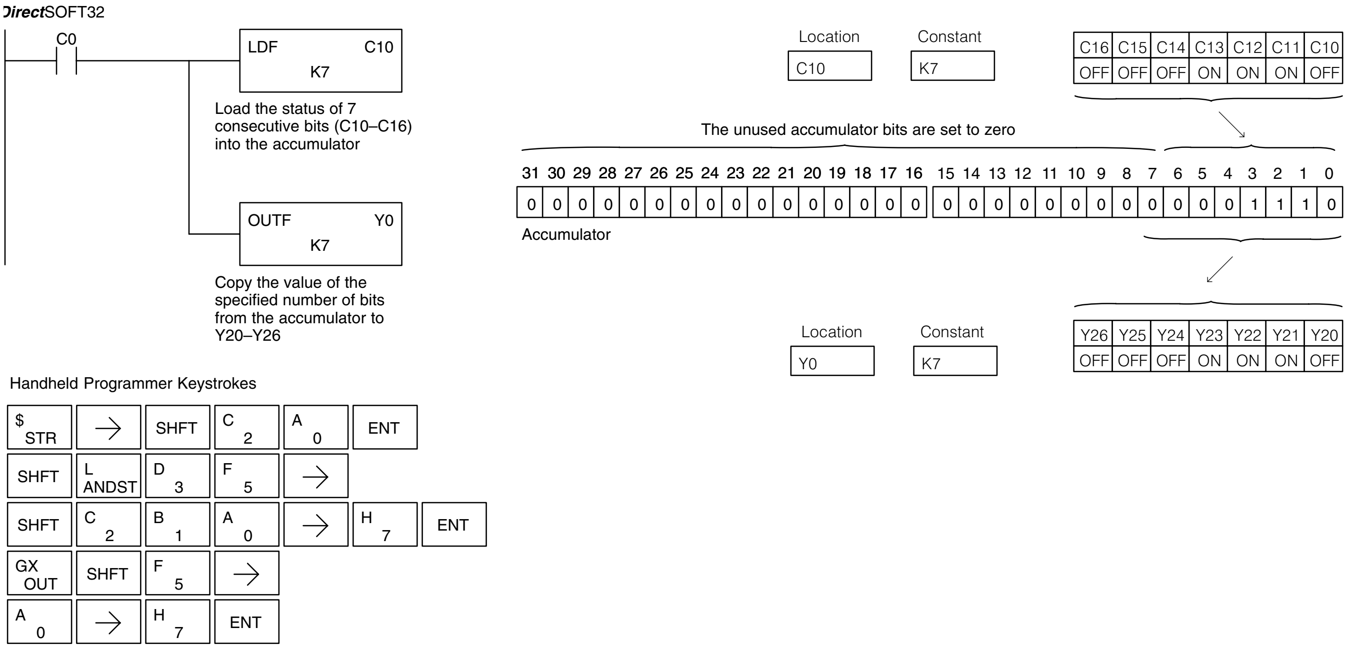
Out Formatted (OUTF)

The Out Formatted instruction outputs 1–32 bits from the accumulator to the specified discrete memory locations. The instruction requires a starting location (Aaaa) for the destination and the number of bits (Kbbb) to be output.



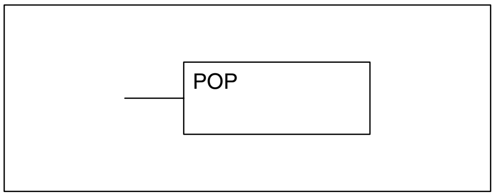
Operand Data Type		DL130 Range	
	A	aaa	bbb
Inputs	X	0–77	—
Outputs	Y	0–77	—
Control Relays	C	0–377	—
Constant	K	—	1–32

In the following example, when C0 is on, the binary pattern of C10–C16 (7 bits) will be loaded into the accumulator using the Load Formatted instruction. The lower 7 bits of the accumulator are output to Y0–Y6 using the Out Formatted instruction.



Pop (POP)

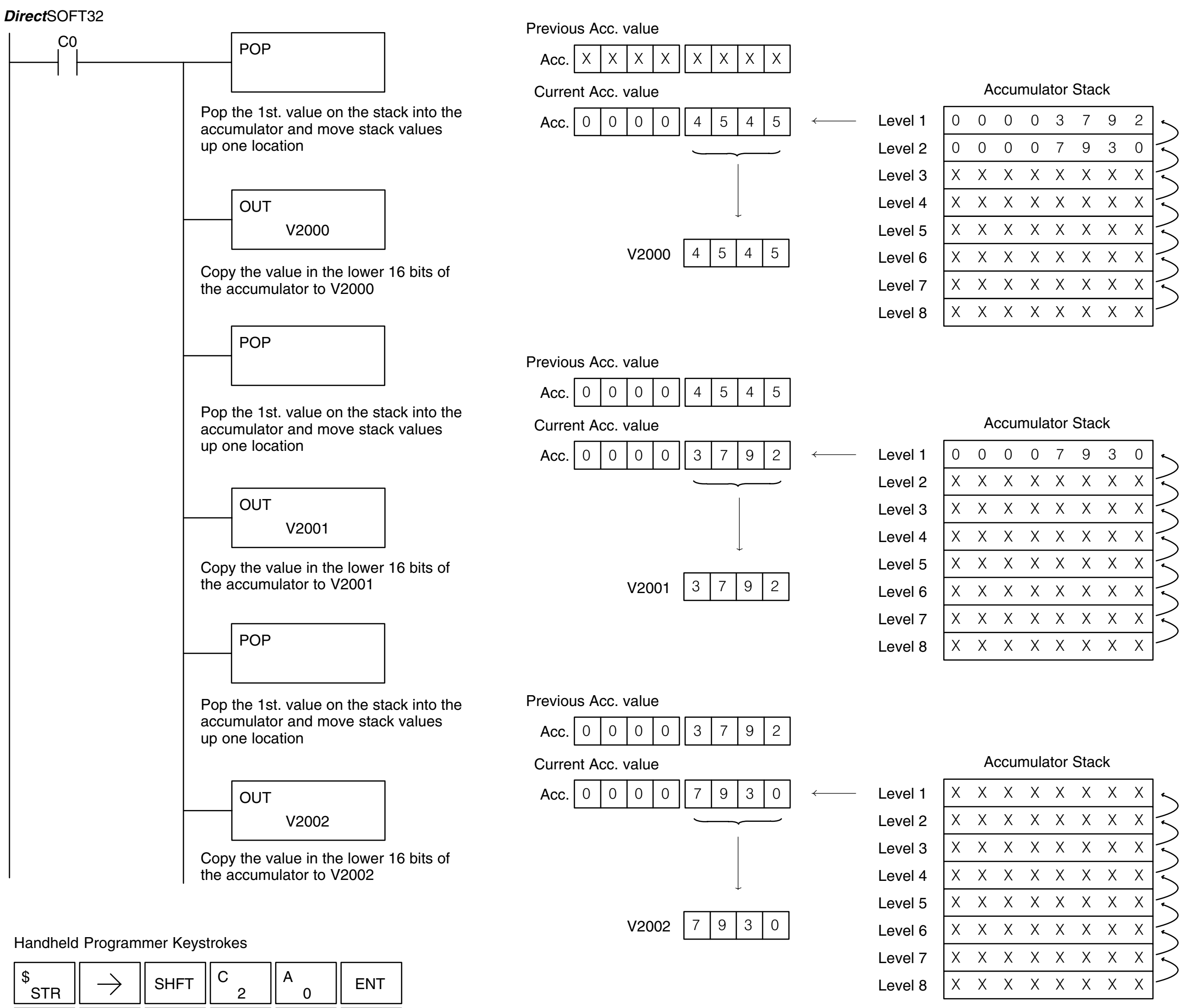
The Pop instruction moves the value from the first level of the accumulator stack (32 bits) to the accumulator and shifts each value in the stack up one level.



Discrete Bit Flags	Description
SP63	on when the result of the instruction causes the value in the accumulator to be zero.

Pop Instruction Continued

In the example below, when C0 is on, the value 4545 that was on top of the stack is moved into the accumulator using the Pop instruction The value is output to V2000 using the Out instruction. The next Pop moves the value 3792 into the accumulator and outputs the value to V2001. The last Pop moves the value 7930 into the accumulator and outputs the value to V2002. Please note if the value in the stack were greater than 16 bits (4 digits) the Out Double instruction would be used and 2 V memory locations for each Out Double must be allocated.



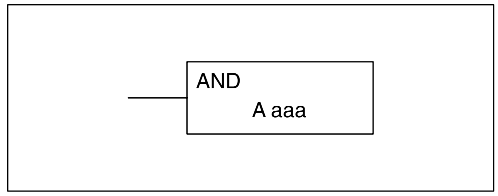
Handheld Programmer Keystrokes

$ STR	→	SHFT	C 2	A 0	ENT			
SHFT	P CV	SHFT	O INST#	P CV	ENT			
GX OUT	→	SHFT	V AND	C 2	A 0	A 0	A 0	ENT
SHFT	P CV	SHFT	O INST#	P CV	ENT			
GX OUT	→	SHFT	V AND	C 2	A 0	A 0	B 1	ENT
SHFT	P CV	SHFT	O INST#	P CV	ENT			
GX OUT	→	SHFT	V AND	C 2	A 0	A 0	C 2	ENT

Logical Instructions (Accumulator)

And (AND)

The And instruction is a 16 bit instruction that logically ands the value in the lower 16 bits of the accumulator with a specified V memory location (Aaaa). The result resides in the accumulator. The discrete status flag indicates if the result of the And is zero.

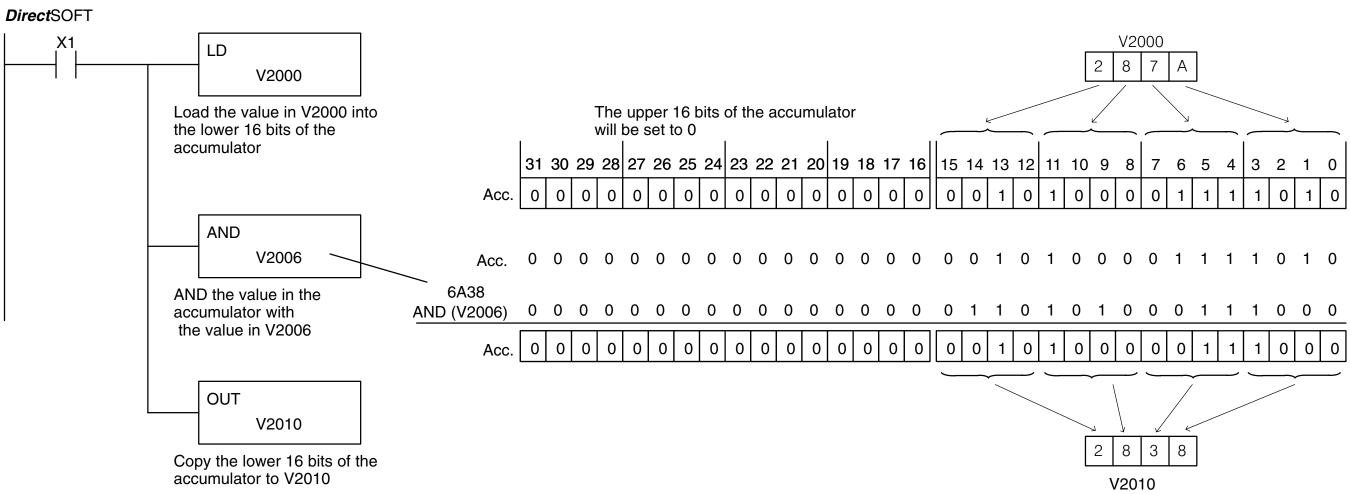


Operand Data Type		DL130 Range
	A	**aaa**
V memory	V	All (See page 4–28)

Discrete Bit Flags	Description
SP63	Will be on if the result in the accumulator is zero

NOTE: The status flags are only valid until another instruction that uses the same flags is executed.

In the following example, when X1 is on, the value in V2000 will be loaded into the accumulator using the Load instruction. The value in the accumulator is anded with the value in V2006 using the And instruction. The value in the lower 16 bits of the accumulator is output to V2010 using the Out instruction.

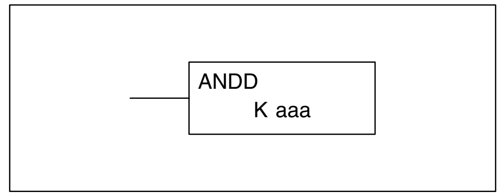


Handheld Programmer Keystrokes

$ STR	→	B 1	ENT					
SHFT	L ANDST	D 3	→	C 2	A 0	A 0	A 0	ENT
V AND	→	SHFT	V AND	C 2	A 0	A 0	G 6	ENT
GX OUT	→	SHFT	V AND	C 2	A 0	B 1	A 0	ENT

And Double (ANDD)

The And Double is a 32 bit instruction that logically ands the value in the accumulator with two consecutive V memory locations or an 8 digit (max.) constant value (Aaaa). The result resides in the accumulator. Discrete status flags indicate if the result of the And Double is zero or a negative number (the most significant bit is on).

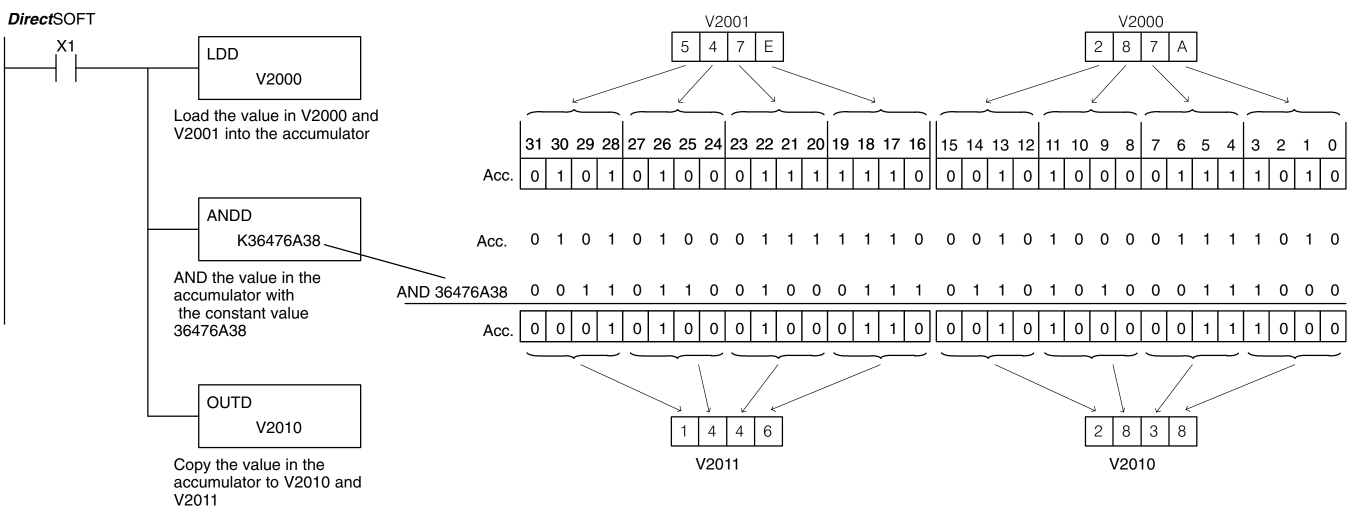


Operand Data Type		DL130 Range
		aaa
V memory	V	All (See page 4–28)
Constant	K	0–FFFFFFFF

Discrete Bit Flags	Description
SP63	Will be on if the result in the accumulator is zero
SP70	Will be on is the result in the accumulator is negative

NOTE: The status flags are only valid until another instruction that uses the same flags is executed.

In the following example, when X1 is on, the value in V2000 and V2001 will be loaded into the accumulator using the Load Double instruction. The value in the accumulator is anded with 36476A38 using the And double instruction. The value in the accumulator is output to V2010 and V2011 using the Out Double instruction.

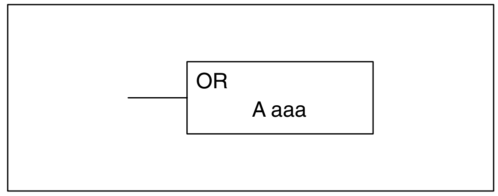


Handheld Programmer Keystrokes

$ STR	→	B 1	ENT											
SHFT	L ANDST	D 3	D 3	→	C 2	A 0	A 0	A 0	ENT					
V AND	SHFT	D 3	→	SHFT	K JMP	D 3	G 6	E 4	H 7	G 6	SHFT	A 0	SHFT	D 3
I 8	ENT													
GX OUT	SHFT	D 3	→	C 2	A 0	B 1	A 0	ENT						

Or (OR)

The Or instruction is a 16 bit instruction that logically ors the value in the lower 16 bits of the accumulator with a specified V memory location (Aaaa). The result resides in the accumulator. The discrete status flag indicates if the result of the Or is zero.

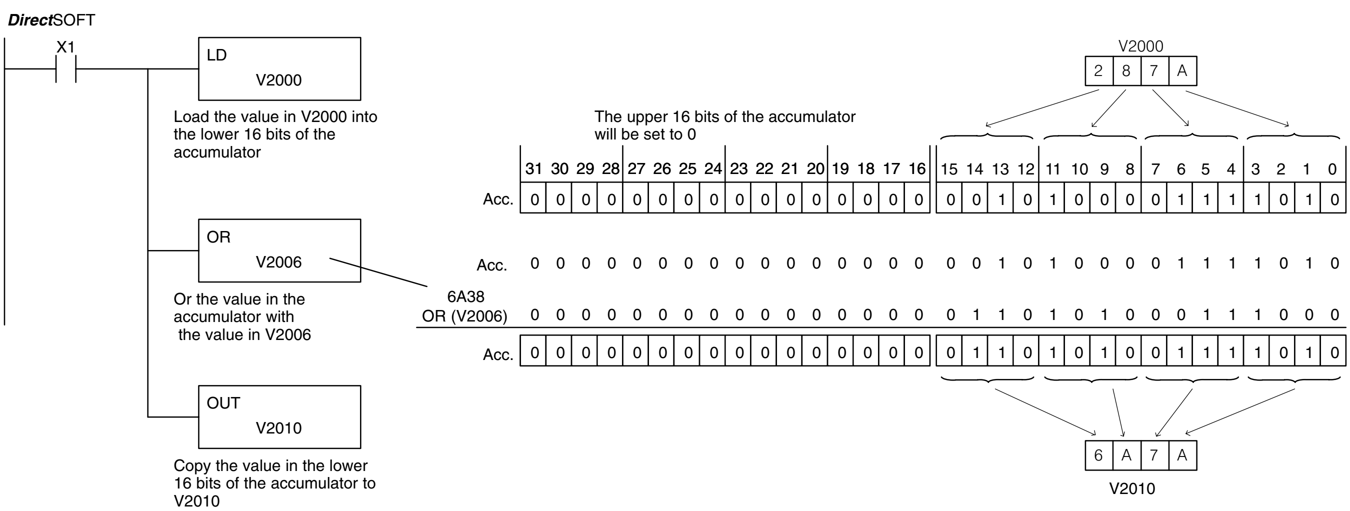


Operand Data Type		DL130 Range
	A	aaa
V memory	V	All (See page 4–28)

Discrete Bit Flags	Description
SP63	Will be on if the result in the accumulator is zero

NOTE: The status flags are only valid until another instruction that uses the same flags is executed.

In the following example, when X1 is on, the value in V2000 will be loaded into the accumulator using the Load instruction. The value in the accumulator is ored with V2006 using the Or instruction. The value in the lower 16 bits of the accumulator are output to V2010 using the Out instruction.

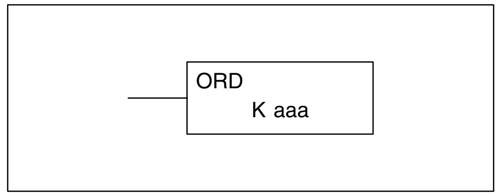


Handheld Programmer Keystrokes

$ STR	→	B 1	ENT					
SHFT	L ANDST	D 3	→	C 2	A 0	A 0	A 0	ENT
Q OR	→	SHFT	V AND	C 2	A 0	A 0	G 6	ENT
GX OUT	→	SHFT	V AND	C 2	A 0	B 1	A 0	ENT

Or Double (ORD)

The Or Double is a 32 bit instruction that ors the value in the accumulator with the value (Aaaa), which is either two consecutive V memory locations or an 8 digit (max.) constant value. The result resides in the accumulator. Discrete status flags indicate if the result of the Or Double is zero or a negative number (the most significant bit is on).

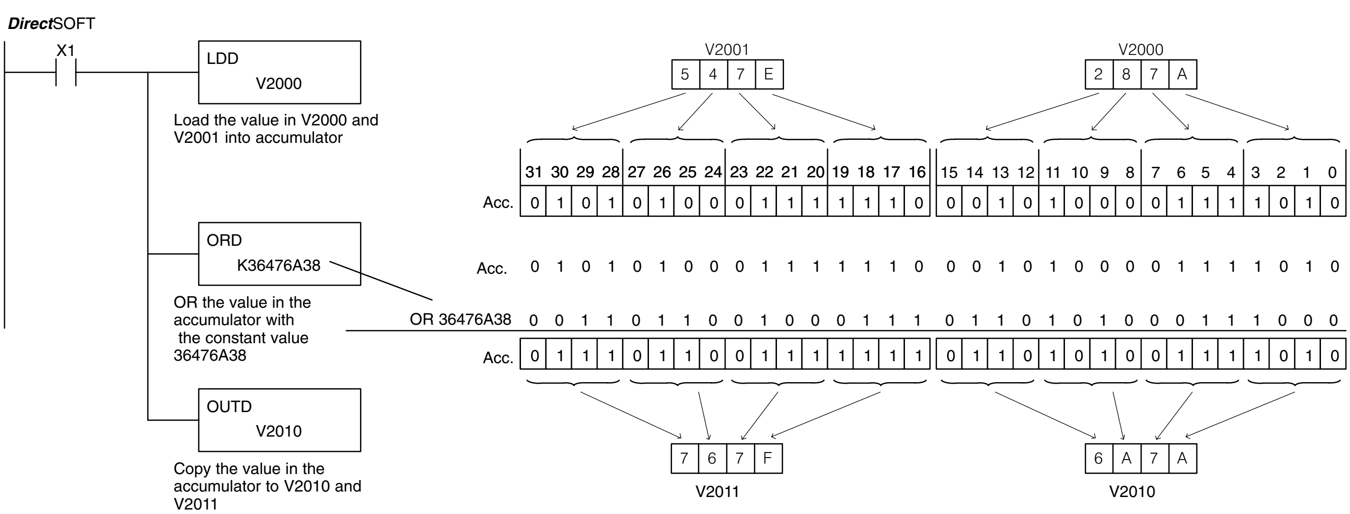


Operand Data Type		DL130 Range
		aaa
V memory	V	All (See page 4–28)
Constant	K	0–FFFFFFFF

Discrete Bit Flags	Description
SP63	Will be on if the result in the accumulator is zero
SP70	Will be on is the result in the accumulator is negative

NOTE: The status flags are only valid until another instruction that uses the same flags is executed.

In the following example, when X1 is on, the value in V2000 and V2001 will be loaded into the accumulator using the Load Double instruction. The value in the accumulator is ored with 36476A38 using the Or Double instruction. The value in the accumulator is output to V2010 and V2011 using the Out Double instruction.

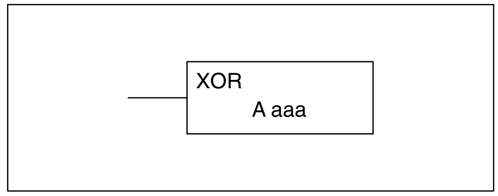


Handheld Programmer Keystrokes

$ STR	→	B 1	ENT														
SHFT	L ANDST	D 3	D 3	→	C 2	A 0	A 0	A 0	ENT								
Q OR	SHFT	D 3	→	SHFT	K JMP	D 3	G 6	E 4	H 7	G 6	SHFT	A 0	SHFT	D 3	I 8	ENT
GX OUT	SHFT	D 3	→	C 2	A 0	B 1	A 0	ENT									

Exclusive Or (XOR)

The Exclusive Or instruction is a 16 bit instruction that performs an exclusive or of the value in the lower 16 bits of the accumulator and a specified V memory location (Aaaa). The result resides in the in the accumulator. The discrete status flag indicates if the result of the XOR is zero.

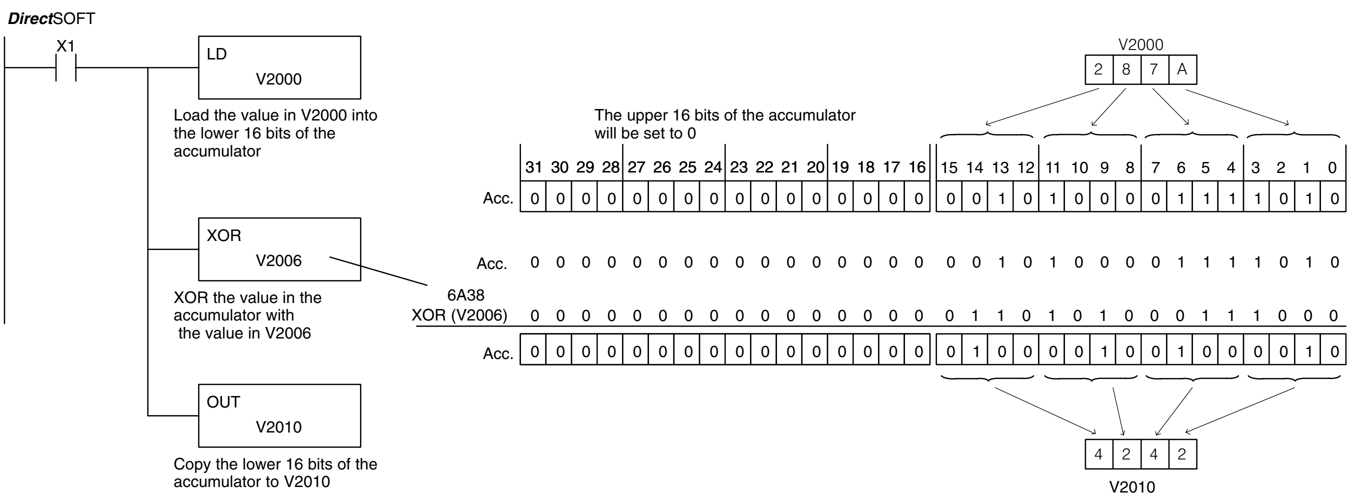


Operand Data Type		DL130 Range
	A	aaa
V memory	V	All (See page 4–28)

Discrete Bit Flags	Description
SP63	Will be on if the result in the accumulator is zero

NOTE: The status flags are only valid until another instruction that uses the same flags is executed.

In the following example, when X1 is on, the value in V2000 will be loaded into the accumulator using the Load instruction. The value in the accumulator is exclusive ored with V2006 using the Exclusive Or instruction. The value in the lower 16 bits of the accumulator are output to V2010 using the Out instruction.

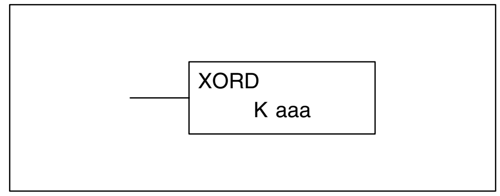


Handheld Programmer Keystrokes

$ STR	→	SHFT	X SET	B 1	ENT					
SHFT	L ANDST	D 3	→	SHFT	V AND	C 2	A 0	A 0	A 0	ENT
SHFT	X SET	SHFT	Q OR	→	SHFT	V AND	C 2	A 0	A 0	G 6	ENT
GX OUT	→	SHFT	V AND	C 2	A 0	B 1	A 0	ENT		

Exclusive Or Double (XORD)

The Exclusive OR Double is a 32 bit instruction that performs an exclusive or of the value in the accumulator and the value (Aaaa), which is either two consecutive V memory locations or an 8 digit (max.) constant. The result resides in the accumulator. Discrete status flags indicate if the result of the Exclusive Or Double is zero or a negative number (the most significant bit is on).

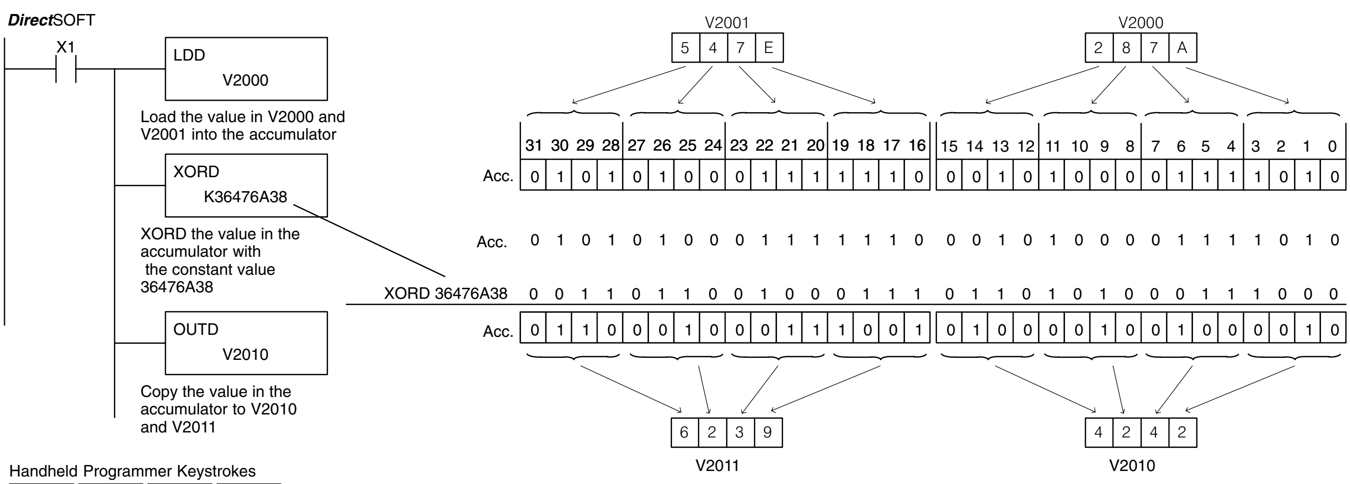


Operand Data Type		DL130 Range
	A	aaa
V memory	V	All (See page 4–28)
Constant	K	0–FFFFFFFF

Discrete Bit Flags	Description
SP63	Will be on if the result in the accumulator is zero
SP70	Will be on is the result in the accumulator is negative

NOTE: The status flags are only valid until another instruction that uses the same flags is executed.

In the following example, when X1 is on, the value in V2000 and V2001 will be loaded into the accumulator using the Load Double instruction. The value in the accumulator is exclusively ored with 36476A38 using the Exclusive Or Double instruction. The value in the accumulator is output to V2010 and V2011 using the Out Double instruction.

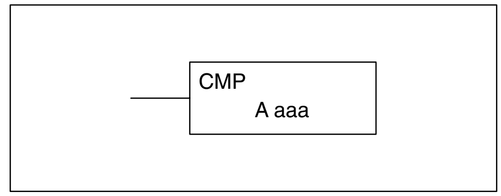


Handheld Programmer Keystrokes

$ STR	→	B 1	ENT							
SHFT	L ANDST	D 3	D 3	→	C 2	A 0	A 0	A 0	ENT	
SHFT	X SET	Q OR	SHFT	D 3	→	SHFT	K JMP			
D 3	G 6	E 4	H 7	G 6	SHFT	A 0	SHFT	D 3	I 8	ENT
GX OUT	SHFT	D 3	→	C 2	A 0	B 1	A 0	ENT		

Compare (CMP)

The compare instruction is a 16 bit instruction that compares the value in the lower 16 bits of the accumulator with the value in a specified V memory location (Aaaa). The corresponding status flag will be turned on indicating the result of the comparison.

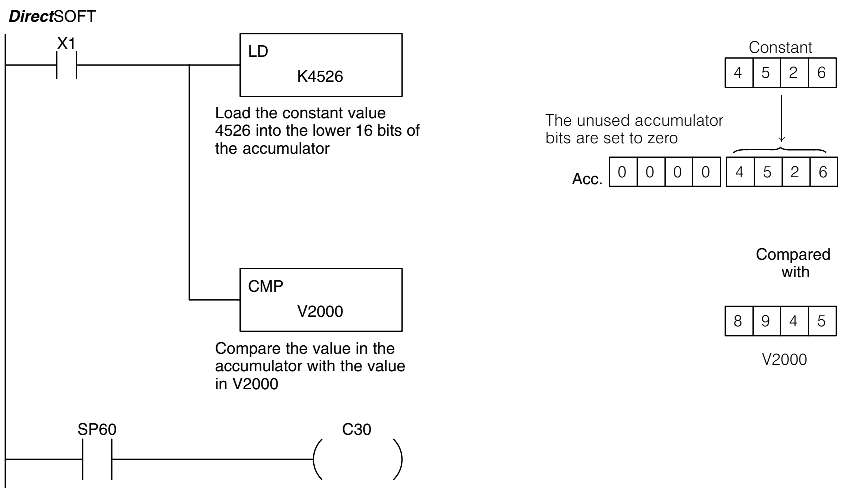


Operand Data Type		DL130 Range
	A	aaa
V memory	V	All (See page 4–28)

Discrete Bit Flags	Description
SP60	On when the value in the accumulator is less than the instruction value.
SP61	On when the value in the accumulator is equal to the instruction value.
SP62	On when the value in the accumulator is greater than the instruction value.

NOTE: The status flags are only valid until another instruction that uses the same flags is executed.

In the following example when X1 is on, the constant 4526 will be loaded into the lower 16 bits of the accumulator using the Load instruction. The value in the accumulator is compared with the value in V2000 using the Compare instruction. The corresponding discrete status flag will be turned on indicating the result of the comparison. In this example, if the value in the accumulator is less than the value specified in the Compare instruction, SP60 will turn on energizing C30.

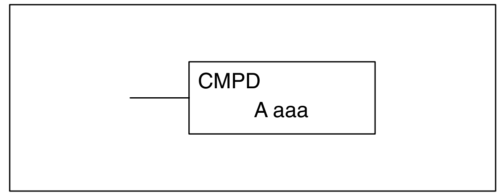


Handheld Programmer Keystrokes

$ STR	→	B 1	ENT							
SHFT	L ANDST	D 3	→	SHFT	K JMP	E 4	F 5	C 2	G 6	ENT
SHFT	C 2	SHFT	M ORST	P CV	→	C 2	A 0	A 0	A 0	ENT
$ STR	→	SHFT	SP STRN	G 6	A 0	ENT				
GX OUT	→	SHFT	C 2	D 3	A 0	ENT				

Compare Double (CMPD)

The Compare Double instruction is a 32–bit instruction that compares the value in the accumulator with the value (Aaaa), which is either two consecutive V memory locations or an 8–digit (max.) constant. The corresponding status flag will be turned on indicating the result of the comparison.



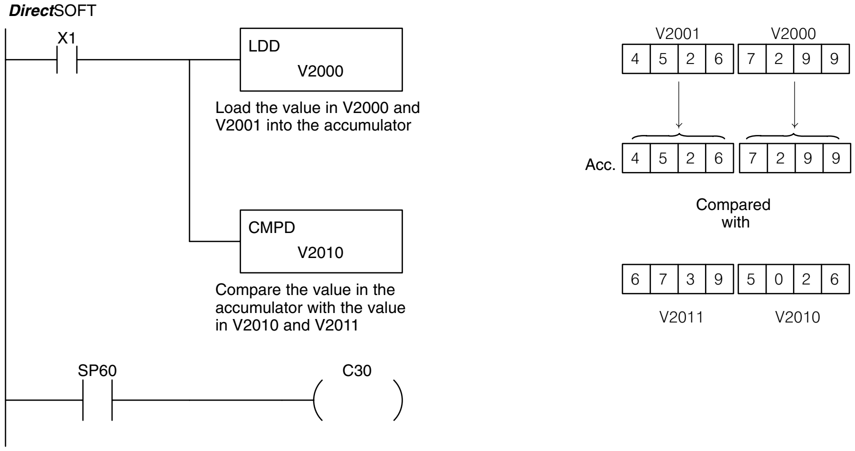
Operand Data Type		DL130 Range
	A	aaa
V memory	V	All (See page 4–28)
Constant	K	1–FFFFFFFF

Discrete Bit Flags	Description
SP60	On when the value in the accumulator is less than the instruction value.
SP61	On when the value in the accumulator is equal to the instruction value.
SP62	On when the value in the accumulator is greater than the instruction value.

NOTE: The status flags are only valid until another instruction that uses the same flags is executed.

In the following example when X1 is on, the value in V2000 and V2001 will be loaded into the accumulator using the Load Double instruction. The value in the accumulator is compared with the value in V2010 and V2011 using the CMPD instruction. The corresponding discrete status flag will be turned on indicating the result of the comparison. In this example, if the value in the accumulator is less than the value specified in the Compare instruction, SP60 will turn on energizing C30.

*Direct*SOFT



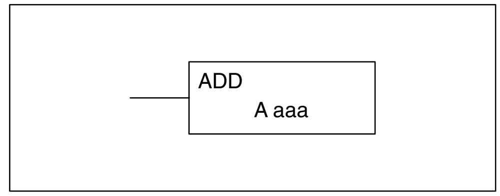
Handheld Programmer Keystrokes

$ STR	→	B 1	ENT							
SHFT	L ANDST	D 3	D 3	→	C 2	A 0	A 0	A 0	ENT	
SHFT	C 2	SHFT	M ORST	P CV	D 3	→	C 2	A 0	B 1	A 0	ENT
$ STR	→	SHFT	SP STRN	G 6	A 0	ENT				
GX OUT	→	SHFT	C 2	D 3	A 0	ENT				

Math Instructions

Add (ADD)

Add is a 16 bit instruction that adds a BCD value in the accumulator with a BCD value in a V memory location (Aaaa). The result resides in the accumulator.

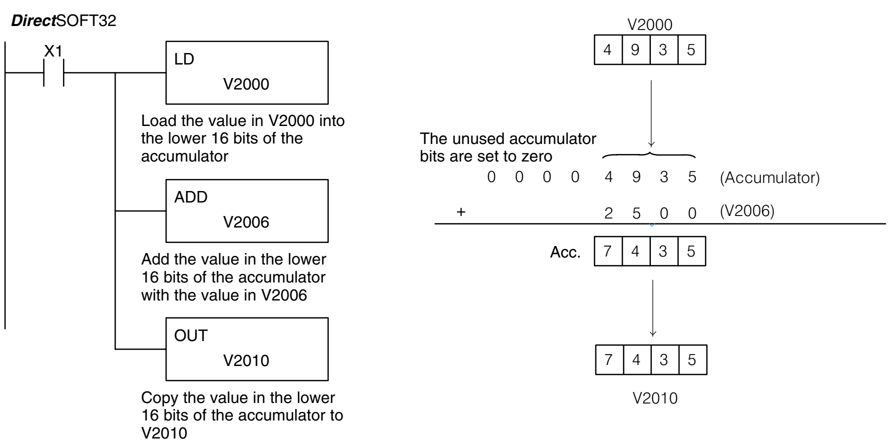


Operand Data Type		DL130 Range
	A	aaa
V memory	V	All (See page 4–28)

Discrete Bit Flags	Description
SP63	On when the result of the instruction causes the value in the accumulator to be zero.
SP66	On when the 16 bit addition instruction results in a carry.
SP67	On when the 32 bit addition instruction results in a carry.
SP70	On anytime the value in the accumulator is negative.
SP75	On when a BCD instruction is executed and a NON–BCD number was encountered.

NOTE: The status flags are only valid until another instruction that uses the same flags is executed.

In the following example, when X1 is on, the value in V2000 will be loaded into the accumulator using the Load instruction. The value in the lower 16 bits of the accumulator are added to the value in V2006 using the Add instruction. The value in the accumulator is copied to V2010 using the Out instruction.

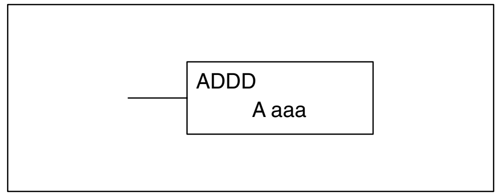


Handheld Programmer Keystrokes

$ STR	→	B 1	ENT						
SHFT	L ANDST	D 3	→	C 2	A 0	A 0	A 0	ENT	
SHFT	A 0	D 3	D 3	→	C 2	A 0	A 0	G 6	ENT
GX OUT	→	SHFT	V AND	C 2	A 0	B 1	A 0	ENT	

Add Double (ADDD)

Add Double is a 32 bit instruction that adds the BCD value in the accumulator with a BCD value (Aaaa), which is either two consecutive V memory locations or an 8–digit (max.) BCD constant. The result resides in the accumulator.

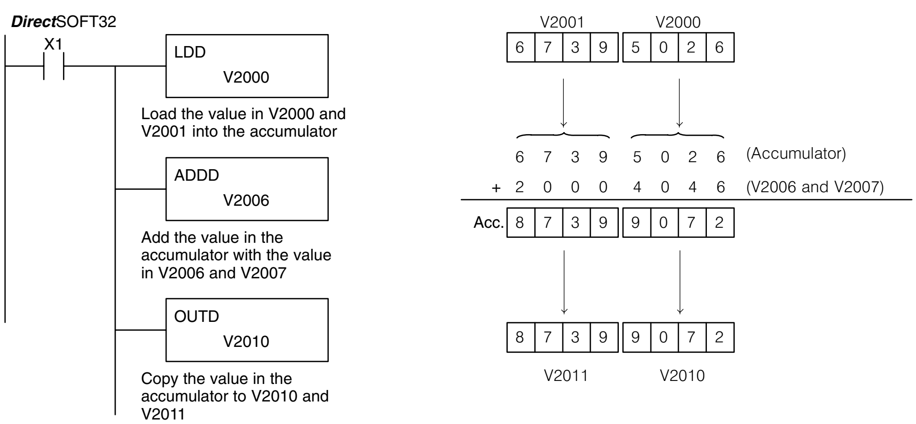


Operand Data Type		DL130 Range
	A	aaa
V memory	V	All (See page 4–28)
Constant	K	0–99999999

Discrete Bit Flags	Description
SP63	On when the result of the instruction causes the value in the accumulator to be zero.
SP66	On when the 16 bit addition instruction results in a carry.
SP67	On when the 32 bit addition instruction results in a carry.
SP70	On anytime the value in the accumulator is negative.
SP75	On when a BCD instruction is executed and a NON–BCD number was encountered.

NOTE: The status flags are only valid until another instruction that uses the same flags is executed.

In the following example, when X1 is on, the value in V2000 and V2001 will be loaded into the accumulator using the Load Double instruction. The value in the accumulator is added with the value in V2006 and V2007 using the Add Double instruction. The value in the accumulator is copied to V2010 and V2011 using the Out Double instruction.

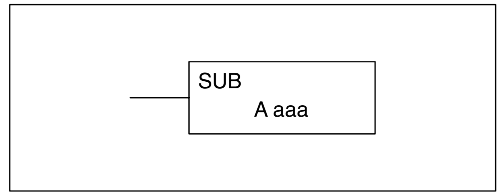


Handheld Programmer Keystrokes

$ STR	→	B 1	ENT							
SHFT	L ANDST	D 3	D 3	→	C 2	A 0	A 0	A 0	ENT	
SHFT	A 0	D 3	D 3	D 3	→	C 2	A 0	A 0	G 6	ENT
GX OUT	SHFT	D 3	→	SHFT	V AND	C 2	A 0	B 1	A 0	ENT

Subtract (SUB)

Subtract is a 16 bit instruction that subtracts the BCD value (Aaaa) in a V memory location from the BCD value in the lower 16 bits of the accumulator. The result resides in the accumulator.

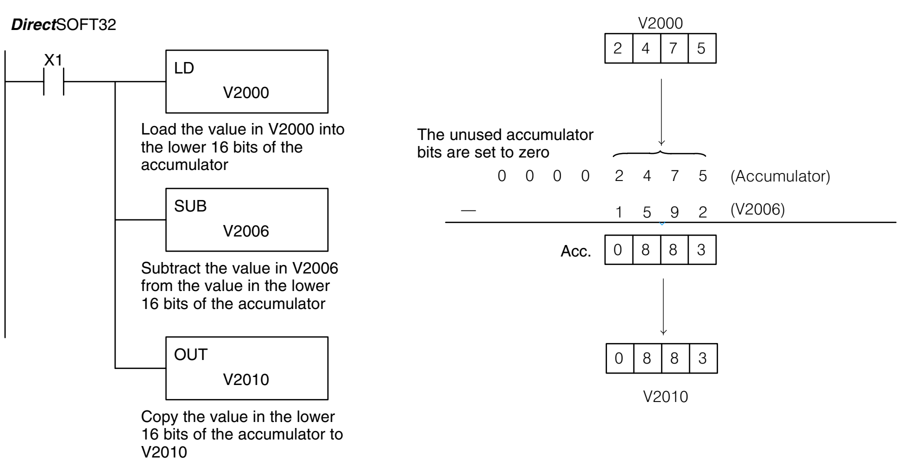


Operand Data Type		DL130 Range
	A	aaa
V memory	V	All (See page 4–28)

Discrete Bit Flags	Description
SP63	On when the result of the instruction causes the value in the accumulator to be zero.
SP64	On when the 16 bit subtraction instruction results in a borrow.
SP65	On when the 32 bit subtraction instruction results in a borrow.
SP70	On anytime the value in the accumulator is negative.
SP75	On when a BCD instruction is executed and a NON–BCD number was encountered.

NOTE: The status flags are only valid until another instruction that uses the same flags is executed.

In the following example, when X1 is on, the value in V2000 will be loaded into the accumulator using the Load instruction. The value in V2006 is subtracted from the value in the accumulator using the Subtract instruction. The value in the accumulator is copied to V2010 using the Out instruction.

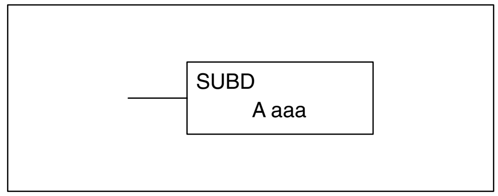


Handheld Programmer Keystrokes

$ STR	→	B 1	ENT								
SHFT	L ANDST	D 3	→	C 2	A 0	A 0	A 0	ENT			
SHFT	S RST	U ISG	B 1	→	SHFT	V AND	C 2	A 0	A 0	G 6	ENT
GX OUT	→	SHFT	V AND	C 2	A 0	B 1	A 0	ENT			

Subtract Double (SUBD)

Subtract Double is a 32 bit instruction that subtracts the BCD value (Aaaa), which is either two consecutive V memory locations or an 8-digit (max.) constant, from the BCD value in the accumulator. The result resides in the accumulator.

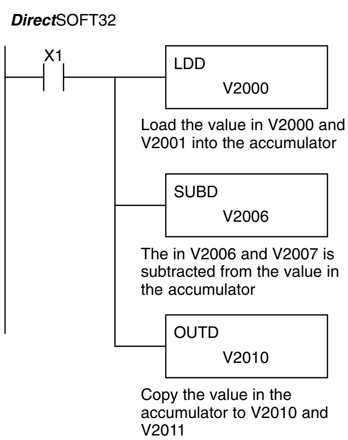


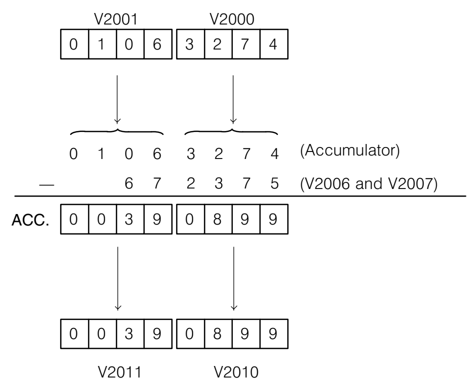
Operand Data Type		DL130 Range
	A	**aaa**
V memory	V	All (See page 4–28)
Constant	K	0–99999999

Discrete Bit Flags	Description
SP63	On when the result of the instruction causes the value in the accumulator to be zero.
SP64	On when the 16 bit subtraction instruction results in a borrow.
SP65	On when the 32 bit subtraction instruction results in a borrow.
SP70	On anytime the value in the accumulator is negative.
SP75	On when a BCD instruction is executed and a NON–BCD number was encountered.

NOTE: The status flags are only valid until another instruction that uses the same flags is executed.

In the following example, when X1 is on, the value in V2000 and V2001 will be loaded into the accumulator using the Load Double instruction. The value in V2006 and V2007 is subtracted from the value in the accumulator. The value in the accumulator is copied to V2010 and V2011 using the Out Double instruction.



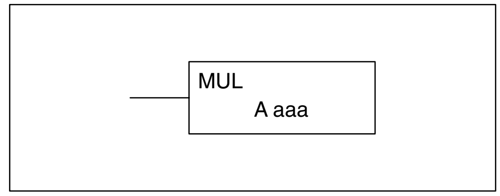


Handheld Programmer Keystrokes

$ STR	→	B 1	ENT								
SHFT	L ANDST	D 3	D 3	→	C 2	A 0	A 0	A 0	ENT		
SHFT	S RST	SHFT	U ISG	B 1	D 3	→	C 2	A 0	A 0	G 6	ENT
GX OUT	SHFT	D 3	→	C 2	A 0	B 1	A 0	ENT			

Multiply (MUL)

Multiply is a 16 bit instruction that multiplies the BCD value (Aaaa), which is either a V memory location or a 4–digit (max.) constant, by the BCD value in the lower 16 bits of the accumulator The result can be up to 8 digits and resides in the accumulator.

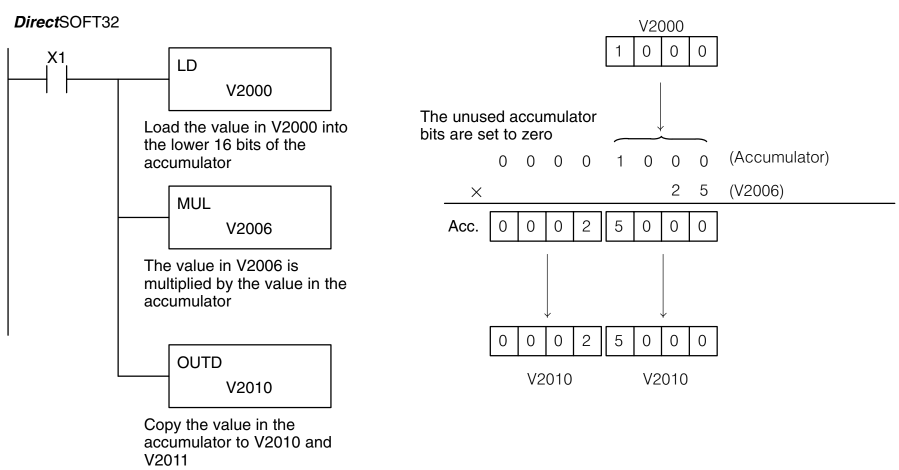


Operand Data Type		DL130 Range
	A	aaa
V memory	V	All (See page 4–28)
Constant	K	0–9999

Discrete Bit Flags	Description
SP63	On when the result of the instruction causes the value in the accumulator to be zero.
SP70	On anytime the value in the accumulator is negative.
SP75	On when a BCD instruction is executed and a NON–BCD number was encountered.

NOTE: The status flags are only valid until another instruction that uses the same flags is executed.

In the following example, when X1 is on, the value in V2000 will be loaded into the accumulator using the Load instruction. The value in V2006 is multiplied by the value in the accumulator. The value in the accumulator is copied to V2010 and V2011 using the Out Double instruction.

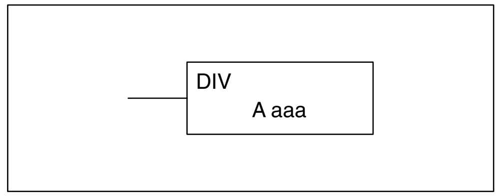


Handheld Programmer Keystrokes

$ STR	→	B 1	ENT						
SHFT	L ANDST	D 3	→	C 2	A 0	A 0	A 0	ENT	
SHFT	M ORST	U ISG	L ANDST	→	C 2	A 0	A 0	G 6	ENT
GX OUT	SHFT	D 3	→	C 2	A 0	B 1	A 0	ENT	

Divide (DIV)

Divide is a 16 bit instruction that divides the BCD value in the accumulator by a BCD value (Aaaa), which is either a V memory location or a 4-digit (max.) constant. The first part of the quotient resides in the accumulator and the remainder resides in the first stack location.

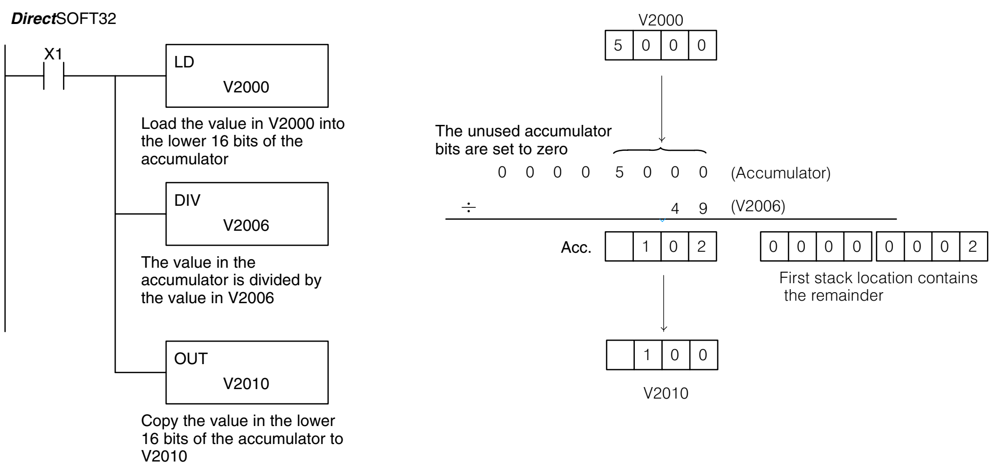


Operand Data Type		DL130 Range
	A	**aaa**
V memory	V	All (See page 4–28)
Constant	K	0–9999

Discrete Bit Flags	Description
SP53	On when the value of the operand is larger than the accumulator can work with.
SP63	On when the result of the instruction causes the value in the accumulator to be zero.
SP70	On anytime the value in the accumulator is negative.
SP75	On when a BCD instruction is executed and a NON–BCD number was encountered.

NOTE: The status flags are only valid until another instruction that uses the same flags is executed.

In the following example, when X1 is on, the value in V2000 will be loaded into the accumulator using the Load instruction. The value in the accumulator will be divided by the value in V2006 using the Divide instruction. The value in the accumulator is copied to V2010 using the Out instruction.

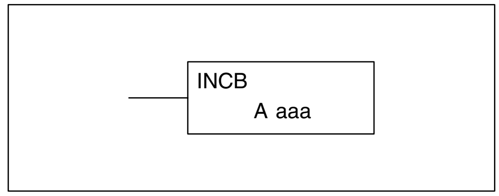


Handheld Programmer Keystrokes

$ STR	→	B 1	ENT						
SHFT	L ANDST	D 3	→	C 2	A 0	A 0	A 0	ENT	
SHFT	D 3	I 8	V AND	→	C 2	A 0	A 0	G 6	ENT
GX OUT	→	SHFT	V AND	C 2	A 0	B 1	A 0	ENT	

Increment Binary (INCB)

The Increment Binary instruction increments a binary value in a specified V memory location by “1” each time the instruction is executed.

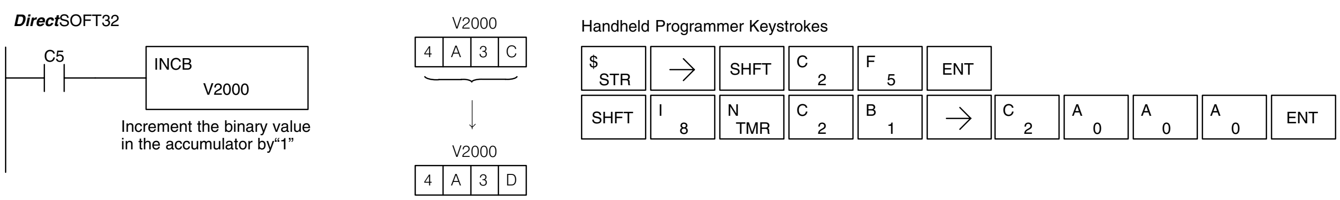


Operand Data Type		DL105 Range
	A	**aaa**
V memory	V	All (See page 4–28)

Discrete Bit Flags	Description
SP63	on when the result of the instruction causes the value in the accumulator to be zero.

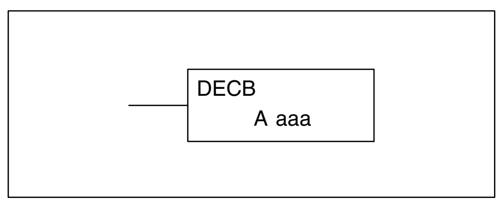
NOTE: The status flags are only valid until another instruction that uses the same flags is executed.

In the following example when C5 is on, the binary value in V2000 is increased by 1.



Decrement Binary (DECB)

The Decrement Binary instruction decrements a binary value in a specified V memory location by “1” each time the instruction is executed.

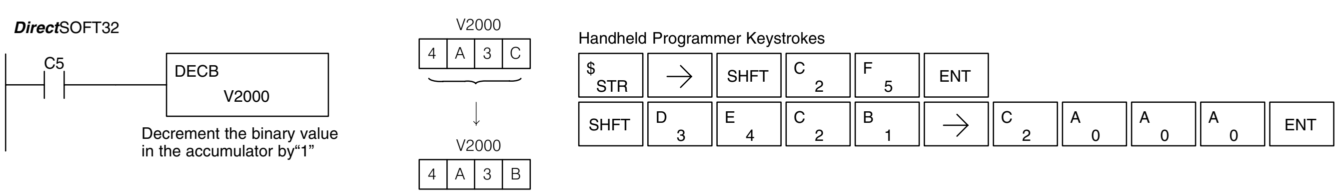


Operand Data Type		DL130 Range
	A	**aaa**
V memory	V	All (See page 4–28)

Discrete Bit Flags	Description
SP63	on when the result of the instruction causes the value in the accumulator to be zero.

NOTE: The status flags are only valid until another instruction that uses the same flags is executed.

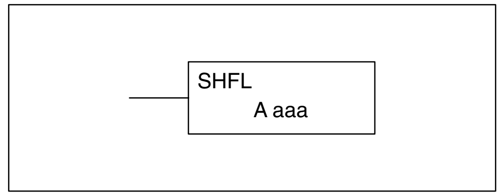
In the following example when C5 is on, the value in V2000 is decreased by 1.



Bit Operation Instructions

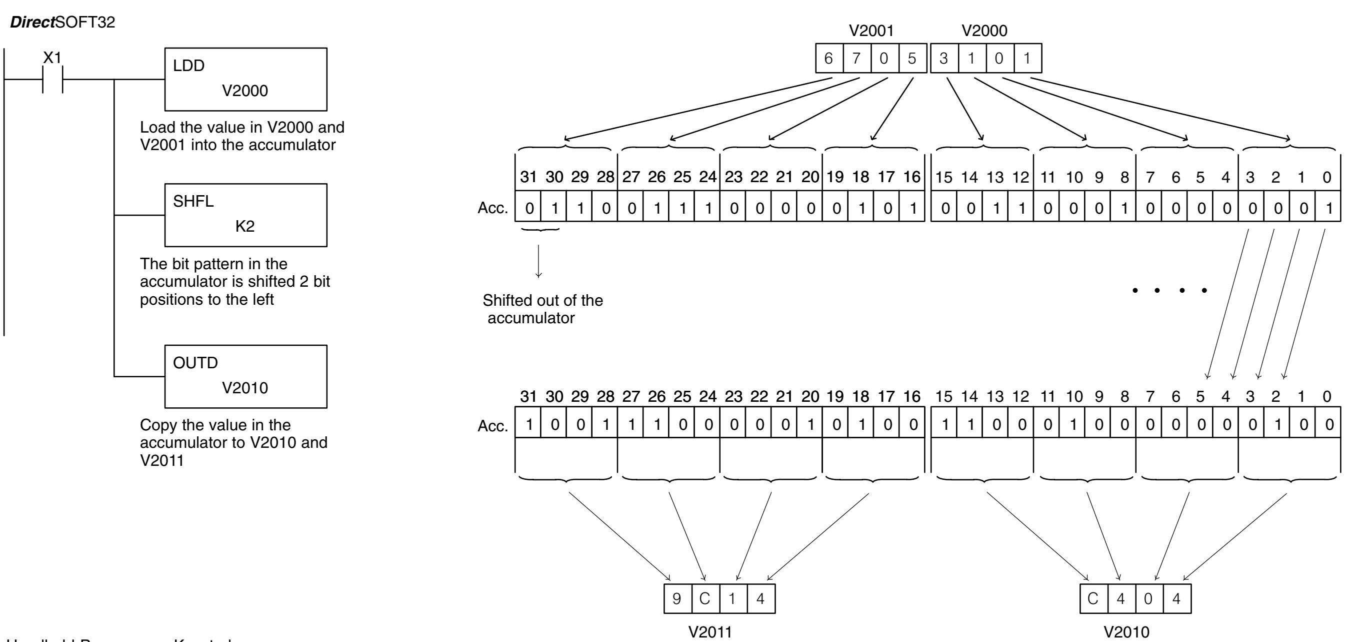
Shift Left (SHFL)

Shift Left is a 32 bit instruction that shifts the bits in the accumulator a specified number (Aaaa) of places to the left. The vacant positions are filled with zeros and the bits shifted out of the accumulator are discarded.



Operand Data Type		DL130 Range
	A	aaa
V memory	V	All (See page 4–28)
Constant	K	1–32

In the following example, when X1 is on, the value in V2000 and V2001 will be loaded into the accumulator using the Load Double instruction. The bit pattern in the accumulator is shifted 2 bits to the left using the Shift Left instruction. The value in the accumulator is copied to V2010 and V2011 using the Out Double instruction.

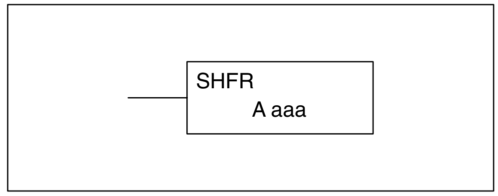


Handheld Programmer Keystrokes

$ STR	→	B 1	ENT						
SHFT	L ANDST	D 3	D 3	→	C 2	A 0	A 0	A 0	ENT
SHFT	S RST	SHFT	H 7	F 5	L ANDST	→	C 2	ENT	
GX OUT	SHFT	D 3	→	C 2	A 0	B 1	A 0	ENT	

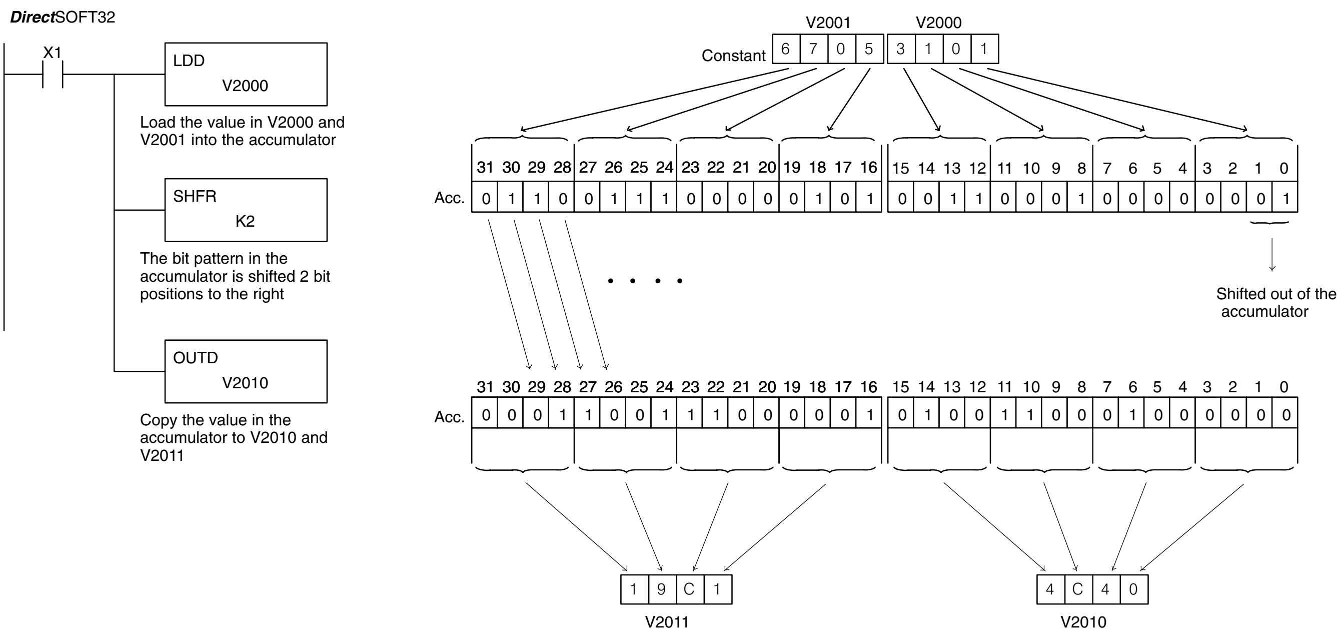
Shift Right (SHFR)

Shift Right is a 32 bit instruction that shifts the bits in the accumulator a specified number (Aaaa) of places to the right. The vacant positions are filled with zeros and the bits shifted out of the accumulator are lost.



Operand Data Type		DL130 Range
	A	aaa
V memory	V	All (See page 4–28)
Constant	K	1–32

In the following example, when X1 is on, the value in V2000 and V2001 will be loaded into the accumulator using the Load Double instruction. The bit pattern in the accumulator is shifted 2 bits to the right using the Shift Right instruction. The value in the accumulator is copied to V2010 and V2011 using the Out Double instruction.

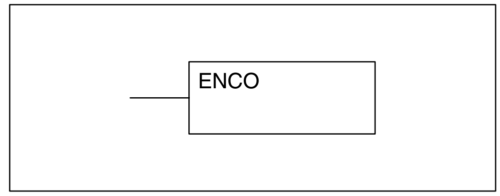


Handheld Programmer Keystrokes

$ STR	→	B 1	ENT						
SHFT	L ANDST	D 3	D 3	→	C 2	A 0	A 0	A 0	ENT
SHFT	S RST	SHFT	H 7	F 5	R ORN	→	C 2	ENT	
GX OUT	SHFT	D 3	→	C 2	A 0	B 1	A 0	ENT	

Encode (ENCO)

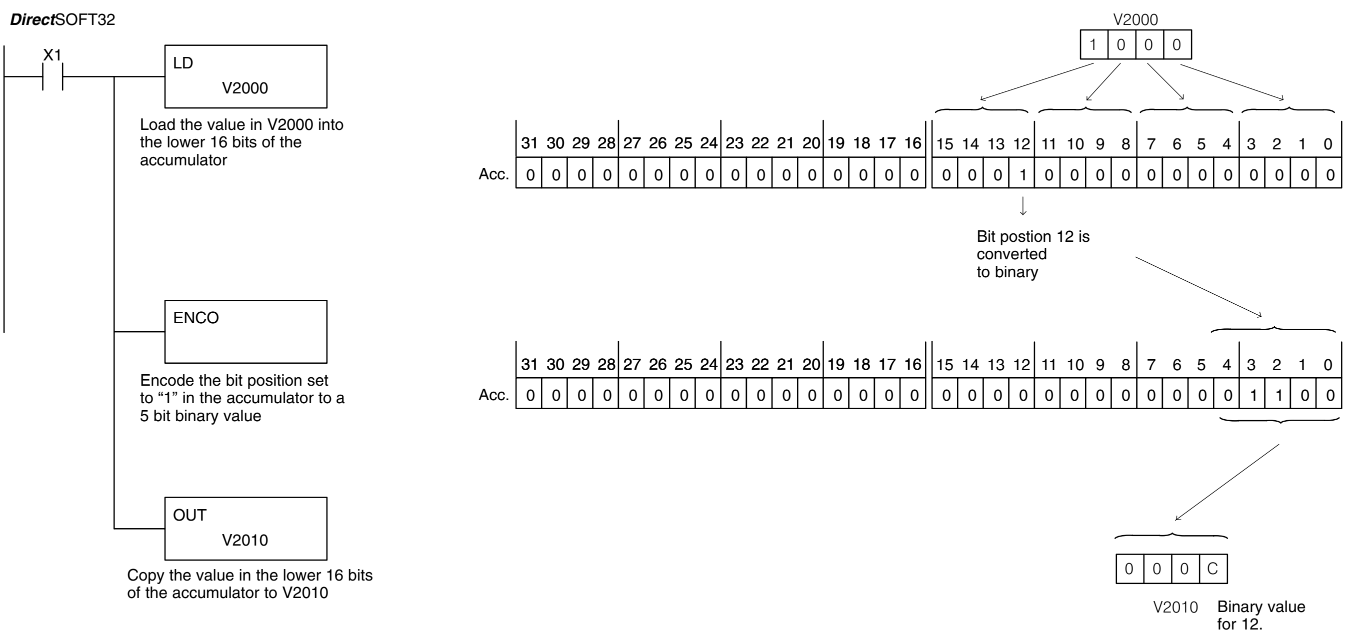
The Encode instruction encodes the bit position in the accumulator having a value of 1, and returns the appropriate binary representation. If the most significant bit is set to 1 (Bit 31), the Encode instruction would place the value HEX 1F (decimal 31) in the accumulator. If the value to be encoded is 0000 or 0001, the instruction will place a zero in the accumulator. If the value to be encoded has more than one bit position set to a “1”, the least significant “1” will be encoded and SP53 will be set on.



Discrete Bit Flags	Description
SP53	On when the value of the operand is larger than the accumulator can work with.

NOTE: The status flags are only valid until another instruction that uses the same flags is executed.

In the following example, when X1 is on, The value in V2000 is loaded into the accumulator using the Load instruction. The bit position set to a “1” in the accumulator is encoded to the corresponding 5 bit binary value using the Encode instruction. The value in the lower 16 bits of the accumulator is copied to V2010 using the Out instruction.

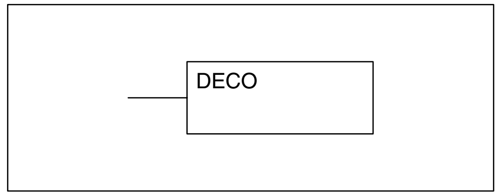


Handheld Programmer Keystrokes

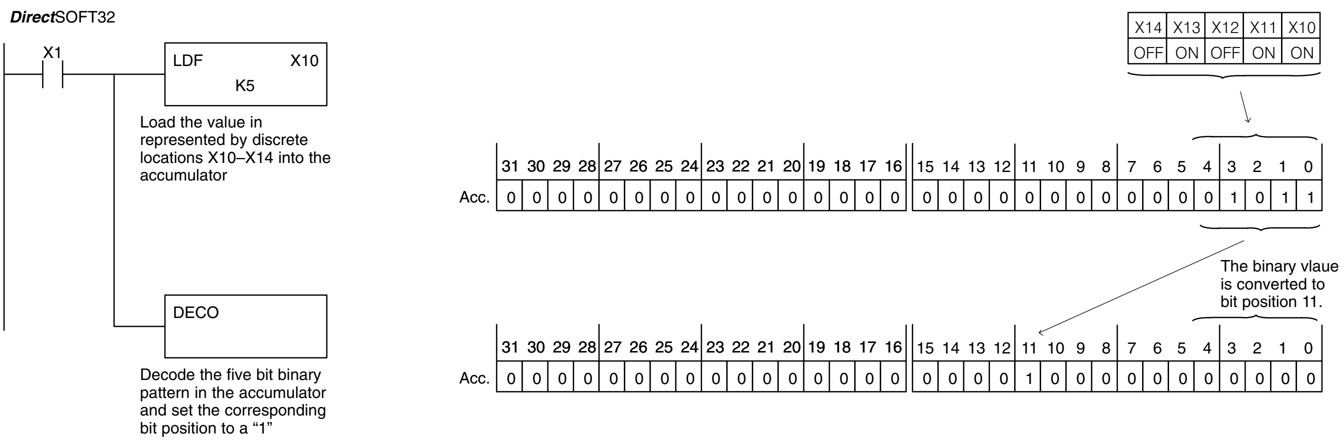
$ STR	→	B 1	ENT					
SHFT	L ANDST	D 3	→	C 2	A 0	A 0	A 0	ENT
SHFT	E 4	N TMR	C 2	O INST#	ENT			
GX OUT	→	SHFT	V AND	C 2	A 0	B 1	A 0	ENT

Decode (DECO)

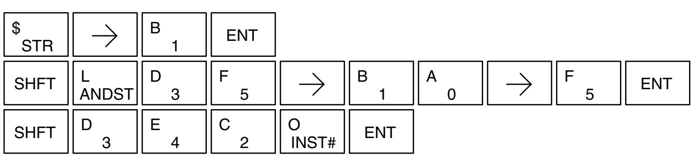
The Decode instruction decodes a 5 bit binary value of 0–31 (0–1F HEX) in the accumulator by setting the appropriate bit position to a 1. If the accumulator contains the value F (HEX), bit 15 will be set in the accumulator. If the value to be decoded is greater than 31, the number is divided by 32 until the value is less than 32 and then the value is decoded.



In the following example when X1 is on, the value formed by discrete locations X10–X14 is loaded into the accumulator using the Load Formatted instruction. The five bit binary pattern in the accumulator is decoded by setting the corresponding bit position to a “1” using the Decode instruction.



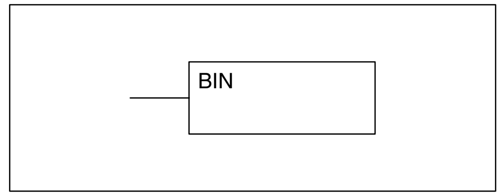
Handheld Programmer Keystrokes



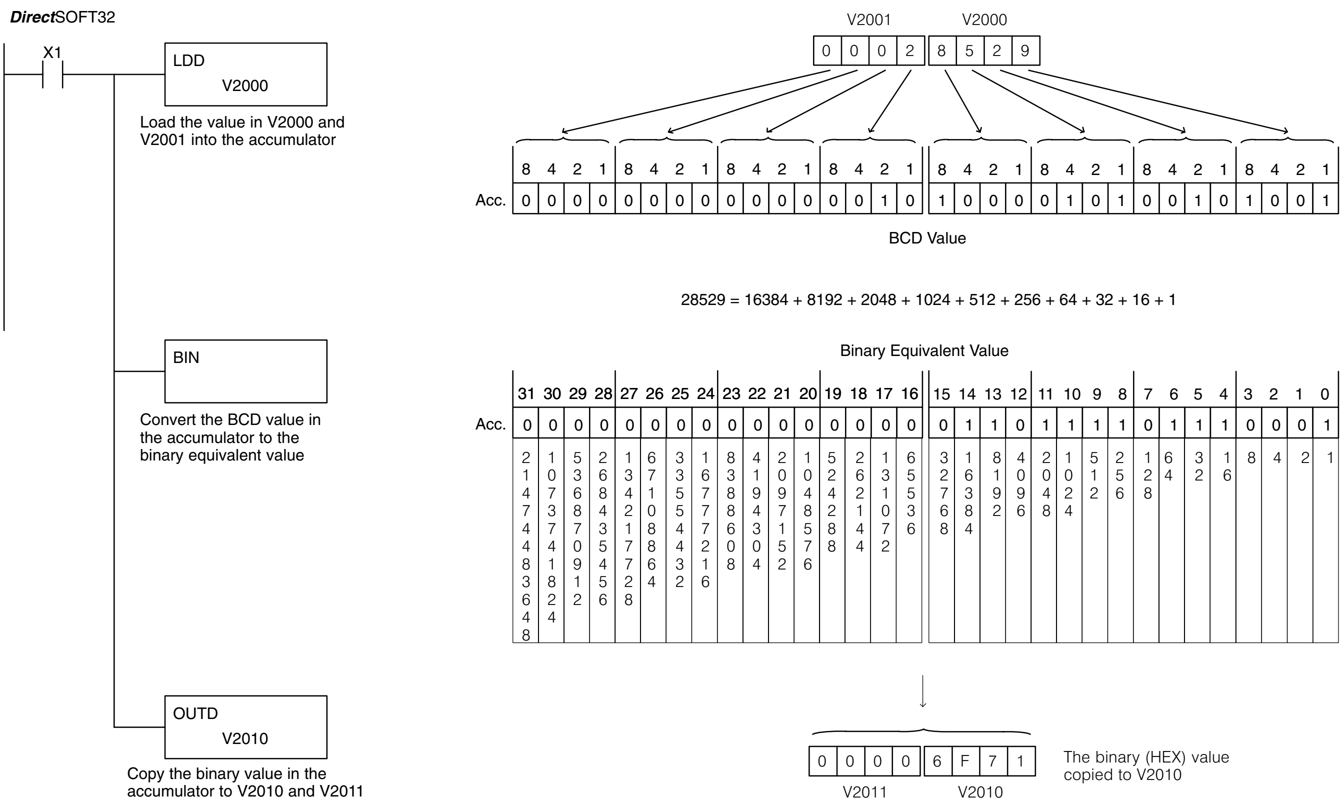
Number Conversion Instructions (Accumulator)

Binary (BIN)

The Binary instruction converts a BCD value in the accumulator to the equivalent binary value. The result resides in the accumulator.



In the following example, when X1 is on, the value in V2000 and V2001 is loaded into the accumulator using the Load Double instruction. The BCD value in the accumulator is converted to the binary (HEX) equivalent using the BIN instruction. The binary value in the accumulator is copied to V2010 and V2011 using the Out Double instruction. (The handheld programmer will display the binary value in V2010 and V2011 as a HEX value.)

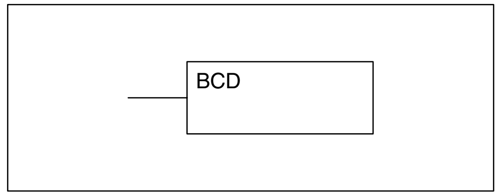


Handheld Programmer Keystrokes

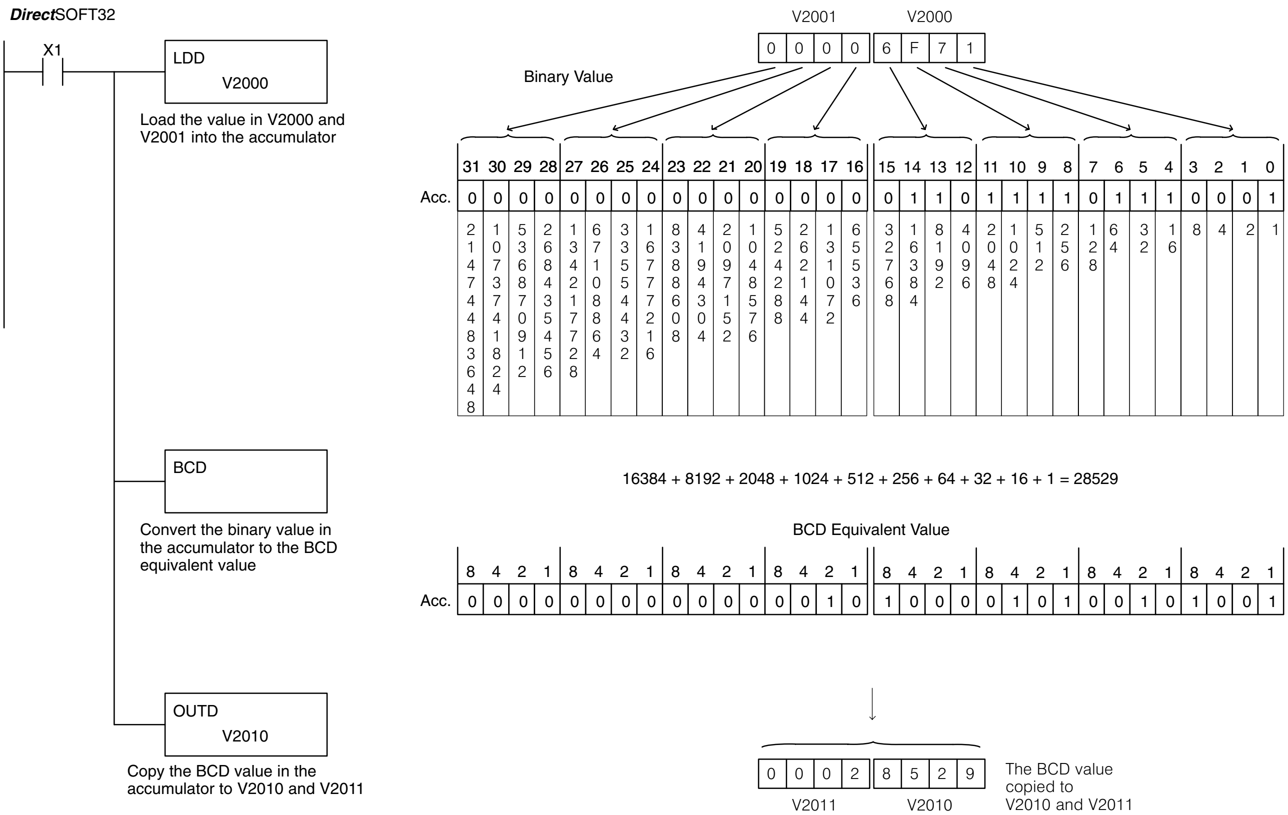
$ STR	→	B 1	ENT						
SHFT	L ANDST	D 3	D 3	→	C 2	A 0	A 0	A 0	ENT
SHFT	B 1	I 8	N TMR	ENT					
GX OUT	SHFT	D 3	→	C 2	A 0	B 1	A 0	ENT	

Binary Coded Decimal (BCD)

The Binary Coded Decimal instruction converts a binary value in the accumulator to the equivalent BCD value. The result resides in the accumulator.



In the following example, when X1 is on, the binary (HEX) value in V2000 and V2001 is loaded into the accumulator using the Load Double instruction. The binary value in the accumulator is converted to the BCD equivalent value using the BCD instruction. The BCD value in the accumulator is copied to V2010 and V2011 using the Out Double instruction.



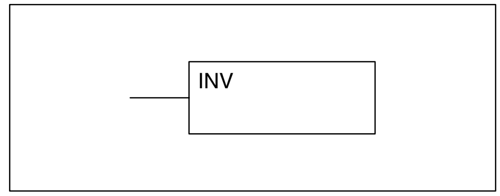
Handheld Programmer Keystrokes

$ STR	→	B 1	ENT					
SHFT	L ANDST	D 3	D 3	→	C 2	A 0	A 0	A 0	ENT
SHFT	B 1	C 2	D 3	ENT				
GX OUT	SHFT	D 3	→	C 2	A 0	B 1	A 0	ENT

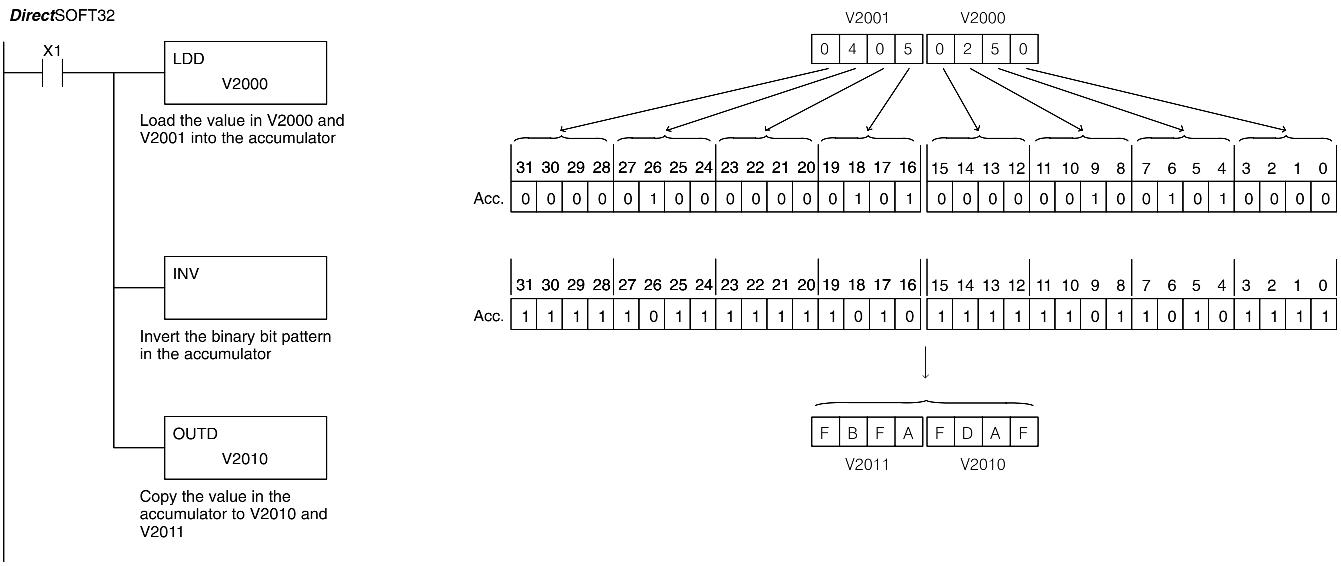
Standard RLL Instructions

Invert (INV)

The Invert instruction inverts or takes the one's complement of the 32 bit value in the accumulator. The result resides in the accumulator.



In the following example, when X1 is on, the value in V2000 and V2001 will be loaded into the accumulator using the Load Double instruction. The value in the accumulator is inverted using the Invert instruction. The value in the accumulator is copied to V2010 and V2011 using the Out Double instruction.



Handheld Programmer Keystrokes

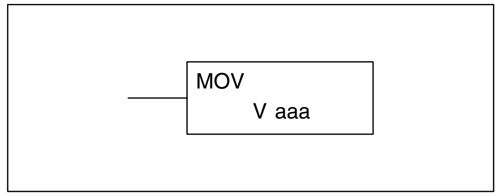
$ STR	→	B 1	ENT					
SHFT	L ANDST	D 3	D 3	→	C 2	A 0	A 0	A 0	ENT
SHFT	I 8	N TMR	V AND	ENT				
GX OUT	SHFT	D 3	→	C 2	A 0	B 1	A 0	ENT

Standard RLL Instructions

Table Instructions

Move (MOV)

The Move instruction moves the values from a V memory table to another V memory table the same length. The function parameters are loaded into the first level of the accumulator stack and the accumulator by two additional instructions. Listed below are the steps necessary to program the Move function.

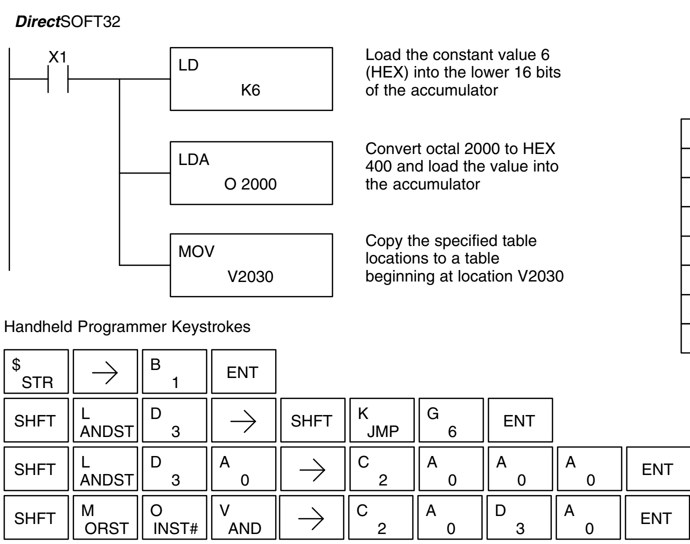


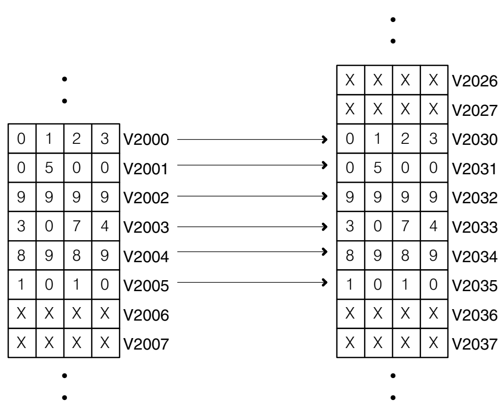
- Step 1:— Load the number of V memory locations to be moved into the first level of the accumulator stack. This parameter is a HEX value (K40 max, 100 octal).
- Step 2:— Load the starting V memory location for the locations to be moved into the accumulator. This parameter is a HEX value.
- Step 3:— Insert the MOVE instruction which specifies starting V memory location (Vaaa) for the destination table.

Helpful Hint: — For parameters that require HEX values when referencing memory locations, the LDA instruction can be used to convert an octal address to the HEX equivalent and load the value into the accumulator.

Operand Data Type		DL130 Range
		aaa
V memory	V	All (See page 4–28)

In the following example, when X1 is on, the constant value (K6) is loaded into the accumulator using the Load instruction. This value specifies the length of the table and is placed in the first stack location after the Load Address instruction is executed. The octal address 2000 (V2000), the starting location for the source table is loaded into the accumulator. The destination table location (V2030) is specified in the Move instruction.

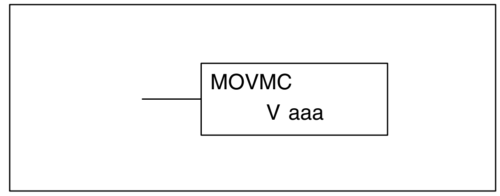


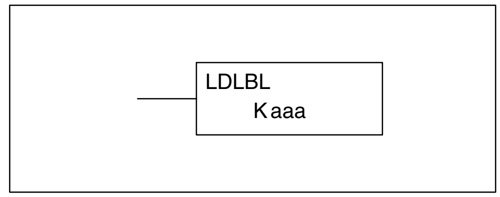


Move Memory Cartridge / Load Label

(MOVMC), (LDLBL)

The Move Memory Cartridge instruction is used to copy data between V memory and program ladder memory. The Load Label instruction is *only* used with the MOVMC instruction when copying data *from* program ladder memory *to* V memory.





To copy data between V memory and program ladder memory, the function parameters are loaded into the first two levels of the accumulator stack and the accumulator by two additional instructions. Listed below are the steps necessary to program the Move Memory Cartridge and Load Label functions.

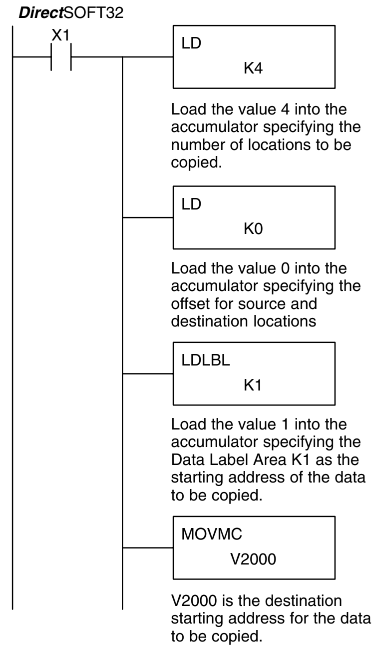
- Step 1:— Load the number of words to be copied into the second level of the accumulator stack.
- Step 2:— Load the offset for the data label area in ladder memory and the beginning of the V memory block into the first level of the stack.
- Step 3:— Load the *source data label* (LDLBL Kaaa) into the accumulator when copying data from ladder memory to V memory. Load the *source address* (LDA Oaaa) into the accumulator when copying data from V-memory to ladder memory. This is the source location of the value. Source addresses in V-memory must be entered in HEX.
- Step 4:— Insert the MOVMC instruction which specifies destination V-memory (Vaaa), or data label (Kaaa). This is the copy destination.

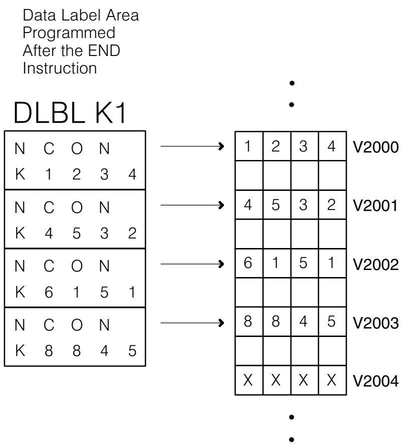
Operand Data Type		DL130 Range
	A	aaa
V memory	V	All (See page 4–28)

NOTE: See Appendix E for an explanation of the DL105 memory system.

Copy Data From a Data Label Area to V Memory

In the example to the right, data is copied from a Data Label Area to V memory. When X1 is on, the constant value (K4) is loaded into the accumulator using the Load instruction. This value specifies the length of the table and is placed in the second stack location after the next Load and Load Label (LDLBL) instructions are executed. The constant value (K0) is loaded into the accumulator, specifying the offset for the source and destination data. It is placed in the first stack location after the LDLBL instruction is executed. The source address where data is being copied from is loaded into the accumulator using the LDLBL instruction. The MOVMC instruction specifies the destination starting location and executes the copying of data from the Data Label Area to V memory.





Handheld Programmer Keystrokes

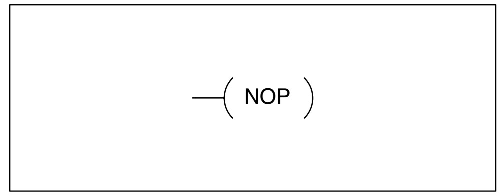
$ STR	→	B 1	ENT								
SHFT	L ANDST	D 3	→	SHFT	K JMP	E 4	ENT				
SHFT	L ANDST	D 3	→	SHFT	K JMP	A 0	ENT				
SHFT	L ANDST	D 3	L ANDST	B 1	L ANDST	→	B 1	ENT			
SHFT	M ORST	O INST#	V AND	M ORST	C 2	→	C 2	A 0	A 0	A 0	ENT

Standard RII Instructions

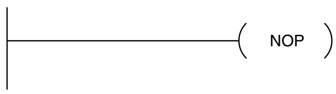
CPU Control Instructions

No Operation (NOP)

The No Operation is an empty (not programmed) memory location.



***Direct*SOFT32**

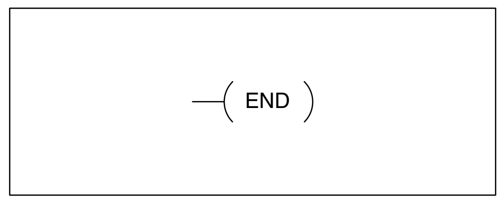


Handheld Programmer Keystrokes

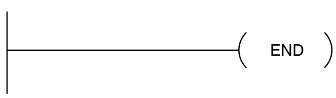
SHFT | N TMR | O INST# | P CV | ENT

End (END)

The End instruction marks the termination point of the normal program scan. An End instruction is required at the end of the main program body. If the End instruction is omitted an error will occur and the CPU will not enter the Run Mode. Data labels, subroutines and interrupt routines are placed after the End instruction. The End instruction is not conditional; therefore, no input contact is allowed.



***Direct*SOFT32**

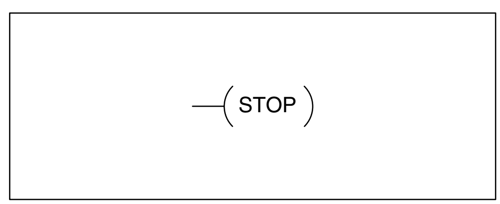


Handheld Programmer Keystrokes

SHFT | E 4 | N TMR | D 3 | ENT

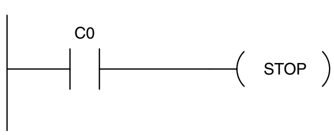
Stop (STOP)

The Stop instruction changes the operational mode of the CPU from Run to Program (Stop) mode. This instruction is typically used to stop PLC operation in an error condition.



In the following example, when C0 turns on, the CPU will stop operation and switch to the program mode.

***Direct*SOFT32**



Handheld Programmer Keystrokes

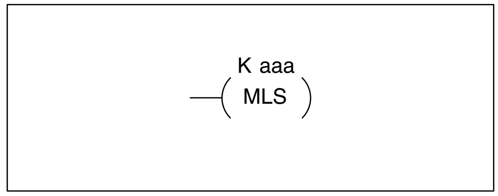
$ STR | → | SHFT | C 2 | A 0 | ENT

SHFT | S RST | SHFT | T MLR | O INST# | P CV | ENT

Program Control Instructions

Master Line Set (MLS)

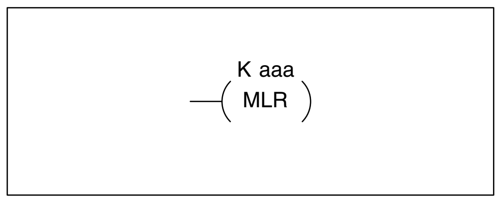
The Master Line Set instruction allows the program to control sections of ladder logic by forming a new power rail controlled by the main left power rail. The main left rail is always master line 0. When a MLS K1 instruction is used, a new power rail is created at level 1. Master Line Sets and Master Line Resets can be used to nest power rails up to seven levels deep.



Operand Data Type		DL130 Range
		aaa
Constant	K	1–7

Master Line Reset (MLR)

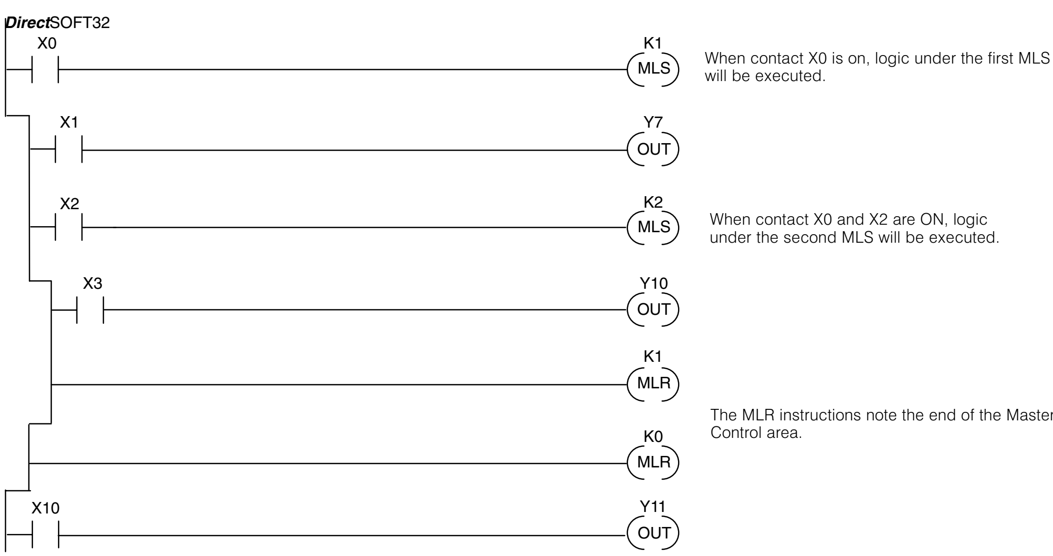
The Master Line Reset instruction marks the end of control for the corresponding MLS instruction. The MLR reference is one less than the corresponding MLS.



Operand Data Type		DL130 Range
		aaa
Constant	K	0–6

Understanding Master Control Relays

The Master Line Set (MLS) and Master Line Reset (MLR) instructions allow you to quickly enable (or disable) sections of the RLL program. This provides program control flexibility. The following example shows how the MLS and MLR instructions operate by creating a sub power rail for control logic.



MLS/MLR Example In the following MLS/MLR example logic between the first MLS K1 (A) and MLR K0 (B) will function only if input X0 is on. The logic between the MLS K2 (C) and MLR K1 (D) will function only if input X10 and X0 is on. The last rung is not controlled by either of the MLS coils.

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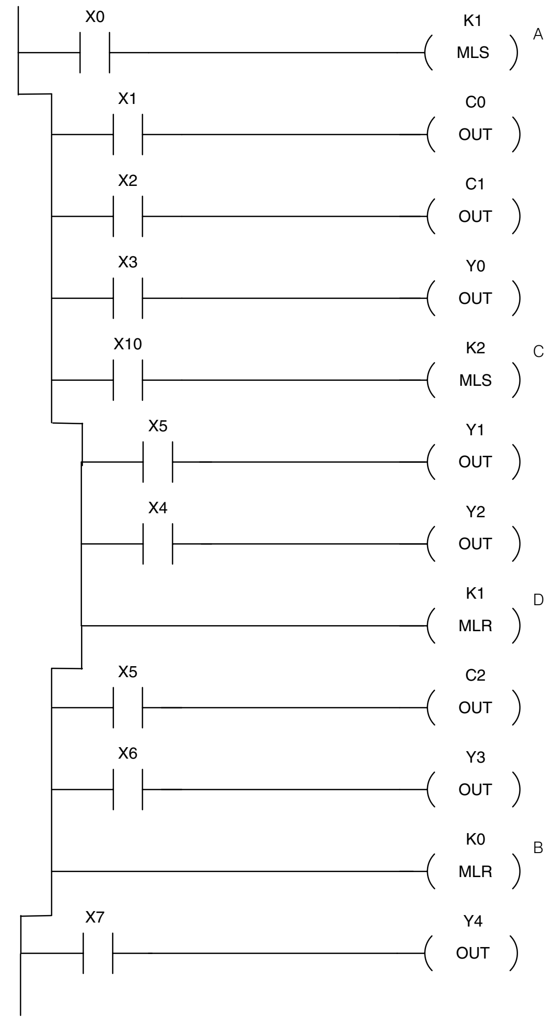


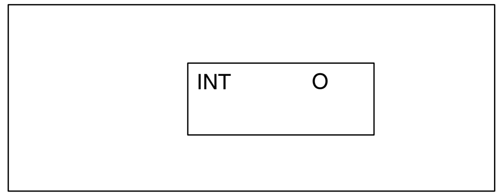
Handheld Programmer Keystrokes

$ STR	→	A 0	ENT		
Y MLS	→	B 1	ENT		
$ STR	→	B 1	ENT		
GX OUT	→	SHFT	C 2	A 0	ENT
$ STR	→	C 2	ENT		
GX OUT	→	SHFT	C 2	B 1	ENT
$ STR	→	D 3	ENT		
GX OUT	→	A 0	ENT		
$ STR	→	B 1	A 0	ENT	
Y MLS	→	C 2	ENT		
$ STR	→	F 5	ENT		
GX OUT	→	B 1	ENT		
$ STR	→	E 4	ENT		
GX OUT	→	C 2	ENT		
T MLR	→	B 1	ENT		
$ STR	→	F 5	ENT		
GX OUT	→	SHFT	C 2	C 2	ENT
$ STR	→	G 6	ENT		
GX OUT	→	D 3	ENT		
T MLR	→	A 0	ENT		
$ STR	→	H 7	ENT		
GX OUT	→	E 4	C 2	ENT	

Interrupt Instructions

Interrupt (INT)

The Interrupt instruction allows a section of ladder logic to be placed below the main body of the program and executed only when needed. High-Speed I/O Modes 10, 20, and 40 can generate an interrupt. With Mode 40, you may select an external interrupt (input X0), or a time-based interrupt (5–999 mS).



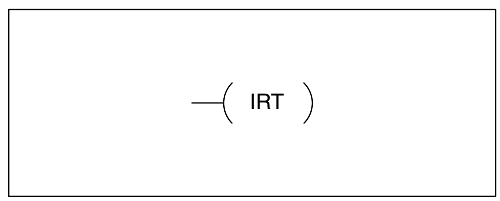
Typically, interrupts are used in an application when a fast response to an input is needed or a program section must execute faster than the normal CPU scan. The interrupt label and all associated logic must be placed after the End statement in the program. When an interrupt occurs, the CPU will complete execution of the current instruction it is processing in ladder logic, then execute the interrupt routine. After interrupt routine execution, the ladder program resumes from the point at which it was interrupted.

See Chapter 3, the section on Mode 40 (Interrupt) Operation for more details on interrupt configuration. In the DL105, only one interrupt is available.

Operand Data Type		DL130 Range
Constant	O	0

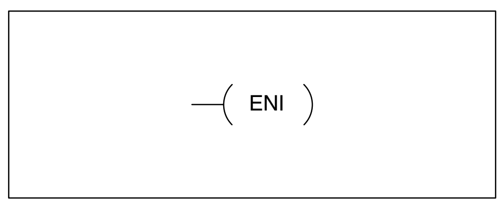
Interrupt Return (IRT)

An Interrupt Return is normally executed as the last instruction in the interrupt routine. It returns the CPU to the point in the main program from which it was called. The Interrupt Return is a stand-alone instruction (no input contact on the rung).



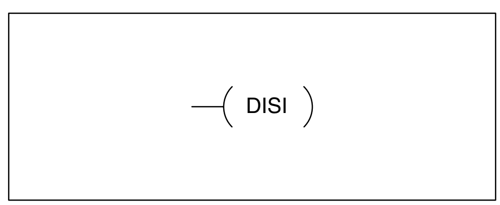
Enable Interrupts (ENI)

The Enable Interrupt instruction is placed in the main ladder program (before the End instruction), enabling the interrupt. The interrupt remains enabled until the program executes a Disable Interrupt instruction.



Disable Interrupts (DISI)

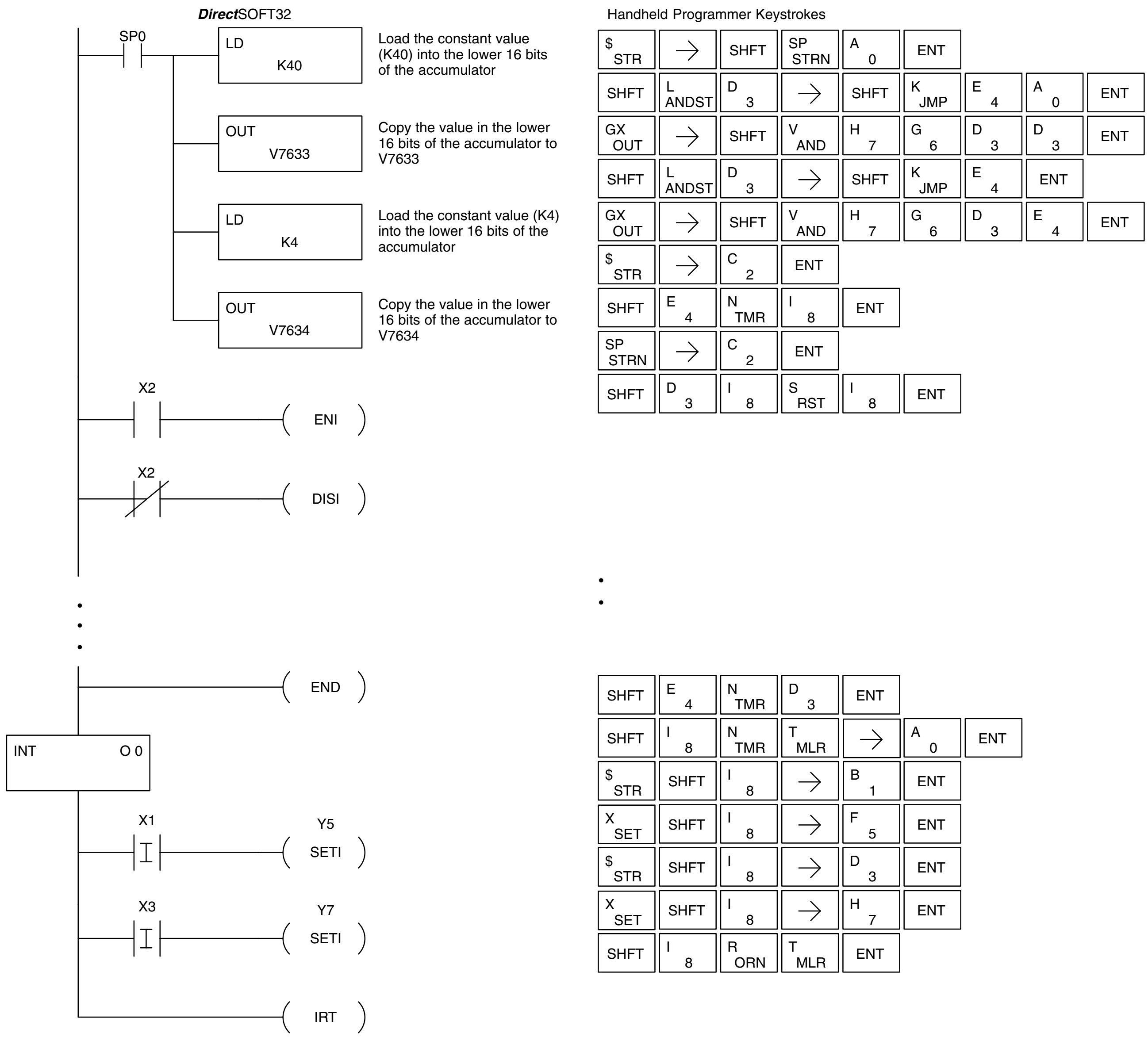
A Disable Interrupt instruction in the main body of the application program (before the End instruction) will disable the interupt (either extenal or timed). The interrupt remains disabled until the program executes an Enable Interrupt instruction.



External Interrupt Program Example

In the following example, we do some initialization on the first scan, using the first-scan contact SP0. The interrupt feature is the HSIO Mode 40. Then we configure X0 as the external interrupt by writing to its configuration register, V7634. See Chapter 3, Mode 40 Operation for more details.

During program execution, when X2 is on the interrupt is enabled. When X2 is off the interrupt will be disabled. When an interrupt signal (X0) occurs the CPU will jump to the interrupt label INT O 0. The application ladder logic in the interrupt routine will be performed. The CPU will return to the main body of the program after the IRT instruction is executed.



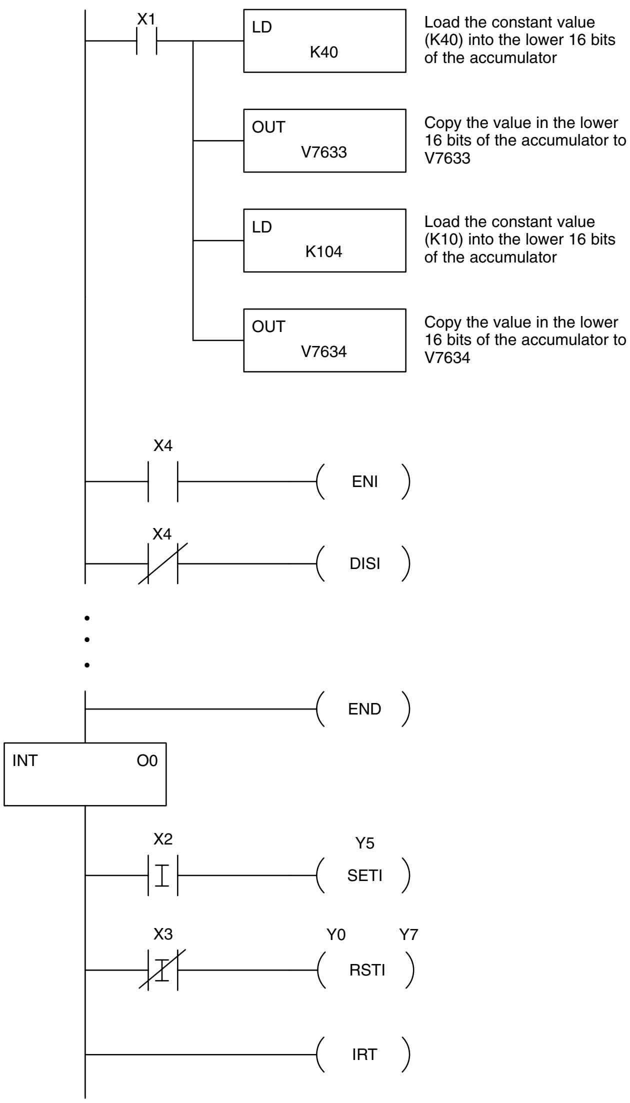
NOTE: Only one interrupt is available in the DL105 and it must be Int 0.

Timed Interrupt Program Example

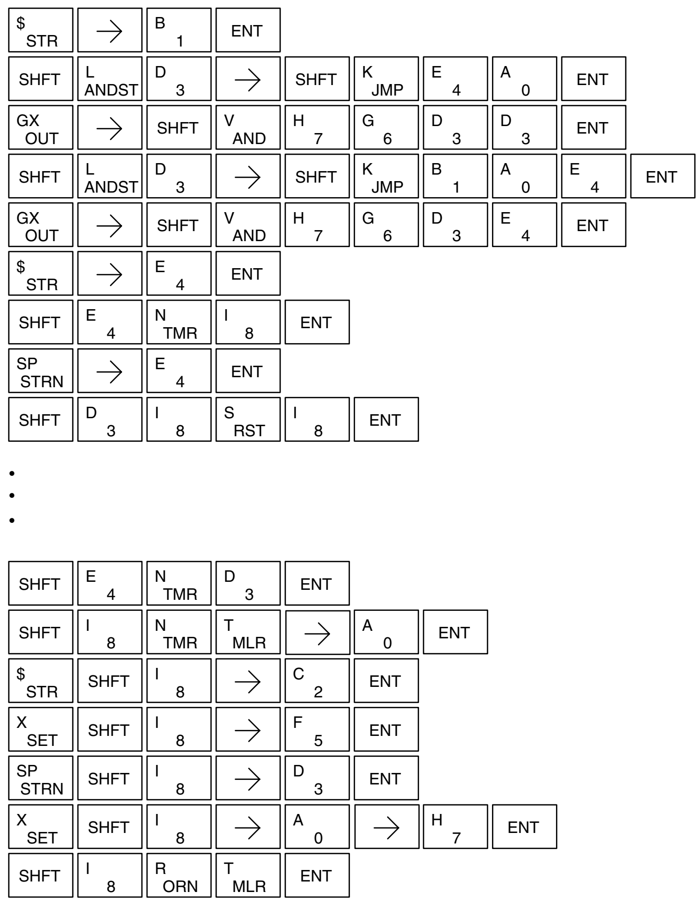
In the following example, we do some initialization on the first scan, using the first-scan contact SP0. The interrupt feature is the HSIO Mode 40. Then we configure the HSIO timer as a 10 mS interrupt by writing K104 to the configuration register for X0 (V7634). See Chapter 3, Mode 40 Operation for more details.

When X4 turns on, the interrupt will be enabled. When X4 turns off, the interrupt will be disabled. Every 10 mS the CPU will jump to the interrupt label INT O 0. The application ladder logic in the interrupt routine will be performed. If X3 is not on Y0–Y7 will be reset to off and then the CPU will return to the main body of the program.

*Direct*SOFT32



Handheld Programmer Keystrokes

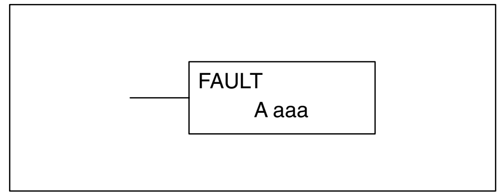


NOTE: Only one interrupt is available in the DL105 and it must be Int 0.

Message Instructions

Fault (FAULT)

The Fault instruction is used to display a message on the handheld programmer or in the ***Direct***SOFT32 status bar. The message has a maximum of 23 characters and can be either V memory data, numerical constant data or ASCII text.



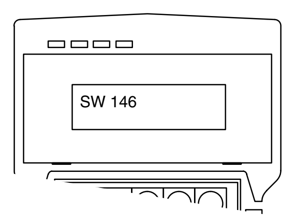
To display the value in a V memory location, specify the V memory location in the instruction. To display the data in ACON (ASCII constant) or NCON (Numerical constant) instructions, specify the constant (K) value for the corresponding data label area.

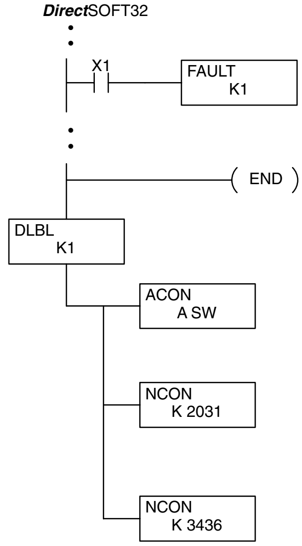
Operand Data Type		DL130 Range
	A	aaa
V memory	V	All (See page 4–28)
Constant	K	1–FFFF

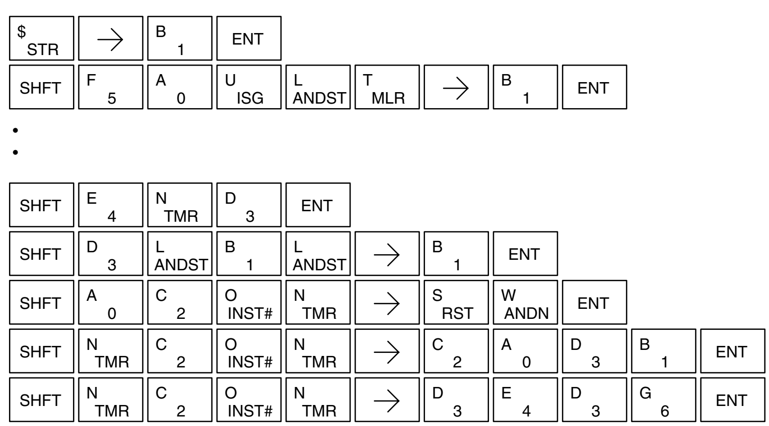
NOTE: The FAULT instruction takes a considerable amount of time to execute. This is because the FAULT parameters are stored in EEPROM. Be sure to consider the instructions execution times (shown in Appendix C) if you are attempting to use the FAULT instructions in applications that require faster than normal execution cycles.

Fault Example

In the following example when X1 is on, the message SW 146 will display on the handheld programmer. The NCONs use the HEX ASCII equivalent of the text to be displayed. (The HEX ASCII for a blank is 20, a 1 is 31, 4 is 34 ...)







Data Label (DLBL)

The Data Label instruction marks the beginning of an ASCII / numeric data area. DLBLs are programmed after the End statement. A maximum of 32 DLBL instructions can be used in a program. Multiple NCONs and ACONs can be used in a DLBL area.

DLBL K aaa

Operand Data Type		DL130 Range
		aaa
Constant	K	1–FFFF

ASCII Constant (ACON)

The ASCII Constant instruction is used with the DLBL instruction to store ASCII text for use with other instructions. Two ASCII characters can be stored in an ACON instruction. If only one character is stored in a ACON a leading space will be inserted.

ACON
A aaa

Operand Data Type		DL130 Range
		aaa
ASCII	A	0–9 A–Z

Numerical Constant (NCON)

The Numerical Constant instruction is used with the DLBL instruction to store the HEX ASCII equivalent of numerical data for use with other instructions. Two digits can be stored in an NCON instruction.

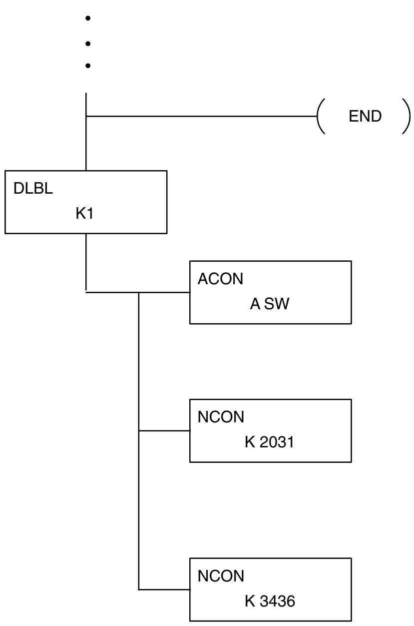
NCON
K aaa

Operand Data Type		DL130 Range
		aaa
Constant	K	0–FFFF

Data Label Example

In the following example, an ACON and two NCON instructions are used within a DLBL instruction to build a text message. See the FAULT instruction for information on displaying messages. The DV-1000 Manual also has information on displaying messages.

DirectSOFT32



Handheld Programmer Keystrokes

SHFT	E 4	N TMR	D 3	ENT						
SHFT	D 3	L ANDST	B 1	L ANDST	→	B 1	ENT			
SHFT	A 0	C 2	O INST#	N TMR	→	S RST	W ANDN	ENT		
SHFT	N TMR	C 2	O INST#	N TMR	→	C 2	A 0	D 3	B 1	ENT
SHFT	N TMR	C 2	O INST#	N TMR	→	D 3	E 4	D 3	G 6	ENT

6

Drum Instruction Programming

In This Chapter. . . .

Introduction

Purpose

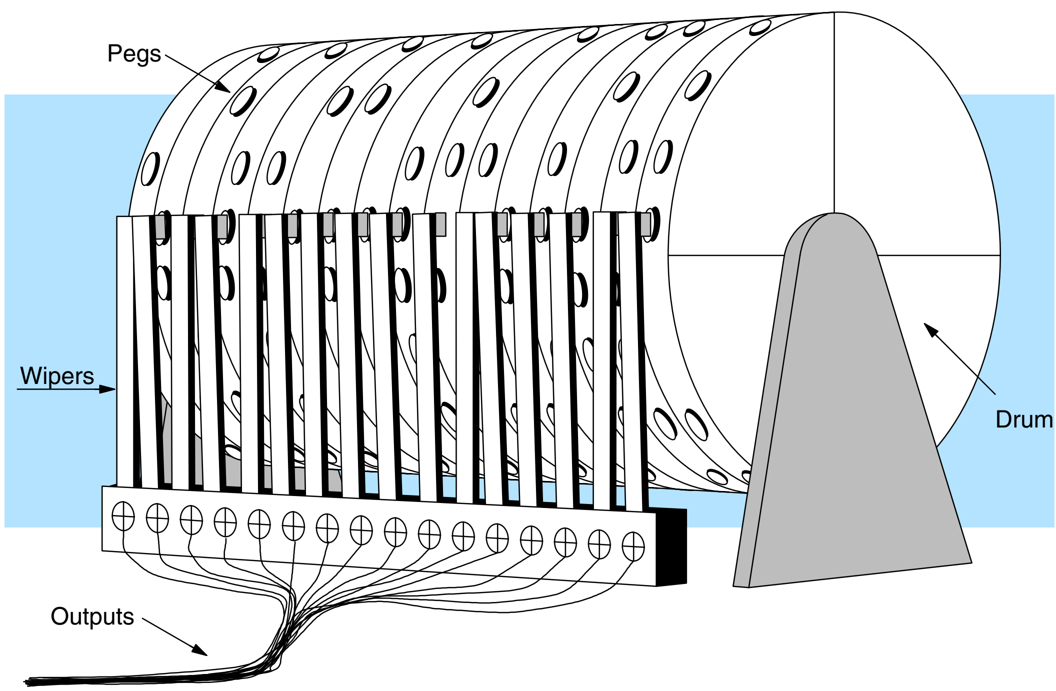
The Event Drum (EDRUM) instruction in the F1–130 CPU electronically simulates an electro-mechanical drum sequencer. The instruction offers enhancements to the basic principle, which we describe first.

Drum Terminology

Drum instructions are best suited for repetitive processes that consist of a finite number of steps. They can do the work of many rungs of ladder logic with elegant simplicity. Therefore, drums can save a lot of programming and debugging time.

We introduce some terminology associated with the drum instruction by describing the original mechanical drum shown below. The mechanical **drum** generally has pegs on its curved surface. The pegs are populated in a particular **pattern**, representing a set of desired actions for machine control. A motor or solenoid rotates the drum a precise amount at specific times. During rotation, stationary wipers sense the presence of pegs (present = on, absent = off). This interaction makes or breaks electrical contact with the wipers, creating electrical **outputs** from the drum. The outputs are wired to devices on a machine for On/Off control.

Drums usually have a finite number of positions within one rotation, called **steps**. Each step represents some process step. At powerup, the drum **resets** to a particular step. The drum rotates from one step to the next based on a **timer**, or on some external **event**. During special conditions, a machine operator can manually increment the drum step using a **jog** control on the drum's drive mechanism. The contact closure of each wiper generates a unique on/off pattern called a **sequence**, designed for controlling a specific machine. Because the drum is circular, it automatically repeats the sequence once per rotation. Applications vary greatly, and a particular drum may rotate once per second, or as slowly as once per week.



Electronic drums provide the benefits of mechanical drums and more. For example, they have a **preset** feature that is impossible for mechanical drums: The preset function lets you move from the present step *directly* to any other step on command!

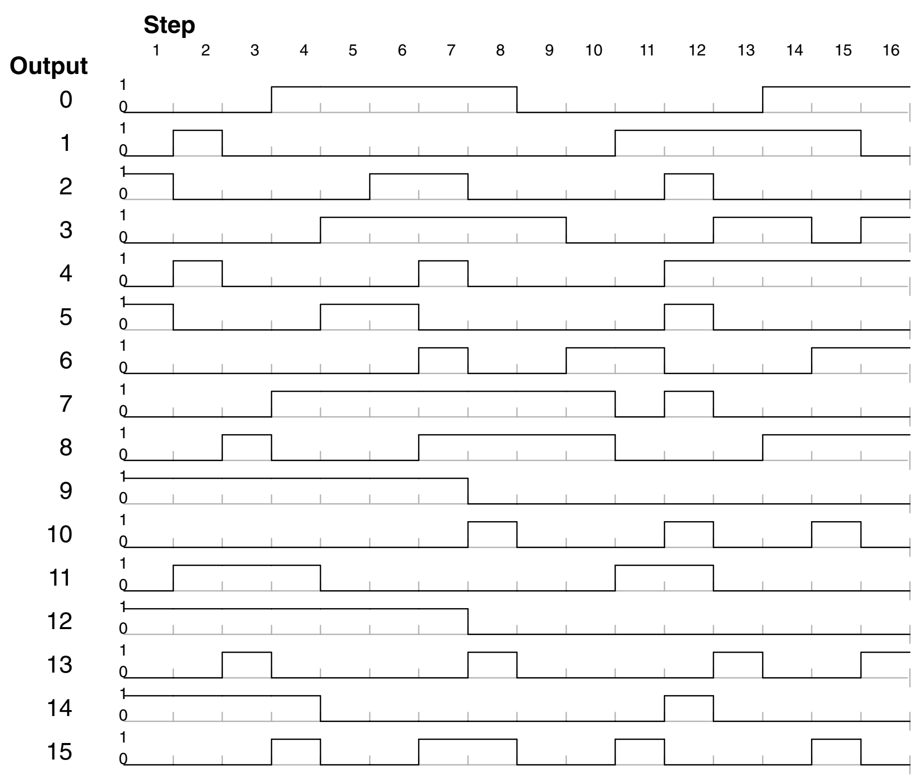
Drum Chart Representation

For editing purposes, the electronic drum is presented in chart form in ***Direct***SOFT32 and in this manual. Imagine slicing the surface of a hollow drum cylinder between two rows of pegs, then pressing it flat. Now you can view the drum as a chart as shown below. Each row represents a step, numbered 1 through 16. Each column represents an output, numbered 0 through 15 (to match word bit numbering). The solid circles in the chart represent pegs (On state) in the mechanical drum, and the open circles are empty peg sites (Off state).

STEP	OUTPUTS															
	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	○	●	○	●	○	○	●	○	○	○	●	○	○	●	○	○
2	○	●	○	●	●	○	●	○	○	○	○	●	○	○	●	○
3	○	●	●	●	●	○	●	●	○	○	○	○	○	○	○	○
4	●	●	○	●	●	○	●	○	●	○	○	○	○	○	○	●
5	○	○	○	●	○	○	●	○	●	○	●	○	●	○	○	●
6	○	○	○	●	○	○	●	○	●	○	●	○	●	●	○	●
7	●	○	○	●	○	○	●	●	●	●	○	●	●	●	○	●
8	●	○	●	○	○	●	○	●	●	○	○	○	●	○	○	●
9	○	○	○	○	○	○	○	●	●	○	○	○	●	○	○	○
10	○	○	○	○	○	○	○	●	●	●	○	○	○	○	○	○
11	●	○	○	○	●	○	○	○	○	●	○	○	○	○	●	○
12	○	●	○	○	●	●	○	○	●	○	●	●	○	●	●	○
13	○	○	●	○	○	○	○	○	○	○	○	●	●	○	●	○
14	○	○	○	○	○	○	○	●	○	○	○	●	●	○	●	●
15	●	○	○	○	○	●	○	●	○	●	○	●	○	○	●	●
16	○	○	●	○	○	○	○	●	○	●	○	●	●	○	○	●

Output Sequences

The mechanical drum sequencer derives its name from sequences of control changes on its electrical outputs. The following figure shows the sequence of On/Off controls generated by the drum pattern above. Compare the two, and you will find that they are equivalent! If you can see their equivalence, you are well on your way to understanding drum instruction operation.



Step Transitions

Drum Instruction Parameters

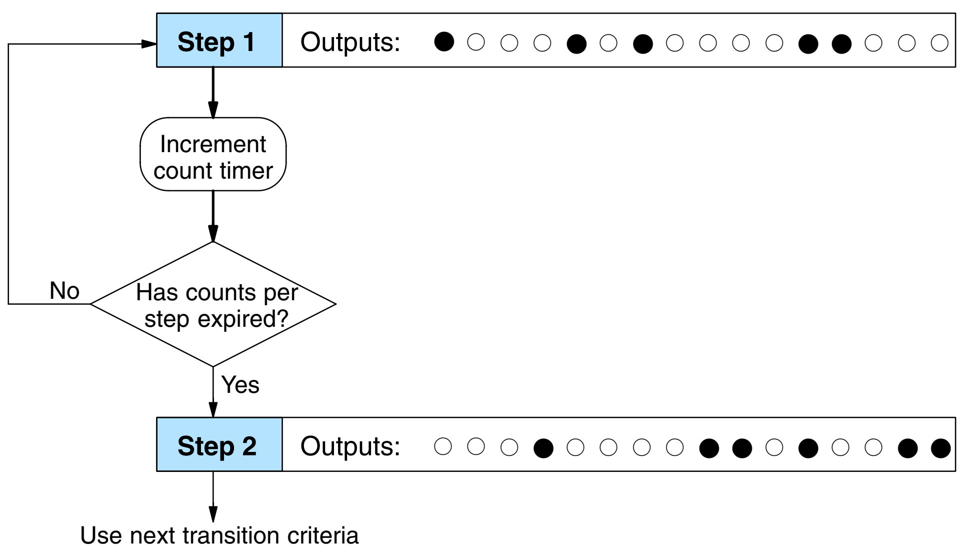
EDRUM operation in the F1–130 includes the following features:

- Up to 16 steps
- Time-based step transitions
- Event-based step transitions
- Up to 16 discrete outputs per drum (X, Y, or C type)

The EDRUM has 16 steps, and each step has 16 outputs. Refer to the figure below. Each output can be either an X, Y, or C coil, offering a lot of programming flexibility. We assign Step 1 an arbitrary unique output pattern (○= Off, ●= On) as shown. When programming the EDRUM instruction, you also determine both the output assignment and the On/Off state (pattern) at that time. All steps use the same output assignment, but each step may have its own unique output pattern.

Timer-Only Transitions

Drums move from one step to another based on time and/or an external event (input). Each step has its own transition condition which you assign during the drum instruction entry. The figure below shows how timer-only transitions work.



The drum stays in Step 1 for a specific duration (user-programmable). The timebase of the timer is programmable, from 0.01 seconds to 99.99 seconds. This establishes the resolution, or the duration of each "tick of the clock". Each step uses the same timebase, but has its own unique counts per step, which you program. When the counts for Step 1 have expired, then the drum moves to Step 2. The outputs change immediately to match the new pattern for Step 2.

The drum spends a specific amount of time in each step, given by the formula:

Time in step = 0.01 seconds X Timebase x Counts per step

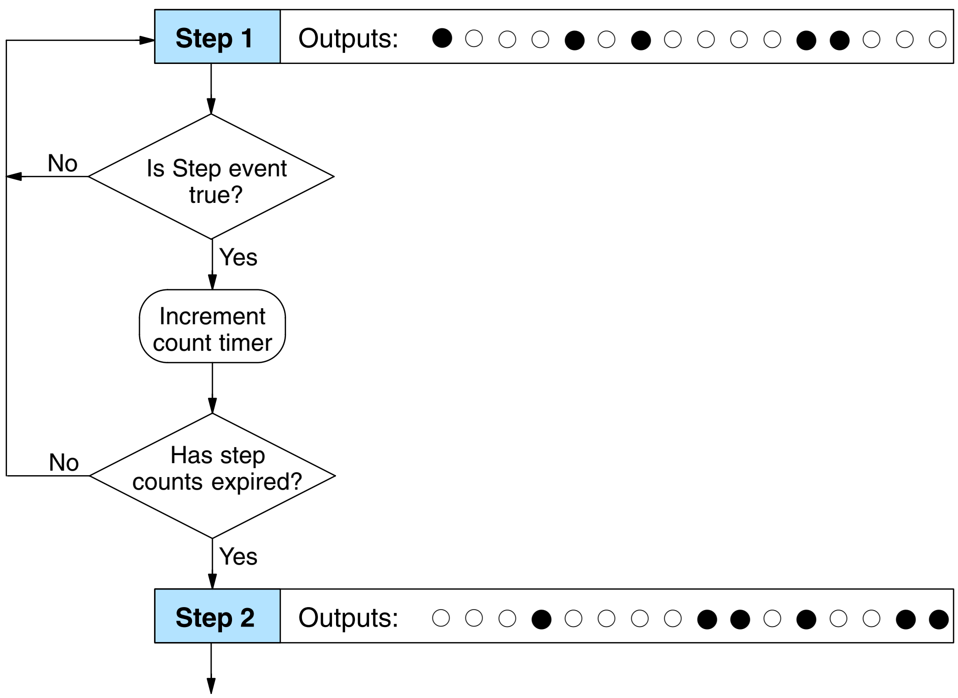
For example, if you program a 5 second time base and 12 counts for Step 1, then the drum will spend 60 seconds in Step 1. The maximum time for any step is given by the formula:

Max Time per step = 0.01 seconds X 9999 X 9999
= 999,800 seconds = 277.7 hours = 11.6 days

NOTE: When first choosing the timebase resolution, a good rule of thumb is to make it about 1/10 the duration of the shortest step in your drum. Then you will be able to optimize the duration of that step in 10% increments. Other steps with longer durations allow optimizing by even smaller increments (percentage-wise). Also, note that the drum instruction executes once per CPU scan. Therefore, it is pointless to specify a drum timebase that is much faster than the CPU scan time.

Timer and Event Transitions

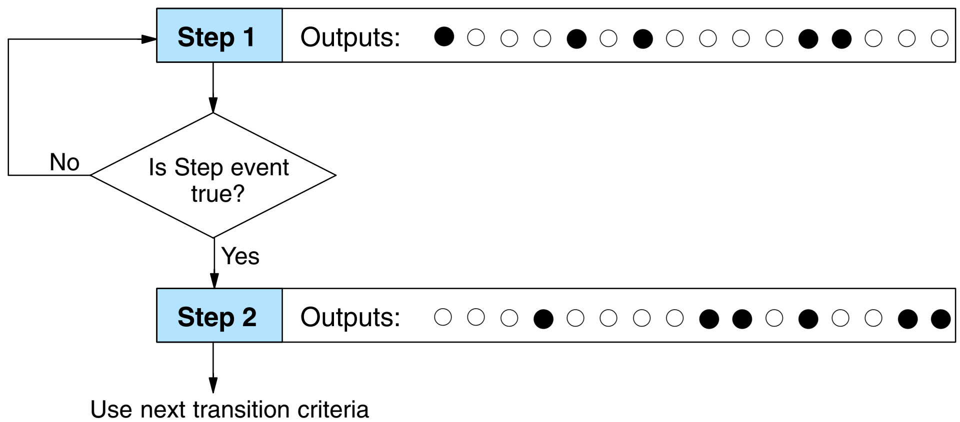
Step transitions may also occur based on time and/or external events. The figure below shows how step transitions work in these cases.



When the drum enters Step 1, it sets the output pattern as shown. Then it begins polling the external input programmed for that step. You can define event inputs as X, Y, or C discrete point types. Suppose we select X0 for the Step 1 event input. If X0 is off, then the drum remains in Step 1. When X0 is On, the event criteria is met and the timer increments. The timer increments as long as the event (X0) remains true. When the counts for Step 1 have expired, then the drum moves to Step 2. The outputs change immediately to match the new pattern for Step 2.

Event-Only Transitions

Step transitions do not require both the event and the timer criteria programmed for each step. You have the option of programming just one of the two, and even mixing transition types among all the steps of the drum. For example, you might want Step 1 to transition on an event, Step 2 to transition on time only, and Step 3 to transition on both time and an event. Furthermore, you may elect to use only part of the 16 steps, and only part of the 16 outputs.



Counter Assignments

Each drum instruction uses the resources of four counters in the CPU. When programming the drum instruction, you select the first counter number. The drum also uses the next three counters automatically. The counter bit associated with the first counter turns on when the drum has completed its cycle, going off when the drum is reset. These counter values and the counter bit precisely indicate the progress of the drum instruction, and can be monitored by your ladder program.

Suppose we program a timer drum to have 8 steps, and we select CT10 for the counter number (remember, counter numbering is in octal). Counter usage is shown to the right. The right column holds typical values, interpreted below.

Counter Assignments

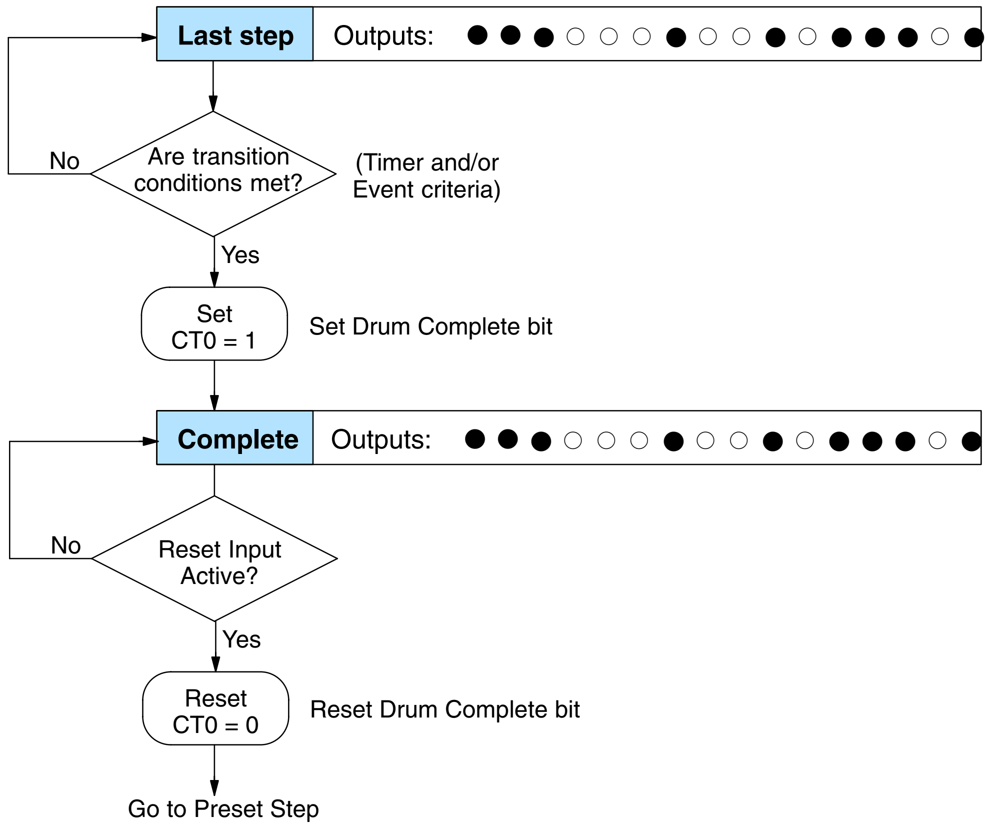
CT10	Counts in step	V1010	1528
CT11	Timer Value	V1011	0200
CT12	Preset Step	V1012	0001
CT13	Current Step	V1013	0004

CT10 shows that we are at the 1528th count in the current step, which is step 4 (shown in CT13). If we have programmed step 4 to have 3000 counts, then the step is just over half completed. CT11 is the count timer, shown in units of 0.01 seconds. So, each least-significant-digit change represents 0.01 seconds. The value of 200 means that we have been in the current count (1528) for 2 seconds (0.01 x 100). Finally, CT12 holds the preset step value which was programmed into the drum instruction. When the drum's Reset input is active, it presets to step 1 in this case. The value of CT12 changes only if the ladder program writes to it, or the drum instruction is edited and the program is restarted. Counter bit CT10 turns on when the drum cycle is complete, and turns off when the drum is reset.

Last Step Completion

The last step in a drum sequence may be any step number, since partial drums are valid. Refer to the following figure. When the transition conditions of the last step are met, the drum sets the counter bit corresponding to the counter named in the drum instruction box (such as CT0). Then it moves to a final “drum complete” state. The drum outputs remain in the pattern defined for the last step. Having finished a drum cycle, the Start and Jog inputs have no effect at this point.

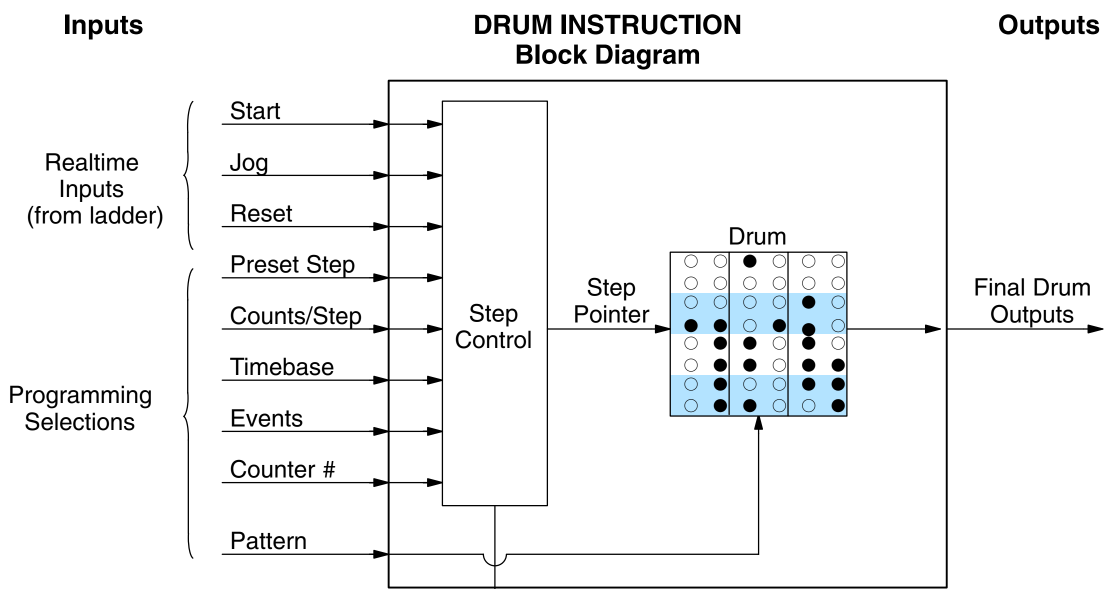
The drum leaves the “drum complete” state when the Reset input becomes active (or on a program-to–run mode transition). It resets the drum complete bit (such as CT0), and then goes directly to the appropriate step number defined as the preset step.



Overview of Drum Operation

Drum Instruction Block Diagram

The drum instruction utilizes various inputs and outputs in addition to the drum pattern itself. Refer to the figure below.



Counter Assignments

CT0	Counts in step	V1000	xxxx
CT1	Timer Value	V1001	xxxx
CT2	Preset Step	V1002	xxxx
CT3	Current Step	V1003	xxxx

The drum instruction accepts several inputs for step control, the main control of the drum. The inputs and their functions are:

- **Start** – The Start input is effective only when Reset is off. When Start is on, the drum timer runs if it is in a timed transition, and the drum looks for the input event during event transitions. When Start is off, the drum freezes in its current state (Reset must remain off), and the drum outputs maintain their current on/off pattern.
- **Jog** – The jog input is only effective when Reset is off (Start may be either on or off). The jog input increments the drum to the next step on each off-to-on transition.
- **Reset** – The Reset input has priority over the Start input. When Reset is on, the drum moves to its preset step. When Reset is off, then the Start input operates normally.
- **Preset Step** – A step number from 1 to 16 that you define (typically is step 1). The drum moves to this step whenever Reset is on, and whenever the CPU first enters run mode.

- **Counts/Step** – The number of timer counts the drum spends in each step. Each step has its own counts parameter. However, programming the counts/step is optional.
- **Timer Value** – the current value of the counts/step timer.
- **Counter #** – The counter number specifies the first of four consecutive counters which the drum uses for step control. You can monitor these to determine the drum's progress through its control cycle. The DL105 has 64 counters (CT0 – CT77 in octal).
- **Events** – Either an X, Y, C, S, T, or CT type discrete point serves as step transition inputs. Each step has its own event. However, programming the event is optional.

WARNING: The outputs of a drum are enabled any time the CPU is in Run Mode. The Start Input **does not** have to be on, and the Reset input does not disable the outputs. Upon entering Run Mode, drum outputs automatically turn on or off according to the pattern of the current step of the drum. This initial step number depends on the counter memory configuration: non-retentive versus retentive.

Powerup State of Drum Registers

The choice of the starting step on powerup and program-to-run mode transitions are important to consider for your application. Please refer to the following chart. If the counter memory is configured as non-retentive, the drum is initialized the same way on every powerup or program-to-run mode transition. However, if the counter memory is configured to be retentive, the drum will stay in its previous state.

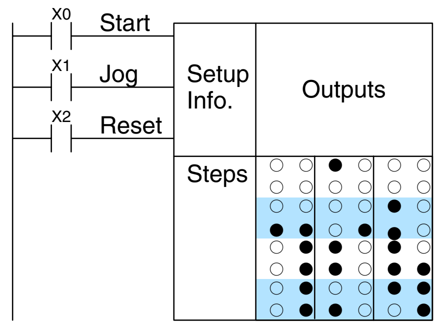
Counter Number	Function	Initialization on Powerup	
		Non-Retentive Case	Retentive Case
CT(n)	Current Step Count	Initialize = 0	Use Previous (no change)
CT(n + 1)	Counter Timer Value	Initialize = 0	Use Previous (no change)
CT(n + 2)	Preset Step	Initialize = Preset Step #	Use Previous (no change)
CT(n + 3)	Current Step #	Initialize = Preset Step #	Use Previous (no change)

Applications with relatively fast drum cycle times typically will need to be reset on powerup, using the non-retentive option. Applications with relatively long drum cycle times may need to resume at the previous point where operations stopped, using the retentive case. The default option is the retentive case. This means that if you initialize scratchpad V-memory, the memory will be retentive.

Drum Control Techniques

Drum Control Inputs

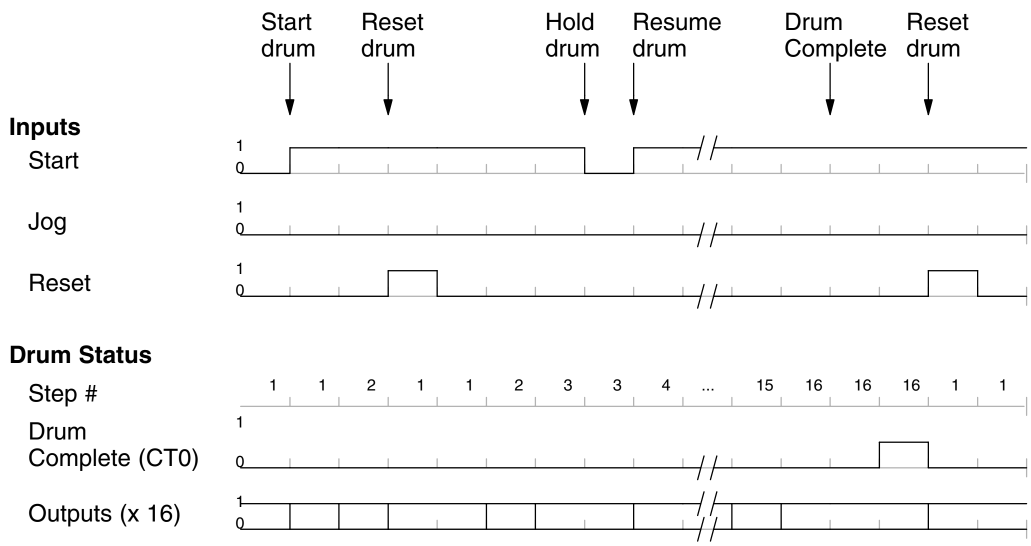
Now we are ready to put together the concepts on the previous pages and demonstrate general control of the drum instruction box. The drawing to the right shows a simplified generic drum instruction. Inputs from ladder logic control the Start, Jog, and Reset Inputs. The first counter bit of the drum (CT0, for example) indicates the drum cycle is done.



The timing diagram below shows an arbitrary timer drum input sequence and how the drum responds. As the CPU enters Run mode it initializes the step number to the preset step number (typically it is Step 1). When the Start input turns on the drum begins running, waiting for an event and/or running the timer (depends on the setup).

After the drum enters Step 2, Reset turns On while Start is still On. Since Reset has priority over Start, the drum goes to the preset step (Step 1). Note that the drum is *held* in the preset step during Reset, and that step *does not run* (respond to events or run the timer) until Reset turns off.

After the drum has entered step 3, the Start input goes off momentarily, halting the drum's timer until Start turns on again.

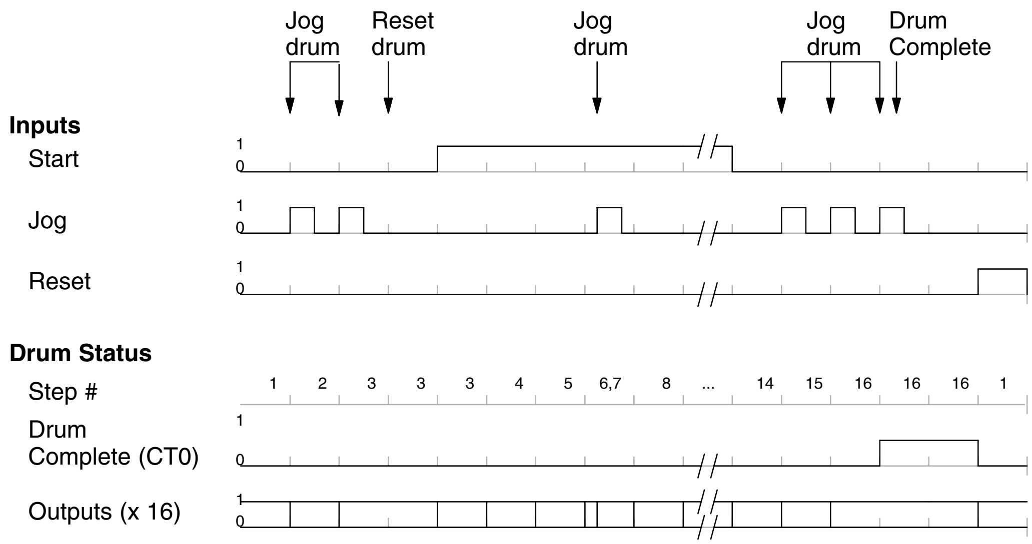


When the drum completes the last step (Step 16 in this example), the Drum Complete bit (CT0) turns on, and the step number remains at 16. When the Reset input turns on, it turns off the Drum Complete bit (CT0), and forces the drum to enter the preset step.

NOTE: The timing diagram shows all steps using equal time durations. Step times can vary greatly, depending on the counts/step programmed.

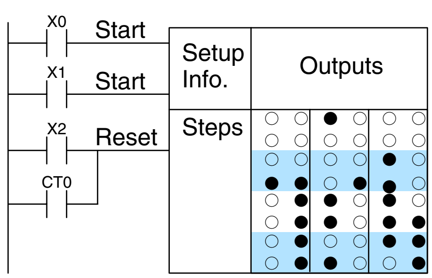
In the figure below, we focus on how the Jog input works on event drums. To the left of the diagram, note that the off-to-on transitions of the Jog input increments the step. Start may be either on or off (however, Reset must be off). Two jogs takes the drum to step three. Next, the Start input turns on, and the drum begins running normally. During step 6 another Jog input signal occurs. This increments the drum to step 7, setting the timer to 0. The drum begins running immediately in step 7, because Start is already on. The drum advances to step 8 normally.

As the drum enters step 14, the Start input turns off. Two more Jog signals moves the drum to step 16. However, note that a third Jog signal is required to move the drum through step 16 to "drum complete". Finally, a Reset input signal arrives which forces the drum into the preset step and turns off the drum complete bit.



Self-Resetting Drum

Applications often require drums that automatically start over once they complete a cycle. This is easily accomplished, using the drum complete bit. In the figure to the right, the drum instruction setup is for CT0, so we logically OR the drum complete bit (CT0) with the Reset input. When the last step is done, the drum turns on CT0 which resets itself to the preset step, also resetting CT0. Contact X2 still works as a manual reset.



Initializing Drum Outputs

The outputs of a drum are enabled any time the CPU is in run mode. On program-to-run mode transitions, the drum goes to the preset step, and the outputs energize according to the pattern of that step. If your application requires all outputs to be off at powerup, make the preset step in the drum a "reset step", with all outputs off.

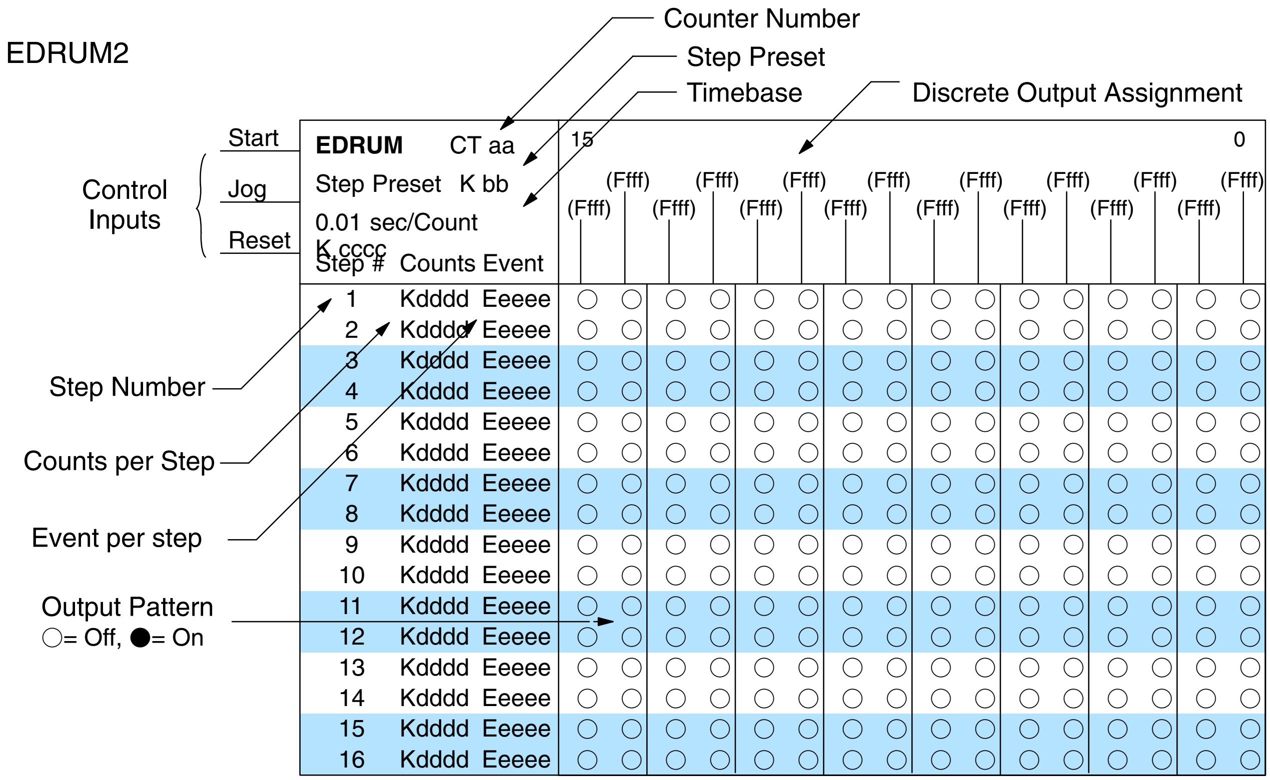
Using Complex Event Step Transitions

Each event-based transition accepts only one contact reference for the event. However, this does not limit events to just one contact. Just use a control relay contact such as C0 for the step transition event. Elsewhere in ladder logic, you may use C0 as an output coil, making it dependent on many other "events" (contacts).

Drum Instruction

Event Drum (EDRUM)

The Event Drum (EDRUM) features time-based and event-based step transitions. It operates according to the general principles of drum operation covered in the beginning of this chapter. Below is the instruction as displayed by ***Direct***SOFT32.



The Event Drum features 16 steps and 16 discrete outputs. Step transitions occur on timed and/or event basis. The jog input also advances the step on each off-to-on transition. Time is specified in counts per step, and events are specified as discrete contacts. Unused steps must be programmed with “counts per step” = 0, and event = “K0000”. The discrete output points may be individually assigned.

Whenever the Start input is energized, the drum’s timer is enabled. As long as the event is true for the current step, the timer runs during that step. When the step count equals the counts per step, the drum transitions to the next step. This process stops when the last step is complete, or when the Reset input is energized. The drum enters the preset step chosen upon a CPU program-to-run mode transition, and whenever the Reset input is energized.

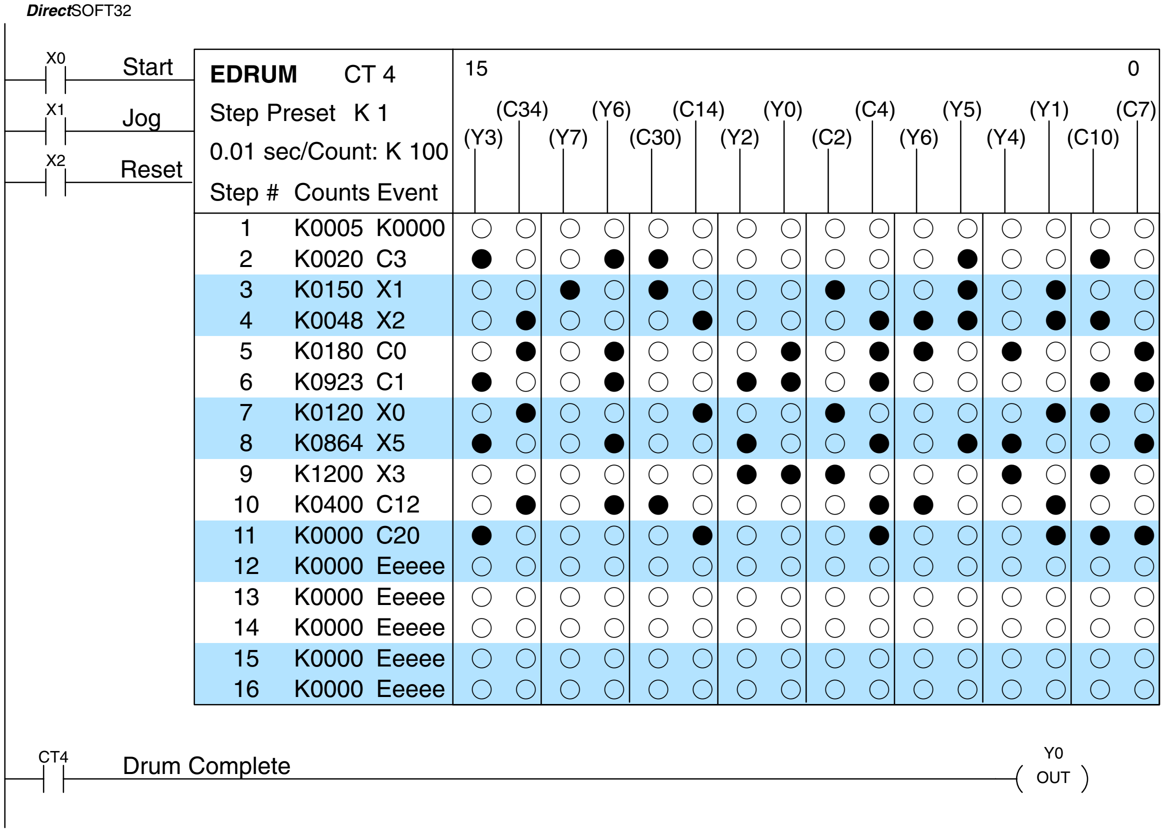
Drum Parameters	Field	Data Types	Ranges
Counter Number	aa	–	0 – 74
Preset Step	bb	K	1 – 16
Timer base	cccc	K	0.01 – 99.99 seconds
Counts per step	dddd	K	0 – 9999
Event	eeee	X, Y, C, S, T, CT	see page 4–28
Discrete Outputs	ffff	X, Y, C	see page 4–28

Drum instructions use four counters in the CPU. The ladder program can read the counter values for the drum's status. The ladder program may write a new preset step number to CT(n+2) at any time. However, the other counters are for monitoring purposes only.

Counter Number	Ranges of (n)	Function	Counter Bit Function
CT(n)	0 – 74	Counts in step	CTn = Drum Complete
C(n+1)	1 – 75	Timer value	CT(n+1) = (not used)
CT(n+2)	2 –76	Preset Step	CT(n+2) = (not used)
CT(n+3)	3 –77	Current Step	CT(n+1) = (not used)

The following ladder program shows the EDRUM instruction in a typical ladder program, as shown by ***Direct***SOFT32. Steps 1 through 11 are used, and all sixteen output points are used. The preset step is step 1. The timebase runs at (K100 x 0.01) = 0.1 second per count. Therefore, the duration of step 1 is (5 x 0.1) = 0.5 seconds. Note that step 1 is time-based only (event = "K0000"). And, the output pattern for step 1 programs all outputs off, which is a typically desirable powerup condition. In the last rung, the Drum Complete bit (CT4) turns on output Y0 upon completion of the last step (step 10). A drum reset also resets CT4.

DirectSOFT32

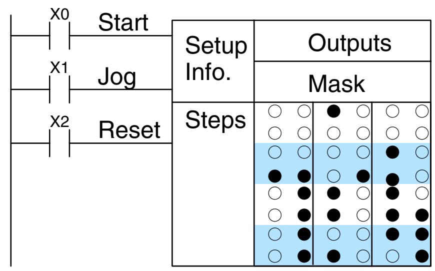


Handheld Programer Drum Mnemonics

The EDRUM instruction may be programmed using either ***Direct***SOFT32 or a handheld programmer. This section covers entry via the handheld programmer (Refer to the ***Direct***SOFT32 manual for drum instruction entry using that tool).

First, enter Store instructions for the ladder rungs controlling the drum's ladder inputs. In the example to the right, the timer drum's Start, Jog, and Reset inputs are controlled by X0, X1 and X2 respectively. The required keystrokes are listed beside the mnemonic.

These keystrokes *precede* the EDRUM instruction mnemonic. Note that the ladder rungs for Start, Jog, and Reset inputs are *not* limited to being single–contact rungs.



Handheld Programmer Keystrokes

Store X0 [$ STR] [→] [A 0] [ENT]

(Repeat for Store X1 and Store X2)

After the Store instructions, enter the EDRUM (using Counter CT0) as shown:

Handheld Programmer Keystrokes

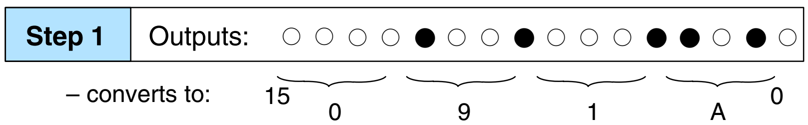
EDRUM CNT0 [SHFT] [E 4] [D 3] [R ORN] [U ISG] [M ORST] [→] [A 0] [ENT]

After entering the EDRUM mnemonic as above, the handheld programmer creates an input form for all the drum parameters. The input form consists of approximately fifty or more default mnemonic entries containing DEF (define) statements. The default mnemonics are already "input" for you, so they appear automatically. Use the NXT and PREV keys to move forward and backward through the form. Only the editing of default values is required, thus eliminating many keystrokes. The entries required for the basic timer drum are in the chart below.

Drum Parameters	Multiple Entries	Mnemonic / Entry	Default Mnemonic	Valid Data Types	Ranges
Start Input	–	STR (plus input rung)	–	–	–
Jog Input	–	STR (plus input rung)	–	–	–
Reset Input	–	STR (plus input rung)		–	–
Drum Mnemonic	–	DRUM CNT aa	–	K	0 – 74
Preset Step	1	bb	DEF K0000	K	1 – 16
Timer base	1	cccc	DEF K0000	K	2 – 9999
Output points	16	ffff	DEF 0000	X, Y, C *	see page 4–28
Counts per step	16	dddd	DEF K0000	K	0 – 9999
Events	16	dddd	DEF K0000	X, Y, C, S, T, CT	see page 4–28
Output pattern	16	gggg	DEF K0000	K	0 – FFFF

NOTE: Default entries for output points and events are "DEF 0000", which means they are unassigned. If you need to go back and change an assigned output as unused again, enter "K0000". The entry will again show as "DEF 0000".

Using the DRUM entry chart (two pages before), we show the method of entry for the basic time/event drum instruction. First, we convert the output pattern for each step to the equivalent hex number, as shown in the following example.



The following diagram shows the method for entering the previous EDRUM example on the HHP. The default entries of the form are in parenthesis. After the drum instruction entry (on the fourth row), the remaining keystrokes over-write the numeric portion of each default DEF statement. **NOTE**: Drum editing requires Handheld Programmer firmware version 1.7 or later.

Handheld Programmer Keystrokes

NOTE: You may use the NXT and PREV keys to skip past entries for unused outputs or steps.

		Handheld Programmer Keystrokes
Start		$ STR, →, A 0, ENT
Jog		$ STR, →, B 1, ENT
Reset		$ STR, →, C 2, ENT
Drum Inst.		SHFT, E 4, D 3, R ORN, U ISG, M ORST, →, A 0, ENT
Preset Step	(DEF K0001)	NEXT
Time Base	(DEF K0000)	G 6, E 4, NEXT
Outputs 1	(DEF 0000)	SHFT, C 2, H 7, NEXT
	(DEF 0000)	SHFT, C 2, B 1, A 0, NEXT
	(DEF 0000)	SHFT, Y MLS, B 1, NEXT
	(DEF 0000)	SHFT, Y MLS, E 4, NEXT
	(DEF 0000)	SHFT, Y MLS, F 5, NEXT
	(DEF 0000)	SHFT, Y MLS, G 6, NEXT
	(DEF 0000)	SHFT, C 2, E 4, NEXT
	(DEF 0000)	SHFT, C 2, C 2, NEXT
	(DEF 0000)	SHFT, Y MLS, A 0, NEXT
	(DEF 0000)	SHFT, Y MLS, C 2, NEXT
	(DEF 0000)	SHFT, C 2, B 1, E 4, NEXT
	(DEF 0000)	SHFT, C 2, D 3, A 0, NEXT
	(DEF 0000)	SHFT, Y MLS, G 6, NEXT
	(DEF 0000)	SHFT, Y MLS, H 7, NEXT
	(DEF 0000)	SHFT, C 2, D 3, E 4, NEXT
16	(DEF 0000)	SHFT, Y MLS, B 1, NEXT

Handheld Programmer Keystrokes cont'd

		Handheld Programmer Keystrokes cont'd
Counts/ Step 1	(DEF K0000)	F 5, NEXT
	(DEF K0000)	C 2, A 0, NEXT
	(DEF K0000)	B 1, F 5, A 0, NEXT
	(DEF K0000)	E 4, F 5, NEXT
	(DEF K0000)	B 1, I 8, A 0, NEXT
	(DEF K0000)	J 9, C 2, D 3, NEXT
	(DEF K0000)	B 1, C 2, A 0, NEXT
	(DEF K0000)	I 8, G 6, E 4, NEXT
	(DEF K0000)	B 1, C 2, A 0, A 0, NEXT
	(DEF K0000)	E 4, A 0, A 0, NEXT
	(DEF K0000)	NEXT
	(DEF K0000)	NEXT
	(DEF K0000)	NEXT
	(DEF K0000)	NEXT
	(DEF K0000)	NEXT
16	(DEF K0000)	NEXT

skip over unused steps

(Continued on next page)

Handheld Programmer Keystrokes cont'd

Events

1	(DEF 0000)	NEXT				← skip over unused event
	(DEF 0000)	SHFT	Y MLS	E 4	NEXT	
	(DEF 0000)	SHFT	X SET	B 1	NEXT	
	(DEF 0000)	SHFT	X SET	C 2	NEXT	
	(DEF 0000)	SHFT	C 2	A 0	NEXT	
	(DEF 0000)	SHFT	C 2	B 1	NEXT	
	(DEF 0000)	SHFT	X SET	A 0	NEXT	
	(DEF 0000)	SHFT	X SET	F 5	NEXT	
	(DEF 0000)	SHFT	X SET	D 3	NEXT	
	(DEF 0000)	SHFT	Y MLS	H 7	NEXT	
	(DEF 0000)	SHFT	C 2	C 2	A 0	NEXT
	(DEF 0000)	NEXT				
	(DEF 0000)	NEXT				
	(DEF 0000)	NEXT				
	(DEF 0000)	NEXT				
16	(DEF 0000)	NEXT				

Handheld Programmer Keystrokes cont'd

Output Pattern

1	(DEF K0000)	NEXT				← step 1 pattern = 0000
	(DEF K0000)	J 9	I 8	B 1	C 2	NEXT
	(DEF K0000)	C 2	I 8	J 9	E 4	NEXT
	(DEF K0000)	E 4	E 4	H 7	G 6	NEXT
	(DEF K0000)	F 5	B 1	G 6	J 9	NEXT
	(DEF K0000)	J 9	D 3	E 4	D 3	NEXT
	(DEF K0000)	E 4	E 4	I 8	G 6	NEXT
	(DEF K0000)	J 9	E 4	F 5	J 9	NEXT
	(DEF K0000)	D 3	I 8	SHFT	A 0	NEXT
	(DEF K0000)	F 5	I 8	G 6	E 4	NEXT
	(DEF K0000)	I 8	E 4	E 4	H 7	NEXT
	(DEF K0000)	NEXT				
	(DEF K0000)	NEXT				
	(DEF K0000)	NEXT				← unused steps
	(DEF K0000)	NEXT				
16	(DEF K0000)	NEXT				

Last rung

$ STR	GY CNT	A 0	NEXT
SHFT	Y MLS	A 0	NEXT

NOTE: You may use the NXT and PREV keys to skip past entries for unused outputs or steps.

7

RLL*PLUS* Stage Programming

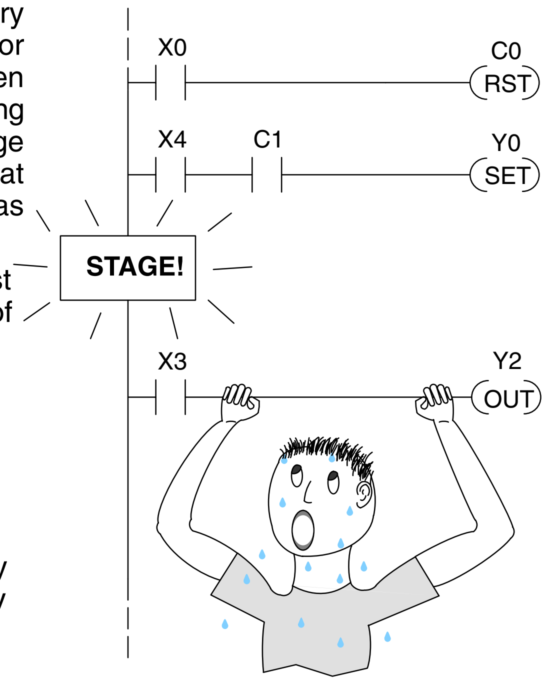
In This Chapter. . . .

Introduction to Stage Programming

Stage Programming provides a way to organize and program complex applications with relative ease, when compared to purely relay ladder logic (RLL) solutions. Stage programming does not replace or negate the use of traditional boolean ladder programming. This is why Stage Programming is also called RLL^{PLUS}. You won't have to discard any training or experience you already have. Stage programming simply allows you to divide and organize a RLL program into groups of ladder instructions called stages. This allows quicker and more intuitive ladder program development than traditional RLL alone provides.

Overcoming "Stage Fright"

Many PLC programmers in the industry have become comfortable using RLL for every PLC program they write... but often remain skeptical or even fearful of learning new techniques such as stage programming. While RLL is great at solving boolean logic relationships, it has disadvantages as well:



- Large programs can become almost unmanageable, because of a lack of structure.
- In RLL, latches must be tediously created from self-latching relays.
- When a process gets stuck, it is difficult to find the rung where the error occurred.
- Programs become difficult to modify later, because they do not intuitively resemble the application problem they are solving.

It's easy to see that these inefficiencies consume a lot of additional time, and time is money. *Stage programming overcomes these obstacles!* We believe a few moments of studying the stage concept is one of the greatest investments in programming speed and efficiency a PLC programmer can make!

So, we encourage you to study stage programming and add it to your "toolbox" of programming techniques. This chapter is designed as a self-paced tutorial on stage programming. For best results:

- Start at the beginning and do not skip over any sections.
- Study each stage programming concept by working through each example. The examples build progressively on each other.
- Read the stage Questions and Answers at the end of the chapter for a quick review.

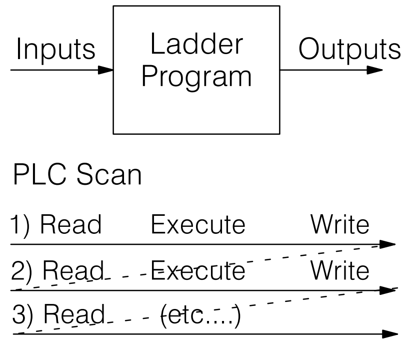
Learning to Draw State Transition Diagrams

Introduction to Process States

Those familiar with ladder program execution know that the CPU must scan the ladder program repeatedly, over and over. Its three basic steps are:

1. Read the inputs
2. Execute the ladder program
3. Write the outputs

The benefit is that a change at the inputs can affect the outputs in just a few milliseconds.



Most manufacturing processes consist of a series of activities or conditions , each lasting for several seconds. minutes, or even hours. We might call these "process states", which are either active or inactive at any particular time. A challenge for RLL programs is that a particular input event may last for just a brief instant. We typically create latching relays in RLL to preserve the input event in order to maintain a process state for the required duration.

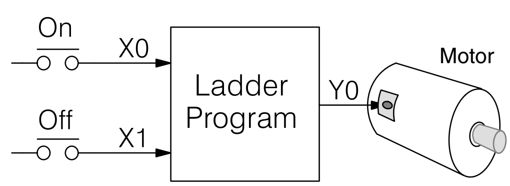
We can organize and divide ladder logic into sections called "stages", representing process states. But before we describe stages in detail, we will reveal **the secret to understanding stage programming:** state transition diagrams.

The Need for State Diagrams

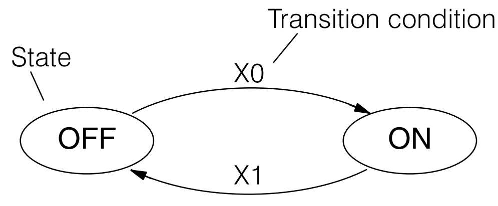
Sometimes we need to forget about the scan nature of PLCs, and focus our thinking toward the states of the process we need to identify. Clear thinking and concise analysis of an application gives us the best chance at writing efficient, bug-free programs. *State diagrams are just a tool to help us draw a picture of our process!* You'll discover that if we can get the picture right, **our program will also be right!**

A 2–State Process

Consider the simple process shown to the right, which controls an industrial motor. We will use a green momentary SPST pushbutton to turn the motor on, and a red one to turn it off. The machine operator will press the appropriate pushbutton for just a second or so. The two states of our process are ON and OFF.



The next step is to draw a *state transition diagram*, as shown to the right. It shows the two states OFF and ON, with two transition lines in-between. When the event X0 is true, we transition from OFF to ON. When X1 is true, we transition from ON to OFF.

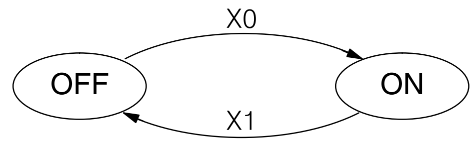


Output equation: Y0 = ON

If you're following along, you are very close to grasping the concept and the problem-solving power of state transition diagrams. The output of our controller is Y0, which is true any time we are in the ON state. In a boolean sense, Y0=ON state.

Next, we will implement the state diagram first as RLL, then as a stage program. This will help you see the relationship between the two methods in problem solving.

The state transition diagram to the right is a picture of the solution we need to create. The beauty of it is this: it expresses the problem independently of the programming language we may use to realize it. In other words, *by drawing the diagram we have already solved the control problem!*



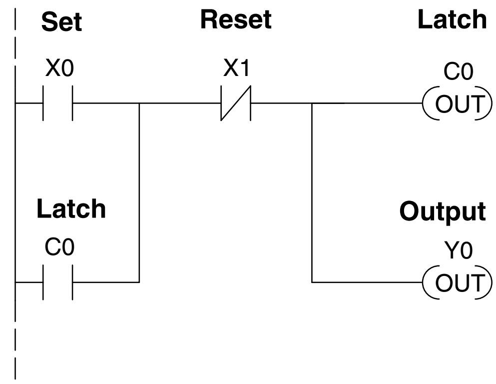
Output equation: Y0 = ON

First, we'll translate the state diagram to traditional RLL. Then we'll show how easy it is to translate the diagram into a stage programming solution.

RLL Equivalent

The RLL solution is shown to the right. It consists of a self-latching control relay, C0. When the On pushbutton (X0) is pressed, output coil C0 turns on and the C0 contact on the second row latches itself on. So, X0 **sets the latch** C0 on, and it remains on after the X0 contact opens. The motor output Y0 also has power flow, so the motor is now on.

When the Off pushbutton (X1) is pressed, it opens the normally-closed X1 contact, which **resets the latch**. Motor output Y0 turns off when the latch coil C0 goes off.

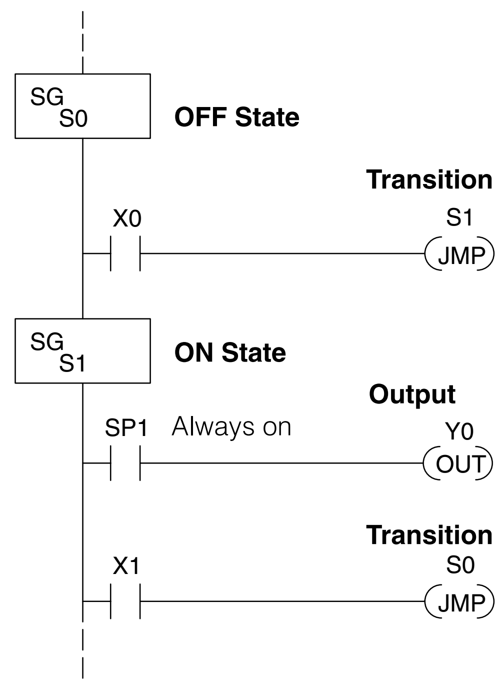


Stage Equivalent

The stage program solution is shown to the right. The two inline stage boxes S0 and S1 correspond to the two states OFF and ON. The ladder rung(s) below each stage box belong to each respective stage. This means that the PLC only has to scan those rungs when the corresponding stage is active!

For now, let's assume we begin in the OFF State, so stage S0 is active. When the On pushbutton (X0) is pressed, a stage transition occurs. The JMP S1 instruction executes, which simply turns off the stage bit S0 and turns on stage bit S1. So on the next PLC scan, the CPU will not execute stage S0, but will execute stage S1!

In the On State (stage S1), we want the motor to always be on. The special relay contact SP1 is defined as always on, so Y0 turns the motor on.

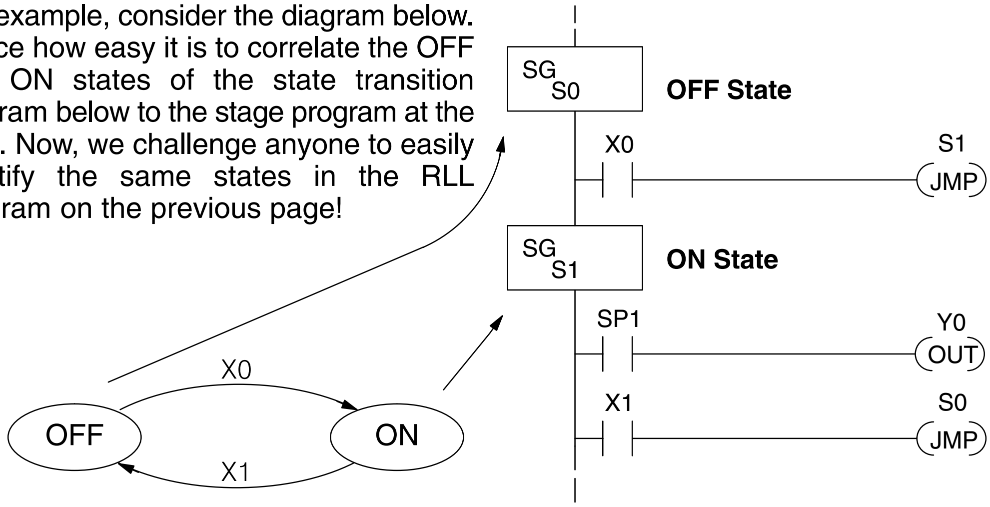


When the Off pushbutton (X1) is pressed, a transition back to the Off State occurs. The JMP S0 instruction executes, which simply turns off the stage bit S1 and turns on stage bit S0. On the next PLC scan, the CPU will not execute stage S1, so the motor output Y0 will turn off. The Off state (stage 0) will be ready for the next cycle.

Let's Compare

Right now, you may be thinking "I don't see the big advantage to Stage Programming... in fact, the stage program is longer than the plain RLL program". Well, now is the time to exercise a bit of faith. As control problems grow in complexity, stage programming quickly out-performs RLL in simplicity, program size, etc.

For example, consider the diagram below. Notice how easy it is to correlate the OFF and ON states of the state transition diagram below to the stage program at the right. Now, we challenge anyone to easily identify the same states in the RLL program on the previous page!

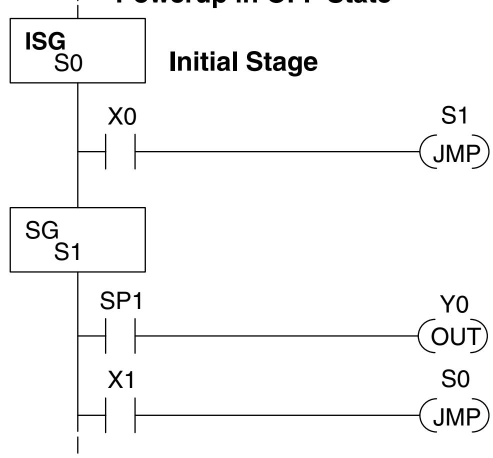


Initial Stages

At powerup and Program-to-Run Mode transitions, the PLC always begins with all normal stages (SG) off. So, the stage programs shown so far have actually had no way to get started (because rungs are not scanned unless their stage is active).

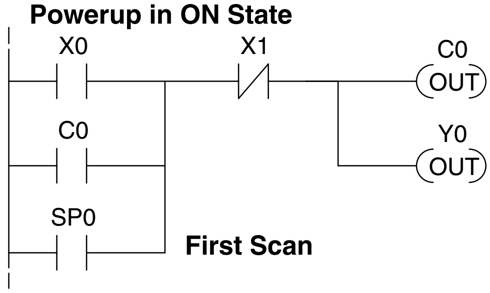
Assume that we want to always begin in the Off state (motor off), which is how the RLL program works. The Initial Stage (ISG) is defined to be active at powerup. In the modified program to the right, we have changed stage S0 to the ISG type. This ensures the PLC will scan contact X0 after powerup, because Stage S0 is active. **After powerup, an Initial Stage (ISG) works just like any other stage!**

Powerup in OFF State

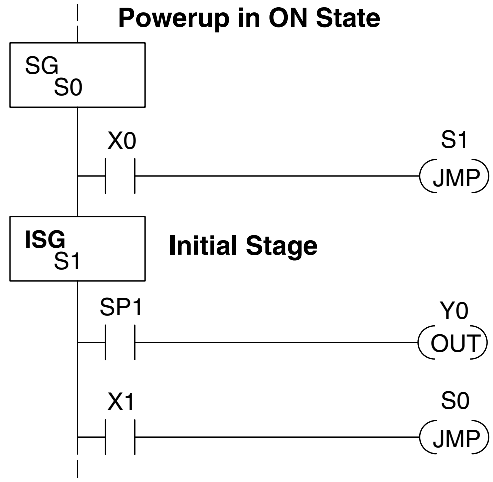


We can change both programs so that the motor is ON at powerup. In the RLL below, we must add a first scan relay SP0, latching C0 on. In the stage example to the right, we simply make Stage S1 an initial stage (ISG) instead of S0.

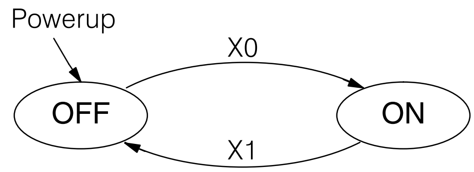
Powerup in ON State



Powerup in ON State



We can mark our desired powerup state as shown to the right, which helps us remember to use the appropriate Initial Stages when creating a stage program. It is permissible to have as many initial stages as the process requires.



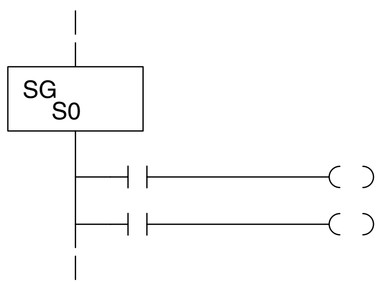
What Stage Bits Do

You may recall that a stage is just a section of ladder program which is either active or inactive at a given moment. All stage bits (S0 to S77) reside in the PLC's image register as individual status bits. Each stage bit is either a boolean 0 or 1 at any time.

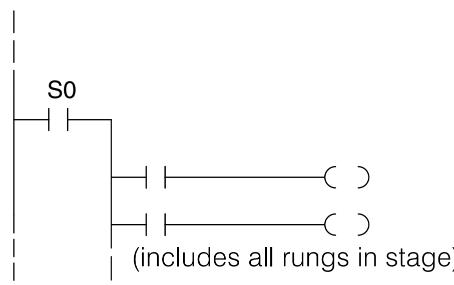
Program execution always reads ladder rungs from top to bottom, and from left to right. The drawing below shows the effect of stage bit status. The ladder rungs below the stage instruction continuing until the next stage instruction or the end of program belong to stage 0. Its equivalent operation is shown on the right. When S0 is true, the two rungs have power flow.

- If Stage bit S0 = 0, its ladder rungs *are not* scanned (executed).
- If stage bit S0 = 1, its ladder rungs *are* scanned (executed).

Actual Program Appearance



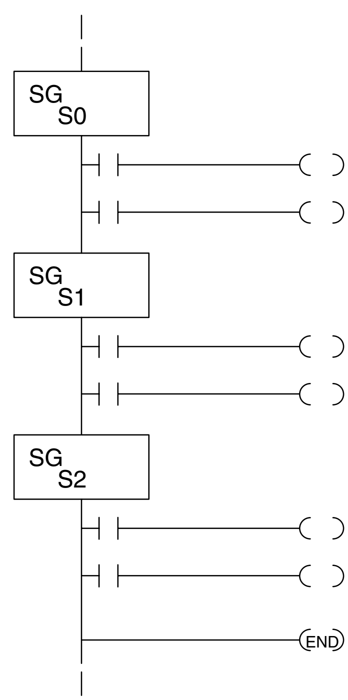
Functionally Equivalent Ladder



Stage Instruction Characteristics

The inline stage boxes on the left power rail divide the ladder program rungs into stages. Some stage rules are:

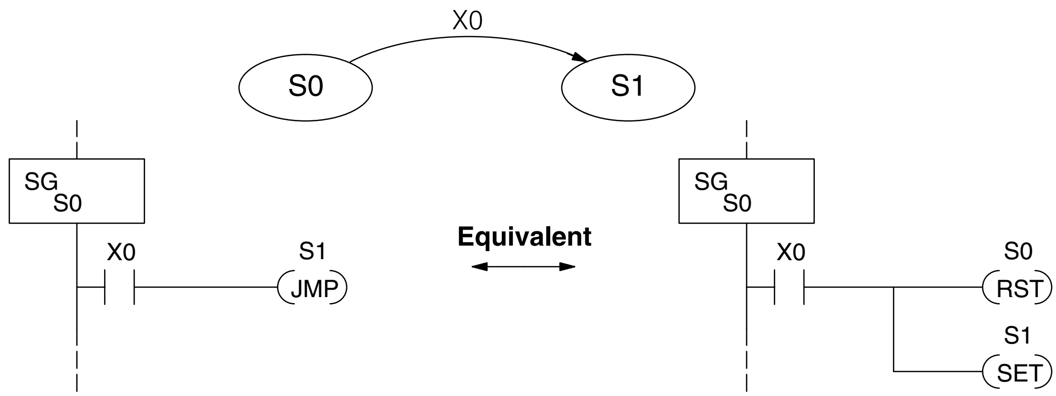
- **Execution** – Only logic in active stages are executed on any scan.
- **Transitions** – Stage transition instructions take effect on the next occurrence of the stages involved.
- **Octal numbering** – Stages are numbered in octal, like I/O points, etc. So “S8” is not valid.
- **Total Stages** – The DL105 offers up to 256 stages (S0 to S377 in octal).
- **No duplicates** – Each stage number is unique and can be used just once.
- **Any order** – You can skip numbers and sequence the stage numbers in any order.
- **Last Stage** – the last stage in the ladder program includes all rungs from its stage box until the end coil.



Using the Stage Jump Instruction for State Transitions

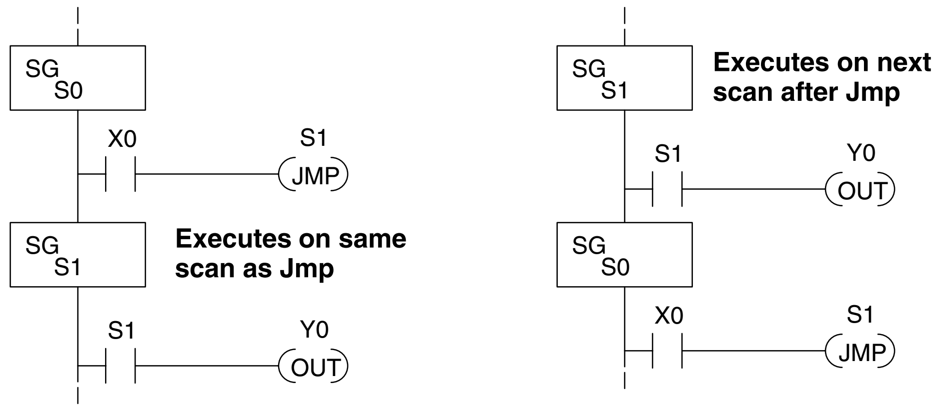
Stage Jump, Set, and Reset Instructions

The stage JMP instruction we have used deactivates the stage in which the instruction occurs, while activating the stage in the JMP instruction. Refer to the state transition shown below. When contact X0 energizes, the state transition from S0 to S1 occurs. The two stage examples shown below are equivalent. So, the stage Jump instruction is equal to a Stage Reset of the current stage, plus a Stage Set instruction for the stage to which we want to transition.



Please Read Carefully – The jump instruction is easily misunderstood. The “jump” does not occur immediately like a GOTO or GOSUB program control instruction when executed. Here’s how it works:

- The jump instruction resets the stage bit of the stage in which it occurs. All rungs in the stage still finish executing during the current scan, *even if there are other rungs in the stage below the jump instruction!*
- The reset will be in effect on the following scan, so the stage that executed the jump instruction previously will be inactive and bypassed.
- The stage bit of the stage named in the Jump instruction will be set immediately, so the stage will be executed on its next occurrence. In the left program shown below, stage S1 executes during the *same scan* as the JMP S1 occurs in S0. In the example on the right, Stage S1 executes on the *next scan* after the JMP S1 executes, because stage S1 is located *above* stage S0.

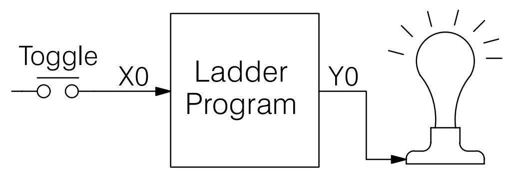


Note: Assume we start with Stage 0 active and stage 1 inactive for both examples.

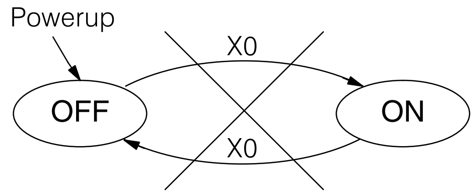
Stage Program Example: Toggle On/Off Lamp Controller

A 4–State Process

In the process shown to the right, we use an ordinary momentary pushbutton to control a light bulb. The ladder program will latch the switch input, so that we will push and release to turn on the light, push and release again to turn it off (sometimes called toggle function). Sure, we could just buy a mechanical switch with the alternate on/off action built in... However, this example is educational and also fun!



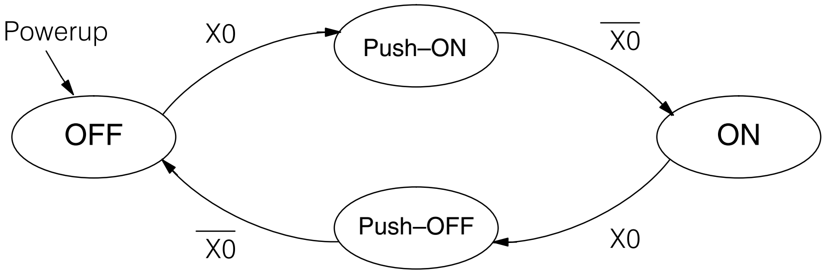
Next we draw the state transition diagram. A typical first approach is to use X0 for both transitions (like the example shown to the right). However, *this is incorrect* (please keep reading).



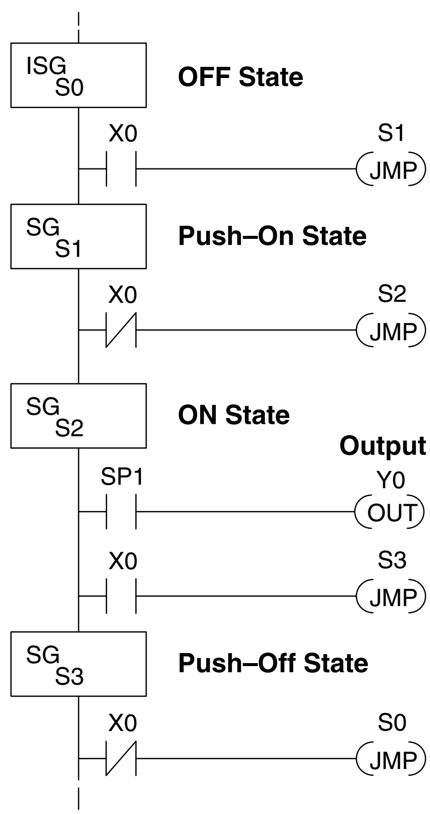
Output equation: Y0 = ON

Note that this example differs from the motor example, because now we have just one pushbutton. When we press the pushbutton, both transition conditions are met. We would just transition around the state diagram at top speed. If implemented in stage, this solution would flash the light on or off each scan (obviously undesirable)!

The solution is to make the the push and the release of the pushbutton separate events. Refer to the new state transition diagram below. At powerup we enter the OFF state. When switch X0 is pressed, we enter the Press-ON state. When it is released, we enter the ON state. Note that X0 with the bar above it denotes X0 NOT.



Output equation: Y0 = ON



When in the ON state, another push and release cycle similarly takes us back to the OFF state. Now we have two unique states (OFF and ON) used when the pushbutton is released, which is what was required to solve the control problem.

The equivalent stage program is shown to the right. The desired powerup state is OFF, so we make S0 an initial stage (ISG). In the ON state, we add special relay contact SP1, which is always on.

Note that even as our programs grow more complex, it is still easy to correlate the state transition diagram with the stage program!

Four Steps to Writing a Stage Program

By now, you've probably noticed that we follow the same steps to solve each example problem. The steps will probably come to you automatically if you work through all the examples in this chapter. It's helpful to have a checklist to guide us through the problem solving. The following steps summarize the stage program design procedure:

1. Write a Word Description of the application.

Describe all functions of the process in your own words. Start by listing what happens first, then next, etc. If you find there are too many things happening at once, try dividing the problem into more than one process. Remember, you can still have the processes communicate with each other to coordinate their overall activity.

2. Draw the Block Diagram.

Inputs represent all the information the process needs for decisions, and outputs connect to all devices controlled by the process.

- Make lists of inputs and outputs for the process.
- Assign I/O point numbers (X and Y) to physical inputs and outputs.

3. Draw the State Transition Diagram.

The state transition diagram describes the central function of the block diagram, reading inputs and generating outputs.

- Identify and name the states of the process.
- Identify the event(s) required for each transition between states.
- Ensure the process has a way to re-start itself, or is cyclical.
- Choose the powerup state for your process.
- Write the output equations.

4. Write the Stage Program.

Translate the state transition diagram into a stage program.

- Make each state a stage. Remember to number stages in octal. Up to 256 total stages are available in the DL205, numbered 0 to 377 in octal.
- Put transition logic inside the stage which originates each transition (the stage each arrow points *away* from).
- Use an initial stage (ISG) for any states that must be active at powerup.
- Place the outputs or actions in the appropriate stages.

You'll notice that Steps 1 through 3 just *prepare* us to write the stage program in Step 4. However, the program virtually writes itself because of the preparation beforehand. Soon you'll be able to start with a word description of an application and create a stage program in one easy session!

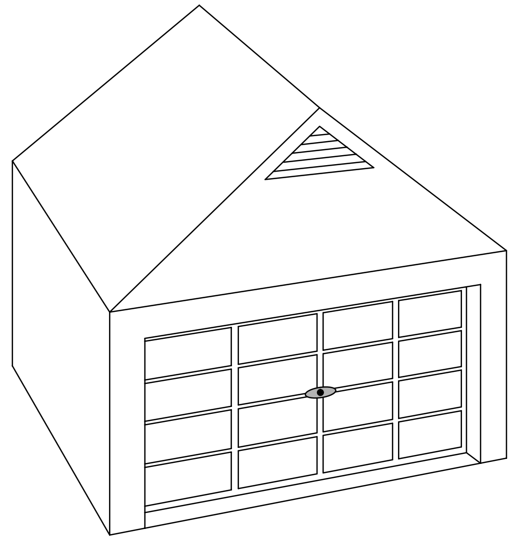
Stage Program Example: A Garage Door Opener

Garage Door Opener Example

In this next stage programming example we'll create a garage door opener controller. Hopefully most readers are familiar with this application, and we can have fun besides!

The first step we must take is to describe how the door opener works. We will start by achieving the basic operation, waiting to add extra features later. Stage programs are very easy to modify.

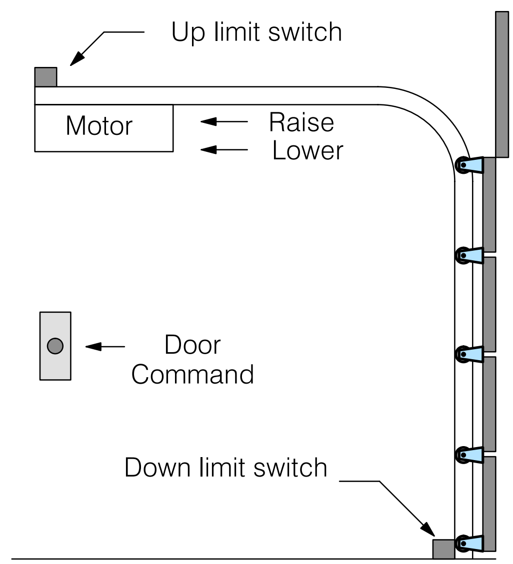
Our garage door controller has a motor which raises or lowers the door on command. The garage owner pushes and releases a momentary pushbutton once to raise the door. After the door is up, another push-release cycle will lower the door.



In order to identify the inputs and outputs of the system, it's sometimes helpful to sketch its main components, as shown in the door side view to the right. The door has an up limit and a down limit switch. Each limit switch closes only when the door has reach the end of travel in the corresponding direction. In the middle of travel, neither limit switch is closed.

The motor has two command inputs: raise and lower. When neither input is active, the motor is stopped.

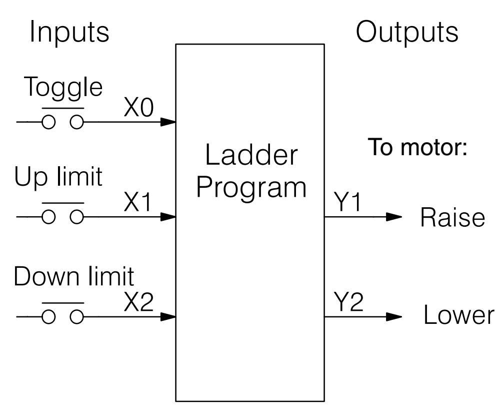
The door command is just a simple pushbutton. Whether wall-mounted as shown, or a radio-remote control, all door control commands logical OR together as one pair of switch contacts.



Draw the Block Diagram

The block diagram of the controller is shown to the right. Input X0 is from the pushbutton door control. Input X1 energizes when the door reaches the full up position. Input X2 energizes when the door reaches the full down position. When the door is positioned between fully up or down, both limit switches are open.

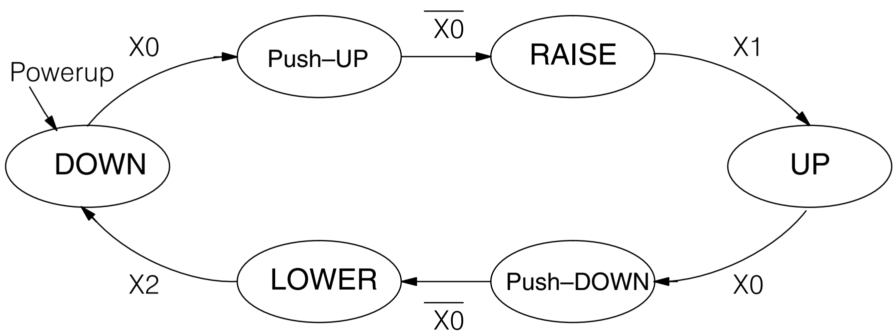
The controller has two outputs to drive the motor. Y1 is the up (raise the door) command, and Y2 is the down (lower the door) command.



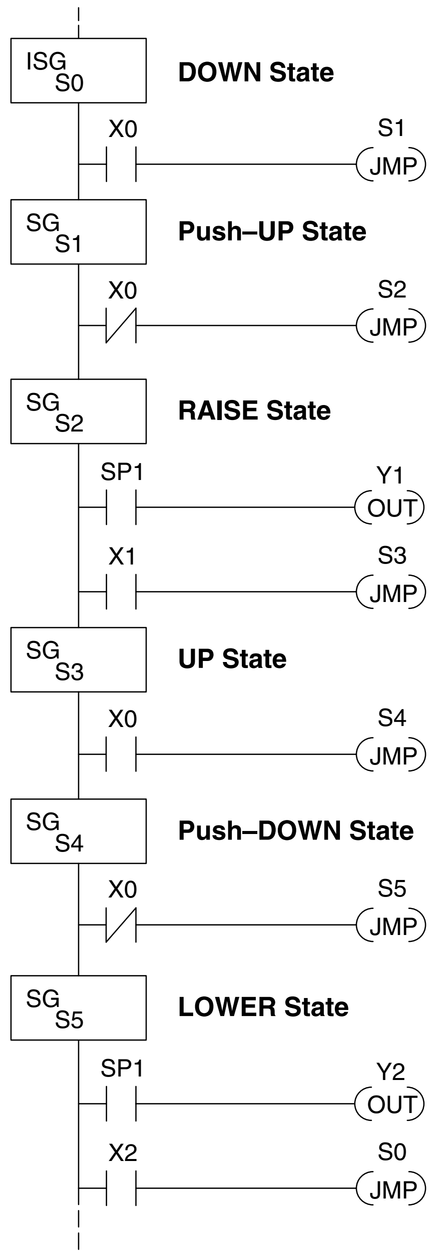
Draw the State Diagram

Now we are ready to draw the state transition diagram. Like the previous light bulb controller example, this application also has just one switch for the command input. Refer to the figure below.

- When the door is down (DOWN state), nothing happens until X0 energizes. Its push and release brings us to the RAISE state, where output Y1 turns on and causes the motor to raise the door.
- We transition to the UP state when the up limit switch (X1) energizes, and turns off the motor.
- Then nothing happens until another X0 press-release cycle occurs. That takes us to the LOWER state, turning on output Y2 to command the motor to lower the door. We transition back to the DOWN state when the down limit switch (X2) energizes.



Output equations: Y1 = RAISE Y2 = LOWER



The equivalent stage program is shown to the right. For now, we will assume the door is down at powerup, so the desired powerup state is DOWN. We make S0 an initial stage (ISG). Stage S0 remains active until the door control pushbutton activates. Then we transition (JMP) to Push-UP stage, S1.

A push-release cycle of the pushbutton takes us through stage S1 to the RAISE stage, S2. We use the always-on contact SP1 to energize the motor's raise command, Y1. When the door reaches the fully-raised position, the up limit switch X1 activates. This takes us to the UP Stage S3, where we wait until another door control command occurs.

In the UP Stage S3, a push-release cycle of the pushbutton will take us to the LOWER Stage S5, where we activate Y2 to command the motor to lower the door. This continues until the door reaches the down limit switch, X2. When X2 closes, we transition from Stage S5 to the DOWN stage S0, where we began.

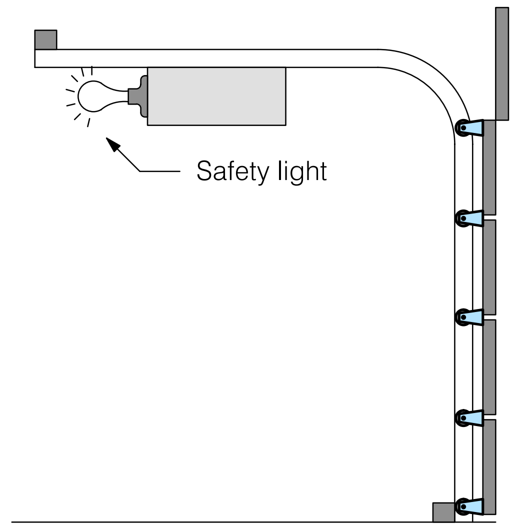
NOTE: The only special thing about an initial stage (ISG) is that it is automatically active at powerup. Afterwards, it is just like any other.

Add Safety Light Feature

Next we will add a safety light feature to the door opener system. It's best to get the main function working first as we have done, then adding the secondary features.

The safety light is standard on many commercially-available garage door openers. It is shown to the right, mounted on the motor housing. The light turns on upon any door activity, remaining on for approximately 3 minutes afterwards.

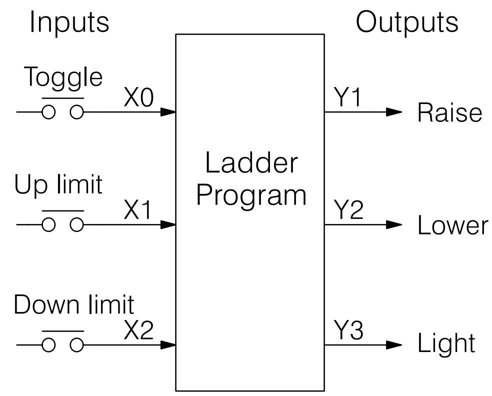
This part of the exercise will demonstrate the use of parallel states in our state diagram. Instead of using the JMP instruction, we'll use the set and reset commands.



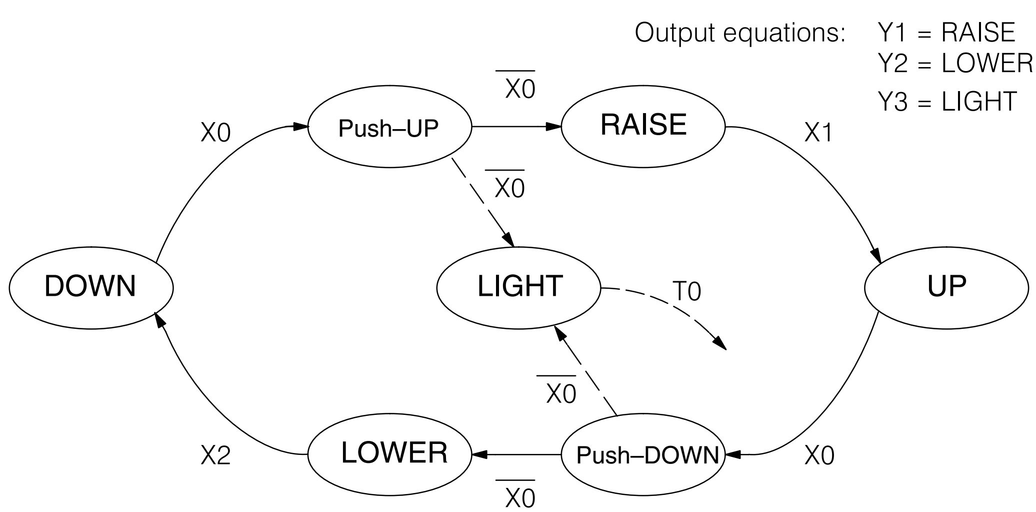
Modify the Block Diagram and State Diagram

To control the light bulb, we add an output to our controller block diagram, shown to the right, Y3 is the light control output.

In the diagram below, we add an additional state called "LIGHT". Whenever the garage owner presses the door control switch and releases, the RAISE or LOWER state is active *and the LIGHT state is simultaneously active.* The line to the Light state is dashed, because it is not the primary path.



We can think of the Light state as a parallel process to the raise and lower state. The paths to the Light state are not a transition (Stage JMP), but a State Set command. In the logic of the Light stage, we will place a three-minute timer. When it expires, timer bit T0 turns on and resets the Light stage. The path out of the Light stage goes nowhere, indicating the Light stage just becomes inactive, and the light goes out!



Using a Timer Inside a Stage

The finished modified program is shown to the right. The shaded areas indicate the program additions.

In the Push-UP stage S1, we add the Set Stage Bit S6 instruction. When contact X0 opens, we transition from S1 and go to two new active states: S2 and S6. In the Push-DOWN state S4, we make the same additions. So, any time someone presses the door control pushbutton, the light turns on.

Most new stage programmers would be concerned about where to place the Light Stage in the ladder, and how to number it. The good news is that it doesn't matter!

- Just choose an unused stage number, and use it for the new stage and as the reference from other stages.
- Placement in the program is not critical, so we place it at the end.

You might think that each stage has to be directly under the stage that transitions to it. While it is good practice, it is not required (that's good, because our two locations for the Set S6 instruction make that impossible). Stage numbers and how they are used determines the transition paths.

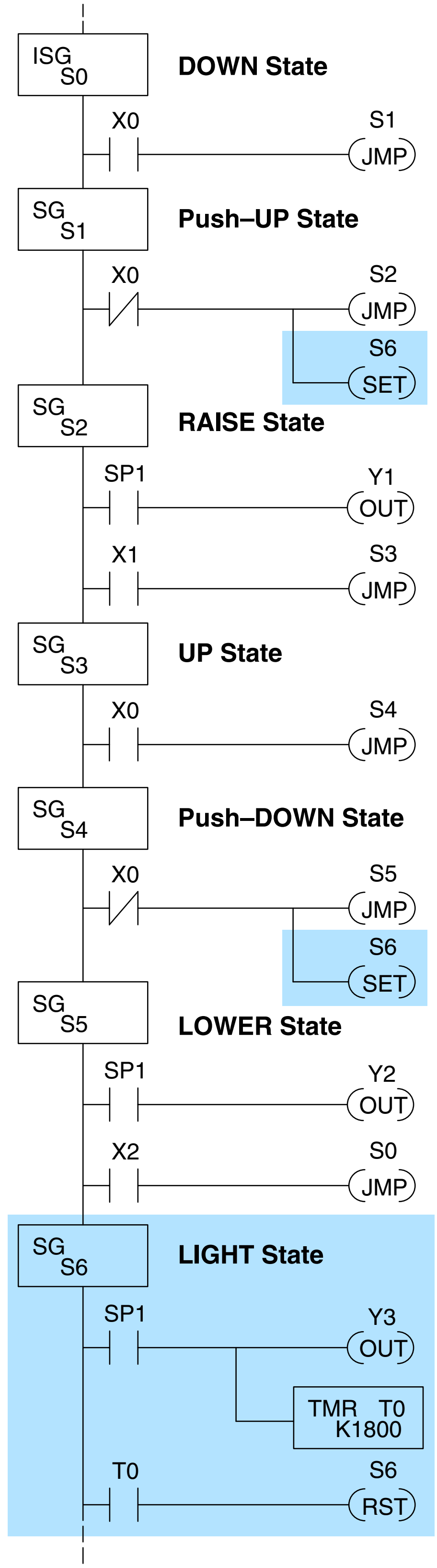
In stage S6, we turn on the safety light by energizing Y3. Special relay contact SP1 is always on. Timer T0 times at 0.1 second per count. To achieve 3 minutes time period, we calculate:

$$K= \frac{3 \text{ min. x } 60 \text{ sec/min}}{0.1 \text{ sec/count}}$$

K=1800 counts

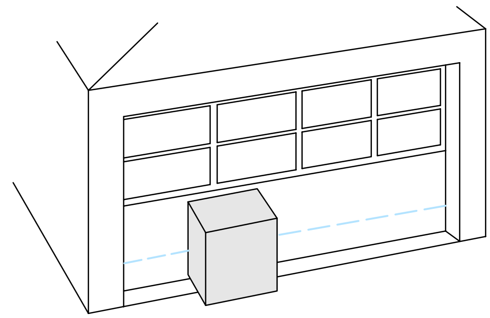
The timer has power flow whenever stage S6 is active. The corresponding timer bit T0 is set when the timer expires. So three minutes later, T0=1 and the instruction Reset S6 causes the stage to be inactive.

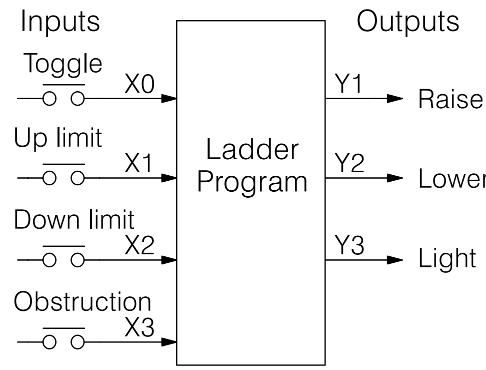
While Stage S6 is active and the light is on, stage transitions in the primary path continue normally and independently of Stage 6. That is, the door can go up, down, or whatever, but the light will be on for precisely 3 minutes.



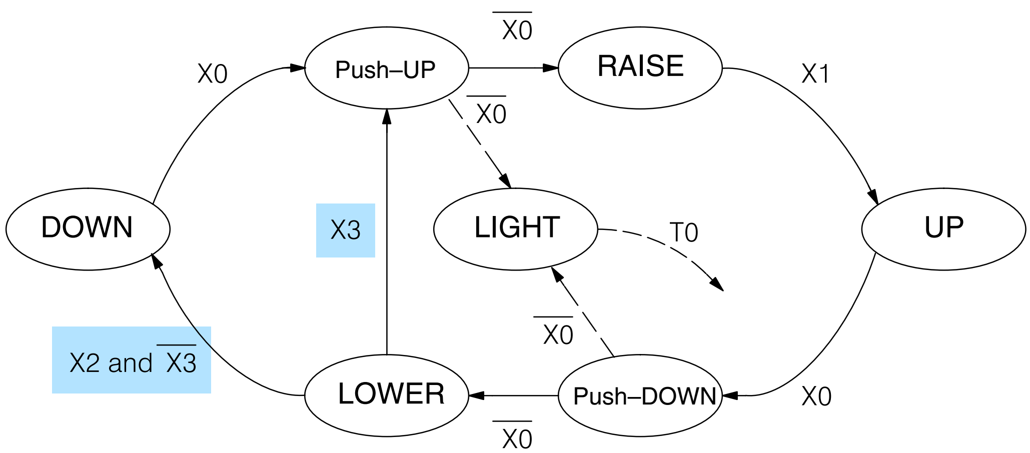
Add Emergency Stop Feature

Some garage door openers today will detect an object under the door. This halts further lowering of the door. Usually implemented with a photocell ("electric-eye"), a door in the process of being lowered will halt and begin raising. We will define our safety feature to work in this way, adding the input from the photocell to the block diagram as shown to the right. X3 will be on if an object is in the path of the door.





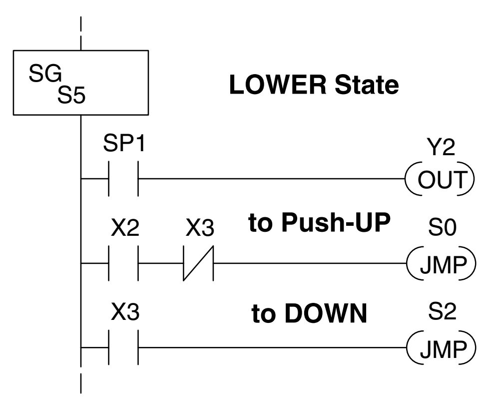
Next, we make a simple addition to the state transition diagram, shown in shaded areas in the figure below. Note the new transition path at the top of the LOWER state. If we are lowering the door and detect an obstruction (X3), we then jump to the Push-UP State. We do this instead of jumping directly to the RAISE state, to give the Lower output Y2 one scan to turn off, before the Raise output Y1 energizes.



Exclusive Transitions

It is theoretically possible that the down limit (X2) and the obstruction input (X3) could energize at the same moment. In that case, we would "jump" to the Push-UP and DOWN states simultaneously, which does not make sense.

Instead, we give priority to the obstruction by changing the transition condition to the DOWN state to [X2 AND NOT X3]. This ensures the obstruction event has the priority. The modifications we must make to the LOWER stage (S5) logic are shown to the right. The first rung remains unchanged. The second and third rungs implement the transitions we need. Note the opposite relay contact usage for X3, which ensures the stage will execute only one of the JMP instructions.

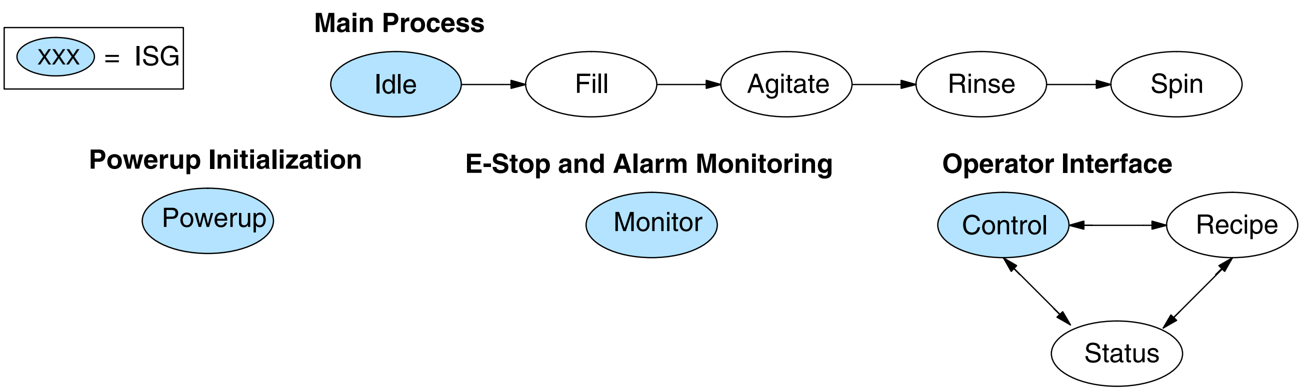


Stage Program Design Considerations

Stage Program Organization

The examples so far in this chapter used one self-contained state diagram to represent the main process. However, we can have multiple processes implemented in stages, all in the same ladder program. New stage programmers sometimes try to turn a stage on and off each scan, based on the false assumption that only one stage can be on at a time. For ladder rungs that you want to execute each scan, just put them in a stage that is always on.

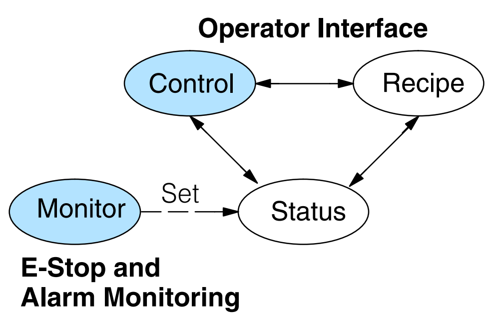
The following figure shows a typical application. During operation, the primary manufacturing activity Main Process, Powerup Initialization, E-Stop and Alarm Monitoring, and Operator Interface are all running. At powerup, three initial stages shown begin operation.



In a typical application, the separate stage sequences above operate as follows:

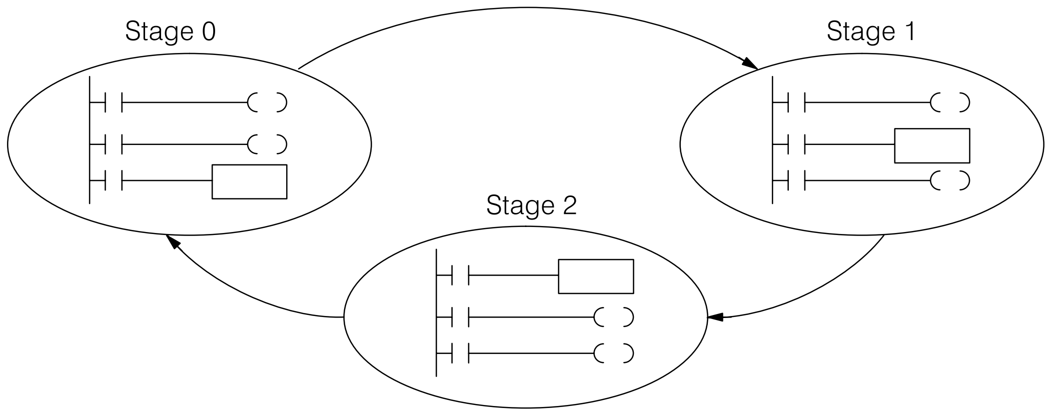
- **Powerup Initialization** – This stage contains ladder rung tasks done just once at powerup. Its last rung resets the stage, so this stage is only active for one scan (or only as many scans that are required).
- **Main Process** – this stage sequence controls the heart of the process or machine. One pass through the sequence represents one part cycle of the machine, or one batch in the process.
- **E-Stop and Alarm Monitoring** – This stage is always active because it is watching for errors that could indicate an alarm condition or require an emergency stop. It is common for this stage to reset stages in the main process or elsewhere, in order to initialize them after an error condition.
- **Operator Interface** – this is another task that must always be active and ready to respond to an operator. It allows an operator interface to change modes, etc. independently of the current main process step.

Although we have separate processes, there can be coordination among them. For example, in an error condition, the Status Stage may want to automatically switch the operator interface to the status mode to show error information as shown to the right. The monitor stage could set the stage bit for Status and Reset the stages Control and Recipe.



How Instructions Work Inside Stages

We can think of states or stages as simply dividing up our ladder program as depicted in the figure below. Each stage contains only the ladder rungs which are needed for the corresponding state of the process. The logic for transitioning out of a stage is contained within that stage. It's easy to choose which ladder rungs are active at powerup by using an "initial" stage type (ISG).



Most all instructions work just like they do in standard RLL. You can think of a stage just like a miniature RLL program which is either active or inactive.

Output Coils – As expected, output coils in active stages will turn on or off outputs according to power flow into the coil. However, note the following:

- Outputs work as usual, provided each output reference (such as "Y3") is used in only one stage.
- An output can be referenced from more than one stage, as long as only one of the stages is active at a time.
- If an output coil is controlled by more than one stage simultaneously, the active stage nearest the bottom of the program determines the final output status during each scan. Therefore, use the OROUT instruction instead when you want multiple stages to have a logical OR control of an output.

One-Shot or PD coils – Use care if you must use a Positive Differential coil in a stage. Remember that the input to the coil must make a 0–1 transition. If the coil is already energized on the first scan when the stage becomes active, the PD coil will not work. This is because the 0–1 transition did not occur.

PD coil alternative: If there is a task which you want to do only once (on 1 scan), it can be placed in a stage which transitions to the next stage on the same scan.

Counter – In using a counter inside a stage, the stage must be active for one scan before the input to the counter makes a 0–1 transition. Otherwise, there is no real transition and the counter will not count.

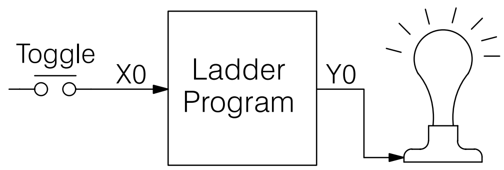
The ordinary Counter instruction does have a restriction inside stages: it may not be reset from other stages using the RST instruction for the counter bit. However, the special Stage Counter provides a solution (see next paragraph).

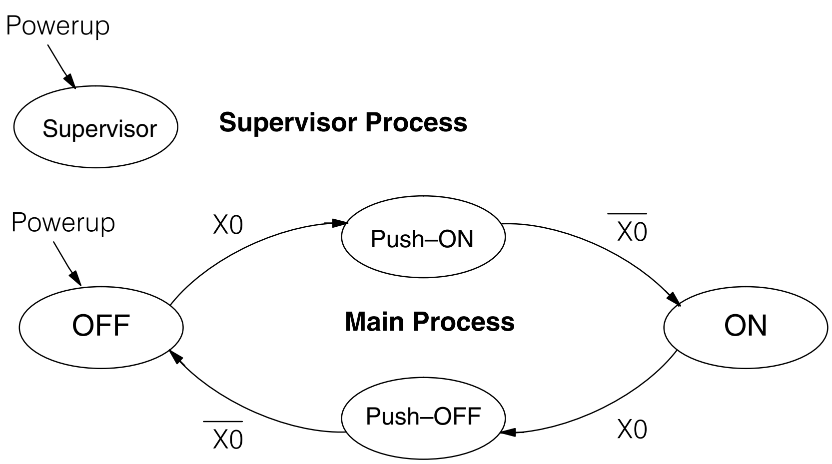
Stage Counter – The Stage Counter has the benefit that its count may be globally reset from other stages by using the RST instruction. It has a count input, but no reset input. This is the only difference from a standard counter.

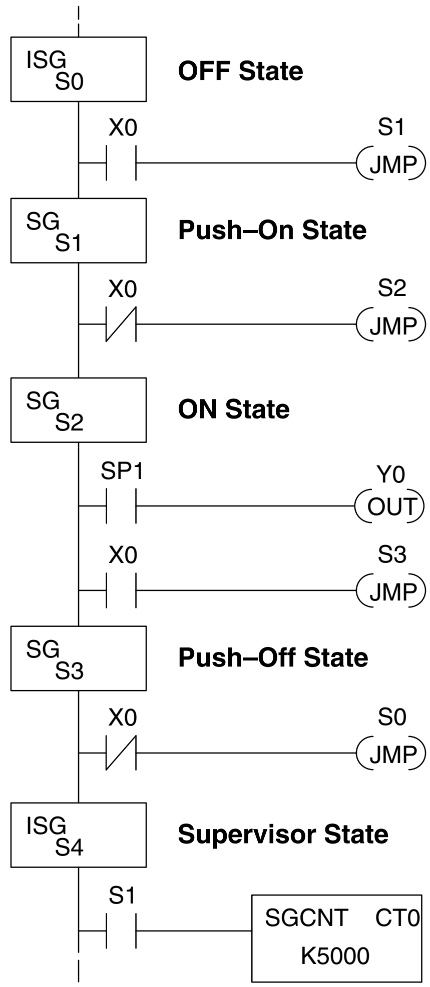
Drum – Realize that the drum sequencer is its own process, and is a different programming method than stage programming. If you need to use a drum with stages, be sure to place the drum instruction in an ISG stage that is always active.

Using a Stage as a Supervisory Process

You may recall the light bulb on-off controller example from earlier in this chapter. For the purpose of illustration, suppose we want to monitor the "productivity" of the lamp process, by counting the number of on-off cycles which occurs. This application will require the addition of a simple counter, but the key decision is in where to put the counter.







New stage programming students will typically try to place the counter inside one the the stages of the process they are trying to monitor. The problem with this approach is that the stage is active only part of the time. In order for the counter to count, the count input must transition from off to on at least one scan after its stage activates. Ensuring this requires extra logic that can be tricky.

In this case, we only need to add another supervisory stage as shown above, to "watch" the main process. The counter inside the supervisor stage uses the stage bit S1 of the main process as its count input. *Stage bits used as a contact let us monitor a process!*

Note that both the Supervisor stage and the OFF stage are initial stages. The supervisor stage remains active indefinitely.

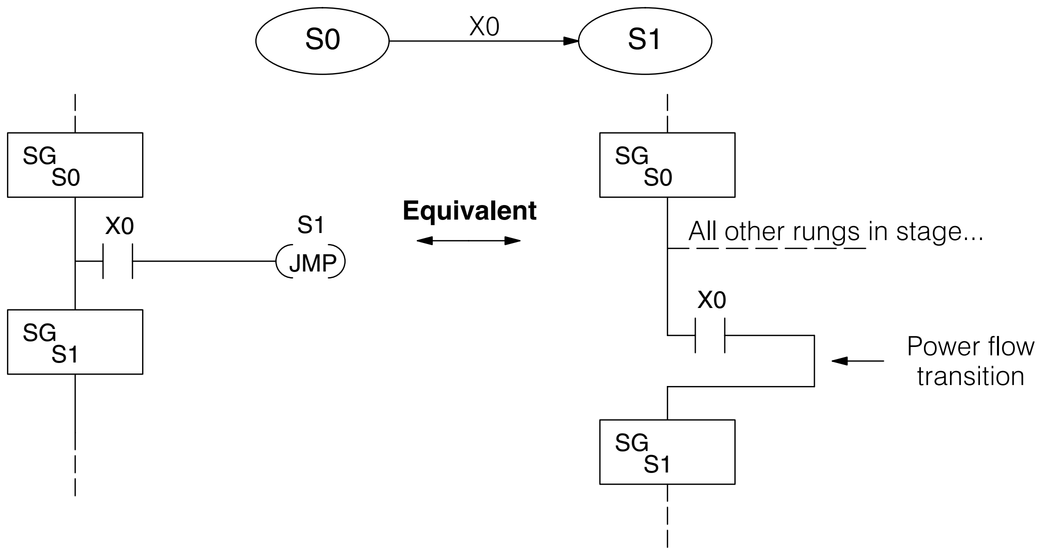
Stage Counter

The counter in the above example is a special Stage Counter. Note that it does not have a reset input. The count is reset by executing a Reset instruction, naming the counter bit (CT0 in this case). The Stage Counter has the benefit that its count may be globally reset from other stages. The standard Counter instruction does not have this global reset capability. You may still use a regular Counter instruction inside a stage... however, the reset input to the counter is the only way to reset it.

Power Flow Transition Technique

Our discussion of state transitions has shown how the stage JMP instruction makes the current stage inactive and the next stage (named in the JMP) active. As an alternative way to enter this in ***Direct***SOFT32, you may use the power flow method for stage transitions.

The main requirement is that the current stage be located directly above the next (jump-to) stage in the ladder program. This arrangement is shown in the diagram below, by stages S0 and S1, respectively.

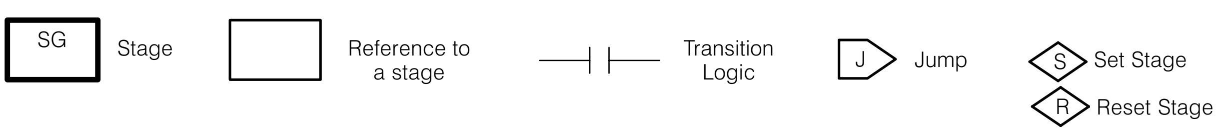


Recall that the stage JMP instruction may occur anywhere in the current stage, and the result is the same. However, power flow transitions (shown above) must occur as the last rung in a stage. All other rungs in the stage will precede it. The power flow transition method is also achievable on the handheld programmer, by simply following the transition condition with the stage instruction for the next stage.

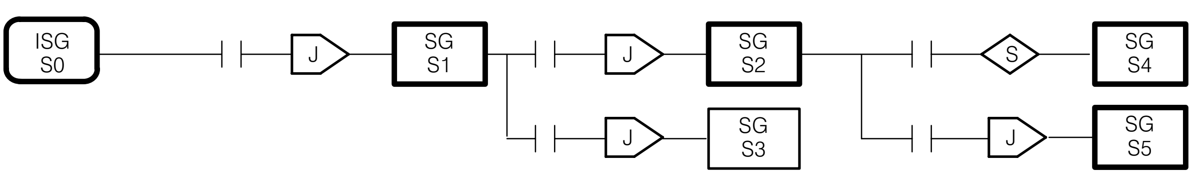
The power flow transition method does eliminate one stage JMP instruction, its only advantage. However, it is not as easy to make program changes as using the stage JMP. Therefore, we advise using stage JMP transitions for most programmers.

Stage View in DirectSOFT32

The stage View option in ***Direct***SOFT32 will let you view the ladder program as a flow chart. The figure below shows the symbol convention used in the diagrams. You may find the stage view useful as a tool to verify that your stage program has faithfully reproduced the logic of the state transition diagram you intend to realize.



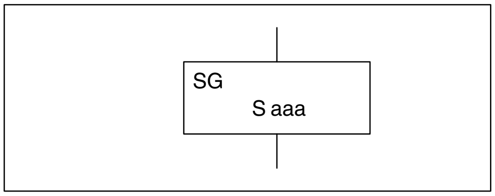
The following diagram is a typical stage view of a ladder program containing stages. Note the left-to-right direction of the flow chart.



RLL^{PLUS} Stage Instructions

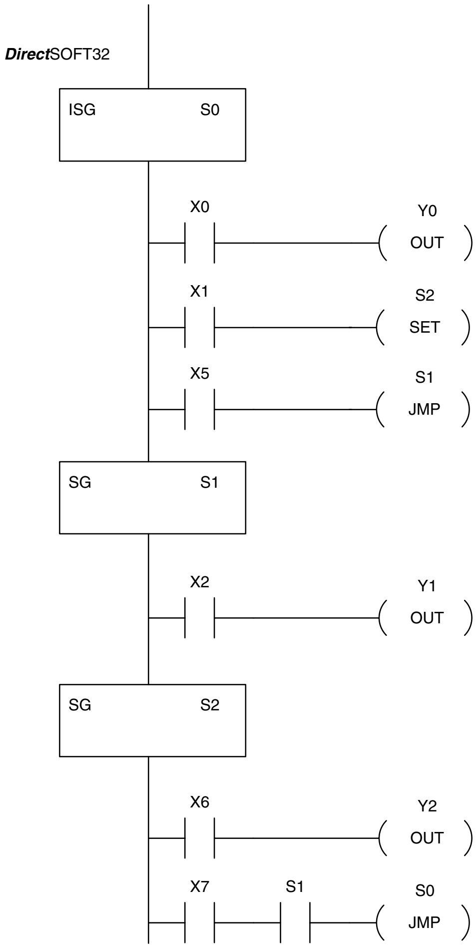
Stage (SG)

The Stage instructions are used to create structured RLL^{PLUS} programs. Stages are program segments which can be activated by transitional logic, a jump or a set stage that is executed from an active stage. Stages are deactivated one scan after transitional logic, a jump, or a reset stage instruction is executed.



Operand Data Type		DL130 Range
		aaa
Stage	S	0–377

The following example is a simple RLL^{PLUS} Stage program. This program utilizes an initial stage, and jump instructions to create a structured program.

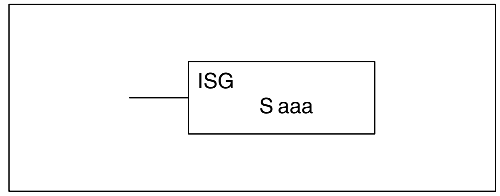


Handheld Programmer Keystrokes

U ISG	→	A 0	ENT		
$ STR	→	A 0	ENT		
GX OUT	→	A 0	ENT		
$ STR	→	B 1	ENT		
X SET	→	SHFT	S RST	C 2	ENT
$ STR	→	F 5	ENT		
K JMP	→	B 1	ENT		
2 SG	→	B 1	ENT		
$ STR	→	C 2	ENT		
GX OUT	→	B 1	ENT		
2 SG	→	C 2	ENT		
$ STR	→	G 6	ENT		
GX OUT	→	C 2	ENT		
$ STR	→	H 7	ENT		
V AND	→	SHFT	S RST	B 1	ENT
K JMP	→	A 0	ENT		

Initial Stage (ISG)

The Initial Stage instruction is normally used as the first segment of an RLL^{PLUS} Stage program. Multiple Initial Stages are allowed in a program. They will be active when the CPU enters the Run mode allowing for a starting point in the program.

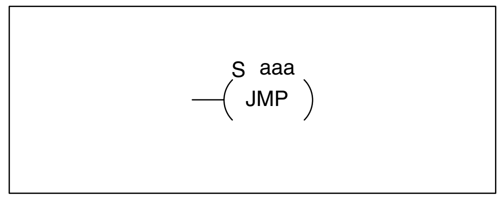


Operand Data Type		DL130 Range
		aaa
Stage	S	0–377

Initial Stages are also activated by transitional logic, a jump or a set stage executed from an active stage.

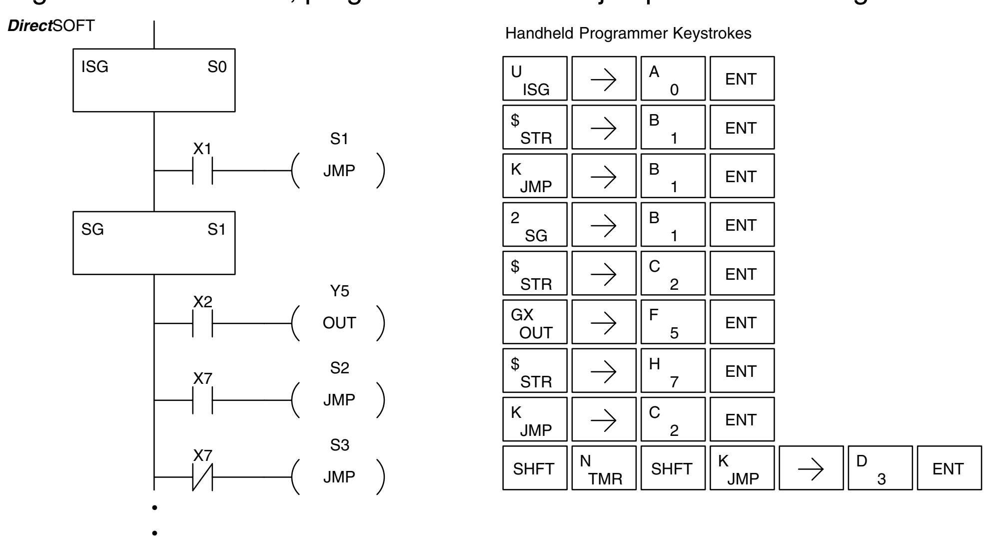
JUMP (JMP)

The Jump instruction allows the program to transition from an active stage containing the jump instruction to another stage (specified in the instruction). The jump occurs when the input logic is true. The active stage containing the Jump will deactivate 1 scan later.



Operand Data Type		DL130 Range
		aaa
Stage	S	0–377

In the following example, only stage ISG0 will be active when program execution. begins. When X1 is on, program execution will jump from Initial Stage 0 to Stage 1.



NOTE: The F1–130 CPU does not have the Not Jump instruction (as does other PLC families). You may still achieve the same result by using the Jump instruction, while inverting the sense of contact logic that activates that instruction.

Questions and Answers about Stage Programming

We include the following commonly-asked questions about Stage Programming as an aid to new students. All question topics are covered in more detail in this chapter.

Q. What does stage programming do that I can't do with regular RLL programs?

A. Stages allow you to identify all the states of your process before you begin programming. This approach is more organized, because you divide up a ladder program into sections. As stages, these program sections are active only when they are actually needed by the process. Most processes can be organized into a sequence of stages, connected by event-based transitions.

Q. Isn't a stage really just like a software subroutine?

A. No, it is very different. A subroutine is called by a main program when needed, and executes just once before returning to the point from which it was called. A stage, however, is part of the main program. It represents a state of the process, so an active stage executes on every scan of the CPU until it becomes inactive.

Q. What are Stage Bits?

A. A stage bit is just a single bit in the CPU's image register, representing the active/inactive status of the stage in real time. For example, the bit for Stage 0 is referenced as "S0". If S0 = 0, then the ladder rungs in Stage 0 are bypassed (not executed) on each CPU scan. If S0 = 1, then the ladder rungs in Stage 0 are executed on each CPU scan. Stage bits, when used as contacts, allow one part of your program to monitor another part by detecting stage active/inactive status.

Q. How does a stage become active?

A. There are three ways:

- If the Stage is an initial stage (ISG), it is automatically active at powerup.
- Another stage can execute a stage JMP instruction naming this stage, which makes it active upon its next occurrence in the program.
- A program rung can execute a Set Stage Bit instruction (such as Set S0).

Q. How does a stage become inactive?

A. There are three ways:

- Standard Stages (SG) are automatically inactive at powerup.
- A stage can execute a stage JMP instruction, resetting its Stage Bit to 0.
- Any rung in the program can execute a Reset Stage Bit instruction (such as Reset S0).

Q. What about the power flow technique of stage transitions?

A. The power flow method of connecting adjacent stages (directly above or below in the program) actually is the same as the stage Jump instruction executed in the stage above, naming the stage below. Power flow transitions are more difficult to edit in ***Direct***SOFT32, we list them separately from two preceding questions.

Q. Can I have a stage which is active for only one scan?

A. Yes, but this is not the intended use for a stage. Instead, just make a ladder rung active for 1 scan by including a stage Jump instruction at the bottom of the rung. Then the ladder will execute on the last scan before its stage jumps to a new one.

Q. Isn't a stage JMP just like a regular GOTO instruction used in software?

A. No, it is very different. A GOTO instruction sends the program execution immediately to the code location named by the GOTO. A stage JMP simply resets the stage Bit of the current stage, while setting the stage Bit of the stage named in the JMP instruction. Stage bits are 0 or 1, determining the inactive/active status of the corresponding stages. A stage JMP has the following results:

- When the JMP is executed, the remainder of the current stage's rungs are executed, even if they reside past(under) the JMP instruction. On the following scan, that stage is not executed, because it is inactive.
- The stage named in the stage JMP instruction will be executed upon its next occurrence. If located past (under) the current stage, it will be executed on the same scan. If located before (above) the current stage, it will be executed on the following scan.

Q. How can I know when to use stage JMP, versus a Set Stage Bit or Reset Stage Bit?

A. These instructions are used according to the state diagram topology you have derived:

- Use a stage JMP instruction for a state transition... moving from one state to another.
- Use a Set Stage Bit instruction when the current state is spawning a new parallel state or stage sequence, or when a supervisory state is starting a state sequence under its command.
- Use a Reset Bit instruction when the current state is the last state in a sequence and its task is complete, or when a supervisory state is ending a state sequence under its command.

Q. What is an initial stage, and when do I use it?

A. An initial stage (ISG) is automatically active at powerup. Afterwards, it works just like any other stage. You can have multiple initial stages, if required. Use an initial stage for ladder that must always be active, or as a starting point.

Q. Can I have place program ladder rungs outside of the stages, so they are always on?

A. It is possible, but it's not good software design practice. Place ladder that must always be active in an initial stage, and do not reset that stage or use a stage JMP instruction inside it. It can start other stage sequences at the proper time by setting the appropriate stage Bit(s).

Q. Can I have more than one active stage at a time?

A. Yes, and this is a normal occurrence for many programs. However, it is important to organize your application into separate processes, each made up of stages. And a good process design will be mostly sequential, with only one stage on at a time. However, all the processes in the program may be active simultaneously.

8

Maintenance and Troubleshooting

In This Chapter. . . .

Hardware System Maintenance

Standard Maintenance

No regular or preventative maintenance is required for this product (there are no internal batteries); however, a routine maintenance check (about every one or two months) of your PLC and control system is good practice, and should include the following items:

- **Air Temperature** – Check the air temperature in the control cabinet, so the operating temperature range of any component is not exceeded.
- **Air Filter** – If the control cabinet has an air filter, clean or replace it periodically as required.
- **Fuses or breakers** – verify that all fuses and breakers are intact.
- **DL105 Air Vents** – check that all air vents are clear. If the exterior case needs cleaning, disconnect the input power, and carefully wipe the case using a damp cloth. Do not let water enter the case through the air vents and do not use strong detergents because this may discolor the case.

Diagnostics

Diagnostics

Your DL105 Micro PLC performs many pre-defined diagnostic routines with every CPU scan. The diagnostics can detect various errors or failures in the PLC. The two primary error classes are *fatal* and *non-fatal*.

Fatal Errors

Fatal errors are errors which may cause the system to function improperly, perhaps introducing a safety problem. The CPU will automatically switch to Program Mode if it is in Run Mode. (Remember, in Program Mode all outputs are turned off.) If the fatal error is detected while the CPU is in Program Mode, the CPU will not allow you to transition to Run Mode until the error has been corrected.

Some examples of fatal errors are:

- Power supply failure
- Parity error or CPU malfunction
- Particular programming errors

Non-fatal Errors

Non-fatal errors are errors that need your attention, but should not cause improper operation. They do not cause or prevent any mode transitions of the CPU. The application program can use special relay contacts to detect non-fatal errors, and even take the system to an orderly shutdown or switch the CPU to Program Mode if desired. An example of a non-fatal error is:

- Particular programming errors

Finding Diagnostic Information

The programming devices will notify you of an error if one occurs while online.

- ***Direct***SOFT32 provides the error number and an error message.
- The handheld programmer displays error numbers and short descriptions of the error.

Appendix B has a complete list of error messages in order by error number.

Many error messages point to supplemental V-memory locations which contain related information. Special relays (SP contacts) also provide error indications.

V-memory Error Code Locations

The following table names the specific memory locations that correspond to certain types of error messages.

Error Class	Error Category	Diagnostic V-memory
User-Defined	Error code used with FAULT instruction	V7751
System Error	Fatal Error code	V7755
	Major Error code	V7756
	Minor Error code	V7757
Grammatical	Address where syntax error occurs	V7763
	Error Code found during syntax check	V7764
CPU Scan	Number of scans since last Program to Run Mode transition	V7765
	Current scan time (ms)	V7775
	Minimum scan time (ms)	V7776
	Maximum scan time (ms)	V7777

Special Relays (SP) Corresponding to Error Codes

The special relay table also includes status indicators which can indicate errors. For a more detailed description of each of these special relays refer to Appendix D.

CPU Status Relays	
SP12	Terminal Run mode
SP16	Terminal Program mode
SP20	STOP instruction was executed
SP22	Interrupt enabled
System Monitoring Relays	
SP40	Critical error
SP41	Non-critical error
SP44	Program memory error
SP50	Fault instruction was executed
SP51	Watchdog timeout
SP52	Syntax error
SP53	Cannot solve the logic

Accumulator Status Relays	
SP60	Acc. is less than value
SP61	Acc. is equal to value
SP62	Acc. is greater than value
SP63	Acc. result is zero
SP64	Half borrow occurred
SP65	Borrow occurred
SP66	Half carry occurred
SP67	Carry occurred
SP70	Result is negative (sign)
SP71	Pointer reference error
SP73	Overflow
SP75	Data is not in BCD
SP76	Load zero

DL105 Micro PLC Error Codes

These errors can be generated by the CPU or by the Handheld Programmer, depending on the actual error. Appendix B provides a more complete description of the error codes.

The errors can be detected at various times. However, most of them are detected at power-up, on entry to Run Mode, or when a Handheld Programmer key sequence results in an error or an illegal request.

Error Code	Description
E003	Software time-out
E004	Invalid instruction (RAM parity error in the CPU)
E099	Program memory exceeded
E151	Invalid command
E155	RAM failure
E210	Power fault
E312	Communications error 2
E313	Communications error 3
E316	Communications error 6
E320	Time out
E321	Communications error
E501	Bad entry
E502	Bad address
E503	Bad command
E504	Bad reference / value
E505	Invalid instruction
E506	Invalid operation
E520	Bad operation – CPU in Run
E524	Bad operation – CPU in Program

Error Code	Description
E526	Unit is offline
E527	Unit is online
E528	CPU mode
E540	CPU locked
E541	Wrong password
E542	Password reset
E601	Memory full
E602	Instruction missing
E604	Reference missing
E620	Out of memory
E621	EEPROM Memory not blank
E622	No Handheld Programmer EEPROM
E624	V memory only
E625	Program only
E627	Bad write operation
E628	Memory type error (should be EEPROM)
E640	Mis-compare
E650	Handheld Programmer system error
E651	Handheld Programmer ROM error
E652	Handheld Programmer RAM error

Program Error Codes

The following table lists program syntax and runtime error codes. Error detection occurs during a Program-to-Run mode transition, or when you use AUX 21 – Check Program. The CPU will also turn on SP52 and store the error code in V7755. Appendix B provides a more complete description of the error codes.

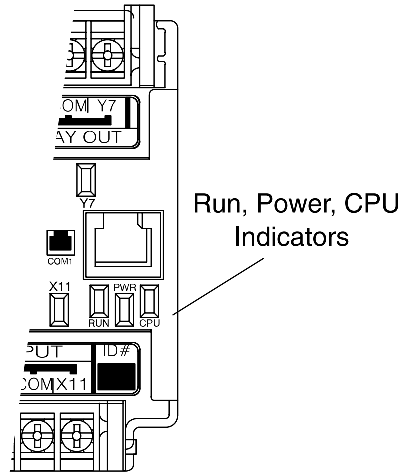
Error Code	Description
E4**	No Program in CPU
E401	Missing END statement
E402	Missing LBL
E406	Missing IRT
E421	Duplicate stage reference
E422	Duplicate SBR/LBL reference
E431	Invalid ISG/SG address
E436	Invalid INT address
E438	Invalid IRT address
E440	Invalid Data Address
E441	ACON/NCON
E451	Bad MLS/MLR

Error Code	Description
E452	X input used as output coil
E453	Missing T/C
E454	Bad TMRA
E455	Bad CNT
E456	Bad SR
E461	Stack Overflow
E462	Stack Underflow
E463	Logic Error
E464	Missing Circuit
E471	Duplicate coil reference
E472	Duplicate TMR reference
E473	Duplicate CNT reference

CPU Indicators

The DL105 Micro PLCs have indicators on the front to help you diagnose problems with the system. In normal runtime operation only the RUN and PWR indicators are on. The table below is a quick reference to potential problems.

Indicator Status	Potential Problems
PWR (LED off)	1. System voltage incorrect 2. PLC power supply faulty
RUN (LED off)	1. CPU programming error 2. (CPU in program mode)
CPU (LED on)	1. Electrical noise interference 2. Internal CPU defective

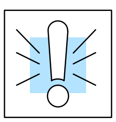


PWR Indicator

In general there are three reasons for the CPU power status LED (PWR) to be OFF:

1. Power to the unit is incorrect or is not applied.
2. PLC power supply is faulty.
3. Other component(s) have the power supply shut down.

If the voltage to the power supply is not correct, the PLC may not operate properly or may not operate at all. Use the following guidelines to correct the problem.



WARNING: To minimize the risk of electrical shock, always disconnect the system power before inspecting the physical wiring.

1. First, disconnect the external power.
2. Verify that all external circuit breakers or fuses are still intact.
3. Check all incoming wiring for loose connections. If you're using a separate termination block, check those connections for accuracy and integrity.
4. If the connections are acceptable, reconnect the system power and verify the voltage at the DL105 power input is within specification. If the voltage is not correct shut down the system and correct the problem.
5. If all wiring is connected correctly and the incoming power is within the specifications, the PLC internal supply may be faulty.

The best way to check for a faulty PLC is to substitute a known good one to see if this corrects the problem. The removable connectors on the DL105 make this relatively easy. If there has been a major power surge, it is possible the PLC internal power supply has been damaged. If you suspect this is the cause of the power supply damage, consider installing an AC line conditioner to attenuate damaging voltage spikes in the future.

RUN Indicator

If the CPU will not enter the Run mode (the RUN indicator is off), the problem is usually in the application program, unless the CPU has a fatal error. If a fatal error has occurred, the CPU LED should be on. (You can use a programming device to determine the cause of the error.)

Both of the programming devices, Handheld Programmer and ***Direct***SOFT32, will return an error message describing the problem. Depending on the error, there may also be an AUX function you can use to help diagnose the problem. The most common programming error is “Missing END Statement”. All application programs require an END statement for proper termination. A complete list of error codes can be found in Appendix B.

CPU Indicator

If the CPU indicator is on, a fatal error has occurred in the CPU. Generally, this is not a programming problem but an actual hardware failure. You can power cycle the system to clear the error. If the error clears, you should monitor the system and determine what caused the problem. You will find this problem is sometimes caused by high frequency electrical noise introduced into the CPU from an outside source. Check your system grounding and install electrical noise filters if the grounding is suspected. If power cycling the system does not reset the error, or if the problem returns, you should replace the CPU.

Communications Problems

If you cannot establish communications with the CPU, check these items.

- The cable is disconnected.
- The cable has a broken wire or has been wired incorrectly.
- The cable is improperly terminated or grounded.
- The device connected is not operating at the correct baud rate (9600 baud).
- The device connected to the port is sending data incorrectly.
- A grounding difference exists between the two devices.
- Electrical noise is causing intermittent errors.
- The PLC has a bad communication port and should be replaced.

For problems in communicating with ***Direct***SOFT32 on a personal computer, refer to the ***Direct***SOFT32 manual. It includes a troubleshooting section that can help you diagnose PC problems in communications port setup, address or interrupt conflicts, etc.

I/O Point Troubleshooting

Possible Causes If you suspect an I/O error, there are several things that could be causing the problem.

- High-Speed I/O configuration error
- A blown fuse in your machine or panel (the DL105 does not have internal I/O fuses)
- A loose terminal block
- The auxiliary 24 VDC supply has failed
- The Input or Output Circuit has failed

Some Quick Steps When troubleshooting the DL105 Micro PLCs there are a few facts you should be aware of. These facts may assist you in quickly correcting an I/O problem.

- HSIO configuration errors are commonly mistaken for I/O point failure during program development. If the I/O point in question is in X0–X3, or Y0–Y2, check all parameter locations listed in Chapter 3 that apply to the HSIO mode you have selected.
- The output circuits cannot detect shorted or open output points. If you suspect one or more faulty points, measure the voltage drop from the common to the suspect point. Remember when using a Digital Volt Meter, leakage current from an output device such as a triac or a transistor must be considered. A point which is off may appear to be on if no load is connected the point.
- The I/O point status indicators are logic-side indicators. This means the LED which indicates the on or off status reflects the status of the point with respect to the CPU. On an output point the status indicators could be operating normally while the actual output device (transistor, triac etc.) could be damaged. With an input point, if the indicator LED is on the input circuitry is probably operating properly. Verify the LED goes off when the input signal is removed.
- Leakage current can be a problem when connecting field devices to an I/O point. False input signals can be generated when the leakage current of an output device is great enough to turn on the connected input device. To correct this install a resistor in parallel with the input or output of the circuit. The value of this resistor will depend on the amount of leakage current and the voltage applied but usually a 10K to 20KΩ resistor will work. Verify the wattage rating of the resistor is correct for your application.
- Because of the removable terminal blocks on the DL105, the easiest method to determine if an I/O circuit has failed is to replace the unit if you have a spare. However, if you suspect a field device is defective, that device may cause the same failure in the replacement PLC as well. As a point of caution, you may want to check devices or power supplies connected to the failed I/O circuit before replacing the unit with a spare.

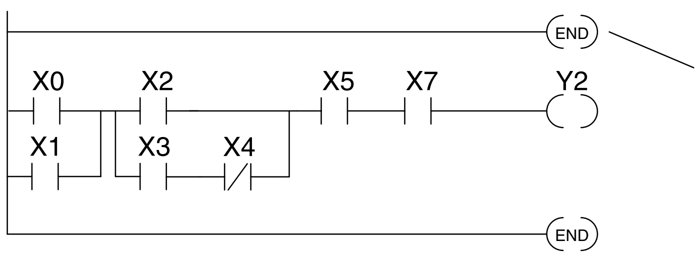
Testing Output Points

Output points can be set on or off in the DL105 series CPUs. If you want to do an I/O check out independent of the application program, follow the procedure below:

Step	Action
1	Use a handheld programmer or ***Direct***SOFT32 to communicate online to the PLC.
2	Change to Program Mode.
3	Go to address 0.
4	Insert an “END” statement at address 0. (This will cause program execution to occur only at address 0 and prevent the application program from turning the I/O points on or off).
5	Change to Run Mode.
6	Use the programming device to set (turn) on or off the points you wish to test.
7	When you finish testing I/O points delete the “END” statement at address 0.

WARNING: Depending on your application, forcing I/O points may cause unpredictable machine operation that can result in a risk of personal injury or equipment damage. Make sure you have taken all appropriate safety precautions prior to testing any I/O points.

Handheld Programmer Keystrokes Used to Test an Output Point



Insert an END statement at the beginning of the program. This disables the remainder of the program.

From a clear display, use the following keystrokes

STAT ENT

```
16P STATUS
BIT REF   X
```

Use the PREV or NEXT keys to select the Y data type

NEXT A 0 ENT

```
  Y  10   Y   0
□□□□□□□□□□□□□□□□
```

Use arrow keys to select point, then use ON and OFF to change the status

← ← SHFT ON INS

Y2 is now on

```
  Y  10   Y   0
□□□□□□□□□□□□□■□□
```

Noise Troubleshooting

Electrical Noise Problems

Noise is one of the most difficult problems to diagnose. Electrical noise can enter a system in many different ways and they fall into one of two categories, conducted or radiated. It may be difficult to determine how the noise is entering the system but the corrective actions for either of the types of noise problems are similar.

- Conducted noise is when the electrical interference is introduced into the system by way of a attached wire, panel connection ,etc. It may enter through an I/O circuit, a power supply connection, the communication ground connection, or the chassis ground connection.
- Radiated noise is when the electrical interference is introduced into the system without a direct electrical connection, much in the same manner as radio waves.

Reducing Electrical Noise

While electrical noise cannot be eliminated it can be reduced to a level that will not affect the system.

- Most noise problems result from improper grounding of the system. A good earth ground can be the single most effective way to correct noise problems. If a ground is not available, install a ground rod as close to the system as possible. Ensure all ground wires are single point grounds and are not daisy chained from one device to another. Ground metal enclosures around the system. A loose wire can act as a large antenna, introducing noise into the system. Therefore, tighten all connections in your system. Loose ground wires are more susceptible to noise than the other wires in your system. Review Chapter 2 Installation, Wiring, and Specifications if you have questions regarding how to ground your system.
- Electrical noise can enter the system through the power source for the PLC and I/O circuits. Installing an isolation transformer for all AC sources can correct this problem. DC sources should be well-grounded good quality supplies.
- Separate input wiring from output wiring. Never run low-voltage I/O wiring close to high voltage wiring.

Machine Startup and Program Troubleshooting

The DL105 Micro PLCs provide several features that can help you debug your program before and during machine startup. This section discusses the following topics which can be very helpful.

- Program Syntax Check
- Duplicate Reference Check
- Special Instructions
- Run Time Edits
- Forcing I/O Points

Syntax Check

Even though the Handheld Programmer and ***Direct***SOFT32 provide error checking during program entry, you may want to check a program that has been modified. Both programming devices offer a way to check the program syntax. For example, you can use AUX 21, CHECK PROGRAM to check the program syntax from a Handheld Programmer, or you can use the PLC Diagnostics menu option within ***Direct***SOFT32. This check will find a wide variety of programming errors. The following example shows how to use the syntax check with a Handheld Programmer.

Use AUX 21 to perform syntax check

CLR | C 2 | B 1 | AUX | ENT

```
AUX 21 CHECK PRO
1:SYN 2:DUP REF
```

Select syntax check (default selection)

ENT

(You may not get the busy display if the program is not very long.)

```
BUSY
```

One of two displays will appear

Error Display (example)

```
$00050 E401
MISSING END
```

(shows location in question)

Syntax OK display

```
NO SYNTAX ERROR
?
```

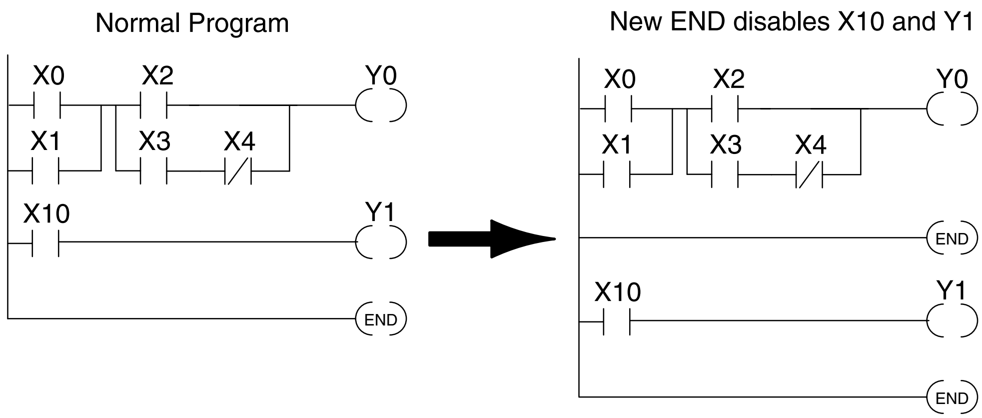
See the Error Codes Section for a complete listing of programming error codes. If you get an error, just press CLR and the Handheld will display the instruction where the error occurred. Correct the problem and continue running the Syntax check until the NO SYNTAX ERROR message appears.

Special Instructions

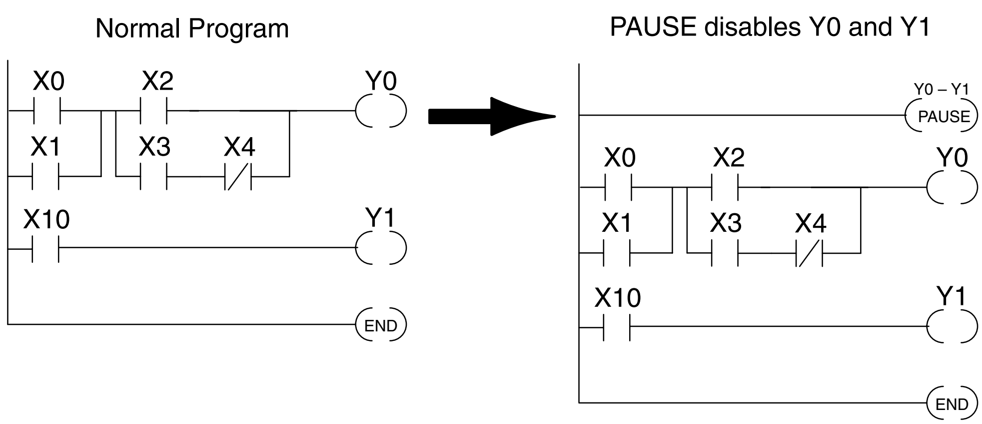
There are several instructions that can be used to help you debug your program during machine startup operations.

- END
- PAUSE
- STOP

END Instruction: If you need a way to quickly disable part of the program, just insert an END statement prior to the portion that should be disabled. When the CPU encounters the END statement, it assumes that is the end of the program. The following diagram shows an example.

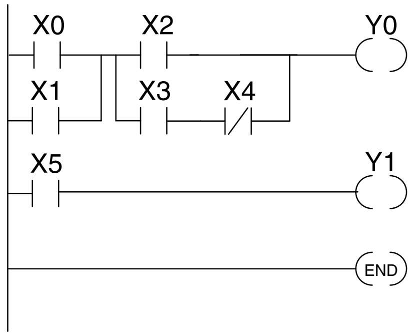


PAUSE Instruction: This instruction provides a quick way to allow the inputs (or other logic) to operate while disabling selected outputs. The output image register is still updated, but the output circuits are not. For example, you could make this conditional by adding an input contact or CR to control the instruction with a switch or a programming device. Or, you could just add the instruction without any conditions so the selected outputs would be disabled at all times.

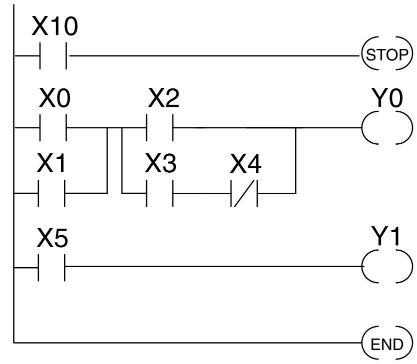


STOP Instruction: Sometimes during machine startup you need a way to quickly turn off all the outputs and return to Program Mode. You can use the STOP instruction. When this instruction is executed the CPU automatically exits Run Mode and enters Program Mode. Remember, all outputs are turned off during Program Mode. The following diagram shows an example of a condition that returns the CPU to Program Mode.

Normal Program



STOP puts CPU in Program Mode



In the example shown above, you could trigger X10 which would execute the STOP instruction. The CPU would enter Program Mode and all outputs would be turned off.

Duplicate Reference Check

You can also check for multiple uses of the same output coil. Both programming devices offer a way to check for this condition.. For example, you can AUX 21, CHECK PROGRAM to check for duplicate references from a Handheld Programmer, or you can use the PLC Diagnostics menu option within ***Direct***SOFT32. The following example shows how to perform the duplicate reference check with a Handheld Programmer.

Use AUX 21 to perform syntax check

CLR | C 2 | B 1 | AUX | ENT

```
AUX 21 CHECK PRO
1:SYN 2:DUP REF
```

Select duplicate reference check

→ | ENT (You may not get the busy display if the program is not very long.)

```
BUSY
```

One of two displays will appear

Error Display (example)
(shows location in question)

```
$00024 E471
DUP COIL REF
```

Syntax OK display

```
NO DUP REFS
?
```

If you get an error, just press CLR and the Handheld will display the instruction where the error occurred. Correct the problem and continue running the Duplicate Reference check until no duplicate references are found.

NOTE: You can use the same coil in more than one location, especially in programs containing Stage instructions and / or OROUT instructions. The Duplicate Reference check will find occurrences, even though they are acceptable.

Run Time Edits

The DL105 Micro PLC allows you to make changes to the application program during Run Mode. These edits are not “bumpless.” Instead, CPU scan is momentarily interrupted (and the outputs are maintained in their current state) until the program change is complete. This means if the output is off, it will remain off until the program change is complete. If the output is on, it will remain on.

WARNING: Only authorized personnel fully familiar with all aspects of the application should make changes to the program. Changes during Run Mode become effective immediately. Make sure you thoroughly consider the impact of any changes to minimize the risk of personal injury or damage to equipment. There are some important operational changes during Run Time Edits.

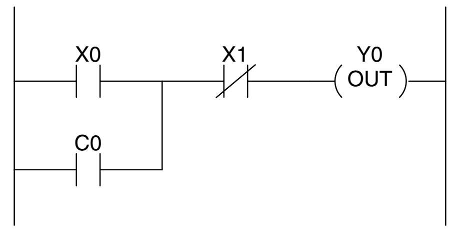
1. If there is a syntax error in the new instruction, the CPU *will not* enter the Run Mode.
2. If you delete an output coil reference and the output was on at the time, the output will remain on until it is forced off with a programming device.
3. Input point changes are not acknowledged during Run Time Edits. So, if you’re using a high-speed operation and a critical input comes on, the CPU may not see the change.

Not all instructions can be edited during a Run Time Edit session. The following list shows the instructions that can be edited.

Mnemonic	Description
TMR	Timer
TMRF	Fast timer
TMRA	Accumulating timer
TMRAF	Accumulating fast timer
CNT	Counter
UDC	Up / Down counter
SGCNT	Stage counter
STR, STRN	Store, Store not
AND, ANDN	And, And not
OR, ORN	Or, Or not
STRE, STRNE	Store equal, Store not equal
ANDE, ANDNE	And equal, And not equal
ORE, ORNE	Or equal, Or not equal
STR, STRN	Store greater than or equal Store less than
AND, ANDN	And greater than or equal And less than

Mnemonic	Description
OR, ORN	Or greater than or equal Or less than
LD	Load data (constant)
LDD	Load data double (constant)
ADDD	Add data double (constant)
SUBD	Subtract data double (constant)
MUL	Multiply (constant)
DIV	Divide (constant)
CMPD	Compare accumulator (constant)
ANDD	And accumulator (constant)
ORD	Or accumulator (constant)
XORD	Exclusive or accumulator (constant)
LDF	Load discrete points to accumulator
OUTF	Output accumulator to discrete points
SHFR	Shift accumulator right
SHFL	Shift accumulator left
NCON	Numeric constant

We'll use the program logic shown to describe how this process works. In the example, we'll change X0 to C10. Note, the example assumes you have already placed the CPU in Run Mode.



Use the MODE key to select Run Time Edits

MODE NEXT NEXT ENT

```
*MODE CHANGE*
RUN TIME EDIT?
```

Press ENT to confirm the Run Time Edits

ENT

(Note, the RUN LED on the D2–HPP Handheld starts flashing to indicate Run Time Edits are enabled.)

```
*MODE CHANGE*
RUNTIME EDITS
```

Find the instruction you want to change (X0)

SHFT | X SET | A 0 | SHFT | FD REF FIND

```
$00000 STR X0
```

Press the arrow key to move to the X. Then enter the new contact (C10).

→ → SHFT | C 2 | B 1 | A 0 | ENT

```
RUNTIME EDIT?
STR C10
```

Press ENT to confirm the change

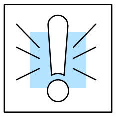
ENT

(Note, once you press ENT, the next address is displayed.

```
OR C0
```

Forcing I/O Points

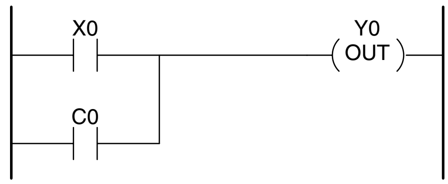
There are many times, especially during machine startup and troubleshooting, that you need the capability to force an I/O point to be either on or off. Before you use a programming device to force any data type it is important you understand how the DL105 CPUs process the forcing requests.



WARNING: Only authorized personnel fully familiar with the application should make program changes. Do thoroughly consider the impact of any changes to minimize the risk of personal injury or damage to equipment.

Bit Forcing — Bit forcing temporarily changes the status of a discrete bit. For example, you may want to force an input on even though the program has turned it off. This allows you to change the point status stored in the image register. The forced value will be valid until the CPU writes to the image register location during the next scan. This is useful you just need to force a bit on to trigger another event.

The following diagrams show a brief example of how you could use the D2–HPP Handheld Programmer to force an I/O point. The example assumes you have already placed the CPU into Run Mode.



From a clear display, use the following keystrokes

STAT ENT

```
16P STATUS
BIT REF   X
```

Use the PREV or NEXT keys to select the Y data type. (Once the Y appears, press 0 to start at Y0.)

NEXT A 0 ENT

```
  Y  10         Y    0
□ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □
```

Use arrow keys to select point, then use ON and OFF to change the status

← ← SHFT ON INS

Y2 is now on

```
  Y  10         Y    0
□ □ □ □ □ □ □ □ □ □ □ □ □ ■ □ □
```

Bit Forcing with Direct Access

From a blank display, use the following keystrokes to force Y7 ON

SHFT Y MLS H 7 SHFT ON INS

Solid fill indicates point is on.

```
BIT FORCE
Y7                    ■
```

From a blank display, use the following keystrokes to force Y7 OFF

SHFT Y MLS H 7 SHFT OFF DEL

No fill indicates point is off.

```
BIT FORCE
Y7                    □
```

A

Auxiliary Functions

In This Appendix. . . .

Introduction

Purpose of Auxiliary Functions

Many CPU setup tasks involve the use of Auxiliary (AUX) Functions. The AUX Functions perform many different operations, including clearing ladder memory, displaying the scan time, and copying programs to EEPROM in the handheld programmer. They are divided into categories that affect different system resources. You can access the AUX Functions from ***Direct***SOFT32 or from the D2–HPP Handheld Programmer. The manuals for those products provide step-by-step procedures for accessing the AUX Functions. Some of these AUX Functions are designed specifically for the Handheld Programmer setup, so they will not be needed (or available) with the ***Direct***SOFT32 package. Even though this Appendix provides many examples of how the AUX functions operate, you should supplement this information with the documentation for your choice of programming device. Note, the Handheld Programmer may have additional AUX functions that are not supported with the DL105 PLCs.

AUX Function and Description		DL105
AUX 2* — RLL Operations		
21	Check Program	❍
22	Change Reference	❍
23	Clear Ladder Range	❍
24	Clear All Ladders	❍
AUX 3* — V-Memory Operations		
31	Clear V Memory	❍
AUX 4* — I/O Configuration		
41	Show I/O Configuration	❍
AUX 5* — CPU Configuration		
51	Modify Program Name	❍
53	Display Scan Time	❍
54	Initialize Scratchpad	❍
55	Set Watchdog Timer	❍
57	Set Retentive Ranges	❍
58	Test Operations / Pause Over-ride	❍
5B	HSIO Interface Configuration	❍

AUX Function and Description		DL105
AUX 6* — Handheld Programmer Configura-tion		
61	Show Revision Numbers	❍
62	Beeper On / Off	HP
65	Run Self Diagnostics	HP
AUX 7* — EEPROM Operations		
71	Copy CPU memory to HPP EEPROM	HP
72	Write HPP EEPROM to CPU	HP
73	Compare CPU to HPP EEPROM	HP
74	Blank Check (HPP EEPROM)	HP
75	Erase HPP EEPROM	HP
76	Show EEPROM Type (CPU and HPP)	HP
AUX 8* — Password Operations		
81	Modify Password	❍
82	Unlock CPU	❍
83	Lock CPU	❍

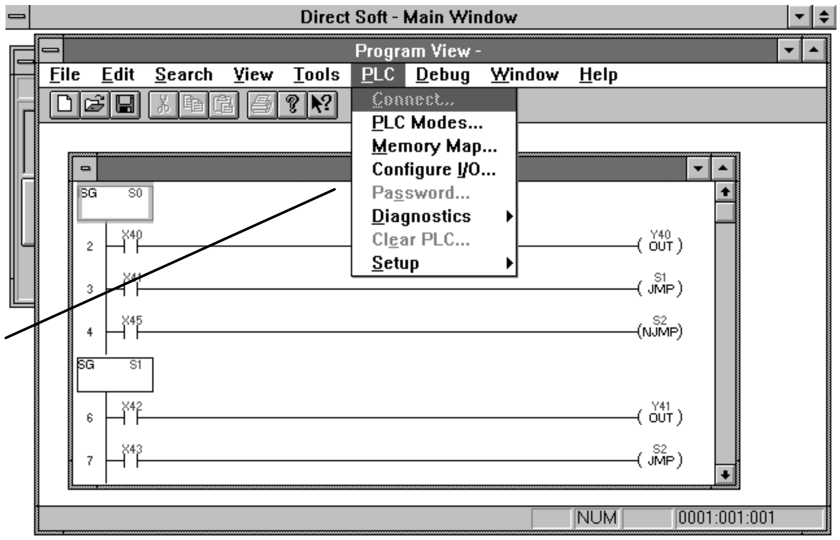
❍ — supported

HP — Handheld Programmer function

Accessing AUX Functions via *Direct*SOFT32

***Direct*SOFT32** provides various menu options during both online and offline programming. Some of the AUX functions are only available during online programming, some only during offline programming, and some during both online and offline programming. The following diagram shows and example of the PLC operations menu available within ***Direct*SOFT32**.

Menu Options



Accessing AUX Functions via the Handheld Programmer

You can also access the AUX functions by using a Handheld Programmer. Plus, remember some of the AUX functions are only available from the Handheld. Sometimes the AUX name or description cannot fit on one display. If you want to see the complete description, just press the arrow keys to scroll left and right. Also, depending on the current display, you may have to press CLR more than once.

CLR AUX

```
AUX FUNCTION SELECTION
AUX 2* RLL OPERATIONS
```

Use NXT or PREV to cycle through the menus

NEXT

```
AUX FUNCTION SELECTION
AUX 3* V OPERATIONS
```

Press ENT to select sub-menus

ENT

```
AUX 3* V OPERATIONS
AUX 31 CLR V MEMORY
```

You can also enter the exact AUX number to go straight to the sub-menu.

Enter the AUX number directly

CLR D 3 B 1 AUX

```
AUX 3* V OPERATIONS
AUX 31 CLR V MEMORY
```

AUX 2* — RLL Operations

RLL Operations auxiliary functions allow you to perform various operations on the ladder program.

AUX 21
Check Program

Both the Handheld and ***Direct***SOFT32 automatically check for errors during program entry. However, there may be occasions when you want to check a program that has already been in the CPU. Two types of checks are available:

- Syntax
- Duplicate References

The Syntax check will find a wide variety of programming errors, such as missing END statements. If you perform this check and get an error, see Appendix B for a complete listing of programming error codes. Correct the problem and then continue running the Syntax check until the message “NO SYNTAX ERROR appears.

Use the Duplicate Reference check to verify you have not used the same output coil reference more than once. Note, this AUX function will also find the same outputs even if they have been used with the OROUT instruction, which is perfectly acceptable.

This AUX function is available on the PLC Diagnostics sub-menu from within ***Direct***SOFT32.

AUX 22
Change Reference

There will probably be times when you need to change an I/O address reference or control relay reference. AUX 22 allows you to quickly and easily change all occurrences, (within an address range), of a specific instruction. For example, you can replace every instance of X5 with X10.

AUX 23
Clear Ladder Range

There have been many times when we’ve taken existing programs and added or removed certain portions to solve new application problems. By using AUX 23 you can select and delete a portion of the program. ***Direct***SOFT32 does not have a menu option for this AUX function, but you can just select the appropriate portion of the program and cut it with the editing tools.

AUX 24
Clear Ladders

AUX 24 clears the entire program from CPU memory. Before you enter a new program, you should always clear ladder memory. This AUX function is available on the PLC/Clear PLC sub-menu within ***Direct***SOFT32.

AUX 3* — V-memory Operations

AUX 31
Clear V Memory

AUX 31 clears all the information from the V-memory locations available for general use. This AUX function is available on the PLC/Clear PLC sub-menu within ***Direct***SOFT32.

AUX 4* — I/O Configuration

AUX 41
Show I/O Configuration

This AUX function allows you to display the current I/O configuration on the DL105. Both the Handheld Programmer and ***Direct***SOFT32 will show the I/O configuration is fixed at F1–130:10 DI / 8 DO.

AUX 5* — CPU Configuration

The following auxiliary AUX functions allow you to setup, view, or change the CPU configuration.

AUX 51 Modify Program Name

DL105 PLCs can use a program name for the CPU program or a program stored on EEPROM in the Handheld Programmer. (Note, you cannot have multiple programs stored on the EEPROM.) The program name can be up to eight characters in length and can use any of the available characters (A–Z, 0–9). AUX 51 allows you to enter a program name. You can also perform this operation from within ***Direct***SOFT32 by using the PLC/Setup sub-menu. Once you've entered a program name, you can only clear the name by using AUX 54 to reset the system memory. Make sure you understand the possible effects of AUX 54 before you use it!

AUX 53 Display Scan Time

AUX 53 displays the current, minimum, and maximum scan times. The minimum and maximum times are the ones that have occurred since the last Program Mode to Run Mode transition. You can also perform this operation from within ***Direct***SOFT32 by using the PLC/Diagnostics sub-menu.

AUX 54 Initialize Scratchpad

The CPU maintains system parameters in a memory area often referred to as the "scratchpad". In some cases, you may make changes to the system setup that will be stored in system memory. For example, if you specify a range of Control Relays (CRs) as retentive, these changes are stored.

NOTE: You may never have to use this feature unless you have made changes that affect system memory. Usually, you'll only need to initialize the system memory if you are changing programs and the old program required a special system setup. You can usually change from program to program without ever initializing system memory.

AUX 54 resets the system memory to the default values. You can also perform this operation from within ***Direct***SOFT32 by using the PLC/Setup sub-menu.

AUX 55 Set Watchdog Timer

DL105 PLCs have a "watchdog" timer that is used to monitor the scan time. The default value set from the factory is 200 ms. If the scan time exceeds the watchdog time limit, the CPU automatically leaves RUN mode and enters PGM mode. The Handheld displays the following message E003 S/W TIMEOUT when the scan overrun occurs.

Use AUX 55 to increase or decrease the watchdog timer value. You can also perform this operation from within ***Direct***SOFT32 by using the PLC/Setup sub-menu.

AUX 57 Set Retentive Ranges

DL105 CPUs provide certain ranges of retentive memory by default. Some of the retentive memory locations are backed up by a super-capacitor, and others are in non-volatile EEPROM. The EEPROM memory locations are V4000 to 4177, and V7630 to V7647. The default ranges are suitable for many applications, but you can change them if your application requires additional retentive ranges or no retentive ranges at all (see Appendix E).

The default settings are:

Memory Area	DL105	
	Default Range	Available Range
Control Relays	C300 – C377	C0 – C377
V Memory	V2000 – V7777	V0 – V7777
Timers	None by default	T0 – T77
Counters	CT0 – CT77	CT0 – CT77
Stages	None by default	S0 – S377

Use AUX 57 to change the retentive ranges. You can also perform this operation from within ***Direct***SOFT32 by using the PLC/Setup sub-menu.

WARNING: The DL105 CPUs do not have battery-backed RAM. The super-capacitor will retain the values in the event of a power loss, but only up to 3 weeks. (The retention time may be as short as 4 1/2 days in 60 degree C operating temperature.)

AUX 58
Test Operations

AUX 58 is used to override the output disable function of the Pause instruction. Use AUX 58 to program a single output or a range of outputs which will operate normally even when those points are within the scope of the pause instruction.

AUX 5B
Counter Interface Configuration

AUX 5B is used with the High-Speed I/O (HSIO) function to select the configuration. You can choose the type of counter, set the counter parameters, etc. See Chapter 3 for a complete description of how to select the various counter features.

AUX 6* — Handheld Programmer Configuration

The following auxiliary functions allow you to setup, view, or change the Handheld Programmer configuration.

AUX 61
Show Revision Numbers

As with most industrial control products, there are cases when additional features and enhancements are made. Sometimes these new features only work with certain releases of firmware. By using AUX 61 you can quickly view the CPU and Handheld Programmer firmware revision numbers. This information (for the CPU) is also available from within ***Direct***SOFT32 from the PLC/Diagnostics sub-menu.

AUX 62
Beeper On / Off

The Handheld has a beeper that provides confirmation of keystrokes. You can use Auxiliary (AUX) Function 62 to turn off the beeper.

AUX 65
Run Self Diagnostics

If you think the Handheld Programmer is not operating correctly, you can use AUX 65 to run a self diagnostics program. You can check the following items.

- Keypad
- Display
- LEDs and Backlight
- Handheld Programmer EEPROM check

AUX 7* — EEPROM Operations

The following auxiliary functions allow you to move the ladder program from one area to another and perform other program maintenance tasks.

Transferrable Memory Areas

Many of these AUX functions allow you to copy different areas of memory to and from the CPU and handheld programmer. The following table shows the areas that may be mentioned.

Option and Memory Type	DL105 Default Range
1:PGM — Program	$00000 – $02047
2:V — V memory	$00000 – $03777
3:SYS — System	Non-selectable copies system parameters
4:etc (All)— Program, System and *non-volatile* V-memory only	Non-selectable

AUX 71 CPU to HPP EEPROM

AUX 71 copies information from the CPU memory to an EEPROM installed in the Handheld Programmer.You can copy different portions of EEPROM (HP) memory to the CPU memory as shown in the previous table.

AUX 72 HPP EEPROM to CPU

AUX 72 copies information from the EEPROM installed in the Handheld Programmer to CPU memory in the DL105. You can copy different portions of EEPROM (HP) memory to the CPU memory as shown in the previous table.

AUX 73 Compare HPP EEPROM to CPU

AUX 73 compares the program in the Handheld programmer (EEPROM) with the CPU program. You can compare different types of information as shown previously.

AUX 74 HPP EEPROM Blank Check

AUX 74 allows you to check the EEPROM in the handheld programmer to make sure it is blank. It's a good idea to use this function anytime you start to copy an entire program to an EEPROM in the handheld programmer.

AUX 75 Erase HPP EEPROM

AUX 75 allows you to clear all data in the EEPROM in the handheld programmer. You should use this AUX function before you copy a program from the CPU.

AUX 76 Show EEPROM Type

You can use AUX 76 to quickly determine what size EEPROM is installed in the Handheld Programmer.

AUX 8* — Password Operations

There are several AUX functions available that you can use to modify or enable the CPU password. You can use these features during on-line communications with the CPU, or, you can also use them with an EEPROM installed in the Handheld Programmer during off-line operation. This will allow you to develop a program in the Handheld Programmer and include password protection.

- AUX 81 — Modify Password
- AUX 82 — Unlock CPU
- AUX 83 — Lock CPU

AUX 81
Modify Password

You can use AUX 81 to provide an extra measure of protection by entering a password that prevents unauthorized machine operations. The password must be an eight-character numeric (0–9) code. Once you've entered a password, you can remove it by entering all zeros (00000000). (This is the default from the factory.)

Once you've entered a password, you can lock the CPU against access. There are two ways to lock the CPU with the Handheld Programmer.

- The CPU is always locked after a power cycle (if a password is present).
- You can use AUX 82 and AUX 83 to lock and unlock the CPU.

You can also enter or modify a password from within ***Direct***SOFT32 by using the PLC/Password sub-menu. This feature works slightly differently in ***Direct***SOFT32. Once you've entered a password, the CPU is automatically locked when you exit the software package. It will also be locked if the CPU is power cycled.

WARNING: Make *sure* you remember the password *before* you lock the CPU. Once the CPU is locked you cannot view, change, or erase the password. If you do not remember the password, you have to return the CPU to the factory for password removal.

NOTE: The DL105 CPUs support multi-level password protection of the ladder program. This allows password protection while not locking the communication port to an operator interface. The multi-level password can be invoked by creating a password with an upper case “A” followed by seven numeric characters (e.g. A1234567).

AUX 82
Unlock CPU

AUX 82 can be used to unlock a CPU that has been password protected. ***Direct***SOFT32 will automatically ask you to enter the password if you attempt to communicate with a CPU that contains a password.

AUX 83
Lock CPU

AUX 83 can be used to lock a CPU that contains a password. Once the CPU is locked, you will have to enter a password to gain access. Remember, this is not necessary with ***Direct***SOFT32 since the CPU is automatically locked whenever you exit the software package.

DL105 Error Codes

B

In This Appendix. . . .

— Error Code Table

DL105 Error Code	Description
E003 SOFTWARE TIME-OUT	If the program scan time exceeds the time allotted to the watchdog timer, this error will occur. SP51 will be on and the error code will be stored in V7755. To correct this problem use AUX 55 to extend the time allotted to the watchdog timer.
E004 INVALID INSTRUCTION	The CPU attempted to execute an instruction code, but the RAM contents had a parity error. Performing a program download to the CPU in an electrically noisy environment can corrupt a program's contents. Clear the CPU program memory, and download the program again.
E099 PROGRAM MEMORY EXCEEDED	If the compiled program length exceeds the amount of available CPU RAM this error will occur. SP52 will be on and the error code will be stored in V7755. Reduce the size of the application program.
E151 BAD COMMAND	A parity error has occurred in the application program. SP44 will be on and the error code will be stored in V7755 .This problem may possibly be due to electrical noise. Clear the memory and download the program again. Correct any grounding problems. If the error returns replace the Micro PLC.
E155 RAM FAILURE	A checksum error has occurred in the system RAM. SP44 will be on and the error code will be stored in V7755. This problem may possibly be due to a low battery, electrical noise or a CPU RAM failure. Clear the memory and download the program again. Correct any grounding problems. If the error returns replace the CPU.
E210 POWER FAULT	A short duration power drop-out occurred on the main power line supplying power to the base.

DL105 Error Code	Description
E312 HP COMM ERROR 2	A data error was encountered during communications with the CPU. Clear the error and retry the request. If the error continues check the cabling between the two devices, replace the handheld programmer, then if necessary replace the CPU. The error code will be stored in V7756.
E313 HP COMM ERROR 3	An address error was encountered during communications with the CPU. Clear the error and retry the request. If the error continues check the cabling between the two devices, replace the handheld programmer, then if necessary replace the CPU. The error code will be stored in V7756.
E316 HP COMM ERROR 6	A mode error was encountered during communications with the CPU. Clear the error and retry the request. If the error continues replace the handheld programmer, then if necessary replace the CPU. The error code will be stored in V7756.
E320 HP COMM TIME-OUT	The CPU did not respond to the handheld programmer communication request. Check to insure cabling is correct and not defective. Power cycle the system if the error continues replace the CPU first and then the handheld programmer if necessary.
E321 COMM ERROR	A data error was encountered during communication with the CPU. Check to insure cabling is correct and not defective. Power cycle the system and if the error continues replace the CPU first and then the handheld programmer if necessary.
E4** NO PROGRAM	A syntax error exists in the application program. The most common is a missing END statement. Run AUX21 to determine which one of the E4** series of errors is being flagged. SP52 will be on and the error code will be stored in V7755.
E401 MISSING END STATEMENT	All application programs must terminate with an END statement. Enter the END statement in appropriate location in your program. SP52 will be on and the error code will be stored in V7755.
E402 MISSING LBL	A MOVMC or LDLBL instruction was used without the appropriate label. Refer to the Chapter 5 for details on these instructions. SP52 will be on and the error code will be stored in V7755.
E406 MISSING IRT	An interrupt routine in the program does not end with the IRT instruction. SP52 will be on and the error code will be stored in V7755.
E421 DUPLICATE STAGE REFERENCE	Two or more SG or ISG labels exist in the application program with the same number. A unique number must be allowed for each Stage and Initial Stage. SP52 will be on and the error code will be stored in V7755.
E422 DUPLICATE LBL REFERENCE	Two or more LBL instructions exist in the application program with the same number. A unique number must be allowed for each and label. SP52 will be on and the error code will be stored in V7755.
E431 INVALID ISG/SG ADDRESS	An ISG or SG instruction must not be placed after the end statement (such as inside a subroutine). SP52 will be on and the error code will be stored in V7755.

DL105 Error Code	Description
E436 INVALID INT ADDRESS	An INT must be programmed after the end statement, not in the main body of the program. SP52 will be on and the error code will be stored in V7755.
E438 INVALID IRT ADDRESS	An IRT must be programmed after the end statement, not in the main body of the program. SP52 will be on and the error code will be stored in V7755.
E440 INVALID DATA ADDRESS	Either the DLBL instruction has been programmed in the main program area (not after the END statement), or the DLBL instruction is on a rung containing input contact(s).
E441 ACON/NCON	An ACON or NCON must be programmed after the end statement, not in the main body of the program. SP52 will be on and the error code will be stored in V7755.
E451 BAD MLS/MLR	MLS instructions must be numbered in ascending order from top to bottom.
E452 X AS COIL	An X data type is being used as a coil output.
E453 MISSING T/C	A timer or counter contact is being used where the associated timer or counter does not exist.
E454 BAD TMRA	One of the contacts is missing from a TMRA instruction.
E455 BAD CNT	One of the contacts is missing from a CNT or UDC instruction.
E456 BAD SR	One of the contacts is missing from the SR instruction.
E461 STACK OVERFLOW	More than nine levels of logic have been stored on the stack. Check the use of OR STR and AND STR instructions.
E462 STACK UNDERFLOW	An unmatched number of logic levels have been stored on the stack. Insure the number of AND STR and OR STR instructions match the number of STR instructions.
E463 LOGIC ERROR	A STR instruction was not used to begin a rung of ladder logic.
E464 MISSING CKT	A rung of ladder logic is not terminated properly.
E471 DUPLICATE COIL REFERENCE	Two or more OUT instructions reference the same I/O point.
E472 DUPLICATE TMR REFERENCE	Two or more TMR instructions reference the same number.
E473 DUPLICATE CNT REFERENCE	Two or more CNT instructions reference the same number.

DL105 Error Code	Description
E501 BAD ENTRY	An invalid keystroke or series of keystrokes was entered into the handheld programmer.
E502 BAD ADDRESS	An invalid or out of range address was entered into the handheld programmer.
E503 BAD COMMAND	An invalid command was entered in the handheld programmer.
E504 BAD REF/VAL	An invalid value or reference number was entered with an instruction.
E505 INVALID INSTRUCTION	An invalid instruction was entered into the handheld programmer.
E506 INVALID OPERATION	An invalid operation was attempted by the handheld programmer.
E520 BAD OP–RUN	An operation which is invalid in the RUN mode was attempted by the handheld programmer.
E524 BAD OP–PGM	An operation which is invalid in the PROGRAM mode was attempted by the handheld programmer.
E526 OFF LINE	The handheld programmer is in the OFFLINE mode. To change to the ONLINE mode use the MODE the key.
E527 ON LINE	The handheld programmer is in the ON LINE mode. To change to the OFF LINE mode use the MODE the key.
E528 CPU MODE	The operation attempted is not allowed during a Run Time Edit.
E540 CPU LOCKED	The CPU has been password locked. To unlock the CPU use AUX82 with the password.
E541 WRONG PASSWORD	The password used to unlock the CPU with AUX82 was incorrect.
E542 PASSWORD RESET	The CPU powered up with an invalid password and reset the password to 00000000. A password may be re-entered using AUX81.

DL105 Error Code	Description
E601 MEMORY FULL	Attempted to enter an instruction which required more memory than is available in the CPU.
E602 INSTRUCTION MISSING	A search function was performed and the instruction was not found.
E604 REFERENCE MISSING	A search function was performed and the reference was not found.
E620 OUT OF MEMORY	An attempt to transfer more data between the CPU and handheld programmer than the receiving device can hold.
E621 EEPROM NOT BLANK	An attempt to write to a non-blank EEPROM in the handheld programmer was made. Erase the EEPROM and then retry the write.
E622 NO HPP EEPROM	A data transfer was attempted with no EEPROM (or possibly a faulty EEPROM) installed in the handheld programmer.
E623 SYSTEM EEPROM	A function was requested with an EEPROM in the handheld programmer which contains system information only.
E624 V-MEMORY ONLY	A function was requested with an EEPROM in the handheld programmer which contains V-memory data only.
E625 PROGRAM ONLY	A function was requested with an EEPROM in the handheld programmer which contains program data only.
E627 BAD WRITE	An attempt to write to a write-protected or faulty EEPROM in the handheld programmer was made. Check the write protect jumper and replace the EEPROM if necessary.
E628 EEPROM TYPE ERROR	The wrong size EEPROM is being used in the handheld programmer. This error occurs when the program size is larger than what the HPP can hold.
E640 COMPARE ERROR	A compare between the EEPROM handheld programmer and the CPU was found to be in error.
E650 HPP SYSTEM ERROR	A system error has occurred in the handheld programmer. Power cycle the handheld programmer. If the error returns replace the handheld programmer.
E651 HPP ROM ERROR	A ROM error has occurred in the handheld programmer. Power cycle the handheld programmer. If the error returns replace the handheld programmer.
E652 HPP RAM ERROR	A RAM error has occurred in the handheld programmer. Power cycle the handheld programmer. If the error returns replace the handheld programmer.

C

Instruction Execution Times

In This Appendix. . . .

Introduction

This appendix contains several tables that provide the instruction execution times for DL105 Micro PLCs. Many of the execution times depend on the type of data used with the instruction. Registers may be classified into the following types:

- Data (word) Registers
- Bit Registers

V-Memory Data Registers

Some V-memory locations are considered data registers, such as timer or counter current values. Standard user V memory is classified as a V-memory data register. Note that you can load a bit pattern into these types of registers, even though their primary use is for data registers. The following locations are data registers:

Data Registers	DL105
Timer Current Values	V0 – V77
Counter Current Values	V1000 – V1077
User Data Words	V2000 – V2377 V4000 – V4177

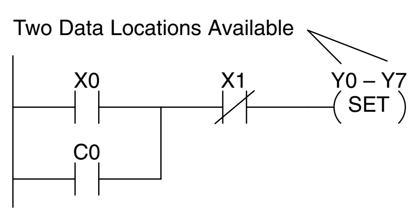
V-Memory Bit Registers

You may recall that some of the discrete points such as X, Y, C, etc. are automatically mapped into V memory (see Appendix E). The following bit registers contain this data:

Bit Registers	DL105
Input Points (X)	V40400 – V 40407
Output Points (Y)	V40500 – V40507
Control Relays (C)	V40600 – V40617
Timer Status Bits	V41100 – V41103
Counter Status Bits	V41140 – V41143
Stages	V41000 – V41017

How to Read the Tables

Some instructions can have more than one parameter. For example, the SET instruction shown in the ladder program to the right can set a single point or a range of points.



In these cases, execution times that depend on the amount and type of parameters. The execution time tables list execution times for both situations, as shown below:

SET	1st #:	X, Y, C, S		17.4 μs
	2nd #:	X, Y, C, S,	(N pt)	12.0μs+5.4μsxN
RST	1st #:	X, Y, C, S		19.5 μs
	2nd #:	X, Y, C, S,	(N pt)	10.5μs+5.2μsxN

Execution depends on numbers of locations and types of data used

Instruction Execution Times

Boolean Instructions

Boolean Instructions		DL105	
Instruction	**Legal Data Types**	**Execute**	**Not Execute**
STR	X, Y, C, T, CT,S, SP	3.3 μs	3.3 μs
STRN	X, Y, C, T, CT,S, SP	3.9 μs	3.9 μs
OR	X, Y, C, T, CT, S, SP	2.7 μs	2.7 μs
ORN	X, Y, C, T, CT,S, SP	3.3 μs	3.3 μs
AND	X, Y, C, T, CT, S, SP	2.1 μs	2.1 μs
ANDN	X, Y, C, T, CT, S, SP	2.7 μs	2.7 μs
ANDSTR	None	1.2 μs	1.2 μs
ORSTR	None	1.2 μs	1.2 μs
OUT	X, Y, C	3.4 μs	3.4 μs
OROUT	X, Y, C	8.6 μs	8.6 μs
PD	X, Y, C	13.5 μs	13.5 μs
SET	1st #: X, Y, C, S 2nd #: X, Y, C, S (N pt)	17.4 μs 12.0μs+5.4μsxN	6.8 μs 6.8 μs
RST	1st #: T, CT 2nd #: T, CT (N pt)	31.6 μs 17μs+14.6μsxN	6.8 μs 6.8 μs
PAUSE	1wd: Y 2wd: Y (N points)	19.0 μs 15μs+4μs x N	19.0 μs 15μs+4μs x N
RST	1st #: X, Y, C, S 2nd #: X, Y, C, S (N pt)	17.7 μs 10.5μs+5.2μsxN	6.8 μs 6.8 μs

Comparative Boolean Instructions

Comparative Boolean Instructions			DL105	
Instruction	**Legal Data Types**		**Execute**	**Not Execute**
STRE	1st	2nd		
	V: Data Reg.	V:Data Reg. V:Bit Reg. K:Constant	77 μs 158 μs 57 μs	13.8 μs 13.8 μs 13.8 μs
	V: Bit Reg.	V:Data Reg. V:Bit Reg. K:Constant	158 μs 240 μs 139 μs	13.8 μs 13.8 μs 13.8 μs
STRNE	1st	2nd		
	V: Data Reg.	V:Data Reg. V:Bit Reg. K:Constant	77 μs 158 μs 57 μs	13.8 μs 13.8 μs 13.8 μs
	V: Bit Reg.	V:Data Reg. V:Bit Reg. K:Constant	158 μs 240 μs 139 μs	13.8 μs 13.8 μs 13.8 μs

Comparative Boolean (cont.)			DL105	
Instruction	**Legal Data Types**		**Execute**	**Not Execute**
ORE	1st	2nd		
	V: Data Reg.	V:Data Reg. V:Bit Reg. K:Constant	75 µs 158 µs 55 µs	12.0 µs 12.0 µs 12.0 µs
	V: Bit Reg.	V:Data Reg. V:Bit Reg. K:Constant	158 µs 239 µs 137 µs	12.0 µs 12.0 µs 12.0 µs
ORNE	1st	2nd		
	V: Data Reg.	V:Data Reg. V:Bit Reg. K:Constant	75 µs 158 µs 55 µs	12.0 µs 12.0 µs 12.0 µs
	V: Bit Reg.	V:Data Reg. V:Bit Reg. K:Constant	158 µs 239 µs 137 µs	12.0 µs 12.0 µs 12.0 µs
ANDE	1st	2nd		
	V: Data Reg.	V:Data Reg. V:Bit Reg. K:Constant	75 µs 158 µs 55 µs	12.0 µs 12.0 µs 12.0 µs
	V: Bit Reg.	V:Data Reg. V:Bit Reg. K:Constant	158 µs 239 µs 137 µs	12.0 µs 12.0 µs 12.0 µs
ANDNE	1st	2nd		
	V: Data Reg.	V:Data Reg. V:Bit Reg. K:Constant	75 µs 158 µs 55 µs	12.0 µs 12.0 µs 12.0 µs
	V: Bit Reg.	V:Data Reg. V:Bit Reg. K:Constant	158 µs 239 µs 137 µs	12.0 µs 12.0 µs 12.0 µs
STR	1st	2nd		
	T, CT	V:Data Reg. V:Bit Reg. K:Constant	78 µs 158 µs 57 µs	13.8 µs 13.8 µs 13.8 µs
	1st	2nd		
	V: Data Reg.	V:Data Reg. V:Bit Reg. K:Constant	78 µs 159 µs 57 µs	13.8 µs 13.8 µs 13.8 µs
	V: Bit Reg.	V:Data Reg. V:Bit Reg. K:Constant	159 µs 241 µs 139 µs	13.8 µs 13.8 µs 13.8 µs
STRN	1st	2nd		
	T, CT	V:Data Reg. V:Bit Reg. K:Constant	78 µs 158 µs 57 µs	13.8 µs 13.8 µs 13.8 µs
	1st	2nd		
	V: Data Reg.	V:Data Reg. V:Bit Reg. K:Constant	78 µs 159 µs 57 µs	13.8 µs 13.8 µs 13.8 µs
	V: Bit Reg.	V:Data Reg. V:Bit Reg. K:Constant	159 µs 241 µs 139 µs	13.8 µs 13.8 µs 13.8 µs

Comparative Boolean (cont.)			DL105	
Instruction	Legal Data Types		Execute	Not Execute
OR	1st	2nd		
	T, CT	V:Data Reg. V:Bit Reg. K:Constant	75 µs 158 µs 55 µs	12.0 µs 12.0 µs 12.0 µs
	1st	2nd		
	V: Data Reg.	V:Data Reg. V:Bit Reg. K:Constant	75 µs 158 µs 55 µs	12.0 µs 12.0 µs 12.0 µs
	V: Bit Reg.	V:Data Reg. V:Bit Reg. K:Constant	158 µs 240 µs 137 µs	12.0 µs 12.0 µs 12.0 µs
ORN	1st	2nd		
	T, CT	V:Data Reg. V:Bit Reg. K:Constant	75 µs 158 µs 55 µs	12.0 µs 12.0 µs 12.0 µs
	1st	2nd		
	V: Data Reg.	V:Data Reg. V:Bit Reg. K:Constant	75 µs 158 µs 55 µs	12.0 µs 12.0 µs 12.0 µs
	V: Bit Reg.	V:Data Reg. V:Bit Reg. K:Constant	158 µs 240 µs 137 µs	12.0 µs 12.0 µs 12.0 µs
AND	1st	2nd		
	T, CT	V:Data Reg. V:Bit Reg. K:Constant	76 µs 158 µs 55 µs	12.0 µs 12.0 µs 12.0 µs
	1st	2nd		
	V: Data Reg.	V:Data Reg. V:Bit Reg. K:Constant	75 µs 158 µs 55 µs	12.0 µs 12.0 µs 12.0 µs
	V: Bit Reg.	V:Data Reg. V:Bit Reg. K:Constant	158 µs 240 µs 137 µs	12.0 µs 12.0 µs 12.0 µs
ANDN	1st	2nd		
	T, CT	V:Data Reg. V:Bit Reg. K:Constant	76 µs 158 µs 55 µs	12.0 µs 12.0 µs 12.0 µs
	1st	2nd		
	V: Data Reg.	V:Data Reg. V:Bit Reg. K:Constant	76 µs 158 µs 55 µs	12.0 µs 12.0 µs 12.0 µs
	V: Bit Reg.	V:Data Reg. V:Bit Reg. K:Constant	158 µs 240 µs 137 µs	12.0 µs 12.0 µs 12.0 µs

Immediate Instructions

Immediate Instructions		DL105	
Instruction	Legal Data Types	Execute	Not Execute
STRI	X	27 µs	9.8 µs
STRNI	X	26 µs	8.6 µs
ORI	X	27 µs	9.8 µs
ORNI	X	26 µs	8.6 µs
ANDI	X	25 µs	8.0 µs
ANDNI	X	24 µs	6.8 µs
OROUTI	Y	45 µs	45 µs
SETI	1st #: Y 2nd #: Y (N pt)	25.5 µs 5.5 µs+20 x N	6.8 µs 6.8 µs
RSTI	1st #: Y 2nd #: Y (N pt)	25.5 µs 5 µs+20.5 x N	6.8 µs 6.8 µs

Timer, Counter, Shift Register, EDRUM Instructions

Timer, Counter, Shift Register, and Drum Instructions			DL105	
Instruction	Legal Data Types		Execute	Not Execute
TMR	1st	2nd		
	T	V:Data Reg. V:Bit Reg. K:Constant	75 µs 158 µs 66 µs	31 µs 31 µs 31 µs
TMRF	1st	2nd		
	T	V:Data Reg. V:Bit Reg. K:Constant	75 µs 158 µs 66 µs	31 µs 31 µs 31 µs
TMRA	1st	2nd		
	T	V:Data Reg. V:Bit Reg. K:Constant	94 µs 304 µs 95 µs	56 µs 264 µs 45 µs
TMRAF	1st	2nd		
	T	V:Data Reg. V:Bit Reg. K:Constant	98 µs 304 µs 95 µs	54 µs 264 µs 49 µs
CNT	1st	2nd		
	CT	V:Data Reg. V:Bit Reg. K:Constant	68 µs 148 µs 56 µs	61 µs 141 µs 45 µs
SGCNT	1st	2nd		
	CT	V:Data Reg. V:Bit Reg. K:Constant	57 µs 140 µs 46 µs	64 µs 148 µs 53 µs

Timer, Counter, Shift Register, and Drum Instructions Cont'd		DL105	
Instruction	**Legal Data Types**	**Execute**	**Not Execute**
UDC	1st 2nd CT V:Data Reg. V:Bit Reg. K:Constant	 103 µs 310 µs 102 µs	 74 µs 281 µs 70 µs
SR	C (N points to shift)	30 µs+4.6 µs xN	17.2 µs
EDRUM	CT	320 µs	221 µs

Accumulator Data Instructions

Accumulator / Stack Load and Output Data Instructions		DL105	
Instruction	**Legal Data Types**	**Execute**	**Not Execute**
LD	V:Data Reg. V:Bit Reg. K:Constant P:Indir. (Data) P:Indir. (Bit)	68 µs 149 µs 62 µs 169 µs 256 µs	8.4 µs 8.4 µs 8.4 µs 8.4 µs 8.4 µs
LDD	V:Data Reg. V:Bit Reg. K:Constant P:Indir. (Data) P:Indir. (Bit)	72 µs 266 µs 64 µs 172 µs 373 µs	8.4 µs 8.4 µs 8.4 µs 8.4 µs 8.4 µs
LDF	1st 2nd X, Y, C, S K:Constant T, CT, SP (N pt)	77 µs+6.2 µs xN	10 µs
LDA	O: (Octal constant for address)	58 µs	8.4 µs
OUT	V:Data Reg. V:Bit Reg. P:Indir. (Data) P:Indir. (Bit)	60 µs 132 µs 162 µs 239 µs	8.4 µs 8.4 µs 8.4 µs 8.4 µs
OUTD	V:Data Reg. V:Bit Reg. P:Indir. (Data) P:Indir. (Bit)	68 µs 276 µs 196 µs 384 µs	8.4 µs 8.4 µs 8.4 µs 8.4 µs
OUTF	1st 2nd X, Y, C K:Constant (N pt)	36 µs+7.6 µs xN	8 µs
POP	None	55 µs	7.2 µs

Logical Instructions

Logical (Accumulator) Instructions		DL105	
Instruction	Legal Data Types	Execute	Not Execute
AND	V:Data Reg. V:Bit Reg.	63 µs 261 µs	10.4 µs 10.4 µs
ANDD	K:Constant	53 µs	8.4 µs
OR	V:Data Reg. V:Bit Reg.	59 µs 257 µs	10.4 µs 10.4 µs
ORD	K:Constant	49 µs	8.4 µs
XOR	V:Data Reg. V:Bit Reg.	60 µs 257 µs	10.4 µs 10.4 µs
XORD	K:Constant	49 µs	8.4 µs
CMP	V:Data Reg. V:Bit Reg.	59 µs 259 µs	10.4 µs 10.4 µs
CMPD	V:Data Reg. V:Bit Reg. K:Constant	63 µs 257 µs 54 µs	8.4 µs 8.4 µs 8.4 µs

Math Instructions

Math Instructions (Accumulator)		DL105	
Instruction	Legal Data Types	Execute	Not Execute
ADD	V:Data Reg. V:Bit Reg.	198 µs 397 µs	10.6 µs 10.6 µs
ADDD	V:Data Reg. V:Bit Reg. K:Constant	198 µs 397 µs 188 µs	8.4 µs 8.4 µs 8.4 µs
SUB	V:Data Reg. V:Bit Reg.	200 µs 397 µs	10.6 µs 10.6 µs
SUBD	V:Data Reg. V:Bit Reg. K:Constant	198 µs 392 µs 190 µs	8.4 µs 8.4 µs 8.4 µs
MUL	V:Data Reg. V:Bit Reg. K:Constant	497 µs 483 µs 487 µs	10.6 µs 10.6 µs 8.4 µs
DIV	V:Data Reg. V:Bit Reg. K:Constant	909 µs 1108 µs 899 µs	10.6 µs 10.6 µs 8.4 µs
INCB	V:Data Reg. V:Bit Reg.	83 µs 349 µs	10.4 µs 10.4 µs
DECB	V:Data Reg. V:Bit Reg.	82 µs 351 µs	10.4 µs 10.4 µs

Bit Instructions

Bit Instructions (Accumulator)		DL105	
Instruction	Legal Data Types	Execute	Not Execute
SHFR	V:Data Reg. (N bits) V:Bit Reg. (N bits) K:Constant (N bits)	44μs+14.6 x N 243μs+14.6 x N 34μs+14.6 x N	10.4 μs 10.4 μs 8.4 μs
SHFL	V:Data Reg. (N bits) V:Bit Reg. (N bits) K:Constant (N bits)	44μs+14.6 x N 243μs+14.6 x N 34μs+14.6 x N	10.4 μs 10.4 μs 8.4 μs
ENCO	None	62 μs	7.2 μs
DECO	None	34 μs	7.2 μs

Number Conversion Instructions

Number Conversion Instructions (Accumulator)		DL105	
Instruction	Legal Data Types	Execute	Not Execute
BIN	None	359 μs	7.2 μs
BCD	None	403 μs	7.2 μs
INV	None	27 μs	5.0 μs

Table Instructions

Table Instructions		DL105	
Instruction	Legal Data Types	Execute	Not Execute
MOV	Move V:data reg. to V:data reg. Move V:bit reg. to V:data reg. Move V:data reg to V:bit reg. Move V:bit reg. to V:bit reg. N= #of words	450μs+17 x N 430μs+244 x N 460μs+215 x N 490μs+448 x N	6.2μs 6.2μs 6.2μs 6.2μs
MOVMC	Move V:Data Reg. to E^2 Move V:Bit Reg. to E^2 Move from E^2 to V:Data Reg. Move from E^2 to V:Bit Reg. N= #of words	— — 250μs+201xN —	— — 6.2μs —
LDLBL	K	58μs	8.4μs

CPU Control Instructions

CPU Control Instructions		DL105	
Instruction	Legal Data Types	Execute	Not Execute
NOP	None	0 µs	0 µs
END	None	27 µs	27 µs
STOP	None	16 µs	5 µs

Program Control Instructions

Program Control Instructions		DL105	
Instruction	Legal Data Types	Execute	Not Execute
MLS	K (1–7)	12 µs	12 µs
MLR	K (0–6) N= 1 to 7	13 µs + 2.4 x N	13 µs + 2.4 x N

Interrupt Instructions

Interrupt Instructions		DL105	
Instruction	Legal Data Types	Execute	Not Execute
ENI	None	9 µs	5 µs
DISI	None	8 µs	5 µs
INT	O0	0 µs	0 µs
IRT	None	1.6 µs	—

Message Instructions

Message Instructions		DL105	
Instruction	Legal Data Types	Execute	Not Execute
FAULT	V:Data Reg. V:Bit Reg. K:Constant	171 µs 253 µs 2798 µs	8.4 µs 8.4 µs 8.4 µs
DLBL	K	0 µs	0 µs
NCON	K	0 µs	0 µs
ACON	K	0 µs	0 µs

RLL*PLUS* Instructions

RLL*PLUS* Instructions		DL105	
Instruction	Legal Data Types	Execute	Not Execute
ISG	S	31 µs	32 µs
SG	S	31 µs	32 µs
JMP	S	14 µs	8 µs

Special Relays

D

In This Appendix. . . .

DL105 PLC Special Relays

“Special Relays” are just contacts that are set by the CPU operating system to indicate a particular system event has occurred. These contacts are available for use in your ladder program. Knowing just the right special relay contact to use for a particular situation can save lot of programming time. Since the CPU operating system sets and clears special relay contacts, the ladder program only has to use them as inputs in ladder logic.

Startup and Real-Time Relays

SP0	First scan	on for the first scan after a power cycle or program to run transition only. The relay is reset to off on the second scan. It is useful where a function needs to be performed only on program startup.
SP1	Always ON	provides a contact to insure an instruction is executed every scan.
SP3	1 minute clock	on for 30 seconds and off for 30 seconds.
SP4	1 second clock	on for 0.5 second and off for 0.5 second.
SP5	100 ms clock	on for 50 ms. and off for 50 ms.
SP6	50 ms clock	on for 25 ms. and off for 25 ms.
SP7	Alternate scan	on every other scan.

CPU Status Relays

SP12	Terminal run mode	on when the CPU is in the run mode.
SP16	Terminal program mode	on when the CPU is in the program mode.
SP20	Forced stop mode	on when the STOP instruction is executed.
SP22	Interrupt enabled	on when interrupts have been enabled using the ENI instruction.

System Monitoring

SP40	Critical error	on when a critical error such as I/O communication loss has occurred.
SP41	Warning	on when a non critical error such as a low battery has occurred.
SP44	Program memory error	on when a memory error such as a memory parity error has occurred.
SP50	Fault instruction	on when a Fault Instruction is executed.
SP51	Watch Dog timeout	on if the CPU Watch Dog timer times out.
SP52	Grammatical error	on if a grammatical error has occurred either while the CPU is running or if the syntax check is run. V7755 will hold the exact error code.
SP53	Solve logic error	on if CPU cannot solve the logic.

Accumulator Status

SP60	Value less than	on when the accumulator value is less than the instruction value.
SP61	Value equal to	on when the accumulator value is equal to the instruction value.
SP62	Greater than	on when the accumulator value is greater than the instruction value.
SP63	Zero	on when the result of the instruction is zero (in the accumulator.)
SP64	Half borrow	on when the 16 bit subtraction instruction results in a borrow.
SP65	Borrow	on when the 32 bit subtraction instruction results in a borrow.
SP66	Half carry	on when the 16 bit addition instruction results in a carry.
SP67	Carry	when the 32 bit addition instruction results in a carry.
SP70	Sign	on anytime the value in the accumulator is negative.
SP71	Invalid octal number	on when an Invalid octal number was entered. This also occurs when the V-memory specified by a pointer (P) is not valid.
SP73	Overflow	on if overflow occurs in the accumulator when a signed addition or subtraction results in an incorrect sign bit.
SP75	Data error	on if a BCD number is expected and a non–BCD number is encountered.
SP76	Load zero	on when any instruction loads a value of zero into the accumulator.

HSIO Pulse Catch Relay

SP100	X0 is on	X0 — on for 1 scan after a pulse on X0 occurs.

Equal Relays for HSIO Mode 10 Counter Presets

SP540	Current = target value	on when the counter current value equals the value in V2320.
SP541	Current = target value	on when the counter current value equals the value in V2322.
SP542	Current = target value	on when the counter current value equals the value in V2324.
SP543	Current = target value	on when the counter current value equals the value in V2326.
SP544	Current = target value	on when the counter current value equals the value in V2330.
SP545	Current = target value	on when the counter current value equals the value in V2332.
SP546	Current = target value	on when the counter current value equals the value in V2334.
SP547	Current = target value	on when the counter current value equals the value in V2336.
SP550	Current = target value	on when the counter current value equals the value in V2340.
SP551	Current = target value	on when the counter current value equals the value in V2342.
SP552	Current = target value	on when the counter current value equals the value in V2344.
SP553	Current = target value	on when the counter current value equals the value in V2346
SP554	Current = target value	on when the counter current value equals the value in V2350.
SP555	Current = target value	on when the counter current value equals the value in V2352.
SP556	Current = target value	on when the counter current value equals the value in V2354.
SP557	Current = target value	on when the counter current value equals the value in V2356.
SP560	Current = target value	on when the counter current value equals the value in V2360.
SP561	Current = target value	on when the counter current value equals the value in V2362.
SP562	Current = target value	on when the counter current value equals the value in V2364.
SP563	Current = target value	on when the counter current value equals the value in V2366.
SP564	Current = target value	on when the counter current value equals the value in V2370.
SP565	Current = target value	on when the counter current value equals the value in V2372.
SP566	Current = target value	on when the counter current value equals the value in V2374.
SP567	Current = target value	on when the counter current value equals the value in V2376.

E

PLC Memory

In This Appendix. . . .

— DL105 PLC Memory

DL105 PLC Memory

When designing a PLC application, it is important for the PLC user to understand the different types of memory in the PLC. Two types of memory are used by the DL105 CPU, RAM and EEPROM. This memory can be configured by the PLC user as either retentive or non–retentive memory.

Retentive memory is memory that is configured by the user to maintain values through a power cycle or a PROGRAM to RUN transition. Non–retentive memory is memory that is configured by the PLC user to clear data after a power cycle or a PROGRAM to RUN transition. The retentive ranges can can be configured with either the handheld programmer using AUX 57 or ***Direct***SOFT32 (PLC Setup).

The contents of RAM memory can be written to and read from for an infinite number of times, but RAM requires a power source to maintain the contents of memory.The contents of RAM are maintained by the internal power supply (5VDC) only while the PLC is powered by an external source, normally 120VAC. When power to the PLC is turned off, the contents of RAM are maintained by a “Super–Capacitor”. If the Super–Capacitor ever discharges, the contents of RAM will be lost. The data retention time of the Super–Capacitor backed RAM is 3 weeks maximum, and 4 1/2 days minimum (at 60° C).

The contents of EEPROM memory can be read from for an infinite number of times but there is a limit to the number of times it can be written to (typical specification is 100,000 writes). EEPROM does not require a power source to maintain the memory contents. It will retain the contents of memory indefinately.

PLC user V–memory is stored in both volatile RAM and non–volatile EEPROM memory. Data being stored in RAM uses V2000–V2377. Data stored in EEPROM uses V4000–V4177 and V7630–V7647.

Data values that must be retained for long periods of time, when the PLC is powered off, should be stored in EEPROM based V–memory.

Data values that are continually changing or which can be initialized with program logic should be stored in RAM based V–memory.

F

European Union Directives (CE)

In This Appendix. . . .

— European Union (EU) Directives
— Basic EMC Installation Guidelines

European Union (EU) Directives

NOTE: The information contained in this section is intended as a guideline and is based on our interpretation of the various standards and requirements. Since the actual standards are issued by other parties and in some cases Governmental agencies, the requirements can change over time without advance warning or notice. Changes or additions to the standards can possibly invalidate any part of the information provided in this section.

This area of certification and approval is absolutely vital to anyone who wants to do business in Europe. One of the key tasks that faced the EU member countries and the European Economic Area (EEA) was the requirement to bring several similar yet distinct standards together into one common standard for all members. The primary purpose of a single standard was to make it easier to sell and transport goods between the various countries and to maintain a safe working and living environment. The Directives that resulted from this merging of standards are now legal requirements for doing business in Europe. Products that meet these Directives are required to have a CE mark to signify compliance.

Member Countries

As of January 1, 1997, the members of the EU are Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, The Netherlands, Portugal, Spain, Sweden, and the United Kingdom. Iceland, Liechtenstein, and Norway together with the EU members make up the European Economic Area (EEA) and all are covered by the Directives.

Applicable Directives

There are several Directives that apply to our products. Directives may be amended, or added, as required.

- **Electromagnetic Compatibility Directive (EMC)** — this Directive attempts to ensure that products placed on the market do not generate electromagnetic disturbances that would affect other apparatus, including radio and/or telecommunications equipment.
- **Machinery Safety Directive** — this Directive covers the safety aspects of the equipment, installation, etc. There are several areas involved, including testing standards covering both electrical noise immunity and noise generation.
- **Low Voltage Directive** — this Directive is also safety related and covers electrical equipment that has voltage ranges of 50–1000VAC and/or 75–1500VDC.
- **Battery Directive** — this Directive covers the production, recycling, and disposal of batteries.

Compliance

Certain standards within each Directive already require mandatory compliance. The EMC Directive, which has gained the most attention, became mandatory as of January 1, 1996. The Low Voltage Directive became mandatory as of January 1, 1997.

Ultimately, we are all responsible for our various pieces of the puzzle. As manufacturers, we must test our products and document any test results and/or installation procedures that are necessary to comply with the Directives. As a machine builder, you are responsible for installing the products in a manner which will ensure compliance is maintained. You are also responsible for testing any combinations of products that may (or may not) comply with the Directives when used together.

The end user of the products must comply with any Directives that may cover maintenance, disposal, etc. of equipment or various components. *Although we strive to provide the best assistance available, it is impossible for us to test all possible configurations of our products with respect to any specific Directive. Because of this, it is ultimately your responsibility to ensure that your machinery (as a whole) complies with these Directives and to keep up with applicable Directives and/or practices that are required for compliance.*

As of July 1, 1997, the DL105 (F1–130DR–CE, F1–130DD–CE, F1–130DR–D, and F1–130DD–D versions only), DL205, DL305, and DL405 PLC systems manufactured by Koyo Electronics Industries or FACTS Engineering, when properly installed and used, conform to the Electromagnetic Compatibility (EMC), Low Voltage Directive, and Machinery Directive requirements of the following standards.

- **Emissions**
  EN50081–1 Generic domestic and light industrial environment
  EN50081–2 Generic heavy industrial environment
- **Immunity**
  EN50082–1 Generic domestic and light industrial environment
  EN50082–2 Generic heavy industrial environment
- **Low Voltage Directive**
  EN61131–2 PLC Product Standard
  EN61010–1 Installation Category 1
- **Machinery Directive**
  EN60204–1 Safety of Machinery

Special Installation Manual

The installation requirements to comply with the requirements of the Machinery Directive, EMC Directive and Low Voltage Directive are slightly more complex than the normal installation requirements found in the United States. To help with this, we have published a special manual which you can order:

- **DA–EU–M** – EU Installation Manual that covers special installation requirements to meet the EU Directive requirements. Order this manual to obtain the most up-to-date information.

Other Sources of Information

Although the EMC Directive gets the most attention, other basic Directives, such as the Machinery Directive and the Low Voltage Directive, also place restrictions on the control panel builder. Because of these additional requirements it is recommended that the following publications be purchased and used as guidelines:

- BSI publication TH 42073: February 1996 – covers the safety and electrical aspects of the Machinery Directive
- EN 60204–1:1992 – General electrical requirements for machinery, including Low Voltage and EMC considerations
- IEC 1000–5–2: EMC earthing and cabling requirements
- IEC 1000–5–1: EMC general considerations

It may be possible for you to obtain this information locally; however, the official source of applicable Directives and related standards is:

The Office for Official Publications of the European Communities
L–2985 Luxembourg; quickest contact is via the World Wide Web at
http://euro–op.eu.int/indexn.htm

Another source is:

British Standards Institution – Sales Department
Linford Wood
Milton Keynes
MK14 6LE
United Kingdom; the quickest contact is via the World Wide Web at
http://www.bsi.org.uk

Basic EMC Installation Guidelines

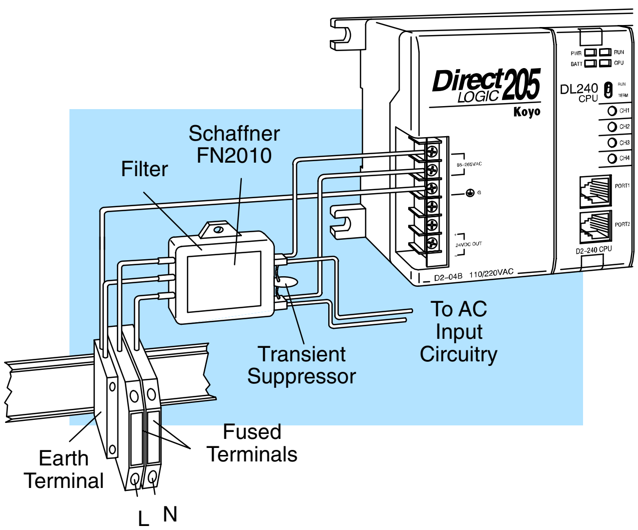
Enclosures

The simplest way to meet the safety requirements of the Machinery and Low Voltage Directives is to house all control equipment in an industry standard lockable steel enclosure. This has an added benefit because it will also help ensure that the EMC characteristics are well within the requirements of the EMC Directive. Although the RF emissions from the PLC equipment, when measured in the open air, are well below the EMC Directive limits, certain configurations can increase emission levels.

For example, where several identical DL305 or DL405 CPU and expansion rack power supplies are incorporated into one enclosure, small variations in the RF emission frequencies of the different supplies can add together to raise the total emission levels. Standard industrial steel enclosures without any special shielding measures will easily provide 30–50 dB attenuation which gives a wide margin for error. Holes in the enclosure, for the passage of cables or to mount operator interfaces, will only expose single PLC units, so no special precautions need to be taken. However, glass door enclosures should be avoided in situations where multiple units are housed in the control cubicle.

AC Mains Filters

DL105, DL205 and DL305 AC powered base power supplies require extra mains filtering to comply with the EMC Directive on conducted RF emissions. All PLC equipment has been tested with filters from Schaffner, which reduce emissions to negligible levels if the filters are properly grounded (earth ground). A filter with a current rating suitable to supply all PLC power supplies and AC input modules should be selected. We suggest the FN2010 for DL105/DL205 systems and the FN2080 for DL305 systems. DL405 systems do not require extra filtering.



Suppression and Fusing

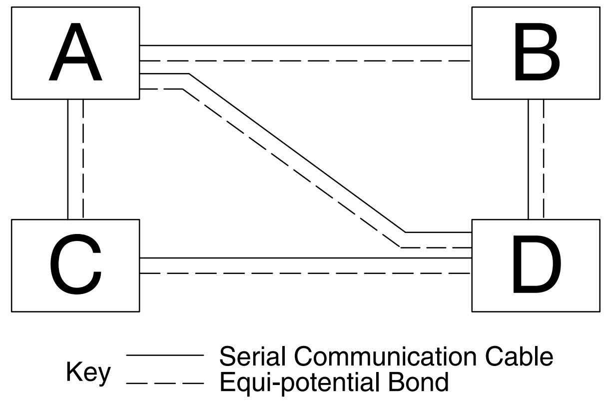
In order to comply with the fire risk requirements of the Low Voltage and Machinery Directive electrical standards EN 61010–1, and EN 60204–1, by limiting the power into "unlimited" mains circuits with power leads reversed, it is necessary to fuse both AC and DC supply inputs. You should also install a transient voltage suppressor across the power input connections of the PLC. Choose a suppressor such as a metal oxide varistor, with a rating of 275VAC working voltage for 230V nominal supplies (150VAC working voltage for 115V supplies) and high energy capacity (eg. 140 joules).

Transient suppressors must be protected by fuses and the capacity of the transient suppressor must be greater than the blow characteristics of the fuses or circuit breakers to avoid a fire risk. A recommended AC supply input arrangement for Koyo PLCs is to use twin 3 amp TT fused terminals with fuse blown indication, such as DINnectors DN–F10L terminals, or twin circuit breakers, wired to a Schaffner FN2010 filter or equivalent, with high energy transient suppressor soldered directly across the output terminals of the filter. PLC system inputs should also be protected from voltage impulses by deriving their power from the same fused, filtered, and surge-suppressed supply.

Internal Enclosure Grounding

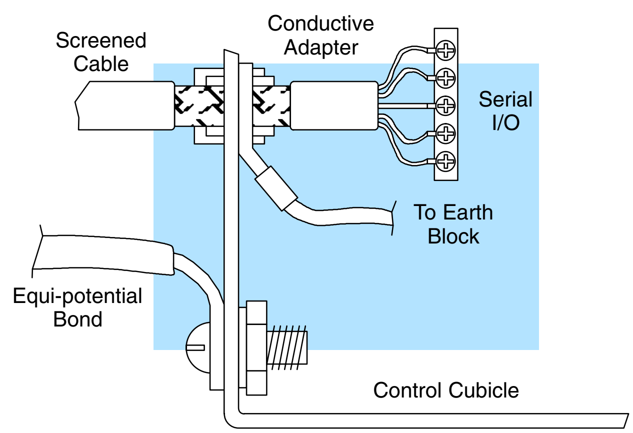
A heavy-duty star earth terminal block should be provided in every cubicle for the connection of all earth ground straps, protective earth ground connections, mains filter earth ground wires, and mechanical assembly earth ground connections. This should be installed to comply with safety and EMC requirements, local standards, and the requirements found in IEC 1000–5–2.The Machinery Directive also requires that the common terminals of PLC input modules, and common supply side of loads driven from PLC output modules should be connected to the protective earth ground terminal.

Equi–potential Grounding



Adequate site earth grounding must be provided for equipment containing modern electronic circuitry. The use of isolated earth electrodes for electronic systems is forbidden in some countries. Make sure you check any requirements for your particular destination. IEC 1000–5–2 covers equi-potential bonding of earth grids adequately, but special attention should be given to apparatus and control cubicles that contain I/O devices, remote I/O racks, or have inter-system communications with the primary PLC system enclosure. An equi-potential bond wire must be provided alongside all serial communications cables, and to any separate items of the plant which contain I/O devices connected to the PLC. The diagram shows an example of four physical locations connected by a communications cable.

Communications and Shielded Cables



Good quality 24 AWG minimum twisted-pair shielded cables, with overall foil and braid shields are recommended for analog cabling and communications cabling outside of the PLC enclosure. To date it has been a common practice to only provide an earth ground for one end of the cable shield in order to minimize the risk of noise caused by earth ground loop currents between apparatus. The procedure of only grounding one end, which primarily originated as a result of trying to reduce hum in audio systems, is no longer applicable to the complex industrial environment. Shielded cables are also efficient emitters of RF noise from the PLC system, and can interact in a parasitic manner in networks and between multiple sources of interference.

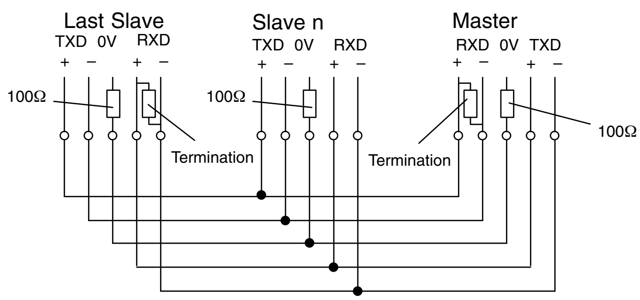
The recommendation is to use shielded cables as electrostatic "pipes" between apparatus and systems, and to run heavy gauge equi-potential bond wires alongside all shielded cables. When a shielded cable runs through the metallic wall of an enclosure or machine, it is recommended in IEC 1000–5–2 that the shield should be connected over its full perimeter to the wall, preferably using a conducting adapter, and not via a pigtail wire connection to an earth ground bolt. Shields must be connected to every enclosure wall or machine cover that they pass through.

Analog and RS232 Cables

Providing an earth ground for both ends of the shield for analog circuits provides the perfect electrical environment for the twisted pair cable as the loop consists of signal and return, in a perfectly balanced circuit arrangement, with connection to the common of the input circuitry made at the module terminals. RS232 cables are handled in the same way.

Multidrop Cables

RS422 twin twisted pair, and RS485 single twisted pair cables also require a 0V link, which has often been provided in the past by the cable shield. It is now recommended that you use triple twisted pair cabling for RS422 links, and twin twisted pair cable for RS485 links. This is because the extra pair can be used as the 0V inter-system link. With loop DC power supplies earth grounded in both systems, earth loops are created in this manner via the inter-system 0v link. The installation guides encourage earth loops, which are maintained at a low impedance by using heavy equi-potential bond wires. **To account for non–European installations using single-end earth grounds, and sites with far from ideal earth ground characteristics, we recommend the addition of 100 ohm resistors at each 0V link connection in network and communications cables.**



Shielded Cables within Enclosures

When you run cables between PLC items within an enclosure which also contains susceptible electronic equipment from other manufacturers, remember that these cables may be a source of RF emissions. There are ways to minimize this risk. Standard data cables connecting PLCs and/or operator interfaces should be routed well away from other equipment and their associated cabling. You can make special serial cables where the cable shield is connected to the enclosure's earth ground at both ends, the same way as external cables are connected.

Network Isolation

For safety reasons, it is a specific requirement of the Machinery Directive that a keyswitch must be provided that isolates any network input signal during maintenance, so that remote commands cannot be received that could result in the operation of the machinery. The FA–ISONET does not have a keyswitch! Use a keylock and switch on your enclosure which when open removes power from the FA–ISONET. To avoid the introduction of noise into the system, any keyswitch assembly should be housed in its own earth grounded steel box and the integrity of the shielded cable must be maintained.

Again, for further information on EU directives we recommend that you get a copy of our EU Installation Manual (DA–EU–M). Also, if you are connected to the World Wide Web, you can check the EU Commision's official site at: http://eur–op.eu.int/

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1

Getting Started

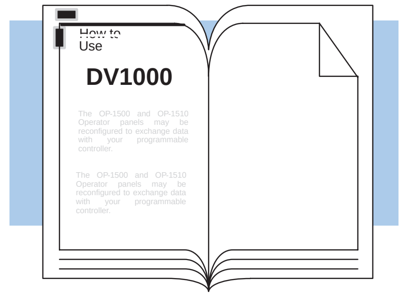
In This Chapter. . . .

— Introduction
— *Direct*VIEW™ 1000 Features
— Display and Keypad Basics
— Setup Parameters, the Key to DV-1000 Success
— Quick Tour of DV-1000 Operation
— Operator Interface Design Basics
— Frequently Asked Questions
— Specifications

Introduction

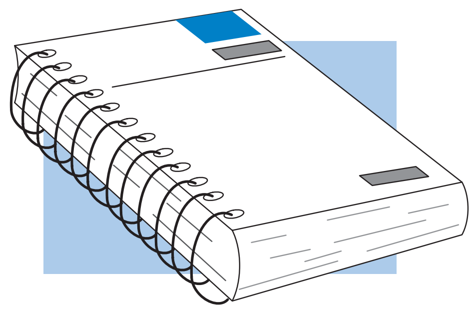
The Purpose of this Manual

This manual shows the various features and modes of the ***Direct***VIEW 1000 (DV-1000). Your application may require the use of some of these modes, or all of them. This manual can help you decide which modes to use, and how to configure the CPU to support the DV-1000 in those modes. In the chapters on DV-1000 operational modes there are example programs to help you write the required supporting ladder program. If you are a new user, however, you may need to refer to the User Manual for the PLC you are using.



Supplemental Manuals

The DL105 User Manual (D1-USER-M), the DL205 User Manual (D2–USER–M), the DL305 User Manual (D3-USER-M; make sure you have the version covering the DL350 CPU) and the DL405 User Manual (D4–USER–M) contain related information, such as the instruction set definitions for your CPU type. In addition, the ***Direct***Soft Quick Start Manual (QS-DSOFT-M) may also be useful. These manuals are not absolutely necessary to use the DV-1000, but might come in handy for an occasional reference.



Technical Support

We realize that even though we strive to be the best, we may have arranged our information in such a way you cannot find what you are looking for. First, check these resources for help in locating the information:

- **Table of Contents** – chapter and section listing of contents, in the front of this manual
- **Quick Guide to Contents** – chapter summary listing on the next page
- **Appendices** – reference material for key topics
- **Index** – alphabetical listing of key words, at the end of this manual

You can also check our online resources for the latest product support information:

- **Internet** – the address of our Web site is http://www.plcdirect.com
- **Bulletin Board Service (BBS)** – call (770)–844–4209

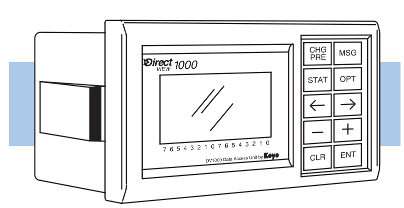
If you still need assistance, please call us at 800–633–0405. Our technical support group is glad to work with you in answering your questions. They are available Monday through Friday from 9:00 A.M. to 6:00 P.M. Eastern Standard Time. If you have a comment or question about any of our products, services, or manuals, please fill out and return the 'Suggestions' card that was shipped with this manual.

Chapters The main contents of this manual are organized into the following seven chapters and Appendices A, B and C:

1	**Getting Started**	provides an overview of the features and provides general specifications. The importance of setup parameters and what they do are shown. "Quick Tour of DV–1000 Operation" covers the operational modes and the main features of each mode. A list of *Frequently Asked Questions* is located near the end of this chapter.
2	**Installation Guide**	explains how to select the CPU type and a communications cable, how to mount the unit in a control panel and connect it to your CPU, and how to install the example programs disk and start ***Direct***SOFT to begin your ladder program.
3	**DV–1000 Setup Parameters**	explains the purpose of setup parameters, how they are used, and gives example programs. Special topics include selecting the Powerup Default Mode.
4	**Message Display Mode**	shows how to access System Messages, including Error Messages and Fault Messages. It covers User Messages, and shows how to create your own text and numeric output and includes several example programs.
5	**Status Display Mode**	tells how to view the status of CPU data types (X, Y, GX, C, SP, T, CT, S, V and P).
6	**Change Preset Mode**	covers the concept of changing V-memory data, the three types of titles you may attach to the values as labels, and password protection (optional) for changing preset values. An Operator's Guide covers the keypad procedure for changing presets.
7	**Bit Control Mode**	discusses how to enter and exit Bit Control Mode, and how to use it in machine debug applications.
A	**Troubleshooting Guide**	Appendix A provides a list of typical problems you may encounter along with the most likely causes and solutions.
B	**Reference Data**	Appendix B provides the setup parameter tables and a table of ASCII characters and their hex ASCII codes.
C	**DV–1000 Worksheets**	Appendix C provides worksheets that you may copy and use to plan your application program.

Direct*VIEW* 1000 Data Access Unit Overview

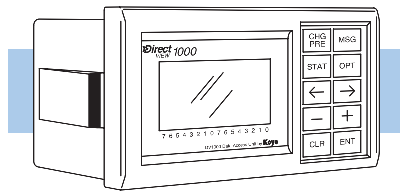
The DV-1000 is a small, low-cost data access unit which connects directly to all DL105, DL205 and DL405 CPUs, and to DL305 models having a D3–350 CPU (it is not compatible with the other DL305 CPUs). Its main purpose is to provide access for monitoring and controlling data in the CPU, and is usually permanently installed in an operator interface, but it can also be used portably as a debugging tool.



***Direct*VIEW (DV-1000)**

*Direct*VIEW™ 1000 Features

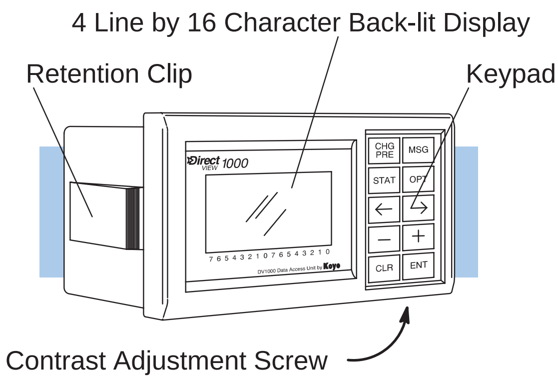
The ***Direct***VIEW™ 1000 (DV-1000) has several different modes which are accessible from its keypad. *Most modes require some ladder logic in the PLC and setup parameters in V-memory, which are essential for the DV-1000 to function!* This manual contains many program examples to acquaint you with all the capabilities of the DV-1000, and help you with the required setup parameters and ladder program. Some of the main features and benefits are:



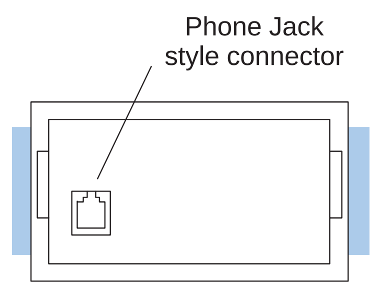
***Direct*VIEW (DV-1000)**

- Works with all DL105, DL205 and DL405 CPUs, and DL350 CPUs
- Features a 4-line by 16-character back-lit display
- Monitors V-memory data values
- Displays text and numeric data generated with your ladder program
- Can change preset (any V-memory) values
- Displays CPU-generated error messages (message log)
- Single cable connection to CPU
- Easy snap-in mounting
- The DV-1000 device is UL® Listed

Getting Acquainted Before connecting the DV-1000 to your PLC, we'll first study its main features. The drawing below shows a front and rear view of the unit. The 4-line by 16-character display is back-lit for viewing in various ambient lighting conditions. You can control the contrast of the LCD segments by adjusting a potentiometer accessible with a small screwdriver under the bottom of the unit. To the right of the display is a keypad featuring ten keys. These are general-purpose keys that allow you to select various operating modes, select particular data for monitoring, and to change data values. The DV-1000 is designed to fit into a rectangular cutout in the control panel of an operator interface. A retention clip on each side keeps it in place after installation. A modular jack at the rear of the unit provides an easy connection to the CPU.



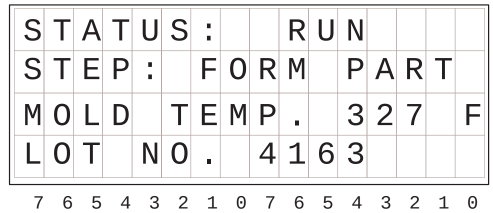
Front view



Rear view

Display

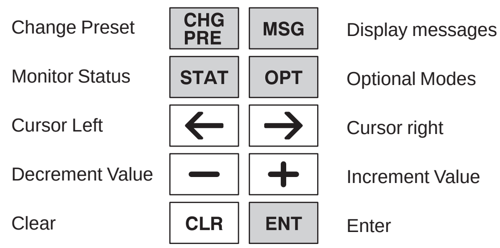
The DV-1000 display contains 4 lines by 16 characters, and each character is formed by a 5 x 7 LCD dot matrix. The unit's internal processor generates an ASCII character set, and outputs menu messages associated with the keypad.



You can create your own messages by using ladder logic and special setup parameters in V-memory. The permanent numbers below the bottom edge of the display label individual bits of byte or word status displays.

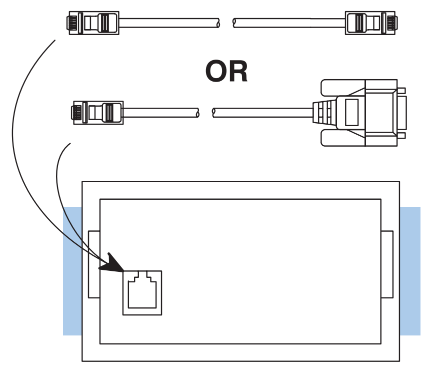
Keypad

The keypad contains ten keys, located along the right side of the DV-1000. The primary keys on the unit have a blue colored background, and are dedicated for changing the operational modes. The secondary keys have a gray colored background, and are multi-purpose keys used for cursor movements and incrementing or decrementing values in the display.



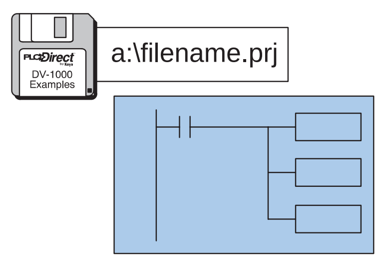
Cables

There are basically two types of cables that may be used with the DV-1000. The type you will use depends mainly on the PLC type that will connect to your DV-1000. Therefore, the appropriate cable must be ordered as a separate item. See Chapter 2 for specific part number information for the proper cable.



Software Examples on Disk

The chapters on individual modes contain several ladder program examples. *A diskette containing the files for these examples is included with this manual.* The diskette symbol in the margin beside an example program indicates it is on the diskette. See the section near the end of Chapter 2, titled “Installing the Example Programs”.



NOTE: The DL430 CPU does not support all instructions used in the example programs.

NOTE: ***Direct***SOFT Release 2.0 programming software has a utility to configure the DV-1000; however, before using this utility it is important to understand the V-memory relationship between the DV-1000 and the PLC. See the ***Direct***SOFT Users Manual (DA-DSOFT-M) for more information.

Display and Keypad Basics

This section will familiarize you with how to use the keypad, along with the display response for each key you press. Its purpose is *not to demonstrate all of the modes or display screens*. The remaining chapters in this manual contain that information.

NOTE: These exercises must be done in a safe learning environment. **DO NOT** use a CPU that is actually controlling a process, in order to avoid accidentally changing V-memory data needed by the ladder program.

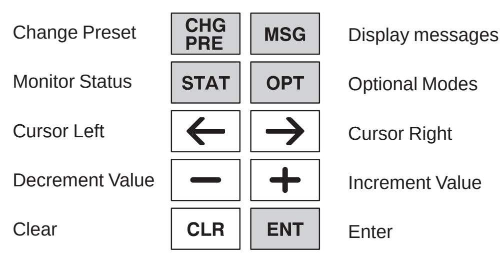
Clear V-memory First!

The following exercises assume the DV-1000 is online with the PLC, and the CPU program, V-memory, and system parameters are clear. If your CPU has random data in these locations, then your displays will likely not match the examples.

1. Connect the communications cable from your personal computer communications port to your PLC's programming port on the CPU.
2. Start ***Direct***SOFT on your personal computer.
3. Select a link to go online with the CPU.
4. Save your program to a project file, if you have a program not yet saved.
5. Verify the CPU is in program mode. From the menu bar, select **PLC**, then **PLC Modes**, then **Program**. Then select "OK", or press Return.
6. From the menu bar, select **PLC**, then **Clear PLC memory,** then **All**. Then select "OK", or press Return.
7. From PLC menu, choose Setup, then **Initialize Scratchpad**. This ensures the DV-1000 setup parameters are initialized to zeros.

Keypad

You may recall that the keypad is color-coded, based on key functions. The blue keys are dedicated for changing the operational modes. The gray keys are multi-purpose, used for cursor movements and incrementing or decrementing values in the display.



Keypad Conventions Used in this Manual

This manual uses some keypad conventions. When keypad entries are required, key symbol(s) will be shown, preceded by the word "Press". Example 1 asks you to press the **Status** Key followed by the **Enter** key. Example 2 asks you to press the **Change Preset** key, followed by pressing the **Cursor Right** Key twice. The graphic arrow points to the resulting display beside or below the key sequence.

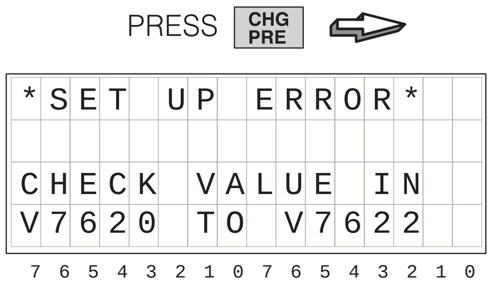
Example 1

Example 2

NOTE: When pressing multiple keys or pressing a key repetitively in a key sequence, please **pause** for a second between keystrokes. This allows the DV-1000 time to process each keystroke before the next keypad entry occurs.

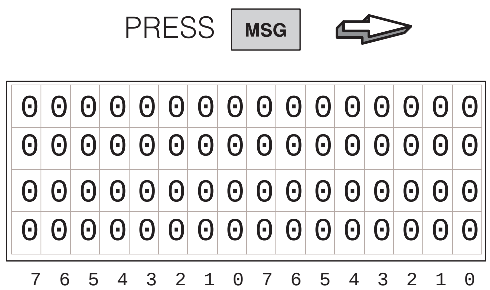
CHG PRE Key
(Change Preset)

Press the **Change Preset** Key when you need to change V-memory data. This mode requires setup parameters in V-memory. Because V-memory is cleared at this point, you will see the error message to the right, which is normal. Note the absence of a cursor in this display, indicating the cursor keys are disabled.



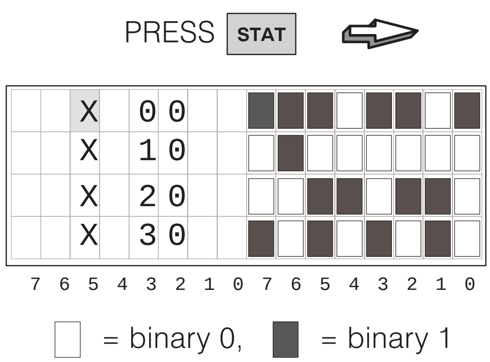
MSG Key
(Message)

Press the **MSG** key to view messages from the CPU. This mode requires setup parameters in V-memory. However, since V-memory is presently cleared the display shows a valid default “message”, consisting of all zeros.



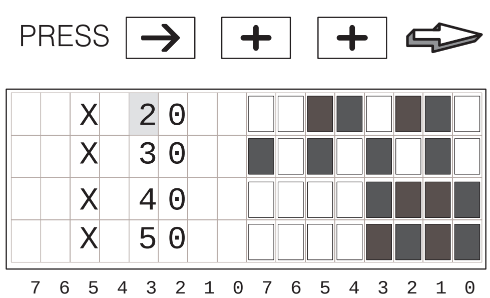
STAT Key
(Status)

Press the **Status** Key to view the current status of various CPU memory locations. This mode *does not* require setup parameters in V-memory. The default memory type displayed upon entry to Monitor Status Mode is the X input type, starting with X0. The right half of the display shows eight discrete points (one byte) per line. The particular binary pattern shown to the right is an example only. Your specific display depends on the current status of your system.

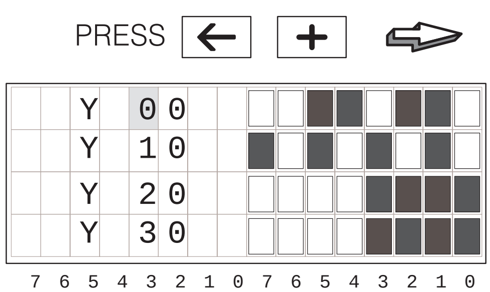


CURSOR and +/– Keys

The **Cursor Right** and **Left** Keys move the cursor on the top line, and the **Plus (+)** and **Minus (–)** Keys scroll the display addresses. If the display is in Status Mode as above, press the **Cursor Right** Key to move the cursor over to the adjacent “0”. With the cursor over the address, press the **Plus (+)** Key twice to increment X00 to become X20.



Now press the **Minus (–)** Key twice to decrement the top display line back to X00. The Plus and Minus keys are also used to select data types, as well. First press the **Cursor Left** key to move the cursor over the top line “X”. Now press the **Plus (+)** Key once, and the “X”s in the display will change to “Y”s.



OPT Key
(Optional Modes)

Press the **Optional Modes** key to gain access to three utilities which do not have dedicated keys. The display will list three items: Bit Control, Password, and Show Err/Msg.

PRESS **OPT**

```
    OPTION
1 BIT CONTROL
2 PASSWORD
3 SHOW ERR/MSG
7 6 5 4 3 2 1 0 7 6 5 4 3 2 1 0
```

CLEAR and ENTER Keys

Later we'll use the **Plus (+)** and **Minus (–)** keys to select the item number. Next we select Bit Control mode by pressing the **Enter** key. The display below appears, asking us to confirm our choice.

PRESS **ENT**

```
DO YOU WANT BIT
CONTROL MODE?
YES:PUSH ENT KEY
NO :PUSH CLR KEY
7 6 5 4 3 2 1 0 7 6 5 4 3 2 1 0
```

At the moment, we will decline actually entering Bit Control mode, by pressing the **Clear** key. The message "Exit Bit Control Mode" confirms our choice, and then the display automatically returns to Status Display Mode after a 1 second delay.

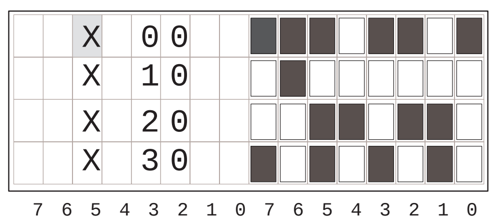
PRESS **CLR**

```

EXIT BIT
CONTROL MODE

7 6 5 4 3 2 1 0 7 6 5 4 3 2 1 0
```

(1 sec. delay)



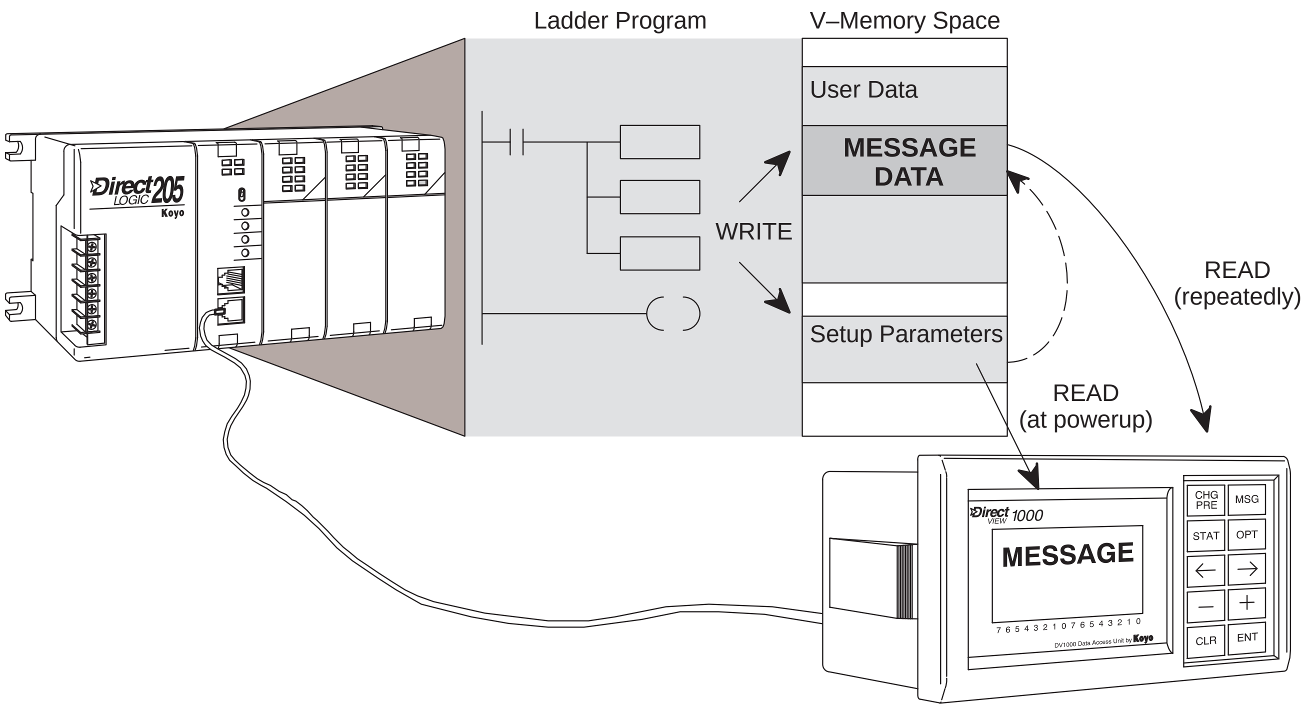
Now that you are familiar with the keypad and display responses, you're ready to learn the secret to successful DV-1000 programming.

Setup Parameters, the Key to DV-1000 Success!

Purpose of Setup Parameters

Most DV-1000 modes require setup parameters. Refer to the figure below. These are V-memory locations in the CPU reserved for DV-1000 use. Their purpose is:

Setup parameters simply tell the DV-1000 where to find its display data. Accordingly, the DV-1000 is completely lost without its setup parameters!

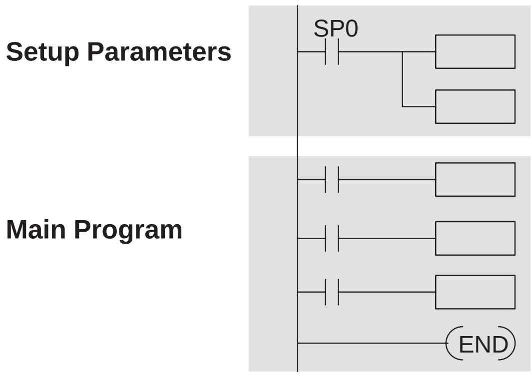


Typically, the ladder program writes the setup parameters to V-memory on the first CPU scan. These point to the locations of blocks of data (also written by the ladder program), which the DV-1000 needs to generate messages, preset lists, etc. By reading setup parameters after powerup, the DV-1000 is able to locate and read its operational data from the data blocks elsewhere in V–memory. The DV-1000 re-reads these data blocks continuously during operation.

Programming Setup Parameters

To the right is a typical program outline to support the DV-1000. On the first scan, the first rung places setup parameters in their reserved V-memory locations. The main program follows, which moves data to or from the data blocks referenced by the setup parameters as required.

Chapter 3 covers setup parameters in general. Then, each chapter on an operational mode includes several setup examples for that mode.



We highly recommend reading Chapter 3 on Setup Parameters thoroughly before attempting to use any mode that requires setup parameters!

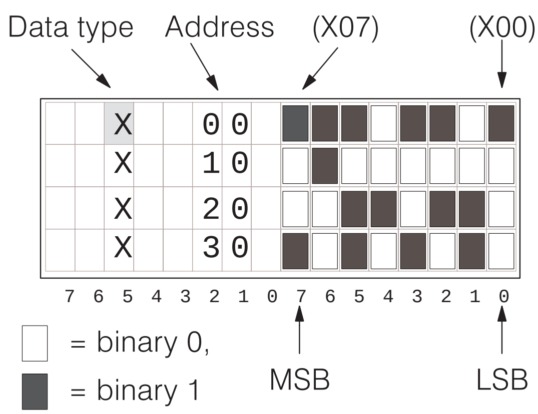
Quick Tour of DV-1000 Operation

The Quick Tour is designed to acquaint you with the primary modes of the DV-1000. Most of the modes require ladder program support in the CPU, and consequently, some learning on your part. Also, many applications do not require the programming of all DV-1000 modes. Therefore, it is important to begin by first identifying the mode(s) most needed for your application. **We recommend all new users read Chapters 1, 2, and 3 thoroughly.** Then you can choose from Chapters 4 through 7 the appropriate material for your application.

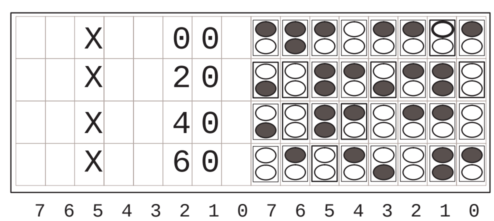
Status Display Mode
(see Chapter 5)

Status Display Mode is accessible at any time by pressing the **Status** Key. *It does not require setup parameters.* The 32-bit status display is the default upon entry to Status Display Mode, as shown below. A 64-bit status display is also selectable.

32-Bit Status

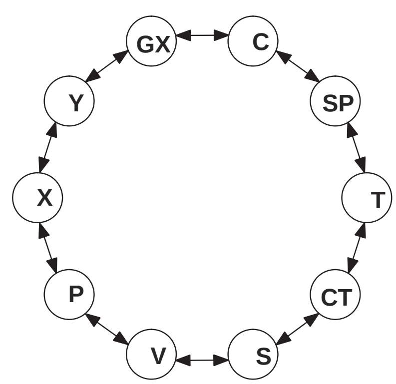


64-Bit Status



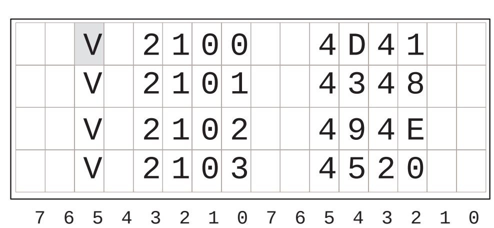
In the left display above, the left column lists the variable type (X in this case). The next column lists the octal address. The top row displays the status of discrete inputs X00 through X07 (or, X00 to X17 on the top row of the right-most display).

Data types X, Y, GX, C, SP, T, CT, S, V, and P are accessible in a circular list, as shown to the right. Cursor keys let you select the data type for viewing. Note that some CPUs feature slightly fewer data types.



This mode features a “bookmark”, which records the data type and address of the V-memory location being viewed when you exit Status Display. It can be recalled during a later use of Status Display Mode later with only an extra key-stroke.

Data types V and P are shown as 4-digit hexadecimal numbers. Cursor keys allow you to randomly access various address locations. If you need to change the data value(s), refer to the section on Change Preset Mode.



Message Display Mode (see Chapter 4)

In Message Display Mode, display output can be from one of three different sources: System Messages (includes Fault Messages and Error Messages), and User Messages as shown.

Fault Messages are generated by using the Fault Message Box in ladder logic.

System Error Messages are automatically generated by the CPU upon an error event. Fault Messages and System Error Messages have display priority over User Messages.

User Messages let you create numeric and text output to the entire display under ladder logic control. *Only User Messages require setup parameters.*

Fault Messsage

```
*PART JAM,ZONE 1
```

Error Message

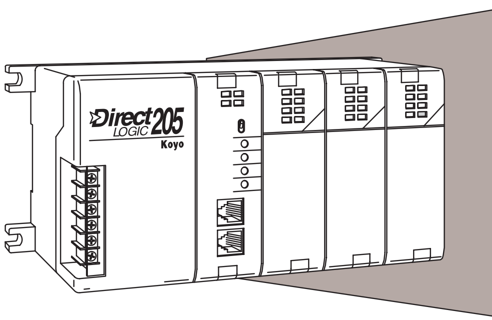
```
E042 NO CPU BATT
```

User Message

```
CONVEYOR SPEEDS
 Line 1= 123 fpm
 Line 2= 456 fpm
 Line 3= 789 fpm
7 6 5 4 3 2 1 0 7 6 5 4 3 2 1 0
```

DL240, DL250, DL350, DL440 and DL450 CPUs can record up to 16 Error Messages and 16 Fault Messages in separate message logs as shown below. It attaches a time/date stamp to messages when they occur. These may be viewed individually with the DV-1000.

Example Message Log



	DATE	TIME	FAULT MESSAGE
01	08/10/95	09:35:50	PART JAMMED
02	08/11/95	08:00:43	BIN EMPTY
03	08/11/95	07:15:53	OVER TEMP
04	08/20/95	17:22:48	LOW FLOW
05	08/30/95	17:22:24	PUMP FAULT
06	08/30/95	17:22:24	GATE STUCK
:	:	:	:
16	08/02/95	9:22:16	SETUP INVALID

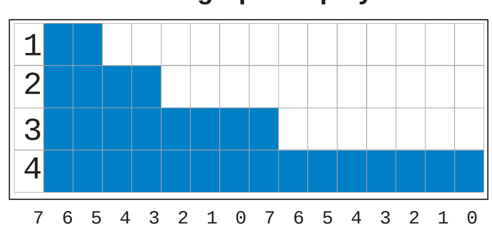
User Messages require ladder programming and setup parameters. Chapter 4 includes several example programs designed to show you how to add these features to your own messages:

- Include text with numerical data
- Blinking characters
- Multiple screens with paging
- Signed numbers (+/–)
- Time and date stamp in message
- Create bar graphs for analog data
- Long messages that scroll

Time and Date Stamp

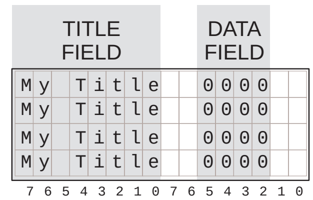
```
MACHINE STATUS
Fault= Bin Empty
Time =11:32:57AM
Date =07/05/95
7 6 5 4 3 2 1 0 7 6 5 4 3 2 1 0
```

Bargraph Display



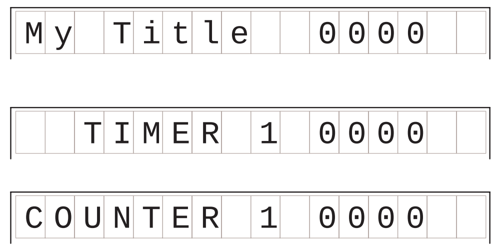
Change Preset Mode (see Chapter 6)

Change Preset Mode presents data that you can view on the display and edit with the keypad. *Setup parameters are required.* Titles (labels) accompany the data, giving them meaning for your application. “Change Preset” just means “change V-memory data value”. Password protection is also available, if desired.

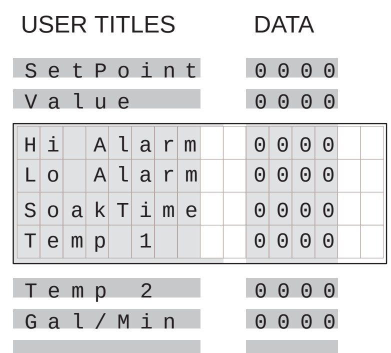


Three types of titles are available in Change Preset Mode:

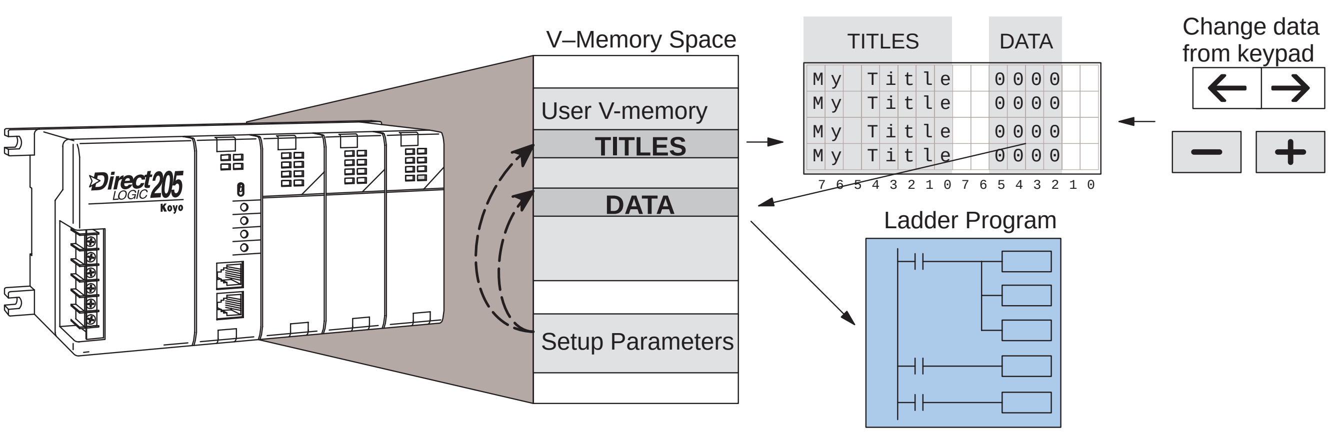
- User–titled Presets allow you to create your own text label of up to eight characters in length.
- Pre-titled Timer labels (1 to 99) are available if you have timers and can use ready-made labels.
- Pre-titled Counter labels (1 to 99) are available if you have counters and can use ready-made labels.



With proper setup parameters, you can establish lists of presets with text labels you create. The Change Preset Mode has built-in display scrolling capability. You can scroll to the variable name of the data you want to change, move the cursor to the data field, and change the data using the keypad. Like using thumb-wheel switches, the data in V-memory changes immediately to match the display.

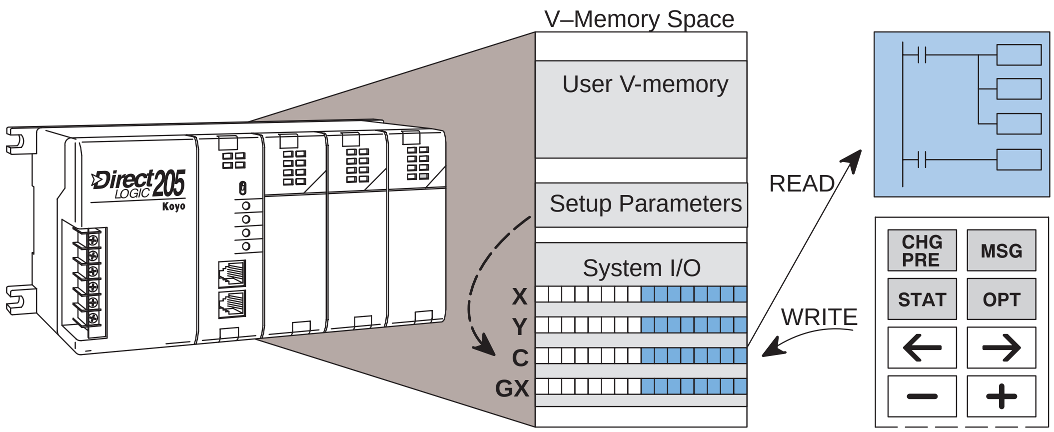


Change Preset operation is depicted below. Setup parameters point to the location of title and data lists in V-memory, also defining the list length. The DV-1000 presents these as matched lists, so that a title and its corresponding data are together on the same display line. Keypad entries can request data changes, which immediately updates the data on the display and the data in V-memory. Finally, the ladder logic program uses the new data to update the machine control process.



Bit Control Mode (see Chapter 7)

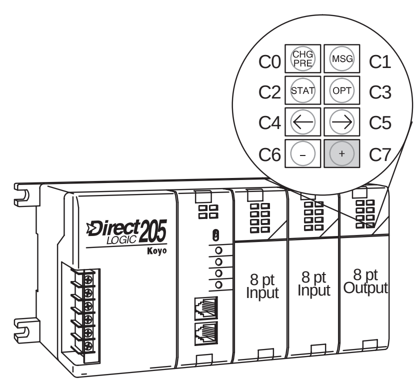
Bit Control Mode temporarily reassigns eight keys on the keypad for dedicated control of eight I/O bits. *A Setup Parameter is required.* In the drawing below, the setup parameter points to a system I/O location for either X, Y, C, or GX type I/O points. This example's setup parameter points to a control relay location, controlling the first eight relays. The keypad switches operate as momentary, normally open switches. When ladder logic uses these bit control I/O points as inputs, keypad entries can request I/O bits to turn on as long as keys are pressed.



While the keypad is in Bit Control Mode, the display may be in either Message Display, Status Display, or Change Preset Mode.

WARNING: Bit Control Mode is designed for debug purposes only. There is no automatic indication that normal keypad functionality has been suspended.

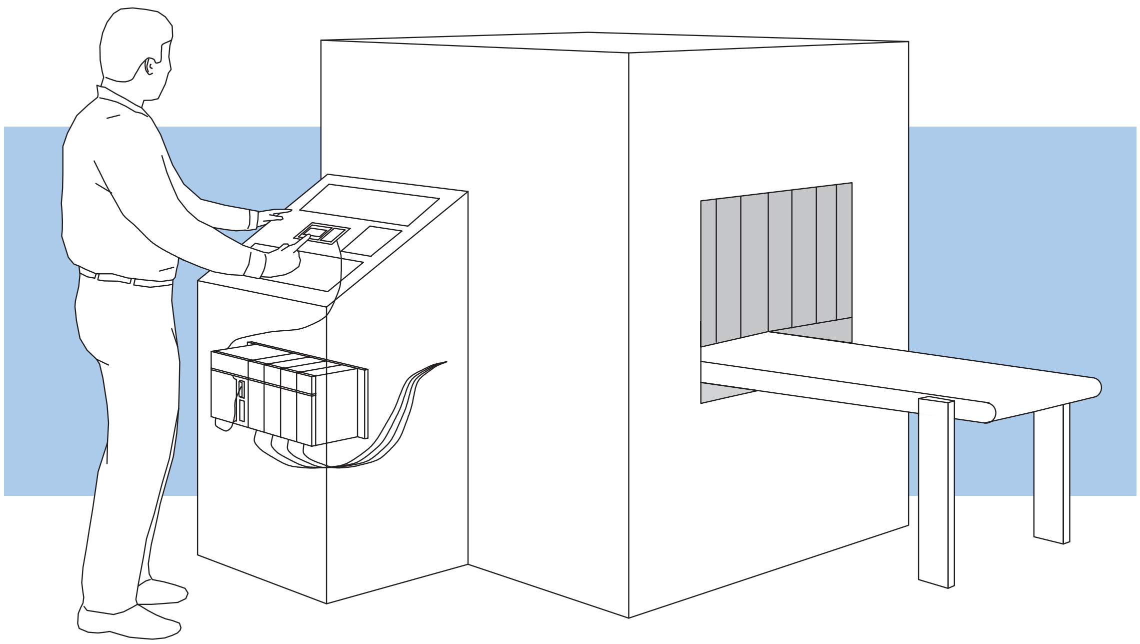
With a simple parameter setup and ladder program, you can use Bit Control Mode to turn on an output module's output points. In the example system to the right, the eight keys shown from the keypad have been configured to turn on control relays C0 through C7. Then the main ladder program uses these to turn on outputs Y0 through Y7.



Operator Interface Design Basics

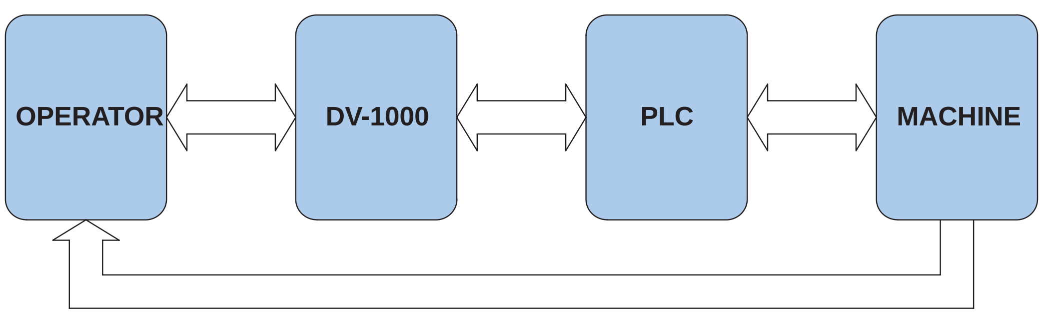
Man-Machine Interface

The DV-1000 provides access to PLC data to the user while the CPU is running the RLL program, and the process or machine is running. In most applications, the DV-1000 is a permanent part of the operator interface. The operator's panel shown in the drawing below is at the top of the control cabinet, located at the side of the machine. The operator panel contains all the dedicated operator interface devices, such as switches, gauges, control knobs, etc. The DV-1000 is one of these devices which forms the entire operator interface.



In the transparent view of the control cabinet, follow the single cable from the DV–1000 to the PLC inside. From there, a wiring bundle connects it through the rear of the control cabinet to sensors and other field devices located inside the machine. The conveyor which moves the product through the machine may also be controlled by the PLC.

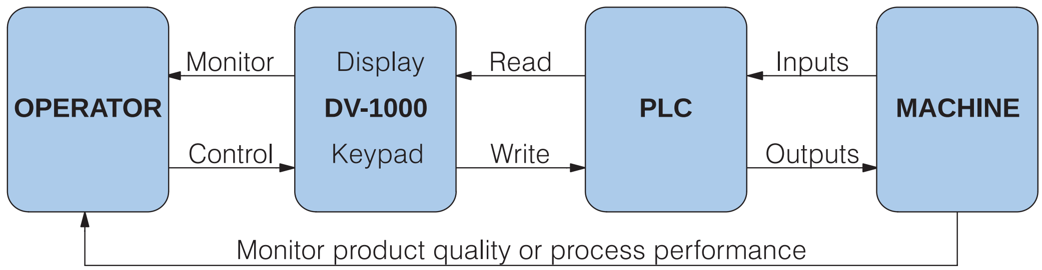
Next we examine the interaction and flow of information between all the players in the man-machine interface. The following diagram arranges them in the order they communicate.



Action begins with the human operator, who wants to know the machine status or make an adjustment to the process. From the control panel, the operator can access data through the DV-1000, which connects to the PLC inside the control cabinet. In turn, the PLC connects to the machine or factory process through wiring to sensors, relays, solenoids, motors, and so on.

Monitor and Control

The DV-1000 features several operating modes that may be used in a variety of ways. But at a basic level, it provides two types of accesses to data: **monitor** and **control.** Refer to the drawing below.



The drawing shows the flow of information between the operator and the machine or process.

Purposes of Monitoring

The control panel *communicates the status of the machine or process to the operator*. Some of the kinds of information it conveys are:

- Production totals
- Machine setup and process status information
- Quality control statistics
- I/O point status for troubleshooting

Use **Message Display Mode** (see Chapter 4) for these types of messages. For example, a diagnostic message that says “Part Jam, Zone 3” gives an operator a good idea of the nature of the problem and its location. Use **Status Display Mode** (see Chapter 5) to view the PLC’s I/O bit status for troubleshooting.

Purposes of Control

The control panel enables an operator to *change the process instructions or setpoints.* Some of the goals accomplished by control inputs are:

- Change a process variable setpoint during runtime (such as temperature) in order to optimize the process or machine performance
- Select a particular product setup from a menu
- Perform machine debug by turning on specific control bits or outputs
- Manually jog a machine or increment through process steps in order to to clear a part jam or fault condition
- Control major machine functions (Start, Stop, etc.) **see note below**

Use **Change Preset Mode** (see Chapter 6) to change process variables or select a product setup menu. Use **Bit Control** (see Chapter 7) for machine debug tasks.

NOTE: For controlling major machine functions such as Start, Stop, Run, Jog, etc, we recommend using individual dedicated control devices, not the DV-1000 keypad.

Frequently Asked Questions

NOTE: If you have general questions regarding the DV-1000 and your application, please check the following list of typical questions we receive. If you have already installed or programmed your DV-1000 and are having difficulties, refer to the Troubleshooting Guide in Appendix A at the end of this manual. If you still need assistance, please call us toll–free for technical support.

Can I use the DV-1000 to change data in the PLC?

Yes. There are two modes available for changing PLC data:

- Change Preset Mode lets you individually edit V-memory locations as a 4-digit BCD number, from a list of either 16 or 32 data word locations, and up to 99 timer presets and 99 counter presets (depending on CPU type).
- Bit Control Mode dedicates 8 of the 10 keys on the keypad for single-bit control. These operate as eight momentary, normally off pushbuttons.

Is there password protection for modes that allow the operator to change PLC data?

Yes, there is for Change Preset Mode. See Chapter 6 for more on this topic.

How many DV-1000s can be connected to the PLC?

A maximum of two DV-1000s may be directly connected to the DL240 and DL450 CPUs. See Chapter 2 for other options, and general information on this topic.

Can the PLC cause the DV-1000 to always power up in a certain mode?

Yes. The powerup default mode may be selected by using a particular entry in the parameter setup table. See Chapter 3 for more on this topic.

Is there a way to cause the DV-1000 to stay in Bit Control Mode (or any mode that I choose)?

You can set up the DV-1000 to power up in particular modes. However, if the operator presses certain keys on the keypad, this takes the DV-1000 out of its original powerup mode.

Can the PLC cause the DV-1000 to change modes during normal operation (PLC run mode)?

No. After establishing the powerup mode, further DV-1000 mode changes only occur upon keypad entry.

When does the DV-1000 read its setup parameters from the PLC?

These are read one time just after powerup, and any time a mode change is requested from the keypad.

What's the best way to enter setup parameters?

We recommend imbedding the setup as a part of the ladder program. Using a SP0 contact on the rung, it only executes on the first PLC scan. See Chapter 3 for more on setup parameters.

I need to display the phrase "TEMP 1", followed by the present value of the temperature in PLC V-memory, and also to allow changing that value right on the display. Is there a way to do this?

Yes. Use Change Preset Mode, with user-titled labels.

Can I use the DV-1000 to change timer or counter presets in the PLC?

Yes. The Change Preset Mode will let you do this. See Chapter 6 for more information on this topic.

Can the display show more ASCII characters than just letters of the alphabet?

Yes, the DV-1000 character set includes several special symbols. See Appendix B for a complete listing of characters and symbols with their ASCII codes.

Do I have to enter the ASCII codes in instruction boxes, or can I just type in the letters?

Actually, you may do it either way. The LD/OUT and LDD/OUTD instructions may place ASCII codes in the text table, or the ACON instruction box can convert characters in the box to ASCII codes (see Chapter 4 for more on this topic).

I need to show more than the display's 4 lines of text. Can I scroll or swap display screens?

Yes. The proper ladder logic will allow you to do this. Examples of multiple display screens and scrolling techniques may be found in Chapter 4.

Can I use the DV-1000 keypad to control machine functions, like Start, Stop, Step Jog, Run, etc.?

While technically possible, we **strongly recommend against** this type of application. Major machine control functions are best implemented with larger, dedicated switches, knobs, etc. The keys on the DV-1000 are intended primarily for various monitoring functions, or for occasionally changing V-memory Preset Values. *See the next question and answer!*

Are there other operator interfaces available from PLC *Direct*?

Yes. Please call our Technical Support Line (1–800–633–0405) for the latest information on other ***Direct***LOGIC compatible products available from us or from industry affiliates.

Can the PLC sense when the operator makes keypad entries?

It depends. Bit Control Mode is designed for general key detection for eight of the ten available keys, which are redefined from their normal function. In the other modes, DV-1000 keypad activity cannot be detected in the PLC.

Can the display indicate when the DV-1000 is in Bit Control Mode?

Yes, but with some qualification. The display can be in Message Display Mode and the keypad in Bit Control Mode simultaneously (which is selectable as a powerup default mode). Ladder programming can detect keypad activity, and coordinate the message display to provide visual feedback from the keypad entry. However, the operator can leave the Message/Bit Control Modes if they desire.

Can I display a numeric value in Message Mode with a leading +/– sign?

Yes. An example ladder program that does this is in Chapter 4.

Can I display a blinking text message during an alarm condition?

Yes. An example ladder program that does this is in Chapter 4.

I plan to use the DV-1000 only with a DL105 or DL205. Are there low-cost *Direct*SOFT programming packages available just for these models?

Yes. The PC–PGM-105 and PC–PGM–205 programming packages are available, each at an attractive price for the DL105-only and DL205-only users.

What is the purpose of the the adjustment screw at the bottom of the DV-1000 housing?

Rotate this screw to adjust the contrast of the LCD segments on the display.

Specifications

CPUs Supported	Status Display
DL130, DL230, DL240, DL250, DL350, DL430, DL440, and DL450 CPUs (see Section 2, Step 5 for specific communication port and cabling information)	Displays 16 or 32 point bit status for the following data types X, Y, GX, C, SP, T, CT, S Displays numeric values for V and P data types.
Cables and Connectors	**Change Preset Values**
For DL105/DL205/DL350/DL450 – Part# DV–1000CBL 6.6ft. (2m) Cable with RJ12 connectors **For DL430/DL440/DL450** – 2 methods: Part# D4–1000CBL, 6.0ft. (1.85m) Cable with an RJ12 and a 15-pin male D-sub connector (preferred), or Part # FA-CABKIT, Use the Universal Cable Kit to attach the DV-1000CBL to the CPU port	DL130, DL230 and DL240 CPUs up to 16 user-titled values DL250, DL350 and all DL405 CPUs up to 32 user-titled values Also includes: 1–99 values titled as TIMERxx 1–99 values titled as COUNTERxx
Message Display	**Bit Control**
One 4 x 16 character message display is available (message must be in CPU program) Displays text and embedded numeric values which update with the application program Displays PLC System Error Messages and Fault Message Outputs	Assigns 8 contiguous points to the DV-1000 keypad Eight keys on the keypad operate as momentary normally open pushbutton switches Bit data types which can be assigned are: X, Y, GX, and C

Environmental

Operating Temperature	32 to 122 °F (0 to 50 °C)
Storage Temperature	–4 to 158 °F (–20 to 70 °C)
Humidity	30 to 95% (non-condensing)
Environmental Air	No corrosive gases
Vibration	MIL STD 810C 514.2
Shock Resistance	MIL STD 810C 516.2
Noise Immunity	NEMA ICS3–304
Regulatory Agency Approvals	UL® Listed
Power	150 mA @ 5VDC obtained through PLC port
Dimensions	5.12” W x 2.83” H x 1.03” D 130mm W x 72mm H x 26mm D
Weight	5.8oz. (165.7 g)

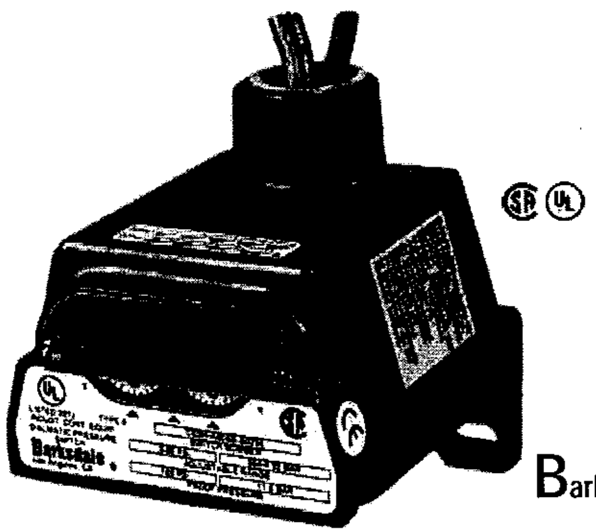
PSH

CD1H, CD2H Pressure Switch

Diaphragm

CD1H, CD2H Series

- High Reliability
- Extremely Versatile
- Calibrated Dial for Easy Set Point Adjustment
- Ideal for Pressure or Vacuum



Barksdale's **CD1H** and **CD2H Housed Diaphragm Pressure Switches** provide an ideal solution for pressure control applications requiring tamper proof external adjustment and environments which require water-tight NEMA 4 housings. These pressure switches are available in single or dual control settings for both positive pressure and vacuum models, to 150 psi. These snap-action switches may be wired normally open or normally closed through a 3/4"-14 NPT conduit connector to free leads to 18". All models feature self-locking set screw adjustment and dials which are calibrated for increasing setting. For applications requiring a highly accurate switch in a durable package, **Barksdale's CD1H** and **CD2H Diaphragm Pressure Switches** are the ideal choice. Stripped models are also available.

CD1H, CD2H Pressure Switch

With Barksdale - Pressure's No Problem

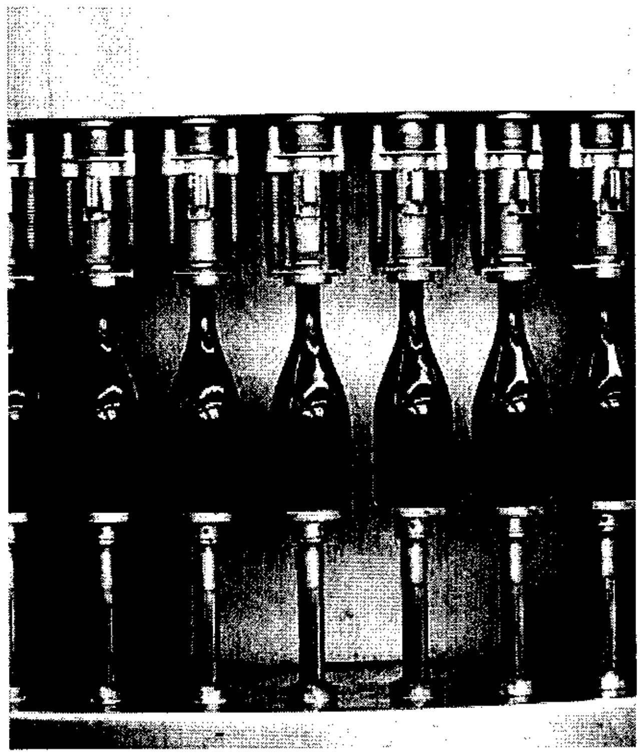
As a recognized leader in the manufacture of pressure product solutions, Barksdale pressure switches meet the demanding needs of our customers. From 29" Hg to 18,000 psi, Barksdale has pressure switches for a variety of applications – from transformers to natural gas compressors to beverage dispensers – and more!

Barksdale's Diaphragm Pressure Switches provide an economical solution for your pressure sensing needs. Diaphragm switches accurately control pressures from 30 inches of mercury vacuum to 150 psi positive pressure, and can be factory pre-set upon request. Setpoint adjustment is easily accomplished by turning the adjustment screws, which are protected by a tamper-resistant cover on housed models. A variety of available factory options allows the Diaphragm switches to be configured to the exact needs of your application.

Diaphragm Pressure Switch Applications

With its economical design and high repeatability, **Barksdale's Diaphragm Pressure Switches** provide an accurate and reliable solution for pressures up to 150 psi, making them ideal for use in:

- Pump & Compressor Monitoring
- Air Proving in HVAC Systems
- Engine Monitoring
- Machine Tools
- Hydraulic Power Units



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Toll-Free: 1-800-835-1060.

CD1H, CD2H Pressure Switch

General Description

Electrical Characteristics — All models incorporate Underwriters' Laboratories, Inc. listed single pole double throw snap-action switching elements.

Performance Characteristics

Accuracy — +/- 0.5% of the adjustable range

Switch

Type — SPDT single or dual circuit

Rating — 10 Amps @ 125/250 VAC, 3 Amps @ 480 VAC; .5 Amps @ 24 VDC (Class A or H Limit Switch); Consult sales drawing for ratings of optional Limit Switches

Physical

Weight — Approximate 1.75 lbs.

Enclosure/Housing — NEMA 4

Electrical Connection — Free leads approximately 18" long, 16 AWG through 3/4" NPT conduit connector.

Pressure Connection — 1/4" NPT internal thread.

Diaphragm — 17-7 PH stainless steel

Approvals/Listings

UL — All models are Underwriters' Laboratories listed in the Electrical Construction Materials Directory under Industrial Control Equipment. Float and Pressure Operated, File E42816, and Canadian Standards Association Listed under Guide 380-W-1.16, Class 3231, File 22355.

CSA — Listed under Guide 380-W-1.16, Class 3231, File 22355

Environmental

Temperature Range

Operating — -65° to +165°F (-54° to +74°C)

Storage — -65° to +200°F (-54° to +93°C)

WIRE CODE				
Lead	Circuit #1		Circuit #2	
	Pressure	Vacuum	Pressure	Vacuum
NormallyClosed	Blue	Red	Orange	Yellow
Common	Purple	Purple	Brown	Brown
NormallyOpen	Red	Blue	Yellow	Orange

Adjustment Instructions

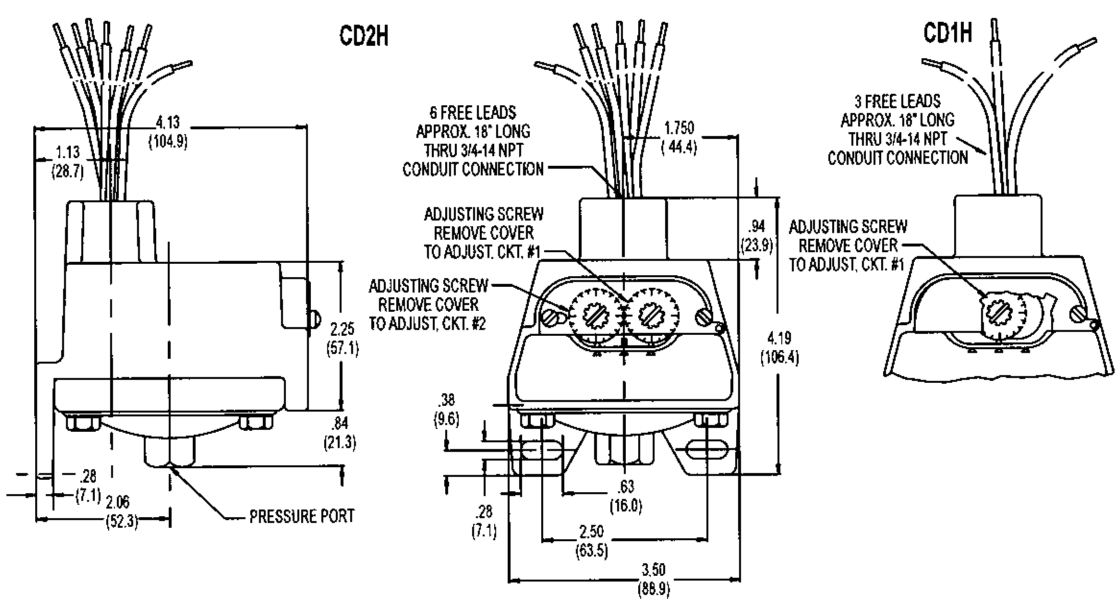
Pressure — Turn self-locking adjustment screw counter clockwise to increase pressure setting

Vacuum — Turn self-locking adjustment screw clockwise to increase vacuum setting

Consult Factory for These Options

Cleaned for Oxygen Service

1/2" NPT Pressure Port



CD1H, CD2H Pressure Switch

Diaphragm

CD1H, CD2H Series

	Code	Description
	H	Hermetically sealed limit switch (optional); Class 1 Division 2. Requires Class AA, CC, or HH limit switch.
Basic Configuration	CD1H	Single setpoint housed
	CD2H	Dual setpoint housed
	VCD1H	Single setpoint housed - Vacuum
	VCD2H	Dual setpoint housed - Vacuum
Limit Switch	-A	10 Amps @ 125/250 VAC; 3 Amps @ 480 VAC; .5 Amp @ 24 VDC (standard for 3SS, 80SS, and 150SS ranges)
	-B	10 Amps @ 125/250/480 VAC; 2 Amps @ 600 VAC; 15 Amps @ 12 VDC (consult dales drawing for deadband values)
	-H	10 Amps @ 125/250 VAC; 3 Amps @ 480 VAC; .5 Amp @ 24 VDC (standard for 2SS and 18SS ranges)
	-M	10 Amps @ 125/250 VAC; 3 Amps @ 480 VAC; 15 Amps @ 12 VDC; 2 Amps @ 24 VDC (consult sales drawing for deadband values)
	-GH	1 Amp @ 125 VAC; 1 Amp @ 24 VDC Gold Contact (consult sales drawing for deadband values)
	-AA	Hermetically sealed; 4 Amps @ 125/250 VAC (consult sales drawing for deadband values)
	-CC	Hermetically sealed; 10 Amps @ 125/250 VAC (consult sales drawing for deadband values)
	-HH	Hermetically sealed; 5 Amps @ 125/250 VAC (consult sales drawing for deadband values)

Adjustable Range

PRESSURE SWITCHES

	Adjustable Range				Approx. Deadband	Proof
	Decreasing - psi (bar)		Increasing - psi (bar)		(Actuation Value)	Pressure
	Min	Max	Min	Max	psi-(bar)	psi (bar)
2SS	0.5 (.03)	34.6 (2.4)	1.9 (.13)	36 (2.4)	.6 - 1.4 (.04 - .1)	83.3" H2O
3SS	.3 (.02)	2.85 (.2)	.18 (.01)	3 (.2)	.07 - .15 (0 - .01)	10 (.7)
18SS	.4 (.03)	17.74 (1.2)	.66 (.04)	18 (1.2)	.12 - .26 (.01 - .02)	60 (4.1)
80SS	.5 (.03)	76.6 (5.2)	3.9 (.3)	80 (5.4)	1.6 - 3.4 (.1 - .2)	160 (10.9)
150SS	1.5 (.1)	144.0 (9.8)	7.5 (.5)	150 (10.2)	2.3 - 6.0 (.2 - .4)	300 (20.4)

VACUUM SWITCHES

	Adjustable Range				Approx. Deadband	Proof
	Decreasing - In. Hg		Increasing - In. Hg		(Actuation Value)	Pressure
	Min	Max	Min	Max	In. Hg	In. Hg
3SS	0.06	5.72	0.34	6	.14 - .28	6
18SS	0.8	29.2	1.6	30	.4 - .8	30

Options

-WXXX	Extra wire length (XXX = inches)
-P2	1/2" NPT Pressure Fitting
-Z1	Oxygen cleaned
-SXXX	Factory pre-set (consult factory)

	CD1H	-A	3SS	

Example: CD1H-A3SS

Miscellaneous:	
Paper Tag	$5.00
Metal Tag:	$10.00

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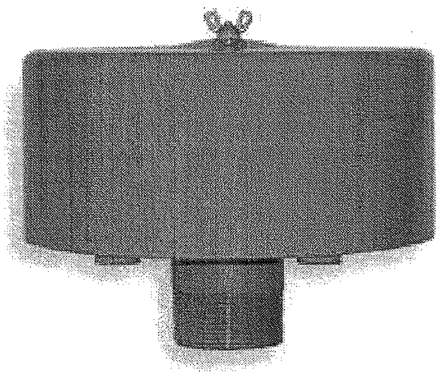
INTAKE FILTER / SILENCER

GRAINGER.
FOR THE ONES WHO GET IT DONE

Print   *printed* November 30, 2007



Filter/Silencer,Inlet

Filter/Silencer, MNPT Inlet 2 In, Polyester Filter Element, Filter Rating 5 Microns, Max Flow CFM 85, For Use With Blower # 5Z188,5Z651,6JD27,6JD28,6JD28, Dia 10 In, Height 7 1/4 In, Decibel Reduction 5, Efficiency Rating 99%, Includes 4FY39 Air Filter

Grainger Item #	4FY33
Your Price (ea.)	**$81.89**
Brand	SOLBERG
Mfr. Model #	FS-31P-200
Ship Qty.	1
Sell Qty. (Will-Call)	1
Ship Weight (lbs.)	7.05
Usually Ships	Today
Catalog Page No.	1038

Additional Info

Filter Silencers and Replacement Cartridges

Steel Filter Silencers

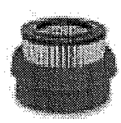
The standard for the small compressor market, these filters/silencers provide over 99% filtration at 5 microns.

Silencing tubes in housing decrease noise level from 5 to 15 dB. Moisture-resistant polyester cloth element handles hot air and oil mist from unload cycle of reciprocating air compressors. (Nos. 5Z665, 5Z766, and 5Z767 use paper element). Low pressure drop of approximately 3- to 5-in. water at rated load. Rugged, seamless drawn all-steel weather hood.

Tech Specs

Item: Air Compressor Filter/Silencer
(M)NPT Outlet (In.): 2
Max. Flow (CFM): 135
Filter Rating (Microns): 5
Filter Media: Polyester
Noise Reduction Rating NRR (dB): 5 to 15
Filter Efficiency (%): 99
Temp. Range (F): -15 to 220
Housing Material: Carbon Steel
Height (In.): 7 1/4
Nipple Length (In.): 2 1/4
Dia. (In.): 10
Design: Silencer Tube

Optional Accessories



Filter Element,5.75 Od

Item #: 4FY39
Brand: SOLBERG
Usually Ships: Today
Your Price (ea): $18.62

Alternate Products

There are currently no alternate products for this item.

For Use With: 5Z188, 5Z651, 6JD27, 6JD29, 6JD88

Notes & Restrictions

There are currently no notes or restrictions for this item.

MSDS

This item does not require a **Material Safety Data Sheet (MSDS).**

Required Accessories

There are currently no required accessories for this item.

Repair Parts

A Repair Part may be available for this item. Visit our Repair Parts Center or contact your local branch for more information.

Roots Blowers, Compressors and Controls

INSTALLATION, OPERATION & MAINTENANCE

Universal RAI®, URAI-J™,URAI-DSL, URAI-J™ DSL, URAI-G™ and Metric Series Blowers

Contents

Do These Things To Get The Most From Your ROOTS™ blower

- ❏ Check shipment for damage. If found, file claim with carrier and notify Roots.
- ❏ Unpack shipment carefully, and check contents against Packing List. Notify Roots if a shortage appears.
- ❏ Store in a clean, dry location until ready for installation. Lift by methods discussed under INSTALLATION to avoid straining or distorting the equipment. Keep covers on all openings. Protect against weather and corrosion if outdoor storage is necessary.
- ❏ Read OPERATING LIMITATIONS and INSTALLATION sections in this manual and plan the complete installation.
- ❏ Provide for adequate safeguards against accidents to persons working on or near the equipment during both installation and operation. See SAFETY PRECAUTIONS.
- ❏ Install all equipment correctly. Foundation design must be adequate and piping carefully done. Use recommended accessories for operating protection.
- ❏ **Make sure both driving and driven equipment is correctly lubricated before start-up. See LUBRICATION.**
- ❏ Read starting check points under OPERATION. Run equipment briefly to check for installation errors and make corrections. Follow with a trial run under normal operating conditions.
- ❏ In event of trouble during installation or operation, do not attempt repairs of Roots furnished equipment. Notify Roots, giving all nameplate information plus an outline of operating conditions and a description of the trouble. Unauthorized attempts at equipment repair may void Roots warranty.
- ❏ Units out of warranty may be repaired or adjusted by the owner. Good inspection and maintenance practices should reduce the need for repairs.

NOTE: Information in this manual is correct as of the date of publication. Roots reserves the right to make design or material changes without notice, and without obligation to make similar changes on equipment of prior manufacture.

For your nearest Roots Office, dial our Customer Service Hot Line toll free; 1 877 363 ROOT(S) (7668) or direct 832-590-2600.

ISRB-2002 rev.0808

ROOTS™ products are sold subject to the current General Terms of Sale, GTS-5001 and Warranty Policy WP-5020. Copies are available upon request.

Contact your local Roots Office or Roots Customer Service Hot Line 1-877-363-ROOT(S) (7668) or direct 832-590-2600.

Safety Precautions

It is important that all personnel observe safety precautions to minimize the chances of injury. Among many considerations, the following should be particularly noted:

- Blower casing and associated piping or accessories may become hot enough to cause major skin burns on contact.
- Internal and external rotating parts of the blower and driving equipment can produce serious physical injuries. Do not reach into any opening in the blower while it is operating, or while subject to accidental starting. Protect external moving parts with adequate guards.
- Disconnect power before doing any work, and avoid bypassing or rendering inoperative any safety or protective devices.
- If blower is operated with piping disconnected, place a strong coarse screen over the inlet and avoid standing in the discharge air stream. **CAUTION: Never cover the blower inlet with your hand or other part of body.**
- Stay clear of the blast from pressure relief valves and the suction area of vacuum relief valves.
- Use proper care and good procedures in handling, lifting, installing, operating and maintaining the equipment.
- Casing pressure must not exceed 25 PSI (1725 mbar) gauge. Do not pressurize vented cavities from an external source, nor restrict the vents without first consulting ROOTS.
- Do not use air blowers on explosive or hazardous gases.
- Other potential hazards to safety may also be associated with operation of this equipment. All personnel working in or passing through the area should be trained to exercise adequate general safety precautions.

Operating Limitations

A ROOTS blower or exhauster must be operated within certain approved limiting conditions to enable continued satisfactory performance. Warranty is contingent on such operation.

Maximum limits for pressure, temperature and speed are specified in TABLE 1 for various models & sizes of blowers & exhausters. These limits apply to all units of normal construction, when operated under standard atmospheric conditions. Be sure to arrange connections or taps for instruments, thermometers and pressure or vacuum gauges at or near the inlet and discharge connections of the unit. These, along with a tachometer, will enable periodic checks of operating conditions.

PRESSURE – The pressure rise, between inlet and discharge, must not exceed the figure listed for the specific unit frame size concerned. Also, in any system where the unit inlet is at a positive pressure above atmosphere a maximum case rating of 25 PSI gauge (1725 mbar) should not be exceeded without first consulting Roots. Never should the maximum allowable differential pressure be exceeded.

On vacuum service, with the discharge to atmospheric pressure, the inlet suction or vacuum must not be greater than values listed for the specific frame size.

TEMPERATURE – Blower & exhauster frame sizes are approved only for installations where the following temperature limitations can be maintained in service:

- Measured temperature rise must not exceed listed values when the inlet is at ambient temperature. Ambient is considered as the general temperature of the space around the unit. This is not outdoor temperature unless the unit is installed outdoors.
- If inlet temperature is higher than ambient, the listed allowable temperature rise values must be reduced by 2/3 of the difference between the actual measured inlet temperature and the ambient temperature.
- The average of the inlet and discharge temperature must not exceed 250°F. (121°C).
- The ambient temperature of the space the blower/motor is installed in should not be highter than 120°F (48.8°C).

SPEED – These blowers & exhausters may be operated at speeds up to the maximum listed for the various frame sizes. They may be direct coupled to suitable constant speed drivers if pressure/temperature conditions are also within limits. At low speeds, excessive temperature rise may be a limiting factor.

Special Note: The listed maximum allowable temperature rise for any particular blower & exhauster may occur well before its maximum pressure or vacuum rating is reached. This may occur at high altitude, low vacuum or at very low speed. The units' operating limit is always determined by the maximum rating reached first. It can be any one of the three: Pressure, Temperature or Speed.

Installation

ROOTS blowers & exhausters are treated after factory assembly to protect against normal atmospheric corrosion. The maximum period of internal protection is considered to be one year under average conditions, if shipping plugs & seals are not removed. Protection against chemical or salt water atmosphere is not provided. Avoid opening the unit until ready to start installation, as corrosion protection will be quickly lost due to evaporation.

If there is to be an extended period between installation and start up, the following steps should be taken to ensure corrosion protection.

- ❑ Coat internals of cylinder, gearbox and drive end bearing reservoir with Nox-Rust VCI-10 or equivalent. Repeat once a year or as conditions may require. Nox-Rust VCI-10 is petroleum soluble and does not have to be removed before lubricating. It may be obtained from Daubert Chemical Co., 2000 Spring Rd., Oak Brook, Ill. 60521.

- ❑ Paint shaft extension, inlet and discharge flanges, and all other exposed surfaces with Nox-Rust X-110 or equivalent.

- ❑ Seal inlet, discharge, and vent openings. It is not recommended that the unit be set in place, piped to the system, and allowed to remain idle for extended periods. If any part is left open to the atmosphere, the Nox-Rust VCI-10 vapor will escape and lose its effectiveness.

- ❑ Protect units from excessive vibration during storage.

- ❑ Rotate shaft three or four revolutions every two weeks.

- ❑ Prior to start up, remove flange covers on both inlet and discharge and inspect internals to insure absence of rust. Check all internal clearances. Also, at this time, remove gearbox and drive end bearing cover and inspect gear teeth and bearings for rust.

Because of the completely enclosed unit design, location of the installation is generally not a critical matter. A clean, dry and protected indoor location is preferred. However, an outdoor location will normally give satisfactory service. Important requirements are that the correct grade of lubricating oil be provided for expected operating temperatures, and that the unit be located so that routine checking and servicing can be performed conveniently. Proper care in locating driver and accessory equipment must also be considered.

Supervision of the installation by a ROOTS Service Engineer is not usually required for these units. Workmen with experience in installing light to medium weight machinery should be able to produce satisfactory results. Handling of the equipment needs to be accomplished with care, and in compliance with safe practices. Unit mounting must be solid, without strain or twist, and air piping must be clean, accurately aligned and properly connected.

Bare-shaft Units: Two methods are used to handle a unit without base. One is to use lifting lugs bolted into the top of the unit headplates. Test them first for tightness and fractures by tapping with a hammer. In lifting, keep the direction of cable pull on these bolts as nearly vertical as possible. If lifting lugs are not available, lifting slings may be passed under the cylinder adjacent to the headplates. Either method prevents strain on the extended drive shaft.

Packaged Units: When the unit is furnished mounted on a baseplate, with or without a driver, use of lifting slings passing under the base flanges is required. Arrange these slings so that no strains are placed on the unit casing or mounting feet, or on any mounted accessory equipment. **DO NOT** use the lifting lugs in the top of the unit headplates.

Before starting the installation, remove plugs, covers or seals from unit inlet and discharge connections and inspect the interior completely for foreign material. If cleaning is required, finish by washing the cylinder, headplates and impeller thoroughly with an appropriate solvent. Turn the drive shaft by hand to make sure that the impellers turn freely at all points. Anti-rust compound on the connection flanges and drive shaft extension may also be removed at this time with the same solvent. Cover the flanges until ready to connect piping.

Mounting

Care will pay dividends when arranging the unit mounting. This is especially true when the unit is a “bare-shaft” unit furnished without a baseplate. The convenient procedure may be to mount such a unit directly on a floor or small concrete pad, but this generally produces the least satisfactory results. It definitely causes the most problems in leveling and alignment and may result in a “Soft Foot” condition. Correct soft foot before operation to avoid unnecessary loading on the casing and bearings. Direct use of building structural framing members is not recommended.

For blowers without a base, it is recommended that a well anchored and carefully leveled steel or cast iron mounting plate be provided. The plate should be at least 1 inch (25 mm) thick, with its top surface machined flat, and large enough to provide leveling areas at one side and one end after the unit is mounted. It should have properly sized studs or tapped holes located to match the unit foot drilling. Proper use of a high quality machinist’s level is necessary for adequate installation.

With the mounting plate in place and leveled, set the unit on it without bolting and check for rocking. If it is not solid, determine the total thickness of shims required under one foot to stop rocking. Place half of this under each of the diagonally-opposite short feet, and tighten the mounting studs or screws. Rotate the drive shaft to make sure the impellers turn freely. If the unit is to be direct coupled to a driving motor, consider the height of the motor shaft and the necessity for it to be aligned very accurately with the unit shaft. Best unit arrangement is directly bolted to the mounting plate while the driver is on shims of at least 1/8 inch (3mm) thickness. This allows adjustment of motor position in final shaft alignment by varying the shim thickness.

Aligning

When unit and driver are factory mounted on a common baseplate, the assembly will have been properly aligned and is to be treated as a unit for leveling purposes. Satisfactory installation can be obtained by setting the baseplate on a concrete slab that is rigid and free of vibration, and leveling the top of the base carefully in two directions so that it is free of twist. The slab must be provided with suitable anchor bolts. The use of grouting under and partly inside the leveled and shimmed base is recommended.

It is possible for a base-mounted assembly to become twisted during shipment, thus disturbing the original alignment. For this reason, make the following checks after the base has been leveled and bolted down. Disconnect the drive and rotate the unit shaft by hand. It should turn freely at all points. Loosen the unit foot hold-down screws and determine whether all feet are evenly in contact with the base. If not, insert shims as required and again check for free impeller rotation. Finally, if unit is direct coupled to the driver, check shaft and coupling alignment carefully and make any necessary corrections.

In planning the installation, and before setting the unit, consider how piping arrangements are dictated by the unit design and assembly. Drive shaft rotation must be established accordingly and is indicated by an arrow near the shaft.

Typical arrangement on vertical units has the drive shaft at the top with counterclockwise rotation and discharge to the left. Horizontal units are typically arranged with the drive shaft at the left with counterclockwise rotation and discharge down. See Figure 4 for other various unit arrangements and possible conversions.

When a unit is DIRECT COUPLED to its driver, the driver RPM must be selected or governed so as not to exceed the maximum speed rating of the unit. Refer to Table 1 for allowable speeds of various unit sizes.

A flexible type coupling should always be used to connect the driver and unit shafts.

When direct coupling a motor or engine to a blower you must insure there is sufficient gap between the coupling halves and the element to prevent thrust loading the blower bearings. When a motor, engine or blower is operated the shafts may expand axially. If the coupling is installed in such a manner that there is not enough room for expansion the blower shaft can be forced back into the blower and cause the impeller to contact the gear end headplate resulting in damage to the blower. The two shafts must be in as near perfect alignment in all directions as possible, and the gap must be established with the motor armature on its electrical center if end-play exists. Coupling manufacturer's recommendations for maximum misalignment, although acceptable for the coupling, are normally too large to achieve smooth operation and maximum life of the blower.

The following requirements of a good installation are recommended. When selecting a coupling to be fitted to the blower shaft ROOTS recommends a taper lock style coupling to insure proper contact with the blower shaft. If the coupling must have a straight bore the coupling halves must be fitted to the two shafts with a line to line thru .001" interference fit. Coupling halves must be warmed up per coupling manufacturer's recommendations. Maximum deviation in offset alignment of the shafts should not exceed .005" (.13 mm) total indicator reading, taken on the two coupling hubs. Maximum deviation from parallel of the inside coupling faces should not exceed .001" (.03 mm) when checked at six points around the coupling.

When a unit is BELT DRIVEN, the proper selection of sheave diameters will result in the required unit speed. When selecting a sheave to be fitted to the blower shaft ROOTS recommends a taper lock style sheave to insure proper contact with the blower shaft. This flexibility can lead to operating temperature problems caused by unit speed being too low. Make sure the drive speed selected is within the allowable range for the specific unit size, as specified under Table 1.

Belt drive arrangements usually employ two or more V-belts running in grooved sheaves. Installation of the driver is less critical than for direct coupling, but its shaft must be level and parallel with the unit shaft. **The driver should be mounted on the inlet side of a vertical unit (horizontal piping) and on the side nearest to the shaft on a horizontal unit. SEE PAGE 6 - Acceptable Blower Drive Arrangement Options.** The driver must also be mounted on an adjustable base to permit installing, adjusting and removing the V-belts. To position the driver correctly, both sheaves need to be mounted on their shafts and the nominal shaft center distance known for the belt lengths to be used.

CAUTION: Drive couplings and sheaves (pulleys) should have an interference fit to the shaft of the blower (set screw types of attachment generally do not provide reliable service.) It is recommended that the drive coupling or sheave used have a taper lock style bushing which is properly sized to provide the correct interference fit required. Drive couplings, that require heating to fit on the blower shaft, should be installed per coupling manufacturer recommendations. A drive coupling or sheave should not be forced on to the shaft of the blower as this could affect internal clearances resulting in damage to the blower.

Engine drive applications often require special consideration to drive coupling selection to avoid harmful torsional vibrations. These vibrations may lead to blower damage if not dampened adequately. It is often necessary to install a flywheel and/or a torsionally soft elastic element coupling based on the engine manufacturer recommendations.

The driver sheave should also be mounted as close to its bearing as possible, and again should fit the shaft correctly. Position the driver on its adjustable base so that 2/3 of the total movement is available in the direction away from the unit, and mount the assembly so that the face of the sheave is accurately in line with the unit sheave. This position minimizes belt wear, and allows sufficient adjustment for both installing and tightening the belts. After belts are installed, adjust their tension in accordance with the manufacturer's instructions. However, only enough tension should be applied to prevent slippage when the unit is operating under load. Excessive tightening can lead to early bearing concerns or shaft breakage.

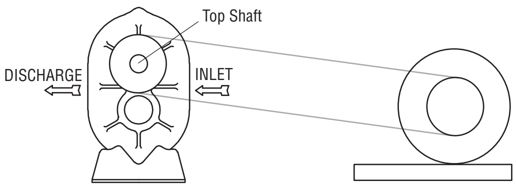
Before operating the drive under power to check initial belt tension, first remove covers from the unit connections. Make sure the interior is still clean, then rotate the shaft by hand. Place a coarse screen over the inlet connection to prevent anything being drawn into the unit while it is operating, and avoid standing in line with the discharge opening. Put oil in the sumps per instructions under **LUBRICATION.**

Piping

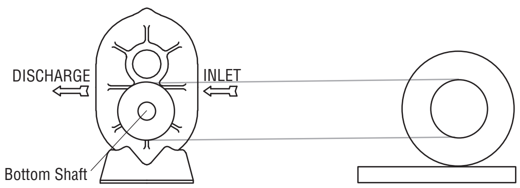
Before connecting piping, remove any remaining anti-rust compound from unit connections. Clean pipe should be no

Acceptable Blower Drive Arrangement Options

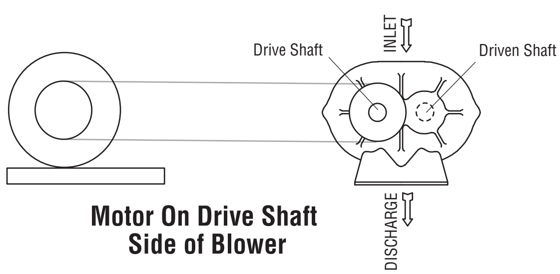
ACCEPTABLE



Motor On Inlet Side of Blower (Top Shaft)

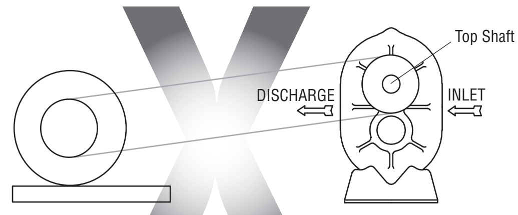


Motor On Inlet Side of Blower (Bottom Shaft)

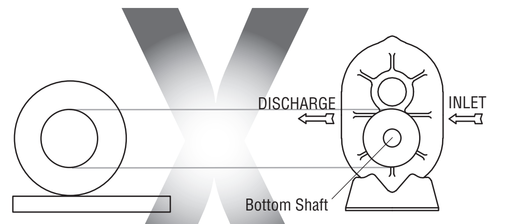


Motor On Drive Shaft Side of Blower

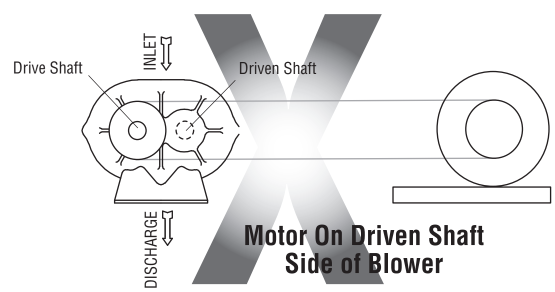
UNACCEPTABLE



Motor On Discharge Side of Blower (Top Shaft)



Motor On Discharge Side of Blower (Bottom Shaft)



Motor On Driven Shaft Side of Blower

smaller than unit connections. In addition, make sure it is free of scale, cuttings, weld beads, or foreign material of any kind. To further guard against damage to the unit, especially when an inlet filter is not used, install a substantial screen of 16 mesh backed with hardware cloth at or near the inlet connections. Make provisions to clean this screen of collected debris after a few hours of operation. It should be removed when its usefulness has ended, as the wire will eventually deteriorate and small pieces going into the unit may cause serious damage.

Pipe flanges or male threads must meet the unit connections accurately and squarely. DO NOT attempt to correct misalignment by springing or cramping the pipe. In most cases this will distort the unit casing and cause impeller rubbing. In severe cases it can prevent operation or result in a broken drive shaft. For similar reasons, piping should be supported near the unit to eliminate dead weight strains. Also, if pipe expansion is likely to occur from temperature change, installation of flexible connectors or expansion joints is advisable.

Figure 3 represents an installation with all accessory items that might be required under various operating conditions. Inlet piping should be completely free of valves or other restrictions. When a shut-off valve can not be avoided, make sure a full size vacuum relief is installed nearest the unit inlet. This will protect against unit overload caused by accidental closing of the shut-off valve.

Need for an inlet silencer will depend on unit speed and pressure, as well as sound-level requirements in the general surroundings. An inlet filter is recommended, especially in dusty or sandy locations. A discharge silencer is also normally suggested, even though Whispair units operate at generally lower noise levels than conventional rotary blowers. Specific recommendations on silencing can be obtained from your local ROOTS distributor.

Discharge piping requires a pressure relief valve, and should include a manual unloading valve to permit starting the unit under no-load conditions. Reliable pressure/vacuum gauges and good thermometers at both inlet and discharge are recommended to allow making the important checks on unit operating conditions. The back-pressure regulator shown in Figure 3 is useful mainly when volume demands vary while the unit operates at constant output. If demand is constant, but somewhat lower than the unit output, excess may be blown off through the manual unloading valve.

In multiple unit installations where two or more units operate with a common header, use of check valves is mandatory. These should be of a direct acting or free swinging type, with one valve located in each line between the unit and header. Properly installed, they will protect against damage from reverse rotation caused by air and material back-flow through an idle unit.

After piping is completed, and before applying power, rotate the drive shaft by hand again. If it does not move with uniform freedom, look for uneven mounting, piping strain, excessive belt tension or coupling misalignment.

DO NOT operate the unit at this time unless it has been lubricated per instructions.

Technical Supplement for 32, 33, 36, 42, 45, 47, 53, 56, 59, 65, 68, 615 Universal RAI-G blowers

ROOTS Universal RAI-G rotary positive gas blowers are a design extension of the basic Universal RAI blower model. URAI-G blower uses (4) mechanical seals in place of the standard inboard lip seals to minimize gas leakage into the atmosphere. The seal chambers are piped to plugged connections. These should be opened periodically to confirm that there is no build-up of oil due to leakage by the mechanical seal. Special traps may be required for vacuum operation. These units are intended for gases which are compatible with cast iron case material, steel shafts, 300/400 series stainless steel and carbon seal components, viton o-rings and the oil/grease lubricants. If there are any questions regarding application or operation of this gas blower, please contact factory.

Precaution: URAI-G blowers: Care must be used when opening the head plate seal vent chamber plugs (43) as some gas will escape–if it is a pressure system, or the atmospheric air will leak in-if the system is under vacuum. There is a possibility of some gas leakage through the mechanical seals. This leakage on the gear end will escape through the gear box vent, and on the drive end, through the grease release fittings. If the gas leakage is undesirable, each seal chamber must be purged with an inert gas through one purge gas hole (43) per seal . There are two plugged purge gas holes(1/8 NPT) provided per seal. The purge gas pressure must be maintained one psi above the discharge gas pressure. Also, there exists a possibility of gear end oil and drive end grease leakage into the gas stream.

The lubricants selected must be compatible with the gas.

URAI GAS Blower Oil and Grease Specifications

The specified oil should be ROOTS synthetic P/N 813-106- of the proper viscosity.

When servicing drive end bearings of a Gas blower, use the specified NLGI #2 premium grade aluminum complex* grease, ROOTS P/N T20019001, with 300°F (149°C) service temperature and moisture resistance and good mechanical stability.

*ROOTS Synthetic Oil & Grease is superior in performance to petroleum based products. It has high oxidation stability, excellent corrosion protection, extremely high film strength and low coefficient of friction. Typical oil change intervals are increased 2-3 times over petroleum based lubricants. Also, ROOTS Synthetic Oil is 100% compatible with petroleum based oils. Simply drain the oil in the blower and refill the reservoirs with ROOTS Synthetic Oil to maintain optimum performance of your ROOTS blower.

Due to sludge build-up and seal leakage problems, Roots recommendation is **DO NOT USE** Mobil SHC synthetic oils in Roots blowers.

For Units with a Grease Lubricated Drive End

A simple but very effective lubrication system is employed on the drive shaft end bearings. Hydraulic pressure relief fittings are provided to vent any excess grease, preventing pressure build-up on the seals. A restriction plug and metering orifice prevent loss of lubricant from initial surges in lubricant pressure but permit venting excess lubricant under steadily rising pressures.

For grease lubricated drive end blowers see page 16, table 4, regarding specified greasing intervals.

When servicing drive end bearings of Non Gas blower, use the specified NLGI #2 premium grade microgel grease with 250°F (121°C) service temperature and moisture resistance and good mechanical stability. ROOTS specifies Shell Darina EP NLGI Grade 2. Product Code 71522 or Shell Darina SD 2 product code 506762B.

URAI GAS Blower Oil and Grease Specifications

The specified oil should be ROOTS synthetic P/N 813-106- of the proper viscosity.

When servicing drive end bearings of a Gas blower, use the specified NLGI #2 premium grade aluminum complex* grease, ROOTS P/N T20019001, with 300°F (149°C) service temperature and moisture resistance and good mechanical stability.

NOTE: Lithium based greases are not compatible with the ROOTS Synthetic grease used when assembling a Gas blower or the non-soap base grease used when assembling a standard URAI blower. Lithium based grease is not approved for any ROOTS blowers.

Using a pressure gun, slowly force new lubricant into each drive end bearing housing until traces of clean grease comes out of the relief fitting. The use of an electric or pneumatic grease gun could force the grease in too rapidly and thus invert the seals and should not be used.

To fill the gearbox, remove the breather plug (25) and the oil overflow plug (21) - see page 14. Fill the reservoir up to the overflow hole. Place the breather and the overflow plug back into their respective holes.

After a long shutdown, it is recommended that the grease fittings be removed, the old grease flushed out with kerosene or #10 lubricating oil, drained thoroughly, and bearings refilled with new grease. Be sure grease relief fittings are reinstalled. Grease should be added using a hand operated grease gun to the drive end bearings at varying time intervals depending on duty cycle and RPM. Table 4 has been prepared as a general greasing schedule guide based on average operating conditions. More frequent intervals may be necessary depending on the grease operating temperature and unusual circumstances.

For Units with Splash Lubrication on Both Ends

Bearings and oil seals are lubricated by the action of the timing gears or oil slingers which dip into the main oil sumps causing oil to splash directly on gears and into bearings and seals. A drain port is provided below each bearing to prevent an excessive amount of oil in the bearings. Seals located inboard of the bearings in each headplate effectively retain oil within the sumps. Any small leakage that may occur should the seals wear passes into a cavity in each vented headplate and is drained downward.

Oil sumps on each end of the blower are filled by removing top vent plugs, Item (25), and filling until oil reaches the middle of the oil level sight gauge when the unit is not operating, Item (45 or 53), DO NOT FILL PAST THE MIDDLE OF THE SIGHT GLASS.

Initial filling of the sumps should be accomplished with the blower not operating, in order to obtain the correct oil level. Approximate oil quantities required for blowers of the various models and configurations are listed in Table 3. Use a good grade of industrial type non-detergent, rust inhibiting, anti-foaming oil and of correct viscosity per Table 2. ***ROOTS synthetic oil (ROOTS P/N 813-106-) is highly recommended and specified.** ROOTS does not recommend automotive type lubricants, as they are not formulated with the properties mentioned above.

The oil level may rise or fall on the gauge during operation, to an extent depending somewhat on oil temperature and blower speed.

Proper lubrication is usually the most important single consideration in obtaining maximum service life and satisfactory operation from the unit. Unless operating conditions are quite severe, a weekly check of oil level and necessary addition of lubricant should be sufficient. During the first week of operation, check the oil levels in the oil sumps about once a day, and watch for leaks. Replenish as necessary. Thereafter, an occasional check should be sufficient. It is recommended that the oil be changed after initial 100 hours of operation. Frequent oil changing is not necessary unless the blower is operated in a very dusty location.

Normal life expectancy of petroleum based oils is about 2000 hours with an oil temperature of about 180°F (82°C). As the oil temperature increases by increments of 15-18°F (8°C - 10°C), the life is reduced by half. Example: Oil temperatures of 210-216°F (99°C - 102°C) will produce life expectancy of 1/4 or 500 hours. Therefore, it is considered normal to have oil change periods of 500 hours with petroleum based oils.

Normal life expectancy of ROOTS™ Synthetic Oil is about 4000 to 8000 hours with an oil temperature of about 180°F (82°C). As the oil temperature increases by increments of 15-18°F (8°C - 10°C), the life is reduced by half. Example: Oil temperatures of 210-216°F (99°C - 102°C) will produce life expectancy of 1/4 or 1000 to 2000 hours.

NOTE: To estimate oil temperature, multiply the discharge temperature of the blower by 0.80. Example: if the discharge air temperature of the blower is 200° F, it is estimated that the oil temperature is 160° F.

*ROOTS™ Synthetic Oil & Grease is superior in performance to petroleum based products. It has high oxidation stability, excellent corrosion protection, extremely high film strength and low coefficient of friction. Typical oil change intervals are increased 2-3 times over petroleum based lubricants. Also, ROOTS™ Synthetic Oil is 100% compatible with petroleum based oils. Simply drain the oil in the blower and refill the reservoirs with ROOTS™ Synthetic Oil to maintain optimum performance of your ROOTS™ blower.

Before operating a blower under power for the first time, recheck the unit and the installation thoroughly to reduce the likelihood of avoidable troubles. Use the following procedure check list as a guide, but consider any other special conditions in the installation.

- ❑ Be certain that no bolts, tools, rags, or debris have been left in the blower air chamber or piping.
- ❑ If an outdoor intake without filter is used, be sure the opening is located so it cannot pick up dirt and is protected by a strong screen or grille. Use of the temporary protective screen as described under INSTALLATION is strongly recommended.
- ❑ Recheck blower leveling, drive alignment and tightness of all mounting bolts if installation is not recent. If belt drive is used, adjust belt tension correctly.
- ❑ Turn drive shaft by hand to make sure impellers still rotate without bumping or rubbing at any point.
- ❑ Ensure oil levels in the main oil sumps are correct.
- ❑ Check lubrication of driver. If it is an electric motor, be sure that power is available and that electrical overload devices are installed and workable.
- ❑ Open the manual unloading valve in the discharge air line. If a valve is in the inlet piping, be sure it is open.
- ❑ Bump blower a few revolutions with driver to check that direction of rotation agrees with arrow near blower shaft, and that both coast freely to a stop.

After the preceding points are cleared, blower is ready for trial operation under "no-load" conditions. The following procedure is suggested to cover this initial operation test period.

a. Start blower, let it accelerate to full speed, then shut off. Listen for knocking sounds, both with power on and as speed slows down.

b. After blower comes to a complete stop, repeat above, but let blower run 2 or 3 minutes. Check for noises, such as knocking sounds.

c. After blower comes to a complete stop, operate blower for about 10 minutes unloaded. Check oil levels. Observe cylinder and headplate surfaces for development of hot spots such as burned paint, indicating impeller rubs. Be aware of any noticeable increase in vibration.

Assuming that all trials have been satisfactory, or that necessary corrections have been made, the blower should now have a final check run of at least one hour under normal operating conditions. After blower is restarted, gradually close the discharge unloading valve to apply working pressure. At this point it is recommended that a pressure gauge or manometer be connected into the discharge line if not already provided, and that thermometers be in both inlet and discharge lines. Readings from these instruments will show whether pressure or temperature ratings of the blower are being exceeded.

During the final run, check operating conditions frequently and observe the oil levels at reasonable intervals. If excessive noise or local heating develops, shut down immediately and determine the cause. If either pressure rise or temperature rise across the blower exceeds the limit specified in this manual, shut down and investigate conditions in the piping system. Refer to the TROUBLESHOOTING CHECKLIST for suggestions on various problems that may appear.

The blower should now be ready for continuous duty operation at full load. During the first few days make periodic checks to determine whether all conditions remain steady, or at least acceptable. This may be particularly important if the blower is supplying air to a process system where conditions can vary. At the first opportunity, stop the blower and clean the temporary inlet protective screen. If no appreciable amount of debris has collected, the screen may be removed. See comments under INSTALLATION. At this same time, verify leveling, coupling alignment or belt tension, and mounting bolt tightness.

Should operating experience prove that blower capacity is a little too high for the actual air requirements, a small excess may be blown off continuously through the manual unloading or vent valve. Never rely on the pressure relief valve as an automatic vent. Such use may cause the discharge pressure to become excessive, and can also result in unsafe operation of the valve itself. If blower capacity appears to be too low, refer to the TROUBLESHOOTING CHECKLIST.

Vibration Assessment Criteria

With measurements taken at the bearing locations on the housings, see chart below for an appropriate assessment guide for rotary lobe blowers rigidly mounted on stiff foundations.

In general, blower vibration levels should be monitored on a regular basis and the vibration trend observed for progressive or sudden change in level. If such a change occurs, the cause should be determined through spectral analysis.

As shown on the chart below, the level of all pass vibration will determine the need to measure discrete frequency vibration levels and the action required.

All Pass Vibration (in/sec)	Discrete Frequency Vibration (in/sec)	Action
0.45 or less	N/R	Acceptable
Greater than 0.45 but 1.0 or less	0.45 or less @ any frequency	Acceptable
	Greater than 0.45 @ any frequency	Investigate
Greater than 1.0	Less than 1.0	Investigate
	Greater than 1.0	Investigate

Troubleshooting Checklist

Trouble	Item	Possible Cause	Remedy
No flow	1	Speed too low	Check by tachometer and compare with published performance
	2	Wrong rotation	Compare actual rotation with Figure 1 Change driver if wrong
	3	Obstruction in piping	Check piping, valves, silencer to assure open flow path
Low capacity	4	Speed too low	See item 1, If belt drive, check for slippage and readjust tension
	5	Excessive pressure rise	Check inlet vacuum and discharge pressure and compare with Published performance
	6	Obstruction in piping	See item 3
	7	Excessive slip	Check inside of casing for worn or eroded surfaces causing excessive clearances
Excessive power	8	Speed too high	Check speed and compare with published performance
	9	Excessive pressure rise	See Item 5
	10	Impeller rubbing	Inspect outside of cylinder for high temperature areas, then check for impeller contact at these points. Correct blower mounting, drive alignment
	11	Scale, sludge, rust or product build up	Clean blower appropriately
Damage to bearings or gears	12	Inadequate lubrication	Check oil sump levels in gear and drive end headplates
	13	Excessive lubrication	Check oil levels. If correct, drain and refill with clean oil of recommended grade
	14	Excessive pressure rise	See Item 5
	15	Coupling misalignment	Check carefully. Realign if questionable
	16	Excessive belt tension	Readjust for correct tension
Vibration	17	Misalignment	See Item 15
	18	Impellers rubbing	See Item 10
	19	Worn bearings/gears	Check gear backlash and condition of bearings, and replace as indicated
	20	Unbalanced or rubbing impeller	Scale or process material may build up on casing and impellers, or inside impellers. Remove build-up to restore original clearances and impeller balance
	21	Driver or blower loose	Tighten mounting bolts securely
	22	Piping resonances	Determine whether standing wave pressure pulsations are present in the piping
	23	Scale/sludge build-ups	Clean out interior of impeller lobes to restore dynamic balance
	24	Casing strain	Re-work piping alignment to remove excess strain
Driver stops, or will not start	25	Impeller stuck	Check for excessive hot spot on headplate or cylinder. See item 10. Look for defective shaft bearing and/or gear teeth
	26	Scale, sludge, rust or product build-up	Clean blower appropriately
Excessive breather	27	Broken seal	Replace seals
Blow-by or excessive oil leakage to vent area	28	Defective O-ring	Replace seals and O-ring
Excessive oil leakage in vent area	29	Defective/plugged breather	Replace breather and monitor oil leakage
	30	Oil level too high	Check sump levels in gear and drive headplates.
	31	Oil type or viscosity incorrect	Check oil to insure it meets recommendations. Drain then fill with clean oil of recommended grade.
	32	Blower running hot	Check blower operating conditions to ensure they are within the operating limitations defined in this manual.

A good program of consistent inspection and maintenance is the most reliable method of minimizing repairs to a blower. A simple record of services and dates will help keep this work on a regular schedule. Basic service needs are:

- Lubrication
- Checking for hot spots
- Checking for increases or changes in vibration and noise
- Recording of operating pressures and temperatures

Above all, a blower must be operated within its specified rating limits, to obtain satisfactory service life.

A newly installed blower should be checked often during the first month of full-time operation. Attention there after may be less frequent assuming satisfactory performance. Lubrication is normally the most important consideration and weekly checks of lubricant levels in the gearbox and bearing reservoirs should be customary. Complete oil change schedules are discussed under **LUBRICATION.**

Driver lubrication practices should be in accordance with the manufacturer's instructions. If direct connected to the blower through a lubricated type coupling, the coupling should be checked and greased each time blower oil is changed. This will help reduce wear and prevent unnecessary vibration. In a belted drive system, check belt tension periodically and inspect for frayed or cracked belts.

In a new, and properly installed, unit there is no contact between the two impellers, or between the impellers and cylinder or headplates. Wear is confined to the bearings (which support and locate the shafts) the oil seals, and the timing gears. All are lubricated and wear should be minimal if clean oil of the correct grade is always used. Seals are subject to deterioration as well as wear, and may require replacement at varying periods.

Shaft bearings are designed for optimum life under average conditions with proper lubrication and are critical to the service life of the blower. Gradual bearing wear may allow a shaft position to change slightly, until rubbing develops between impeller and casing. This will cause spot heating, which can be detected by observing these surfaces. Sudden bearing situations is usually more serious. Since the shaft and impeller are no longer supported and properly located, extensive general damage to the blower casing and gears is likely to occur.

Oil seals should be considered expendable items, to be replaced whenever drainage from the headplate vent cavity becomes excessive or when the blower is disassembled for any reason. Some oil seal leakage may occur since an oil film under the lip is required for proper operation. Periodically leaked oil should be wiped off from surfaces. Minor seal leakage should not be considered as indicating seal replacement.

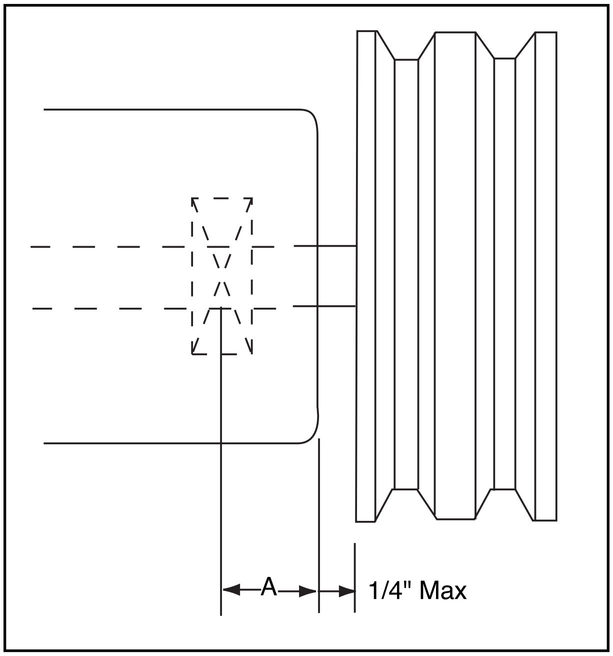
Timing gear wear, when correct lubrication is maintained, should be negligible. Gear teeth are cut to provide the correct amount of backlash, and gears correctly mounted on the shafts will accommodate a normal amount of tooth wear without permitting contact between lobes of the two impellers. However, too high an oil level will cause churning and excessive heating. This is indicated by unusually high temperature at the bottom of the gear housing. Consequent heating of the gears will result in loss of tooth-clearance , backlash and rapid wear of the gear teeth usually will develop. Continuation of this tooth wear will eventually produce impeller contacts (knocking), and from this point serious damage will be unavoidable if blower operation is continued. A similar situation can be produced suddenly by gear tooth fracture, which is usually brought on by sustained overloading or momentary shock loads.

Problems may also develop from causes other than internal parts damage. Operating clearances within a blower are only a few thousandths of an inch. This makes it possible for impeller interference or casing rubs to result from shifts in the blower mounting, or from changes in piping support. If this type of trouble is experienced, and the blower is found to be clean, try removing mounting strains. Loosen blower mounting bolts and reset the leveling and drive alignment. Then tighten mounting again, and make sure that all piping meets blower connections accurately and squarely Foreign materials in the blower will also cause trouble, which can only be cured by disconnecting the piping and thoroughly cleaning the blower interior.

A wide range of causes & solutions for operating troubles are covered in the **TROUBLE SHOOTING CHECKLIST.** The remedies suggested should be performed by qualified mechanics with a good background. Major repairs generally are to be considered beyond the scope of maintenance, and should be referred to an authorized ROOTS distributor.

Warranty situations should not be repaired at all, unless specific approval has been obtained through ROOTS before starting work. Unauthorized disassembly within the warranty period may void the warranty.

Figure 2 - Allowable Overhung Loads for V-Belt Drives Universal RAI®/URAI®-J Units



$$\text{Belt Pull lbs} = \frac{252100 \bullet \text{Motor HP}}{\text{Blower RPM} \bullet \text{Sheave Diameter}}$$

$$\text{Shaft Load (lb.in)} = \text{Belt Pull} \bullet \left(A + 1/4" + \frac{\text{Sheave Width}}{2}\right)$$

Frame Size	Dim. "A"	Max. Allow. Shaft Load (lb-in.)	Min. Sheave Diameter	Max. Sheave Width
22, 24	0.61	150	4.00	1.75
32, 33, 36	0.80	400	5.00	1.91
42, 45, 47	1.02	650	5.00	2.31
53, 56, 59	1.13	1,325	6.00	3.06
65, 68, 615	1.36	2,250	8.00	3.44
76, 711, 718	1.16	2,300	9.50	3.75

NOTE:

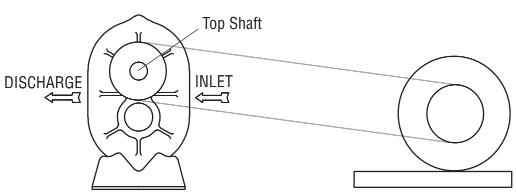
Arc of sheave belt contact on the smaller sheave not to be less than 170°

Driver to be installed on the inlet side for vertical units, and on the drive shaft side for horizontal units.

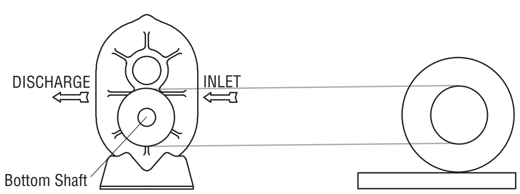
ROOTS recommends the use of two or more 3V, 5V or 8V belts and sheaves.

Acceptable Blower Drive Arrangement Options

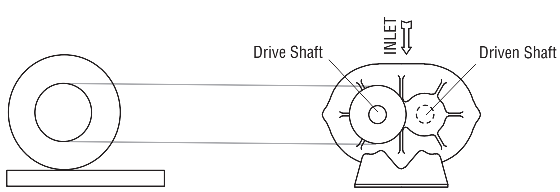
ACCEPTABLE



Motor On Inlet Side of Blower (Top Shaft)

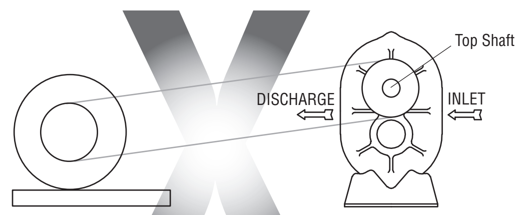


Motor On Inlet Side of Blower (Bottom Shaft)

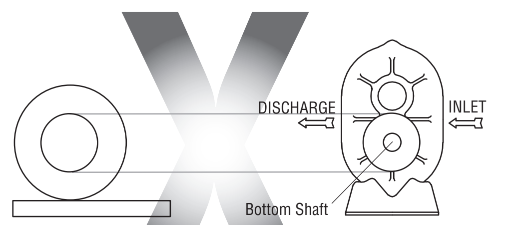


Motor On Drive Shaft Side of Blower

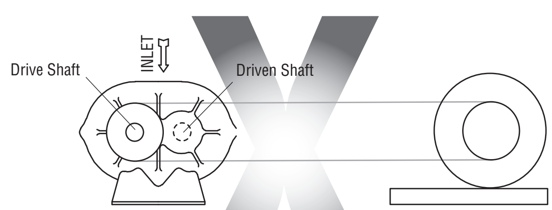
UNACCEPTABLE



Motor On Discharge Side of Blower (Top Shaft)

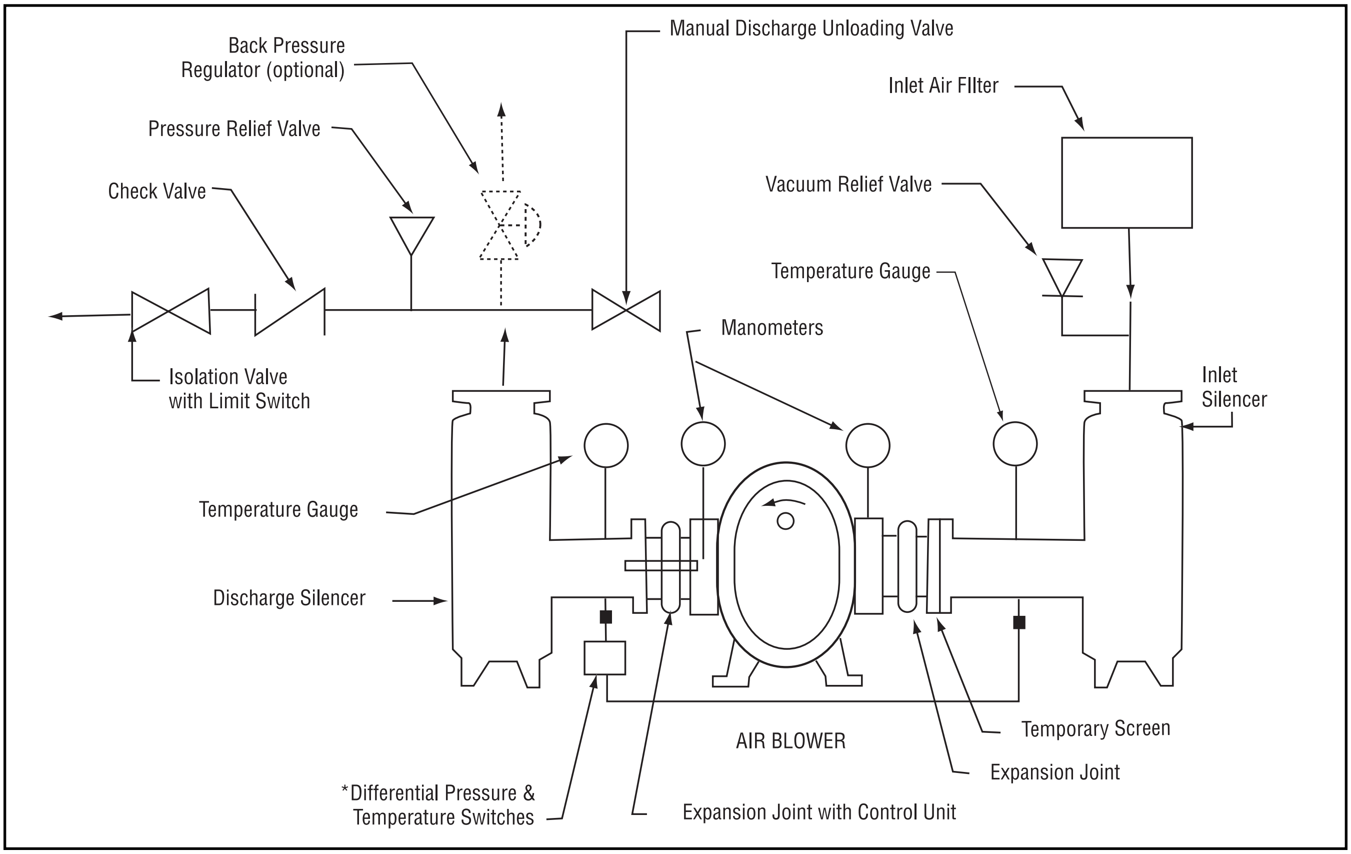


Motor On Discharge Side of Blower (Bottom Shaft)



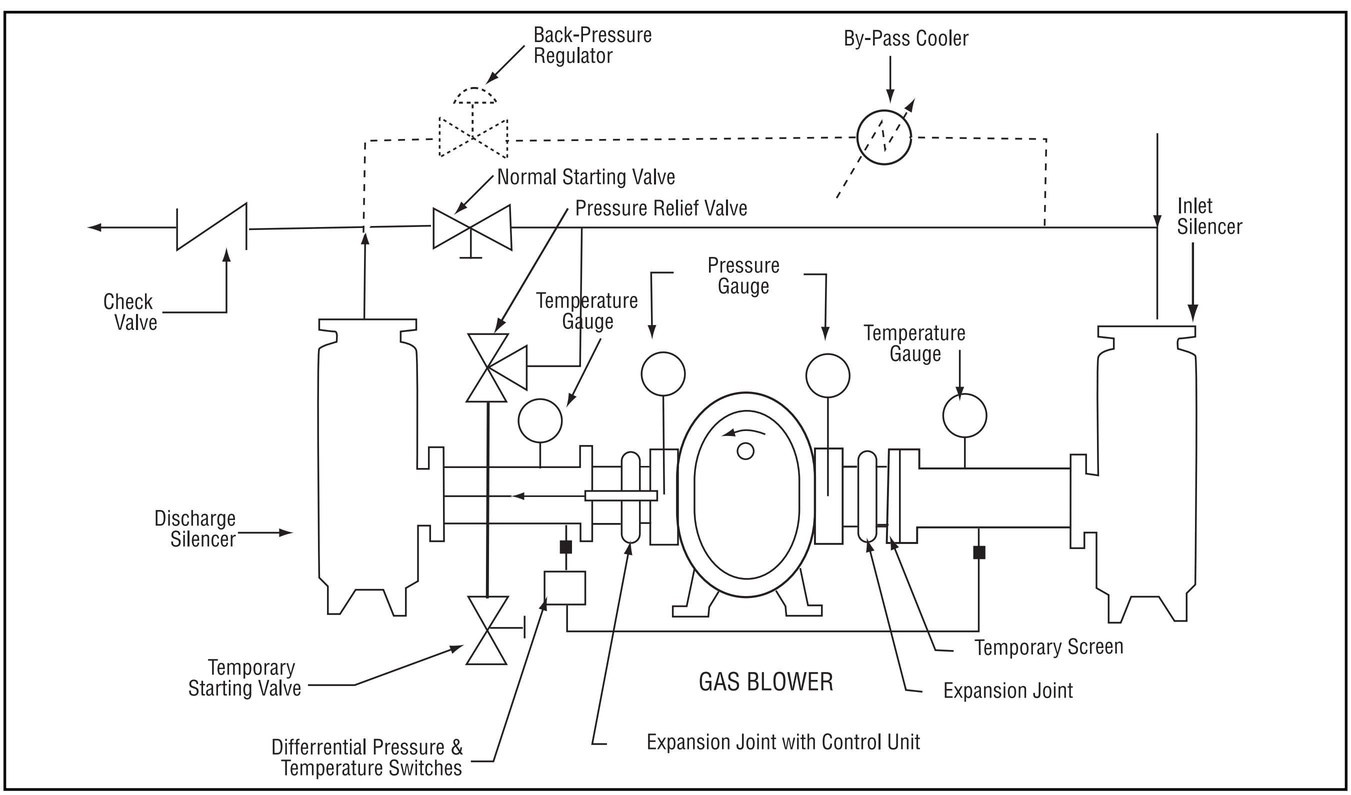
Motor On Driven Shaft Side of Blower

Figure 3a - Air Blower Installation with Accessories



Above are suggested locations for available accessories.

Figure 3b -Gas Blower Installation with Accessories



Above are suggested locations for available accessories.

Figure 4

Blower Orientation Conversion

Model	Reversible Rotation	Whispair™ Design
Universal RAI	yes	no
URAI-J Whispair™	no	yes
URAI-G	yes	no

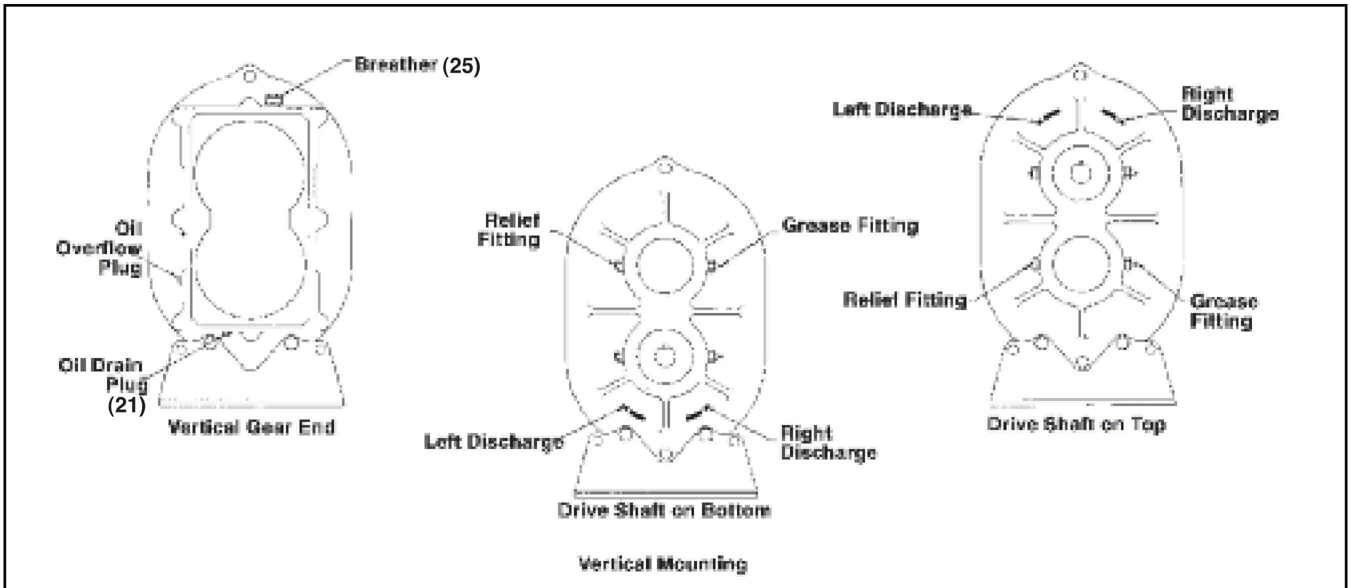
Special Note: WHISPAIR™ models are designed to operate with only one shaft rotation direction to take full advantage of the Whispair feature. Therefore, a WHISPAIR™ blower may be operated in the following combinations.

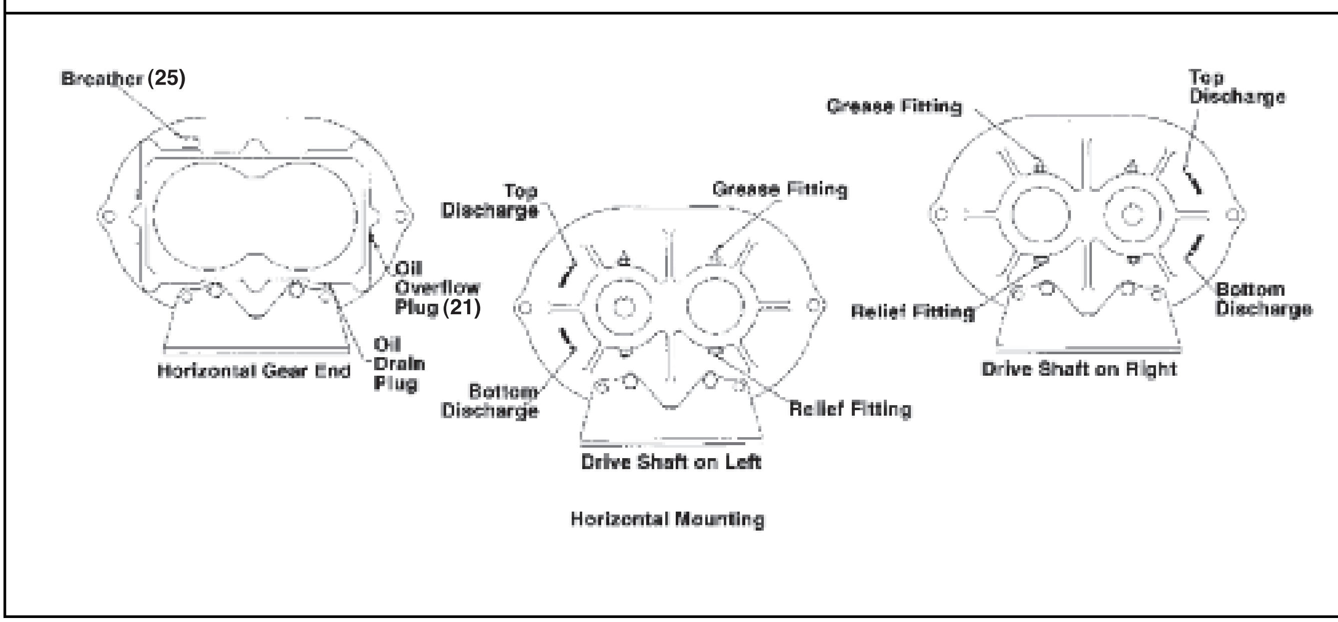
- CCW Rotation: Bottom Shaft; Right side discharge or a Left Shaft; Bottom discharge
- CCW Rotation: Top Shaft; Left side discharge or a Right Shaft; Top discharge

or

- CW Rotation: Bottom Shaft; Left side discharge or a Right Shaft Bottom discharge
- CW Rotation: Top Shaft; Right side discharge or a Left Shaft Top discharge

Blower Orientation and Lubrication Points: Grease Lubricated Drive End
Universal RAI series & URAI-G gas blowers





Drive End Breather Orientation for U-RAI series - DSL with Oil Lube

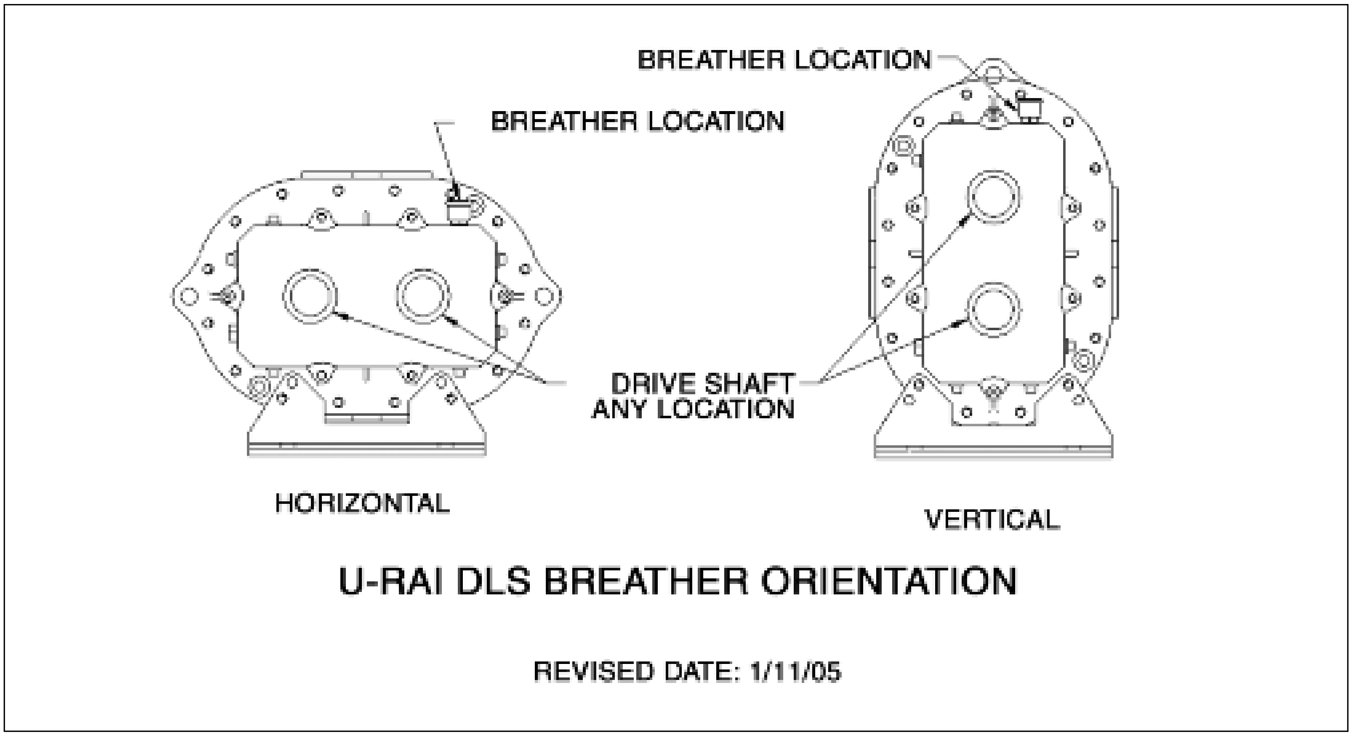


Table 1 - Universal RAI series, Universal URAI-DSI & URAI-G gas blower, Maximum Allowable Operating Conditions

Frame Size	Gear Diameter (Inch)	Speed RPM	Temp. Rise F°	(C°)	Delta Pressure PSI	(mbar)	Inlet Vacuum INHG	(mbar)
22	2.5	5275	225	(125)	12	(827)	15	(500)
24	2.5	5275	210	(117)	7	(483)	15	(500)
32	3.5	3600	240	(133)	15	1034	16	(539)
33	3.5	3600	225	(125)	12	(827)	15	(500)
36	3.5	3600	225	(125)	7	(483)	15	(500)
42	4.0	3600	240	(133)	15	(1034)	16	(539)
45	4.0	3600	225	(125)	10	(690)	16	(539)
47	4.0	3600	225	(125)	7	(483)	15	(500)
53	5.0	2850	225	(125)	15	(1034)	16	(539)
56	5.0	2850	225	(125)	13	(896)	16	(539)
59	5.0	2850	225	(125)	7	(483)	15	(500)
65	6.0	2350	250	(130)	15	(1034)	16	(539)
68	6.0	2350	240	(133)	14	(965)	16	(539)
615	6.0	2350	130	(72)	7	(483)	14	(472)
76	7.0	2050	250	(139)	15	(1034)	16	(539)
711	7.0	2050	225	(125)	10	(690)	16	(539)
718	7.0	2050	130	(72)	6	(414)	12	(405)

Table 2 - Recommended Oil Grades

Ambient Temperature °F (°C)	ISO Viscosity No.
Above 90° (32°)	320
32° to 90° (0° to 32°)	220
0° to 32° (-18° to 0°)	150
Below 0° (-18°)	100

URAI GAS Blower Oil and Grease Specifications

The specified oil should be ROOTS synthetic P/N 813-106- of the proper viscosity.

Table 3 - Approximate Oil Sump Capacities

These capacities are provided to assist in stocking the correct amount of oil. Exact sump capacities may differ slightly. See "Lubrication" section for proper filling instructions.

UNIVERSAL RAI, URAI-J, URAI-G

Frame Size	Gear End Capacity Fl. Oz. (Liters)	
	Vertical	Horizontal
22	3.4 (.1)	6.1 (.18)
24	3.4 (.1)	6.1 (.18)
32	8.5 (.25)	10.5 (.31)
33	8.5 (.25)	10.5 (.31)
36	8.5 (.25)	10.5 (.31)
42	12.7 (.37)	14.5 (.43)
45	12.7 (.37)	14.5 (.43)
47	12.7 (.37)	14.5 (.43)
53	16.0 (.47)	27.6 (.82)
56	16.0 (.47)	27.6 (.82)
59	16.0 (.47)	27.6 (.82)
65	28.3 (.84)	52.1 (1.54)
68	28.3 (.84)	52.1 (1.54)
615	28.3 (.84)	52.1 (1.54)
76	32.3 (.96)	59.5 (1.76)
711	32.3 (.96)	59.5 (1.76)
718	32.3 (.96)	59.5 (1.76)

See page 14 and 15 for illustration of vertical and horizontal configurations.

UNIVERSAL URAI series-DSL Splash Lubricated Drive End

Note that the gear end sump capacity is provided on the adjacent table.

Frame Size	Drive End Capacity Fl. Oz. (Liters)	
	Vertical	Horizontal
32	4.0 (.12)	6.5 (.19)
33	4.0 (.12)	6.5 (.19)
36	4.0 (.12)	6.5 (.19)
42	5.5 (.16)	10.8 (.32)
45	5.5 (.16)	10.8 (.32)
47	5.5 (.16)	10.8 (.32)
53	7.5 (.22)	14.8 (.44)
56	7.5 (.22)	14.8 (.44))
59	7.5 (.22)	14.8 (.44)
65	16 (0.47)	31 (0.91)
68	16 (0.47)	31 (0.91)
615	16 (0.47)	31 (0.91)

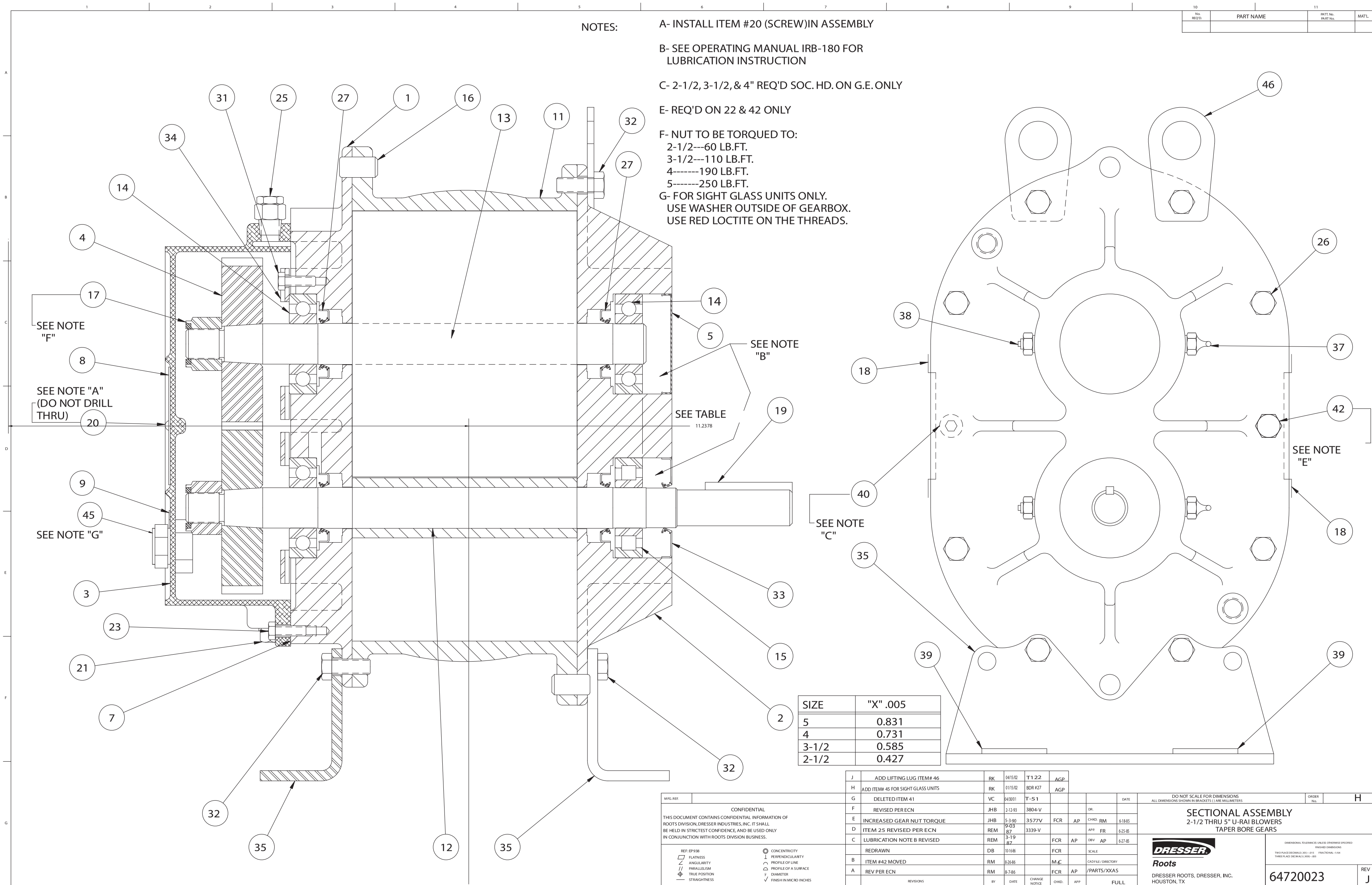
Table 4 - Universal URAI series with Grease Lubricated Drive End: Specified Bearing Greasing Intervals

Speed In RPM	Operating Hours Per Day		
	8	16	24
	Greasing Intervals in Weeks		
750-1000	7	4	2
1000-1500	5	2	1
1500-2000	4	2	1
2000-2500	3	1	1
2500-3000	2	1	1
3000 and up	1	1	1

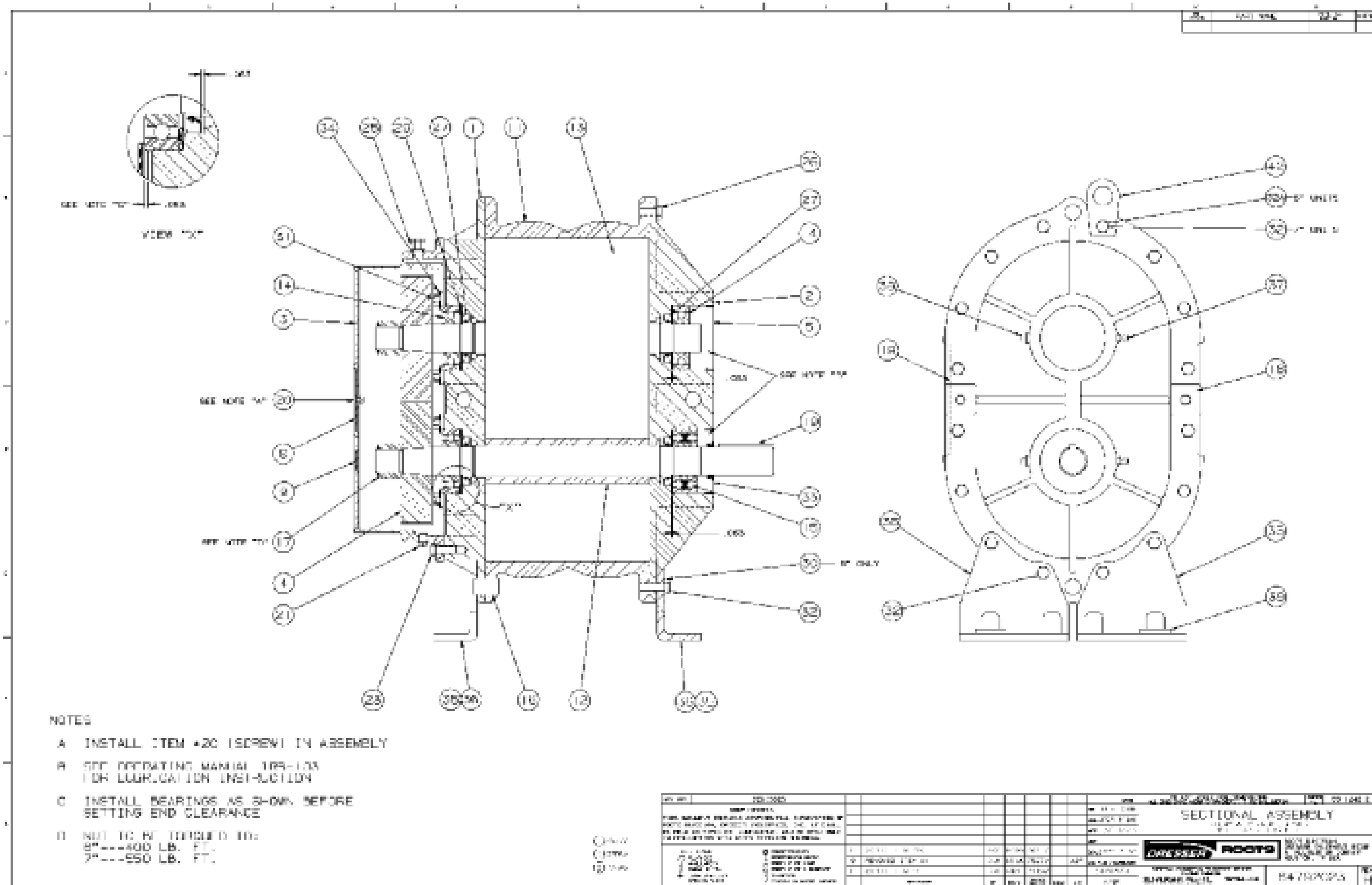
The specified grease for servicing drive end bearings of a Gas blower, use a NLGI #2 premium grade aluminum complex* grease, ROOTS P/N T20019001 with 300°F (149°C) service temperature and moisture resistance and good mechanical stability.

When servicing drive end bearings of Non Gas blower, use a NLGI #2 premium grade microgel grease with 250°F (121°C) service temperature and moisture resistance and good mechanical stability. ROOTS specifies Shell Darina EP NLGI Grade 2. Product Code 71522.

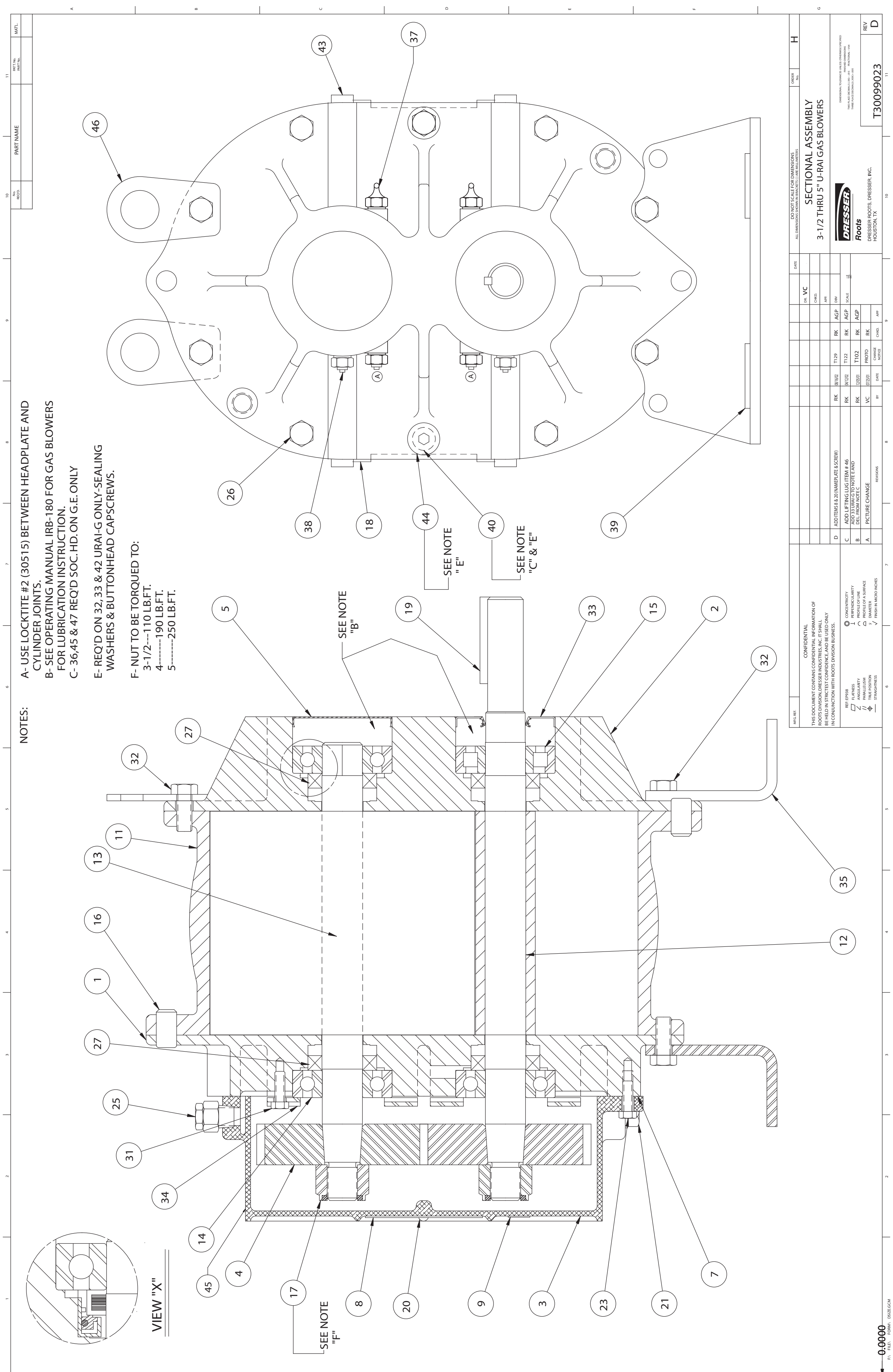
NOTE: Lithium based greases are not compatible with the ROOTS Synthetic grease used when assembling a Gas blower or the non-soap base grease used when assembling a standard URAI blower. Lithium based grease is not approved for any ROOTS blowers.



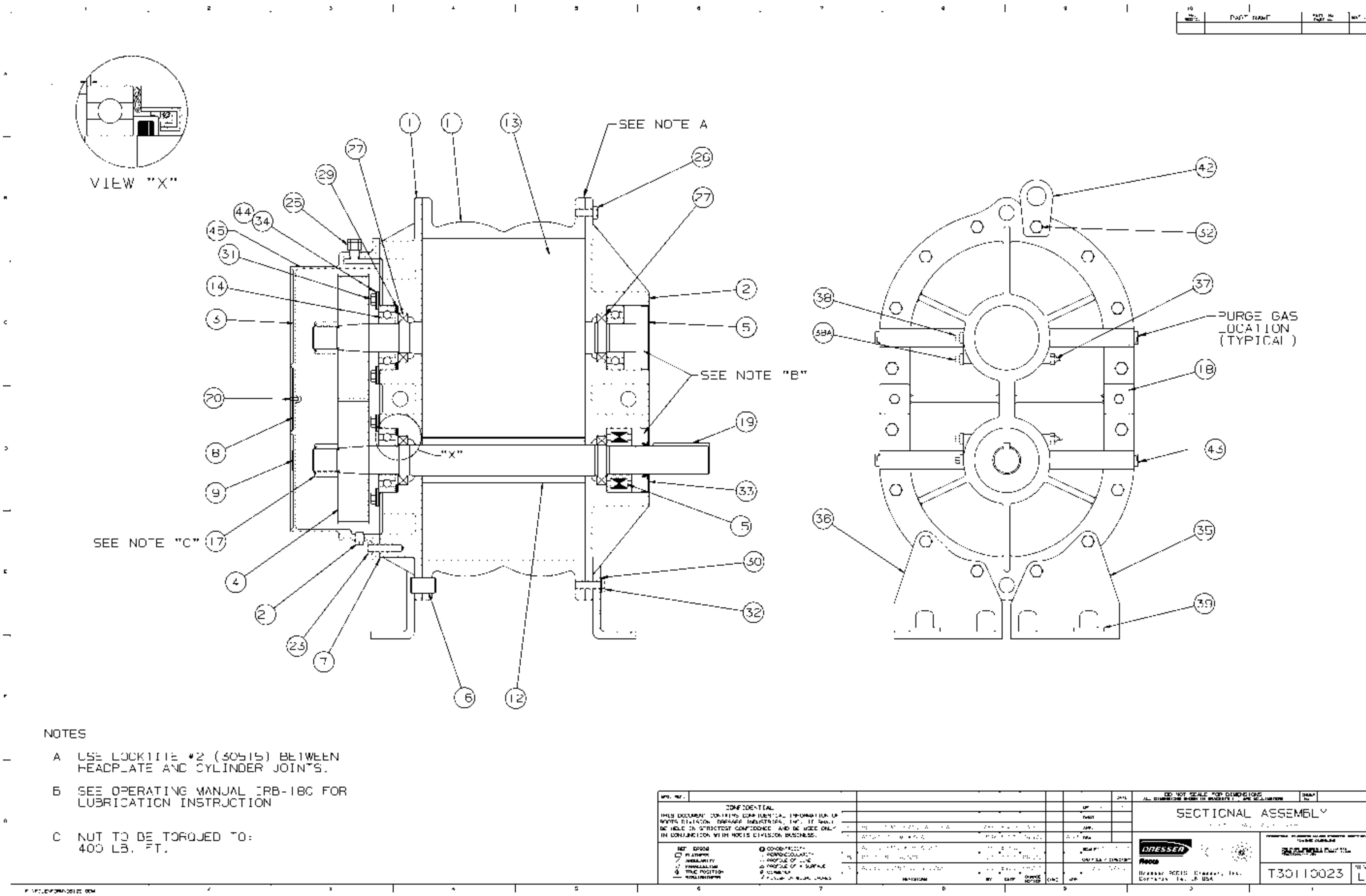
Assembly of UNIVERSAL RAI Series, Air Blowers, 2-1/2” Through 5” Gear Diameter



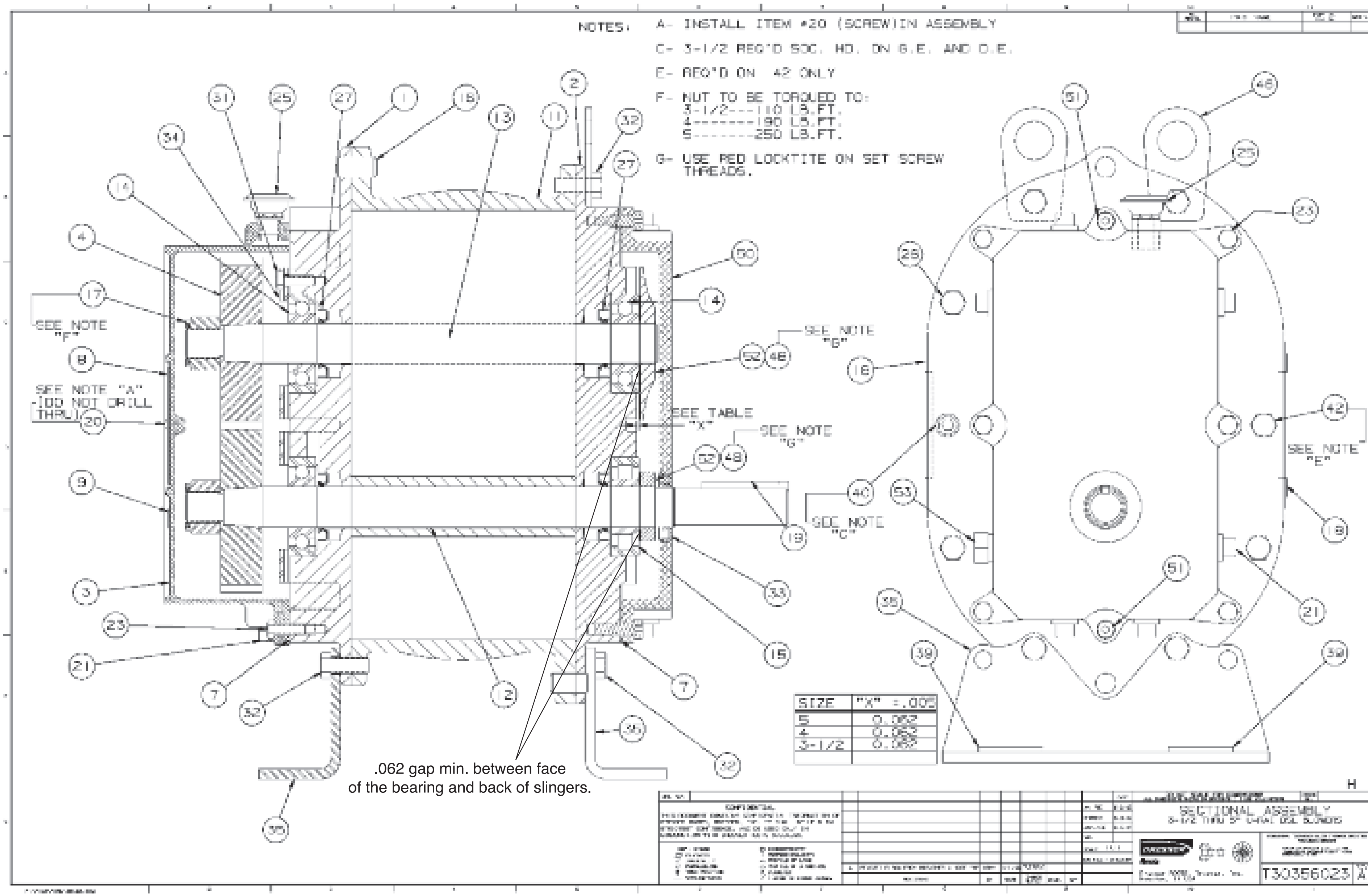
Assembly of UNIVERSAL RAI Blowers, 6” and 7” Diameter



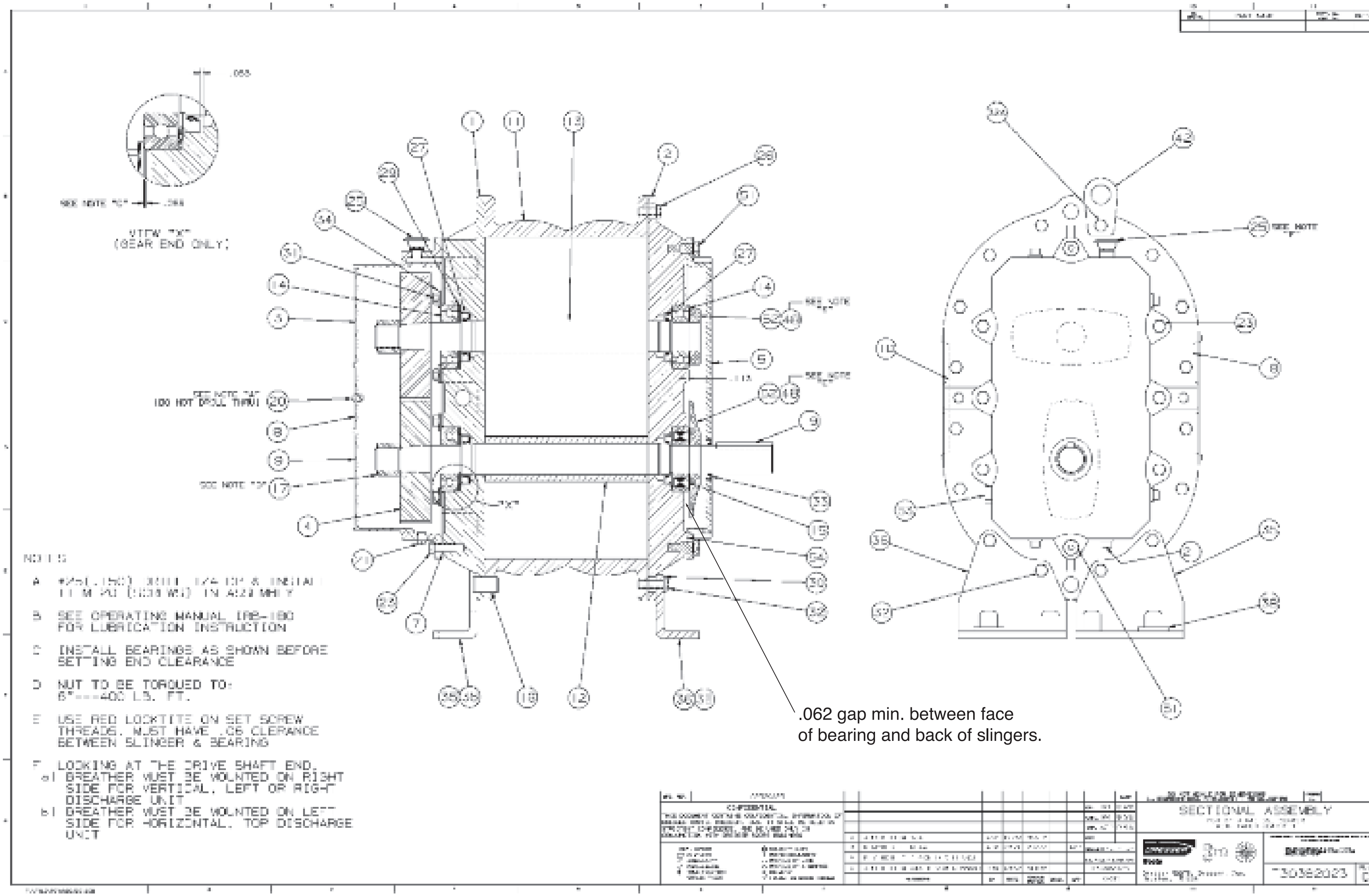
Assembly of UNIVERSAL RAI-G Series Gas Blowers, 3-1/2"Through 5" Gear Diameter



Assembly of UNIVERSAL RAI Series Gas Blowers, 6” Gear Diameter



Assembly of UNIVERSAL RAI Series - DSL with Splash Lubricated Drive End 3-5” Gear Diameter



Assembly of UNIVERSAL RAI Series - DSL with Splash Lubricated Drive End 6” Gear Diameter

Universal RAI Series Blowers Parts List 2-1/2" – 5" Gear Diameter

(Refer to drawing #64720023)

Item #	Part Name	Qty.
1	Headplate Gear End	1
2	Headplate Drive End	1
3	Gearbox	1
4	Timing Gears	2
5	Cover-Blind (Plug Opening)	1
7	Gasket, Gear Box	1
11	Cylinder	1
12	Impeller & Shaft Drive	1
13	Impeller & Shaft Driven	1
14	Bearing, Ball	3
15	Bearing, Roller	1
16	Pin, Dowel	4
17	Gear Nut	2
19	Key	1
21	Plug, Pipe	3
23	Screw Hex	6
25	Breather (Plug Vent)	1
26	Screw, Hex	*
27	Seal, Lip Bearing	4
31	Screw, Hex, Nylock	4
32	Screw, Hex	6
33	Seal Lip-Drive	1
34	Clamp Plate	2
35	Foot	2
37	Fitting, Grease	2
38	Fitting, Relief	2
39	Washer Mounting	4
40	Screw Socket	2
42	Screw Hex	2

*Quantities vary by blower.

Universal RAI Series Blowers Parts List 6" & 7" Gear Diameter

(Refer to drawing #64792023)

Item #	Part Name	Qty.
1	Headplate Gear End	1
2	Headplate Drive End	1
3	Gearbox	1
4	Timing Gears	2
5	Cover-Blind (Plug Opening)	1
7	Gasket, Gear Box	1
11	Cylinder	1
12	Impeller & Shaft Drive	1
13	Impeller & Shaft Driven	1
14	Bearing, Ball	3
15	Bearing, Roller	1
16	Pin, Dowel	4
17	Gear Nut	2
19	Key	1
21	Plug, Pipe	3
23	Screw Hex Nylock	8
25	Breather (Plug Vent)	1
26	Screw, Hex	*
27	Seal, Lip Bearing	4
29	Washer, Spring Wavy	2
31	Screw, Hex, Nylock	4
32	Screw, Hex	10
33	Seal Lip-Drive	1
34	Clamp Plate	2
35	Foot	2
37	Fitting, Grease	2
38	Fitting, Relief	2
39	Washer Mounting	4

*Quantities vary by blower.

Universal RAI-DSL Series Blowers Parts List 3-1/2" – 5" Gear Diameter

(Refer to drawing #T30356023)

Item #	Part Name	Qty.
1	Headplate Gear End	1
2	Headplate Drive End	1
3	Gearbox	1
4	Timing Gears	2
7	Gasket, Gear Box, DE Cover	1
11	Cylinder	1
12	Impeller & Shaft Drive	1
13	Impeller & Shaft Driven	1
14	Bearing, Ball	3
15	Bearing, Roller	1
16	Pin, Dowel	4
17	Gear Nut	2
19	Key	1
21	Plug, Pipe	3
23	Screw Hex	6
25	Breather (Plug Vent)	1
26	Screw, Hex	*
27	Seal, Lip Bearing	4
31	Screw, Hex, Nylock	4
32	Screw, Hex	6
33	Seal Lip-Drive	1
34	Clamp Plate	2
35	Foot	2
39	Washer Mounting	4
40	Screw Socket	2
42	Screw Hex	2
48	DE Oil Slinger Set Screw	4
50	Drive End Cover	1
52	Drive End Oil Slinger	2
53	Oil Sight Glass	2

*Quantities vary by blower.

Universal RAI®-DSL Series Blowers Parts List 6" Gear Diameter

(Refer to drawing #T30382023)

Item #	Part Name	Qty.
1	Headplate Gear End	1
2	Headplate Drive End	1
3	Gearbox	1
4	Timing Gears	2
7	Gasket, Gear Box	1
11	Cylinder	1
12	Impeller & Shaft Drive	1
13	Impeller & Shaft Driven	1
14	Bearing, Ball	3
15	Bearing, Roller	1
16	Pin, Dowel	4
17	Gear Nut	2
19	Key	1
21	Plug, Pipe	3
23	Screw Hex Nylock	8
25	Breather (Plug Vent)	1
26	Screw, Hex	*
27	Seal, Lip Bearing	4
31	Screw, Hex, Nylock	4
32	Screw, Hex	10
33	Seal Lip-Drive	1
34	Clamp Plate	2
35	Foot	2
39	Washer Mounting	4
48	DE Oil Slinger Set Screw	4
50	Drive End Cover	1
52	Drive End Oil Slinger	2
53	Oil Sight Glass	2

*Quantities vary by blower.

Universal RAI Series Gas Blowers Parts List
3-1/2" & 5" Gear Diameter

(Refer to drawing #T30099023)

Item #	Part Name	Qty.
1	Headplate Gear End	1
2	Headplate Drive End	1
3	Gearbox	1
4	Timing Gears	2
5	Cover-Blind (Plug Opening)	1
7	Gasket, Gear Box	1
11	Cylinder	1
12	Impeller & Shaft Drive	1
13	Impeller & Shaft Driven	1
14	Bearing, Ball	3
15	Bearing, Roller	1
16	Pin, Dowel	4
17	Gear Nut	2
19	Key	1
21	Plug, Pipe	3
23	Screw Hex	8
25	Breather (Plug Vent)	1
26	Screw, Hex	14*
27	Seal, Bearing	4
31	Screw, Hex	4
32	Screw, Hex	4
33	Seal Lip-Drive	1
34	Clamp Plate	2
35	Foot	2
37	Fitting, Grease	2
38	Fitting, Relief	2
39	Washer Mounting	4
40	Screw Socket	2
42	Screw Hex	2

*Quantities vary by blower.

Specified Lubricants

ROOTS Synthetic Oil: ISO-VG-220 Grade

	Part Number
Quart	813-106-001
Gallon	813-106-002
Case (12 qts)	813-106-008

ROOTS Synthetic Oil: ISO-VG-320 Grade

	Part Number
Quart	813-106-004
Gallon	813-106-005
Case (12 qts)	813-106-007

ROOTS Synthetic Grease: NLGI #2

	Part Number
14.5 oz. Tube	T200019-001
5 Gallon Pail	T200019-003
Case (30 tubes)	T200019-002

Universal RAI Series Gas Blowers Parts List
6" Gear Diameter

(Refer to drawing #T3011023)

Item #	Part Name	Qty.
1	Headplate Gear End	1
2	Headplate Drive End	1
3	Gearbox	1
4	Timing Gears	2
5	Cover-Blind (Plug Opening)	1
7	Gasket, Gear Box	1
7*	Gasket DE Cover	1
11	Cylinder	1
12	Impeller & Shaft Drive	1
13	Impeller & Shaft Driven	1
14	Bearing, Ball	3
15	Bearing, Roller	1
16	Pin, Dowel	4
17	Gear Nut	2
19	Key	1
21	Plug, Pipe	3
23	Screw Hex Nylock	8
25	Breather (Plug Vent)	1
26	Screw, Hex	14**
27	Seal, Bearing	4
31	Screw, Hex	4
32	Screw, Hex	10
33	Seal Lip-Drive	1
34	Clamp Plate	2
35	Foot	2
37	Fitting, Grease	2
38	Fitting, Relief	2
39	Washer Mounting	4
40	Screw Socket	2
42	Screw Hex	2
43	Plug	8
51	Shoulder Bolt	2
53	Oil Sight Glass	2

*DE cover gasket is not the same as the gasket used on the GE. You must specify the gasket required when ordering.
**Quantities vary by blower.

UNIVERSAL RAI (URAI) AIR BLOWERS

URAI AIR BLOWERS (with Grease Lubricated Drive End)

BOM # *	FRAME SIZE	INLET/DISCH CONN.	SHAFT DIAMETER	BARE WEIGHT
65102020	22	1" NPT	0.625"	32
65103020	24	2" NPT	0.625"	43
71048020	32	1.25" NPT	0.750"	69
65105020	33	2" NPT	0.750"	74
65106020	36	2.5" NPT	0.750"	102
65108020	42	1.5" NPT	0.875"	88
65109020	45	2.5" NPT	0.875"	109
65110020	47	3" NPT	0.875"	128
65112020	53	2.5" NPT	1.125"	143
65113020	56	4" NPT	1.125"	170
65114020	59	4" NPT	1.125"	204
65116020	65	3" NPT	1.375"	245
65117020	68	5" NPT	1.375"	285
65118020	615	6" Flange	1.375"	425
65120020	76	4" NPT	1.562"	400
65121020	711	6" Flange	1.562"	530
65122020	718	8" Flange	1.562"	650

Refer to Specification Sheet S-12K84

URAI DSL AIR BLOWERS (with Dual Splash Lubrication *DSL*)

BOM # *	FRAME SIZE	INLET/DISCH CONN.	SHAFT DIAMETER	BARE WEIGHT
T30378020	32	1.25" NPT	0.750"	72
T30379020	33	2" NPT	0.750"	77
T30380020	36	2.5" NPT	0.750"	105
T30352020	42	1.5" NPT	0.875"	92
T30353020	45	2.5" NPT	0.875"	113
T30354020	47	3" NPT	0.875"	132
T30359020	53	2.5" NPT	1.125"	148
T30360020	56	4" NPT	1.125"	175
T30361020	59	4" NPT	1.125"	209
T30384020	65	3" NPT	1.375"	250
T30385020	68	5" NPT	1.375"	290
T30386020	615	6" Flange	1.375"	430

Refer to Specification Sheet S-27S03

Universal RAI air blowers include detachable mounting feet which permit vertical or horizontal installation. The units are center timed for rotation in either direction. The bearings on the URAI are grease lubricated on the drive end and splash lubricated on the gear end. The URAI-DSL is splash lubricated on BOTH ends.

UNIVERSAL RAI (URAI) GAS BLOWERS

URAI-G™ GAS BLOWERS (with Grease Lubricated Drive End)

BOM # *	FRAME SIZE	INLET/DISCH CONN.	SHAFT DIAMETER	BARE WEIGHT
710480G0	32	1.25" NPT	0.750"	69
651050G0	33	2" NPT	0.750	74
651060G0	36	2.5" NPT	0.750	102
651080G0	42	1.5" NPT	0.875"	88
651090G0	45	2.5" NPT	0.875	109
651100G0	47	3" NPT	0.875	128
651120G0	53	2.5" NPT	1.125"	143
651130G0	56	4" NPT	1.125	170
651140G0	59	4" NPT	1.125	204
651160G0	65	3" NPT	1.375"	245
651170G0	68	5" NPT	1.375	285
651180G0	615	6" NPT	1.375	425

Refer to Specification Sheet S-60A01

Universal RAI-G™ gas blowers include detachable mounting feet which permit vertical or horizontal installation. **Feet are different for vertical and horizontal mounting**.

The units are center timed for rotation in either direction. The bearings on the Universal RAI-GTM are grease lubricated on the drive end and splash lubricated on the gear end. ROOTS Synthetic lubricant is recommended.

UNIVERSAL RAI (URAI-J) WHISPAIR AIR BLOWERS

URAI-J WHISPAIR AIR BLOWERS (with Grease Lubed Drive End)

BOM # *	FRAME SIZE	INLET/DISCH CONN.	SHAFT DIAMETER	BARE WEIGHT
74065020	33J	2" NPT	0.750"	84
74086020	36J	2.5" NPT	0.750	112
74066020	45J	2.5" NPT	0.875"	119
74087020	47J	3" NPT	0.875	138
74067020	56J	4" NPT	1.125"	180

Refer to Specification Sheet S-33A93

URAI-J-DSL WHISPAIR AIR BLOWERS (with Dual Splash Lubrication *DSL*)

BOM # *	FRAME SIZE	INLET/DISCH CONN.	SHAFT DIAMETER	BARE WEIGHT
T30417020	33J	2" NPT	0.750"	87
T30418020	36J	2.5" NPT	0.750	115
T30410020	45J	2.5" NPT	0.875"	122
T30412020	47J	3" NPT	0.875	141
T30415020	56J	4" NPT	1.125"	185

Refer to Specification Sheet S-30S03

URAI-J METRIC WHISPAIR AIR BLOWERS (with Grease Lubed Drive End)

BOM # *	FRAME SIZE	INLET/DISCH CONN.	SHAFT DIAMETER	BARE WEIGHT
TBD	33J	2" BSP	19 mm	84
740860M0	36J	2.5" BSP	19 mm	112
TBD	45J	2.5" BSP	24 mm	119
TBD	47J	3" BSP	24 mm	138
TBD	56J	4" BSP	28 mm	180

URAI-J-DSL METRIC WHISPAIR AIR BLOWERS (with Dual Splash Lubrication *DSL*)

BOM # *	FRAME SIZE	INLET/DISCH CONN.	SHAFT DIAMETER	BARE WEIGHT
TBD	33J	2" BSP	19 mm	87
T304660M0	36J	2.5" BSP	19 mm	115
TBD	45J	2.5" BSP	24 mm	122
T304550M0	47J	3" BSP	24 mm	141
TBD	56J	4" BSP	28 mm	185

Universal RAI-J air blowers incorporate the patented WhispairTM design in addition to the same features as the original URAI blowers. The URAI-J's are center timed, however the WhispairTM benefits can only be realized when the jet is located in the discharge position.

UNIVERSAL RAI METRIC (URAI-M) AIR BLOWERS

NOTE: METRIC URAI product has metric shaft diameter and connection sizes

URAI-METRIC AIR BLOWERS (with Grease Lubricated Drive End)

BOM # *	FRAME SIZE	INLET/DISCH CONN.	SHAFT DIAMETER	BARE WEIGHT
651020M0	22	1" BSP	16 mm	32
651030M0	24	2" BSP	16 mm	43
710480M0	32	1 1/4" BSP	19 mm	69
651050M0	33	2" BSP	19 mm	74
651060M0	36	2 1/2" BSP	19 mm	102
651080M0	42	1 1/2" BSP	24 mm	88
651090M0	45	2 1/2" BSP	24 mm	109
651100M0	47	3" BSP	24 mm	128
651120M0	53	2 1/2" BSP	28 mm	143
651130M0	56	4" BSP	28 mm	170
651140M0	59	4" BSP	28 mm	204
T30392060	65	3" BSP	32 mm	245
T30394060	68	5" BSP	32 mm	285
T30390060	615	150 NP10	32 mm	425
T30396060	76	4" BSP	38 mm	400
T30398060	711	150 NP10	38 mm	530
T30400060	718	200 NP10	38 mm	650

URAI-DSL-METRIC AIR BLOWERS (with Dual Splash Lubrication *DSL*)

BOM # *	FRAME SIZE	INLET/DISCH CONN.	SHAFT DIAMETER	BARE WEIGHT
T30463060	32	1 1/4" BSP	19 mm	72
T30464060	33	2" BSP	19 mm	77
T30465060	36	2 1/2" BSP	19 mm	105
T30451060	42	1 1/2" BSP	24 mm	92
T30452060	45	2 1/2" BSP	24 mm	113
T30453060	47	3" BSP	24 mm	132
T30459060	53	2 1/2" BSP	28 mm	148
T30460060	56	4" BSP	28 mm	175
T30461060	59	4" BSP	28 mm	209
T30472060	65	3" BSP	32 mm	250
T30473060	68	5" BSP	32 mm	290
T30474060	615	150 NP 10	32 mm	430

Universal RAI air blowers include detachable mounting feet which permit vertical or horizontal installation. The units are center timed for rotation in either direction. The bearings on the URAI are grease lubricated on the drive end and splash lubricated on the gear end. The URAI-DSL is splash lubricated on BOTH ends.

About Dresser, Inc.

Dresser, Inc. is a leader in providing highly engineered infrastructure products for the global energy industry. The company has leading positions in a broad portfolio of products including air and gas handling equipment, valves, actuators, meters, switches, regulators, piping products, natural gas-fueled engines, and retail fuel dispensers and associated retail point of sale systems. Leading brand names within the Dresser portfolio include Dresser ROOTS™ blowers, compressors and controls, Wayne® retail fueling systems, Waukesha® natural gas-fired engines, Masoneilan® control valves, Mooney® regulators, Consolidated® pressure relief valves, and ROOTS® rotary gas meters. It has manufacturing and customer service facilities located strategically worldwide and a sales presence in more than 100 countries. The company's website can be accessed at www.dresser.com

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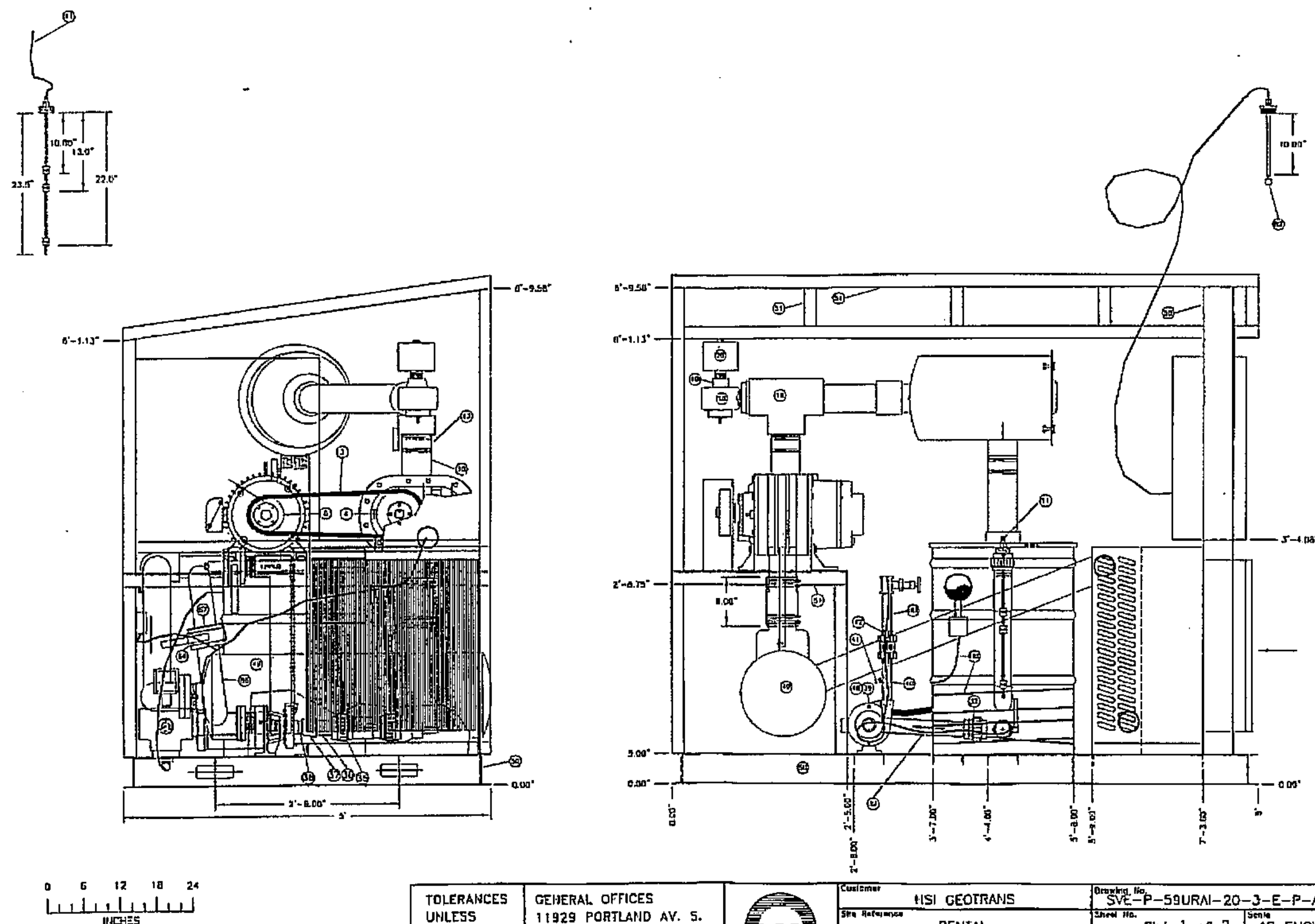


TOLERANCES UNLESS OTHERWISE SPECIFIED ± .250"	GENERAL OFFICES 11929 PORTLAND AV. S. BURNSVILLE, MN. 55337 Tel: 612/707-9101 Fax: 612/707-1075	PRODUCT LEVEL CONTROL, INC.	Customer: HSI GEOTRANS	Drawing No.: SVE-P-59URAI-20-3-E-P-AFT
			Site Reference: RENTAL	Sheet No.: Sht 1 of 2 — Scale: AS SHOWN
			Cust. No.: . — PLC Sales No.: 01-074	Title Line 1: SOIL VAPOR SYSTEM
			Drawn By: BGG — Drawn Date: 6/22/01	Title Line 2: .

100 Series
Temperature Controls

Types B100, C100, E100, F100

UNITED ELECTRIC CONTROLS

Installation and Maintenance Instructions

Please read all instructional literature carefully and thoroughly before starting. Refer to the final page for the listing of Recommended Practices, Liabilities and Warrantees.

GENERAL

Types B100 and C100 (Immersion Stem)

Temperature variations are sensed by a liquid filled sensor which expands or contracts against a bellows which in turn actuates or deactuates a snap-action switch at a predetermined set point.

Types E100 and F100 (Bulb & Capillary)

Temperature variations of a liquid filled sensing bulb are hydraulically transmitted to a bellows or diaphragm which either actuates or deactuates a snap-acting switch at a predetermined set point.

MAXIMUM TEMPERATURE IS THE HIGHEST TEMPERATURE TO WHICH A SENSING ELEMENT MAY BE OCCASIONALLY OPERATED WITHOUT ADVERSELY AFFECTING SET POINT CALIBRATION AND REPEATABILITY. MAXIMUM TEMPERATURE LIMITS STATED IN LITERATURE MUST NEVER BE EXCEEDED, EVEN BY SURGES IN THE SYSTEM. OCCASIONAL OPERATION OF UNIT UP TO MAX. TEMPERATURE IS ACCEPTABLE (E.G. START-UP, TESTING). CONTINUOUS OPERATION SHOULD BE RESTRICTED TO THE DESIGNATED ADJUSTABLE RANGE.

Part I - Installation

Tools Needed

Adjustable wrench
Flathead screwdriver
Hammer (for alternate wire knockouts)

MOUNTING

INSTALL UNIT WHERE SHOCK, VIBRATION AND TEMPERATURE FLUCTUATIONS ARE MINIMAL. ORIENT UNIT SO THAT MOISTURE IS PREVENTED FROM ENTERING THE ENCLOSURE. SHOULD THE CONTROL BE INSTALLED WHERE HEAVY CONDENSATION OR WASHDOWN IS EXPECTED, VERTICAL MOUNTING IS RECOMMENDED (PRESSURE CONNECTION DOWN).

Do not mount unit in ambient temperatures exceeding published limits. 100 Series Temperature Controls can be mounted in any position, provided the electrical conduit is not facing up.

For remote mounting, mount the unit via the (2) 1/4" screw clearance holes on the enclosure (See Dimensions on back page.) Fully immerse the bulb and 6" capillary in the control zone. For best control it is generally desirable to place the bulb close to the heating or cooling source in order to sense temperature fluctuations quickly. Be sure to locate the bulb so that it will not be exposed to temperatures beyond the instrument range limits.

FOR LOCAL MOUNTING, ALWAYS HOLD A WRENCH ON THE TEMPERATURE HOUSING HEX WHEN MOUNTING UNIT. DO NOT TIGHTEN BY TURNING ENCLOSURE. THIS WILL DAMAGE SENSOR AND WEAKEN SOLDERED OR WELDED JOINTS.

WIRING

DISCONNECT ALL SUPPLY CIRCUITS BEFORE WIRING UNIT. ELECTRICAL RATINGS STATED IN LITERATURE AND NAMEPLATES MUST NOT BE EXCEEDED-OVERLOAD ON A SWITCH CAN CAUSE FAILURE ON THE FIRST CYCLE. WIRE UNITS ACCORDING TO NATIONAL AND LOCAL ELECTRICAL CODES. MAXIMUM RECOMMENDED WIRE SIZE IS14 AWG.

Remove the two screws retaining the cover and cover gasket. Two cast-in 7/8" diameter knockouts for electrical conduit are located on the side and rear of enclosure. These can easily be knocked out by placing the blade of a screwdriver in the groove and rapping sharply with a hammer. A 1/2" NPT conduit connection is located on the side of the enclosure.

Connect conduit to the case and wire directly to the switch terminals according to local and national electrical codes. Bring the wires up to terminals from the rear of the case allowing enough slack so as not to affect switch movement when making setting adjustments. The three switch terminals are clearly labeled "common", "norm open", and "norm closed". If lead wires are supplied, color coding is as follows:

	SPDT	DPDT (Option 1010) SWT1	DPDT (Option 1010) SWT2
Common	Violet	Violet	Yellow
Normally Open	Blue	Blue	Orange
Normally Closed	Black	Black	Red

A grounding screw and clamp (cast in symbol) is provided which meets a 35 lb. pull test. Keep the wire as short as possible to prevent interference with the plunger and, when provided, the adjustable differential switch wheel.

Part II - Adjustments

Tools Needed

5/8" open end wrench

NOTE: For set point adjustments and recalibration, connect control to a calibrated temperature source and stabilize unit.

Types C100 and F100

Remove cover. Switch has a hex screw adjustment inside enclosure. If switch transfer point differs from actual temperature, adjust setting. To raise the temperature setting, turn the hex in (clockwise), and to lower the setting turn the screw out (counterclockwise). When making adjustments, do not exceed the maximum temperature rating on nameplate.

Types B100 and E100 (with reference dial)

Controls are factory calibrated for maximum accuracy at the midpoint of the scale.

To re-calibrate, turn dial to desired set point. If the actual temperature and set point temperature do not agree, turn adjustment screw clockwise to raise and counterclockwise to lower temperature setting.

Part III - Replacements

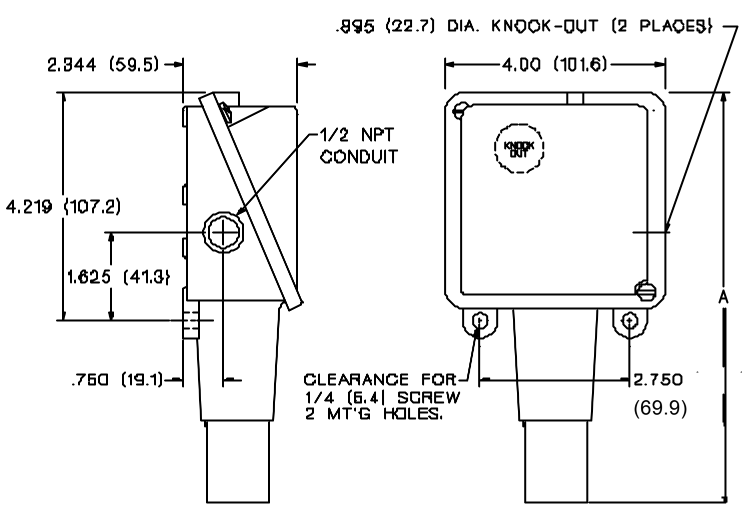
Tools Needed
Flathead screwdriver

USE ONLY FACTORY AUTHORIZED REPLACEMENT PARTS AND PROCEDURES. ALWAYS DISCONNECT SUPPLY CIRCUITS BEFORE REMOVING COVER.

REPLACEMENT OF SWITCHES

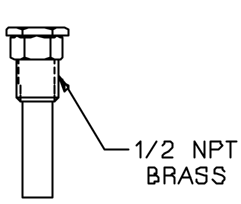
1. Remove cover, switch mounting screws, switch and insulator.
2. Disconnect switch wires at switch terminal.
3. Wire new switch per wiring instructions.
4. Mount switch and insulator inside enclosure and re-calibrate per PART II.

Dimensions

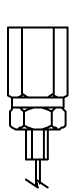


Types B100, C100, E100, F100

Models	Dimension A Inches	mm	NPT
120,121	10.44	265,10	Immersion stem
1BC-M9BB	8.75	222,23	Bulb & capillary



Models 120-121



Models 1BC-M9BB

RECOMMENDED PRACTICES AND WARNINGS

United Electric Controls Company recommends careful consideration of the following factors when specifying and installing UE pressure and temperature units. Before installing a unit, the Installation and Maintenance instructions provided with unit must be read and understood.

- To avoid damaging unit, proof pressure and max temperature limits stated in literature and on nameplates must never be exceeded, even by surges in the system. Operation of the unit up to proof pressure or max temperature is acceptable on a limited basis (i.e.start-up, testing) but continuous operation must be restricted to the designated adjustable range. Excessive cycling at proof pressure or maximum temperature limits could reduce sensor life.
- A back-up unit is necessary for applications where damage to a primary unit could endanger life, limb or property. A high or low limit switch is necessary for applications where dangerous runaway condition could result.
- The adjustable range must be selected so that incorrect, inadvertent or malicious setting at any range point can not result in an unsafe system condition.
- Install unit where shock, vibration and ambient temperature fluctuations will not damage unit or affect operation. Orient unit so that moisture does not enter the enclosure via the electrical connection.
- Unit must not be altered or modified after shipment. Consult UE if modification is necessary.
- Monitor operation to observe warning signs of possible damage to unit, such as drift in set point. Check unit immediately.
- Preventative maintenance and periodic testing is necessary for critical applications where damage could endanger property or personnel.
- For all applications, a factory set unit should be tested before use.
- Electrical ratings stated in literature and on nameplate must not be exceeded. Overload on a switch can cause damage, even on the first cycle. Wire unit according to local and national electrical codes, using wire size recommended in installation sheet.
- Use only factory authorized replacement parts and procedures.
- Do not mount unit in ambient temp. exceeding published limits.
- For remote mounted temperature units, capillary lengths beyond 10 feet can increase chance of error, and may require re-calibration of set point and indication.

LIMITED WARRANTY

UE warrants that the product thereby purchased is, upon delivery, free from defects in material and workmanship and that any such product which is found to be defective in such workmanship or material will be repaired or replaced by UE (F.O.B. UE); provided, however, that this warranty applies only to equipment found to be so defective within a period of 12 months after installation by buyer but not to exceed 18 months after delivery by the seller. **Except for the limited warranty of repair and replacement stated above, UE disclaims all warranties whatsoever with respect to the product, including all implied warranties of merchantability or fitness for any particular purpose.**

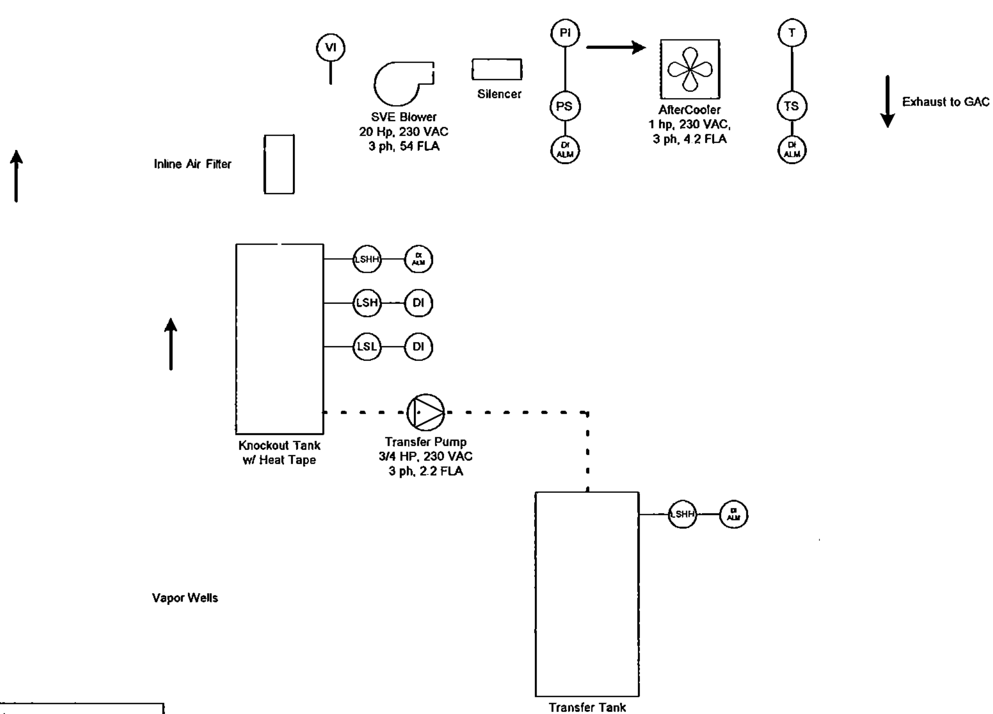
LIABILITY LIMITATION

The sole and exclusive remedy of buyer for any liability or seller for any claim, including incurred in connection with (I) breach of any warranty whatsoever expressed or implied, (II) a breach of contract, (III) a negligent act or acts (or negligent failure to act) committed by seller, or (IV) an act for which strict liability will be imputed to seller, is limited to the limited warranty or repair and replacement stated herein. **In no event shall the seller be liable for any special, indirect, consequential or other damages of a like general nature, including, without limitation, loss of profits or production, or loss or expenses of any nature incurred by any third party.**

UNITED ELECTRIC CONTROLS

P.O. Box 9143, Watertown, MA 02471-9143 USA
617 926-1000 Fax 617 926-2568

HSI GeoTrans



Water
Air
Product

LSHH - High High Level	AF - Air Flow Meter
LSH - High Level	pH - pH
LSL - Low Level	LEL - LEL
LSLL - Low Low Level	CO - Conductivity
V - Vacuum	TU - Turbidity
P - Pressure	CO - Conductivity
T - Temperature	S - Switch
D - Depth	G - Gauge
WF - Water Flow Meter	T - Transducer
TU - Turbidity	

Rev.	Date	By	Description
4			
3			
2			
1			
0			

PRODUCT LEVEL CONTROL INC

HSI GeoTrans	2001-074.vsd		0
SVE Rental	1 of 6		None
Tempe, AZ	DRH		06/01/01
2001-074	PROCESS FLOW DIAGRAM		

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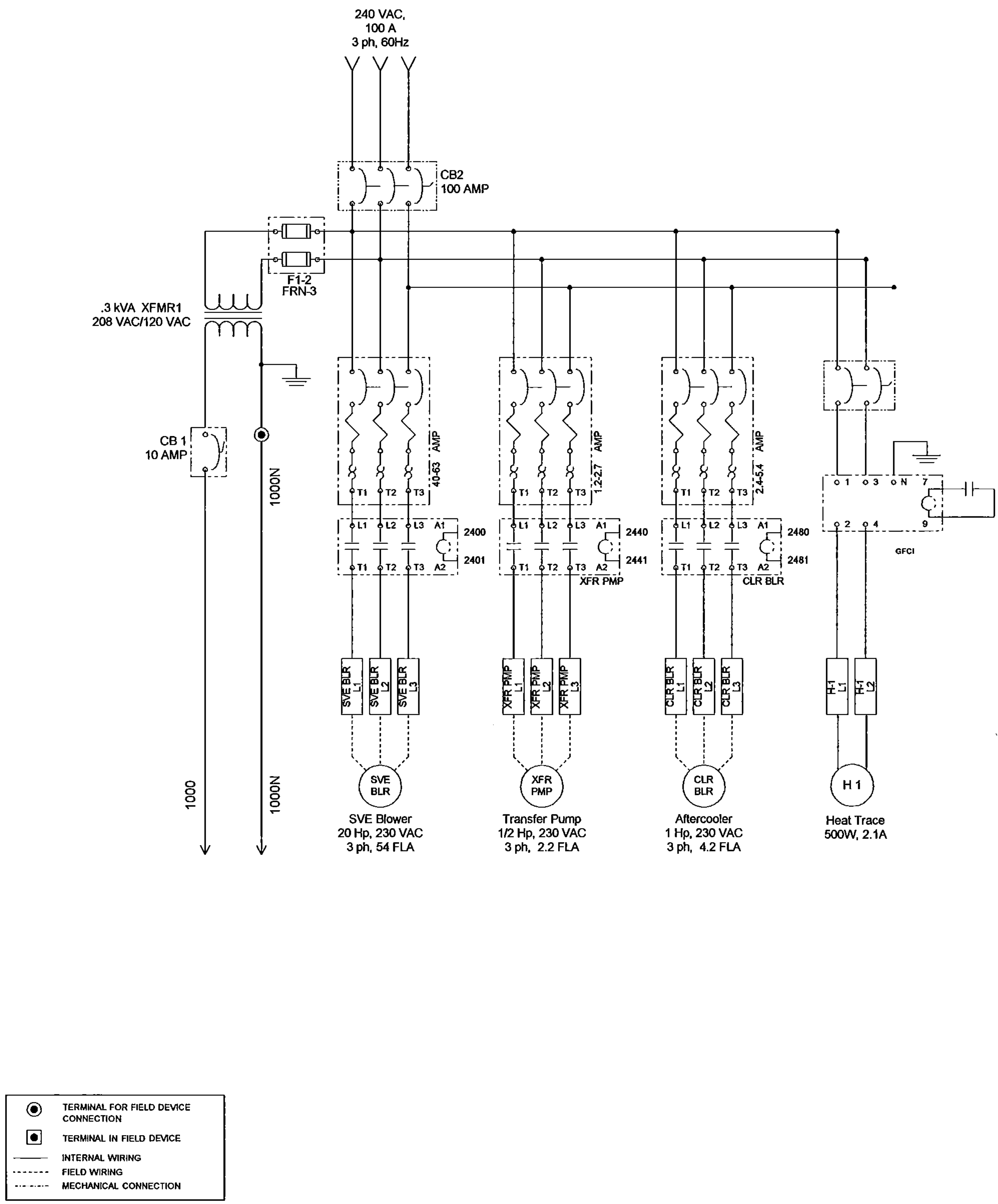

PRODUCT LEVEL CONTROL, INC.	HSI GeoTrans	2001-074.vsd	01
	SVE Rental	2 6	NONE
	Tempe, AZ	DRH	06/01/01
	2001-074	Power Wiring Diagram	

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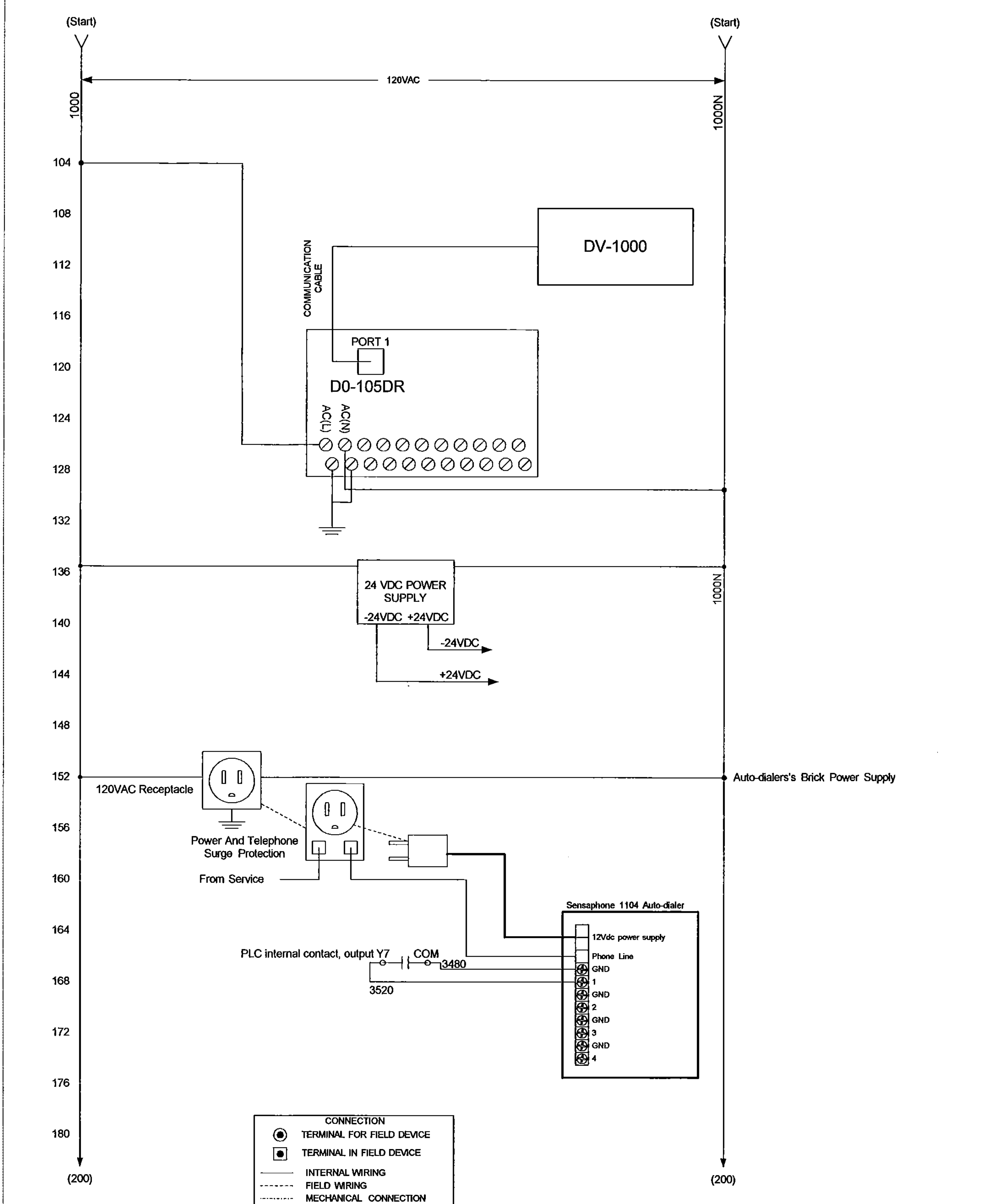

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PRODUCT LEVEL CONTROL INC

Customer: HSI GeoTrans		Drawing No.: 2001-074.vsd	Rev.: 0
Site Reference: SVE Rental		Sheet No.: Sheet 3 of 6	Scale: NONE
Tempe, AZ		Drawn By: DRH	Drawn Date: 06/01/01
Cust. P.O. No.	PLC Sales No.: 2001-074	Title: Communications & Power Supply	

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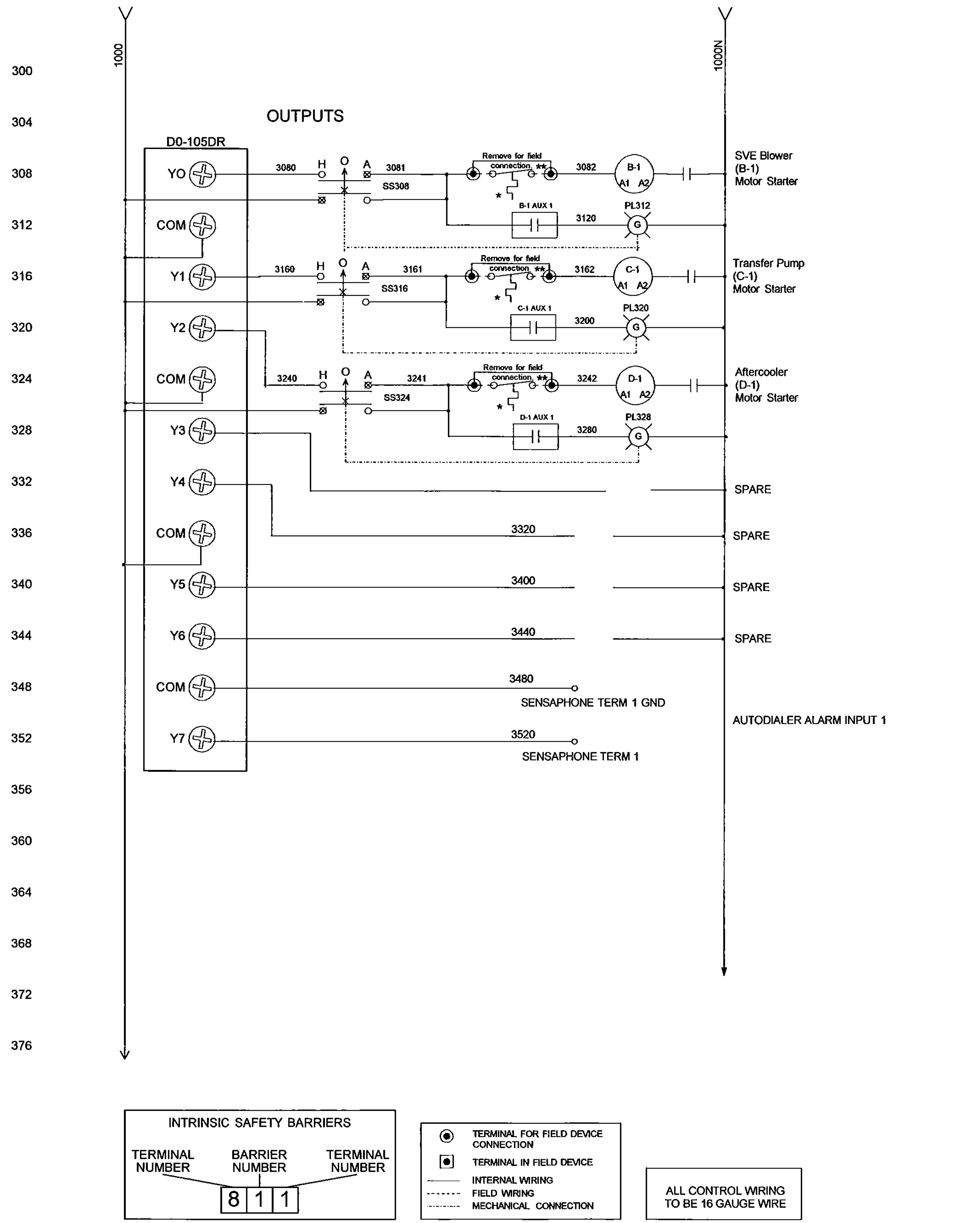

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PRODUCT LEVEL CONTROL, INC

Customer: HSI GeoTrans	Drawing No. 2001-074.vsd	Rev. 0	
Site Reference: SVE Rental	Sheet No. Sheet 5 of 6	Scale NONE	
Tempe, AZ	Drawn by DRH	Drawn Date 08/15/01	
Cust. P.O. No.	PLC Sales No. 2001-074	Title DIGITAL OUTPUTS	

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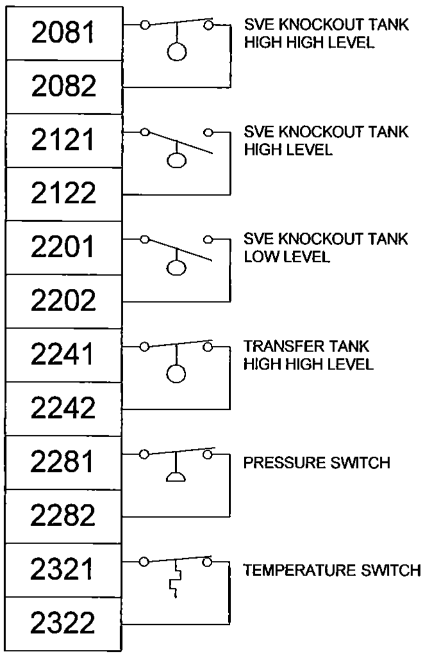
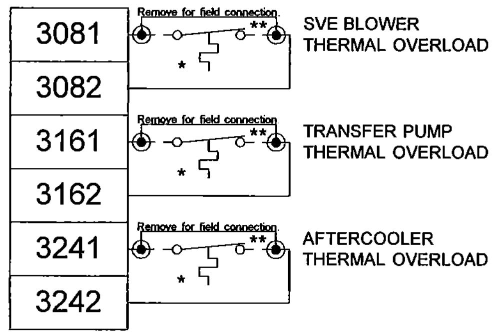
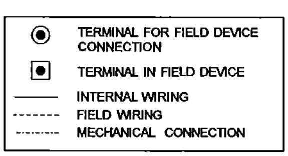
CONNECTION DIAGRAM FOR FIELD DEVICES

INTRINSIC INPUTS



NON-INTRINSIC INPUTS





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PRODUCT LEVEL CONTROL, INC.

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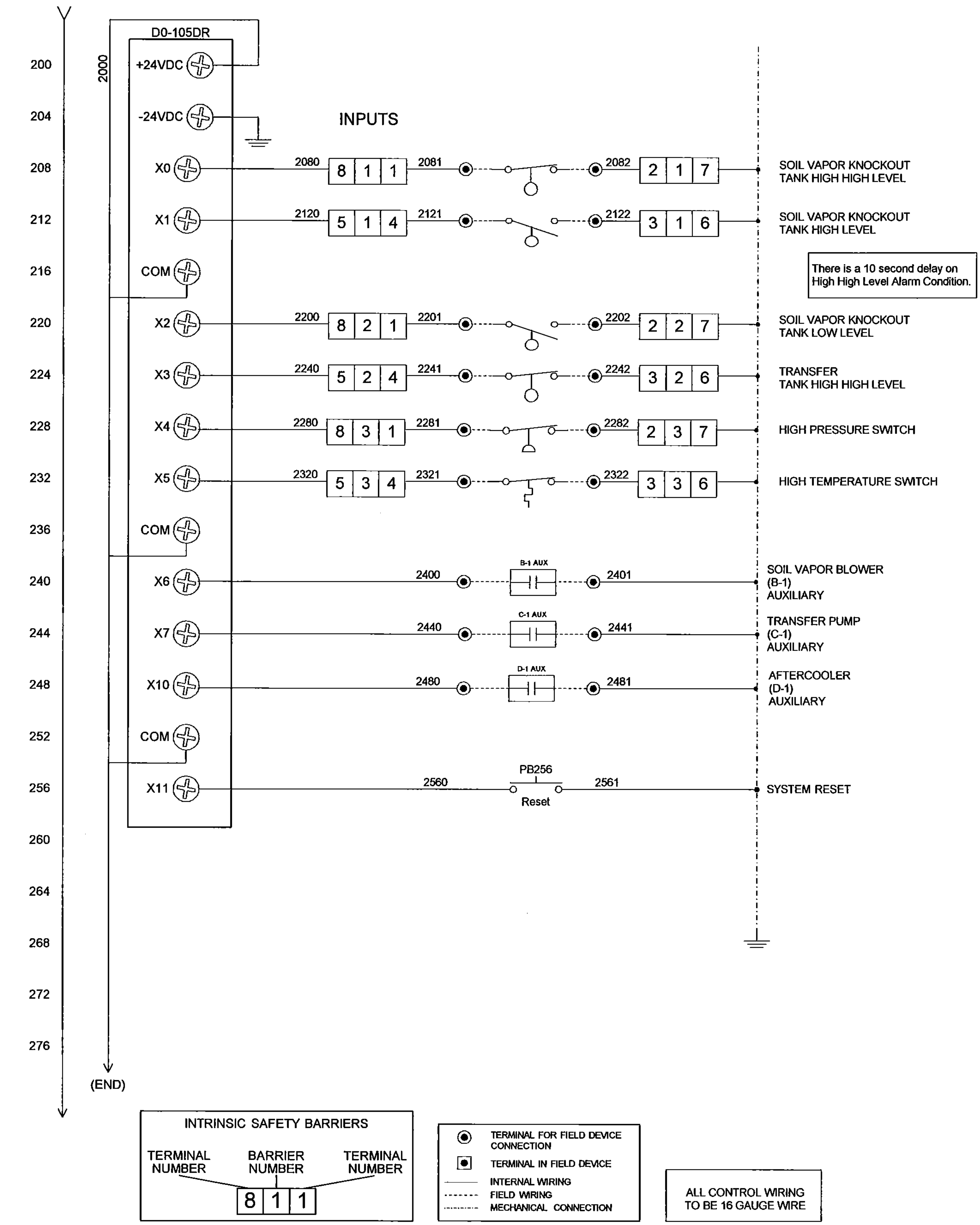
Site Reference: SVE Rental	Sheet No. Sheet 6 of 6		Scale: NONE
Tempe, AZ	Drawn By: DRH	Drawn Date: 06/01/01	
Cust. P.O. No.	PLC Sales No. 2001-074	Title: FIELD CONNECTIONS	



Rev	Date	By	Description
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PRODUCT LEVEL CONTROL INC

Customer: HSI GeoTrans		Drawing No.: 2001-074.vsd	Rev.: 0
Site Reference: SVE Rental		Sheet No.: Sheet 4 of 6	Scale: NONE
Tempe, AZ		Drawn By: DRH	Drawn Date: 08/15/01
Cust. P.O. No.:	PLC Sales No.: 2001-074	Title: Digital Inputs - Low Voltage	

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TELEMETRY

CELL682

Wireless Alarms

SENSAPHONE®

REMOTE MONITORING SOLUTIONS

USER'S MANUAL

VERSION 1.2

SENSAPHONE®

REMOTE MONITORING SOLUTIONS

Every effort has been made to ensure that the information in this document is complete, accurate and up-to-date. Sensaphone assumes no responsibility for the results of errors beyond its control. Sensaphone also cannot guarantee that changes in equipment made by other manufacturers, and referred to in this manual, will not affect the applicability of the information in this manual.

First Edition, version 1.2, November 2010

Written and produced by Sensaphone

Please address comments on this publication to:

Sensaphone

901 Tryens Road

Aston, PA 19014

IMPORTANT SAFETY INSTRUCTIONS

Your Cell682 has been carefully designed to give you years of safe, reliable performance. As with all electrical equipment, however, there are a few basic precautions you should take to avoid hurting yourself or damaging the unit:

• Read the installation and operating instructions in this manual carefully. Be sure to save it for future reference.

• Read and follow all warning and instruction labels on the product itself.

• To protect the Cell682 from overheating, make sure all openings on the unit are not blocked. Do not place on or near a heat source, such as a radiator or heat register.

• Do not use your Cell682 near water, or spill liquid of any kind into it.

• Be certain that your power source matches the rating listed on the AC power transformer. If you're not sure of the type of power supply to your facility, consult your dealer or local power company.

• Do not allow anything to rest on the power cord. Do not locate this product where the cord will be abused by persons walking on it.

• Do not overload wall outlets and extension cords, as this can result in the risk of fire or electric shock.

• Never push objects of any kind into this product through ventilation holes as they may touch dangerous voltage points or short out parts that could result in a risk of fire or electric shock.

• To reduce the risk of electric shock, do not disassemble this product, but return it to Sensaphone Customer Service or another approved repair facility when any service or repair work is required. Opening or removing covers may expose you to dangerous voltages or other risks. Incorrect reassembly can cause electric shock when the unit is subsequently used.

• If anything happens that indicates that your Cell682 is not working properly or has been damaged, unplug it immediately and follow the procedures in the manual for having it serviced. Return the unit for servicing under the following conditions:

1. The power cord or plug is frayed or damaged.
2. Liquid has been spilled into the product or it has been exposed to water.
3. The unit has been dropped, or the enclosure is damaged.
4. The unit doesn't function normally when you're following the operating instructions.

CAUTION: To reduce the risk of fire or injury to persons, read and follow these instructions:

1. Replace the battery only with the same or equivalent type recommended by the manufacturer.
2. Do not dispose of the battery in a fire. The cell may explode. Check with local codes for possible special disposal instructions.
3. Do not open or mutilate the battery. Released electrolyte is corrosive and may cause damage to the eyes or skin. It may be toxic if swallowed.
4. Exercise care in handling battery in order not to short the battery with conducting materials such as rings, bracelets, and keys. The battery or conductor may overheat and cause burns.

FCC REQUIREMENTS

This equipment has been tested and found to comply with the limits for a Class B digital device, pursuant to Part 15 of the FCC rules. These limits are designed to provide reasonable protection against harmful interference in a residential installation. This equipment generates, uses and can radiate radio frequency energy, and if not installed and used in accordance with the instructions, may cause harmful interference to radio communications. However, there is no guarantee that interference will not occur in a particular installation. If this equipment does cause harmful interference to radio or television reception, which can be determined by turning the equipment off and on, the user is encouraged to try to correct the interference by one or more of the following measures:

- Reorient or relocate the receiving antenna.
- Increase the separation between the equipment and the receiver.
- Connect the equipment into an outlet on a circuit different from that to which the receiver is connected.
- Consult the dealer or an experienced radio/TV technician help.

This device complies with Part 15 of the FCC Rules. Operation is subject to the following two conditions: 1) this device may not cause harmful interference, and 2) this device must accept any interference received, including interference that may cause undesired operation.

If you experience trouble with the Cell682, or you need information on obtaining service or repairs, please contact:

Sensaphone
901 Tryens Road
Aston, PA 19014
Phone: 610.558.2700
FAX: 610.558.0222

2 YEAR LIMITED WARRANTY

PLEASE READ THIS WARRANTY CAREFULLY BEFORE USING THE PRODUCT.

THIS LIMITED WARRANTY CONTAINS SENSAPHONE'S STANDARD TERMS AND CONDITIONS. WHERE PERMITTED BY THE APPLICABLE LAW, BY KEEPING YOUR SENSAPHONE PRODUCT BEYOND THIRTY (30) DAYS AFTER THE DATE OF DELIVERY, YOU FULLY ACCEPT THE TERMS AND CONDITIONS SET FORTH IN THIS LIMITED WARRANTY.

IN ADDITION, WHERE PERMITTED BY THE APPLICABLE LAW, YOUR INSTALLATION AND/OR USE OF THE PRODUCT CONSTITUTES FULL ACCEPTANCE OF THE TERMS AND CONDITIONS OF THIS LIMITED WARRANTY (HEREINAFTER REFERRED TO AS "LIMITED WARRANTY OR WARRANTY"). IF YOU DO NOT AGREE TO THE TERMS AND CONDITIONS THIS WARRANTY, INCLUDING ANY LIMITATIONS OF WARRANTY, INDEMNIFICATION TERMS OR LIMITATION OF LIABILITY, THEN YOU SHOULD NOT USE THE PRODUCT AND SHOULD RETURN IT TO THE SELLER FOR A REFUND OF THE PURCHASE PRICE. THE LAW MAY VARY BY JURISDICTION AS TO THE APPLICABILITY OF YOUR INSTALLATION OR USE ACTUALLY CONSTITUTING ACCEPTANCE OF THE TERMS AND CONDITIONS HEREIN AND AS TO THE APPLICABILITY OF ANY LIMITATION OF WARRANTY, INDEMNIFICATION TERMS OR LIMITATIONS OF LIABILITY.

1. **WARRANTOR**: IN THIS WARRANTY, WARRANTOR SHALL MEAN "DEALER, DISTRIBUTOR, AND/OR MANUFACTURER."

2. **ELEMENTS OF WARRANTY**: THIS PRODUCT IS WARRANTED TO BE FREE FROM DEFECTS IN MATERIALS AND CRAFTSMANSHIP WITH ONLY THE LIMITATIONS AND EXCLUSIONS SET OUT BELOW.

3. **WARRANTY AND REMEDY**: TWO-YEAR WARRANTY — IN THE EVENT THAT THE PRODUCT DOES NOT CONFORM TO THIS WARRANTY AT ANY TIME DURING THE TIME OF TWO YEARS FROM ORIGINAL PURCHASE, WARRANTOR WILL REPAIR THE DEFECT AND RETURN IT TO YOU AT NO CHARGE.

THIS WARRANTY SHALL TERMINATE AND BE OF NO FURTHER EFFECT AT THE TIME THE PRODUCT IS: (1) DAMAGED BY EXTRANEOUS CAUSE SUCH AS FIRE, WATER, LIGHTNING, ETC. OR NOT MAINTAINED AS REASONABLE AND NECESSARY; OR (2) MODIFIED; OR (3) IMPROPERLY INSTALLED; OR (4) MISUSED; OR (5) REPAIRED OR SERVICED BY SOMEONE OTHER THAN WARRANTORS' AUTHORIZED PERSONNEL OR SOMEONE EXPRESSLY AUTHORIZED BY WARRANTOR'S TO MAKE SUCH SERVICE OR REPAIRS; (6) USED IN A MANNER OR PURPOSE FOR WHICH THE PRODUCT WAS NOT INTENDED; OR (7) SOLD BY ORIGINAL PURCHASER.

LIMITED WARRANTY, LIMITATION OF DAMAGES AND DISCLAIMER OF LIABILITY FOR DAMAGES: THE WARRANTOR'S OBLIGATION UNDER THIS WARRANTY IS LIMITED TO REPAIR OR REPLACEMENT OF THE PRODUCT, AT THE WARRANTOR'S OPTION AS TO REPAIR OR REPLACEMENT. IN NO EVENT SHALL WARRANTORS BE LIABLE OR RESPONSIBLE FOR PAYMENT OF ANY INCIDENTAL, CONSEQUENTIAL, SPECIAL AND/OR PUNITIVE DAMAGES OF ANY KIND, INCLUDING BUT NOT LIMITED TO ANY LABOR COSTS, PRODUCT COSTS, LOST REVENUE, BUSINESS INTERRUPTION LOSSES, LOST PROFITS, LOSS OF BUSINESS, LOSS OF DATA OR INFORMATION, OR FINANCIAL LOSS, FOR CLAIMS OF ANY NATURE, INCLUDING BUT NOT LIMITED TO CLAIMS IN CONTRACT, BREACH OF WARRANTY OR TORT, AND WHETHER OR NOT CAUSED BY WARRANTORS' NEGLIGENCE. IN THE EVENT THAT IT IS DETERMINED IN ANY ADJUDICATION THAT THE LIMITED WARRANTIES OF REPAIR OR REPLACEMENT ARE INAPPLICABLE, THEN THE PURCHASER'S SOLE REMEDY SHALL BE PAYMENT

TO THE PURCHASER OF THE ORIGINAL COST OF THE PRODUCT, AND IN NO EVENT SHALL WARRANTORS BE LIABLE OR RESPONSIBLE FOR PAYMENT OF ANY INCIDENTAL, CONSEQUENTIAL, SPECIAL AND/OR PUNITIVE DAMAGES OF ANY KIND, INCLUDING BUT NOT LIMITED TO ANY LOST REVENUE, BUSINESS INTERRUPTION LOSSES, LOST PROFITS, LOSS OF BUSINESS, LOSS OF DATA OR INFORMATION, OR FINANCIAL LOSS, FOR CLAIMS OF ANY NATURE, INCLUDING BUT NOT LIMITED TO CLAIMS IN CONTRACT, BREACH OF WARRANTY OR TORT, AND WHETHER OR NOT

CAUSED BY WARRANTORS' NEGLIGENCE.

WITHOUT WAIVING ANY PROVISION IN THIS LIMITED WARRANTY, IF A CIRCUMSTANCE ARISES WHERE WARRANTORS ARE FOUND TO BE LIABLE FOR ANY LOSS OR DAMAGE ARISING OUT OF MISTAKES, NEGLIGENCE, OMISSIONS, INTERRUPTIONS, DELAYS, ERRORS OR DEFECTS IN WARRANTORS' PRODUCTS OR SERVICES, SUCH LIABILITY SHALL NOT EXCEED THE TOTAL AMOUNT PAID BY THE CUSTOMER FOR WARRANTORS' PRODUCT AND SERVICES OR $250.00, WHICHEVER IS GREATER. YOU HEREBY RELEASE WARRANTORS FROM ANY AND ALL OBLIGATIONS, LIABILITIES AND CLAIMS IN EXCESS OF THIS LIMITATION.

INDEMNIFICATION AND COVENANT NOT TO SUE: YOU WILL INDEMNIFY, DEFEND AND HOLD HARMLESS WARRANTORS, THEIR OWNERS, DIRECTORS, OFFICERS, EMPLOYEES, AGENTS, SUPPLIERS OR AFFILIATED COMPANIES, AGAINST ANY AND ALL CLAIMS, DEMANDS OR ACTIONS BASED UPON ANY LOSSES, LIABILITIES, DAMAGES OR COSTS, INCLUDING BUT NOT LIMITED TO DAMAGES THAT ARE DIRECT OR INDIRECT, INCIDENTAL, SPECIAL OR CONSEQUENTIAL, AND INCLUDING ATTORNEYS FEES AND LEGAL COSTS, THAT MAY RESULT FROM THE INSTALLATION, OPERATION, USE OF, OR INABILITY TO USE WARRANTORS' PRODUCTS AND SERVICES, OR FROM THE FAILURE OF THE WARRANTORS' SYSTEM TO REPORT A GIVEN EVENT OR CONDITION, WHETHER OR NOT CAUSED BY WARRANTORS' NEGLIGENCE.

YOU AGREE TO RELEASE, WAIVE, DISCHARGE AND COVENANT NOT TO SUE WARRANTORS, THEIR OWNERS, DIRECTORS, OFFICERS, EMPLOYEES, AGENTS, SUPPLIERS OR AFFILIATED COMPANIES, FOR ANY AND ALL LIABILITIES POTENTIALLY ARISING FROM ANY CLAIM, DEMAND OR ACTION BASED UPON ANY LOSSES, LIABILITIES, DAMAGES OR COSTS, INCLUDING BUT NOT LIMITED TO DAMAGES THAT ARE DIRECT OR INDIRECT, INCIDENTAL, SPECIAL OR CONSEQUENTIAL, AND INCLUDING ATTORNEYS FEES AND LEGAL COSTS, THAT MAY RESULT FROM THE INSTALLATION, OPERATION, USE OF, OR INABILITY TO USE WARRANTORS' PRODUCTS AND SERVICES, OR FROM THE FAILURE OF THE WARRANTORS' SYSTEM TO REPORT A GIVEN EVENT OR CONDITION, WHETHER OR NOT CAUSED BY WARRANTORS' NEGLIGENCE, EXCEPT AS NECESSARY TO ENFORCE THE EXPRESS TERMS OF THIS LIMITED WARRANTY.

EXCLUSIVE WARRANTY: THE LIMITED WARRANTY OR WARRANTIES DESCRIBED HEREIN CONSTITUTE THE SOLE WARRANTY OR WARRANTIES TO THE PURCHASER. ALL IMPLIED WARRANTIES ARE EXPRESSLY DISCLAIMED, INCLUDING: THE WARRANTY OF MERCHANTABILITY AND THE WARRANTY OF FITNESS FOR A PARTICULAR USE AND THE WARRANTY OF FITNESS FOR A PARTICULAR PURPOSE AND THE WARRANTY OF NON-INFRINGEMENT AND/OR ANY WARRANTY ARISING FROM A COURSE OF DEALING, USAGE, OR TRADE PRACTICE.

IT MUST BE CLEAR THAT THE WARRANTORS ARE NOT INSURING YOUR PREMISES OR BUSINESS OR GUARANTEEING THAT THERE WILL NOT BE DAMAGE TO YOUR PERSON OR PROPERTY OR BUSINESS IF YOU USE THIS PRODUCT. YOU SHOULD MAINTAIN INSURANCE COVERAGE SUFFICIENT TO PROVIDE COMPENSATION FOR ANY LOSS, DAMAGE, OR EXPENSE THAT MAY ARISE IN CONNECTION WITH THE USE OF PRODUCTS OR SERVICES, EVEN IF CAUSED BY WARRANTORS' NEGLIGENCE. THE WARRANTORS ASSUME NO LIABILITY FOR INSTALLATION OF THE PRODUCT AND/

OR INTERRUPTIONS OF THE SERVICE DUE TO STRIKES, RIOTS, FLOODS, FIRE, AND/OR ANY CAUSE BEYOND SELLER'S CONTROL, FURTHER SUBJECT TO THE LIMITATIONS EXPRESSED IN ANY LICENSE AGREEMENT OR OTHER AGREEMENT PROVIDED BY WARRANTORS TO PURCHASER.

THE AGREEMENT BETWEEN THE WARRANTORS AND THE PURCHASER, INCLUDING BUT NOT LIMITED TO THE TERMS AND CONDITIONS HEREIN SHALL NOT BE GOVERNED BY THE CONVENTION FOR THE INTERNATIONAL SALE OF GOODS. WHERE APPLICABLE, THE UNIFORM COMMERCIAL CODE AS ADOPTED BY THE STATE OF DELAWARE SHALL APPLY.

4. **PROCEDURE FOR OBTAINING PERFORMANCE OF WARRANTY**: IN THE EVENT THAT THE PRODUCT DOES NOT CONFORM TO THIS WARRANTY, THE PRODUCT SHOULD BE SHIPPED OR DELIVERED FREIGHT PREPAID TO A WARRANTOR WITH EVIDENCE OF ORIGINAL PURCHASE.

5. **LEGAL REMEDIES AND DISCLAIMER**: SOME JURISDICTIONS MAY NOT ALLOW, OR MAY PLACE LIMITS UPON, THE EXCLUSION AND/OR LIMITATION OF IMPLIED WARRANTIES, INCIDENTAL DAMAGES AND/OR CONSEQUENTIAL DAMAGES FOR SOME TYPES OF GOODS OR PRODUCTS SOLD TO CONSUMERS AND/OR THE USE OF INDEMNIFICATION TERMS. THUS, THE EXCLUSIONS, INDEMNIFICATION TERMS AND LIMITATIONS SET OUT ABOVE MAY NOT APPLY, OR MAY BE LIMITED IN THEIR APPLICATION, TO YOU. IF THE IMPLIED WARRANTIES CAN NOT BE EXCLUDED, AND THE APPLICABLE LAW PERMITS LIMITING THE DURATION OF IMPLIED WARRANTIES, THEN THE IMPLIED WARRANTIES HEREIN ARE TO BE LIMITED TO THE SAME DURATION AS THE APPLICABLE WRITTEN WARRANTY OR WARRANTIES HEREIN. THE WARRANTY OR WARRANTIES HEREIN MAY GIVE YOU SPECIFIC LEGAL RIGHTS THAT WILL DEPEND UPON THE APPLICABLE LAW. YOU MAY ALSO HAVE OTHER LEGAL RIGHTS DEPENDING UPON THE LAW IN YOUR JURISDICTION.

6. **CHOICE OF FORUM AND CHOICE OF LAW**: IN THE EVENT THAT A DISPUTE ARISES OUT OF OR IN CONNECTION WITH THIS LIMITED WARRANTY, THEN ANY CLAIMS OR SUITS OF ANY KIND CONCERNING SUCH DISPUTES SHALL ONLY AND EXCLUSIVELY BE BROUGHT IN EITHER THE COURT OF COMMON PLEAS OF DELAWARE COUNTY, PENNSYLVANIA OR THE UNITED STATES DISTRICT COURT FOR THE EASTERN DISTRICT OF PENNSYLVANIA.

REGARDLESS OF THE PLACE OF CONTRACTING OR PERFORMANCE, THIS LIMITED WARRANTY AND ALL QUESTIONS RELATING TO ITS VALIDITY, INTERPRETATION, PERFORMANCE AND ENFORCEMENT SHALL BE GOVERNED BY AND CONSTRUED IN ACCORDANCE WITH THE LAWS OF THE STATE OF DELAWARE, WITHOUT REGARD TO THE PRINCIPLES OF CONFLICTS OF LAW.

Effective date 05/01/2004

PHONETICS, INC. d.b.a. SENSAPHONE

901 Tryens Road

Aston, PA 19014
Phone: 610.558.2700 Fax: 610.558.0222
www.sensaphone.com

TABLE OF CONTENTS

CHAPTER 1: INTRODUCTION

Congratulations on your purchase of the Cell682 by Sensaphone.

The Cell682 is a powerful monitoring, alarm, and control system. Its built-in wireless technology means you won't need a telephone line to communicate with the unit. It can monitor and control your environment and equipment using eight dry contact inputs, six analog inputs, built-in power failure detection, and two relay outputs. It can perform simplex or duplex alternating pump control using a level transducer or float switches. The unit can also perform machine-to-machine control among multiple Cell682 devices. Up to 8 machine-to-machine control algorithms can be configured per device so that input conditions on one Cell682 can logically control outputs on another using simple, fill-in-the-blank, comparison programming. The unit features several communication options including: voice telephone call, e-mail, and text messaging. You can also request a status report from any e–mail compatible device. The Cell682 is fully programmable via the included Cell682 Software package for Windows or through the unit's web page at www.Cell682.com. Activation of a wireless messaging plan required.

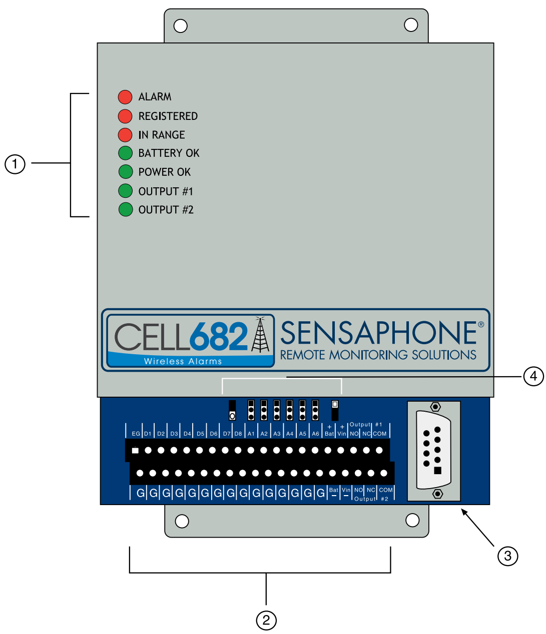
The Cell682 will produce a web page of input and output status and alarm acknowledgement history that can be viewed at **www.cell682.com**. You can also program the unit or control outputs from the web page. The Cell682 is the ultimate choice for remote monitoring and control where telephone lines are nonexistent or too expensive. Applications include pump houses, cable TV huts, remote equipment rooms, and tower light monitoring.

On the front of the unit are LED indicators to show the operating status (Power, Battery OK, In-Range, Registered, Alarm, and Outputs). All programming is stored in nonvolatile memory so that all programming is retained even without power. A complete status report of all monitored conditions can be retrieved via e-mail for viewing on a computer or text messaging device. The Cell682.com web page can be updated on demand to allow viewing of the current conditions at the site from any internet-connected computer. The unit comes in a plastic NEMA-4X enclosure with internal rechargeable battery backup, power supply and antenna.

FEATURES

- 8 Dry Contact Inputs: NO, NC, Pulse Count, Equipment Run-Time
- 6 Analog Inputs: 2.8K and 10K Thermistor (temperature), or 4–20mA
- 2 Relay Outputs: 20 different automatic and manual modes
- Local Logic Control
- Machine-to-Machine Control among Cell682 units
- Duplex and Simplex Pump Control
- Wireless Alarm Message Delivery via Voice, E-mail, or text message.
- Status & Programming via web page
- NEMA 4X enclosure and Battery Backup

CELL682 DIAGRAM



1. LEDs
2. Terminal blocks
3. RS-232 DCE
4. Jumpers for Temperature or 4–20mA settings

QUICK START

When installing and programming a Cell682 there are several steps required for all installations. Listed below are those required for a typical installation and start-up of the Cell682.

1) Confirm wireless coverage for the installation site. The CELL682 uses GSM cellular providers such as T-Mobile and AT&T. You can check "data" coverage using their respective websites or contact Sensaphone technical support and we'll check it for you.
2) Activate a wireless service plan for the unit. Contact Sensaphone and have your serial number available. This is required for the unit to operate. Activation enables access to your unit via the CELL682 website, as well as provides for notification of alarms via e-mail and voice phone call.
3) Install the unit in an area that provides good cellular reception. An optional external antenna with 16' cable is available, if necessary.
4) Attach the antenna to the top of the enclosure and plug-in the power supply. Connect the black battery wire (taped to the inside of the enclosure) to the (BAT -) terminal.
5) Once the unit powers-up, make sure the In Range and Registered LED's are lit.
6) Configure the input jumpers, if necessary, and connect the sensors to the terminal strip.
7) Verify status on the web site. (the PIN number is the last four digits of the serial number and the default password is "cell682").

CELL682 WEB PAGE

Your CELL682 is accessible via the Internet at www.CELL682.com. Simply enter your PIN and password (default is cell682) and you will be logged in to the web page for your device. Your PIN is the last 4 digits of your serial number. Be sure to change your password for security purposes. To see the current values click the Status Refresh link and in about 2 minutes you will see the current input and output values displayed on the page. You can make programming changes and even control the relay outputs from the web page. If any programming was performed using a direct connection to the serial port of the CELL682, then be sure to click the Programming Refresh link on the web page, so that you will be viewing the latest programming in the device..

TECHNICAL SUPPORT

This instruction manual will help you install and program the Cell682 properly. Be sure to read it completely before beginning the installation process. If there are any questions or problems that arise upon installation or operation, please contact our Technical Support team:

SENSAPHONE®
901 Tryens Road
Aston, PA 19014
Phone: 610.558.2700
FAX: 610.558.0222
support@sensaphone.com

CHAPTER 2: INSTALLATION

OPERATING ENVIRONMENT

The Cell682 should be mounted and operated in a clean, dry environment. The unit must communicate to the wireless network, so care must be taken not to install the unit inside a metal cabinet or other location that will prevent the unit from receiving a radio signal unless the antenna can be relocated to a location free of obstruction. The unit is microprocessor-controlled and, as a result, should not be installed near devices that generate strong electromagnetic fields. Such interference is typically generated by power switching equipment such as motors, contactors, or variable frequency drives. Where this is unavoidable, mount the unit in a separate, grounded steel enclosure with an external antenna (see Appendix F: Accessories). A poor operating environment may result in unwanted system resets and/or system lockup. The temperature range the unit can operate in is -22°F to 140°F (-30°C to 60°C).

WARNING: Attach the antenna before applying power to the Cell682. Never remove the antenna while the unit is powered on.

ACTIVATING YOUR CELL682

Your Cell682 device *must* be activated on the wireless network before you can send or receive messages *and* before any local programming is performed for the first time.

To activate your Cell682 device, fill out the registration form included with the package and follow the instructions, or contact your sales representative with the device serial number.

Your Cell682 is activated when the “In Range” and “Registered” LEDs are lit.

MOUNTING THE CELL682 (NEMA-4X HOUSING)

Locate a suitable mounting location for the Cell682 enclosure that provides good radio reception and convenient wiring to your equipment and power. On the top and bottom of the housing are mounting tabs to attach the unit to a wall. The mounting surface should be sturdy enough to support 10 lbs. The unit should be mounted using four #10-32 bolts where appropriate, or four #10 tapping screws. (The screw kit for the Cell682 includes (4) #10-32 screws, (4) #10-32 nuts, and (4) #10 lockwashers). When mounting the unit to a wall, make sure the mounting screws fully engage a solid member (for example, a stud) of the support structure. Mount the Cell682 in an upright position so that you can easily connect wires to the terminal strips. The dimensions of the NEMA-4x enclosure are: 12.1” x 8.0” x 5.5” / 30.7 x 20.3 x 13.9cm. See Figure 1.

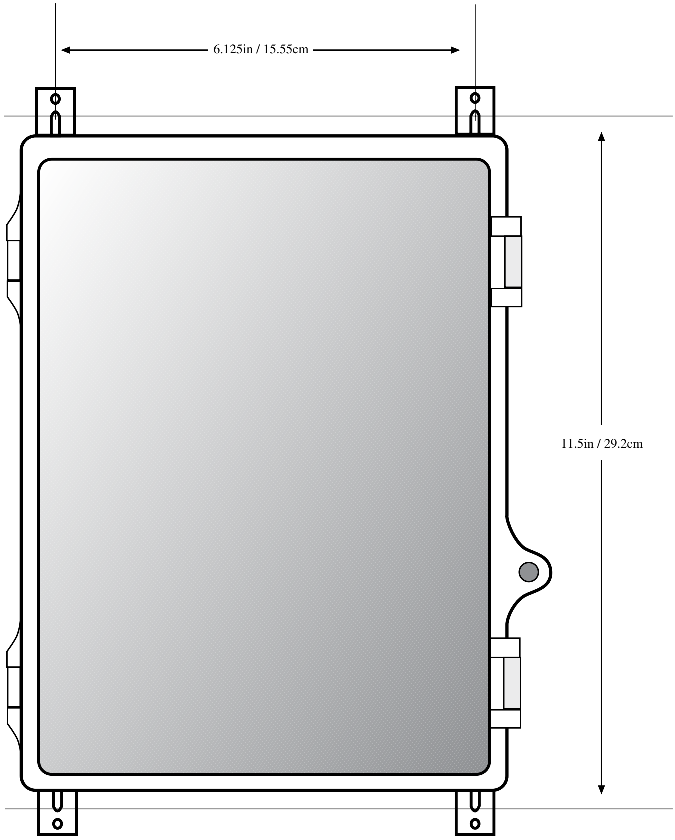


Figure 1: NEMA-4 Mounting diagram

LOCKING THE NEMA 4X ENCLOSURE

The Cell682 enclosure can be locked by installing a small padlock through the loop on the front door of the enclosure. See Figure 2.

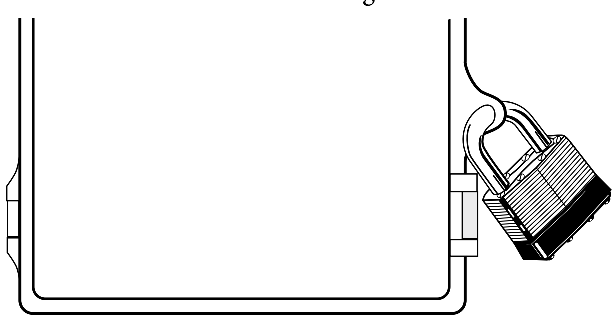


Figure 2: Locking the NEMA-4x enclosure

ANTENNA INFORMATION

The Cell682 comes with a unity-gain antenna designed specifically for the frequency range required. In order to comply with FCC RF exposure, the external antenna must be mounted in a location where people will never come within 20cm of the antenna. The gain of the antenna may not exceed 0dBi. For optimum antenna performance, there should be no metal objects within close proximity of the antenna.

> **WARNING:** Do not over-tighten the antenna on the Cell682; this may cause permanent damage to the device.

The antenna must be connected before the device is powered up.

CONNECTING THE POWER SUPPLY

The Cell682 requires a 18VDC power supply to operate. This power supply will charge the internal 12V battery and provide the necessary power to transmit messages over the wireless network.

WARNING: Do not substitute supplies with lower capacity.

Connect the positive terminal of the Power Supply to the **+Vin** terminal on the Cell682.

Connect the negative terminal of the Power Supply to the **-Vin** terminal on the Cell682.

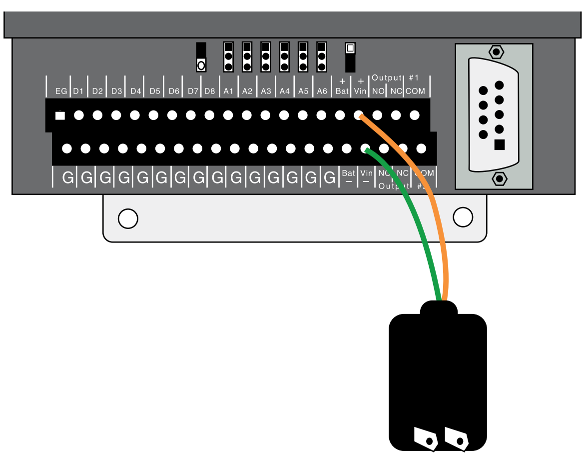


Figure 3: Power Supply Wiring

CONNECTING THE BATTERY

The CELL682 contains an internal 12V rechargeable battery that must be wired to the terminal strip at the time of installation (see procedure below). The battery will power the system for several hours in the event of a power failure. The unit incorporates circuitry to maintain the proper charge for a 12V gel-cell battery whenever the power supply is plugged-in. The unit also includes special circuitry to prevent the battery from being damaged in the event of an extended power outage. The battery should provide approximately 3-5 years of service life before needing replacement depending on temperature and the number of charge/discharge cycles.

WIRING PROCEDURE

Connect the positive terminal of the battery (red wire) to the + **Bat** terminal on the Cell682.

Connect the negative terminal of the battery (black wire) to the – **Bat** terminal on the Cell682.

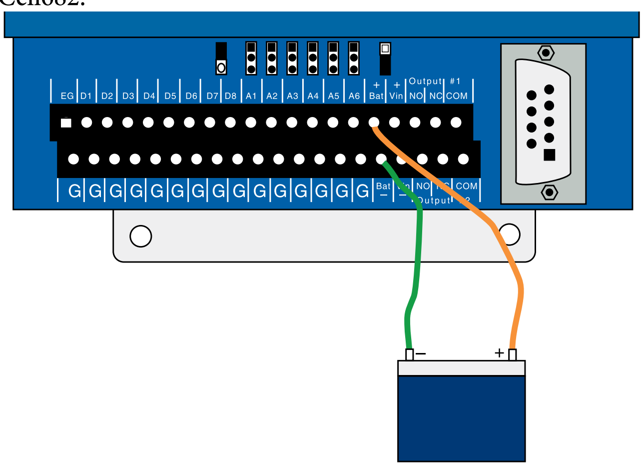


Figure 4: Battery connection

The battery is considered low at 12.0V and the Battery LED will blink at this voltage level. If main power is less than 7.0V and the battery voltage reaches 11V, the battery LED will go out and the unit will go into hibernation mode (a low-power mode in which the unit shuts down). The unit will return to its regular operating mode when either the main power is restored or the battery voltage rises above 11.5V. If the battery voltage continues to fall below 10.5V, the unit will disconnect the battery to prevent deep discharge damage to the battery. The unit will not reconnect the battery until the battery voltage rises above 12.5V.

GROUNDING

Connect a #14AWG copper wire to the earth ground terminal (marked "EG") on the left end of the terminal strip and connect the other end to a ground rod or metal cold water pipe *(See Figure 6)*. It is extremely important that the earth ground connection be as short as possible. The ground rod should have sufficient depth to provide a low impedance connection to earth. This connection is required for the surge/lightning protection circuits to function properly.

NOTE: Proper earth grounding of the Cell682 is required for warranty coverage.

Ground rods can typically be found at local electrical supply houses and/or hardware stores. You MUST contact your state "Call before you dig" hotline at least *two* days before you install your ground rod, to insure that it is safe to install the ground rod in a chosen area.

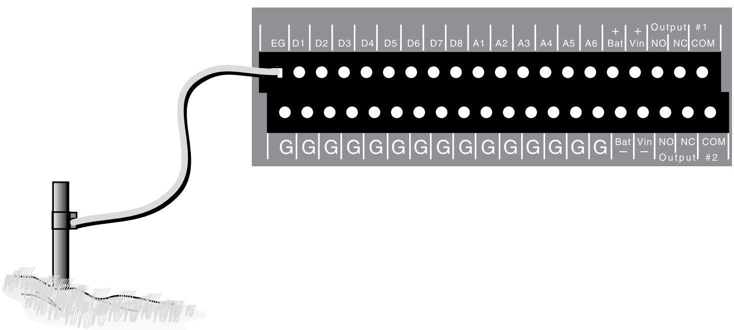


Figure 5: Grounding the Cell682

WIRING SENSORS TO DRY CONTACT INPUTS

The Cell682 has 8 Dry Contact inputs that can be used to monitor Normally Open (N.O.) or Normally Closed (N.C.) sensors. In addition, they can also be used for pulse counting and equipment run-time accumulation. When used for pulse count or run time functions, the unit will count the pulse (or accumulate time) when the input changes to the opposite of its normal state.

Dry contact sensors are wired to the terminals labeled D1 through D8. The corresponding Ground terminals are located on the lower level terminal strip. The input type is programmed within the Cell682 Software or website.

WARNING: Do not use sensors, switches, or relays that supply any voltage or current to the Cell682.

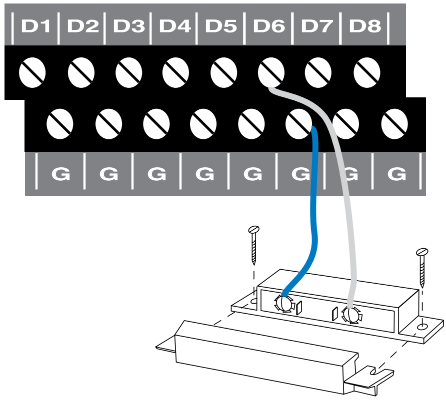


Figure 6: Sensor connected to a dry contact input]

Any N.O. or N.C. sensor can be attached to the Cell682 using 18–24 gauge wire. For distances of 1000' or more, use heavier gauge wire. When running wire outdoors it is recommended that shielded cable be used. Connect the shield to a good earth ground or metallic cold water pipe. The total resistance of the circuit cannot be greater than 100 ohms. Use wire appropriate for the application. See the wire length recommendations, later in this chapter.

The Cell682 may have more than one sensor connected to the same terminal, however, the normal condition for each sensor on the same terminal must be identical (either all N.O. or all N.C.).

NORMALLY CLOSED SENSORS

To wire more than one normally closed sensor on one input, they must be connected in series. Connect a lead from the first sensor to one of the Dry Contact Inputs on the terminal strip. Next, take the other lead from the first sensor and connect it to one lead from the next sensor. Continue connecting sensors end-to-end until you have connected all of your sensors. Take the second lead from your last sensor and connect it to the ground screw on the Cell682 terminal strip. See Figure 7.

Multiple N.C. inputs are typically magnetic reed switches to monitor the security of windows and doors.

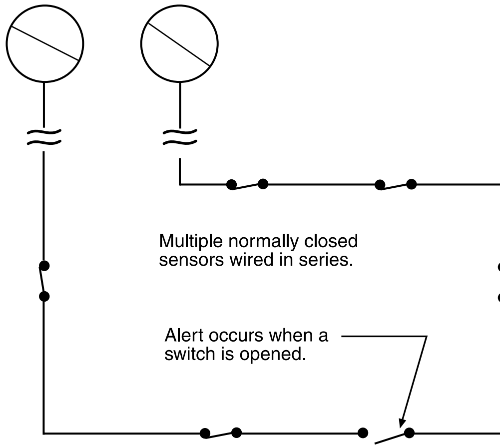


Figure 7: Connecting multiple N.C. sensors to one input terminal

NORMALLY OPEN SENSORS

To wire several normally open sensors to one Dry Contact input, connect them in parallel. To do this, take one lead from each sensor and attach it one of the Dry Contact Input terminals. Then take the second lead from each sensor and attach it to the corresponding ground terminal. See Figure 8.

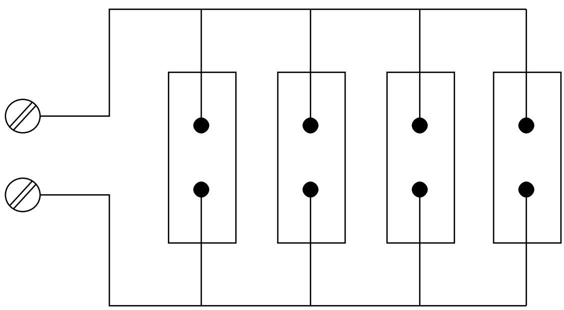


Figure 8: Connecting multiple N.O. sensors to one input terminal

WIRING SENSORS TO ANALOG INPUTS

The Cell682 has 6 Analog inputs that can be used to monitor 2.8K or 10K Thermistors (temperature) or 4–20mA transducers. Analog transducers are wired to the terminals labeled A1 through A6. The corresponding Ground terminals are located on the lower level terminal strip. The input must be configured by setting the corresponding jumper in either the Temperature or 4–20mA position. See figure below:

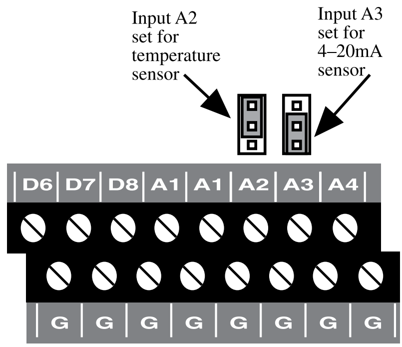


Figure 9: Input A2 configured for temp, A3 configured for 4-20mA

Temperature: The unit will accept 2.8K or 10K thermistors. These should be wired to an Analog Input terminal and the adjacent ground terminal. For compatible thermistors check the accessory list or thermistor data in the appendices. 10K Thermistor temperature range: -60°F to 175°F (-51°C to 79°C).

4–20mA: A 4–20mA transducer requires you to have an external DC power supply for the transducer. Connect the positive wire of your transducer to the positive terminal of your DC power supply. Connect the negative terminal of the transducer to an Analog Input terminal on the Cell682. Connect the negative terminal from your power supply to the adjacent ground terminal on the Cell682.

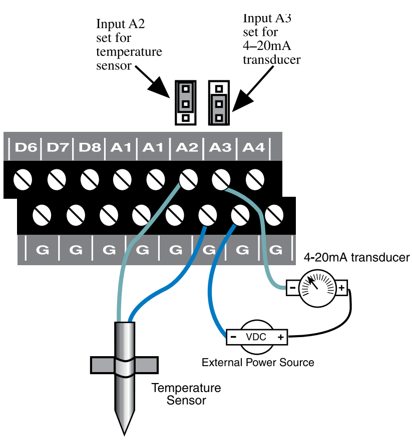


Figure 10: A thermistor and a 4–20mA transducer connected to the unit

WIRING RECOMMENDATIONS

The Cell682 will work fine in indoor environments using unshielded cable. When wiring will be subject to long lengths (>100') or if run outdoors, it is highly recommended that shielded cable be used and that the shield be connected to an earth ground. This is particularly important for sensor wires that are run in conduit with other noise-generating conductors, such as 60Hz AC. It is strongly recommended that input wiring be run in a conduit separated from AC power or output wiring. When wire runs are long or are in close proximity to large power consuming, power generating, or power switching equipment, it is highly recommended that shielded wire be used.

Also, be sure to use the appropriate gauge wire based on the distance and sensor type. See chart below:

Wire Gauge	Thermistor	NO/NC Contact & 4–20mA
#24	250’	1000’
#22	500’	2000’
#20	1000’	4000’

When preparing wire for connection to the terminal blocks, strip 1⁄4” of insulation from the conductor (see figure below).

Figure 11: Wire stripped for connection

NOTE: All wiring should comply with Section 17 of the UL requirements.

LED INDICATORS

The LEDs provide on-site alarm and status information. Listed below are descriptions of how the LEDs work.

ALARM:

LED Off: No alarms

LED Blinking: Unacknowledged alarm exists

LED On: Acknowledged alarm exists

REGISTERED:

LED Off: Not registered (unit not activated)

LED Blinking: Cell682 is sending or receiving messages

LED On: Registered

IN RANGE:

LED Off: Not in range of wireless network

LED On: In range of wireless network

BATTERY OK:

LED Off: No Battery

LED Blinking: Battery condition low

LED On: Battery OK

POWER OK:

LED Off: Power is Off

LED Blinking slow: Power very low (unit hibernating)

LED Blinking fast: Power is low

LED On: Power is OK

OUTPUT #1:

LED Off: Output Relay #1 is off.

LED On: Output Relay #1 is on.

OUTPUT #2:

LED Off: Output Relay #2 is off.

LED On: Output Relay #2 is on.

CHAPTER 3: SOFTWARE INSTALLATION

This section describes how to install and configure the Cell682 Programming Software for your computer.

INSTALLING AND STARTING THE SOFTWARE

Minimum requirements:

- Microsoft Windows™ 2000, XP, Vista, or 7
- CD-ROM drive
- Serial Port (or USB-to-serial adapter)Installation

The Cell682 Programming Software is easy to install. Make sure that all Windows applications are closed before attempting to run Setup. If you encounter problems during installation, please call Sensaphone Technical Support at 610-558-2700. The Cell682 Software will install to a directory named *C:\Program Files\Cell682*, unless you choose to change the directory name.

1. Start Windows.
2. Insert the Cell682 CD-ROM. The installation program should run automatically. Follow the prompts as directed.

If the software does not install automatically, then click the *Windows Start* button, and select *Run*, then type in d:\setup.exe. Click *OK*. Follow the prompts as directed.

3. Reboot your computer when the installation is complete.

ACTIVATING YOUR CELL682

Your Cell682 device *must* be registered on the wireless network before you can send or receive messages *and* before any local programming is performed for the first time.

To activate your Cell682 device, fill out the registration form included with the package and follow the instructions, or contact your sales representative with the device serial number.

Your Cell682 is activated when the “In Range” and “Registered” LEDs are lit.

Note: The *Registered* LED will blink when the Cell682 is sending or receiving messages.

CONNECTING LOCALLY

The Cell682 Software will allow you to connect with the unit to view status and program it. First, connect a serial cable to a serial port on your computer. Connect the other end to the 9-pin RS-232 connector on the Cell682. Run the Cell682 Software. The following screen will appear.

Figure 1: First-Run Unit Information form

Click the *New* button to set-up a new Cell682 unit. The *Edit Cell682 Unit* screen will appear (see right).

Figure 2: Edit Cell682 Unit

Enter the PIN, Name, Description, and Comm Port settings for this unit. The PIN is the last four digits of the serial number. The unit Name can be up to 20 characters, the Description can be up to 30 characters. Click *OK*. Now click the *Connect* button and the software should connect and start downloading the programming from the unit.

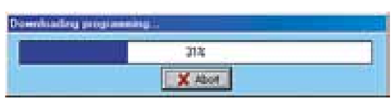


Figure 3: Programming Download in progress

If this was a new unit (factory default settings) the Name you entered on the edit screen will automatically be copied into the unit. After downloading the programming, the main Cell682 window will appear (see next page).

Figure 4: Main Cell682 Window: System Tab

This is a good time to enter a new Password. The Password, while not required for local access, is required for all remote communication. The password can be up to 8 characters. Click *Apply* when finished.

CHECKING WIRELESS SIGNAL STRENGTH

The Cell682 performs all of its communication over the wireless network, so it is very important that there be sufficient signal strength at the installation site. You can check the received signal strength from within the Cell682 software while connected through the serial port. Login to your Cell682 and then click on Help then About from the main menu. A list of items will appear about the Software Version, Firmware Version, etc… the last item is called Signal Quality. In order for the Cell682 to operate properly this number must be greater than 10. A higher number is better. Values typically range from 0 to 50. See the sample screen below:

Figure 5: System Information Window

If your Signal Quality value is less than 10 you must either relocate/reposition the unit to improve its ability to communicate with the wireless network or add an external antenna that can be installed in a better location. Contact Sensaphone technical support for assistance.

CELL682 WEB PAGE

You can view status and change settings in your Cell682 via the internet. This makes it possible to manage your unit from anywhere in the world. See Chapter 10 for detailed information on using the web page.

HOW IT WORKS

You can perform CELL682 programming using either the CELL682 Software or the webpage. Generally, if you are at the unit's location it's faster to perform the programming using the software while directly connected to the device. Alternatively you can program the unit remotely using the CELL 682 web page. The PIN number of your unit is the last 4 digits of the unit's serial number. The default password for the web page is "cell682". You should change this password for security purposes.

If you performed programming using the CELL 682 software then you must click the Programming Refresh link on the web page to have those programming changes updated on the website. To get just the current status of the Inputs and Outputs, you should click the Status Refresh Link. This will retrieve the latest input status from your unit. It may take a few minutes for this process to complete.

CHAPTER 4: INPUT PROGRAMMING

The Cell682 features 8 dry contact inputs and 6 analog inputs. The analog inputs are configurable as temperature or 4–20mA. The contact inputs can be used with Normally Open (NO) or Normally Closed (NC) sensors. The analog inputs can be used with 2.8K or 10K thermistors for temperature monitoring (available from Sensaphone) or any 4–20mA transducer. The monitored temperature range is -60° to 175° F (-51° to 79° C). See page 20 for 2.8K range. Programmable table values can be entered when using 4–20mA transducers to scale the reading to the appropriate units of measure.

Note: It is highly recommended that if you make any programming changes locally (at the unit via the serial port) after your web page has been initialized, that you click the *Programming Refresh* Link on the web page soon thereafter. This is to ensure that the information you are viewing on the web page is up to date. This will also ensure that the alarm log information displayed on the web page is accurate.

ALARM STATES

Each Dry Contact or Analog input is monitored based on the programming parameters that define the input type and the alarm limits for each input. Based on this programming all inputs will always be in one of four *Alarm States*: Normal, Alarm, Unacknowledged Alarm, or Normal-Unacknowledged. Each of these alarm states is defined below:

A "**Normal**" alarm state means that an input is either:

a) Within the programmed alarm limits.

b) A Normally Open input is open, or a Normally Closed input is closed.

c) An input is beyond its limits or is opposite of its programmed normality, but has not yet met its programmed alarm *Recognition Time*.

An input that is in an "**Alarm**" state means that:

a) The selected input is currently beyond its programmed alarm limits or is opposite of its programmed normality.

b) The selected input has exceeded the programmed recognition time.

c) The alarm has been acknowledged.

An input that is in an "**Unacknowledged Alarm**" state means that:

a) The selected input is currently beyond its programmed alarm limits or is opposite of its programmed normality.

b) The selected input has exceeded the programmed recognition time.

c) The alarm has not been acknowledged.

An input that is in a "**Normal** but **Unacknowledged**" state means that:

a) The selected input is within its programmed alarm limits.

b) A Normally Open input is open, or a Normally Closed input is closed.

c) A prior alarm on the selected input has not yet been acknowledged.

DRY CONTACT INPUTS

The 8 dry contact inputs can be programmed for normally open (NO) or normally closed (NC) operation. In addition, you can have the Cell682 count the number of times the input changes state (pulse count) and maintain the amount of time that the input is in the opposite state (Run Time). Click on the *Dry Contact* Tab to display the main status screen.

Figure 1: Dry Contact tab

This screen displays the current status of all 8 dry contact inputs. If any of the inputs were in alarm the *Alarm State* column would display the word "Alarm." If the alarm was unacknowledged, the Alarm State would say "Alarm;Unack" and a button would appear at the bottom of the screen to acknowledge the alarm.

DRY CONTACT PROGRAMMING

Click the input name to bring up the properties screen for the selected input. The following screen will appear:

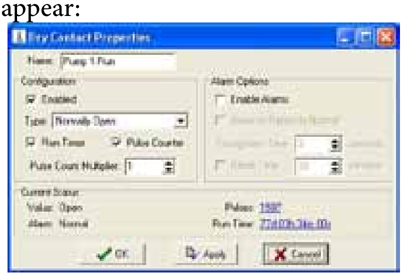


Figure 2: Dry Contact properties

If a dry contact changes from its Normal state to the opposite state for the duration of the programmed recognition time, the input will go into alarm. Note that it must be a continuous change to be recognized as an alarm. Once an alarm trips, the unit will begin its notification sequence (unless you are online through the serial port, in which case you can acknowledge the alarm directly and cancel the notification process). Listed below are definitions for each of the parameters for programming the dry contact inputs.

CONFIGURING THE INPUT NAME

The input *Name* is used to describe the condition being monitored. It can be up to 20 characters.

INPUT ENABLE/DISABLE

A channel must be *Enabled* for the input to be read by the Cell682. When a channel is enabled its status will appear on the status screen and on the web page.

CONFIGURING THE INPUT TYPE

The input *Type* can be either Normally Open or Normally Closed. When an input changes from its normal condition to the opposite condition, the Pulse Count (if enabled) will increment, the Run Timer (if enabled) will start running, and the Alarm Recognition timer will start running (if alarms are enabled).

CONFIGURING THE RUN TIMER

The *Run Timer* can be used to track how long an input condition has existed. This can be useful for monitoring pump or generator run times. The value can be preset by clicking on the run time value on the lower right part of the screen.

CONFIGURING THE PULSE COUNTER

The *Pulse Counter* can be used to track how many times a contact closure has changed state. Other possibilities include: measuring rainfall from a tipping bucket rain gauge or measuring liquid flow from a pulsed output flow gauge. The maximum value of the Pulse Counter (after the multiplier is applied) is 2 billion. Minimum Pulse Width for Pulse Count: 50ms.

The *Pulse Count Multiplier* allows you to make each pulse equate to a greater value. For example, suppose a flow gauge outputs a single pulse for every 100 gallons. By setting the *Pulse Count Multiplier* to 100 the Pulse Count value now becomes the actual total number of gallons measured by the gauge. The range of values for the Pulse Count Multiplier is 1 to 65,535.

ALARM ENABLE/DISABLE

The *Enable Alarms* checkbox activates the alarm processing functions for the selected channel. When the input exceeds the the programmed alarm limits and exceeds the programmed recognition time the notification process begins.

ALARM ON RETURN-TO-NORMAL

The Cell682 has the capability to notify you when an input (that had previously gone into alarm) returns to normal. When checked, *Alarm on Return-to-Normal* initiates this notification.

ALARM RECOGNITION TIME

The *Recognition Time* is the time required for a fault condition to qualify as an alarm event. The sensor/channel must remain beyond the limits or in a fault condition continuously for this entire period of time in order to become an alarm. The range of values is 0–32,767 seconds.

ALARM RESET TIME

The *Reset Time* is the time allowed for an acknowledged alarm's fault condition to be corrected before the Cell682 resets (reactivates) the alarm and begins the message delivery process all over again. The minimum reset time is 30 minutes, the maximum is 32,767 minutes.

ANALOG INPUTS

The 6 analog inputs can be programmed for 2.8K or 10K thermistor (temperature in degrees Fahrenheit or Celsius) or 4–20mA transducer. The Cell682 will maintain the minimum and maximum values reached for each channel. When 4–20mA is selected you can enter table low and high values to correlate the 4mA and 20mA signals to actual values for your application. Click on the Analog Inputs Tab to display the main status screen.

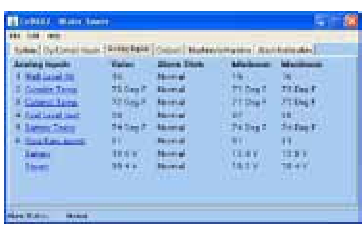


Figure 3: Analog Inputs tab

This screen displays the current status of all 6 analog inputs. If any of the inputs were in alarm the *Alarm State* column would display the word "Alarm." If the alarm was unacknowledged the Alarm State would say "Alarm Unack" and a button would appear at the bottom of the screen to acknowledge the alarm.

ANALOG INPUTS PROGRAMMING

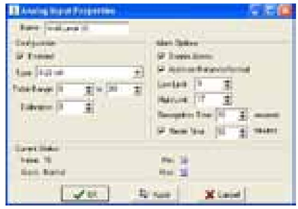


Figure 4: Analog Inputs Properties

CONFIGURING THE INPUT NAME

The input Name is used to describe the condition being monitored. It can be up to 20 characters.

CONFIGURING THE INPUT TYPE

The input Type can be temperature 2.8K (°F/°C), 10K (°F/°C), or 4–20mA. Select the type to match your sensor.

Note: Be sure to put the input jumper in the correct position.

INPUT ENABLE/DISABLE

A channel must be Enabled for the input to be read by the Cell682. When a channel is enabled its status will appear on the status screen and on the web page. Select the type of analog input from the pulldown menu.

SETTING TABLE LIMITS

When 4–20mA is selected, you can enter table low and high values to correlate the 4mA and 20mA signals to actual values for your application. For example, suppose you're using a 4–20mA transducer to measure the depth of water in a 15 foot well. Simply enter a Table Low value of 0 and a Table High value of 15 and the Cell682 will scale the input to read between 0 and 15 feet.

<u>Programmable range</u>

Table Low/High: -16,300 to 16,300

<u>Default settings</u>

Table Low value: 0

Table High value: 100

CALIBRATION

To compensate for minor variances in sensor accuracy, an offset may be programmed for each analog input. For example, if the above input were sensing temperature and was reading 3 degrees too low, then the calibration would be set at 3 as shown above, to obtain an accurate reading. Only Analog-type inputs can be calibrated.

ALARM ENABLE/DISABLE

The Enable Alarms checkbox activates the alarm processing functions for the selected channel. When the input exceeds the the programmed low or high alarm limits and exceeds the programmed recognition time the notification process begins.

ALARM ON RETURN-TO-NORMAL

The Cell682 has the capability to notify you when an input (that had previously gone into alarm) has returned to normal, that is, returns to within the programmed alarm limits. When checked, Alarm on Return-to-Normal initiates this notification.

SETTING THE ALARM LIMITS

Each analog input has a programmable Low and High Alarm limit. When the input value goes beyond the programmed alarm limits for the duration of the recognition time, the Cell682 will go into alarm and initiate the alarm notification process.

<u>Programmable range</u>

Alarm Low/High: -16,300 to 16,300

<u>Default settings</u>

Alarm Low value: 0

Alarm High value: 100

ALARM RECOGNITION TIME

The Recognition Time is the time required for a fault condition to qualify as an alarm event. The sensor/channel must remain beyond the programmed limits continuously for this entire period of time in order to become an alarm. The range of values is 0–32,767 seconds.

ALARM RESET TIME

The Reset Time is the time allowed for an acknowledged alarm's fault condition to be corrected before the Cell682 resets (reactivates) the alarm and begins the message delivery process all over again. The minimum reset time is 30 minutes, the maximum is 32,767 minutes.

POWER INPUT

Power monitoring is a built-in function. The unit will go into alarm when the power level drops below 11.75V for the programmed recognition time. In this state the Power LED will blink.

BATTERY INPUT

Battery monitoring is a built-in function. The unit will go into alarm when the battery level drops below 12.0V for the programmed recognition time. In this state the Battery LED will blink.

SPECIAL FUNCTION INPUTS

When the Cell682 is used for Pump Control, several of the inputs are dedicated to a specific task depending on whether *Dry Contact* or *Analog Level* is selected as the Pump Control method. The tables below identify which inputs are used and what function they serve. Refer to the Pump Control chapter for more information.

<u>Dry Contact Fill/Drain Pump Control</u>

Dry Contact Input #6 – Lead pump float switch

Dry Contact Input #7 – Lag pump float switch

Dry Contact Input #8 – All pumps off float switch

<u>Analog Level Fill/Drain Pump Control</u>

Analog Input #6 – connect to analog (4–20mA) level sensor

CHAPTER 5: OUTPUT PROGRAMMING

The Cell682 has two relay outputs capable of switching up to 0.3A at 120VAC, or 1.0A at 24VDC. The outputs can be controlled in a number of ways both automatically and manually. Some examples are listed below:

- Each relay can be manually turned on or off through the PC software or via the Cell682 web page.
- Either relay can be set to turn on when a particular alarm occurs.
- Either relay can be set to turn on when any alarm occurs.
- Either relay can be set to turn on when any digital or any analog alarm occurs.
- One or both relays can be programmed to operate in pump control mode (simplex/duplex) for fill or drain applications.
- A relay can be controlled automatically based on Dry Contact or Analog input values using greater-than, less-than, or equal-to statements *(See Chapter 7: Machine-to-Machine Control)*.
- A relay may also be controlled by another Cell682 unit using machine-to-machine control. This allows the Cell682 to be used for distant pump/well control applications.

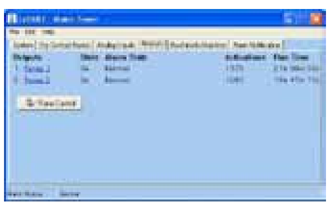


Figure 1: Outputs tab

SETTING THE OUTPUT NAME

To set up the relay outputs, click on the *Outputs* tab. Next, click on the Name for Output 1 (blue) to bring up the *Output 1 Properties* screen. Enter a name for the output which describes the device that the output will be controlling.

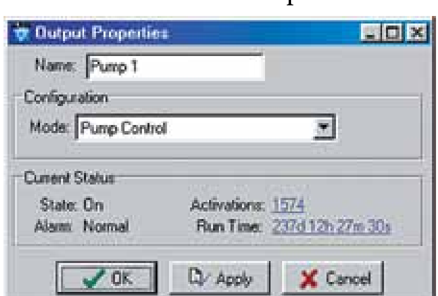


Figure 2: Output Properties screen

CONFIGURING THE OUTPUT OPERATING MODE

Click the drop-down arrow and select the operating *mode* for the output. You can have the relay automatically turn on for a variety of alarm conditions, either individual alarms or if any alarm occurs. If you will be controlling the output manually or via a machine-to-machine command, select *Manual* mode. If you will be using the output for fill or drain pump control, select *Pump Control*. For simplex pump control set only one output to Pump Control mode; for duplex pump control set both outputs to Pump Control mode. See Chapter 6 for more information on pump control programming.

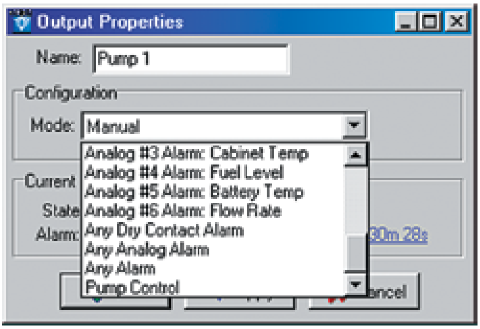


Figure 3: Output Operating mode

SWITCHING THE OUTPUT

To manually turn an output on, click on the current state (On or Off) and select the new state, then click *OK*. See the following screen.

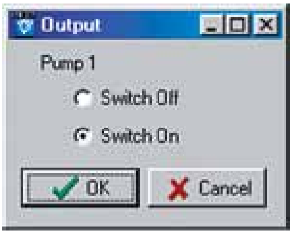


Figure 4: Output manual select

OUTPUT STATUS & STATISTICS

The Cell682 software will display the current state of the output as well as the number of times the relay has turned on, the total time the relay has been on (cumulative), and the alarm status of the output (valid in pump control mode only). This information can be useful for monitoring how often a device (pump, machine, generator, ...) has been activated and for how long. These values can be reset and/or preset by clicking on the displayed value and entering a new one.

CHAPTER 6: PUMP CONTROL

The Cell682 can be used in Fill or Drain pump control applications using either float switches or an analog level transducer. When used with Float Switches, dry contact inputs #6-8 have a dedicated special function (see below):

Pump Control using Float Switches

Dry Contact Input #6 – Lead pump float switch

Dry Contact Input #7 – Lag pump float switch

Dry Contact Input #8 – Pumps-off float switch

When performing pump control using an analog level transducer (4–20mA), analog input #6 is designated as the well level input.

Note: Only normally-open float switches can be used for pump control (e.g. the switch is open when no water is present).

HOW IT WORKS—FLOAT SWITCHES

When performing drain pump control using float switches, three floats are required: Lead, Lag, and Pumps-Off (see Fig 1). The Lead float determines when to turn on the first pump. If the first pump is unable to bring the level below the Pumps-Off float, then the Lag float will close, turning on the second pump. When the level drops below the Pumps-Off float, both pumps are turned off. If any of the floats get stuck (i.e. the lead and pumps-off floats closed, or the lag and pumps-off floats closed) then both pumps will be turned on and an alarm will be tripped on the output or outputs in question. In duplex mode, the Cell682 will automatically alternate between the two pumps to facilitate uniform run time between the two.

If only one relay output is set to pump-control mode, then simplex control is performed. In Simplex mode only the Lead float (Dry Contact #6) and Pumps-Off float (Dry Contact #8) are required. Either output relay can be used in simplex mode.

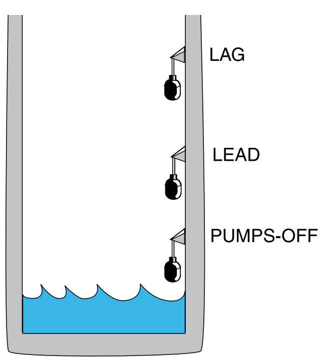


Figure 1: Float positions for a drain application

In a Fill application, the Lag and Pumps-Off floats would change position as shown below:

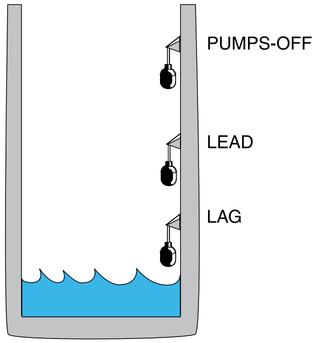


Fig 2. Float positions for a Fill application

In this case, the pumps are attempting to keep the well full. When the well is full all three floats are closed. If the level drops below the Lead float, then the first pump will turn on. If the level rises above the Pumps-Off float then the pump will turn off. If the level continues to fall below the Lag float, then the 2nd pump will turn on. Both pumps will remain on until the Pumps-Off float closes. If only one relay output is set to pump-control mode, then simplex control is performed. In Simplex mode only the Lead float (Dry Contact #6) and Pumps-Off float (Dry Contact #8) are required. Either output relay can be used in simplex mode.

HOW IT WORKS—ANALOG LEVEL SENSOR

When performing pump control with an analog level sensor, the Lead, Lag, and Pumps-Off levels are programmed into the Cell682 software. The unit then measures the actual level on Analog Input #6 and turns on the appropriate relay outputs. If both outputs are set to Pump Control mode, then alternating duplex control will be performed. If only one output is set, then Simplex control will be performed. The analog level sensor must be a 4–20mA transducer that is selected and calibrated based on the depth of the well. The specified output of the transducer must be entered into the Table Range settings for Analog Input #6.

INSTALLATION RECOMMENDATIONS

Be sure to install and wire the Cell682 and associated equipment in accordance with all local codes and regulations. Adhere to Standard Practice/Best Practice policies when installing and wiring any control system. Be sure to include hand-operated switches to disconnect power on all pumps/equipment to insure worker safety when installing and servicing equipment.

PROGRAMMING FOR PUMP CONTROL

To program the unit for Pump Control, click on the Outputs tab.

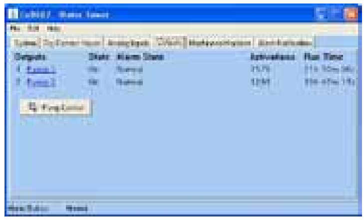


Figure 2: Output properties showing pump control

Next, click on the Pump Control link. This will bring up the pump mode setup screen. Next, select the type of pump control you want to do:

- Drain Analog Level
- Drain Dry Contact Floats
- Fill Analog Level
- Fill Dry Contact Floats

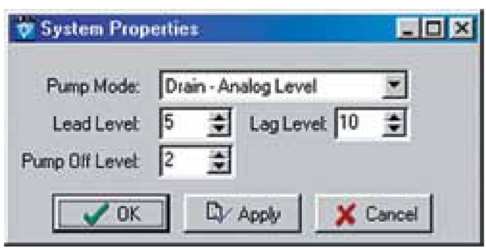


Figure 3: Pump Mode—Analog programming

If you select one of the Analog modes, you will have to fill in the Lead, Lag, and Pumps-Off fields. In Dry Contact Float mode these fields are disabled. Enter the appropriate values and click OK or Apply.

Next, click on the output to use for Pump Control. Click the drop-down box and scroll to the bottom to select Pump Control. Click OK or Apply. This will activate the Pump Control logic. Make sure all input devices and equipment are operational and ready for use. For test purposes you may wish to use hand operated switches to manually control the pumps and simply watch the system LEDs to see if the Cell682 is functioning properly. If you are using “duplex” pump control, select the other output and set it for Pump Control mode also. After verifying that the unit is functioning properly, move your hand-operated pump switches to “Auto” and verify that the Cell682 is properly controlling the system.

OUTPUT WIRING

The output relays on the Cell682 are for low current control signals (0.3A 120VAC/1.0A 24VDC maximum).

DO NOT directly connect the power for the pumps to these relays—THIS WILL PERMANENTLY DAMAGE THE Cell682.

Use the Cell682 outputs to control intermediate motor contactors/relays that will switch actual power to the pumps.

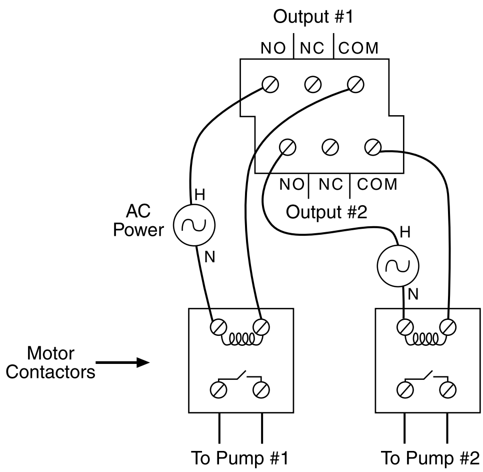


Figure 4: Output wiring to two pumps

CHAPTER 7: MACHINE-TO-MACHINE CONTROL

The Machine-to-Machine Control feature allows you to control outputs of other Cell682 units (or outputs within the same unit) based on input conditions. For example, you can switch an output on a Cell682 unit several miles away if an input on a different unit is greater than a specified value. The output being controlled must be set to manual mode. Up to 8 machine-to-machine control events can be configured per Cell682 unit. Note that when an input condition causes an output to change state, a separate event must be programmed to make the output change back. For example, if you program output #1 to turn on when input #5 is greater than 60, the output will **not** turn off when the input drops below 60. A separate event must be programmed to make the output turn off when the input is less than 60.

To program Machine-to-Machine Control click on the Machine-to-Machine Tab. The following screen will appear:

Figure 1: Machine-to-Machine tab

The 8 peer-to-peer events are listed in the window to the left. Clicking on each one will display a description of the control event programmed for each. To program a new peer-to-peer event click on the first unused (Disabled) peer event and click the *Edit* button. The following screen will appear:

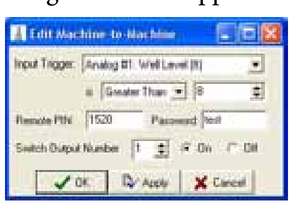


Figure 2: Peer-to-peer Edit screen

Click the down arrow in the *Input Trigger* field to select the input that will initiate the event. If you select a Dry Contact input, you can have the event occur when the selected input goes from *Open-to-Closed* or *Closed-to-Open*. If you select an Analog input you can have the event occur if the input is *equal-to*, *greater-than*, or *less-than* a specified value.

Enter a value for the comparison (range: -16,300 to 16,300).

> **Note:** Peer-to-peer events are triggered as soon as the input meets the trigger conditions. There is no recognition time applied in this case. Also, peer-to-peer events will not be executed while you are on line locally.

Next, enter the *PIN* and *Password* of the Cell682 unit whose output you want to switch. Select the output number and action (either ON or OFF). Click *Apply* or *OK* when finished. Remember, the target output must be set to manual mode, otherwise the command will be ignored. If the password is wrong the command will be ignored as well.

LOCAL OUTPUT CONTROL

You can perform control logic using the same inputs and outputs on a single Cell682 unit. If you want to switch an output on the same Cell682 as the input, then simply enter the unit's own PIN (a password is not required in this case). The output must be set to *manual* mode. Local output control does not use any airtime and also executes instantly (as long as there are no preceding peer-to-peer events that must communicate with a different Cell682 device).

IMPORTANT INFORMATION AND WARNINGS

- It may take several minutes for the peer-to-peer command to reach the destination Cell682.
- Peer-to-peer commands are processed in a sequential, non-predetermined order. This means that if more than one command is triggered, the subsequent commands must wait until the currently processed command is finished. If two peer-to-peer commands are triggered simultaneously that affect the same output, the order of the processing cannot be guaranteed.
- Both the source and destination Cell682 devices must be powered on and operational for peer-to-peer commands to operate correctly.
- If the unit is in the middle of alarm processing, peer-to-peer commands may be delayed while alarms are being sent.
- Peer-to-peer commands are not processed while logged in with the PC software. The user should log off and the serial cable should be unplugged during normal operation to ensure that peer-to-peer commands are properly processed.

- Setting peer-to-peer trigger values too close can cause output oscillations. Peer-to-peer commands are an advanced feature and should be well thought out. Do not use them for critical applications where the risk is unacceptable.
- All peer-to-peer control actions will use a wireless message packet.

SAMPLE APPLICATION

Suppose you had a well and a pump which were several miles apart. When the pump runs, it fills the well. Your goal is to maintain a certain level in the well. If you place one Cell682 unit at each location you can have two peer-to-peer events accomplish your goal. In addition, you can use the Cell682 inputs to monitor other key items such as:

- Well level too low
- Well level too high
- Pump failure
- Power failure
- Generator on
- Temperature

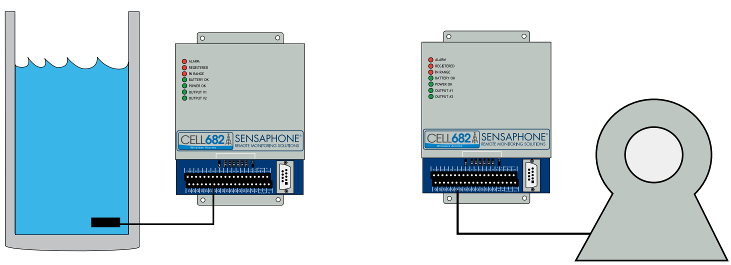


Figure 3: Well and Pump Control via Machine-to-Machine Commands

Let's suppose the well level is 25' and you need to maintain the level between 5' and 20'. The first thing you would need is a level transducer in the well. Next, program your two machine-to-machine events into the Cell682 located at the well. The first would be to turn ON the pump if the level is *Less-Than* 5'. The second event would be to turn the pump OFF if the level is *Greater-Than* 20'. Consider the rate at which the well fills when the pump is running, in order to account for the machine-to-machine command delay time between the Cell682 units. Also note that machine-to-machine control is completely independent of alarm processing, so you can also trip high or low-level alarms based on the well level.

Figure 4: Turn Pump On if Level is Less than 5 feet

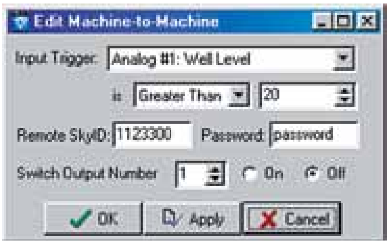


Figure 5: Turn Pump Off is Level is Greater than 20 feet

CHAPTER 8: ALARM NOTIFICATION

The Cell682 can deliver alarm message notifications by voice phone call, internet e-mail, and text messaging to various messaging devices and cell phones. A total of 24 notification destinations can be programmed to be contacted in the event of an alarm. The unit also lets you to set an escalation level for each destination, allowing you to have a group of people contacted first (tier 1) and, if the alarm is not acknowledged, a second group of people (tier 2) contacted. You can program up to 24 tier levels of destinations and include a programmable delay time between each tier.

HOW DOES NOTIFICATION WORK

Once an alarm occurs, the Cell682 will begin sending its alarm message to the programmed destinations. The unit will start with destinations at tier 1. Once the *Tier Delay* expires, the unit will start sending alarm messages to destinations in the next tier. The *Tier Delay* time begins as soon as the alarm occurs, so if it were programmed to 60 minutes, the next tier would start receiving alarm messages one hour after the alarm occurred. The Cell682 will send its alarm message to each destination until it receives acknowledgment, or it will automatically acknowledge the alarm after all destinations have been sent the message or when the last tier delay time has expired.

Note: If you are logged in through the serial port, no alarms will be sent until you log off and disconnect the serial cable. If you acknowledge the alarm through the software before logging off, no alarm messages will be sent. This can be useful for performing on-site maintenance or testing the system. If you are not logged on through the serial port the alarm messages will be sent immediately, one at a time.

VOICE PHONE CALL

The Cell682 can send alarm messages via a voice telephone call. It does this without having a telephone line connected to the unit. When an alarm message is sent as a voice call the number is dialed from the Cell682 Messaging Service Center. The message is spoken from a computer that will customize the message based on the programming in your Cell682 including the programmed *Unit Name*, *PIN*, and *Input Name*. To program a Voice destination, click on the *Alarm Notification* tab.

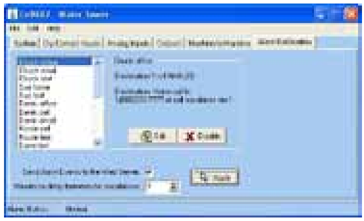


Figure 1: Alarm Notification

This screen provides a list of the programmed alarm destinations. To program or change a destination's information, click on the name of the person to edit (or select *unused* for a new entry) and then click the *Edit* button. The *Edit Destination* screen will appear:

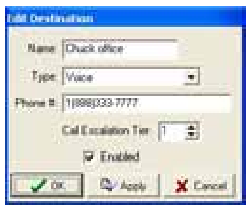


Figure 2: Contact Edit for Voice Call

Enter the name for this destination (up to 14 characters) and in the *Type* field select *Voice*. In the *Phone #* field enter the area code and telephone number. A sample alarm telephone call is shown below:

"CELL682 Alarm Message"

"Low/High temperature alarm at "*Unit Name*",

"Pin number xxxx",

"*input name*", is "xx" degrees "Fahrenheit/Celsius",

"Level crossed limit of "xx" degrees"

"To acknowledge press 1"

Example:

CELL682 Alarm Message

High temperature alarm at "Jim's Ice Cream"

Pin Number "1234"

"Freezer #5" is 38 degrees Fahrenheit

Level crossed limit of 36 degrees

To acknowledge press 1

To acknowledge the alarm your must press 1 on a touch-tone telephone when prompted. The system will reply with "alarm acknowledged" when it receives your acknowledgment. The message will be repeated 3 times so you have 3 chances to acknowledge the alarm during the call. If the the alarm is not acknowledged the system will hang up, wait a few minutes, and then call again. The system will call up to 3 times per telephone number.

INTERNET E-MAIL

The Cell682 can send alarm messages to internet e-mail addresses. The alarm message will comprise information from within your Cell682 including the programmed *Unit Name*, and *Input Name*. To program an e-mail destination, click on the *Alarm Notification* tab.

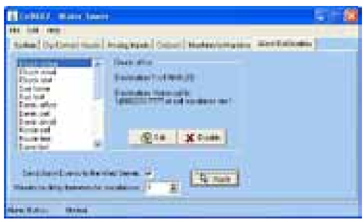


Figure 3: Alarm Notification

This screen provides a list of the programmed alarm destinations. To program or change a destination's information, click on the name of the person to edit (or select *unused* for a new entry) and then click the *Edit* button. The *Edit Destination* screen will appear:

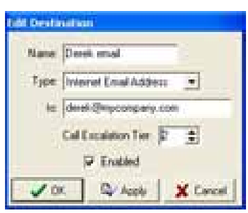


Figure 4: Destination Edit for E-mail

Enter the name for this destination (up to 14 characters) and in the *Type* field select *Internet E-mail*. In the *To:* field enter the e-mail address (up to 34 characters).

> **Warning:** Before entering an e-mail address into the Cell682, be sure to test the address first, using your computer and standard email software. Verify that the address is working and that the message is delivered.

A sample e-mail alarm message is shown below:

```
To: derek@mycompany.com
From: 1234@cell682.com
High Temperature ALARM at "Jim's Ice Cream"
Cell682 #1234
"Freezer #5" is now 38 Deg F
Level crossed limit of 36 Deg F
To acknowledge send 1202
```

ALPHANUMERIC PAGER

The Cell682 can send alarm messages to your alphanumeric pager or mobile text messaging device. The message will be sent to an e-mail address for your pager based on your paging provider and your pin number. The provider-format list below will instruct you on how to enter the e-mail address for your particular service provider. The alarm message will comprise information from within your Cell682 including the programmed *Unit Name* and *Input Name*. To program an e-mail destination click on the *Alarm Notification* tab.

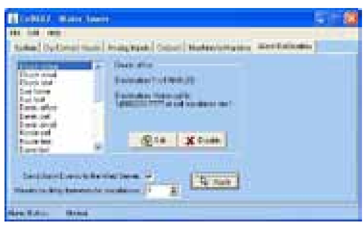


Figure 5: Alarm Notification

This screen provides a list of the programmed alarm destinations. To program or change a destination's information, click on the name of the person to edit (or select *unused* for a new entry) and then click the *Edit* button. The *Destination Edit* screen will appear:

Figure 6: Destination Edit for Alphapager

Enter the name for this destination (up to 14 characters) and in the *Type* field select *Internet E-mail*. In the *To:* field enter the e-mail address as described in the list below (up to 34 characters).

> **Warning:** Before entering an e-mail address into the Cell682, be sure to test the address first, using your computer and standard email software. Verify that the address is working and that the message is delivered.

TEXT MESSAGING TO CELL PHONES

The Cell682 can send alarm messages to your wireless cellular telephone. The message will be sent to an e-mail address for your cell phone based on your cellular provider and your telephone number. The cell-provider/format list below will instruct you on how to enter the e-mail address for your particular service provider. The alarm message will be composed of information from within your Cell682 including the programmed *Unit Name* and *Input Name*. To program an e-mail destination, click on the *Alarm Notification* tab.

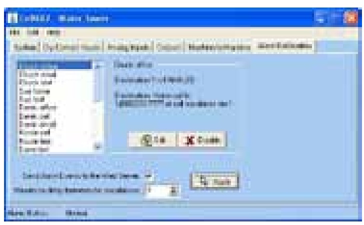


Figure 7: Alarm Notification

This screen provides a list of the programmed alarm destinations. To program or change a destination's information, click on the name of the person to edit (or select *unused* for a new entry) and then click the *Edit* button. The *Edit Destination* screen will appear:

Figure 8: Destination Edit for Cell Phone

Enter the name for this destination (up to 14 characters) and in the *Type* field select *Internet E-mail*. In the *To:* field enter the e-mail address as described in the list below (up to 34 characters).

> **Warning:** Before entering an e-mail address into the Cell682, be sure to test the address first, using your computer and standard email software. Verify that the address is working and that the message is delivered.

Cellular Provider	E-mail Address Format
3 River Wireless	xxxxxxxxxx@sms.3rivers.net
Advantage Communications	xxxxxxxxxx@advantagepaging.com
AirVoice	xxxxxxxxxx@mmode.com
Airtouch Pagers	xxxxxxxxxx@airtouch.net
Airtouch Pagers	xxxxxxxxxx@airtouchpaging.com
Airtouch Pagers	xxxxxxxxxx@alphapage.airtouch.com
Airtouch Pagers	xxxxxxxxxx@myairmail.com
AllTel	xxxxxxxxxx@message.alltel.com
Alltel PCS	xxxxxxxxxx@message.alltel.com
Alltel	xxxxxxxxxx@alltelmessage.com
Ameritech Paging	xxxxxxxxxx@pageapi.com
Arch Pagers (PageNet)	xxxxxxxxxx@archwireless.net
Arch Pagers (PageNet)	xxxxxxxxxx@epage.arch.com
AT&T	xxxxxxxxxx@txt.att.net
Bell South (Blackberry)	xxxxxxxxxx@bellsouthtips.com
Bell South Mobility	xxxxxxxxxx@blsdcs.net
Bell South	xxxxxxxxxx@blsdcs.net
Bell South	xxxxxxxxxx@sms.bellsouth.com
Bell South	xxxxxxxxxx@wireless.bellsouth.com
Bluegrass Cellular	xxxxxxxxxx@sms.bluecell.com
Boost Mobile	xxxxxxxxxx@myboostmobile.com
Boost	xxxxxxxxxx@myboostmobile.com
CallPlus	xxxxxxxxxx@mmode.com
Carolina Mobile Communications	xxxxxxxxxx@cmcpaging.com
Cellular One East Coast	xxxxxxxxxx@phone.cellone.net
Cellular One PCS	xxxxxxxxxx@paging.cellone-sf.com
Cellular One South West	xxxxxxxxxx@swmsg.com
Cellular One West	xxxxxxxxxx@mycellone.com
Cellular One	xxxxxxxxxx@message.cellone-sf.com

Cellular One	xxxxxxxxxx@mobile.celloneusa.com
Cellular One	xxxxxxxxxx@sbcemail.com
Cellular South	xxxxxxxxxx@csouth1.com
Central Vermont Communications	xxxxxxxxxx@cvcpaging.com
CenturyTel	xxxxxxxxxx@messaging.centurytel.net
Cingular (GSM)	xxxxxxxxxx@cingularme.com
Cingular (TDMA)	xxxxxxxxxx@mmode.com
Cingular Wireless	xxxxxxxxxx@mobile.mycingular.net
Cingular	xxxxxxxxxx@cingularme.com
Communication Specialists	xxxxxxx@pageme.comspeco.net
Cook Paging	xxxxxxxxxx@cookmail.com
Corr Wireless Communications	xxxxxxxxxx@corrwireless.net
Dobson Communications Corporation	xxxxxxxxxx@mobile.dobson.net
Dobson-Alex Wireless / Dobson-Cellular One	xxxxxxxxxx@mobile.cellularone.com
Edge Wireless	xxxxxxxxxx@sms.edgewireless.com
GCS Paging	xxxxxxxxxx@webpager.us
GTE	xxxxxxxxxx@gte.pagegate.net
GTE	xxxxxxxxxx@messagealert.com
Galaxy Corporation	xxxxxxxxxx@sendabeep.net
GrayLink / Porta-Phone	xxxxxxxxxx@epage.porta-phone.com
Houston Cellular	xxxxxxxxxx@text.houstoncellular.net
Inland Cellular Telephone	xxxxxxxxxx@inlandlink.com
JSM Tele-Page	xxxxxxxxxx@jsmtel.com
Lauttamus Communication	xxxxxxxxxx@e-page.net
MCI Phone	xxxxxxxxxx@mci.com
MCI	xxxxxxxxxx@pagemci.com
Metro PCS	xxxxxxxxxx@metropcs.sms.us
Metro PCS	xxxxxxxxxx@mymetropcs.com
MetroPCS	xxxxxxxxxx@mymetropcs.com
Metrocall 2-way	xxxxxxxxxx@my2way.com
Metrocall	xxxxxxxxxx@page.metrocall.com
Midwest Wireless	xxxxxxxxxx@clearlydigital.com
Mobilecom PA	xxxxxxxxxx@page.mobilcom.net
Mobilfone	xxxxxxxxxx@page.mobilfone.com
Morris Wireless	xxxxxxxxxx@beepone.net

NPI Wireless	xxxxxxxxx@npiwireless.com
Nextel	xxxxxxxxx@messaging.nextel.com
Nextel	xxxxxxxxx@page.nextel.com
Ntelos	xxxxxxxxx@pcs.ntelos.com
Omnipoint	xxxxxxxxx@omnipoint.com
Omnipoint	xxxxxxxxx@omnipointpcs.com
OnlineBeep	xxxxxxxxx@onlinebeep.net
PCS One	xxxxxxxxx@pcsone.net
Pacific Bell	xxxxxxxxx@pacbellpcs.net
PageMart	xxxxxxxxx@pagemart.net
PageOne NorthWest	xxxxxxxxx@page1nw.com
Pioneer / Enid Cellular	xxxxxxxxx@msg.pioneerenidcellular.com
Price Communications	xxxxxxxxx@mobilecell1se.com
ProPage	xxxxxxxxx@page.propage.net
Public Service Cellular	xxxxxxxxx@sms.pscel.com
Qualcomm	name@pager.qualcomm.com
Qwest	xxxxxxxxx@qwestmp.com
RAM Page.	xxxxxxxxx@ram-page.com
ST Paging	pin@page.stpaging.com
Safaricom	xxxxxxxxx@safaricomsms.com
Satelindo GSM	xxxxxxxxx@satelindogsm.com
Satellink	xxxxxxxxx.pageme@satellink.net
Simple Freedom	xxxxxxxxx@text.simplefreedom.net
Skytel Pagers	xxxxxxxxx@ email.skytel.com
Skytel Pagers	xxxxxxxxx@skytel.com
Smart Telecom	xxxxxxxxx@mysmart.mymobile.ph
Southern LINC	xxxxxxxxx@page.southernlinc.com
Southwestern Bell	xxxxxxxxx@email.swbw.com
Sprint PCS	xxxxxxxxx@messaging.sprintpcs.com
Sprint	xxxxxxxxx@sprintpaging.com
SunCom	xxxxxxxxx@tms.suncom.com
Surewest Communications	xxxxxxxxx@mobile.surewest.com
T-Mobile	xxxxxxxxx@tmomail.net
TIM	xxxxxxxxx@timnet.com
TSR Wireless	xxxxxxxxx@alphame.com
TSR Wireless	xxxxxxxxx@beep.com

Teletouch	xxxxxxxxxx@pageme.teletouch.com
Telus	xxxxxxxxxx@msg.telus.com
The Indiana Paging Co	xxxx@pager.tdspager.com
Triton	xxxxxxxxxx@tms.suncom.com
US Cellular	xxxxxxxxxx@email.uscc.net
USA Mobility	xxxxxxxxxx@mobilecomm.net
Unicel	xxxxxxxxxx@utext.com
Verizon PCS	xxxxxxxxxx@myvzw.com
Verizon Pagers	xxxxxxxxxx@myairmail.com
Verizon	xxxxxxxxxx@vtext.com
Virgin Mobile	xxxxxxxxxx@vmobl.com
Virgin Mobile	xxxxxxxxxx@vxtras.com
WebLink Wireless	xxxxxxxxxx@pagemart.net
West Central Wireless	xxxxxxxxxx@sms.wcc.net
Western Wireless	xxxxxxxxxx@cellularonewest.com
Wyndtell	xxxxxxxxxx@wyndtell.com

ALARM ACKNOWLEDGMENT VIA E-MAIL

An alarm message received via e-mail can be acknowledged by simply selecting "reply" to the original message, as long as the original message is contained in the reply. If not, simply reply with the 4-digit acknowledgment code provided at the end of the message. Once received, this will cancel alarm message delivery to all destinations configured with higher tier levels, and the web page History will show that you have acknowledged the alarm.

ADDITIONAL INFORMATION

You can use tier escalation to organize the destination delivery. Set each destination to its own tier level and set the delay to **two** minutes. In this case a new message will be sent every two minutes to the next tier level.

Rearranging the destination order can be done simply by changing the Tier Levels.

CHAPTER 9: OPERATION

After installation and programming have been completed, the Cell682 is fully operational. This chapter explains how the Cell682 operates.

PART ONE: ALARM NOTIFICATION AND ACKNOWLEDGMENT

There are 3 stages to a complete alarm event: 1) Alarm Recognition, 2) Alarm Notification, and 3) Acknowledgment.

Note that not all fault conditions will go through each stage. For example, some may not meet the recognition time.

ALARM RECOGNITION

1) The Cell682 monitors 8 dry contact inputs, 6 analog inputs, main power, and battery backup. When the status of an input changes or exceeds user-programmed limits, it causes a fault condition.
2) If the fault condition lasts long enough to meet its programmed recognition time, the fault condition becomes an alarm and the Cell682 begins the alarm notification sequence.

ALARM NOTIFICATION

The Cell682 can send alarms via Voice phone call, E-mail, Alphanumeric pager, or Text message to wireless (cell) phone.

DIALOUT NOTE: CALL PROGRESS

The Cell682 monitors call progress when dialing out in voice mode. If it dials out and encounters a busy signal or no answer it will wait about a minute and try again up to 3 times. If the call is answered by an answering machine or voice mail system the alarm message will likely be recorded , however, since the alarm was not acknowledged the system will make additional calls.

ALARM NOTIFICATION—VOICE

When dialing out to a destination programmed as “voice,” the Cell682 waits for the phone to be answered, then recites its identification message, then the message identifying the input that has gone into alarm.

Below is an example of what the Cell682 would say during a typical ‘voice’ notification:

```
CELL682 Alarm Message
High temperature alarm at “Jim’s Ice Cream”
Pin Number “1234”
“Freezer #5” is 38 degrees Fahrenheit
Level crossed limit of 36 degrees
To acknowledge press 1 Alarm Notification—E-mail
```

When sending an alarm message via e-mail the Cell682 will compose a text message based on the Unit's name, PIN, Input name, Input type, current value, and alarm limit (where applicable). A sample alarm message is shown below:

> To: derek@mycompany.com
> From: 1520@cell682.com
>
> Contact ALARM at Oak Station CELL682#1520
> Contact 1 Security is in alarm
> To acknowledge send 1202

ALARM NOTIFICATION–ALPHANUMERIC PAGER

When sending an alarm message to an Alphanumeric pager, the Cell682 leaves a text message on the display of the pager. A sample is shown below:

> Low 4-20ma ALARM at Sensaphone Cell682 #250
> 2 Water Level is now 21
> Level crossed limit of 20
> To acknowledge send 2002

ALARM NOTIFICATION—TEXT MESSAGE TO CELL PHONE

When sending an alarm text message to a cell phone the Cell682 leaves a message on the display of the phone. A sample is shown below

> Low 4-20mA ALARM at Sensaphone Cell682 #250
> 2 Water Level is now 21
> Level crossed limit of 20
> To acknowledge send 2002

TIER DELAY

You can group destinations into tiers and then program a delay time until the next tier gets called. This allows you to contact your primary personnel first and, if necessary, escalate the calling to the next level. Up to 24 tiers can be configured. The Cell682 will start sending alarm messages to all destinations programmed in Tier 1. If the alarm is acknowledged, it will halt the notification process for that alarm and no additional alarm messages will be delivered. If all of the Tier 1 destinations have been sent the alarm message and no acknowledgement was received, the unit will wait the programmed *Tier Delay Time* and then start sending the alarm to the destinations in the next Tier. An example is described below:

Tier 1 destinations:	**Tier 2 destinations:**	**Tier 3 destinations:**
Chuck	Janet	Morton
Mary	George	Zach
Sue	Ron	Tony
Derek	Jason	
Dave	Carmen	

Tier Delay Time: 60 minutes

An alarm occurs at 8:00pm

The Cell682 starts sending alarm messages to members of Tier 1.

No one acknowledges the alarm.

At 9:00pm the Tier delay has expired and the unit begins to send alarm messages to members of Tier 2.

At 9:30pm the Cell682 receives an acknowledgement message and the unit stops the notification process.

The people in Tier 3 do not get contacted.

ALARM ACKNOWLEDGMENT

Acknowledging an alarm will halt the alarm notification process to the destination being called and also to destinations set to higher tier levels. Voice notification alarms must be acknowledged during the original phone call. E-mail, Alphanumeric pager, and Cell phone alarms can be acknowledged by replying back to the original alarm message or by sending the unit a message with the alarm acknowledgment code. The sections below detail the procedure to acknowledge an alarm.

ALARM ACKNOWLEDGMENT—VOICE NOTIFICATION

CELL682 Alarm Message

High temperature alarm at “Jim’s Ice Cream” <unit name>

Pin Number “1234”

“Freezer #5” <input name> is 38 degrees Fahrenheit

Level crossed limit of 36 degrees

To acknowledge press 1

To acknowledge the alarm you must press “1” when prompted. The Cell682 will respond by saying: “Alarm acknowledged”. If the Touch-Tone acknowledgment code is not received the Cell682 will say “error, not acknowledged” and repeat the message 2 more times. If no acknowledgment is received the system will wait a few minutes and then call again. The system will call up to 3 times per telephone number.

Note: An alarm cannot be acknowledged using a pulse (rotary) telephone.

ALARM ACKNOWLEDGMENT—ALPHANUMERIC PAGER

When sending an alarm message to an Alphanumeric pager, the Cell682 leaves a text message on the display of the pager. If you have a two-way alphanumeric pager you can acknowledge the alarm by replying to the original message with the alarm acknowledgement code. For example, if the acknowledgement code was 1503, you would simply reply back with "1503." If you do not have a two-way pager then you can send the Cell682 an e-mail using either a computer or a cell phone. The e-mail address of your Cell682 is PIN@cell682.com, where you would substitute the word PIN with your PIN number. In the message area simply send the unit the alarm acknowledgement code.

ALARM ACKNOWLEDGMENT—TEXT MESSAGE TO CELL PHONE

When sending an alarm message to a cell phone the Cell682 leaves a text message on the display of the phone. You can acknowledge the alarm by sending an email reply back to the Cell682 with the alarm acknowledgement code. For example, if your alarm acknowledgement code was 1107, you would simply reply back with "1107." Alternatively you can send the Cell682 an e-mail using a computer. The e-mail address of your Cell682 is PIN@cell682.com, where you would substitute the word PIN with your PIN number. In the message area simply send the alarm acknowledgement code.

ALARM ACKNOWLEDGMENT—AUTOMATIC

The Cell682 will acknowledge an alarm itself (automatically) if all of the destinations have been contacted and no acknowledgement was received.

PART TWO: STATUS REQUEST

You can request a status report from your Cell682 by sending it a command via e-mail. When the unit receives the command it will assemble a status report and send it back to the originating e-mail address. Only inputs that are *enabled* will be included in the report. If alarm monitoring is not enabled for a particular input, its status will be displayed as *disabled*. To request the status report you need the unit's password and PIN. The e-mail format to request a status report is shown below:

To: *PIN*@cell682.com {replace *PIN* with your unit's PIN number}
Subject:
Message:
p *password* {replace *password* with your unit's password}
gst

A sample e-mail Status Report is shown below:

D1: Pump 1 Run 243:33:12 1591 OK
D2: Pump 2 Run 012:30:00 1295 OK
D3: High Water 000:00:00 0 OK
D4: Door sensor 000:00:00 0 Alarm
D5: Pump 1 fault 000:00:00 0 OK
D6: Pump 2 fault 000:00:00 0 OK
D7: Gen. Run 000:57:49 2 Disabled
D8: Low Fuel 000:00:00 0 OK
A1: Well Level 16 OK
A2: Outside Temp 78 F Disabled
A3: Cabinet Temp 86 F OK
A4: Fuel Level 38 OK
A5: Battery Temp 81 F OK
A6: Flow Rate 33 OK
B: Battery 13.50v OK
P: Power 16.82v OK
O1: Pump 1 On 015:54:44 1573 OK
O2: Pump 2 Off 012:30:00 1295 OK

CHAPTER 10: CELL682 WEB PAGE

The Cell682 Web Page is where you can check status, make programming changes, and even control outputs from any internet connected computer.

Once the Cell682 is installed and turned on you can go to *www.Cell682.com*, enter your *PIN* and *Password (default password is cell682)*, and click *Login*. The web page for your Cell682 will be displayed. The web page presents a view of the system which is very similar to the Cell682 PC Software, except for the fact that it is a snapshot of information from a specific point in time—it is not updating in real-time. To retrieve the latest values you must click either the *Status Refresh or Programming Refresh* links. For security purposes be sure to change your password.

> **Note:** It is highly recommended that if at any time you make any programming changes locally (at the unit via the serial port) that you click the *Programming Refresh* link on the web page soon thereafter, to ensure that the information you are viewing is up to date. This will also ensure that the alarm history information will also be accurate.

STATUS REFRESH

You can retrieve the latest input and output values by clicking the *Status Refresh* link. This will send a message to the Cell682 requesting the latest input and output status information. When the unit receives the request it will immediately send back a reply. During this waiting period the web page will display the input and output values in green italics until the updated information returns. At the top of the screen is a time-stamp which indicates the date and time of the last update.

PROGRAMMING REFRESH

The *Programming Refresh* command will refresh all Cell682 programming as well as input/output status. You only need to click this button if you believe that programming changes may have occurred locally, at the unit, and you want to refresh the information on the web server.

PROGRAMMING VIA THE WEB PAGE

You can change any parameter in your Cell682 from the web page, just as you would using the Cell682 PC Software. All programmable items will appear as Blue links. For the inputs you can click on any item for that channel and the respective programming screen will appear. If you change an item and click *OK*, the change will be sent to your unit. This will take a few minutes to process. Similarly you can change Output programming, Notification programming, and Machine-to-machine programming.

SWITCHING OUTPUTS VIA THE WEB PAGE

To switch an output, Login to the web page and click *Outputs*. Next, click on the Output number you want to switch. On the programming screen, locate the *State* field and select On or Off, then click OK. The command to switch the output will be sent to your unit. Note that this may take 1–2 minutes.

ALARM ACKNOWLEDGEMENT HISTORY

An alarm history log is available on the web page to provide details on alarms that have occurred and whom acknowledged them. The log can be queried by entering a start and end date range, or by selecting one of the *QuickDates* options. Note that the time stamps appearing on the web page do not indicate when the alarm occurred, but rather the time that they were received by the web server.

CHAPTER 11: TESTING THE CELL682

It is extremely important that you test the system after installation to make sure that it is working properly and that all programming is correct. In addition, it is highly recommended that you test and/or verify proper operation on a weekly basis to ensure that the system continues to function as required. *(See Appendix A.)* The following items should be tested:

- Notification to all destinations to make sure that each one is programmed correctly and that the messages are actually delivered.
- Input testing to make sure that the system is reading them correctly and that when a fault occurs the system responds appropriately.
- Output testing to make sure they are wired correctly and that they switch on and off when instructed.
- Control programming—Local control, Machine-to-machine, or Pump control—to make sure that the system is functioning properly, as required for your application.

NOTIFICATION TESTING

Create an alarm and confirm that all destinations receive the alarm message. This can be done by forcing an input into alarm, by temporarily adjusting an alarm limit, or by changing the normality of a Dry Contact input. The Alarm LED on the front of the unit will begin blinking when an alarm has occurred. Be sure to disconnect from the serial port after creating the alarm, otherwise the notifications will not be sent. After confirming that all notification messages were delivered, correct the alarm condition and/or adjust your programming as required.

INPUT TESTING

Check the current value of all of the programmed Dry Contact and Analog Inputs. Make sure that the values being displayed are correct.

For Dry Contact inputs, momentarily reverse the input condition to verify that the unit recognizes the change of state. For example, if you have a normally open sensor connected to Dry Contact #1, force that sensor closed and verify that the unit displays the value as closed.

For analog inputs, verify that the input reading matches the entity being measured. For example, for temperature inputs confirm that the unit is reporting the correct temperature.

For 4–20mA inputs, confirm that the level or value being displayed in the Cell682 matches the actual conditions being measured.

OUTPUT TESTING

Confirm that the power limitations of the outputs will not be exceeded. The Cell682 outputs are rated for a maximum of 0.3A at 120VAC or 1.0A at 24VDC. Test the outputs by switching them on and off manually and confirming that the device being controlled turns on and off. The Output LEDs on the front of the unit should also turn on and off.

CONTROL PROGRAMMING

For applications that utilize control programming it is important to test all scenarios that may affect system operation. This means you should test your system under normal operating conditions as well as abnormal (or failure) conditions to make sure that you have designed your system to operate under the worst-case scenario.

Note that Local and Machine-to-Machine control will not execute while you are connected locally.

To test Local control operation, force input conditions as necessary to activate the output(s). Confirm that the input-to-output control logic is executing properly. Test each programmed control algorithm separately to make sure that each one is functioning as desired.

To test Machine-to-Machine control, force input conditions as necessary to activate the output(s) on your remote Cell682 device(s). Confirm that the outputs on the remote unit(s) have turned on or off as instructed. Test each programmed control algorithm separately to make sure they are all functioning. Have the system go through a complete automated control cycle of your system to confirm that the unit and its programming are operating as intended.

PUMP CONTROL

To test Pump Control using float switches, force the float switch inputs open or closed as necessary, to make the output(s) turn on or off. In a Drain application the first pump would turn on if the Pumps-Off and Lead float switches were closed. The second pump would turn on if the Lag float switch also closed. Both pumps would then turn off when all three float switches opened. In a fill application, the first pump would turn on when the Pumps-Off and Lead floats opened. The second pump would turn on when the Lag float also opens. Both Pumps would turn off when all three floats closed.

To test Pump Control using a level transducer you can temporarily force the input level to a certain value by adjusting the calibration for the Analog Input. In a drain application, force the input to be above the Lead level and the first pump should turn on. If you then set the input above the Lag level, the second pump should also turn on. Setting the input below the Pumps-Off setting will turn both pumps off. In a fill application, setting the input below the lead level will turn the first pump on. Setting the input below the Lag level will turn on the second pump. Setting the input above the pumps-Off level will turn off both pumps.

Once you have confirmed that the Cell682 is controlling the system properly, allow the system to operate automatically. Observe a complete Drain or Fill cycle and verify that the system is operating as required.

APPENDIX A: CHECKING YOUR CELL682 FOR PROPER OPERATION

We recommend that you test your Cell682 weekly to be sure it is functioning properly. This will ensure that when a problem arises the Cell682 will be ready to alert the appropriate personnel. A blank Test Log is included at the back of this manual.

There are several tests to be performed:

1. Request a Status Report from the unit by sending it an e-mail message and verifying the reply. This will test the unit's ability to receive and send a message. It will also verify that all of the inputs are reading properly, the alarm conditions are OK, the electricity is on, and the battery is OK.
2. Create an alarm on each input by tripping all connected sensors. This will verify that each input is being recognized by the unit and that it is programmed properly.

<u>Temperature sensors</u>: Heat or cool the sensor.

<u>Motion sensors</u>: Have someone walk in front of the sensor.

<u>Door and window sensors</u>: Open the door or window.

<u>Water sensors</u>: Apply a small amount of water beneath the sensor or use a wet towel and touch it to the sensor probes.

<u>Humidity sensors</u>: Raise the humidity around the sensor by holding a cup of very hot water beneath it.

<u>4–20mA Transducers</u>: Verify that the Cell682 is reading the proper level by measuring the monitored quantity using alternative methods.

Allow the unit to send its alarm message to all programmed contacts. This will make sure that the Cell682 is programmed properly. It will also prepare personnel to respond appropriately when they receive a call from the Cell682.

3. Test the battery by unplugging the AC adapter and making sure that the Cell682 continues to function. Check the LEDs to make sure that the Power LED starts to blink and the Battery LED glows steadily. Keep the AC adapter unplugged so that a Power Failure alarm occurs. Allow the unit to send its alarm message to all programmed contacts while running on battery backup. Plug in the AC adapter after the unit has finished sending all of its messages.
4. If you require assistance, contact Sensaphone Technical Support at (610) 558-2700.

APPENDIX B: TROUBLESHOOTING

I CAN'T COMMUNICATE WITH MY UNIT LOCALLY.

- Make sure you have entered the proper PIN.
- Make sure the cable is connected from your computer to the Cell682.
- Make sure you have the right Com port selected (*typically 1 or 2*).
- Make sure the unit is receiving power.

I CAN'T ACCESS MY UNIT ON THE WEB PAGE.

- Have you entered the proper *PIN* and *Password*? The default password is "cell682"

WHY IS THE 'IN RANGE' LED OFF?

- If the unit is not within range of the wireless network the LED will not turn on.
- It typically takes 1-2 minutes from power-up for the Cell682 to recognize the wireless network and turn on the LED.
- Make sure the unit is receiving power.

WHY IS THE 'REGISTERED' LED OFF?

- If the IN RANGE LED is lit but the REGISTERED LED is not, then the unit is not activated yet.
- Make sure the unit is receiving power.

WHY IS THE 'BATTERY OK' LED OFF?

- There is no battery connected.
- The battery voltage is low.

WHY IS THE 'POWER OK' LED OFF?

- The main power has failed and the unit is running batteries.
- The voltage at the Vin terminals is low.

WHY IS THE 'ALARM' LED BLINKING?

- There is an unacknowledged alarm.

WHY IS THE 'ALARM' LED ON?

- There is an alarm but it has been acknowledged.

WHY WON'T THE UNIT SEND ME ALARM MESSAGES?

- The Cell682 will not send any alarm messages if you are connected locally.

- There are no destinations programmed.
- None of the destinations are enabled.
- The unit is not activated on the wireless network
- The destinations are not programmed correctly.
- There are no unacknowledged alarms.

MY UNIT WON'T MAKE A VOICE CALL.

- The telephone number is programmed incorrectly.
- The Cell682 will not send any alarm messages if you are connected locally.
- There are no destinations programmed.
- None of the destinations are enabled.
- The unit is not activated on the wireless network
- There are no unacknowledged alarms.

MY UNIT WON'T SEND A TEXT MESSAGE TO MY CELL PHONE OR ALPHANUMERIC PAGER.

- The Destination is programmed incorrectly. You must use the e-mail address format for your cellular or paging provider as specified in chapter 8.
- The Destination type is set incorrectly. It should be set to Internet E-mail Address.
- The Cell682 will not send any alarm messages if you are connected locally.
- There are no destinations programmed.
- None of the destinations is enabled.
- The unit is not activated on the wireless network
- There are no unacknowledged alarms.

WHY DOES THE UNIT CALL PEOPLE EVEN AFTER I ACKNOWLEDGED THE ALARM?

- When an alarm occurs the unit will begin to sequentially broadcast all alarm messages for the first Tier. Depending on how quickly they get dispatched from the messaging center its possible for additional calls to be made even after the alarm has been acknowledged. Once the message is received at the messaging center it will be called regardless of acknowledgement.

MY UNIT WON'T EXECUTE A LOCAL MACHINE-TO-MACHINE COMMAND.

- Machine-to-machine commands will not execute while you are connected locally.
- The output you are trying to switch is not set to manual mode.
- The input condition for the machine-to-machine command is not being met.

MY UNIT WON'T EXECUTE A REMOTE MACHINE-TO-MACHINE COMMAND.

- Machine-to-machine commands will not execute while you are connected locally.
- The output on the remote unit you are trying to switch is not set to manual mode.
- The input condition for the machine-to-machine command is not being met.
- The PIN and Password for the remote unit is programmed incorrectly.

MY CELL682 ISN'T DISPLAYING THE CORRECT VALUE FROM MY 4–20MA TRANSDUCER.

- The analog input jumper isn't set to the 4–20mA position.
- The analog input "type" isn't set to 4–20mA in the software.
- The transducer is not wired correctly.
- The transducer is not calibrated for the desired measurement range.
- The analog input table values aren't programmed to the calibrated range of the transducer.
- The transducer is not compatible with single-ended inputs therefore an isolation device is required.

MY TEMPERATURE SENSOR ISN'T DISPLAYING THE CORRECT VALUE.

- The analog input jumper isn't set to the Temperature position.
- The analog input "type" isn't set to Temperature in the software
- The temperature sensor isn't a compatible 2.8K or 10K thermistor.
- The temperature sensor isn't wired correctly.

WHY DON'T THE VALUES DISPLAYED ON THE WEB PAGE MATCH THE VALUES DISPLAYED IN THE CELL682 SOFTWARE?

- The web page displays a snapshot of the values at a particular moment in time. It does not display real-time values, as is the case when connected locally through the Cell682 software.
- Click the Status Update button on the web page to retrieve a current snapshot.

WHY CAN'T I GET PUMP CONTROL TO WORK?

- The Output(s) are not set to Pump Control mode.
- The Pump Control parameters are programmed incorrectly.
- The level transducer is not wired to analog input #6.
- The level transducer is not reading the proper values.

- The float switches are not wired to Dry Contact inputs #6, #7, and #8.
- The float switches are not Normally Open.
- The Lead, Lag, and Pumps-Off float switches are not wired to the proper inputs.

APPENDIX C: THERMISTOR TABLE

10K THERMISTOR DATA

Degrees Celsius	Resistance (Ohms)
-30	135.2K
-20	78.91K
-10	47.54
0	29.49K
10	18.79K
20	12.25K
30	8,194
40	5,592
50	3,893
60	2,760
70	1,990

2.8K THERMISTOR DATA

Degrees Celsius	Resistance (Ohms)
-50	187,625
-40	94,206
-30	49,549
-20	27,180
-10	15,491
0	9,142
10	5,572
20	3,498
30	2,256
40	1,491
50	1,009
60	697
70	490
80	351

APPENDIX D: CELL682 SPECIFICATIONS

ENVIRONMENTAL INPUTS

Number of Dry Contact Inputs: 8

Dry Contact Input Types: N.O./N.C. contact, pulse count, equipment run time

Dry Contact Input Electrical Characteristics: 47KΩ to 5V

Number of Analog Inputs: 6

Analog Input Types: 2.8K thermistor (-100°F to 124°F / -80°C to 55°C), 10K thermistor (-60°F to 175°F / -51°C to 79°C) and 4–20mA (-16,300 to 16,300)

Analog Input Electrical Characteristics: 22KΩ to 2.5V (temperature) and 250 Ohms to ground (4–20mA)

Input Connector: terminal block

A/D Converter Resolution: 10 bits ±2 LSB

Input Protection: Metal Oxide Varistors and fast acting diode clamps

RELAY OUTPUTS

Number of Relay Outputs: 2

Rating: 0.3A 120VAC / 1.0A 24VDC Maximum

Type: SPDT Form-C Latching

Relay Output Connector: terminal block

LED INDICATORS

Function: Alarm, Radio Registered, Radio In Range, Battery OK, Power OK, Output#1, Output #2

POWER SUPPLY

Power Supply: 18VDC 800mA power transformer

Power Consumption: 50mA typical, 700mA burst (radio transmit)

Power Protection: Metal Oxide Varistor

Battery Backup/Charger: Compatible with 12V sealed gel-cell, 2.2AH

ENVIRONMENTAL

Operating Temperature: -22° to 140°F (-30° to 60°C)

Operating Humidity: 0 to 90% RH non-condensing

Storage Temperature: -22° to 158°F (-30° to 70°C)

PHYSICAL: CELL682 UNIT IN NEMA-4 ENCLOSURE

Dimensions: 12”h x 8”w x 6”d (30.5 x 20.3 x 15.2 cm)

Weight: 8 lbs. (2.7kg)

Specifications subject to change without notice.

APPENDIX E: REPLACING THE BACKUP BATTERY

The back-up battery will provide about 3–5 years of service life depending on usage and temperature. After 5 years (or when backup time is insufficient) the battery should be replaced. Replacement batteries can be ordered from Sensaphone. To replace the battery, follow the instructions below:

1. Disconnect the red battery wire and cover the bare wire with insulating electrical tape.
2. Disconnect the black battery wire and cover the bare wire with insulating electrical tape.
3. Unplug the power transformer.
4. Loosen the compression wiring connectors and allow 6-10” of cable slack to come into the enclosure. This will make it easier to turn the panel over.
5. Remove the four screws securing the Cell682 housing to the back panel and carefully remove the Cell682.
6. Remove the connectors from the battery by carefully pulling and wiggling the connectors from the battery tabs.
7. Remove the screws holding the battery bracket and remove the bracket.
8. Dispose of/recycle the old battery following local recycling regulations for lead batteries.
9. Insert the new replacement battery into the slot and replace the bracket. Secure the bracket with the two screws.
10. Attach the battery connector at the end of the BLACK wire to the -(negative) terminal of the new battery.
11. Attach the battery connector at the end of the RED wire to the +(positive) terminal of the new battery.
12. Place the Cell682 over the four metal stand-offs and re-attach the four screws.
13. Readjust the cables through the compression connectors and secure the fittings.
14. Plug the power transformer into the outlet.
15. Connect the Black battery wire to the “BAT -” terminal.
16. Connect the Red battery wire to the “BAT +” terminal.

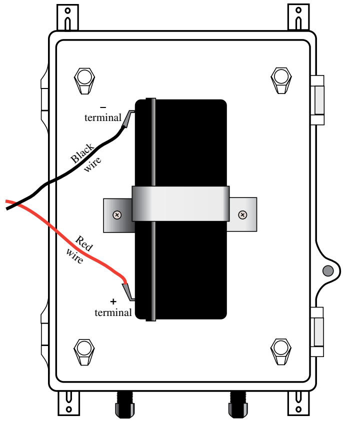


Figure 1: Battery placement

APPENDIX F: OPTIONAL ACCESSORIES

The sensors and accessories listed below are available from Sensaphone and represent the most commonly used devices. Other dry contact sensors or 4–20mA transducers, designed for more specialized applications, may also be used. Commercial or industrial electrical supply houses can provide devices to monitor virtually any condition. For further information, contact a Sensaphone Sales Associate toll-free at 1-877-373-2700.

PART	PART/NUMBER DESCRIPTION
FGD-0006	Magnetic Reed Switch
FGD-0007	Passive Infra-Red Detector
FGD-0010	50’ 2-conductor #22AWG shielded accessory Cable
FGD-0013	Spot Water Detector
FGD-0022	Temp° Alert
FGD-0027	Humidistat
FGD-0049	Smoke Detector with Built-in Relay
FGD-0052	Humidity Transmitter
FGD-0054	Power-Out Alert™
FGD-0056	Zone Water Detector w/Water Rope
FGD-0063	10’ additional Water Rope for FGD-0056
FGD-0067	Surge Suppressor
FGD-0101	2.8K Weatherproof Temperature Probe
FGD-0102	10K Weatherproof Temperature Probe
FGD-0104	10K Outdoor Air Weatherproof Temperature Sensor
FGD-0205	Multipoint Wireless I/O System
ANT-0007	Outdoor GSM Antenna with 16’ Cable

APPENDIX G: RETURNING YOUR CELL682 FOR REPAIR

In the event that the Cell682 does not function properly, we suggest that you do the following:

1. Record your observations regarding the Cell682's malfunction.
2. Call Sensaphone Technical Support toll-free at 1-877-373-2700 or e-mail support@sensaphone.com prior to sending the unit to Sensaphone for repair. Our product support specialists are able to diagnose and correct many unit setup and programming problems over the phone.

If the unit must be sent to Sensaphone for servicing, please do the following:

1. Unplug the power supply, disconnect the battery, and disconnect all wiring.
2. Carefully pack the unit to avoid damage in transit. Use the original container (if available) or a sturdy shipping box.
3. To avoid shipping delays, you must include the following information:
    a) Your name, address and telephone number.
    b) A note explaining the problem.
4. Ship your package to the address below:

    SERVICE DEPARTMENT
    Sensaphone.
    901 Tryens Road
    Aston, PA 19014
5. Ship prepaid and insured via UPS or US Mail to ensure a traceable shipment with recourse for damage or replacement.

Test Log

Date	Inputs	Dialout	Call-In	Battery		Tested By
	Pass ☐ Fail ☐	Pass ☐ Fail ☐	Pass ☐ Fail ☐	Pass ☐ Fail ☐	Pass ☐ Fail ☐	
	Pass ☐ Fail ☐	Pass ☐ Fail ☐	Pass ☐ Fail ☐	Pass ☐ Fail ☐	Pass ☐ Fail ☐	
	Pass ☐ Fail ☐	Pass ☐ Fail ☐	Pass ☐ Fail ☐	Pass ☐ Fail ☐	Pass ☐ Fail ☐	
	Pass ☐ Fail ☐	Pass ☐ Fail ☐	Pass ☐ Fail ☐	Pass ☐ Fail ☐	Pass ☐ Fail ☐	
	Pass ☐ Fail ☐	Pass ☐ Fail ☐	Pass ☐ Fail ☐	Pass ☐ Fail ☐	Pass ☐ Fail ☐	
	Pass ☐ Fail ☐	Pass ☐ Fail ☐	Pass ☐ Fail ☐	Pass ☐ Fail ☐	Pass ☐ Fail ☐	
	Pass ☐ Fail ☐	Pass ☐ Fail ☐	Pass ☐ Fail ☐	Pass ☐ Fail ☐	Pass ☐ Fail ☐	
	Pass ☐ Fail ☐	Pass ☐ Fail ☐	Pass ☐ Fail ☐	Pass ☐ Fail ☐	Pass ☐ Fail ☐	
	Pass ☐ Fail ☐	Pass ☐ Fail ☐	Pass ☐ Fail ☐	Pass ☐ Fail ☐	Pass ☐ Fail ☐	
	Pass ☐ Fail ☐	Pass ☐ Fail ☐	Pass ☐ Fail ☐	Pass ☐ Fail ☐	Pass ☐ Fail ☐	
	Pass ☐ Fail ☐	Pass ☐ Fail ☐	Pass ☐ Fail ☐	Pass ☐ Fail ☐	Pass ☐ Fail ☐	
	Pass ☐ Fail ☐	Pass ☐ Fail ☐	Pass ☐ Fail ☐	Pass ☐ Fail ☐	Pass ☐ Fail ☐	
	Pass ☐ Fail ☐	Pass ☐ Fail ☐	Pass ☐ Fail ☐	Pass ☐ Fail ☐	Pass ☐ Fail ☐	
	Pass ☐ Fail ☐	Pass ☐ Fail ☐	Pass ☐ Fail ☐	Pass ☐ Fail ☐	Pass ☐ Fail ☐	
	Pass ☐ Fail ☐	Pass ☐ Fail ☐	Pass ☐ Fail ☐	Pass ☐ Fail ☐	Pass ☐ Fail ☐	
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	Pass ☐ Fail ☐	Pass ☐ Fail ☐	Pass ☐ Fail ☐	Pass ☐ Fail ☐	Pass ☐ Fail ☐	

Date	Inputs	Dialout	Call-In	Battery		Tested By
	Pass ☐ *Fail* ☐	*Pass* ☐ *Fail* ☐	*Pass* ☐ *Fail* ☐	*Pass* ☐ *Fail* ☐	*Pass* ☐ *Fail* ☐	
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	Pass ☐ *Fail* ☐	*Pass* ☐ *Fail* ☐	*Pass* ☐ *Fail* ☐	*Pass* ☐ *Fail* ☐	*Pass* ☐ *Fail* ☐	
	Pass ☐ *Fail* ☐	*Pass* ☐ *Fail* ☐	*Pass* ☐ *Fail* ☐	*Pass* ☐ *Fail* ☐	*Pass* ☐ *Fail* ☐	
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Date	Inputs	Dialout	Call-In	Battery		Tested By
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	Pass ☐ *Fail* ☐	*Pass* ☐ *Fail* ☐	*Pass* ☐ *Fail* ☐	*Pass* ☐ *Fail* ☐	*Pass* ☐ *Fail* ☐	
	Pass ☐ *Fail* ☐	*Pass* ☐ *Fail* ☐	*Pass* ☐ *Fail* ☐	*Pass* ☐ *Fail* ☐	*Pass* ☐ *Fail* ☐	
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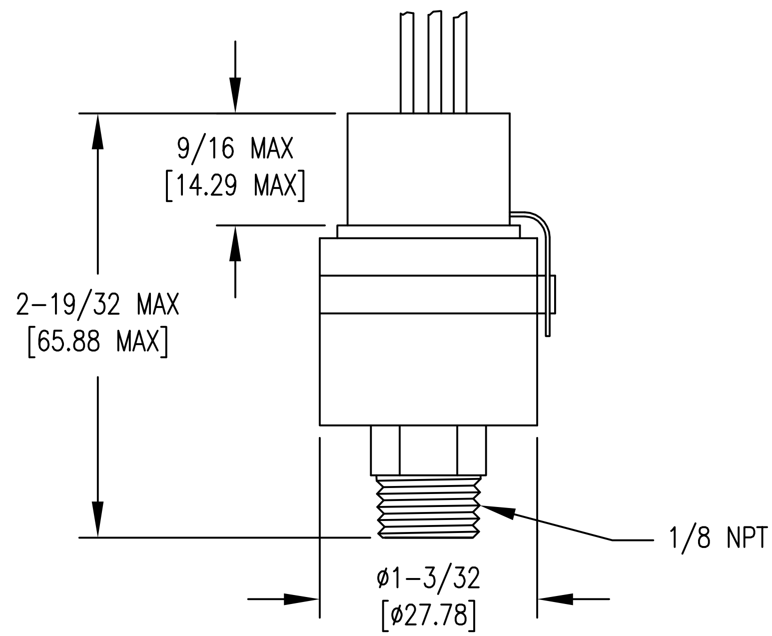
	Pass ☐ *Fail* ☐	*Pass* ☐ *Fail* ☐	*Pass* ☐ *Fail* ☐	*Pass* ☐ *Fail* ☐	*Pass* ☐ *Fail* ☐	
	Pass ☐ *Fail* ☐	*Pass* ☐ *Fail* ☐	*Pass* ☐ *Fail* ☐	*Pass* ☐ *Fail* ☐	*Pass* ☐ *Fail* ☐	
	Pass ☐ *Fail* ☐	*Pass* ☐ *Fail* ☐	*Pass* ☐ *Fail* ☐	*Pass* ☐ *Fail* ☐	*Pass* ☐ *Fail* ☐	
	Pass ☐ *Fail* ☐	*Pass* ☐ *Fail* ☐	*Pass* ☐ *Fail* ☐	*Pass* ☐ *Fail* ☐	*Pass* ☐ *Fail* ☐	
	Pass ☐ *Fail* ☐	*Pass* ☐ *Fail* ☐	*Pass* ☐ *Fail* ☐	*Pass* ☐ *Fail* ☐	*Pass* ☐ *Fail* ☐	
	Pass ☐ *Fail* ☐	*Pass* ☐ *Fail* ☐	*Pass* ☐ *Fail* ☐	*Pass* ☐ *Fail* ☐	*Pass* ☐ *Fail* ☐	
	Pass ☐ *Fail* ☐	*Pass* ☐ *Fail* ☐	*Pass* ☐ *Fail* ☐	*Pass* ☐ *Fail* ☐	*Pass* ☐ *Fail* ☐	
	Pass ☐ *Fail* ☐	*Pass* ☐ *Fail* ☐	*Pass* ☐ *Fail* ☐	*Pass* ☐ *Fail* ☐	*Pass* ☐ *Fail* ☐	
	Pass ☐ *Fail* ☐	*Pass* ☐ *Fail* ☐	*Pass* ☐ *Fail* ☐	*Pass* ☐ *Fail* ☐	*Pass* ☐ *Fail* ☐	
	Pass ☐ *Fail* ☐	*Pass* ☐ *Fail* ☐	*Pass* ☐ *Fail* ☐	*Pass* ☐ *Fail* ☐	*Pass* ☐ *Fail* ☐	

WATER TREATMENT SYSTEM



CD = CRITICAL DIMENSION
STANDARD TOLERANCES UNLESS NOTED:
ALL DECIMAL DIMENSIONS ± .005
ALL ANGLES ± 1°

SCALE 1:1

NO.	CHANGES	BY/DATE

DATE
DWN BY
CHKD
APPD

NAME
APS/ AVS SERIES
ADJUSTABLE PRESSURE SWITCH

ACAD2002

3

MATERIAL
FINISH

DWYER INSTRUMENTS, INC.
MICHIGAN CITY, INDIANA 46360 U.S.A.

FR. NO.

Bulletin A-30 - AVS/APS

INSTALLATION PROCEDURES FOR MODELS:

AVS - APS

VACUUM AND PRESSURE SWITCHES

Dwyer® Instruments Inc.

Dwyer Instruments, Inc.
Michigan City, IN 46361
Ph.219-879-8868

CAUTION

This instrument must not be subjected to temperatures, pressure or electrical loads exceeding those appearing on the name plate, and specifications in our published literature.

INSTALLATIONS AND ASSEMBLY INSTRUCTIONS

Before installing your DII pressure switch, please become familiar with the general information contained in the literature and Technical Specifications Sheet covering the specific switch.

"C" SET
Customer set and field adjustable.

Electric Connection If you switch has standard solder-type terminals, push-on receptacles may be used as interface between your wires and the terminals. These receptacles are available upon request. Should you choose to solder the connection, care must be used when soldering leads to the terminals of these switches, following the recommendations below.

We recommend that a soldering iron with an 1/8"diameter THERMOSTATICALLY controlled tip of 500°F be used and that it not be on the terminal longer than 10 seconds.

Excessive heat and flux can cause serious damage to the switch.

Pressure Connection Use a wrench on the hex part of the fitting only. DO NOT TORQUE the switch body.

PRESSURE SET POINT ADJUSTMENT - JAM NUT STYLE ADJUSTING RING MODELS.

The C switches are readily adjustable throughout their prescribed range by loosening the adjusting ring. Turning the electrical switch clockwise will lower the set point, turning it counterclockwise will increase the set point. When desired set point is reached, the assembly is locked again by tightening the adjustable ring.

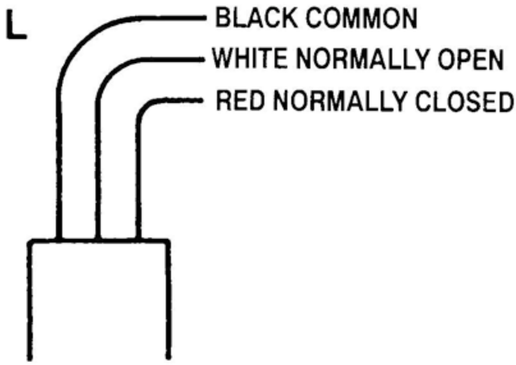
Entire adjustable range may covered by rotating approximately 250° each side of the mean.

The adjusting ring requires very little effort to establish a reliable locked position. By placing a wrench on the fitting hex to hold switch body in position, grip the serrated jam nut with pliers and turn counterclockwise to loosen or clockwise to tighten. Only a slight snug is required to lock in position.

VACUUM SET POINT ADJUSTMENT - VACUUM MODELS

To lower set point turn electrical switch counterclockwise. To raise set point turn electric switch clockwise.

WIRING INSTRUCTION
MODELS APS & AVS



LIMITATION OF APPLICATION LIABILITY:

Dwyer Instruments, Inc. assumes the buyer to be expert in his intended application of DII products. DII claims no special expertise in the application of its products in the buyer's equipment. DII accepts no responsibility for the buyer's selection and use of DII products. Buyer's interpretation and implementation of application suggestions and recommendations by DII, general or specific, transmitted verbally or in writing, published or unpublished, is strictly at the buyer's own risk.

Limited Warranty: The Seller warrants all Dwyer instruments and equipment to be free from defects in workmanship or material under normal use and service for a period of one year from the date of shipment. Liability under this warranty is limited to repair or replacement F.O.B. factory of any parts which prove to be defective within that time or repayment of the purchase price at the Seller's option provided the instruments have been returned, transportation prepaid, within one year from date of purchase. All technical advice, recommendations and services are based on technical data and information which the Seller believes to be reliable and are intended for use by persons having skill and knowledge of the business, at their own discretion. In no case is Seller liable beyond replacement of equipment F.O.B. factory or the full purchase price. This warranty does not apply if the maximum ratings label is removed or if the instrument or equipment is abused, altered, used at ratings above the maximum specified, or otherwise misused in any way.

THIS EXPRESS LIMITED WARRANTY IS IN LIEU OF AND EXCLUDES ALL OTHER REPRESENTATIONS MADE BY ADVERTISEMENTS OR BY AGENTS AND ALL OTHER WARRANTIES, BOTH EXPRESS AND IMPLIED. THERE ARE NO IMPLIED WARRANTIES OF MERCHANTABILITY OR OF FITNESS FOR A PARTICULAR PURPOSE FOR GOODS COVERED HEREUNDER.

CAUTIONS

- Warranty may be void if the switch is either disassembled or modified after leaving factory.
- Warranty is void if temperature, pressure and electrical ratings are exceeded in test or in service.
- If switch is to be exercised more than 20 cycles per minute please consult Dwyer Instruments Inc.
- Do not use these pressure switches on OXYGEN service without prior degreasing and proper preparation.
- Customer media and environment must be compatible with construction materials as outlined in general specifications of DII Literature.
- Install pressure switch by utilizing the hex or wrench flats. Do not torque the switch body.

F-1

Barnebey Sutcliffe Corporation

835 North Cassady Avenue, Columbus, Ohio 43219

Phone: (614) 258-9501 • Fax: (614) 258-3464 • Web: www.bscarbons.com

Operations & Maintenance Manual
Bag Filter
PROTECT™ BF Series

Table of Contents

Introduction

Bag Filter Product Line

Barnebey Sutcliffe Corporation offers the BF series to complement our line of adsorber vessels and equipmen. The BF series should be used upstream of the adsorbers to remove suspended solids prior to the adsorber vessels. Removing the suspended solids particles will increase the life of the adsorber media, increase the performance of the adsorber, and minimize backwash requirements of the adsorber. The BF series can also be used as a stand-alone suspended particle filter.

The BF series is comprised of a filter housing with either a permanent or a removable retainer basket. The retainer steel basket is not intended to perform any filtration, and is only intended to support the bag filter. A bag filter is inserted into the retainer basket and performs the filtration. Bag filters can be selected from a variety of sizes according to the process stream and application, with 5, 10, and 25-micron being the most common sizes for adsorber pre-filtration. Once pressure drop across the unit begins to rize beyond the recommended pressure drop, the bag filter can be exchanged or cleaned.

Pressure drop considerations

Pressure drop will vary according to the flowrate, suspended solids loading, micron size being used, and temperature. A clean filter will produce a minimal pressure drop under 1-psig in most conditions. The rate at which the pressure drop will increase will vary based on the parameters mentioned earlier, and is not predicted here due to its site-specific nature.

Prior to each installation, a consideration has to be made regarding the maximum pressure drop allowed prior to filter changeout or cleanout. The maximum pressure drop at any time should not exceed 15-psig. Pump sizing and overall pressure drop for hydraulic branch should be calculated using the selected maximum pressure drop across a dirty bag filter.

Operation & Startup Guidelines

1. Lifting and handling should be done using appropriately sized hoisting devise. Use nylon strap to snug the vessel around its shell, and towards the upper portion of the shell in order to assure that the lifting point is above the vessel's center of gravity.
2. Install the filter vessel on a leveled foundation that can support its working load.
3. Secure the vessel in place prior to startup.
4. Open top access cover and inspect filter internals, paint/liner, and filter bag(s) for integrity. Be sure to bleed off any pressure accumulation prior to opening the access cover. If the inlet and outlet connections are fully plugged, temperature variation can cause pressure buildup inside the vessel during transportation.
5. Inspect outer fixtures on filter vessel for mechanical damage and integrity (valves, relief valve, gauges, etc.)
6. Install appropriately sized bag filter(s) in case you received them separately.
7. Close all valves and access covers.
8. Connect the filter vessel to process piping. A bag filter flow direction is always from the inside of the bag to the outside of the bag, in order to press the bag against the supporting retainer basket. In all standard piping configurations this means that the top connection on the filter vessel is the inlet while the lower connection is the outlet.
9. Fill the vessel slowly with process fluid and bleed off entrapped air. Filling the vessel rapidly my cause a water hammer affect that may burst the bag filter, damage the retainer basket, or damage the interconnecting piping. Entrapped air may damage the bag filter and will cause inefficient filtering.
10. Vessel is ready for process flow.

Record Keeping

Record keeping may be a regulatory issue in some cases. In absence or in addition to regulatory requirements, we recommend that the following records will be kept. When it comes to troubleshooting a process, its history of performance becomes very valuable.

1. Vessel model number and specifications.
2. Bag filter specifications (micron size and bag material).
3. Number of filters in the operation, and the interconnecting configuration.
4. Process fluid and conditions.
5. Flowrate information.
6. Influent temperature.
7. Operating pressure before and after the filter housing.
8. New (clean bag) pressure-drop value.
9. Ongoing pressure-drop monitoring data.
10. Number of hours or days between filter bag changeouts.
11. Analytical report as required.
12. Any unusual behavior, both mechanical and process related.

Recommended spare parts

- Replacement bag filters
- Replacement pressure gauge
- Replacement closure gasket
- Touchup paint for internal liner (PPG Pitt-Guard DTR no. 97-946)
- Touchup paint for external coating (PPG Pitthane Ultra no. 95-8000)

WARNING!

Always bleed off pressure prior to opening the access cover on a bag filter. In case the bag filter element is completely clogged, bleeding off the pressure downstream of the filter will not be sufficient since pressure may be held inside the bag. Pressure can build up inside a vessel even when not in operation due to temperature variation.

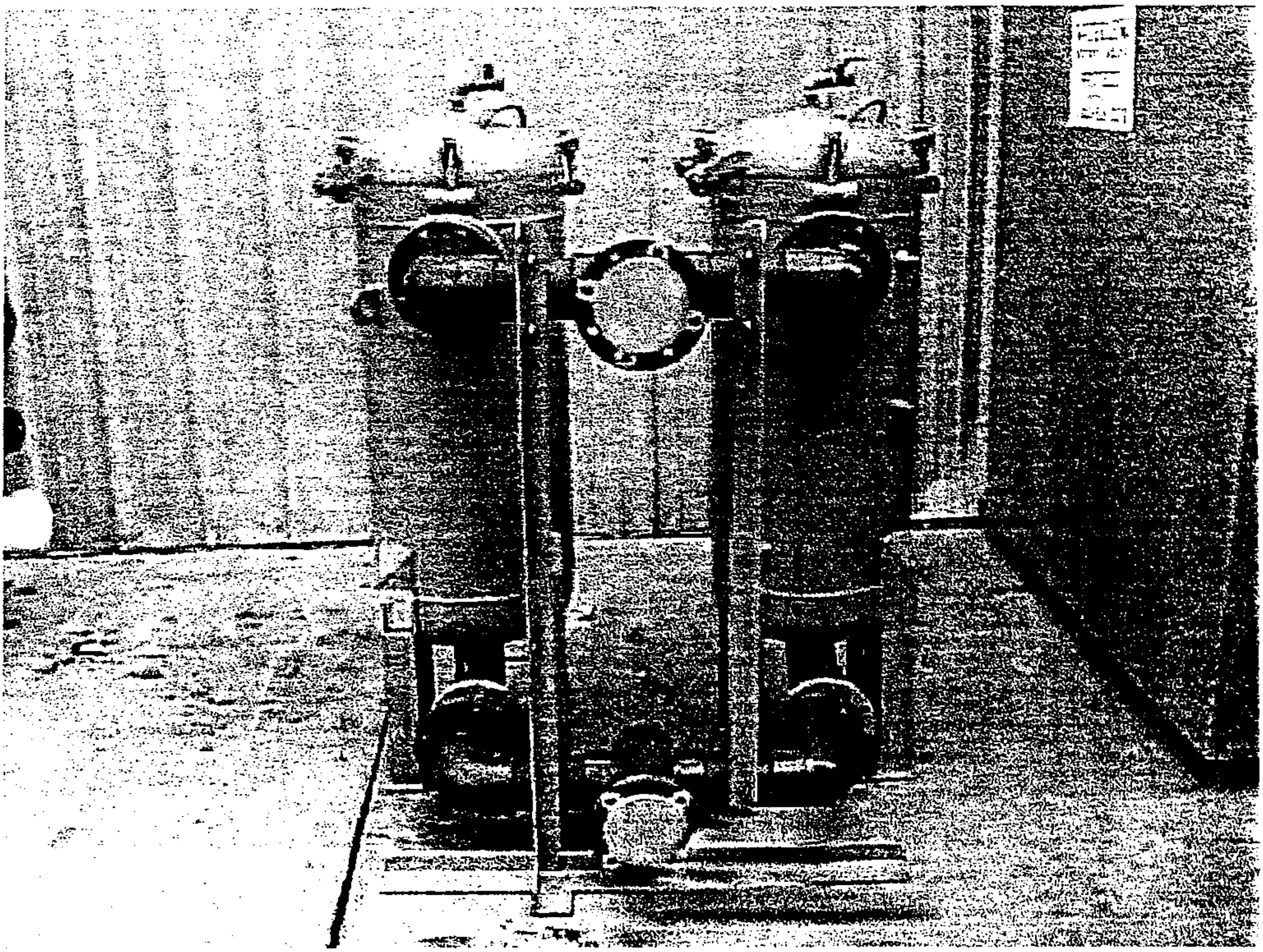
Service & Support

Barnebey Sutcliffe Corporation has service crews around the nation. Our service centers stock a variety of filtration medias to support our product line. To obtain replacement parts, pricing information, or to schedule a changeout, please call (800) 886-2272.

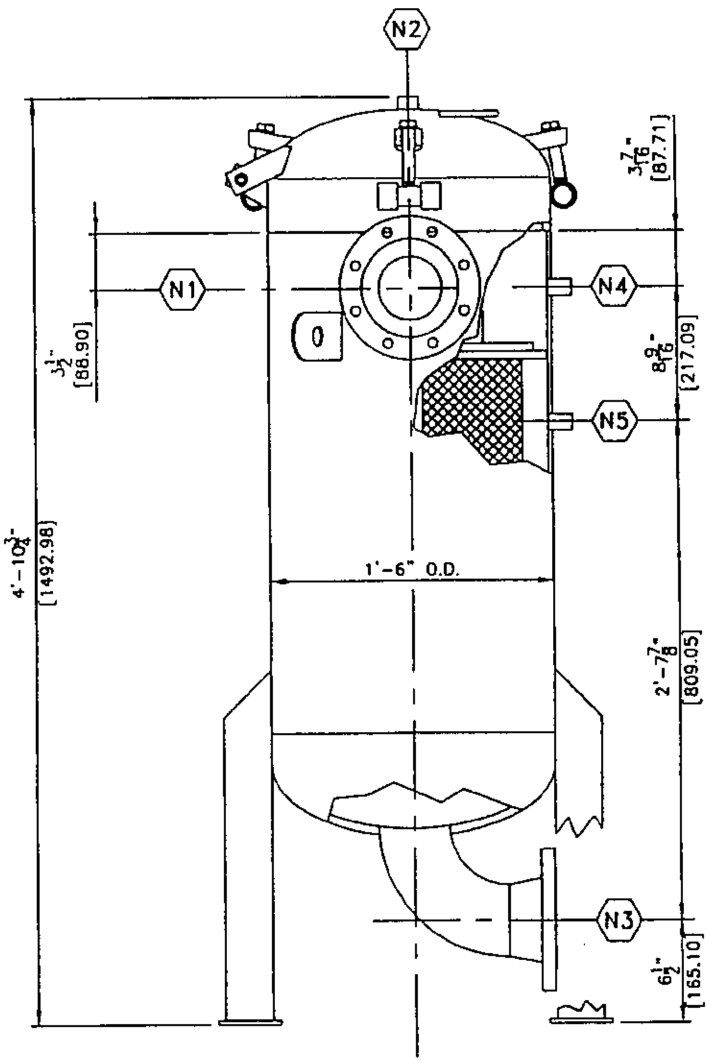
If you have technical questions regarding your application, or if you need spare parts for your system, call the same phone number.

It is always helpful, and speeds up service and support inquiries, if you have the model number and serial number of your equipment.

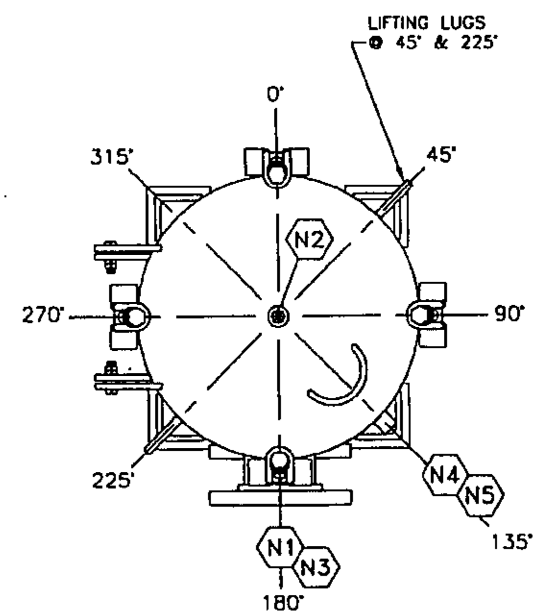
Vessel Drawing



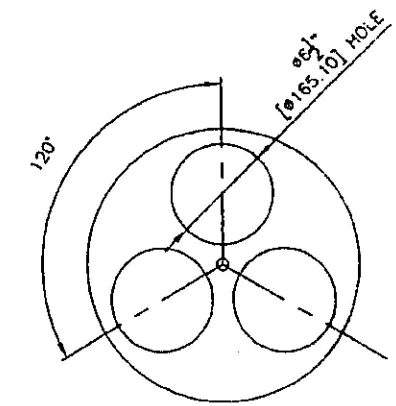
NOZZLE	SERVICE	SIZE
N1	INLET	4" 150# RFSO FLANGE
N2	VENT	3/4" NPT 3000#
N3	OUTLET	4" 150# RFWN FLANGE
N4	PRESSURE GAUGE	1/2" NPT 3000#
N5	PRESSURE GAUGE	1/2" NPT 3000#



ELEVATION VIEW
3/4" = 1'-0"
(SEE PLAN FOR ORIENTATION)



PLAN VIEW
3/4" = 1'-0"



SOCK PLACEMENT DETAIL
3/4" = 1'-0"

WATERLINK®
Br ebey Sutcliffe
1-80 -886-2272

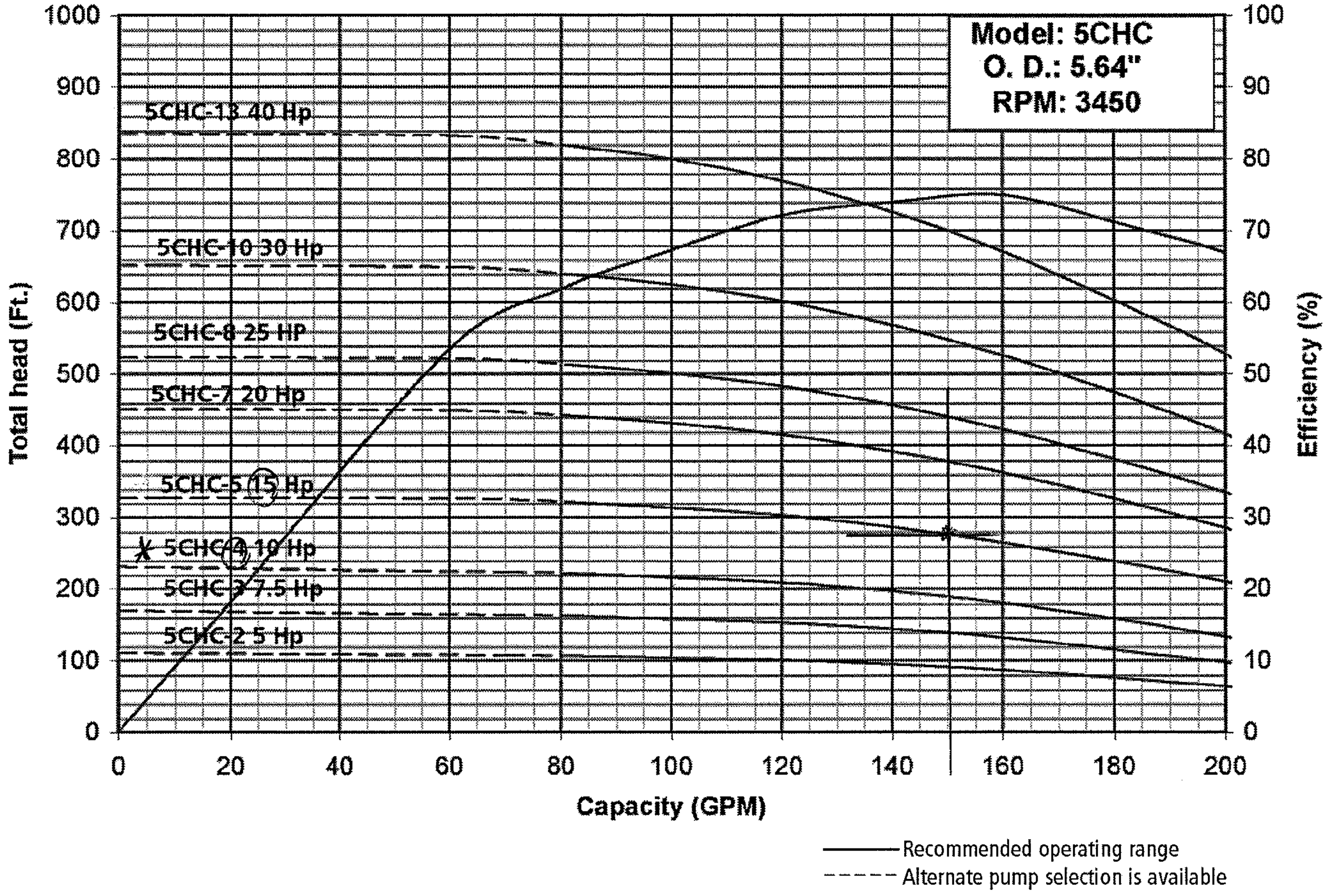
1"= 0"

BF-300
TRIPLE BAG FILTER HOUSING

Design & specifications subjec change

F:\Filtration\Liquid\BF\BF300SALES.dwg 09-14-00 09:11 SC:8 R:14.01

Model 5CHC 150 GPM

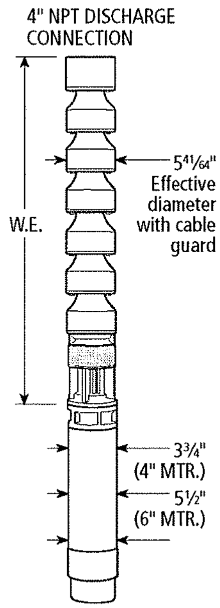


DIMENSIONS AND WEIGHTS

HP	Stages	W.E. Order Number	W.E. Length	W.E. Wt. (lbs.)
5	2	C05CHC005A44B	20.2	57
		C05CHC005A64B	22.8	62
7.5	3	C05CHC007A44B	25.2	70
		C05CHC007A64B	27.5	75
10	4	C05CHC010A64B	32.1	88
15	5	C05CHC015A64B	36.7	101
20	7	C05CHC020A64B	46.1	127
25	8	C05CHC025A64B	50.7	140
30	10	C05CHC030A64B	59.9	166
40	13	C05CHC040A64B	73.8	205

(All dimensions in inches and weights in lbs. Do not use for construction purposes.)

NOTES:
1. All dimensions in inches and weights in lbs.
2. Solid line is recommended operating range.
3. For intermediate horsepower pumps consult factory.
4. Please specify all options changes in W.E. order number.



MATERIALS OF CONSTRUCTION

Part Name	Material
Shaft	ASTM A582 S41600
Coupling	ASTM A582 S41600
Suction Adapter	ASTM A536 Gr. 60-40-18
Suction Bearing	ASTM B584 C89835
Impeller	ASTM A744 CF8M
Taperlock	ASTM A108 Gr. 1018
Intermediate Bowl	ASTM A49 Cl. 30B
Intermediate Bowl Bearing	ASTM B584 C89835 (Std.)
Intermediate Bowl Bearing	Rubber (optional)
Upthrust Collar	Polyethylene
Discharge Bowl	ASTM A48 Cl. 30B
Discharge Bowl Bearing	ASTM B584 C89835
Fasteners	SAE J429 Gr. 8
Cable Guard	ASTM A240 S30400
Suction Strainer	ASTM A240 S30400

GOULDS PUMPS

Submersible Turbine Pumps Engineering Data

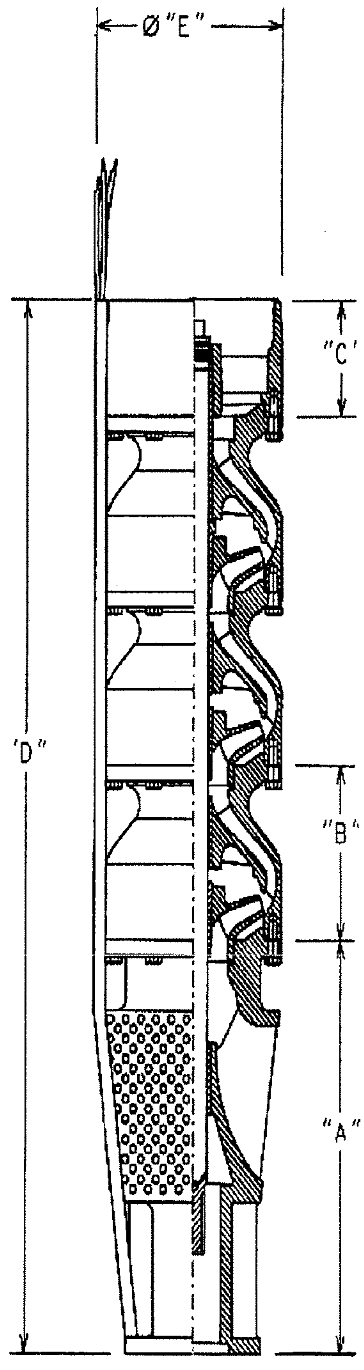
Effective April 1, 2003

Submersible Pump Data

MODEL	NEMA	"A"	"B"	"C"	One Stage "D"	"E"	One Stage Shaft Length	Disch. Size	First Stage Weight	Add'l Stage Weight
5C	4 6	8.25 10.56	4.63	3.06	15.94 18.25	5.64	12.88 13.63	3,4	44 49	13
5T	4 6	8.25 10.56	4.81	3.06	16.13 18.44	5.64	13.06 13.81	3,4	44 49	13
5WA	4 6	8.38 10.56	4.00	3.06	15.44 17.63	5.64	13.25 13.75	3,4	44 49	13
6C	4 6 8	8.44 10.56 12.50	5.13	3.75	17.31 19.44 21.38	6.28	13.63 14.25 15.38	3,4,5	50 55 60	17
6DH	4 6	4.94 9.75	5.50	3.75	14.19 19.00	5.94	10.63 13.75	3,4,5	41 53	16
6RA	6	10.56	3.75	3.75	18.06	5.94	12.88	3,4	90	20
7C	6 8	12.88 14.56	6.38	3.63	22.88 24.56	7.50	18.50 19.25	5,6	75 87	28
7RA	6	8.44	4.50	3.63	16.56	7.90	11.50	3,4	105	28
7T	6 8	12.88 14.56	7.09	3.63	23.59 25.28	7.50	19.06 19.94	5,6	78 90	31
7WA	6 8	12.88 14.56	5.50	3.63	22.00 23.69	7.50	17.75 18.50	5,6	68 80	30
8DH	6 8	12.88 14.56	7.38	3.63	23.88 25.56	7.90	19.25 20.13	5,6	125 137	34
8I	6 8	12.88 14.56	6.38	3.63	22.88 24.56	7.90	18.13 18.88	5,6	90 102	33
8RA	6 8	12.88 14.56	5.00	3.63	21.50 23.19	7.90	17.25 18.13	4,5,6	165 177	36
8RJ	6 8	12.88 14.56	6.50	3.63	23.00 24.69	7.90	17.50 18.88	5,6	90 102	34
9RA	6 8	12.88 14.56	5.50	3.63	22.00 23.69	7.90	17.50 18.50	4,5,6	185 197	46
9RC	6 8 10	15.13 13.25 13.25	8.50	4.50	28.13 26.25 26.25	9.81	24.25 21.50 20.50	5,6,8	194 206 206	64
9T	6 8 10	15.13 13.25 13.25	9.25	4.50	28.88 27.00 27.00	9.81	25.00 22.25 21.25	5,6,8	200 212 212	70
9WA	6 8 10	15.13 13.25 13.25	6.63	4.50	26.25 24.38 24.38	9.81	22.38 19.63 18.63	5,6,8	158 170 170	58
10DH	8 10 12	13.25 13.25 13.25	9.25	4.50	27.00 27.00 27.00	10.00	22.00 22.00 21.00	6,8	185 190 190	65
10RA	6 8 10	15.13 13.25 13.25	6.63	4.50	26.25 24.38 24.38	10.00	22.38 19.63 18.63	4,6,8	280 285 285	76
10RJ	6 8 10	15.13 13.25 13.25	8.40	4.50	28.03 26.15 26.15	10.00	23.38 20.75 19.75	6,8	187 192 192	60
10WA	6 8 10	15.13 13.25 13.25	7.63	4.50	27.25 25.38 25.38	10.00	23.38 20.63 19.63	4,6,8	183 188 188	56

(All dimensions are in inches and weights in lbs.)

SPECIFICATIONS AER SUBJECT TO CHANGE WITHOUT NOTICE



Goulds Pumps

ITT Industries
Engineered for life

Goulds Model VAS Supplemental Data

3B.1A2
January 1, 1983
(Sup. 3B.3W, 7/3/78)

Submersible Cable Selection

SINGLE PHASE — MAXIMUM CABLE LENGTH
(MOTOR TO SERVICE ENTRANCE)

MOTOR RATING		COPPER WIRE SIZE (A)										
VOLTS	HP	14	12	10	8	6	4	2	0	00	000	0000
230	5			216	315	490	750	1142	1540			
	7½				270	362	553	842	1136	1420		
	10					250	425	650	875	1100		

THREE PHASE — MAXIMUM CABLE LENGTH
(MOTOR TO SERVICE ENTRANCE)

MOTOR RATING		COPPER WIRE SIZE (A)										
VOLTS	HP	14	12	10	8	6	4	2	0	00	000	0000
230	5		250	390	620	960	1470	2230				
	7½			290	450	700	1070	1630	2200			
	10				340	520	800	1220	1640	2050		
	15					360	550	830	1130	1410	1680	
	20						420	640	860	1070	1280	1510
	25						340	520	700	870	1040	1230
	30							420	570	710	850	1000
460	5	630	1000	1570	2470							
	7½	460	730	1150	1800	2810						
	10		550	850	1340	2090	3190					
	15			590	920	1430	2190	3340				
	20				700	1100	1670	2550	3440			
	25				570	890	1360	2070	2800	3500		
	30					730	1110	1690	2280	2850	3400	
	40						850	1300	1750	2190	2610	3070
	50						680	1040	1400	1750	2090	2450
	60							870	1180	1470	1760	2070
	75								950	1190	1420	1670
	100									890	1060	1240
	125										1475	1875
	150											1525

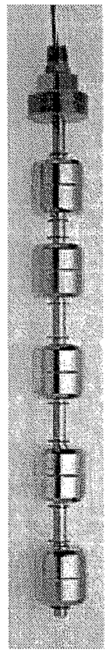
(A) For Aluminum Conductor Lengths — Multiply Lengths Above by 0.5. Maximum Allowable Length of Aluminum is Considerably Shorter Than Copper Wire of the Same Size.

LSL-301 / LSH-301 / LSHH-301

FM - Series Multi-Level Float Switches

FM - Series Multi-Level Float Switches

Dependable and rugged 316 Stainless Steel float level switches for replacement or custom applications.



FM20-xxxx 2" Diameter 316SS Float Switch

These larger, more buoyant floats are perfect for years of corrosive resistant service. Configurable for 1 to 5 levels, these switches may be used to control pumps, alarms or indicate general fluid levels.

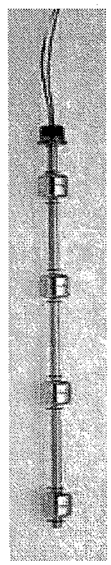
FM22-xxxx 1 ¼" Diameter Buna Float and SS Stem

These highly buoyant floats are ideal for heavy equipment, generators and fluid recovery involving lubricating oils, fuels and wastewater. Easily configured for oil water interface detection.

Part Number	Switch Type	Maximum Switching Current	Maximum Switching Voltage	Maximum Temperature	Maximum Pressure	Specific Gravity
FM20-xxxx	50 watt	.5 Amps	250 VDC	150 C	250 psig	.60
FM22-xxxx	50 watt	.5 Amps	250 VDC	120 C	150 psig	.50

Standard Features:
- 50 Watt Resistive SPST Switches
- 2.5" min. required between levels
- Up to 5 levels, 10' long

Other Available Switches: (UL rated for resistive loads)
- 100 Watt, Full Size SPST, Switch 3Amps (3 levels)
- 100 Watt, Full Size SPDT, Switch 3Amps (3 levels)Up



FM10-xxxx 1" Diameter, SS Multi Level Float Switch

This durable design is ideal for corrosion resistant applications in restrictive spaces

FM11-xxxx 1" Diameter PP Float with SS Stem

The Polypropylene float makes this ideal for general use and potable water applications.

FM12-xxxx 1" Diameter Buna Float with SS Stem

This miniature multi-level is ideal for petroleum products, hydraulic oils and wastewaters.

Part Number	Switch Type	Maximum Switching Current	Maximum Switching Voltage	Maximum Temperature	Maximum Pressure	Specific Gravity
FM10-xxxx	50 watt	.5 Amps	250 VDC	150 C	250 psig	.60
FM11-xxxx	50 watt	.5 Amps	250 VDC	105 C	100 psig	.70
FM12-xxxx	50 watt	.5 Amps	250 VDC	120 C	150 psig	.50

Standard Features:
- 50 Watt Resistive SPST Switches
- 1.5" min. required between levels
- Up to 4 levels, 6' long

Notes:
- Standard fittings, flanges or custom mounting configurations available. Use an adjustable compression fitting to provide more flexibility.
- Temperature devices can be incorporated with your float switch to reduce tank intrusion and assembly costs. See Combination sensors.
- Other switch types and materials available. Contact our technical sales department or submit a custom application

SMD Fluid Controls, Inc.
130 Research Parkway
Meriden, CT 06450
Tel: (203)-235-9330
www.Fluidswitch.com
Solutions@Fluidswitch.com
Fax: (203)-235-3470

FM - Series Multi-Level Float Switches

Please fill in configuration sheet and application specifications and return for quote or order.

Select Part

[ ] **FM20** 2" 316 Stainless Steel (Requires 2.1" hole for external mount)

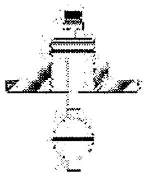
[ ] **FM22** 1 1/4" Buna-N / SS (Requires 1.3" hole for external mount)

[ ] **FM10** 1" 316 Stainless Steel

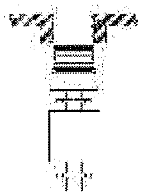
[X] **FM11** 1" PP / SS

[ ] **FM12** 1" Buna-N / SS

Mounting Type [X] External



[ ] Internal



Standard Fittings

Pipe Plugs	[ ] ¼"npt	[ ] ½"npt	[ ] 1"npt	[ ] 2"npt
Bulkhead	[ ] ½"- 13	[X] ¾"-10		
150# Flange	[ ] 1"	[ ] 3"		
Adjustable compression fitting		[ ]	Adjustability + ________"	

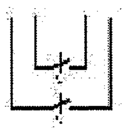
Other: ______________________

Float Stops [X] 300 Series SS Grip Rings **(Standard)** [ ] 316SS Collars with Set Screw

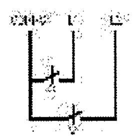
Wire Type ______________ [X] 22 Awg. Teflon **(Standard)**

Lead Length 24 inches 24" **(Standard)**

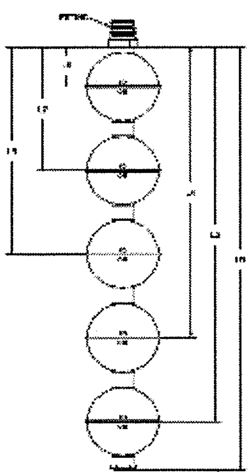
Wiring Configuration [X] Separate **(Standard)**



[ ] Common



NOTE: Switch Points measured from bottom of mounting surface to switch actuation at float center. Please check Normally Closed (NC), Normally Open (NO) or Single Pole Double Through (SPDT). (FM20- 5 levels Max, FM10- 4 Levels Max.)



L1	41"	[ ] NC / [X] NO / [ ] SPDT
L2	47"	[ ] NC / [X] NO / [ ] SPDT
L3	53"	[ ] NC / [X] NO / [ ] SPDT
~~L4~~	____"	[ ] NC / [ ] NO
~~L5~~	____"	[ ] NC / [ ] NO
L0	54"	Length Overall

(+1.5" for FM20, +1" for FM10, Unless Specified)

- FM20 and FM22 Require 2.5" min. between levels
- FM10,11,and 12 Require 1.5" min. between levels
- Other switches and options available, please contact us or submit your requirements using our Application Specifications Sheet

SMD Fluid Controls, Inc.
130 Research Parkway
Meriden, CT 06450

Tel: (203)-235-9330

www.Fluidswitch.com
Solutions@Fluidswitch.com
Fax: (203)-235-3470

FM - Series Multi-Level Float Switches

Application Specification Sheet

Company:

Address:

City: **State:** **Zip**

Contact:

Tel: **Fax:**

E-Mail:

Application Description:

Fluid Type: **Temp:** ________ **[ ]C / [ ]F** **Pressure:** ______psig

Tank or Contact Materials:

Electrical Device or Output to be controlled:

Voltage: **Power:**

Notes and Special Requirements:

Estimated Volume: **Price Target:**

SMD Fluid Controls, Inc.
130 Research Parkway
Meriden, CT 06450

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Solutions@Fluidswitch.com
Fax: (203)-235-3470

Global Water
INSTRUMENTATION, INC.

In the US, call toll free: **1-800-876-1172**
International phone: 1-916-638-3429
Fax: 1-916-638-3270
E-mail: Globalw*globalw.com

WL450 ALL STAINLESS STEEL WATER LEVEL TRANSMITTERS

Submersible stainless steel diaphragm water level transmitters

FEATURES:

- Rugged 316L SS flush-diaphragm sensor
- Highly stable digital temperature compensation
- 16-bit internal digital error correction
- Durable and environmentally neutral Hytrel® cable
- Custom ranges and cable lengths are available
- CE compliant

To Order Call 1-800-876-1172
Water Level Transmitters Options & Prices

On this page:	Downloads (PDF):	Additional Information:
• Water Level Transmitters Product Description • Water Level Transmitters Specifications • Water Level Transmitters Options & Prices	• Water Level Transmitters Brochure • Water Level Transmitters Quickstart Guide ***May take several minutes to download, depending on your internet connection speed.***	• Product Support

Water Level Transmitters Product Description

The Global Water WL450 All Stainless Steel Water Level Transmitters offer standard features and a level of performance that exceeds those of comparably priced transmitters. Plus, the All Stainless Steel Water Level Transmitters are able to provide 316L stainless steel diaphragm and digital temperature compensation and environmentally neutral Hytrel cable make it able to provide this level of performance day after day, over a wide range of operating conditions. This makes the WL450 All Stainless Steel Water Level Transmitters ideally suited to environmental monitoring applications such as test wells, surface water, streams and reservoirs.

For easy ordering, all our standard WL450 All Stainless Steel Water Level Transmitters are set up for 2-wire, 4-20mA output, are calibrated for specific ranges in feet of head and include an appropriate length of Hytrel vented cable. In addition to the standard ranges and cable lengths shown, we can custom range your All Stainless Steel Water Level Transmitters for a small additional fee.

Simple Digital Output
The WL450 All Stainless Steel Water Level Transmitter includes a RS-485 direct to digital output for a modem or other communications network. This avoids the error and complication involved with analog to digital conversion devices.

Water Level Transmitters Specifications

WL450 Water Level Transmitter Sensor & Electronics
Sensor element: 316L stainless steel, flush mounted
Available ranges: 0 to 3′, 0-15′, 0-30′, 0-60′, 0-120′, 0-250′, and 0-500′
Accuracy: Total Error Band ±0.1%, 16 bit digital error correction
Overpressure: Not to exceed 2x full scale range
Operating Temp: 14 to 176°F (-10 to 80°C)
Temp. compensation: Digital over entire operating range
Output: 4-20 mA, 2-wire loop powered
Supply Voltage: 10 to 28 VDC
Load Resistance (Ω): mA: < (supply - 8V) / 0.02A
Communication: RS-485

Water Level Transmitter Housing
Wetted Materials: 316L stainless steel, polyamide, fluorocarbon
Dimensions: 0.825" (21mm) diameter x 3-3/4" (95mm) long
Weight: 1Lb (453.6g)

Water Level Transmitter Cable
Cable: Hytrel-jacketed, vented & shielded
Temperature Range: -22 to 185°F (-30 to 85°C)
Diameter: 0.23" (5.8mm)
Length: Standard 25 feet (up to 1,000 feet total)

Water Level Transmitters Options & Prices

Prices listed are for United States and Canada only. Call or e-mail us for pricing in other countries.
Terms and Conditions

ORDER NOW

WL450-003 All Stainless Steel Water Level Transmitters (PN# AIL003) Water Level Transmitter Range: 0 to 3 ft, Cable length: 25 ft.	$624
WL450-015 All Stainless Steel Water Level Transmitters (PN# AIL015) Water Level Transmitter Range: 0 to 15 ft, Cable length: 25 ft.	$624
WL450-030 All Stainless Steel Water Level Transmitters (PN# AIL030) Water Level Transmitter Range: 0 to 30 ft, Cable length: 50 ft.	$674
WL450-060 All Stainless Steel Water Level Transmitters (PN# AIL060) Water Level Transmitter Range: 0 to 60 ft, Cable length: 100 ft. Note 24V power source or boost regulator required.	$765
WL450-120 All Stainless Steel Water Level Transmitters (PN# AIL120) Water Level Transmitter Range: 0 to 120 ft, Cable length: 150 ft. Note 24V power source or boost regulator required.	$860
WL450-250 All Stainless Steel Water Level Transmitters (PN# AIL250) Water Level Transmitter Range: 0 to 250 ft, Cable length: 300 ft. Note 24V power source or boost regulator required.	$1,141
WL450-500 All Stainless Steel Water Level Transmitters (PN# AIL500) Water Level Transmitter Range: 0 to 500 ft, Cable length: 510 ft. Note 24V power source or boost regulator required.	$1,539
WL450-CUSTOM All Stainless Steel Water Level Transmitters Water Level Transmitter Range: Custom Range, Cable length: Custom Length	$CALL
AILEXE Extra Cable for the WL450 Water Level Transmitters	$2.05/Foot
Titanium Option for Water Level Transmitters	$Call

WATER LEVEL TRANSMITTERS ACCESSORIES

BR100 Boost Regulator (PN# FNA000) $67
12 to 24 Volt boost regulator. For use with 12V battery operated systems. Required if water level transmitter cable is over 50 feet.

RELATED PRODUCTS

WL430 Sewage Lift Station Wastewater Level Sensor $1,072
Includes 40 ft of cable.

WL400 Water Level Sensor $566
When ordering, specify water level range that will cover the maximum water level change for your application (this is not necessarily the total depth of water): 0-3, 0-15, 0-30, 0-60, 0-120, 0-250, and 0-500 ft. NOTE: There is a $50 extra charge for 0-500 ft range sensor. Selecting the smallest water level range possible will ensure the greatest accuracy. Includes 25 feet of cable.

WL500 Water Level Tape Sounder $Varies
For more information on our tape sounders please visit our WL500 Water Level Sounder page.

WL550 Oil Water Interface Meter $Varies

WL650 Sonic Water Level Meter $1,174

Click here to learn about the brands in the ITT Analytics family.

BARNEBEY SUTCLIFFE
A WATERLINK COMPANY

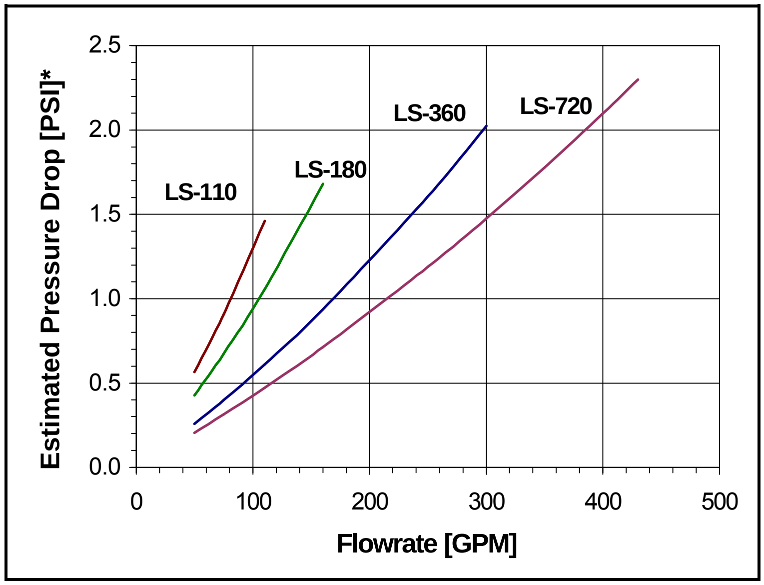
Powerful Solutions for a New Tomorrow

Protect LS Series

The Protect LS series adsorbers are designed as high flow, high pressure vessels which are easily put into service. This LS series can operate at a maximum pressure of 100 psi, maximum temperature of 140 °F, and hold from 3,200 to 20,000 pounds of activated carbon or 110 to 720 ft^3 of other granular media.

Important Features:

- Durable carbon steel construction
- ASME Sec. VIII Div. code design for 100 psi
- Lower header with PVC laterals positioned for superior distribution and eliminates the need for media support bed
- Upper header with PVC laterals allow for backwashing & upflow operation
- Rust-prohibitive exterior coating
- Chemical resistant interior lining
- Rupture disk for high pressure relief
- Manways on top and side shell
- All models available for rent



* Estimated pressure drop based on 8x30 mesh carbon.

Model Number	GAC		Recommended Maximum Flow Rate, gpm	Weight, lbs. (Empty / Operating)
	$ft.^3$	lbs.**		
LS-110	110	3,200	140	4,020 / 17,520
LS-180	180	5,000	200	4,230 / 24,480
LS-360	360	10,000	350	8,550 / 53,370
LS-720	720	20,000	550	16,700 / 101,970

** Weight estimated from vessel volume.

Corporate Capabilities:

Barnebey Sutcliffe has been manufacturing and servicing adsorption equipment for over 80 years. Some of our other products and services include:

- Wide variety of coal & coconut shell carbons
- Broad range of filtration media
- National network of service centers
- Carbon reactivation (hazardous & non-hazardous)
- Vessel rental
- The industry's largest line of NSF certified carbons
- Spent media exchange
- Technical support
- Custom-engineered systems
- ASME Code certified fabrication facility

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Gulf Coast Office• Sulphur, LA • 337-527-0084 • Fax 337-527-0087 / Northeast Regional Office • Downingtown, PA • 610- 870-3070 • Fax 610-870-3072

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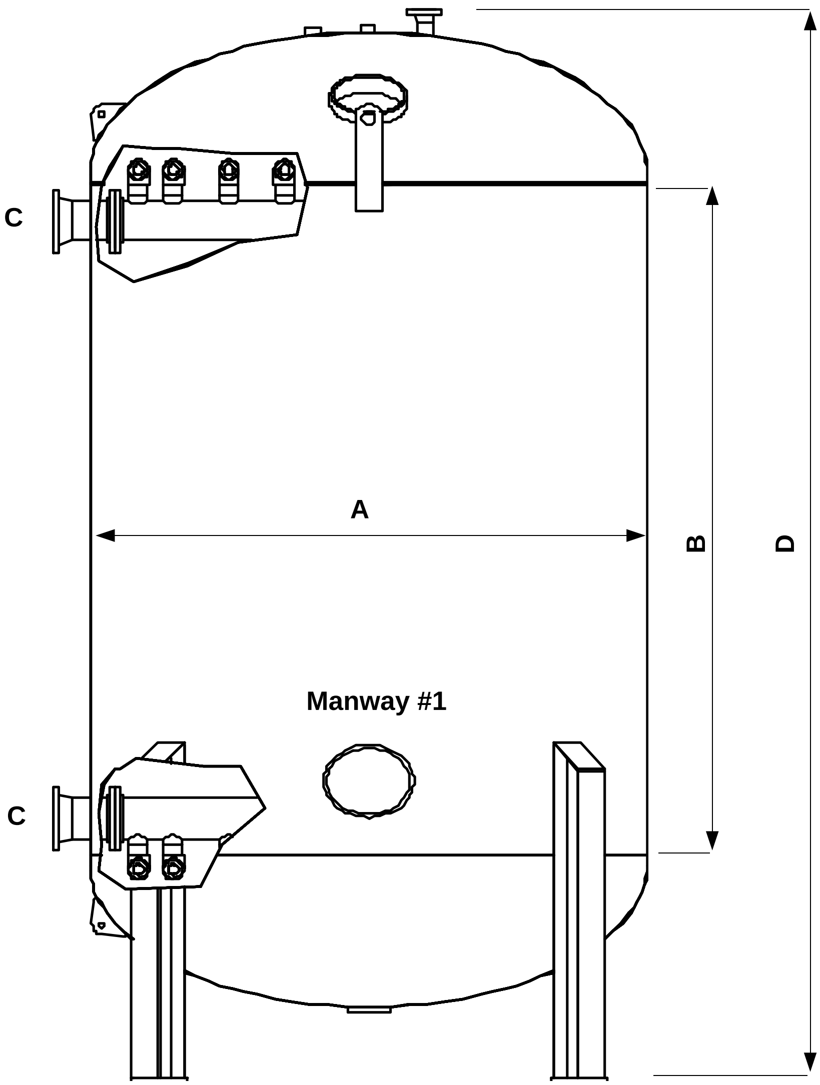

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LS-180	72“	96”	4”	151” ±	2”	2”
LS-360	96”	120”	6”	190” ±	3”	3”
LS-720	120”	144”	8”	230” ±	3”	4”

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Operations & Maintenance Manual
Liquid Phase Adsorber
PROTECT™ LD Series

Table of Contents

Introduction

Granular Activated Carbon (GAC), How it Works

Granular activated carbon removes dissolved organic pollutants from water by a process called adsorption. As water passes through the porous granules of activated carbon, molecules of the organic pollutants are attracted to the surface of the pores and are held there by weak physical forces. The phenomenon is somewhat similar to iron filings being held by a weak magnet. Water contaminants adsorb because the attraction of the carbon surface for them is stronger than the attractive forces that keep them dissolved in solution.

The ability of granular activated carbon to remove large quantities of organic impurities is a function of its highly developed internal pore structure. This unique pore structure is created during the manufacturing process, which involves the crushing and thermal "activation" of select grades of bituminous coal under carefully controlled conditions. As a result of this processing, an extensive network of pores is created inside each carbon granule, providing an enormous internal surface area of 6,000 – 17,000 sq. ft. per gram, depending on the grade of activated carbon used.

Granular activated carbon's great porosity is responsible for its high capacity for trapping and holding organic molecules. For example, just one pound of carbon granules has an effective total (external and internal) surface area equal to that of a 150-acre farm. A single handful of activated carbon has a total surface area equal to that of a football field. Multiply the surface area of that farm or football field by the amount of carbon inside a water treatment facility, and some idea of the magnitude of activated carbon's adsorptive capacity for organic contaminants may be readily obtained.

Unlike other water treatment medias, granular activated carbon does not have to be discarded after being saturated with organic wastes. After the carbon's capacity for adsorbing organic impurities is used up, the granules will be restored to their original adsorptive capacity through "reactivation."

Reactivation is simply the restoration of the carbon's ability to adsorb impurities from water. This restoration of carbon's adsorption capacity is accomplished as the carbon passes through a reactivation kiln at temperatures as high as 1800°F. As the carbon passes through the kiln, the organic impurities are burned from internal surfaces of the individual carbon granules.

More than 90 percent of the original carbon is recovered in the reactivation process. Fresh carbon is added to the water treatment system to compensate for the small losses resulting from reactivation and handling of the carbon.

Activated Carbon Design Criteria

The two most important operating conditions for activated carbon water treatment systems are flow rate of the water stream and concentration of the adsorbate (contaminant) relative to its solubility in water. As a general rule, lower flow rates allow a greater contact time with a unit volume of carbon, thereby improving the ability of the available carbon by allowing time for an adsorbate to migrate through the carbon pore. However, it may be possible to compensate for high flow rates with a smaller particle size. The potential for pressure drop problems must be studied when changing to a smaller particle size.

There are several considerations involved in evaluating a carbon adsorption system. The type of contaminant to be removed is very important (chlorine, general taste and odor, color bodies, specific organics, or all of these). Factors which generally improve the rate of adsorption are low water solubility, organics (made up of carbon atoms), high molecular weight, and neutral or non-polar chemical nature.

Chlorine has a very rapid rate of adsorption. In addition to physical adsorption, chemical reaction occurs on the carbon surface forming chloride ions. The empty bed contact time required for 99% removal of chlorine at a pH of 7 or below is 20 seconds or less, and at pH 8.5 or above, 3 minutes or more. Whereas, color removal requires a much longer contact time, up to (60) sixty minutes or longer.

The pH and the water temperature are important factors influencing the solubility of the contaminant and rate of adsorption. Finally, adsorption is, for the most part, an equilibrium reaction. At bed saturation, when the pores in the carbon granule are fully occupied with a contaminant, and a more absorbable contaminant is introduced to the stream, the less absorbable contaminant will be released back into the stream. In such cases the activated carbon is considered spent and the effluent concentration may be higher than the influent concentration for a particular contaminant.

Operation & Handling Guidelines

GAC Transfer

Granular activated carbon may be loaded into a vessel or unloaded out of a vessel in two ways: (1) Hydraulic Transfer, (2) Dry Loading. The recommended method of loading is hydraulic. Hydraulic transfer of granular activated carbon in water or process liquors provides a clean, fast, and economical means of filling or discharging activated carbon vessels. In addition, hydraulic loading minimizes formation of the air pockets that lead to channeling. Channeling is the absence of even flow distribution in the carbon bed, therefore, reducing the efficiency and capacity of the bed.

Hydraulic Loading Procedure

If the vessel is equipped with a carbon fill line, connect the slurry vessel or trailer to the process vessel through the carbon fill line. In case your process vessel does not have a carbon fill line, stretch a carbon transfer hose over the top manway into the vessel.

1. Prepare to slurry by filling slurry vessel or trailer until water is approximately six-inches (6") over the carbon. If possible, use hot water. Elevated temperature promotes wetting and de-aeration of granular carbon.
2. Fill vessel with water to one-foot (1') above bottom distribution header and laterals. Water will break the fall of the carbon to protect the laterals. Again, if possible use hot water.
3. Make sure that vessel is isolated from process stream and drained.
4. Close all valves and manways on process vessel.
5. Open top inlet/outlet valve (inlet/outlet definition varies based on upflow vs. downflow configuration).
6. Connect carbon transfer hose to top inlet/outlet connection.
7. Pressurize slurry tank or, pull a vacuum on vessel to be loaded.
8. Open carbon transfer-valve on slurry vessel or trailer to start transfer.
9. When process vessel is full or, when slurry tank is empty, shut carbon transfer valve.
10. Relieve pressure and/or vacuum from both slurry tank and process vessel.
11. If process tank is not full, go to step 3 above.
12. Top off vessel with water and allow GAC to soak for 8 hrs to allow air trapped in GAC pores to escape.
13. Initial effluent will be black with carbon fines and dust. This will last for several bed volumes. When starting up this newly charged adsorber, put effluent to sump until it runs clear. When effluent is clear, start normal discharge. NOTE: The carbon fines do not pose an environmental hazard, but they are aesthetically unpleasant if discharged to a receiving stream. Going to the sump for the first few bed volumes allows this water to be pumped to front end of the process where carbon fines will be removed by settling and/or sand filtration (see bed conditioning procedures).

Dry Loading Procedure

1. Make sure that vessel is isolated from process stream and drained.
2. Close all valves and manways on process vessel except top manway.
3. Fill vessel with water to one-foot (1') above the bottom distribution header and laterals. The water will break the fall of the carbon to protect the laterals. If possible, use hot water. Elevated temperature promotes wetting and de-aeration of granular carbon.
4. Empty bags or supersacks (1000 lb.) of carbon into the liquid, continuously adding water to maintain a one-foot (1') layer above carbon. The added water will help prevent channeling, dust, and abrasion.
5. Allow GAC to soak for 8 hrs to allow air trapped in GAC pores to escape.

6. Initial effluent will be black with carbon fines and dust. This will last for several bed volumes. When starting up this newly charged adsorber, put effluent to sump until it runs clear. When effluent is clear, start normal discharge. NOTE: The Carbon fines do not pose an environmental hazard, but they are aesthetically unpleasant if discharged to a receiving stream. Going to the sump for first few bed volumes allows this water to be pumped to front end of process where carbon fines will be removed by settling and/or sand filtration (see bed conditioning procedure).

Hydraulic Removal of Spent GAC

This procedure is possible only if the vessel is equipped with a carbon drain valve. Carbon removal is best accomplished by first placing the vessel in the backwash configuration and backwashing momentarily to fluidize the bed in order to minimize any compaction.

1. Open top manway and verify that water level is six to twelve inches (6" – 12") above carbon bed.
2. Connect carbon drain valve to a recovery tank, slurry trailer, or some other carbon/water separation device. Use a two, three, or four inch (2", 3", or 4") hose – the more, the merrier. The GAC may be separated from water by discharging slurry into a supersack. Supersack will allow water to go through but will capture GAC.
3. Apply air pressure or water pressure to vessel through vent line. Do not exceed 15 psig of induced pressure, or apply vacuum to recovery tank if tank is designed for vacuum.
4. When no more carbon is leaving through drain, vent pressure/vacuum and open manway (in case it is not already open), and rinse all GAC residues from internal fixtures, laterals, and vessel walls.

Dry Removal of Spent GAC

In this procedure, the GAC will be removed through the top manway using a vacuum truck, or some other vacuum collection system.

1. Open top manway.
2. Drain water from vessel. Water is best and fastest drained through lower lateral system. If your vessel is equipped with a drain valve that has a carbon retaining screen, or lateral built into it, you may choose to drain water through this valve. If your drain valve is not equipped with a carbon retaining system, opening drain valve will release carbon granules through the valve.
3. When water is drained, start vacuum operation to remove GAC through top manway.

Be careful not to damage the inside paint/liner, laterals, or any other internals with the suction hose.

Bed Conditioning Procedure

1. Soak the granular activated carbon for a minimum of eight (8) hours to allow entrapped air to displace from between the granules and from the pores of the granules. Not doing so will cause foaming during backwash.
2. Backwash at a rate of (10-12) gpm/ft^2 for a period of 30 minutes, per backwash procedure. An extended backwash period is required to remove any fines created from handling, and to remove air pockets that may have been trapped in the bed.

The backwash flow rate should be controlled during this initial bed conditioning, so that the carbon can expand and stratify. Stratifying a carbon bed during conditioning locates the smaller granules at the top of the bed, away from the lower collection assembly, which could cause: blockage, restricting the service flow rate, increasing pressure drop, or resulting in unpredictable breakthrough readings (breakthrough meaning contaminants that are passing through the GAC bed).

If a virgin or reactivated bed is not backwashed prior to operation, but is backwashed later in the operation, particles that were originally at the top of the bed, and are now fully exhausted, may rearrange and go to the bottom of the bed, causing breakthrough readings before the bed is fully exhausted.

Backwashing as part of conditioning eliminates air pockets, assures that the vessel is full with water, and displaces the air that was released from the pores of the carbon. The wetting period in which the air totally dissipates from within the pores of the carbon is approximately forty-eight (48) hours. Only the initial backwash removes the fines, air that is trapped between the granules, and some of the air from the pores. Periodically, a short backwash will remove the air that migrated from the pore structure and may have possibly formed air pockets that encourage channeling.

Backwash Procedure

If this is your first backwash prior to operation, refer to "bed conditioning" in the previous section.

Always open and close backwash valves slowly. Ramp-up to increase the flowrate to prevent damaging the equipment, particularly the internal piping. It is not unusual to take several minutes to reach full backwash flow.

Backwash flow rate should be approximately 10-12 gallons per minute per square foot of crossectional bed area. The backwash rate should be started at 3 gallons per minute per square foot and gradually increased to achieve 25% bed expansion. If a maximum backwash rate of 10-12 gpm/ft^2 is applied all at once, it may displace the entire GAC bed as a plug and damage the upper distribution laterals. The backwash rate should be maintained for 10-15 minutes or until backwash water clears. This will evacuate the suspended solids that have been mechanically filtered or deposited on the carbon bed, causing channeling and/or increased pressure drop, and reducing flow rate and effectiveness. As mentioned previously, periodical backwash will displace air that was released from the pores during the early part of the operation. Once all the air is released from the pores, the bed is considered "fully seasoned", and is no longer a consideration.

When to Backwash

An activated carbon adsorber in downflow operation will effectively filter suspended matter down to a ten (10) micron particle size, producing the same inherent characteristics as a multi-media pressure filter for suspended solids removal. Activated carbon promotes water instability, inducing precipitation, or inorganics, or minerals in what would otherwise be considered a solids-free stream.

There are two (2) fundamental indicators in determining when backwash is recommended. One, like a multi-media filter, when the pressure differential through the carbon bed increases (typically a five to fifteen (5-15) PSI increase can be tolerated without sacrificing organic adsorption). The second indication is an analytical test that indicates organic breakthrough. Just as a multi-media filter, carbon bed channeling will prevent utilization of the entire activated carbon bed, reducing the adsorption capacity. After backwashing if the analytical results are still unacceptable, the carbon bed is spent or saturated and requires replacement. If a reduction in flow rate is acceptable, this will increase the empty bed contact time and possibly increase the adsorption capacity or bed life.

Duration Between Backwash

Length of filter runs should not be used as an index for backwashing.

Rate of Backwash

Rate of backwash is an important factor in bringing about the proper scouring action and clearing away of suspended matter (silt, clay, colloids, and microorganisms including algae and bacteria). A rinsing velocity capable of expanding the bed by 25% of its original depth is recommended. A general guideline for backwash flowrate is a velocity of ten to twelve (10-12) gpm/ft^2. Refer to technical specification section to find out the backwash flowrate for your system.

Backwash duration usually ranges from four (4) to fifteen (15) minutes and depends on backwash flowrate and site contaminants. Monitor backwash effluent quality to determine site specific backwash duration.

Upflow vs. Downflow Operation

Efficient adsorption may be achieved in either upflow or downflow operation. As a general rule, we recommend upflow operation. Following are some of the considerations. You should decide the mode of operation prior to installation.

- Upflow operation improves contact due to the tendency to fluidize the bed therefore eliminates channeling.
- Upflow operation allows the suspended solids to work their way through the bed.
- Upflow operation will be less susceptible to filter cake formation.
- Upflow operation will have less increase in pressure drop compared to downflow.
- Upflow operation will have a more consistent flowrate due to a more consistent pressure drop.
- If upflow is acceptable, pressure drop will remain more stable in upflow.
- Upflow operation continuously evacuates entrapped air from the carbon bed.
- If you want your bed to act as a mechanical filter, as well as an adsorber, operate in downflow.

Record Keeping

Record keeping may be a regulatory issue in many cases. When it comes to troubleshooting a process, it's history of performance becomes very valuable. Regardless of regulatory requirements, we recommends that the following records will be kept.

1. Adsorber model number and specs.
2. GAC specs.
3. Number of adsorbers in operation.
4. Number of hours per day each adsorber is on-line.
5. Number of days each adsorber is on-line.
6. Flowrate information.
7. Influent temperature.
8. Analytical report of influent contaminant.
9. Analytical report of effluent contaminant.
10. Analytical report of spent carbon.
11. Date of GAC changeouts, GAC type, and pounds changed.
12. Hours between backwash.
13. Backwash flowrate and duration.
14. Gallons treated per carbon bed.
15. Any unusual behavior, both mechanical and process related.

Hazards with Certain Process Conditions

Under certain process conditions, activated carbons may show an affinity for atmospheric oxygen, or may interac with process streams to generate potentially toxic or hazardous levels of hydrogen sulfide, methane, ethanol, carbon dioxide and other gases. These effects can become pronounced in a relatively confined space, such as the headspace of an adsorber. Should entry to confined spaces containing activated carbon become necessary, appropriate ventilation and other safety practices for potentially flammable, toxic or oxygen-deficient environments should be followed.

To avoid possible combustion of the carbon or the material being adsorbed, caution is recommended in contacting activated carbon with strong oxidizing agents, such as chlorine.

Need for Grounding of Carbon Systems

In certain systems, high voltage static electrical charges may accumulate to levels of shock or ignition hazard. As a precaution against possible ignition or shock, all carbon treatment systems should be adequately grounded.

DANGER!

Wet granular activated carbon adsorbs oxygen, therefore creates an oxygen deficient environment. In a confined space where activated carbon is wetted, a hazardous environment is created. SUCH AN EVIRONMENT MAY BE FATAL. Do not use a respirator in such an environment. You must use live air equipment.

Investigation of this matter was prompted by an accident, which occurred on a project in which a granular activated carbon system was being installed. Studies conducted in vessels similar to that in which the accident occurred have shown that low oxygen content exists in vessels containing wet carbon. Laboratory experiments conducted since that time also have revealed that commercial activated carbons in a wet or moist condition will lower the oxygen content of an isolated space. Indications are as follows:

1. The phenomenon occurs with wet activated carbon of all common types.
2. The rate of oxygen uptake naturally varies with the degree of exposure of the wet carbon to the air. Thus it is relatively rapid in a drained bed.
3. There is some indication of a limit to carbon's capacity for oxygen; however, the prudent action should be to assume that all carbon, wet or dry will exhibit this oxygen-depleting characteristic.

Therefore: All confined spaces containing activated carbon, should be presumed as hazardous. Appropriate safety measures should always be taken before entering, as well as when workers are in a confined space. OSHA regulations pertaining to confined space entry and oxygen depleted environments should be strictly adhered to.

Installation and Startup

It is highly recommended that you read this manual in its entirety prior to installation in order to familiarize yourself with the considerations regarding the operation of a liquid adsorber. Read the complete installation section prior to installing the vessels on site.

1. Install skid on a leveled foundation that can support its working load. Anchor bolts are not provided for fastening the skid to its foundation. Note that the skid is not symmetrical, review drawing to determine skid orientation.
2. Install Vessel A on the left side of the skid and Vessel B on the right side of the skid. Use bolts to loosely hold the vessels in place, do not tighten vessels to skid until piping is properly aligned.
3. Install main piping to the lower flanges on the vessels, using studs, nuts, and gaskets. Do not tighten flange connections until the entire piping manifold is assembled and properly aligned.
4. Install upper spools, left and right, to connect pipe manifold to upper vessel connections.
5. Verify that all flange-to-flange connections have a flange gasket in between. Note that there is no need for flange gasket where a standard butterfly valve is installed since the valve liner wraps around the valve body and acts as a gasket seal.
6. Use the pipe jacks to support pipe manifold so that the manifold is not hanging from the vessel's flanges (LD-360 & LD-720 only). Install angle iron pipe support to skid and loosely fasten pipe manifold to angle iron support using u-bolts provided.
7. Tighten all pipe manifold flanges. When torquing down a flanged connection, first make sure that the flanges are aligned, then snug flange bolts in the following sequence: 0°-180°, 90°-270°, 45°-225°, 135°-315°. Finally apply full torque in a rotational sequence until all bolts are stable at final torque level (0°-45°-90°-135°-180°-225°-270°-315°). Do not over-tighten. If you are not an experienced pipe fitter and is not sure how much torque to apply, refer to a pipe fitters manual for torque levels for the different flange sizes and use a torque wrench when performing final tightening.
8. Tighten all skid and flange bolts, and adjust pipe jacks (LD-360 & LD-720 only) to support the weight of the pipe manifold.
9. Mount four (4) sample port assemblies as shown on drawing.
10. Install ventline to the top of each vessel and secure to side brackets using supplied u-bolts.
11. Open manway and inspect internal paint/liner for integrity.
12. While manway is open, inspect laterals and other internal fixtures for integrity and damage during shipment. It is recommended that you enter the vessel to inspect possible cracks in the PVC internals.
13. Close all valves and manways.
14. Decide whether to operate vessel in upflow or downflow mode, and connect to process piping accordingly (see upflow vs. downflow operations).
15. Fill the vessel with GAC as described in GAC Transfer Section.
16. Perform bed conditioning as described in Bed Conditioning Section.
17. System is ready for process flow.

Recommended spare parts

Description	Location	Original qty.	Part no.
Butterfly valve w/ handle	Service face piping	7	Grinnell WC-8281-3
Butterfly valve w/ handle	Backwash face piping	4	Grinnell WC-8281-3
Ball valve	Drain / Slurry lines	1	Kitz K150SCTB
Threaded ball valve	Sample port, vent, drain	10	Apollo 70-105
Flange gasket	Face piping	6	1/8" Garlock non-asbestos
Flange gasket	Drain / Slurry lines	10	1/8" Garlock non-asbestos
Manway gasket	Side shells, top heads	4	1/8" Custom cut EPDM
Rupture disk	Top head	2	BS&B Monoblock w/ armor ring, 100-psi @ 72°F
Touchup paint	Internal liner	1-lot	
Touchup paint	External coating	1-lot	

Note: valve, gasket, and disk size vary by the size of the system you have while model being used in consistent, refer to your system drawing or to the tabulated specifications on the following page for nozzle and connection sizes.

Service & Support

Barnebey Sutcliffe Corporation has full service vacuum and re-bed crews around the nation. Our service centers stock a variety of carbon and other filtration medias. The service crew will bring virgin or reactivated carbon to your site and perform the changeouts per your specifications. To obtain pricing information, or to schedule a changeout, please call (800) 886-2272.

If you have technical questions regarding the type of activated carbon you use, other filtration medias, or if you need spare parts for your system, call the same phone number.

It is always helpful, and speeds up service and support inquiries, if you have the model number and job number of your equipment.

Technical Specifications

	LD-110	LD-180 – Modified	LD-360	LD-720
Design Conditions				
Service Flowrate	110 GPM / Vessel	160 GPM / Vessel	275 GPM / Vessel	430 GPM / Vessel
Backwash Flowrate	230 GPM	330 GPM	590 GPM	930 GPM
Max. Pressure	100 PSI	~~100 PSI~~ 75 PSI	100 PSI	100 PSI
Max. Temperature	140°F	140°F	140°F	140°F
ASME Section VIII	Yes*	Yes*	Yes*	Yes*
Heads Type & Flange	2:1 Ellipse, 2" Flg.	2:1 Ellipse, 2" Flg.	2:1 Ellipse, 2" Flg.	2:1 Ellipse, 2" Flg.
Dimensions				
Vessel O.D.	5'-0"	6'-0"	8'-0"	10'-0"
Straight Shell	8'-0"	8'-0"	10'-0"	12'-0"
Head Thickness	3/8"	3/8"	1/2"	5/8"
Shell Thickness	5/16"	3/8"	1/2"	1/2"
Cross Section	19.23 ft^2	27.69 ft^2	49.22 ft^2	77.24 ft^2
Vessel Height	± 12'-1"	± 12'-8"	± 15'-10"	± 19'-2"
Overall Height	± 13'-5"	± 14'-0"	± 17'-7"	± 21'-0"
Weights				
Empty System	10,635 lbs.	11,035 lbs.	22,620 lbs.	44,040 lbs.
Operating	37,655 lbs.	51,550 lbs.	112,260 lbs.	214,750 lbs.
Internals				
Header	4" SA-106B SCH 40	4" SA-106B SCH 40	6" SA-106B SCH 40	8" SA-106B SCH 40
Laterals	2" PVC SCH 80	2" PVC SCH 80	2" PVC SCH 80	2" PVC SCH 80
Slot Gap	0.016"	0.016"	0.016"	0.016"
Nozzles & Connections				
Inlet / Outlet	4" 150# R.F. Flange	4" 150# R.F. Flange	6" 150# R.F. Flange	8" 150# R.F. Flange
Drain	2" 150# Flange	2" 150# Flange	3" 150# Flange	3" 150# Flange
Vent	2" FPT	2" FPT	2" FPT	2" FPT
Rupture Disk	2" Flange	2" Flange	3" Flange	3" Flange
Top & Side Manway	14"x18"x4"x3/4"	14"x18"x4"x3/4"	14"x18"x4"x3/4"	14"x18"x4"x3/4"
Paint System				
Internal	Sand blast to SSPC-SP5, epoxy primer 7.0 – 8.0 mil DFT, epoxy liner 7.0 – 8.0 DFT			
External	Sand blast to SSPC-SP6, epoxy primer 7.0 – 8.0 DFT, epoxy urethane 2.0 – 3.0 DFT			

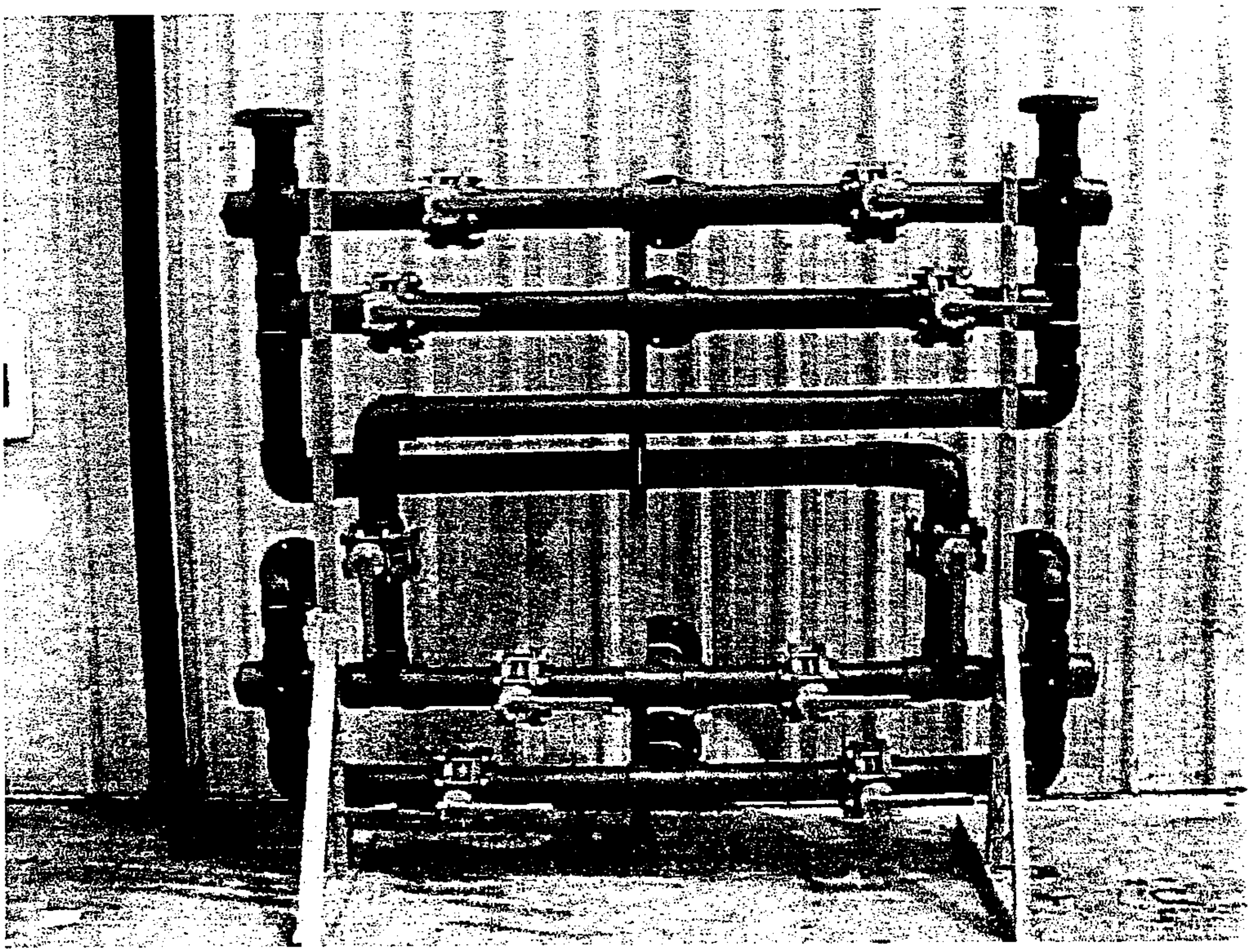
* Vessel is designed per ASME Section VIII code guidelines. The nameplate on your vessel determines whether or not your vessel is code stamped.

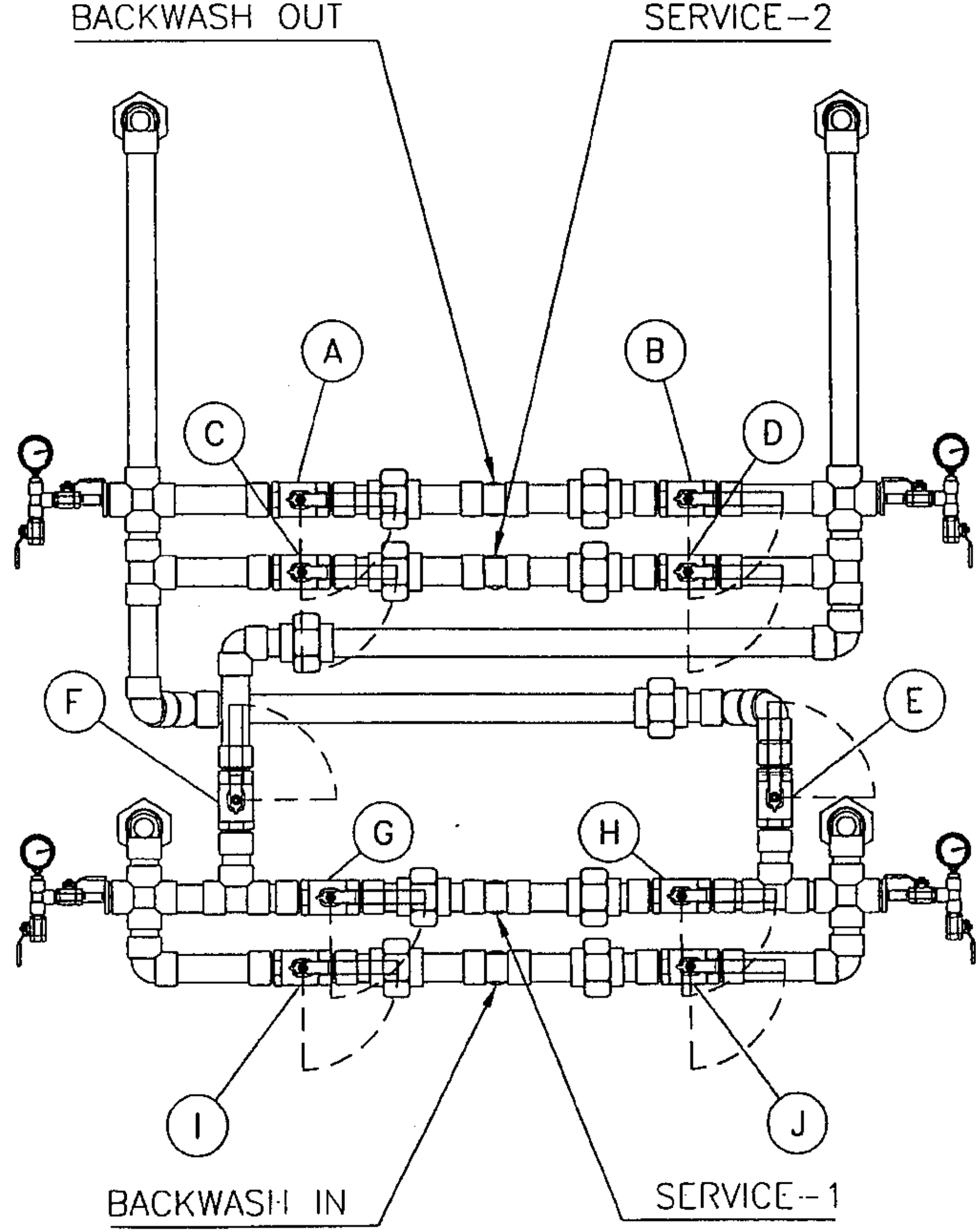
Modes of operation

- When working with the table on the next page, refer to the pipe layout drawing on the following page.
- All valves are in assumed in a closed position except the ones marked with "X" in the table.
- When operating the valves under pressure, always operate valves gradually over a period of 15–30 seconds.
- When changing modes of operation of one vessel while the other vessel is processing, incorrect sequence of valve operation may lead to either system bypass or dead-heading of the flow. When in doubt, turn off feed pump while changing modes of operation.
- Vessel "A" is on the left hand side when facing the vessels from the front (the side with the piping).
- When operating in **downflow**, the label "SERVICE – 2" on the drawing is considered as service inlet. and the label "SERVICE – 1" is considered service outlet.
- When operating in **upflow**, the label "SERVICE – 1" on the drawing is considered as service inlet, and the label "SERVICE – 2" is considered service outlet.
- Some systems are shipped without the optional bypass valve "K".

	Valve Label										
	A	B	C	D	E	F	G	H	I	J	K
Vessel "A" processing			X				X				
Vessel "B" processing				X				X			
Vessel "A" in backwash	X								X		
Vessel "B" in backwash		X								X	
Vessel "A" lead, Vessel "B" lag Downflow			X			X		X			
Vessel "B" lead, Vessel "A" lag Downflow				X	X		X				
Vessel "A" lead, Vessel "B" lag Upflow				X	X		X				
Vessel "B" lead, Vessel "A" lag Upflow			X			X		X			
Vessel "A" and Vessel "B" in parallel			X	X			X	X			
Vessel "A" processing, Vessel "B" in B/W		X	X				X			X	
Vessel "B" processing, Vessel "A" in B/W	X			X				X	X		
System Bypass											X

Lead/Lag Drawing





WATERLINK®
Barnebey Sutcliffe
1-80_-886-2272

STANDARD LEAD/LAG/PARALLEL
PIPING MANIFOLD FOR "MD" SERIES

Not _cale

S. 1 of 1

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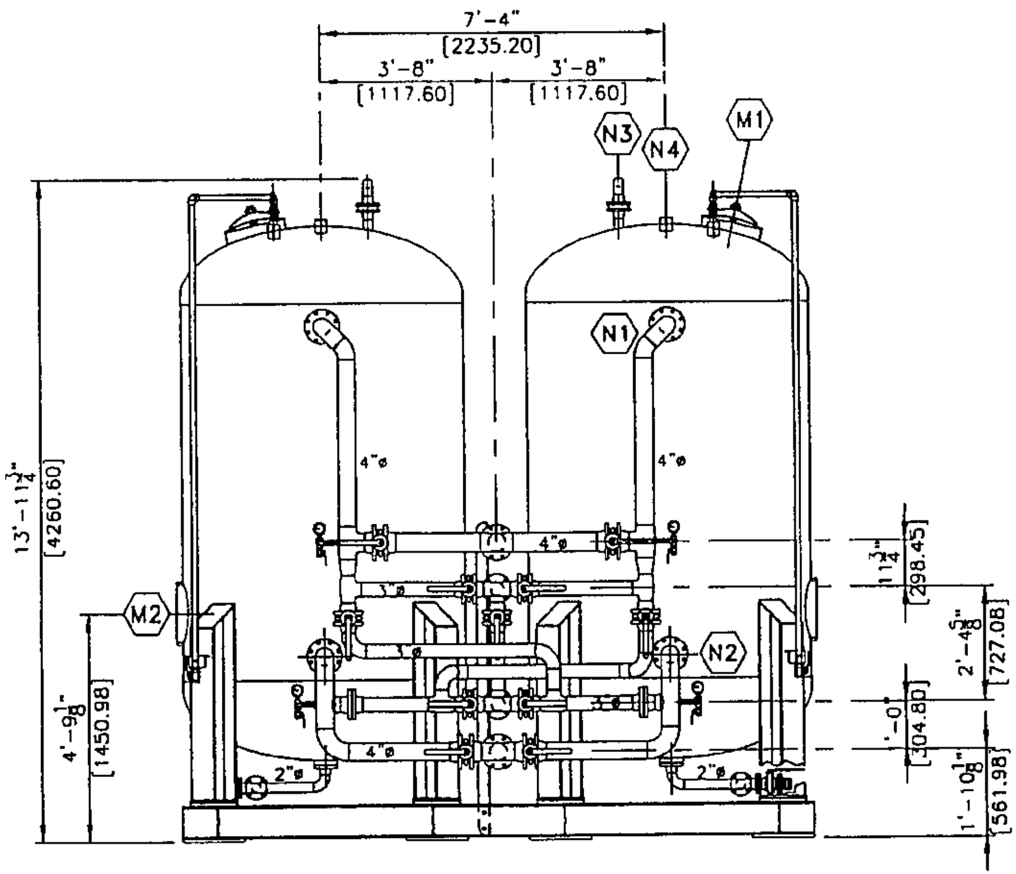
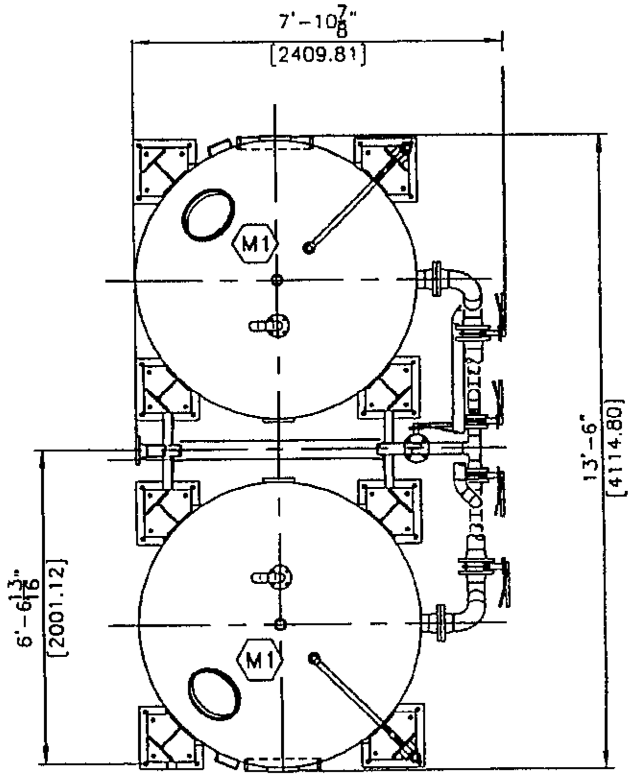
Vessel Drawing

SERVICE FLOWRATE= .. 0 GPM/VESSEL
BACKWASH FLOWRATE= 330 GPM
DESIGN PRESSURE=100 PSI
EST. WEIGHT(EMPTY)= 15500 LBS.
EST. WEIGHT(OPERATING)= 52200 LBS.

NOZZLE	SERVICE	SI.
N1	INLET	4", 150# R.F. FLANGE
N2	OUTLET	4", 150# R.F. FLANGE
N3	DRAIN	2", 150# R.F. FLANGE
N4	VENT	2" FPT
M1/M2	MANWAY	14" X 18", MANWAY



ELEVATION VIEW



PLAN VIEW

WATERLINK®
Ba bey Sutcliffe
1-80 -886-2272

This drawing is a property of Waterlink/Barnebey Sutcliffe Corporation and may NOT be copied wholly or partly or shown to third parties without prior formal written consent by Waterlink/Barnebey Sutcliffe Corporation

1/4' . . -0"

LD-180
LIQUID PHASE ADSORBER

Design & specifications subject change

\Filtration\Liquid\LD\LD180\LD180SALES.dwg 09-14-00 09:12 SC:36 R:14.01

Miscellaneous Cut Sheets

GRINNELL

2" - 12" Series 8000 Butterfly Valve Features

Patent No. 4,552,332 Dated 11-12-85

Pressure Rating:
200 PSIG WOG (non-shock)
150 PSIG WOG (non-shock) TFE
200 PSIG WOG (non-shock) dead-end service
Full Vacuum Service

Patented design complies with MSS-SP-67 and API 609.**
Coast Guard approved to 46CFR56.20-15(b) (1).

1. **ACTUATION HANDLES & ACTUATORS** — A variety of handles, gear operators, and actuators are available.

2. **STEMS** — Stem diameters are sized for rugged service and meet AWWA C-504-80 stem diameter requirements. Two piece design for easy maintenance. Drive stem flatted for actuation.

3. **STEM BUSHINGS** — Upper and lower bronze bushings are standard. Teflon* bushings are available as an option.

4. **STEM/DISC ATTACHMENT** — Rectangular drive ensures proper stem-to-disc assembly. Disc "floats" inside the liner — ensuring positive sealing and extending seat life. No pins or bolts are exposed to flow.

5. **DISC** — Streamlined for maximum flow and minimum seat wear. Special coatings available.

6. **BODY** — Standard long neck body provides full clearance for 2 inches of insulation on ANSI 150 pipe flanges. Valve is designed to fit between 125/150 class ANSI flanges, including slip-on. All lugs are tapped.

7. **LOCATING LUGS** — All wafer style valves have locating lugs for ease of installation.

8. **SEAT** — Elastomer reinforced with phenolic backing ring enables seat to be field replaced. Grinnell's special double seal design eliminates the need for flange gaskets.

9. **POSITIVE STEM RETENTION** — Pin retains stem in body at all times, allowing removal of handle or actuator while under full service pressure.

10. **NOTCHES IN THE NECK FLANGE** — Notches identify bolt holes used to mount handles and gear operators. This feature coupled with disc drive assures correct assembly.

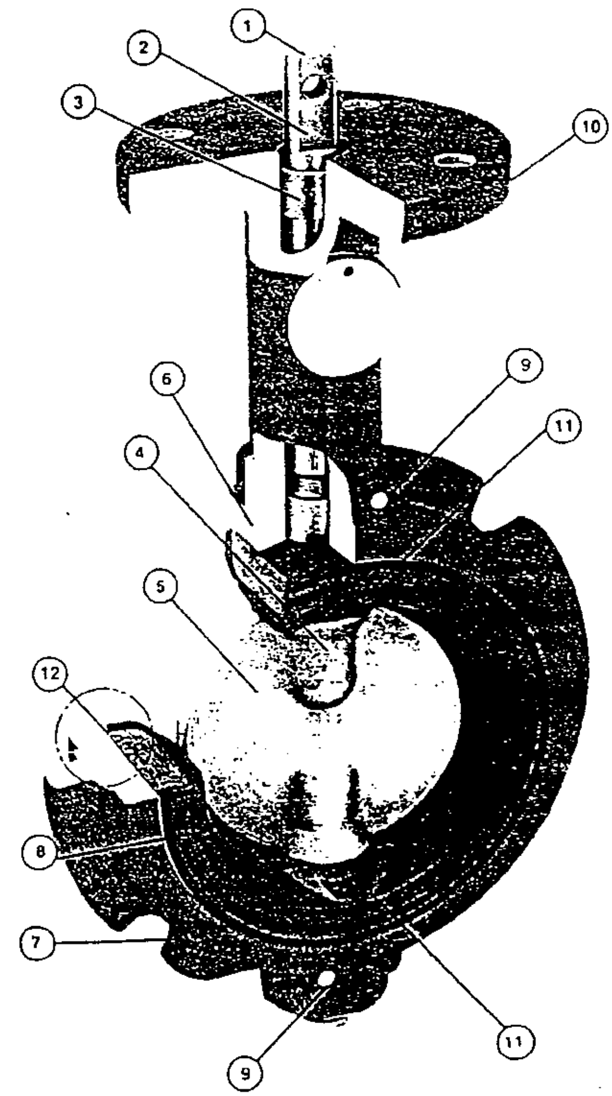
11. **"O"-RING SEALS** — Three back-up stem seal molded into seat liner to support primary seal on flat of disc.

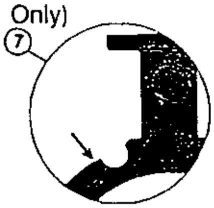
12. **UNIQUE INTEGRAL RETENTION LIP FOR DEAD END SERVICE** — Lip integral to the body prevents liner from moving downstream. Eliminates seat and flange leakage. Permits full rated pressure differential when used with single flange on upstream side. (Lug Style Only)

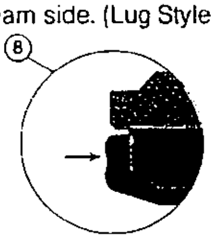
★ Every Butterfly Valve is seat tested for bubble-tight closure.
2" - 12" sizes tested both sides at 110% of rated pressure.

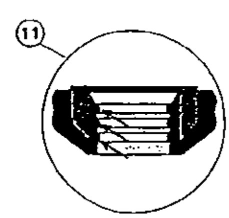
* Teflon — E. I. Dupont trademark or equivalent.

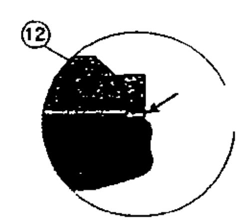
** Butterfly valves can be shell tested per spec. on request.











How to Order: Series 8000 Butterfly Valves

ORDER BY FIGURE NUMBER

SIZE 2-24" —————— **8" W C — 8 2 7 2 — 3 — S**

BODY STYLE
- W- Wafer
- L- Lug

BODY MATERIAL
- B- Bronze
- C- Cast Iron
- D- Ductile Iron
- E- Epoxy Coated C.I.
- N- Electroless NI Plated Iron
- X- Special ■

S - SS-316

SERIES
8-8000

SEAT MATERIAL
- 0- Teflon**
- 1- Buna-N
- 2- EPDM
- 3- Food-Grade Buna-N
- 4- White Neoprene
- 5- Viton*
- 6- Black Neoprene
- 7- Hypalon
- 8- Natural Rubber
- 9- Food-Grade EPDM
- X- Special ■

DISC MATERIAL
- 0- Nickel-plated ductile iron
- 3- PVDF (Kynar) coated***
- 4- Rubber coated
- 7- 316 S.S.
- 8- Bronze (Al-Brz)
- X- Special ■

OPERATOR
- 0- None
- 1- 10 Pos. L/Lock
- 2- Gear Operator
- 3- Double Acting Pneumatic
- 4- Electric
- 5- Spring Return Pneumatic
- 6- Square Nut (with Gear Operator)
- 7- Chain Wheel (with Gear Operator)
- 9- Infinite Lever w/memory Stop
- A-10 Pos. Pushlock
- B- 2 Pos. Pushlock
- C- 2 Pos. L. Lock
- X- Special ■

STEM
- 3- 416 S.S. w/bronze bushings
- 4- 316 S.S. w/bronze bushings
- 5-316 S.S. w/bronze bushing and shaft vent hole
- 6- 416 S.S. w/TFE bushing
- 7- 316 S.S. w/TFE bushing
- X- Special ■

Special Configuration

(leave blank if none)

- S- Sanitary
- R-50 PSI disc
- FP- UL/ULC listed FM Approved
- FS- UL listed FM Approved One Internal Monitor Switch
- FD- UL listed FM Approved Two Internal Monitor Switches

■ Details Required.
*Viton, an E.I. DuPont Trademark or 3-M's Fluorel will be supplied.
**Teflon, an E.I. DuPont Trademark or equivalent will be supplied.
***Kynar, a Pennwall Corp. Trademark or equivalent will be supplied.
Note: Operator designations 3, 4 & 5, must have actuator name, number, and details.

Material Specifications

Material Specifications — ASTM References

BODY		DISC		STEM	
Material	**Spec.**	**Material**	**Spec.**	**Material**	**Spec.**
Cast Iron	A126 CL.B	Ductile Iron	A536, 65-45-12 A395, 60-40-18	416 S.S.	A582, Type 416
Ductile Iron	A536, 65-45-12 A395, 60-40-18	316 S.S.	A351-CF8M	316 S.S.	A276, Type 316
		Aluminum Bronze	B148; C95400		
Aluminum Bronze	B148, C95400	Cast Iron	A126 CL.B		

BUSHINGS	
Material	**Spec.**
Bronze	B584 C93200
Teflon	Gar-Fil *

* GAR-FIL, a Garlock Bearings Inc. Trademark.

Materials Description: Series 8000 Butterfly Valves

SEATS

BUNA-N — Rated for temperatures 0°F to 180°F. Buna-N is also commonly identified as NBR, NITRILE, or HYCAR®. It is an excellent general purpose elastomer suitable for use with air, water as well as most petroleum oils and greases, automotive gasolines (except those which have additives), alcohols and glycols, L-P gases, propane and butane, fuel oils and many other fluids. It also exhibits good abrasion resistance, and excellent resistance to compression set.

VITON — Rated for temperatures 0°F to 300°F.
Viton is an E.I. DuPont trademark. Fluorel is 3M's trademark for the equivalent fluorocarbon elastomer. This material offers higher temperature resistance and outstanding chemical resistance. It is resistant to hydrocarbon products and mineral acids, both dilute and concentrated solutions. However, it is never to be used in steam applications and is relatively poor in water service.

EPDM — Rated for temperatures -20°F to 250°F.
EPDM is an abbreviation of a compound called Ethylene Propylene Diene Monomer. It is also commonly called EPT, Nordel, and EPR. EPDM is used extensively in the HVAC (Heating, Ventilation, Air Conditioning) industry due to its resistance to polar compounds such as water, phosphate esters, ketones, alcohols, and glycols. The EPDM material is also applicable for handling concentrated sulfuric acid, 20% sodium hypochlorite (bleach), chlorinated water for swimming pools, and other alkaline solutions. EPDM is not resistant to hydrocarbon solvents and oils, chlorinated hydrocarbons, turpentine, or any other petroleum based oils.

TEFLON® — Rated for temperatures -20°F to 250°F. The Teflon liner overlays silicone which is bonded to a rigid phenolic ring on the outside seat perimeter. Teflon extends over the seat faces and outside flange seal diameter, completely covering the silicone elastomer layer of the seat which provides the resilience for sealing valve stems and the closed disc

SPECIAL VALVE SEATS

FOOD GRADE BUNA-N — Rated for temperatures 0°F to 180°F
FDA approved Buna-N seat in which all ingredients in the elastomer conform to CFR part 21, section 177.2600. Service conditions are equivalent to those recommended for regular Buna-N including applications where FDA approval is required.

SPECIAL VALVE SEATS (Continued)

FOOD GRADE EPDM — Rated for temperatures -20°F to 250°
FDA approved EPDM seat in which all ingredients in the elastomer conform to CFR part 21, section 177.2600. Service conditions are equivalent to those recommended for regular EPDM including applications where FDA approval is required

WHITE NEOPRENE — Rated for temperatures 0°F to 180°F
FDA approved white Neoprene seat in which all ingredients in the elastomer conform to CFR part 21, section 177.2600. Neoprene has excellent resistance to alcohols, glycols, dilute mineral acids, concentrated caustics, and aqueous salt solutions. White Neoprene is generally used in sanitary applications and although it is slightly inferior to Buna-N in oil resistance, it is markedly better than most elastomers in these applications.

BLACK NEOPRENE — Rated for temperatures 0°F to 180°F
FDA approved black Neoprene seat in which all ingredients in the elastomer conform to CFR 21, section 177.2600. Neoprene offers excellent physical properties where resistence to alcohols, glycols, dilute mineral acids, concentrated caustics, aqueous salt solutions, and mild abrasion resistance is required. The black grade provides better abrasion and oil resistance than the white grade Neoprene, and although it is slightly inferior to Buna-N in oil resistance, it provides excellent service in water/oil, air/oil services.

HYPALON — Rated for temperatures 0°F to 225°F
Hypalon is the E.I. DuPont trademark for chlorosulfonated polyethylene. Hypalon is resistant to most chemicals and greases and is particularly unaffected by aqueous salt solutions, alcohols, weak and concentrated alkalies, and concentrated sulfuric acid. It is not recommended for gasoline, jet fuels, ketones, or chlorinated solvents. Hypalon has excellent abrasion resistance and is unaffected by prolonged immersion in water.

Special elastomer liners are also available for specific applications on request.

DISC COATINGS

PVDF Coated Disc — Rated for temperatures -20°F to 275°F.
Polyvinylidene fluoride also known as Kynar® is a strong, tough fluoroplastic material that is particularly suited to corrosion resistant applications in severe environments. The coating has a high degree of mechanical strength, and is chemically resistant to most acids and bases over a broad temperature range. (min. thickness 20 mils).

Rubber Covered Disc EPDM — Rated for temperatures -20°F to 250°F
EPDM rubber covered disc provides excellent wear and abrasion characteristics for use in highly abrasive environments. The EPDM elastomer also provides the disc with chemical resistance for handling certain acids, esters, ketones and all types of water service where normal metal discs cannot be used due to chemical and/or abrasive conditions. The EPDM covered discs are not recommended for use in hydrocarbon solvents and oils, chlorinated hydrocarbons, turpentine, or any other petroleum based oils. Other rubber materials available upon request.

Note: A. Phenolic reinforced seats standard on 2" - 24"
B. Letter identification of phenolic reinforced liners on I.D. of liner is:

NB = Buna-N	EP = EPDM	CR = Black Neoprene	EM = Food-Grade EPDM
FK = Viton	CS = Hypalon	CF = White Neoprene	

Hycar — Trademark of B. F. Goodrich Nordel and Teflon — Trademarks of E.I. DuPont.
Kynar — Trademark of Pennwalt Corp.

BS&B

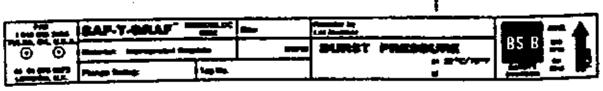
SAFETY SYSTEMS

SAF-T-GRAF™ RUPTURE DISK

INSTALLATION INSTRUCTIONS

BULLETIN
77-8500I

- NEW INSTALLATIONS
- REPLACEMENT OF DISKS IN EXISTING INSTALLATIONS
- ORDER REPLACEMENT DISKS BY LOT NUMBER



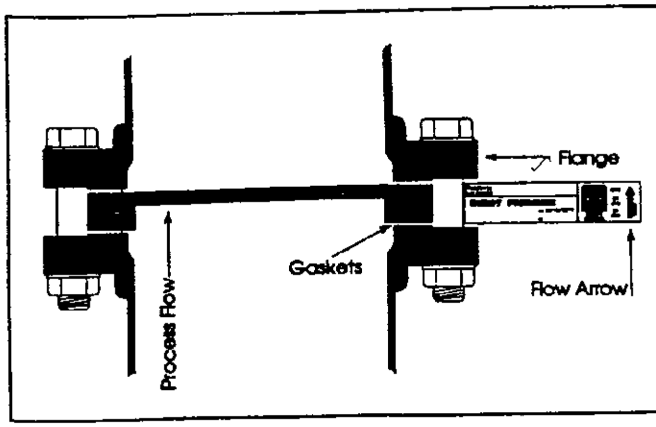
Select proper location

1. **CAUTION-VENT TO SAFE AREA**
   Check the location. Do not locate where personnel or property could be exposed to product and fragments from graphite rupture disks being discharged through the vent opening. Any equipment or property in the vicinity of discharge could be damaged.
2. Consider recoil or "kickback." Recoil is the force the system will experience upon rupture. Recoil (lbs.) is approximately twice the disk rating (psig) times the relief area (in.^{2}). Provide adequate support to piping and connections. If the discharge is free-vented, a baffle plate mounted on the vent opening with extra length studs will minimize recoil.
3. Provide adequate support for the downstream vent piping. The rupture disk should not be subjected to excessive structural bending stresses.
4. The rupture disk must match the companion flange size and rating.
5. Flange materials should be compatible with your process.

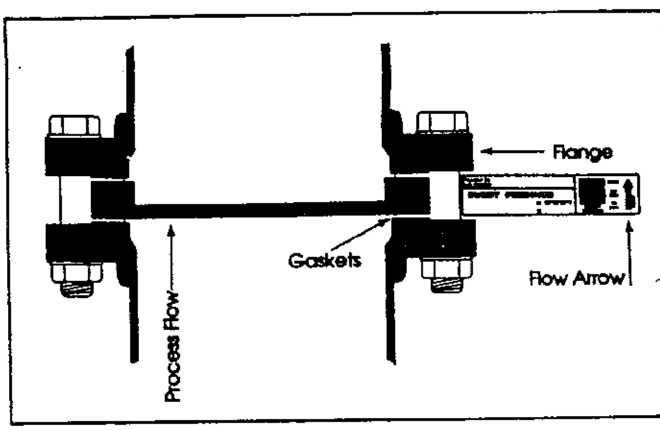
BEFORE YOU INSTALL THE RUPTURE DISK

1. Inspect Flange.
   Clean seating surfaces of both flanges before installing rupture disk. Pits, dirt or grit can damage rupture disk or cause leakage.
2. Inspect Rupture Disk.
   Handle rupture disk carefully — it is a precision instrument. Examine disk surfaces before installing. DO NOT INSTALL THE DISK IF THERE IS ANY DAMAGE. A damaged disk is any disk with visible nicks, scratches — it must not be installed. Installation of a damaged disk may result in premature rupture of the disk. However, even if damaged, it will still open completely below the disk's rated pressure.
3. Disk materials should be compatible with your process.
   NOTE: Corrosion and service conditions may affect disk life thus requiring periodic change.

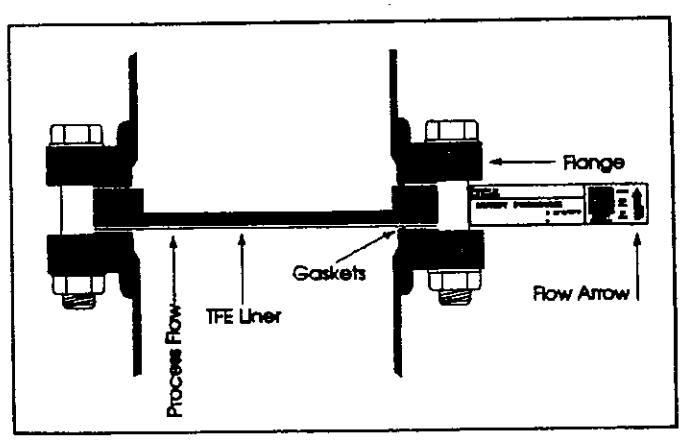
MONOBLOC



INVERTED MONOBLOC



INVERTED MONOBLOC WITH LINER



REPLACE 3/22/01

INSTALL THE GRAPHITE RUPTURE DISK

1. Insert the rupture disk in the pressure system. MAKE SURE FLOW ARROW ON NAMEPLATE POINTS THE DIRECTION YOU WANT FLOW TO OCCUR UPON RUPTURE.

2. Install studs with nuts. Tighten all nuts finger-tight before torquing. Evenly torque the studs to the values in the table below. I torque can be achieved by applying 1/4 of desired final torque to each stud. Repeat pattern by torquing to 3/4 of the desired final torque. Then, using same pattern, torque to full specified torque. Do not over torque. Uneven or excessive torquing may cause a premature burst.

TORQUE TABLE

SIZE		COMPANION FLANGE RATING			TORQUE	
Inches	mm	ANSI	DIN & AFNOR	JIS	ft • lb	N • m
1/2	15	150/300	10/16/25/40	10/16/20/30	6	8
3/4	20	150/300	10/16/25/40	10/16/20/30	8	11
1	25	150/300	10/16/25/40	10/16/20/30	10	14
1 1/2	40	150/300	10/16/25/40	10/16/20/30	14	19
2	50	150	10/16/25/40	10	20	27
2	50	300	—	16/20/30/40	10	14
3	80	150	—	—	40	55
3	80	300	10/16/25/40	10/16/20/30	26	36
4	100	—	—	16/20/30/40	24	33
4	100	150/300	10/16/25/40	—	30	41
6	150	150	10/16/25/40	—	40	55
6	150	300	—	16/20/30/40	31	43
8	200	150	10	—	50	69
8	200	300	16/25/40	10/16/20/30	38	52
10	250	150/300	10/16/25	10/16/20	60	82
10	250	—	40	30/40	50	69
12	300	150	10/16	—	70	96
12	300	300	25/40	10/16/20/30/40	58	80
14	350	150	—	—	75	103
14	350	300	10/16/25/40	10/16/20/30	63	86
16	400	150	16/25	10/16/20/30/40	84	115
16	400	300	10/40	—	68	93
18	450	150	—	—	87	119
18	450	300	10/16	10/16/20	75	103
20	500	150/300	10/16/25/40	10/16/20	85	117
24	600	150/300	10/16/25/40	10/16/20	85	117

NOTES:

1. Torque values are based on free running and lightly oiled threads.
2. The torque values are based on using compressed fiber gaskets. Do not use spiral wound, fiber-filled gaskets.
3. Torque values are for use with companion flanges that have a minimum yield strength of 25,000 PSI. Consult BS&B when u other flange materials such as glass lined, when suppliers recommend a maximum torque value which is lower than the BS required torque value.

LIMITATIONS OF WARRANTIES

BS&B Safety Systems, Inc. warrants its products against defective workmanship and material under normal and proper use in service for a period of twelve (12) months from the date of shipment, when owned by the original buyer and only when subject to normal operating conditions outlined by Buyer when the order is placed; except that, rupture disks are not guaranteed except to burst within specified pressure ranges at temperatures specified at the time of sale.

Where the products involved include a rupture disk inside a rupture disk holder, each must be of the proper type to be utilized with its mating part as otherwise recommended by and manufactured by BS&B. BS&B specifically disclaims any warranty and any and all liability for damages, either direct or indirect, incidental or consequential arising from the use of rupture disk assemblies not wholly comprised of BS&B manufactured products.

Any article not manufactured by BS&B and which is sold hereunder is sold only under such warranties as the manufacturer thereof extends to BS&B and which BS&B to can pass through to the Buyer and enforce with reasonable effort.

Because of the effects of corrosion or erosion caused by acids, chemicals, fumes, rust, dirt, debris and other factors of storage, use, and installation, over which BS&B has no control, BS&B makes no other warranties beyond those expressly stated in this limited warranty.

THE EXPRESSED WARRANTIES HEREINBEFORE GIVEN BY BS&B SAFETY SYSTEMS, INC. ARE EXCLUSIVE AND IN LIEU OF ALL WARRANTIES EXPRESSED OR IMPLIED, BY OPERATION OF LAW OR OTHERWISE, INCLUDING, WITHOUT LIMITATION, ANY IMPLIED WARRANTY OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE.

SAF-T-GRAF™

BS&B

SAFETY SYSTEMS

BS&B Safety Systems
7455 East 46th Street
P.O. Box 470590
Tulsa, OK 74147-0590
Telephone: 918-622-5950
Facsimile: 918-665-3905
Telex: BSB UI 4630133

ISO 9001 Quality System Certification

U.S.A. — TÜV CERT — Cert. Reg. No. QA-346

Europe — Cert. Reg. No. M262

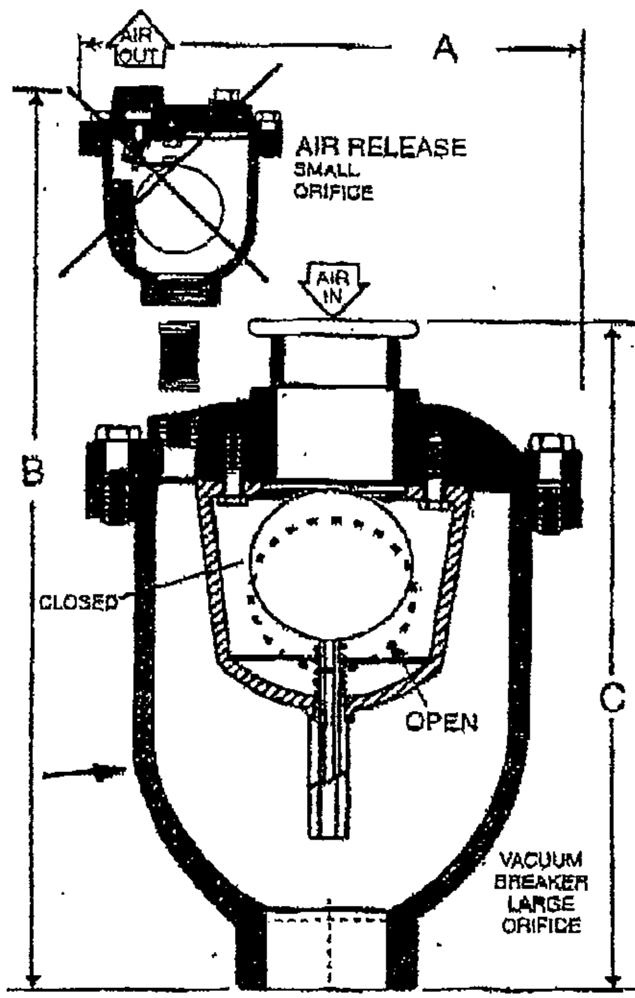
BS&B Safety Systems Ltd.
Centre House
68 Sheen Lane
London SW14 8LP England
Telephone: 44-181-392-1333
Facsimile: 44-181-876-0573
Telex: 892924 BSB EH

LITHO BY BS&B

CLA-VAL

Series 38VB/AR

Vacuum Breaker / Air Release Valve Threaded Style



STYLE
2.
Threaded

VACUUM BREAKER/AIR RELEASE

SIZE NPT	MODEL NO.	A	B
1/2"	38.5	6 1/8"	14"
1"	VB/AR	7 1/2"	15 1/2"
2"	381	10"	18"
3"	VB/AR	10"	18"

*Not Illustrated

VACUUM BREAKER (ONLY)

SIZE	MODEL NO.	A	B	C
1/2"	38.5 VB	6 1/8"	7"	9"
1"	381 VB	7 1/4"	9 1/2"	12"
2"	382 VB	10"	12"	14"
3"	383 VB	10"	12"	15"

CLA-VAL P.O. Box 1325 • Newport Beach, CA 92659-0325 • Phone: 949-722-4800 • Fax: 949-548-5441 • E-mail: claval@cla-val.com • Website cla-val.com

MONARCH INSTRUMENT

Innovation in Instrumentation

QK-101

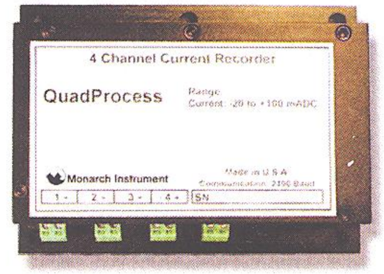
DataChart® QUADPROCESS
4 CHANNEL CURRENT DATA LOGGER

Features

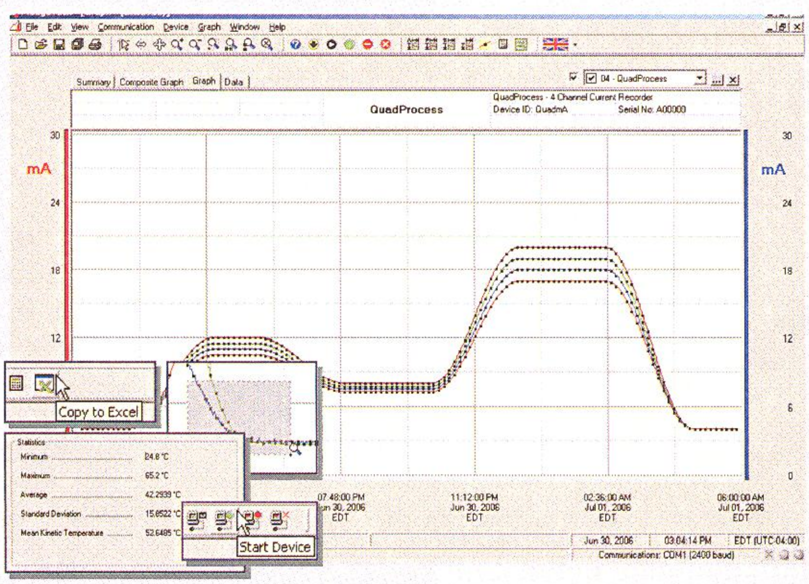
- 16-bit readings provide high resolution
- User-defined engineering units
- Programmable start time and recording interval
- Low cost
- Real-time operation
- Reusable
- Compact
- User-friendly
- CE compliant

Applications

- 4 to 20 mA recording
- pH recording
- Low level signal monitoring
- Photovoltaic studies
- Battery studies
- Biological sensor monitoring
- Factory process control
- Research and development
- Medical and Pharmaceutical
- Environmental studies



The QuadProcess is a 4-channel, battery powered, stand alone current recorder. This is an all-in-one compact, portable, easy to use device that will measure and record up to 32,767 measurements per channel. The storage medium is non-volatile solid state memory, providing maximum data security even if the battery becomes discharged. The device can be started and stopped directly from your computer and its small size allows it to fit almost anywhere. The QuadProcess makes data retrieval quick and easy. Simply plug it into an empty COM or USB port and our user-friendly software does the rest.



Monarch Data Logger Software.
Displays current data in an easy to use graph.

The Windows®-based software package allows the user to effortlessly collect, display and analyze data. A variety of powerful tools allow you to examine, export, and print professional looking data with just a click of the mouse.

Click Monarch Data Logger Software Link for more information or to download the software.

Monarch Instrument, 15 Columbia Drive, Amherst NH 03031
Phone: 800-999-3390 / 603-883-3390. Fax: 603-886-3300
sales@monarchinstrument.com / www.monarchinstrument.com

QUADPROCESS SPECIFICATIONS*

Nominal Range:	±1mA	±25mA	±100mA
Measurement Range:	±1.5mA	±30mA	±120mA
+/- Input Voltage Range:	0 to 2.5V	0 to 2.5V	0 to 2.5V
Resolution:	0.05μA	1μA	5μA
Calibrated Accuracy:	±0.5%FSR	±0.1%FSR	±0.1%FSR
Input Impedance:	50Ω	10Ω	2Ω
Overload Protection:	±20mA	±100mA	±125mA

Specified Accuracy Range: Nominal range @ 25°C

Input Connection: 4, 3-input removable screw terminals

Analog Conversion Time: 133 ms

Frequency Rejection: 60 Hz

Temperature Coefficient: < 100 ppm/°C; < 50 ppm/°C typical

Engineering Units: User may define units up to 10 characters in length. This value is stored within the device.

Scale Factor: User may program any desired scaling factor from ±1.000E-31 to ±9.999E+31. The scaling factor is stored within the device.

Start Modes: Software programmable immediate start or delay start up to six months in advance

Memory: 32,767 readings per channel; 131,068 total readings

Reading Rate: 1 reading every second to 1 every 12 hours

Real Time Recording: May be used with PC to monitor and record data in real-time

Calibration: Digital calibration through software

Calibration Date: Automatically recorded within device

Battery Type: 9V lithium or alkaline battery included; **user replaceable**

Battery Life: 1 year typical

Time Accuracy: ±1 minute/month at 20°C (RS232 port not in use)

Data Format: Date and time stamped A, mA, μA, engineering units specified through software

Software: Windows 95/98/ME/NT/2000/XP/Vista based software

Computer Interface: PC serial or USB (interface cable required); 2,400 baud

Operating Environment: -20 to +60°C, 0 to 95%RH non-condensing

Dimensions: 3.5" x 4.4" x 1.0" (89mm x 112mm x 26mm)

Weight: 13 oz (370 g)

Approvals: CE

Common mode voltage must be less than 3 volts. All inputs must be within 3 volts of all other inputs.

BATTERY WARNING: DISCARD USED BATTERY PROMPTLY. KEEP OUT OF REACH OF CHILDREN. DO NOT DISPOSE OF IN FIRE, RECHARGE, PUT IN BACKWARDS, DISASSEMBLE, OR MIX WITH OTHER BATTERY TYPES. MAY EXPLODE, FLAME OR LEAK AND CAUSE PERSONAL INJURY.

SOFTWARE FEATURES

Multiple Graphs: Simultaneously analyze data from several units or deployments; easily switch to a single data series

Graphical Cursor: One click displays readings by time, value, parameter or sample number

Data Table: Instantly access tabular view for detailed dates, times, values, and annotations

Scaling Options: Autoscale function fits data to the screen, or allows user to manually enter their own values

Formatting Options: Change colors, line styles, plotting options, show or hide channels quickly

Statistics: Calculate averages, min, max, standard deviation, and mean kinetic temperature with the touch of a button

Export Data: Export data in a variety of common formats, or switch to Excel® with a single click

Calibration: Automatically calculate and store calibration parameters

Logger Configuration: Easy set up and launch of data loggers with immediate or delayed start, preferred sample rate, and device ID

Communications: Automatically sets up communications port, or lets user select configuration

*SPECIFICATIONS ARE SUBJECT TO CHANGE WITHOUT NOTICE. SPECIFIC WARRANTY AND REMEDY LIMITATIONS APPLY.

ORDERING INFORMATION

Part Number	Model	Description
5399-0504 –1mA	QUADPROCESS-1mA	±1mA 4 Channel Current Recorder
5399-0504 –25mA	QUADPROCESS-25mA	±25mA 4 Channel Current Recorder
5399-0504 –100mA	QUADPROCESS-100mA	±100mA 4 Channel Current Recorder
5399-9903	IFC110	Software, manual and RS232 interface cable
5399-9934	IFC202	Software, manual and USB interface cable
5399-NIST	NIST	N.I.S.T. Calibration Certificate
5399-9914	U9VL-J	Replacement battery for QuadProcess

Monarch Instrument, 15 Columbia Drive, Amherst NH 03031
Phone: 800-999-3390 / 603-883-3390. Fax: 603-886-3300
sales@monarchinstrument.com / www.monarchinstrument.com

2010.05.13

SIEMENS

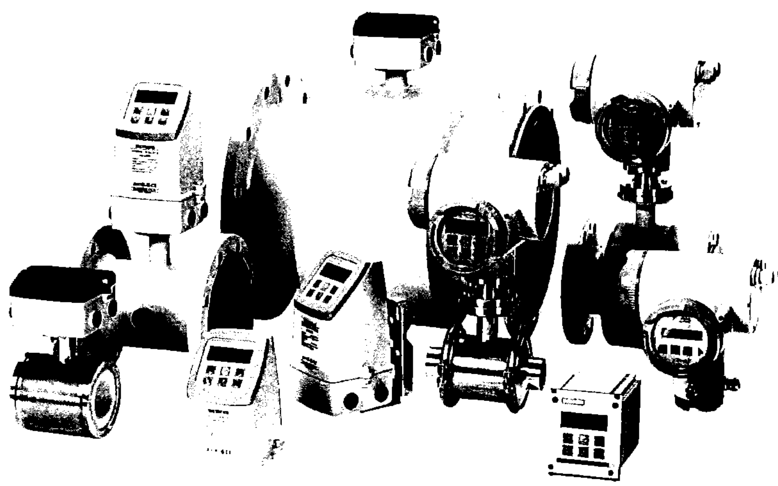
Operating Manual

Edition 05/2006 - Revision 05

SITRANS F M MAGFLO®

Electromagnetic flowmeters

Transmitter types MAG 5000, MAG 6000



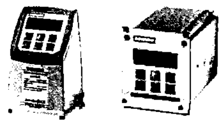
Technical Documentation (handbooks, instructions, manuals etc.) on the complete product range SITRANS F can be found on the internet/intranet on the following links:

English: http://www4.ad.siemens.de/WW/view/en/10806951/133300

Order no.: FDK-521H0739

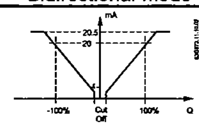
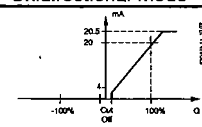
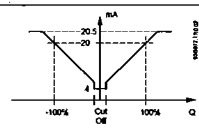
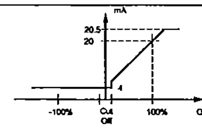
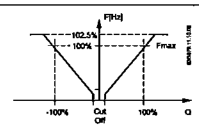
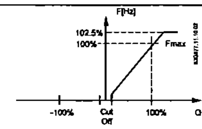
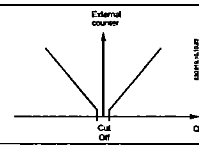
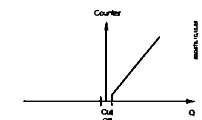
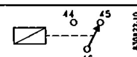
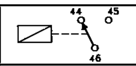
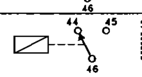
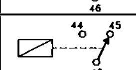
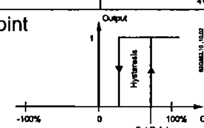
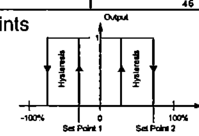
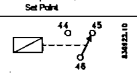
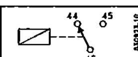
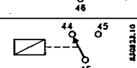
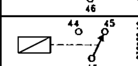
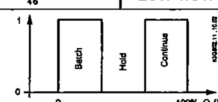
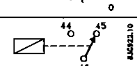
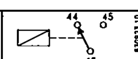
SFIDK.PS.027.Z8.02

1.1 Transmitter type MAG 5000 & MAG 6000

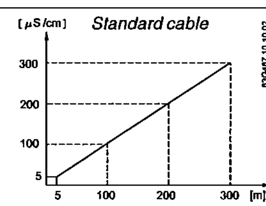
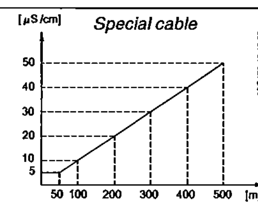
		**MAG 5000 accuracy 0.5%** **MAG 6000 accuracy 0.25%**		
Current output				
	Current	0-20 mA, 4-20 mA or 4-20 mA + alarm		
	Load	< 800 ohm		
	Time constant	0.1-30 s adjustable		
Digital output				
	Frequency	0-10 kHz, 50% duty cycle		
	Time constant	0.1-30 s adjustable		
	Active	24 V DC, 30 mA, 1 KΩ ≤ R_{load} ≤ 10 KΩ, short-circuit-protected		
	Passive	3-30 V DC, max. 110 mA, 200 Ω ≤ R_{load} ≤ 10 KΩ		
Relay	Time constant	Changeover relay, time constant same as current time constant		
	Load	42 V AC/2 A, 24 V DC/1A		
Digital input		11-30 V DC, R_i = 4.4 KΩ		
	Activation time	50 ms		
	Current	$I_{11\ V\ DC}$ = 2.5 mA, $I_{30\ V\ DC}$ = 7 mA		
Functions		Flow rate, 2 totalizers, low flow cut-off, empty pipe cut-off, flow direction, error system, operating time, uni/bidirectional flow, limit switches, pulse output, control for cleaning unit and batch²)		
Galvanic isolation		All inputs and outputs are galvanically isolated		
Cut-off	Low flow	0-9.9% of maximum flow		
	Empty pipe	Detection of empty pipe¹)		
Totalizer		Two eight-digit counters for forward, net or reverse flow		
Display		Background illumination with alphanumerical text, 3 x 20 characters to indicate flow rate, totalized values, settings and faults		
		Reverse flow indicated by negative sign		
	Time constant	Time constant as current output time constant		
Zero point adjustment		Automatic		
Electrode input impedance		> 1 x 10^{14} Ω		
Excitation frequency		Sensor size depending pulsating DC current (125 mA)		
Ambient temperature		Display version during operation: –20 to +50°C		
		Blind version during operation: –20 to +60°C		
		During storage: –40 to +70°C (RH max. 95%)		
Custody transfer approval		PTB (cold water) 6.221 99.19	DANAK OIML R75²) (hot water)	DANAK OIML R117²) (cold water/milk, beer etc.)
Communication				
	Standard	Prepared for client mounted add-on modules²)		
	Optional	HART, Profibus PA & DP, Modbus RTU, CANopen, DeviceNet as add-on module²), HART (MAG 5000)		
Compact				
	Enclosure material	Fibre glass-reinforced polyamide		
	Enclosure rating	IP 67 to EN 60529 and DIN 40050 (1 m w.g. for 30 minutes)		
	Mechanical load	18-1000 Hz random, 3.17 G rms in all directions to EN 60068-2-36		
19" insert				
	Enclosure material	Standard 19" insert of aluminium/steel (DIN 41494)		
		Width: 21 TE		
		Height: 3 HE		
	Enclosure rating	IP 20 to EN 60529 and DIN 40050		
	Mechanical load	Version: 1 G, 1-800 Hz sinusoidal in all directions to EN 60068-2-36		
EMC performance		Emission: EN 50081-1 (Light industry)		
		Immunity: EN 50082-2 (Industry)		
Supply voltage		115-230 V AC +10% to –15%, 50-60 Hz		
		11-30 V DC or 11-24 V AC		
		Fuse: 250 V ~ 500 mA T		
Power consumption		230 V AC: 17 VA		
		24 V DC: 9 W, I_N = 380 mA, I_{ST} = 8A (30 ms)		
		12 V DC: 11 W, I_N = 920 mA, I_{ST} = 4A (250 ms)		

¹) Special cable required in separate mounted installation
²) MAG 6000 only

1.2 Output characteristics MAG 5000 & MAG 6000

Output characteristics	Bidirectional mode		Unidirectional mode	
0-20 mA				
4-20 mA				
Frequency				
Pulse output				
Relay	Power down		Active	
Error relay	No error		Error	
Limit switch or direction switch	1 set point 		2 set points 	
	Low flow (Reverse flow)		Intermediate flow	
	High flow (Forward flow)		High flow/ Low flow	
Batch on digital output *(MAG 6000 only)*				
Batch on relay *(MAG 6000 only)*	Hold		Batch	

1.3.1 Sensor cables and conductivity of medium

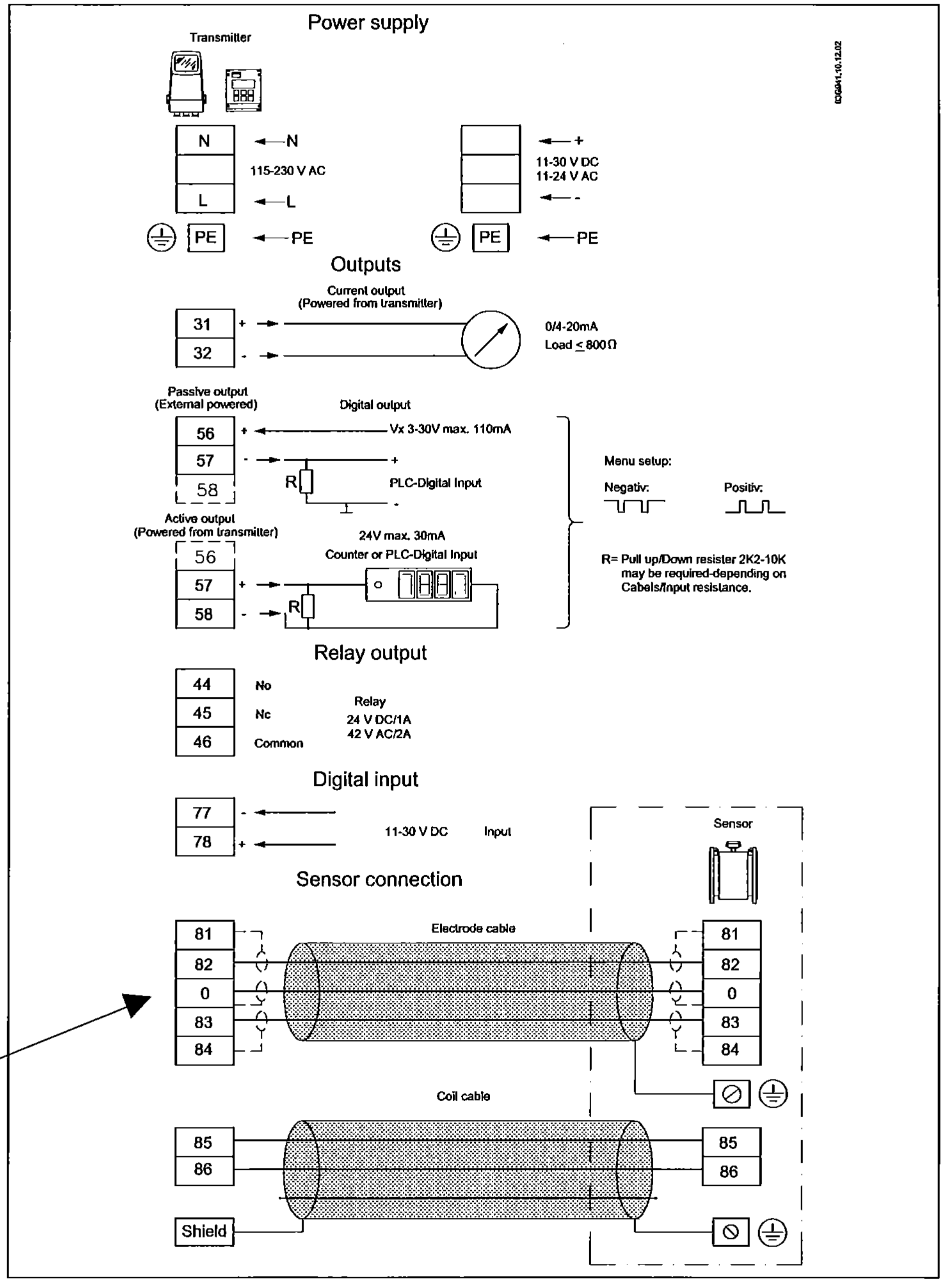
Conductivity of medium	**Compact installation:** Liquids with an electrical conductivity ≥ 5 µS/cm. For a conductivity between 5 and 10 µS/cm, the repeatability may degrade to ±0.5% of actual flow.
	Remote installation:  

Note For detection of empty sensor the min. conductivity must always be ≥ 20 µS/cm and the max. length of electrode cable when remote mounted is 50 metres. Special cable must be used. For remote mounting in Ex applications special cable cannot be used, empty sensor cannot be detected and the electrically conductivity must be ≥ 30 µS/cm.
For remote mounted CT installations the max. cable length is 200 metres.

1.3.2 Minimum accept data for cable

		Coil cable	*Electrode cable*
Basic data	No. of conductors	2	3
	Min. sqr. area	0.5 mm²	0.2 mm²
	Screen	Yes	Yes
	Max. capacitance	N.A.	350 pF/m
Max. cable loop resistance	Media temperature: < 100°C	40 Ω	N.A.
	< 200°C	6 Ω	N.A.

2.1 Transmitter MAG 5000 & MAG 6000 connection diagram



Note
Special cable with individual wire shields (shown as dotted lines) are only requried when using empty pipe function or long cables.
(See "Technical data")

Potential Hazards / Grounding
The mains protective earth wire must be connected to the PE terminal in accordance with the diagram (class 1 power supply).

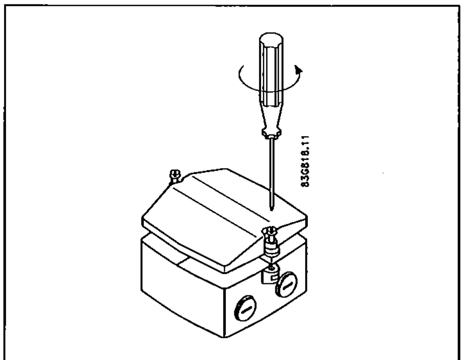
Mechanical counters
When mounting a mechanical counter to terminals 57 and 58 (active output), a 1000 µF capacitor must be connected to the terminals 56 and 58.
Capacitor + is connected to terminal 56 and capacitor – to terminal 58.

Output cables
If long cables in noise environment, we recommend to use screened cable.

Electrodes cables
Dotted connections only to be when using special electrode cable.

Mains supply 115 to 230 V AC from building installation Class II. A switch or circuit-breaker (max. 15 A) shall be included in the building installation. It must be in close proximity to the equipment and within easy reach of the operator, and it shall be marked as the disconnecting device for the equipment.

3.1 Compact installation MAG 5000 & MAG 6000 - *Compact polyamide*

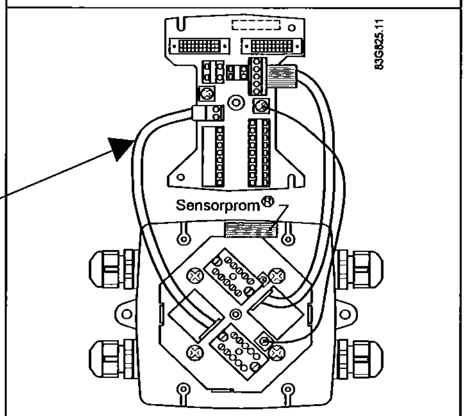


Step 1
Remove and discard the terminal box lid of the sensor.

Fit the PG 13.5 cable glands for the supply and output cables.

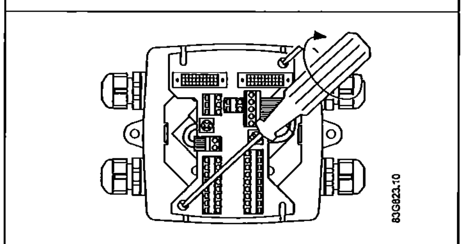
Step 2
Remove the two black plug assemblies for coil and electrode cables in the terminal box and connect them to their corresponding terminal numbers on the connection board.

Note
System will **not** register flow if black plugs are not connected to connection board



Step 3
Connect an earth wire between PE on connection board and bottom of terminal box.
Connect the 2 pin connector and 3 pin connector as shown.

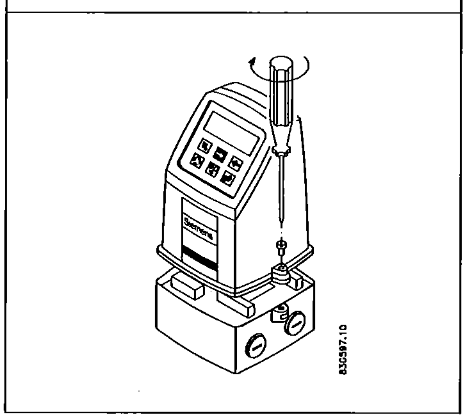
Note
In earlier version the 3 pin connector was a 5 pin connector.



Step 4
Mount the connection plate in the terminal box. The SENSORPROM® unit connections will be established automatically when the connection plate is mounted in the terminal box.

Note
Check that your connection board lines up with the SENSORPROM® unit, if not, move the SENSORPROM® unit to the other side of the terminal box.

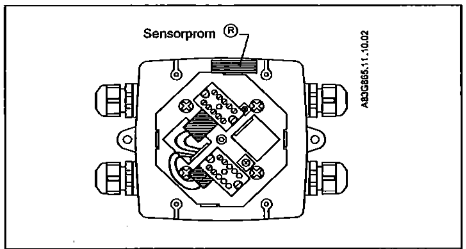
Caution
Exposing the transmitter to direct sunlight may increase the operating temperature above its specified limit, and decrease display visibilty



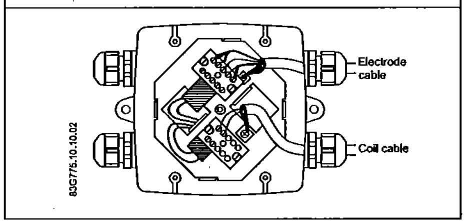
Step 5
Fit the supply and output cables respectively and tighten the cable glands to obtain optimum sealing.
Please refer to the wiring diagram "Electrical connections".

Mount the transmitter on the terminal box.

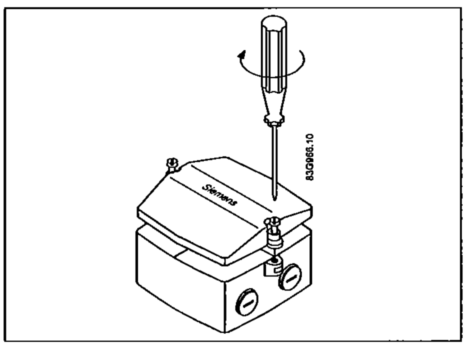
3.2.1 Remote installation - *At the sensor*



Remove the SENSORPROM® unit from the sensor and mount it on the connection plate in the transmitter.

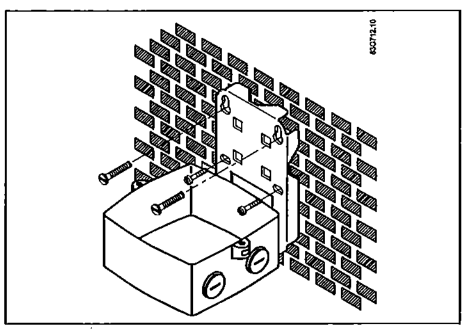


Fit and connect the electrode and coil cables as shown in "Electrical connections".
The unscreened cable ends must be kept as short as possible.
The electrode cable and the coil cable must be kept separate to prevent interference.
Tighten the cable glands well to obtain optimum sealing.

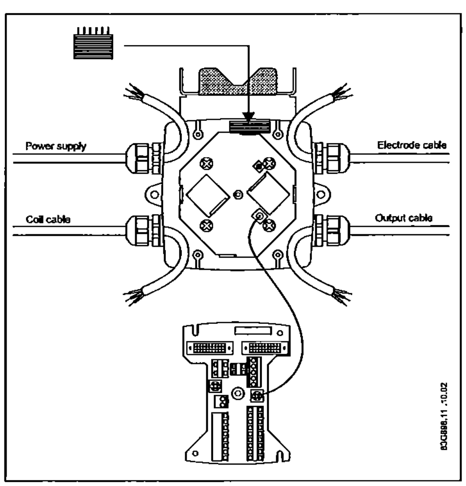


⚠ Mount the terminal box lid before power up.

3.2.2 Remote installation - *Wall mounting transmitter*



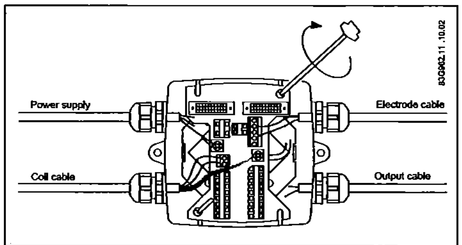
Mount wall bracket on a wall or on a pipe using ordinary hose clips or duct straps.



Take the SENSORPROM® memory unit from the sensor. Mount the SENSORPROM® unit in the wall mounting unit as shown. The text on the SENSORPROM® unit **must** face towards the wall bracket.

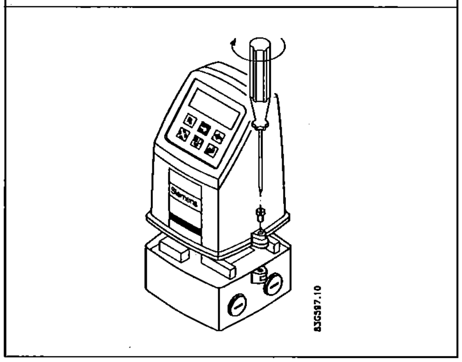
Mount an earth wire between PE on connection board and bottom of terminal box.

3.2.2 Remote installation - *Wall mounting transmitter* *(continued)*



Mount the connection plate in the terminal box. Fix the connection plate with the two diagonal opposite screws.

Fit the coil, electrode, supply and output cables respectively and tighten the cable glands to obtain optimum sealing. Please see the wiring diagram in "Electrical connections".

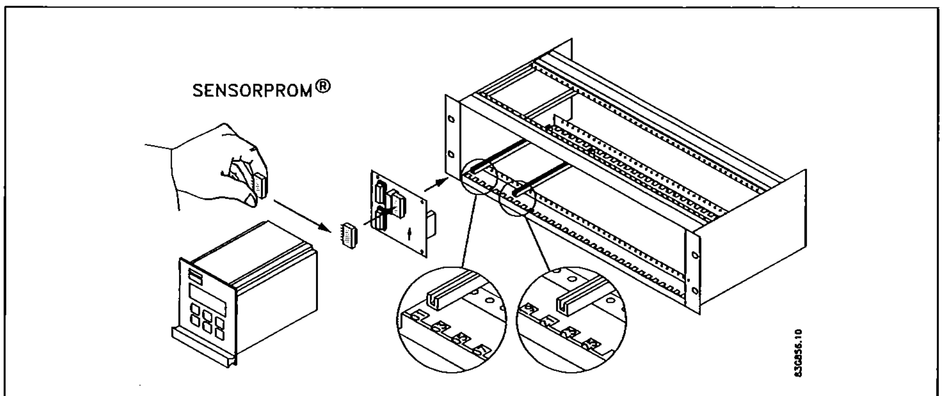


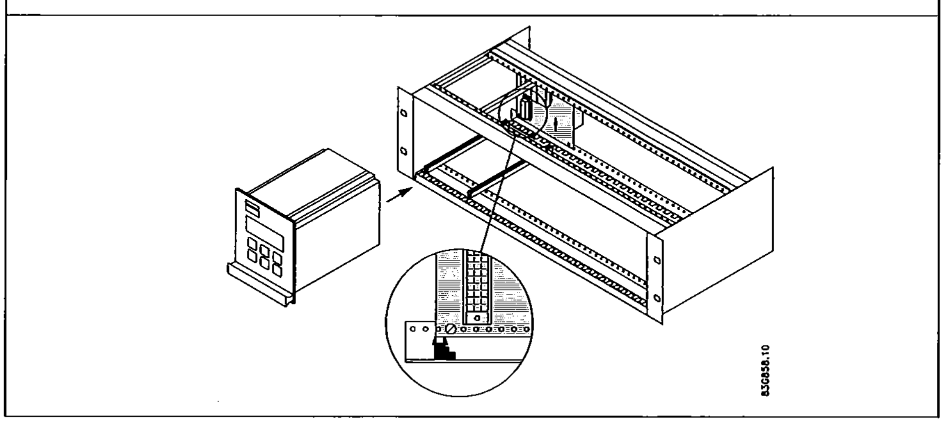
Mount the transmitter on the terminal box.

Attention
When remote mounted, power supply PE wire must be connected to PE terminal.
Coil cable shield must be connected to SHIELD terminal.
Use the supplied insulating tube to insulate the core shield.

Caution
Exposing the transmitter to direct sunlight may increase the operating temperature above its specified limit, and decrease display visibilty

3.2.3 Remote installation - *Transmitter in 19" insert*



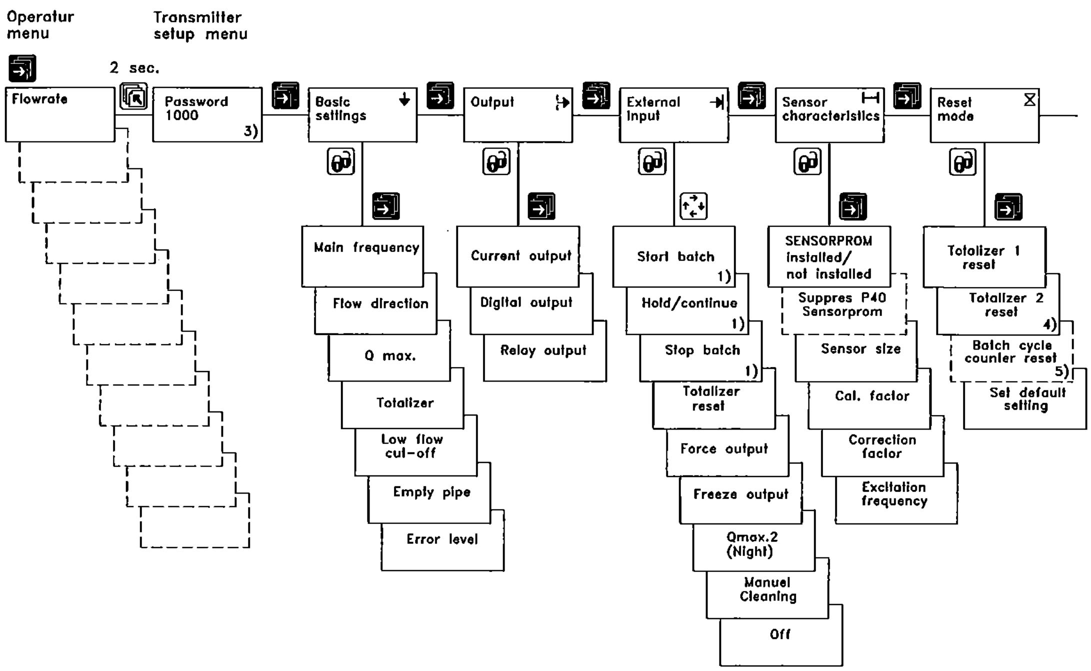


1. Fit the SENSORPROM® memory unit on the connection board supplied with the transmitter. The SENSORPROM® unit is supplied with the sensor in the terminal box.
2. Mount the guide rails into the rack system as shown. Distance between guide rails is 20 TE. Guide rails are supplied with the rack system and not with the transmitter.
3. Mount the connection board as shown.
4. Connect the cables as shown under "Electrical connection".
5. Insert the transmitter into the rack system.

4.1 MAG 5000 & MAG 6000

⇒

TOP UP KEY	This key (hold 2 sec.) is used to switch between operator menu and setup menu. In the transmitter setup menu, a short press will cause a return from a submenu
PAGE FORWARD KEY	This key is used to step forward through the menus.
PAGE BACKWARD KEY	This key is used to step backward through the menus.
CHANGE KEY	This key changes the settings or numerical values.
SELECT KEY	This key selects the figures to be changed.
LOCK/UNLOCK KEY	Process activation



1) Mag 6000 I only

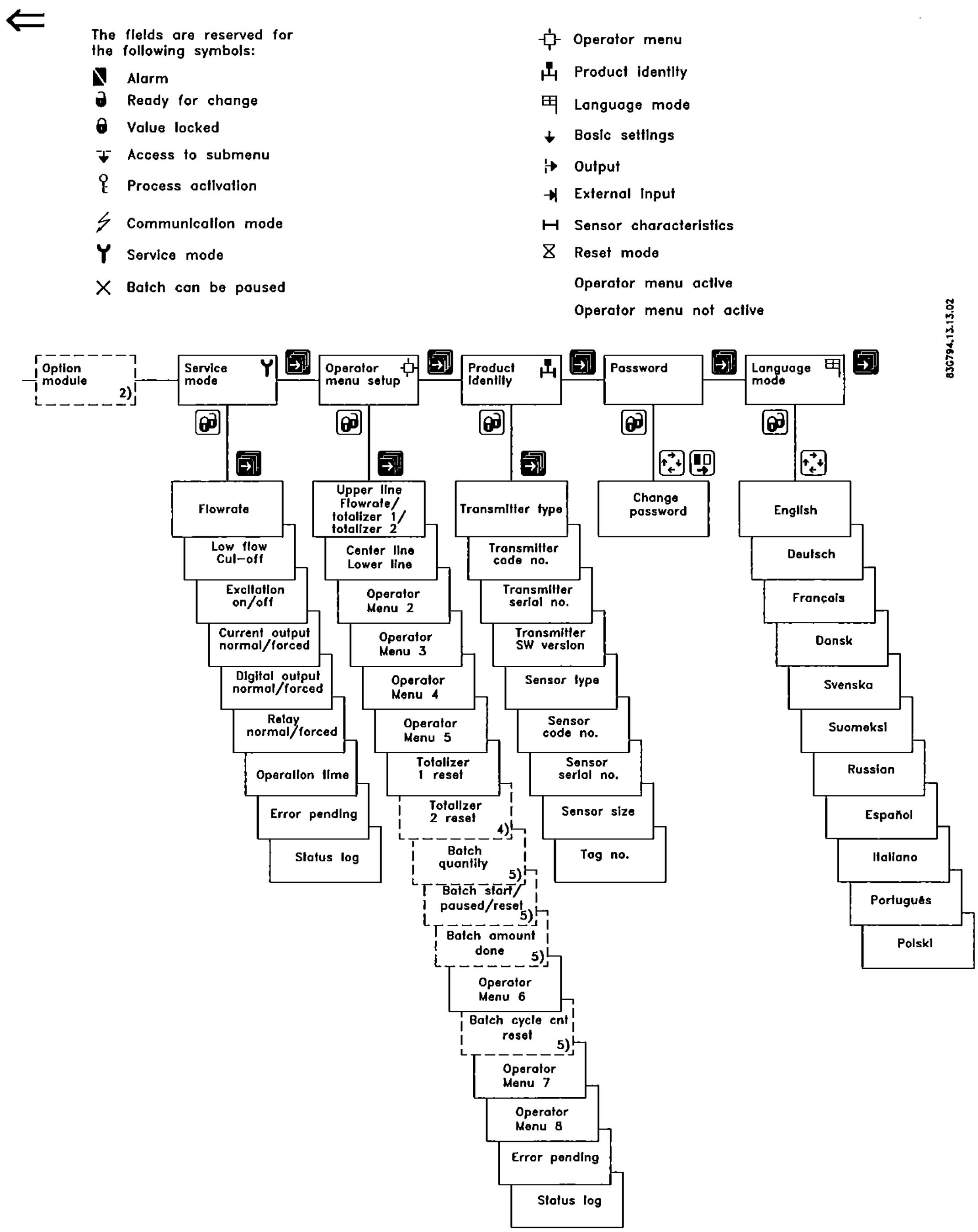
2) Add on module

3) Factory set password: 1000

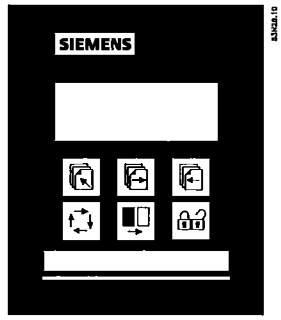
4) Not at Batch

5) At Batch only

4.1 MAG 5000 & MAG 6000 *(continued)*



4.2 Keypad and display layout



Keypad

The keypad is used to set the flowmeter. The function of the keys is as follows:

TOP UP KEY	This key (hold 2 sec.) is used to switch between operator menu and setup menu. In the transmitter setup menu, a short press will cause a return to the previous menu.
FORWARD KEY	This key is used to step forward through the menus. It is the only key normally used by the operator.
BACKWARD KEY	This key is used to step backward through the menus.
CHANGE KEY	This key changes the settings or numerical values.
SELECT KEY	This key selects the figures to be changed.
LOCK/UNLOCK KEY	This key allows the operator to change settings and gives access to submenus.

Display

The display is alphanumerical and indicates flow values, flowmeter settings and error messages.

The upper line is for primary flow readings and will always show either flow rate, totalizer 1 or totalizer 2. The line is divided into 3 fields.

S: Sign field
P: Primary field for numerical value
U: Unit field

The centre line is the title line (T) with individual information according to the selected operator or setup menu.

The lowest line is the subtitle line (ST) which either will add information to the title line or keep individual information independent of the title line.

F: The alarm field. Two flashing triangles will appear by a fault condition.

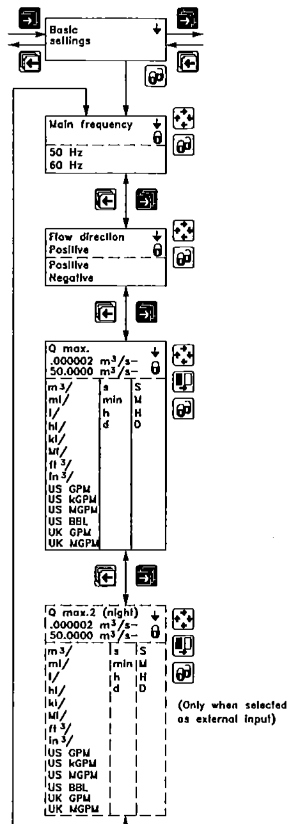
M: The mode field. The symbols indicate the following.

Communication mode	Basic settings	Operator active
Service mode	Output	Operator inactive
Operator menu	External input	
Product identity	Sensor characteristics	
Language mode	Reset mode	

L: The lock field. Indicates the function of the lock key.

Ready for change	Access to submenu
Value locked	RESET MODE: Zero setting of totalizers and initialization of setting

4.3.1 Basic settings



Main frequency
To select the main power supply frequency corresponding to the country in which the flowmeter is installed.
(US = 60 Hz)

Flow direction
Select the correct flow direction in the pipe.

$Q_{max.}$
Sets the measuring range, the analog outputs and the frequency output. Value, decimal point, unit and time can be set individually (setting is dimension dependent).

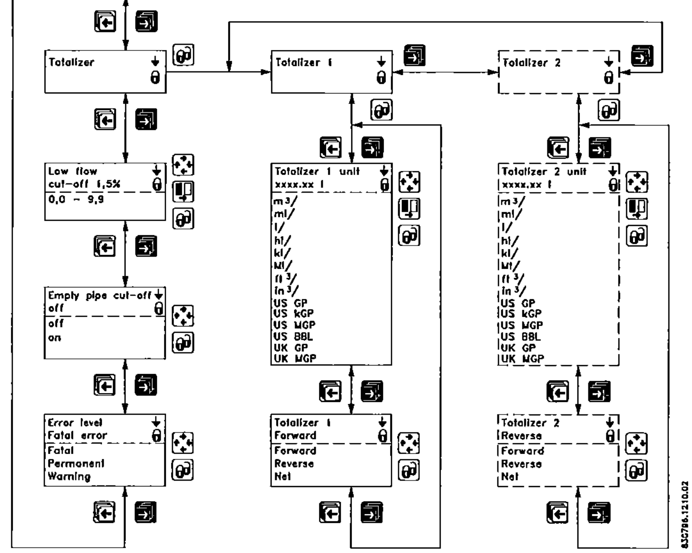
$Q_{max.}2$
Sets the measuring range, the analog outputs and the frequency output. Value, decimal point, unit and time can be set individually (setting is dimension dependent).
Only visible when it has been choosen as external digital input.

Totalizers
To set unit and decimal point.

Low flow cutt off
To set a % of selected $Q_{max.}$. To filter noise in the installation. Influences display and all outputs.

Error level
To select which error level, the flowmeter will detects an error.

Empty pipe cut off
Set on - the alarm will indicate when sensor is running empty.
All readings, display and outputs will indicate zero.



Comma for flow rate, totalizer 1 and totalizer 2 can be individually positioned.

- open the respective window.
- ensure that the cursor is positioned below the comma. Use the SELECT KEY.
- move the comma to the requested position. Use the CHANGE KEY.

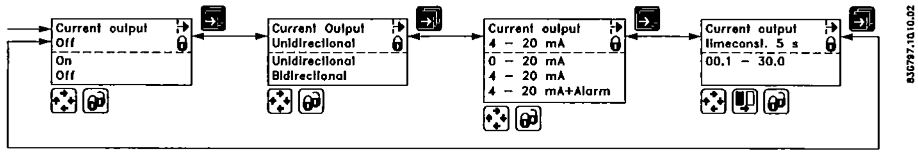
Units are changed by means of the CHANGE KEY with the cursor placed below the unit selected. Select units (cursor moved) by means of the SELECT KEY.

Totalizer 2 is not visible when batch is selected as digital output.

$Q_{max.}$ 2 - is only visible when it has been choosen as external input.

4.3.2 Outputs

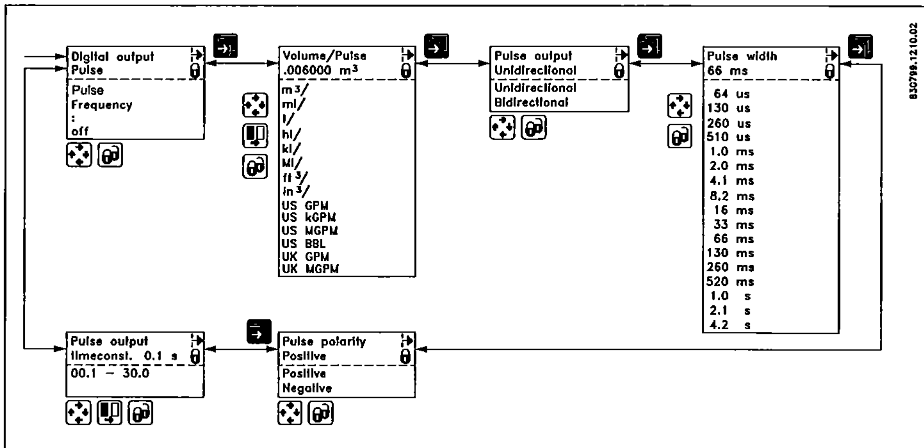
Current output Proportional to flowrate (Terminal 31 and 32)



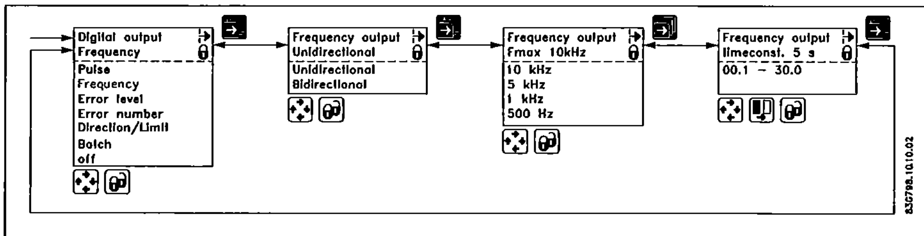
4 - 20 mA + alarm:
Current output gives the following mA, depending on what is selected as error level in basic settings.
Fatal: 1.3 mA, permanent: 2 mA, warning: 3 mA

The current output must be set off when not used.

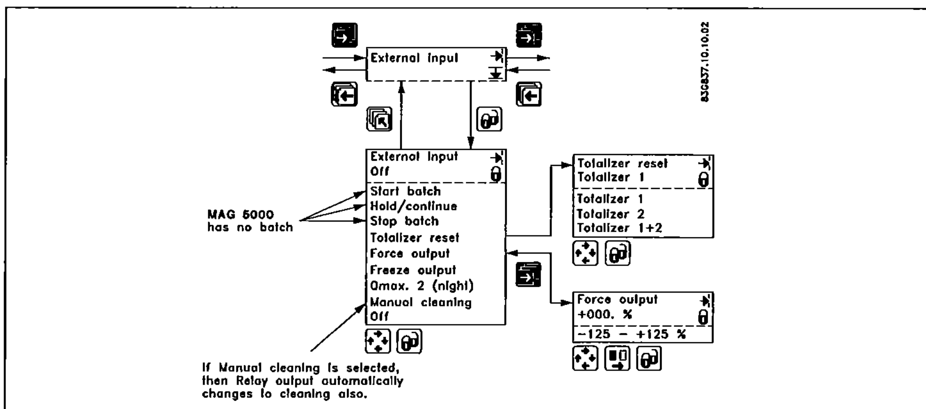
Digital output Pulse/volume (Terminal 56, 57, 58)



Digital output Frequency Proportional to flowrate (Terminal 56, 57, 58)



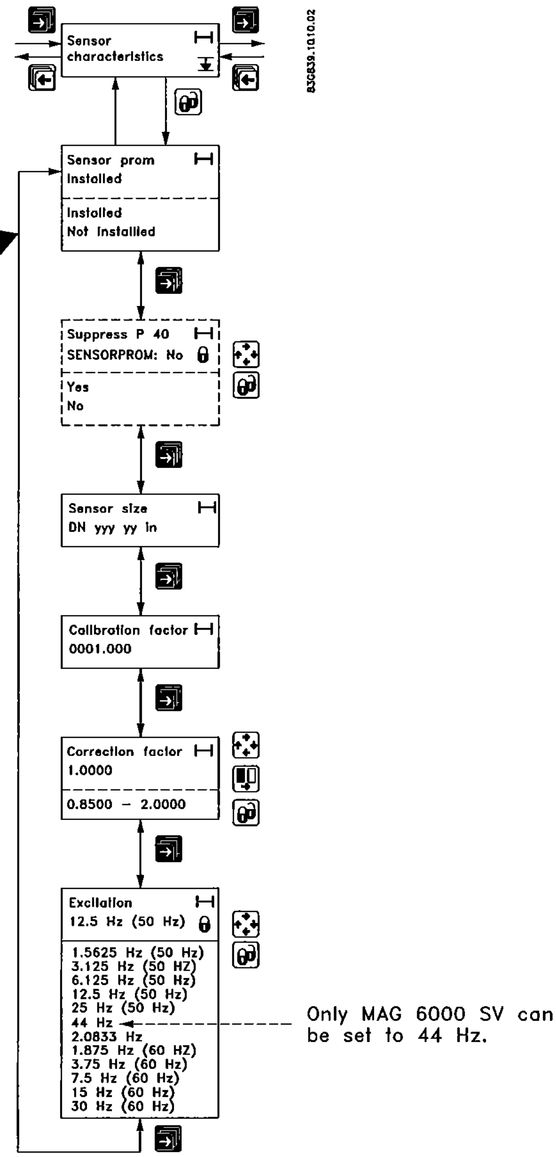
4.3.3 External input



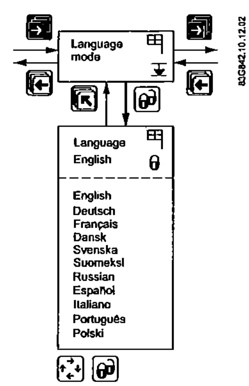
Batch control is available on MAG 6000 only.

4.3.4 Sensor characteristics

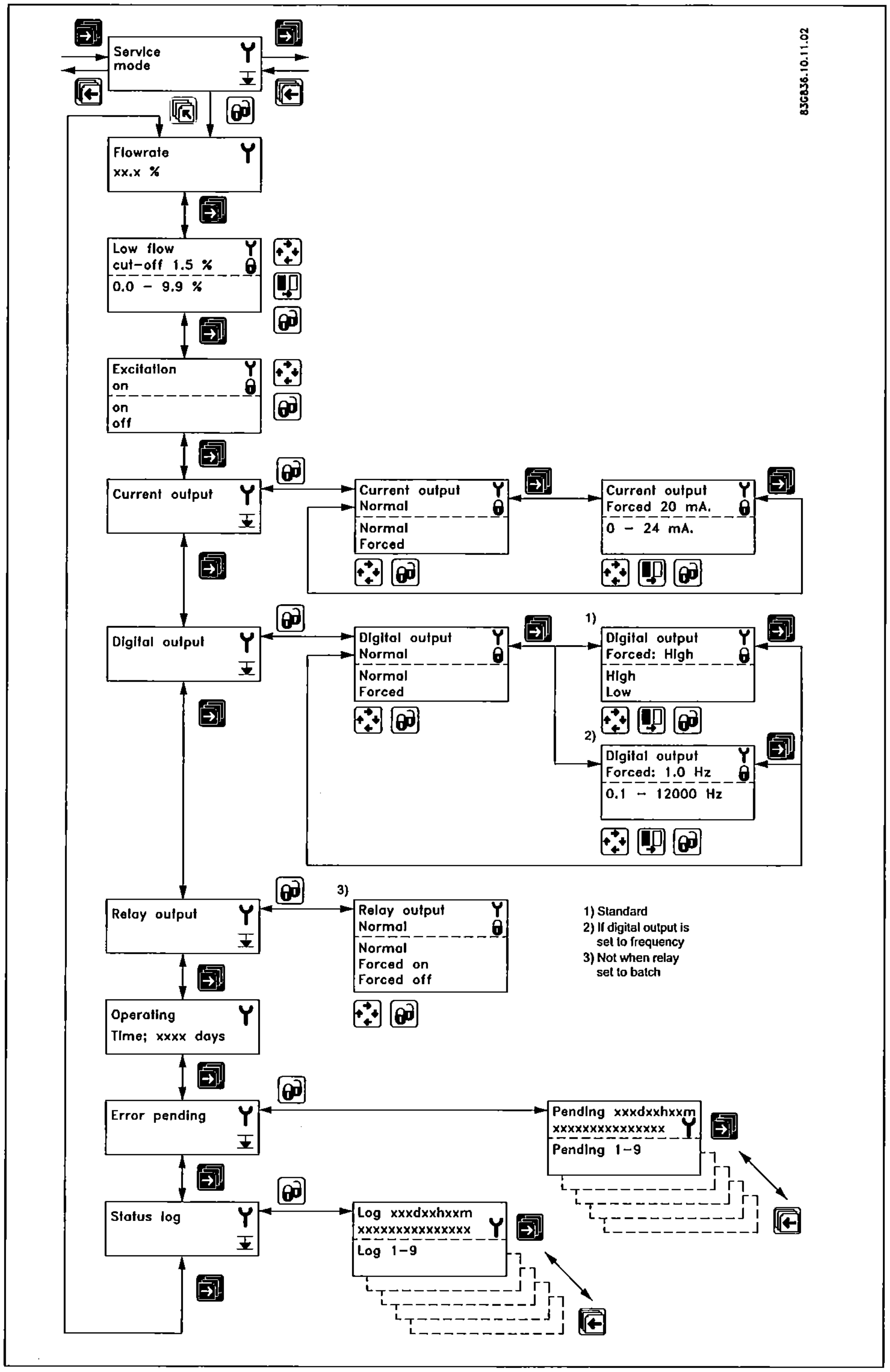
If "SENSORPROM not installed" is shown, refer to chapter 6 in the handbook (depending on type of mounting configuration).



4.3.5 Language mode



4.3.6 Service mode



All previous settings are reinitialised when service mode is exited using the top up key.

The error system

The error system is divided into an error pending list and a status log list. Time is gained as days, minutes and hours since the error has occurred. The first 9 standing errors are stored in error pending. When an error is removed it is removed from error pending. The latest 9 errors are stored in the status log. When an error is removed it is still kept in status log. Errors in status log is stored for 180 days.

Error pending and status log are accessible when enabled in the operator menu.

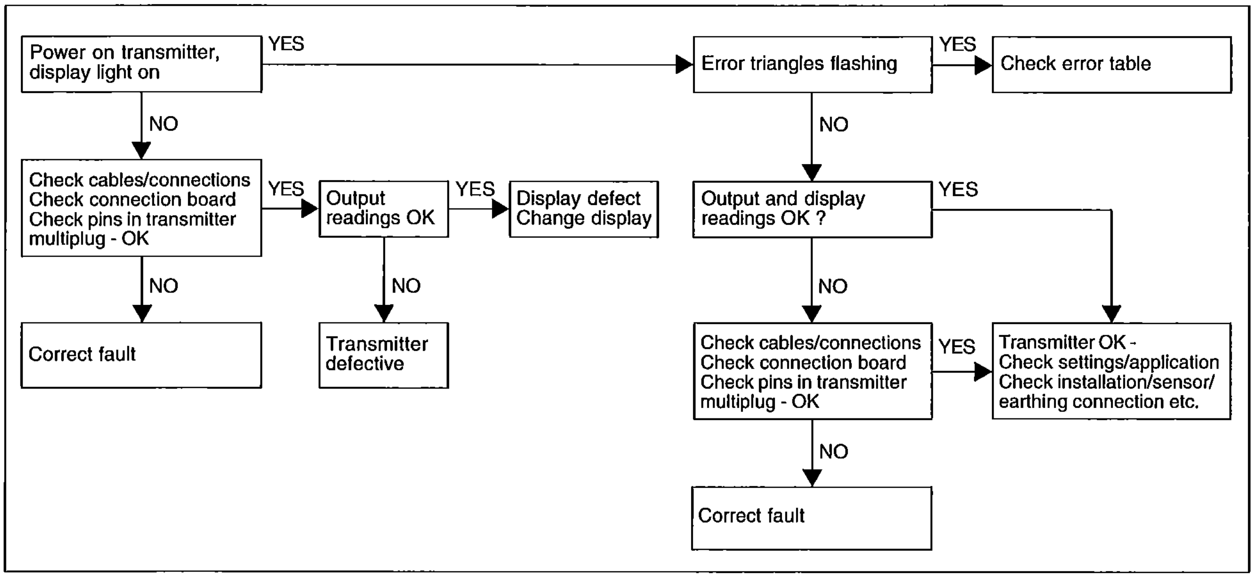
5. Service

Often problems with unstable/wrong measurements occur due to insufficient/wrong earthing or potential equalization. Please check this connection. If OK, the SITRANS F M MAGFLO® transmitter can be checked as described under 9.1 and sensor under 9.3 in the handbook.

5.1 Transmitter check list

When checking SITRANS F M MAGFLO® installations for malfunction the easiest method to check the transmitter is to replace it with another MAG 5000/6000 transmitter with a similar power supply.
A replacement can easily be done as all settings are stored in and downloaded from the SENSORPROM® unit - no extra settings need to be made.

If no spare transmitter is available - then check transmitter according to check table.



5.2 Trouble shooting MAG transmitter

Symptom	Output signals	Error code	Cause	Remedy
Empty display	Minimum		1. No power supply	Power supply Check MAG 5000/6000 for bended pins on the connector
			2. MAG 5000/6000 defective	Replace MAG 5000/6000
No flow signal	Minimum		1. Current output disabled	Turn on current output
			2. Digital output disabled	Turn on digital output
			3. Reverse flow direction	Change direction
		F70	Incorrect or no coil current	Check cables/connections
		W31	Measuring pipe empty	Ensure that the measuring pipe is full
		F60	Internal error	Replace MAG 5000/6000
	Undefined	P42	1. No load on current output	Check cables/connections
			2. MAG 5000/6000 defective	Replace MAG 5000/6000
		P41	Initializing error	Switch off MAG 5000/6000, wait 5 s and switch on again
Indicates flow with no flow in pipe	Undefined		Measuring pipe empty	Select empty pipe cut-off
			Empty pipe cut-off is OFF	Ensure that the measuring pipe is full
			Electrode connection missing/ electrode cable is insufficiently screened	Ensure that electrode cable is connected and sufficiently screened
Unstable flow signal	Unstable		1. Pulsating flow	Increase time constant
			2. Conductivity of medium too low	Use special electrode cable
			3. Electrical noise potential between medium and sensor	Ensure sufficient potential equalization
			4. Air bubbles in medium	Ensure medium does not contain air bubbles
			5. High concentration of particles or fibres	Increase time constant
Measuring error	Undefined		Incorrect installation	Check installation
		P40	No SENSORPROM® unit	Install SENSORPROM® unit
		P44	CT SENSORPROM® unit	Replace SENSORPROM® unit or reset SENSORPROM® unit with MAG CT transmitter
		F61	Deficient SENSORPROM® unit	Replace SENSORPROM® unit
		F62	Wrong type of SENSORPROM® unit	Replace SENSORPROM® unit
		F63	Deficient SENSORPROM® unit	Replace SENSORPROM® unit
		F71	Loss of internal data	Replace MAG 5000/6000
	Maximum	W30	Flow exceeds 100% of $Q_{max.}$	Check $Q_{max.}$ (Basic Settings)
		W21	Pulse overflow • Volume/pulse too small • Pulse width too large	 Change volume/pulse Change pulse width
Measuring approx. 50%			Missing one electrode connection	Check cables
Loss of totalizer data	OK	W20	Initializing error	Reset totalizer manually
##### Signs in display	OK		Totalizer roll over	Reset totalizer or increase totalizer unit

Siemens Flow Instruments A/S
Nordborgvej 81
DK-6430 Nordborg

Order no.: FDK-521H0739-05
Printed in: Denmark

Transmitter MAGFLO MAG 5000/6000

Overview

Transmitter MAG 5000/6000 compact version (left) and 19" insert version (right)

The MAG 5000 and 6000 are microprocessor-based transmitters engineered for high performance, easy installation, commissioning and maintenance. The transmitters evaluate the signals from the SITRANS F M MAGFLO sensors type MAG 1100, MAG 1100 F, MAG 3100 and MAG 5100 W.

Transmitter types:

- MAG 5000: Max. measuring error 0.5% of rate (incl. sensor)
- MAG 6000: Max. measuring error 0.25% of rate (incl. sensor, see also sensor specifications) and with additional features such as: Plug & Play insert bus modules; integrated batch functions.

Benefits

- Superior signal resolution for optimum turn down ratio
- Digital signal processing with many possibilities
- Automatic reading of SENSORPROM data for easy commissioning
- User configurable operation menu with password protection.
- 3 lines, 20 characters display in 11 languages.
- Flow rate in various units
- Totalizer for forward, reverse and net flow as well as additional information available
- Multiple functional outputs for process control, minimum configuration with analogue, pulse/frequency and relay output (status, flow direction, limits)
- Comprehensive self-diagnostic for error indication and error logging (see under SITRANS F M MAGFLO diagnostics)
- Batch control
- Custody transfer approval: PTB, OIML R75, R117, R49
- MAG 6000 with add-on bus modules for HART, MODBUS RTU/RS485, PROFIBUS PA and DP

Application

The MAG flowmeters are suitable for measuring the flow of almost all electrically conductive liquids, pastes and slurries. The main applications can be found in:

- Water and waste water
- Chemical and pharmaceutical industries
- Food & beverage industries
- Power generation and utility

Design

The transmitter is designed as either IP67 NEMA 4X/6 enclosure for compact or wall mounting or 19" version as a 19" insert as a base to be used in:

- 19" rack systems
- Panel mounting IP65/NEMA 4
- Back of panel mounting IP20/NEMA 2
- Wall mounting IP66/NEMA 4

Several options on 19" versions are available such as:

- Transmitters for EEx ATEX approved flow sensors (incl. barriers)
- Transmitters with electrode cleaning unit

Function

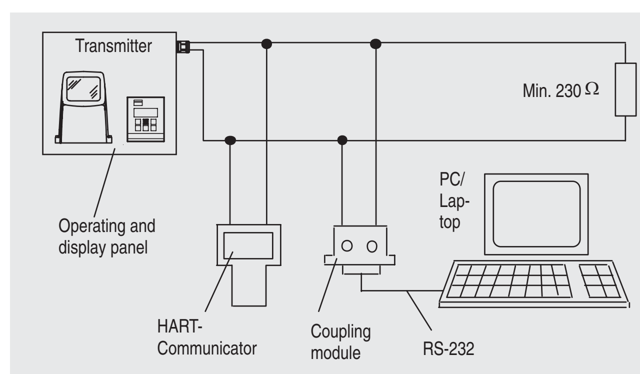
The MAG 5000/6000 are microprocessor-based transmitters with a build-in alphanumeric display in several languages. The transmitters evaluate the signals from the associated electromagnetic sensors and also fulfil the task of a power supply unit which provides the magnet coils with a constant current.

Further information on connection, mode of operation and installation can be found in the data sheets for the sensors.

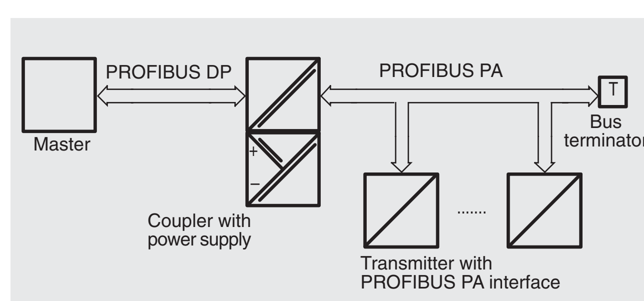
Displays and controls

Operation of the transmitter can be carried out using:

- Control and display unit
- HART communicator
- PC/laptop and SIMATIC PDM software via HART communication
- PC/laptop and SIMATIC PDM software using PROFIBUS communication



HART communication



PROFIBUS PA communication

Technical specifications

Mode of operation and design	
Measuring principle	Electromagnetic with pulsed constant field
Empty pipe	Detection of empty pipe (special cable required in remote mounted installation)
Excitation frequency	Sensor size depending pulsating DC current
Electrode input impedance	$> 1 \times 10^{14}\ \Omega$
Input	
Digital input	11 ... 30 V DC, R_i = 4. 4 KΩ
• Activation time	50 ms
• Current	$I_{DC\ 11\ V}$ = 2.5 mA, $I_{DC\ 30\ V}$ = 7 mA
Output	
Current output	
• Signal range	0 ... 20 mA or 4 ... 20 mA
• Load	< 800 Ω
• Time constant	0.1 … 30 s, adjustable
Digital output	
• Frequency	0 ... 10 kHz, 50% duty cycle (uni/bidirectional)
• Time constant	0.1…30s, adjustable
• Pulse (active)	DC 24 V, 30 mA, 1 KΩ ≤ R_i ≤ 10 KΩ, short-circuit-protected (power supplied from flowmeter)
• Pulse (passive)	DC 3…30 V, max. 110 mA, 200 Ω ≤ R_i ≤ 10 KΩ (powered from connected equipment)
• Time constant	0.1 … 30 s, adjustable
Relay output	
• Time constant	Changeover relay, same as current output
• Load	42 V AC/2 A, 24 V DC/1 A
Low flow cut off	0 ... 9.9% of maximum flow
Galvanic isolation	All inputs and outputs are galvanically isolated
Max. measuring error (incl. sensor)	
• MAG 5000	0.5% of rate
• MAG 6000	0.25% of rate
Rated operation conditions	
Ambient temperature	
• Operation	• Display version: -20 ... +50 °C (-4 ... +122 °F) • Blind version: -20 ... +60 °C (-4 ... +140 °F)
• Storage	-40 ... +70 °C (-40 ... +158 °F)
Mechanical load	
• Compact version	18 ... 1000 Hz, 3,17 G rms, sinusoidal in all directions to IEC 68-2-36
• 19" insert	1 ... 800 Hz, 1 G, sinusoidal in all directions to IEC 68-2-36

Degree of protection	
• Compact version	IP67/NEMA 4X/6 to IEC 529 and DIN 40050 (1 mH_2O 30 min.)
• 19" insert	IP20/NEMA 2 to IEC 529 and DIN 40050
EMC performance	
• Emitted interference	To EN 50081-1 (Light industry)
• Noise immunity	To EN 50082-1 (Industry)
Display and keypad	
Totalizer	Two eight-digit counters for forward, net or reverse flow
Display	Background illumination with alphanumeric text, 3 x 20 characters to indicate flow rate, totalized values, settings and faults; Reverse flow indicated by negative sign
• Time constant	Time constant as current output time constant
Design	
Enclosure material	
• Compact version	Fiber glass reinforced polyamide; optional (IP67 only): AISI 316 stainless steel
• 19"-insert	Standard 19" insert of aluminium/steel (DIN 41494), width: 21 TE, height: 3 HE
• Back of panel	IP20/NEMA 2; Aluminium
• Panel mounting	IP65/NEMA 4; ABS plastic
• Wall mounting	IP66/NEMA 4; ABS plastic
Dimensional drawings	
• Compact version	See dimensional drawings
• 19" insert	See dimensional drawings
Weight	
• Compact version	0.75 kg (2 lb)
• 19" insert	See dimensional drawings
Power supply	• 115 ... 230 V AC +10% -15%, 50 ... 60 Hz, 17 VA • 11 ... 30 V DC or 11 ... 24 V AC
Power consumption	• 230 V AC: 17 VA • 24 V AC : 9 W, I_N = 380 mA, I_{ST} = 8 A (30 ms) • 12 V DC : 11 W, I_N = 920 mA, I_{ST} = 4 A (250 ms)
Certificates and approvals	CE, ULc general purpose, C-tick; FM Class 1, div 2
Custody transfer approval (MAG 5000/6000 CT)	• PTB OIML R49 (cold water) • PTB and DANAK OIML R75 (hot water) • PTB and DANAK OIML R117 (cold water/milk, beer etc.)
Communication	
Standard	
• MAG 5000	Without serial communication or HART as option
• MAG 6000	Prepared for client mounted add-on modules
Optional (MAG 6000 only)	HART, MODBUS RTU/RS485, PROFIBUS PA, PROFIBUS DP as add-on modules

Transmitter MAGFLO MAG 5000/6000

Safety barrier (ia/ib) DN ≤ 300 / 12”

Application	**As combined unit with MAG 6000 only and MAG 1100 Ex / MAG 3100 Ex in the size range DN 2 to 300 / 1/12” to 12”**		
Ex approval	[EEx ia/ib] IIB, ATEX for MAG 3100 Ex and 1100 Ex		
Cable parameter	Group	Capacity in µF	Inductance in mH
• Electrode	IIB	≤ 31	≤ 80
• Coil	IIB	≤ 0.5	≤ 8
Ambient temperature			
• During operation	-20 to +50 °C (-4 to +122 °F)		
• During storage	-20 to +70 °C (-4 to +158 °F)		
Enclosure			
• Material	Standard 19” insert in aluminium/steel (DIN 41494)		
• Width	21 TE (4.75”)		
• Height	3 HE (5.25”)		
• Rating	IP 20 / NEMA 2 to EN 60529 and DIN 40050		
• Mechanical load	1 g, 1 … 800 Hz sinusoidal in all directions to EN 60068-2-36		
EMC performance			
• Emission	EN 50081-1 (Light industry)		
• Immunity	EN 50082-2 (Industry)		

Safety barrier (e/ia) DN ≥ 350 / 14”

Application	**For use with MAG 5000/6000 19” and MAG 3100 Ex in the size range DN 350 to 2000 / 14” to 78”**		
Ex approval	[EEx e ia] IIC ATEX		
Cable parameter	Group	Capacity in µF	Inductance in mH
• Electrode	IIC	≤ 4.1	≤ 80
	IIB	≤ 45	≤ 87
	IIA	≤ 45	≤ 87
Ambient temperature			
• During operation	-20 to +50 °C (-4 to +122 °F)		
• During storage	-20 to +70 °C (-4 to +158 °F)		
Enclosure			
• Material	Standard 19” insert in aluminium/steel (DIN 41494)		
• Width	21 TE (4.75”)		
• Height	3 HE (5.25”)		
• Rating	IP20 / NEMA 2 to EN 60529 and DIN 40050		
• Mechanical load	1 g, 1 … 800 Hz sinusoidal in all directions to EN 60068-2-36		
EMC performance			
• Emission	EN 50081-1 (Light industry)		
• Immunity	EN 50082-2 (Industry)		

Electrode cleaning unit

Application	**For use with transmitters MAG 5000 and 6000 19" to clean the electrodes on sensors MAG 1100, MAG 3100 or MAG 5100 W**
	NB: Must not be used with intrinsically safe ATEX sensors
Cleaning voltage	
AC cleaning	60 V AC
DC cleaning	30 V DC
Cleaning period	60 s + 60 s pause period
Relay	
• Load	42 V / 2 A
Operation	Switch relay activated when cleaning is in progress
• Automatic	Yes
• Manual	No
Indicator lamps	LEDs: "ON" and "CLEANING"
Supply voltage and power consumption	115 … 230 V AC, +10% … -15%, 50 … 60 Hz, 7 VA cleaning, 5 VA stand by 11 … 30 V DC / 11 … 24 V AC, 50 … 60 Hz, 7 VA cleaning, 5 VA stand by
Ambient temperature	
• During operation	-20 to +50 °C (-4 to +122 °F)
• During storage	-20 to +70 °C (-4 to +158 °F)
Enclosure	
• Material	Standard 19" insert in aluminium/steel (DIN 41494)
• Width	21 TE (4.75")
• Height	3 HE (5.25")
• Rating	IP20 / NEMA 2 to EN 60529 and DIN 40050
• Mechanical load	1 g, 1 … 800 Hz sinusoidal in all directions to EN 60068-2-36

Cleaning unit

The Siemens cleaning unit can be used with MAG 5000 or 6000 in 19" insert version.

The cleaning unit can be used in applications where the liner and subsequently the electrodes may be coated with deposits. If the coating is electrically insulating, the electrode signal will be reduced. If the coating is electrically inductive, the electrode signal will be partly short-circuited and in both cases the accuracy of the meter will decrease (dependent on coating type and thickness).

Note:

The cleaning unit cannot be used for inflammable or explosive media!

Empty pipe detection and cleaning facility cannot be used at the same time.

Mode of operation

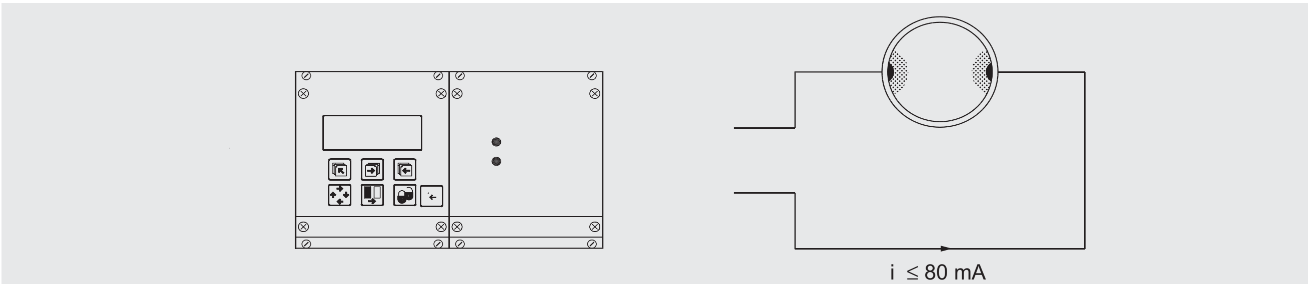
The cleaning unit cleans the electrodes electro-chemically by applying a voltage to the electrodes for approx. 60 seconds. While cleaning, the transmitter stores and holds the latest measured flow reading on the display and also the signal outputs. After an additional pausing period of 60 seconds the flowmeter resumes normal measurement and the cleaning is now completed.

The relay in the transmitter activates the cleaning cycle. In the relay output menu (under cleaning) the cleaning interval can be set between 1 hour and 24 hours.

Cleaning should only take place with liquid in the pipe.This can be detected via the empty pipe function. It is therefore recommended to select "empty pipe detection" ON when using the cleaning.

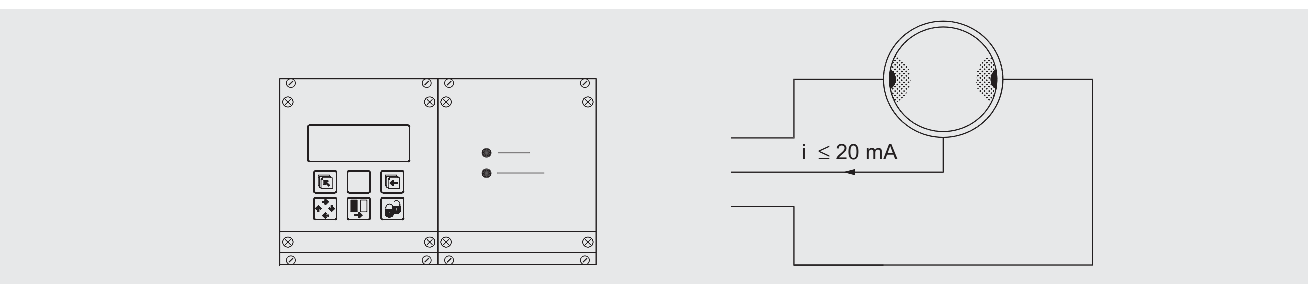
The cleaning sequence can also be controlled manually through the electrical input of the transmitter. Before this is done, ensure that the measuring pipe is full.

AC cleaning



AC-cleaning is used to remove fatty deposits on the electrodes. These fatty deposits are seen in waste water applications, in abattoirs and water applications with oil residuals. During the cleaning process, the surface of the electrodes get warmer, which tends to soften grease particles and the gas bubbles generated mechanically lift deposits away from the surface of the electrodes.

DC cleaning



DC-cleaning is used to eliminate electrically conductive deposits in the measuring pipe influencing the measuring accuracy.

Particularly in district heating applications an electrically conductive deposit (magnetite) may occur and short-circuit the electrode signal. In this case the accuracy of the meter decreases and the signal/noise conditions of the meter become inferior. The problem only arises if the conductivity of the water is less than approx. 250 µS/cm.

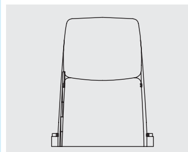
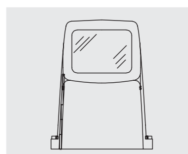
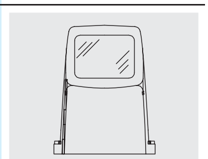
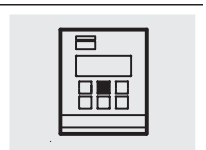
During DC-cleaning electrolysis takes place where the flow of electrons removes the particle deposits from the electrode area.

Note:

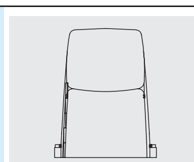
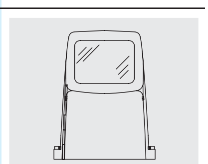
Do not use DC-cleaning on sensors with tantalum electrodes.

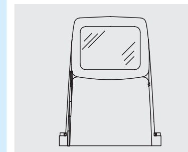
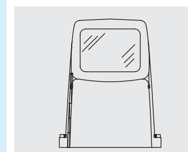
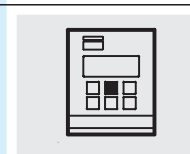
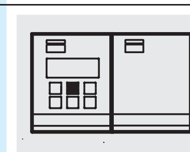
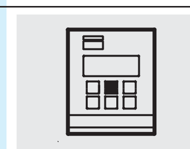
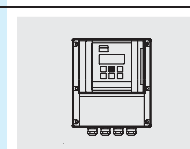
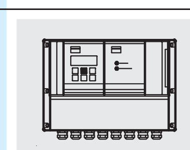
Selection and Ordering Data

Transmitter MAG 5000

Description		Order No.	Symbol
Transmitter MAG 5000 Blind for compact and wall mounting; IP67/NEMA 4X, fibre-glass reinforced polyamide			
• 11 ... 30 V DC / 11 ... 24 V AC		7ME6910-1AA30-0AA0	
• 115/230 V AC, 50/60 Hz		7ME6910-1AA10-0AA0	
Transmitter MAG 5000 Display for compact and wall mounting; IP67/NEMA 4X, fibre-glass reinforced polyamide			
• 11 ... 30 V DC / 11 ... 24 V AC	▶	7ME6910-1AA30-1AA0	
• 115/230 V AC, 50/60 Hz	▶	7ME6910-1AA10-1AA0	
• 115/230 V AC, 50/60 Hz, with HART		7ME6910-1AA10-1BA0	
Transmitter MAG 5000 CT for compact and wall mounting, approved for custody transfer; IP67/NEMA 4X, fibre-glass reinforced polyamide			
• 11 ... 30 V DC / 11 ... 24 V AC		7ME6910-1AA30-1AB0	
• 115/230 V AC, 50/60 Hz		7ME6910-1AA10-1AB0	
Transmitter MAG 5000 for 19" rack and wall mounting			
• 11 ... 30 V DC / 11 ... 24 V AC		7ME6910-2CA30-1AA0	
• 115/230 V AC, 50/60 Hz		7ME6910-2CA10-1AA0	

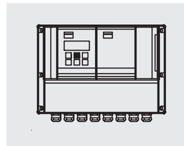
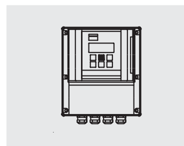
Transmitter MAG 6000

Description		Order No.	Symbol
Transmitter MAG 6000 Blind for compact and wall mounting; IP67/NEMA 4X, fibre-glass reinforced polyamide			
• 11 ... 30 V DC / 11 ... 24 V AC		7ME6920-1AA30-0AA0	
• 115/230 V AC, 50/60 Hz		7ME6920-1AA10-0AA0	
Transmitter MAG 6000 for compact and wall mounting; IP67/NEMA 4X, fibre-glass reinforced polyamide			
• 11 ... 30 V DC / 11 ... 24 V AC	▶	7ME6920-1AA30-1AA0	
• 115/230 V AC, 50/60 Hz	▶	7ME6920-1AA10-1AA0	
IP67/NEMA 4X, AISI 316 stainless steel (without S/S terminal box)			
• 11 ... 30 V DC / 11 ... 24 V AC		7ME6920-1QA30-1AA0	
• 115/230 V AC, 50/60 Hz		7ME6920-1QA10-1AA0	

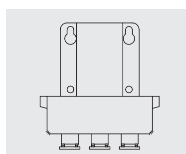
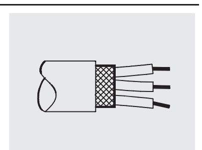
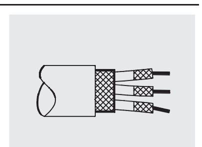
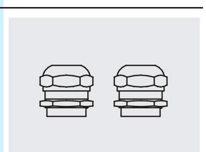
Description	Order No.	Symbol
Transmitter MAG 6000 CT for compact and wall mounting, approved for custody transfer; IP67/NEMA 4X, fibre-glass reinforced polyamide		
• 11 ... 30 V DC / 11 ... 24 V AC	7ME6920-1AA30-1AB0	
• 115/230 V AC, 50/60 Hz	7ME6920-1AA10-1AB0	
Transmitter MAG 6000 SV for compact and wall mounting; special excitation 44 Hz settings for Batch application DN ≤ 25/1"; IP67/NEMA 4X, fibre-glass reinforced polyamide		
11 ... 30 V DC / 11 ... 24 V AC	7ME6920-1AB30-1AA0	
115/230 V AC, 50/60 Hz	7ME6920-1AB10-1AA0	
Transmitter MAG 6000 for 19" rack and wall mounting		
• 11 ... 30 V DC / 11 ... 24 V AC	7ME6920-2CA30-1AA0	
• 115/230 V AC, 50/60 Hz	7ME6920-2CA10-1AA0	
Transmitter MAG 6000 19" (DN ≤ 300/12") Insert with safety barrier [EEx ia/ib] IIB ATEX		
• 11 ... 30 V DC / 11 ... 24 V AC	7ME6920-2NA31-1AA0	
• 115/230 V AC, 50/60 Hz	7ME6920-2NA11-1AA0	
Transmitter MAG 6000 SV for 19" rack and wall mounting; special excitation 44 Hz settings, Batch application DN ≤ 25/1"		
• 11 ... 30 V DC / 11 ... 24 V AC	7ME6920-2CB30-1AA0	
• 115/230 V AC, 50/60 Hz	7ME6920-2CB10-1AA0	
MAG 6000 with IP66/NEMA 4X enclosure; 115/230 V AC, 50/60 Hz	7ME6920-2EA10-1AA0	
MAG 6000 with electrode cleaning unit, complete mounted with IP66/NEMA 4X mounting enclosure		
• 11 ... 30 V DC / 11 ... 24 V AC	7ME6920-2PA30-1AA0	
• 115/230 V AC, 50/60 Hz	7ME6920-2PA10-1AA0	

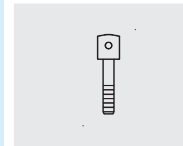
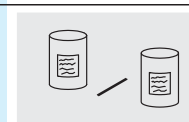
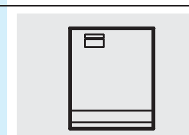
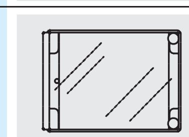
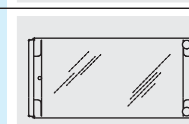
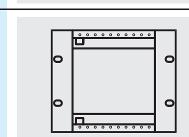
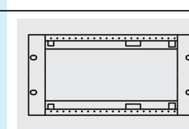
▶ Available ex stock

Transmitter MAGFLO MAG 5000/6000

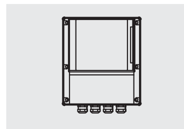
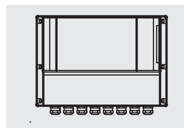
Description	Order No.	Symbol
MAG 6000 with electrode safety barrier, complete mounted with IP66/NEMA 4X wall mounting enclosure, ATEX, 115/230 V AC, 50/60 Hz		
• DN ≤ 300/12“, [EEx ia/ib] IIB	7ME6920-2LA11-1AA0	
• DN ≥ 350/14“, [EEx e ia] IIC	7ME6920-2MA11-1AA0	
MAG 6000 SV, 19” insert, in IP66/NEMA 4X , ABS plastic enclosure, excitation frequency 44 Hz, Batch application DN ≤ 25/1“, 11 … 30 V DC, 11 … 24 V AC, 50/60 Hz	7ME6920-2EB30-1AA0	

Accessories for MAG 5000 and MAG 6000

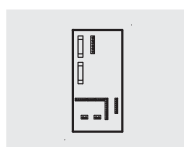
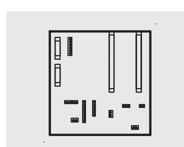
Description	Order No.	Symbol
Wall mounting unit for IP67/NEMA 4X version, wall bracket		
• 4 x M20 cable glands	▶ FDK-085U1018	
• 4 x ½“ NPT cable glands	▶ FDK-085U1053	
Cable for standard electrode or coil, 3 x 1.5 mm² / 18 gage with shield PVC		
• 10 m (33 ft)	▶ FDK-083F0121	
• 20 m (65 ft)	▶ FDK-083F0210	
• 40 m (130 ft)	▶ FDK-083F0211	
• 60 m (200 ft)	▶ FDK-083F0212	
• 100 m (330 ft)	FDK-083F0213	
• 150 m (500 ft)	FDK-083F3052	
• 200 m (650 ft)	FDK-083F3053	
• 500 m (1650 ft)	FDK-083F3054	
Electrode cable for empty pipe or low conductivity, double shielded, 3 x 0.25 mm²		
• 10 m (33 ft)	FDK-083F3020	
• 20 m (65 ft)	▶ FDK-083F3095	
• 40 m (130 ft)	FDK-083F3094	
• 60 m (200 ft)	FDK-083F3093	
• 100 m (330 ft)	FDK-083F3092	
• 150 m (500 ft)	FDK-083F3056	
• 200 m (650 ft)	FDK-083F3057	
• 500 m (1650 ft)	FDK-083F3058	
Cable glands, for above cable, 2 pcs.		
• M20	A5E00822490	
• ½“ NPT	A5E00822501	

Description	Order No.	Symbol
Sealing screws for sensor/transmitter, 2 pcs	FDK-085U0221	
Terminal box, in polyamide, inclusive lid		
• M20	▶ FDK-085U1050	
• ½" NPT	FDK-085U1052	
Terminal box for MAG 6000, in stainless steel, inclusive lid		
• M20	A5E00836867	
• ½" NPT	A5E00836868	
Terminal box (3A) in polyamide, inclusive lid		
• M20	A5E00822478	
• ½" NPT	A5E00822479	
Potting kit for terminal box of MAG sensors for IP68/NEMA 6P	▶ FDK-085U0220	
19“ cleaning unit for electrode cleaning (21TE) incl. back plate		
• 11 ... 30 V DC / 11 ... 24 V AC	FDK-083F5039	
• 115 ... 230 V AC, 50/60 Hz	FDK-083F5036	
19“ safety barrier [EEx e ia] IIC for MAG 3100 Ex, DN 350 ... 2000 (14“ ... 78“) (21TE), incl. back plate	FDK-083F5034	
Panel mounting enclosure for 19“ insert (21TE); IP65/NEMA 4 enclosure in ABS plastic for front panel mounting	FDK-083F5030	
Panel mounting enclosure for 19“ insert (42TE); IP65/NEMA 4 enclosure in ABS plastic for front panel mounting	FDK-083F5031	
Back of panel mounting enclosure for 19“ insert (21TE); IP20/NEMA 2 enclosure in aluminium	FDK-083F5032	
Back of panel mounting enclosure for 19“ insert (42TE); IP20/NEMA 2 enclosure in aluminium	FDK-083F5033	

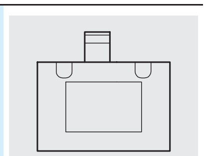
▶ Available ex stock

Description	Order No.	Symbol
IP66/NEMA 4, wall mounting enclosure for 19" inserts (without backplates)		
• 21TE	FDK-083F5037	
• 42TE	▶ FDK-083F5038	
Front cover (7TE)	FDK-083F4525	

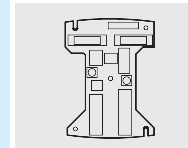
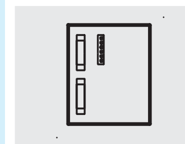
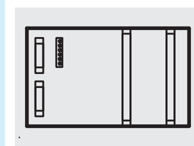
Back plates (if wall enclosure IP66 is used as part)

Description	Order No.	Symbol
Wall unit enclosure IP66, 12 ... 24 V, 115 ... 230 V		
• Transmitter	FDK-083F4121	
• Transmitter ia and safety barrier	FDK-083F4122	
• Transmitter ia/ib and safety barrier	FDK-083F4120	
• Transmitter and cleaning unit	FDK-083F4124	

Communication modules for MAG 6000

Description	Order No.	Symbol
HART (not for MAG 6000 I)	▶ FDK-085U0226	
MODBUS RTU/RS485	▶ FDK-085U0234	
PROFIBUS PA Profile 3	▶ FDK-085U0236	
PROFIBUS DP Profile 3	▶ FDK-085U0237	

Spare parts

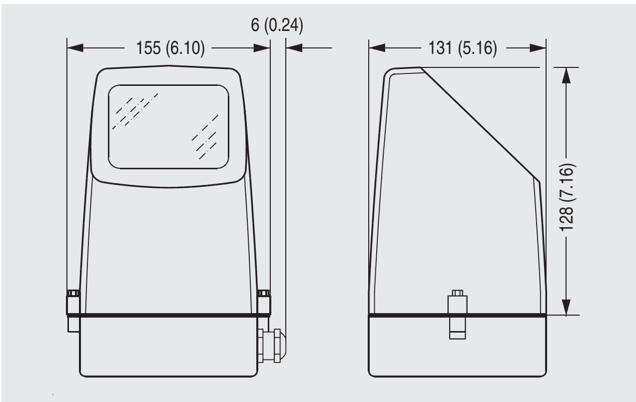
Description	Order No.	Symbol
Connection plate		
• 12 ... 24 V	FDK-083F4149	
• 115 ... 230 V	FDK-083F4148	
19" enclosure, 12 ... 24 V, 115 ... 230 V		
• Transmitter	FDK-083F4117	
• Transmitter ia and safety barrier	FDK-083F4118	
• Transmitter ia/ib and safety barrier	FDK-083F4119	
• Transmitter and cleaning unit	FDK-083F4123	
SENSORPROM memory unit (Sensor code and serial numbers must be specified on order)		
• 2 kB (for MAG 5000/6000/ MAG 6000 I)	FDK-085U1005	
• 250 B (for MAG 2500/3000)	FDK-085U1008	
Display unit for MAG 5000/6000		
• black neutral front	FDK-085U1038	
• Siemens neutral front	FDK-085U1039	

▶ Available ex stock

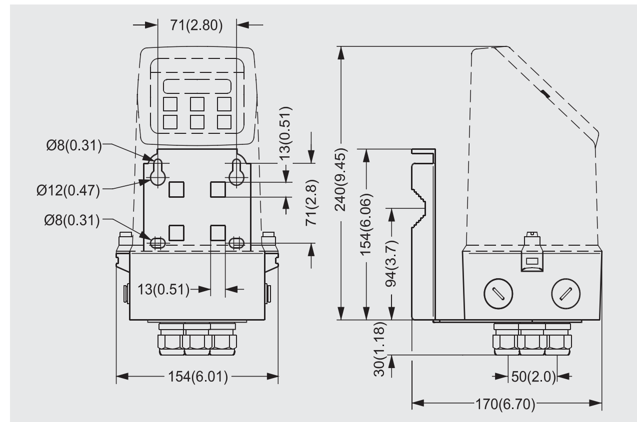
Transmitter MAGFLO MAG 5000/6000

Dimensional drawings

Transmitter IP67/NEMA 4X/6 compact polyamide

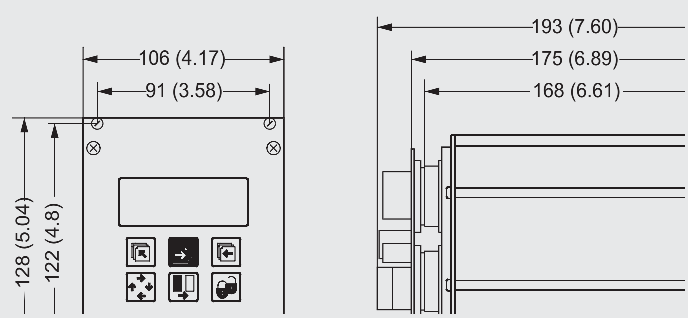


Transmitter integral mounted



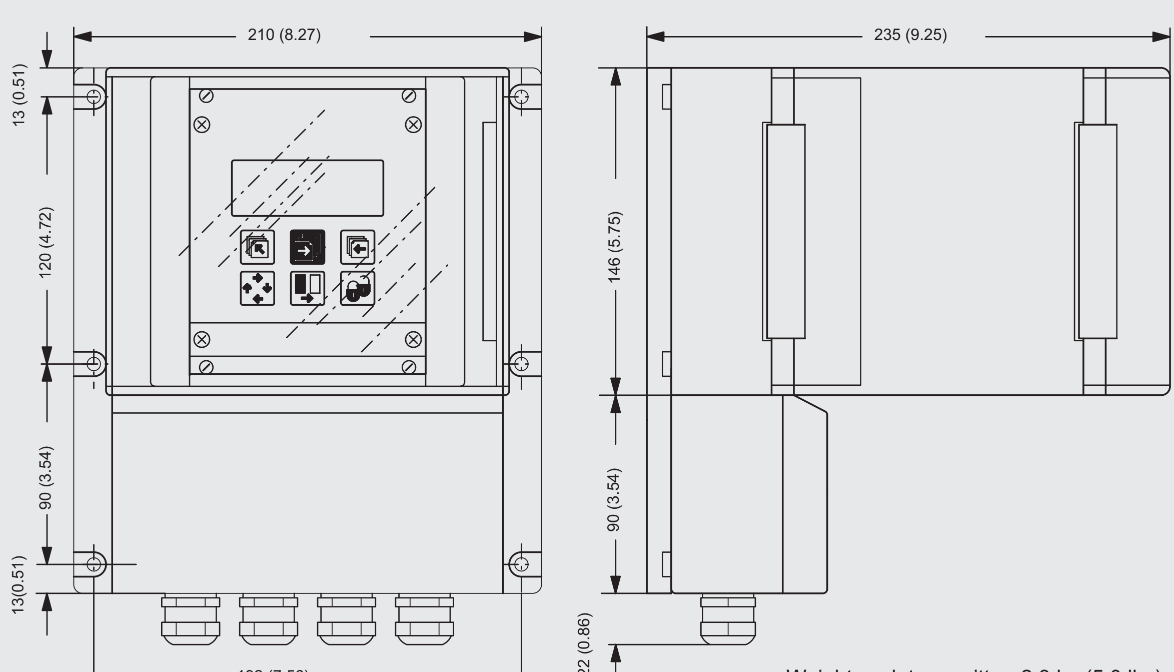
Transmitter wall mounted

Transmitter, 19" IP20/ NEMA 2 standard unit



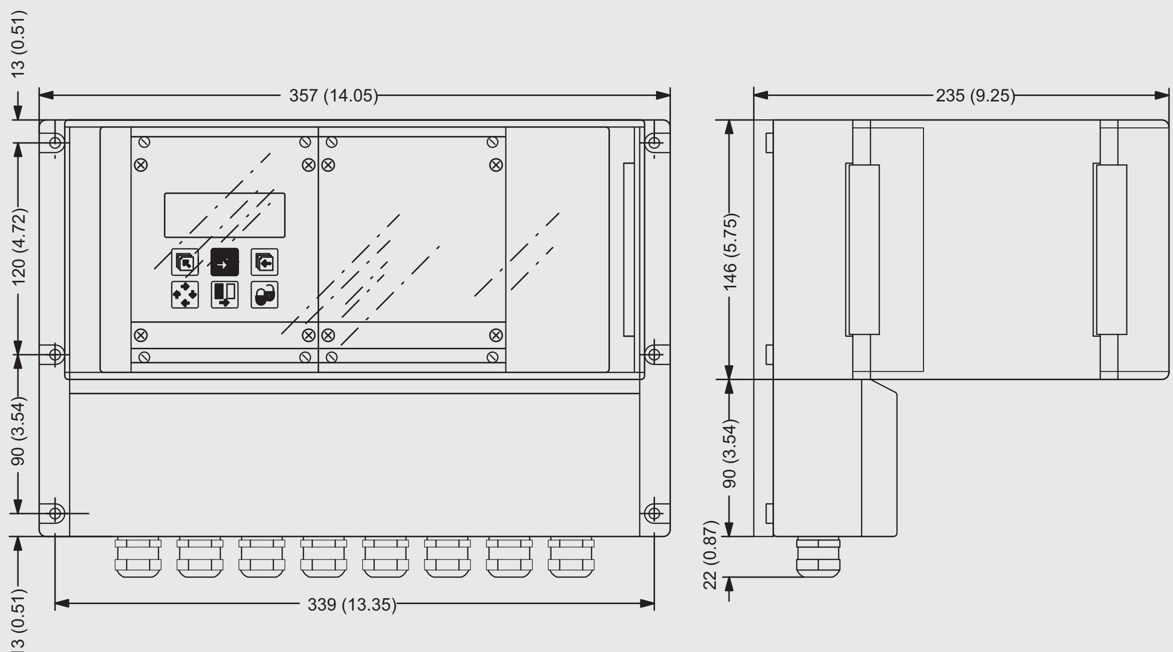
Weight incl. back print 0.8 kg / 1.8 lbs

Transmitter, wall mounting IP66/NEMA 4, 21 TE



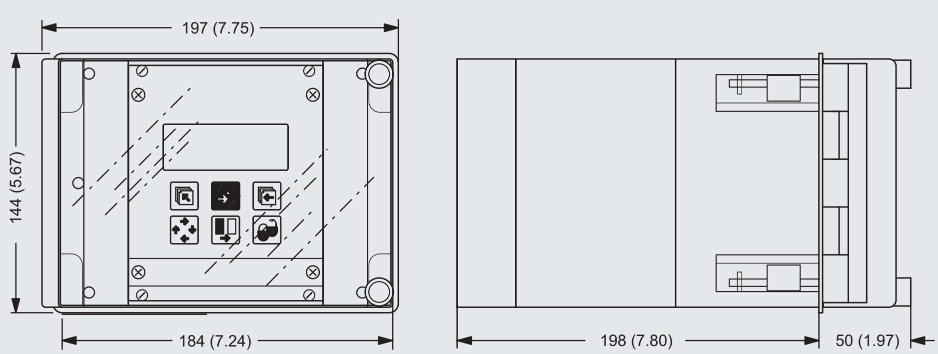
Weight excl. transmitter: 2.3 kg (5.0 lbs)

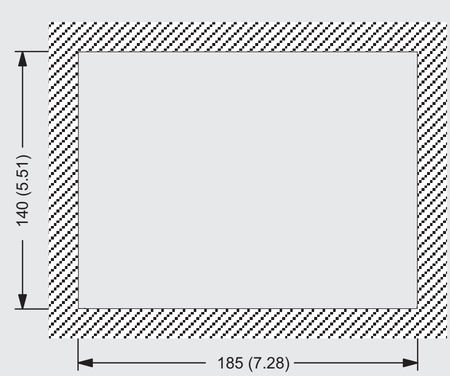
Transmitter, wall mounting IP66/NEMA 4, 42 TE



Weight excl. transmitter: 2.9 kg (7.0 lbs)

Transmitter, panel front IP65/NEMA 4, 21 TE

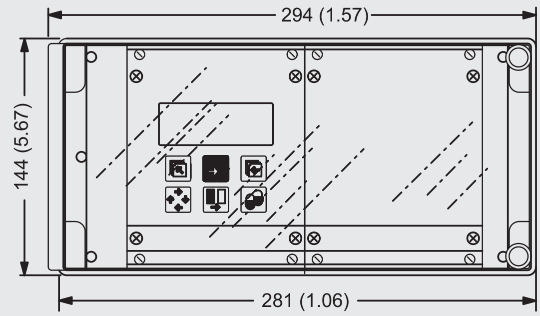


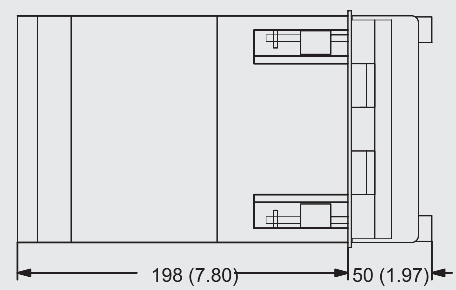


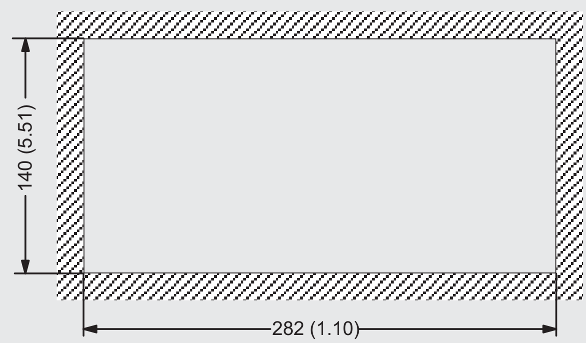
Weight excl. transmitter: 1.2 kg (2.7 lbs)

Transmitter MAGFLO MAG 5000/6000

Transmitter, panel front IP65/NEMA 4, 42 TE

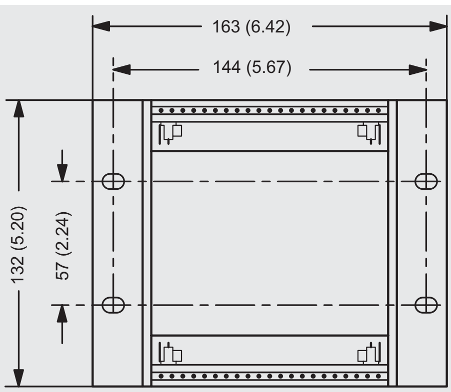


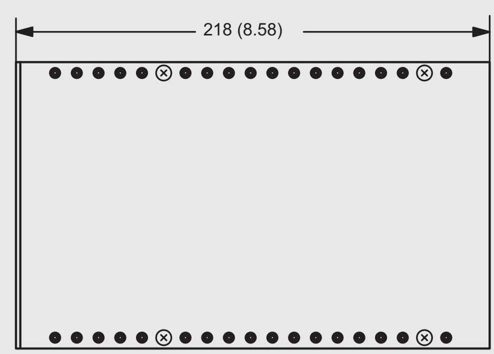




Weight excl. transmitter: 1.6 kg (3.5 lbs)

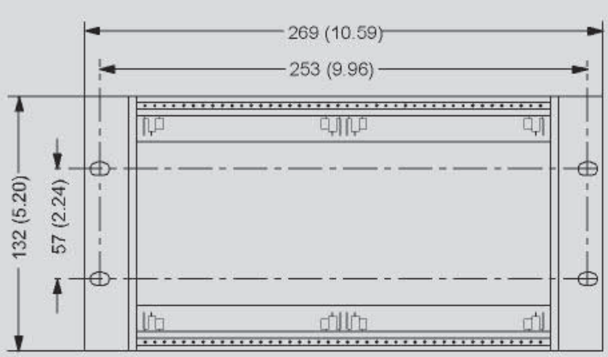
Transmitter, back of panel IP20/NEMA 2, 21 TE





Weight: 0.7 kg (1.6 lbs)

Transmitter, back of panel IP20/NEMA 2, 42 TE



Weight: 0.9 kg (2.0 lbs)

Schematics

Electrical connection

Grounding

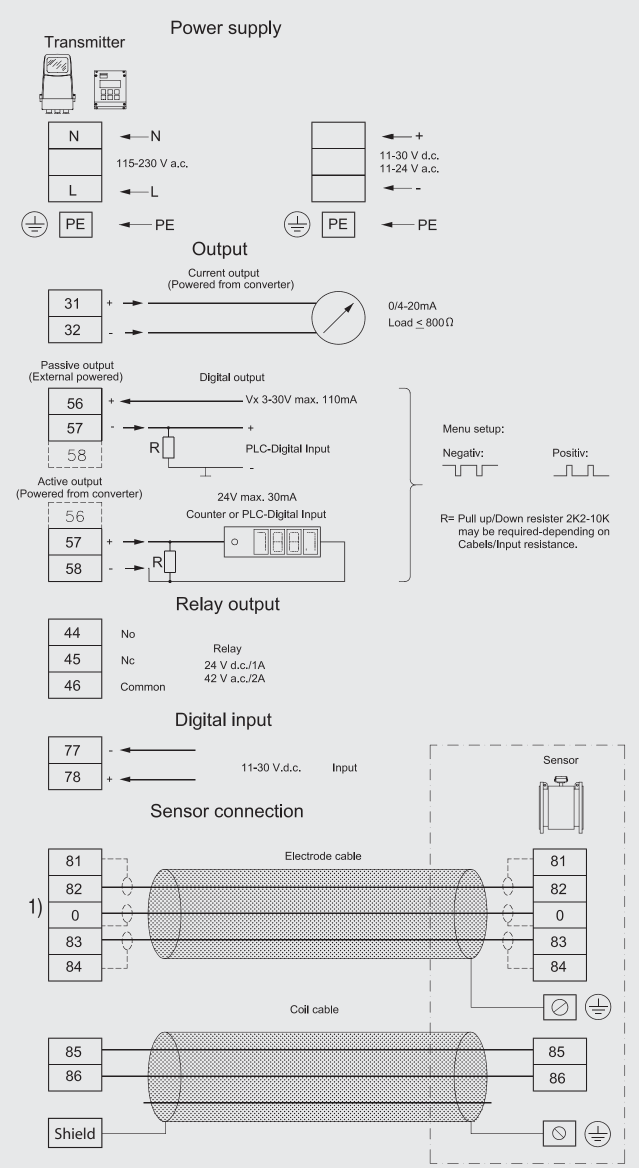
PE must be connected due to safety class 1 power supply.

Mechanical counters

When mounting a mechanical counter to terminals 57 and 58 (active output), a 1000 µF capacitor must be connected to the terminals 56 and 58. Capacitor + is connected to terminal 56 and capacitor - to terminal 58.

Output cables

If the output cable length is long in noisy environment, we recommend to use screened cable.



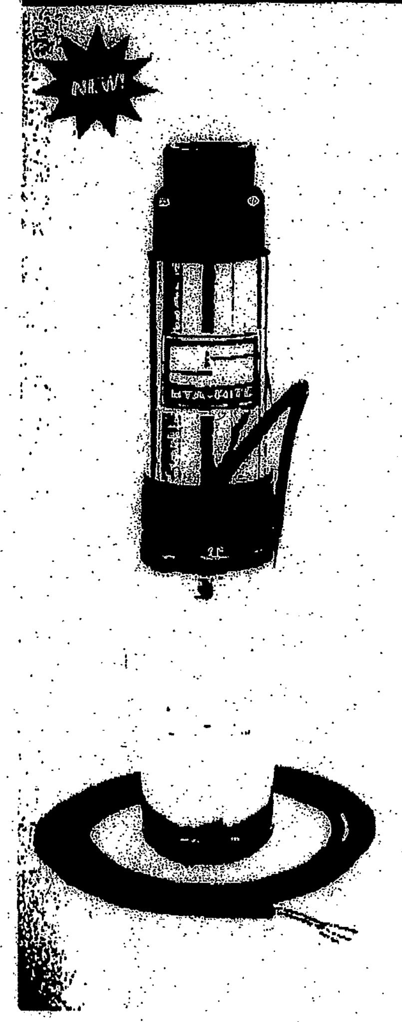
1) Note
Special cable with individual wire shields (shown as dotted lines) are only required when using empty pipe function or long cables

4

P-2

STA-RITE®

high head multi-stage submersible effluent pumps



The new STEP Plus™ 4" submersible effluent pumps in 10 and 20 GPM models offer dependable performance and value for high pressure filtered effluent applications.

These new STEP Plus™ pumps will handle "dry run" conditions where other manufacturers fail.

The 10 and 20 GPM are industry standard 3-3/4" in diameter.

Powered by Franklin Electric submersible motors.

APPLICATIONS

- **Filtered Effluent**... for residential, commercial, and agricultural use.

SPECIFICATIONS

Shell – Stainless steel
Discharge – Fiberglass-reinforced thermoplastic
Discharge Bearing – Nylatron®
Impellers – Delrin®
Diffusers – Polycarbonate
Suction Caps – Polycarbonate with stainless steel wear ring
Thrust Pads – Proprietary spec.
Shaft and coupling – Stainless steel 300 grade
Intake – Fiberglass-reinforced thermoplastic
Intake Screen – Polypropylene
Agency Listing – UL, SSPMA
Jacketed Cord – 300 Volt "SJOW" jacketed 10' leads, 115 Volt, 2-wire with ground
Franklin Electric Motors – Proven field operation

This product is listed to UL Standards for Safety by Underwriters Laboratories Inc. (UL). SSPMA Certified

ST.E.P. *Plus*™

STA-RITE EFFLUENT PUMP

FEATURES

Patented Staging System – Proven SignaSeal™ staging system is designed with a corrosive resistant stainless steel wear surface, that when incorporated with our floating stack design, greatly reduces problems with abrasives, sand lock-up and running dry.

Shaft – Positive drive 300 grade stainless steel 7/16" hexagonal shaft.

Discharge – Fiberglass-reinforced thermoplastic.

Discharge bearing – Exclusive self-lubricating Nylatron® bearing resists wear from sand.

Impellers – Precision molded for perfect balance... ultra smooth for highest performance and efficiency. Allows for 1/8" solids.

Shell – Heavy walled corrosion-resistant stainless steel. Threaded for easy servicing.

ORDERING INFORMATION

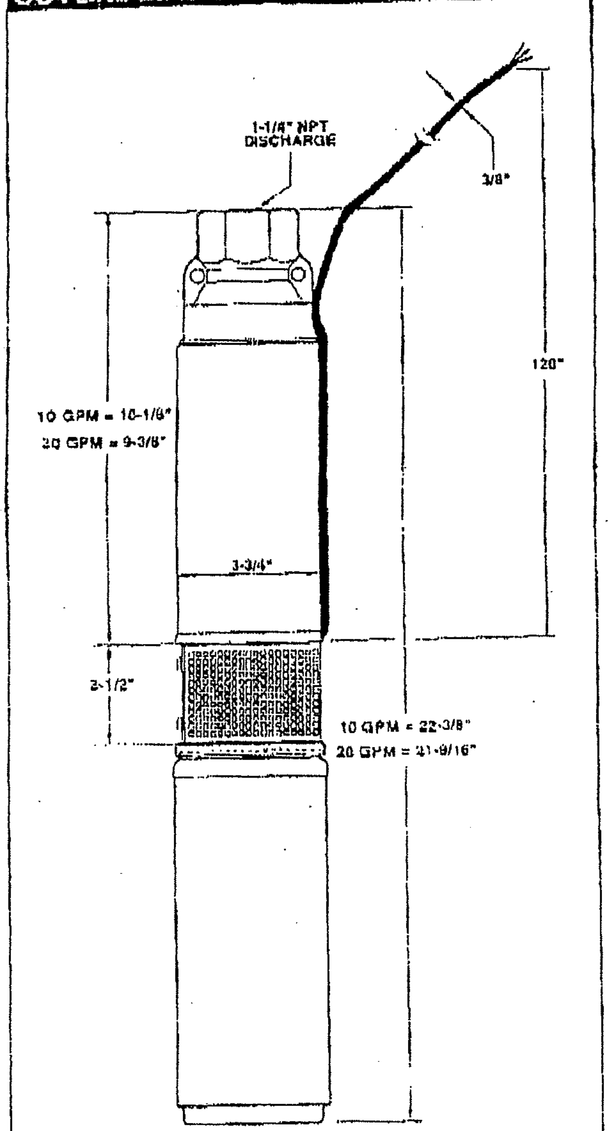
Catalog Number	HP	Max. Load Amps	Volts	Phase/ Cycles	Cord Length
STEP10	1/2	12.0	115	1/60	10'
* STEP20	1/2	12.0	115	1/60	10'

Delrin® is a registered trademark of E.I. DuPont de Nemours and Co. Nylatron® is a registered trademark of Polymer Corp. SignaSeal™ and ST.E.P. Plus™ are trademarks of Sta-Rite Industries, Inc.
In order to provide the best products possible, specifications are subject to change.

STA-RITE

high head multi-stage submersible effluent pumps

OUTLINE DIMENSIONS

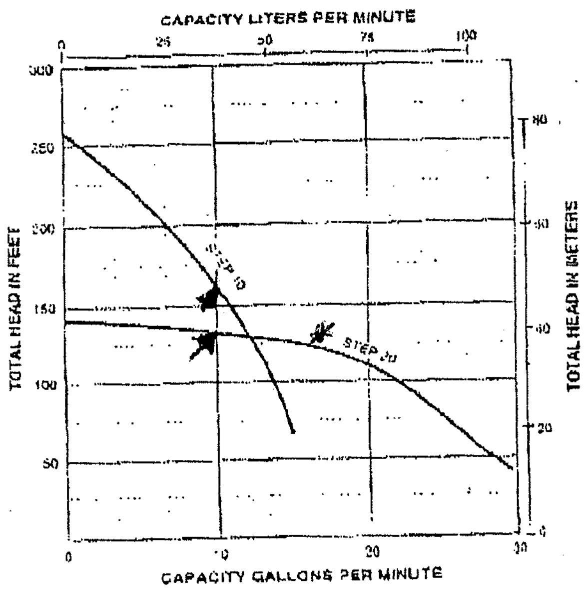


Dimensions (in inches) are for estimating purposes only.

PUMP PERFORMANCE

Catalog Number	Gallons/Liters per Minute	Head (Feet/Meters)	PSI
STEP10	0/0	255/78	110
	5/19	228/69	99
	10/38	170/52	74
	12.5/47	120/37	52
STEP20	0/0	145/44	63
	7.5/28	132/40	57
	15/57	125/38	54
	20/76	112/34	48
	25/95	75/23	32

PUMP PERFORMANCE

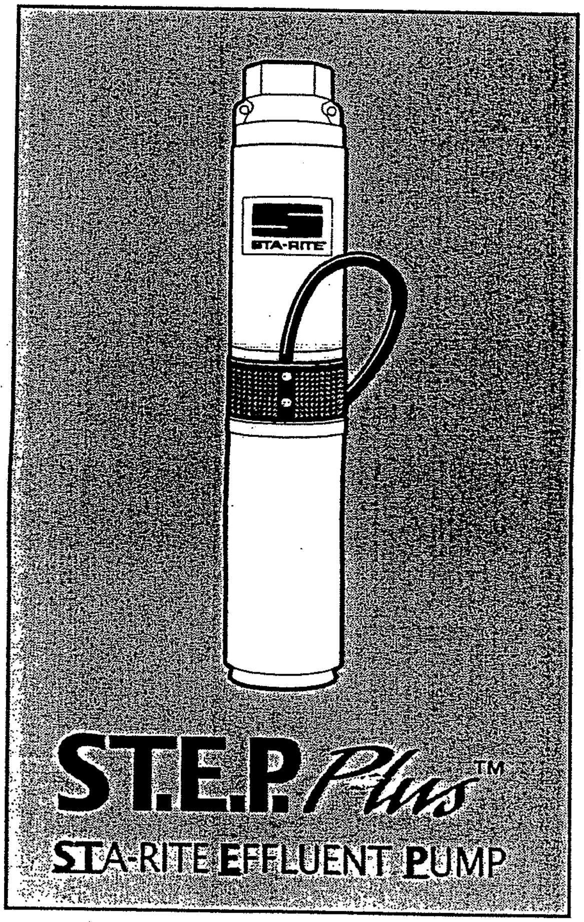


STA-RITE®

293 Wright Street, Delavan, WI 53115

OWNER'S MANUAL

4" Submersible High-Head Filtered Effluent Pump



Installation/Operation/Parts

For further operating, installation, or maintenance assistance:

Call 1-262-728-9181

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SE370 (7/7/00)

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Carefully read and follow all safety instructions in this manual or on pump.

⚠ **This is the safety alert symbol.** When you see this symbol on your pump or in this manual, look for one of the following signal words and be alert to the potential for personal injury!

⚠ DANGER **DANGER** warns about hazards that **will** cause serious personal injury, death or major property damage if ignored.

⚠ WARNING **WARNING** warns about hazards that **can** cause serious personal injury, death or major property damage if ignored.

⚠ CAUTION **CAUTION** warns about hazards that **will** or **can** cause minor personal injury or property damage if ignored.

The word **NOTICE** indicates special instructions which are important but not related to hazards.

To avoid serious or fatal personal injury and possible property damage, carefully read and follow the safety instructions.

1. **⚠ WARNING** **Hazardous pressure** **Under certain conditions, submersible pumps can develop extremely high pressure. Install a pressure relief valve capable of passing entire pump flow at 75 PSI.**

⚠ **Do not allow pump, piping, or any other system component containing water to freeze. Freezing may damage system, leading to injury or flooding. Allowing pump or system components to freeze will void warranty.**

2. **⚠ WARNING** **Hazardous voltage** **Can shock, burn or cause death. To avoid dangerous or fatal electric shock hazard, use pump only in an effluent system. DO NOT install pump in an open body of water (a lake, swimming pool, etc.).**

⚠ Install, ground and wire pump according to local and Canadian Electrical Code or National Electrical Code requirements that apply.

⚠ Disconnect electrical power supply before installing or servicing pump.

⚠ Make sure motor nameplate voltage and frequency match line voltage and frequency of power supply.

1. Install pump according to all plumbing, pump and well code requirements.
2. Install an all leg disconnect switch in the power supply near the pump.
3. Two-wire motors are equipped with automatic thermal overload protection which will open the circuit and stop the motor when a thermal overload (excessive heating) exists. When motor cools, overload will reset and motor will restart automatically. *This can cause the motor to start unexpectedly and without warning.*

GENERAL

Inspect pump and motor for delivery damage. Report any damage immediately to shipping carrier or to Sta-Rite immediately.

Have any installation, repair, or service work done by your Sta-Rite dealer.

Never run pump dry.

During system operation, pump must be submerged at all times.

Pipe joint compound can cause cracking in plastics. Use only teflon tape when sealing joints in plastic pipe.

Warranty is void in the following conditions:

- Water is highly corrosive.
- If entrained gas or air present in water being pumped reduce the flow and cause cavitation (which can damage the pump).
- Pump has been operated with discharge valve closed (severe internal damage will result).

ELECTRICAL

WIRING/GROUNDING

⚠ WARNING **Hazardous voltage** **Can shock, burn, or cause death. Permanently ground pump, motor and control box before connecting power supply to motor.**

Ground pump and motor in accordance with all codes and ordinances that apply. All wiring must meet National Electrical Code and Canadian Electrical Code (whichever applies). Use copper ground wire at least as large as wires carrying current to motor.

Motor is supplied with copper ground wire. Splice to copper conductor that matches motor wire size specified in Table 2. Use only copper wire for connections to pump.

Permanently ground pump and motor before connecting power cable to power supply. Connect ground wire to approved ground first, then connect to equipment being installed.

Do not ground to a gas supply line.

Float switches or any other approved motor control must match motor input in full load amperes.

For more information, contact your local code officials.

INSTALLATION WIRING INSTRUCTIONS

Single Phase, 2 Wire

2-Wire pumps have two power supply wires (Red/Black) and one ground wire (Green).

1. Fasten power supply wire leads securely to pump discharge section; leave 4-5" of slack in leads at this point. Securely fasten leads to plastic pipe within 6" of the pump discharge section.
2. Ground wire must be as large as wires supplying current to motor. Consult current National Electrical Code or Canadian Electrical Code (as applicable) and local codes for grounding information.
3. Use only submersible power supply wires supplied by pump manufacturer. When installing pump, secure supply wires to discharge pipe with Scotch #33 electrical tape. DO NOT damage pump wires.

   NOTICE: To avoid dropping pump or damaging wires or splices, **NEVER** allow pump wires to support weight of pump.

EFFLUENT APPLICATIONS

Effluent applications must meet the following:

⚠ WARNING **Risk of electrical shock.** Do not remove cord and strain relief. Do not connect conduit to pump.

1. Only qualified personnel should install the pump and associated control equipment.
2. Vent sewage tank according to local code.
3. Do not install pump in any location classified as hazardous by National Electrical Code, ANSI/NFPA 70-1984.
4. These pumps are intended for permanent connection only. Provide strain relief at control box for power supply cord connection to box. All control components must be UL listed and suitable for end use application.

PUMP INSTALLATION

1. Make sure that pump and motor are free to rotate by turning the shaft by hand.
2. To prevent dropping pump, lower it by the drop pipe, not by the cables. The electrical cables will not hold the pump weight.
3. Discharge outlet is 1-1/4" NPT threaded.

   NOTICE: Pump discharge is left-hand thread into pump shell. If installing external check valve, hold discharge with pipe wrench to prevent loosening discharge in shell.
4. If pump is to be operated with an open discharge, a discharge valve *must be installed.* Before startup, open this valve about 1/3

open. Start pump. *Slowly* open valve until the desired flow rate is reached. Final setting *must* be within pump's recommended operating range.

OPERATION

1. The pump must be submerged at all times during normal operation. **Do not run pump dry.**
2. Make sure that the float switches are set so that the pump stops before the pump runs dry or breaks suction. If necessary, adjust float switches to achieve this.
3. The motor bearings are lubricated internally. No maintenance is required or possible on the pump or the motor.

Table 1: Recommended Fusing Data

60 Hz/1 Phase 2-Wire Cable

HP	Voltz/Hz/ Phase	Motor Winding Resistance Ohms	Max Load Amps	Locked Rotor Amps	Fuse Size Standard/ Dual Element
1/2	115/60/1	1.0-1.3	12.0	64.8	30/15

Table 2: Power Supply Wire (Cable) Length in Feet

1 Phase, 2 Wire Cable, 60 Hz (Copper Wire Size - Service to motor)

Volts	HP	14 AWG	12 AWG	10 AWG	8 AWG	6 AWG	4 AWG	3 AWG	2 AWG	1 AWG	0 AWG
115	1/2	100	160	250	390	620	960	1190	1460	1780	2160

1. Maximum wire lengths shown maintain motor voltage at 95% of service entrance voltage, running at maximum nameplate amperes. If service entrance voltage will be at least motor nameplate voltage under normal load conditions, 50% additional length is permissable for all sizes.
2. Sizes given are for copper wire. For aluminum wire go two sizes larger (i.e., if table lists #12 copper wire, use #10 aluminum wire.)

Motor Insulation Resistance Readings

Normal Ohm/Megohm readings for all motors, between all leads and ground. Set ohmmeter to 100K scale.

Condition of Motor and Leads	Ohm Value	Megohm Value
New motor, without power cable	20,000,000 (or more)	20.0
Used motor, which can be reinstalled in tank	10,000,000 (or more)	10.0
Motor in Tank – Readings are Power Cable plus Motor		
Do not pull pump for these reasons:		
New Motor	2,000,000 (or more)	2.0
Motor in reasonably good condition	500,000 to 2,000,000	0.5–2.0
Motor which may be damaged or have damaged power cable	20,000 to 500,000	0.02–0.5
Pull pump; replace pump or cable:		
Motor definitely damaged or with damaged power cable	10,000 to 20,000	0.01–0.02
Failed motor or power cable	Less than 10,000	0–0.01

Important Electrical Grounding Information

⚠WARNING **Hazardous voltage. Can shock, burn, or kill. To reduce the risk of electrical shock during pump operation, ground and bond the pump and motor as follows:**

A. To reduce risk of electrical shock from metal parts of the assembly other than the pump, bond together all metal parts accessible at the tank top (including metal discharge pipe, metal tank top, and the like). Use a metal bonding conductor at least as large as the power cable conductors running down the well to the pump's motor.

B. Clamp or weld (or both if necessary) this bonding conductor to the grounding means provided with the pump, which will be the equipment-grounding terminal, the grounding conductor on the pump housing, or an equipment-grounding lead. The equipment-grounding lead, when provided, will be the conductor having green insulation; it may also have one or more yellow stripes.

C. Ground the pump, motor, and any metallic conduit that carries power cable conductors. Ground these back to the service by connecting a copper conductor from the pump, motor, and conduit to the grounding screw provided within the supply-connection box wiring compartment. This conductor must be at least as large as the circuit conductors supplying the pump.

Save these instructions.

TROUBLESHOOTING GUIDE

PROBLEM	CHECK	CORRECTIVE ACTION
Motor will not start but fuses do not blow		
No voltage.	No voltage at disconnect switch.	Replace blown fuses or bad cable, reset circuit breakers.
	Electrical cable bad.	Consult licensed electrician or serviceman.
Fuses blow or overload protector trips when motor starts		
Wrong size fuse, time delay fuse, or circuit breaker.	Check fuse or circuit breaker size against chart, Page 2.	Install correct fuse, time delay fuse, or circuit breaker.
Wire size too small.	Check wire size against chart, Page 3.	Install correct size wire.
Low or high voltage.	Check that line voltage is within ±10% of nameplate rated voltage while motor is running.	If voltage variation is greater than ±10%, call power company or local hydro authority to adjust voltage.
Pump or motor stuck or binding.	Check for locked shaft in pump.	If necessary, pull pump (make all possible above ground checks first). If pump is locked, replace it. Clean tank of all sand, lime, and solids before reinstalling pump.
Power supply wires or motor leads grounded, shorted, or open.	Consult licensed electrician or qualified serviceman.	Have a qualified serviceman or electrician make necessary cable repairs.
Fuses blow or overload protector trips when motor is running		
Low or high voltage.	Check that line voltage is within ±10% of rated nameplate voltage while motor is running.	If voltage variation is more than ±10%, call power company to adjust voltage.
High ambient (atmospheric) temperature.	Check temperature of tank	Protect tank from direct sunlight.
Wire size too small.	Check wire size against chart, Page 3.	Install correct wire size.
Pump starts too frequently		
Leaks in system.	Check plumbing for leaks.	
Level switch.	Check for defective switch or switch out of adjustment.	Re-adjust or replace level switch.
Check valves leaking.	Make sure check valves are not leaking back.	Replace check valves if necessary.
Little or no water delivered		
Check valve stuck.	Examine valve.	If stuck, free valve.
Low voltage.	Check voltage at circuit breaker with pump running. Check incoming wire size and power supply wire size against chart, Page 3.	Install larger wire from meter to circuit breaker. Install larger wire from circuit breaker to pump. If necessary, have power company raise supply voltage.
Plugged intake screen.	Pull pump and check condition of screen.	Clean or replace as necessary.
Check valve at pump discharge stuck.	Pull pump and examine check valve.	Free check valve.
Worn impellers and diffusers.	Make sure system is clear of obstructions and pump is in solid water and operating normally.	Replace pump.
Pump doesn't develop enough pressure ("head").	Check pump curve against operating conditions.	Replace pump with "higher head" pump.
Plugged impellers.	Pull pump.	Replace pump.

LIMITED WARRANTY

Sta-Rite Industries, Inc., warrants to the original consumer of the products listed below, that they will be free from defects in material and workmanship for the Warranty Period from the date of original installation or manufacture as noted.

Product	Warranty Period
Water Systems Products – jet pumps, small centrifugal pumps, submersible pumps and related accessories	*whichever occurs first:* 1 year from date of original installation, or 2 years from date of manufacture
Hydro-Flow Filters	1 year from date of purchase
Signature 2000 Fibrewound Tanks	5 years from date of original installation
Pro-Source Steel Pressure Tanks	5 years from date of original installation
Pro-Source Epoxy-Line Tanks	3 years from date of original installation
Sump/Sewage/Effluent Products	1 year from date of original installation, or 2 years from date of manufacture

Our warranty will not apply to any product that has been subject to negligence, misapplication, improper installation or maintenance. In the event a three phase submersible motor is operated with single phase power through a phase converter, or if three-leg ambient compensated, extra-quick trip overload relays of recommended size are not used, our warranty is void.

Buyer's only remedy and Sta-Rite Industries, Inc.'s only duty is to repair or replace defective products (at Sta-Rite Industries, Inc.'s choice). Buyer agrees to pay all labor and shipping charges associated with this warranty and to request warranty service through the installing dealer as soon as a problem is discovered. If warranty service is requested more than 30 days after the Warranty Period has ended, it will not be honored.

STA-RITE INDUSTRIES, INC. SHALL NOT BE LIABLE FOR ANY CONSEQUENTIAL, INCIDENTAL, OR CONTINGENT DAMAGES WHATSOEVER.

THE FOREGOING WARRANTIES ARE EXCLUSIVE AND IN LIEU OF ALL OTHER EXPRESS WARRANTIES. IMPLIED WARRANTIES, INCLUDING BUT NOT LIMITED TO THE IMPLIED WARRANTIES OF MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE, SHALL NOT EXTEND BEYOND THE WARRANTY PERIOD PROVIDED HEREIN.

Certain states do not permit the exclusion or limitation of incidental or consequential damages or the placing of limitations on the duration of an implied warranty, therefore, the limitations or exclusions herein may not apply. This warranty sets forth specific legal rights and obligations, however, additional rights may exist, which may vary from state to state.

Supersedes all previous publications.

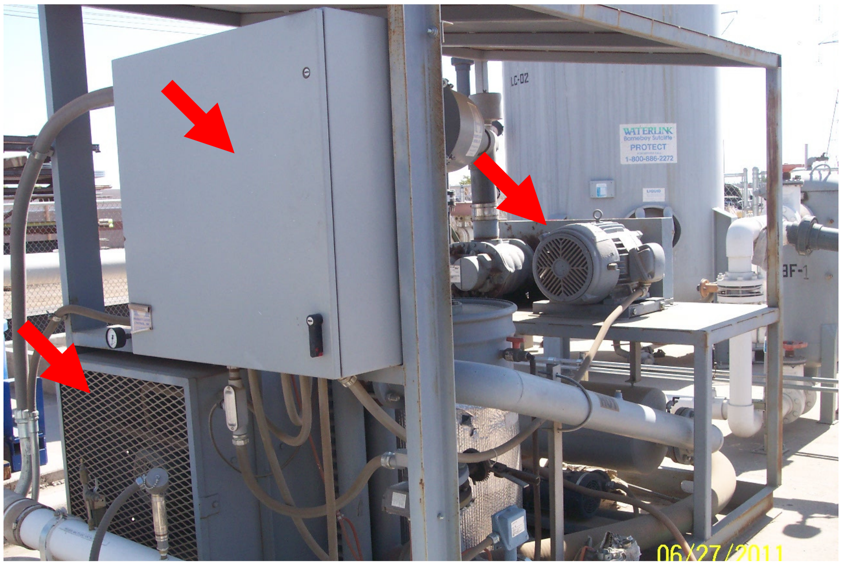
Sta-Rite Industries, Inc. 293 Wright St., Delavan, WI 53115

APPENDIX E

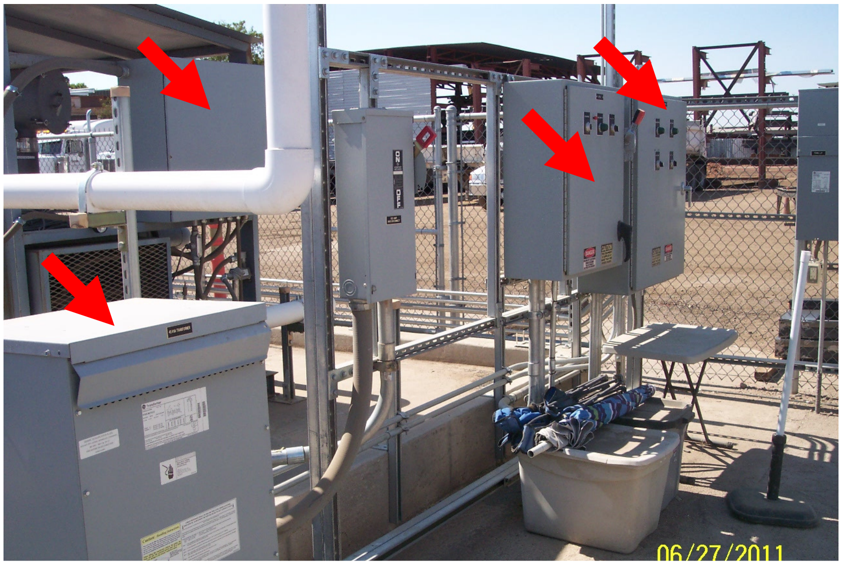
PHOTOGRAPHS

1. View west of the SVE/AS and GW-systems compound; note arrows left to right identify the: AS-system, GW-system, and SVE-system locations.

2. View SW of the SVE-skid; note arrows left to right identify the: discharge heat exchanger, control panel, and SVE blower motor.



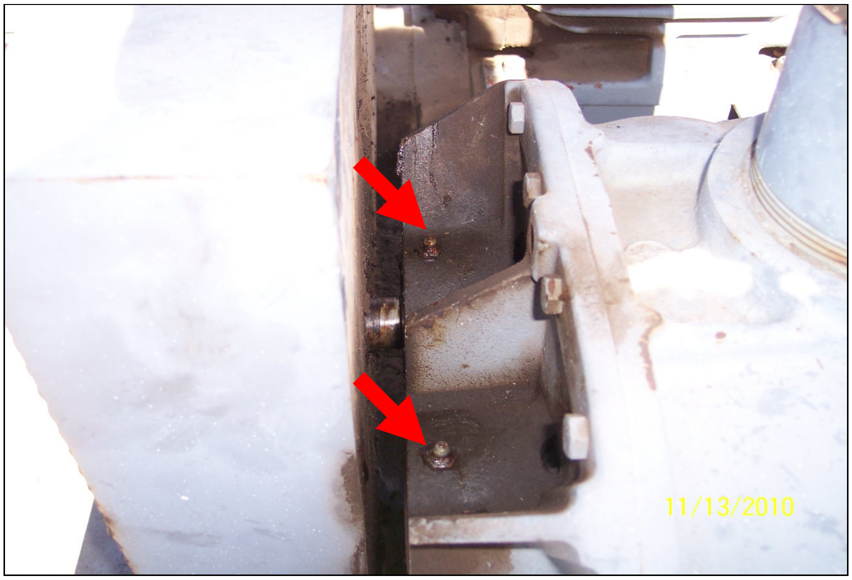
3. View NNW of the systems power control panels; note arrows left to right identify the: SVE-skid disconnect, SVE-skid control panel, CP-3, and CP-4.



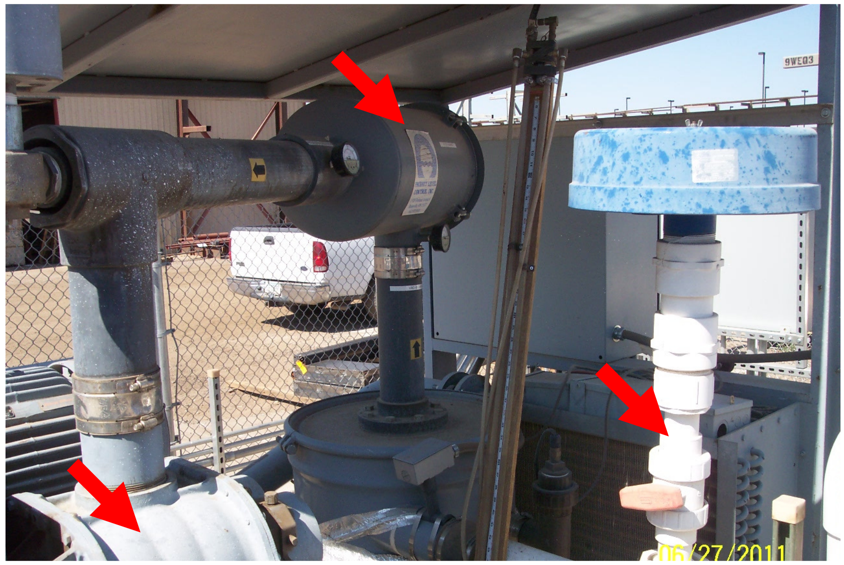
4. At the NEC of compound, view north of the APS power-control panels and meter.

5. View north inside SVE-skid panel of the controls and components.

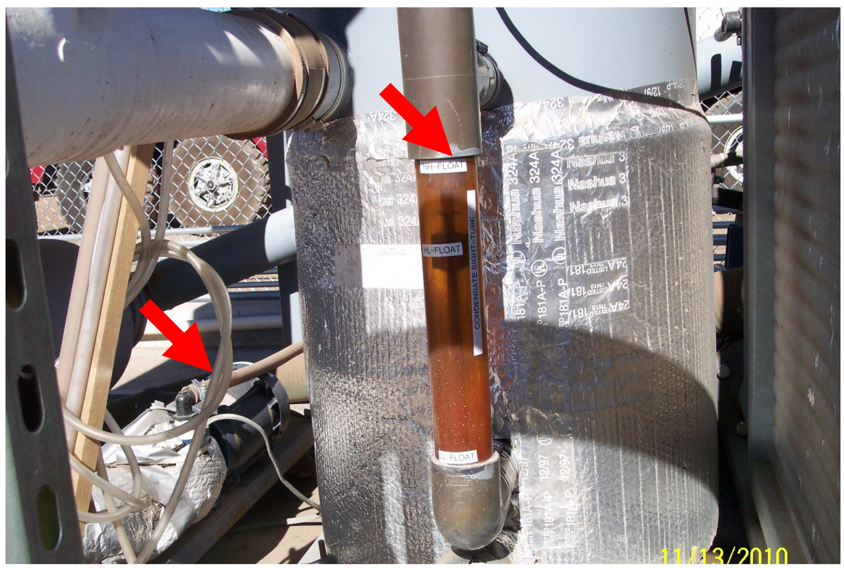
6. Close-up view of the SVE motor bearings grease-ports as indicated by red arrows.



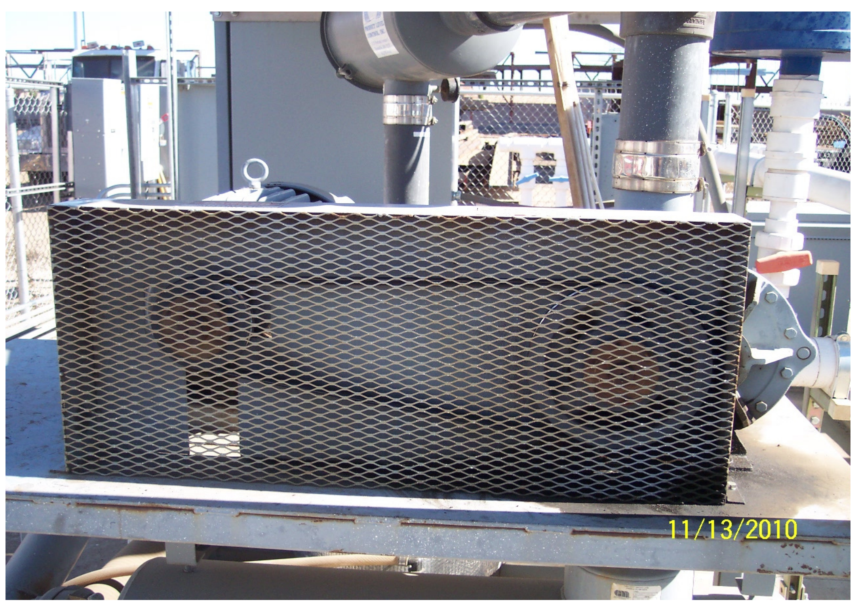
7. View NE of the SVE-skid; note arrows left to right identify the: SVE-motor, air-filter housing atop knock-out tank w/intake and discharge pressure gauges, and air-dilution valve.



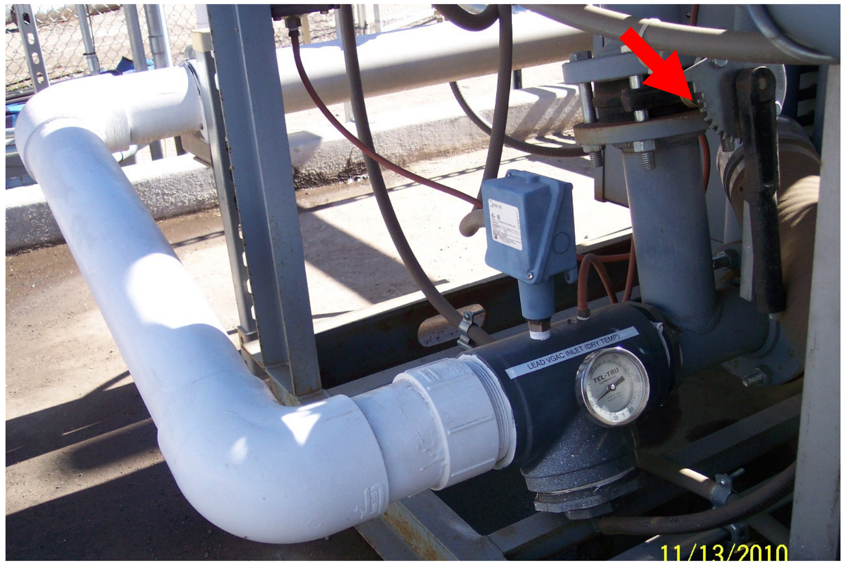
8. View north of knock-out tank; note arrows from left to right identify the KO-tank transfer pump and condensate site-glass.



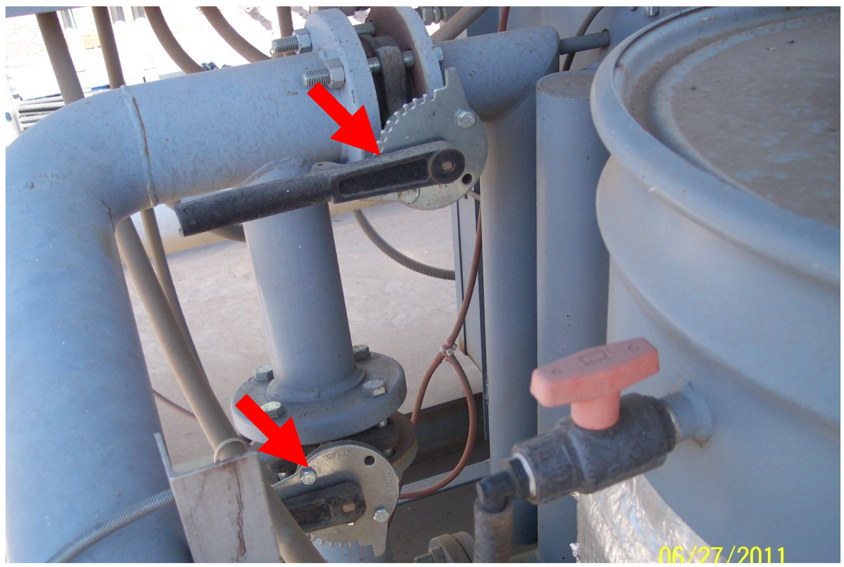
9. View east of the SVE-motor belt housing.



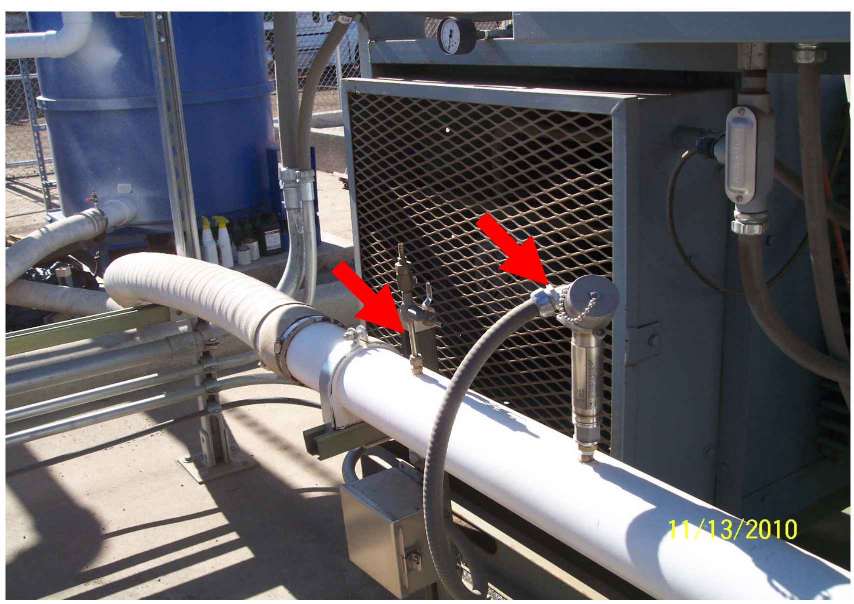
10. View easterly of the post blower lead vgac inlet temperature gauge and high temperature switch housing; note arrow identifies the lower heat exchanger butterfly valve (BFV).



11. View easterly of the heat exchanger upper BFV; note bottom arrow is location of the lower BFV as seen in previous photo.



12. View westerly of the lead vgac inlet pitot-tube and system pressure switch.

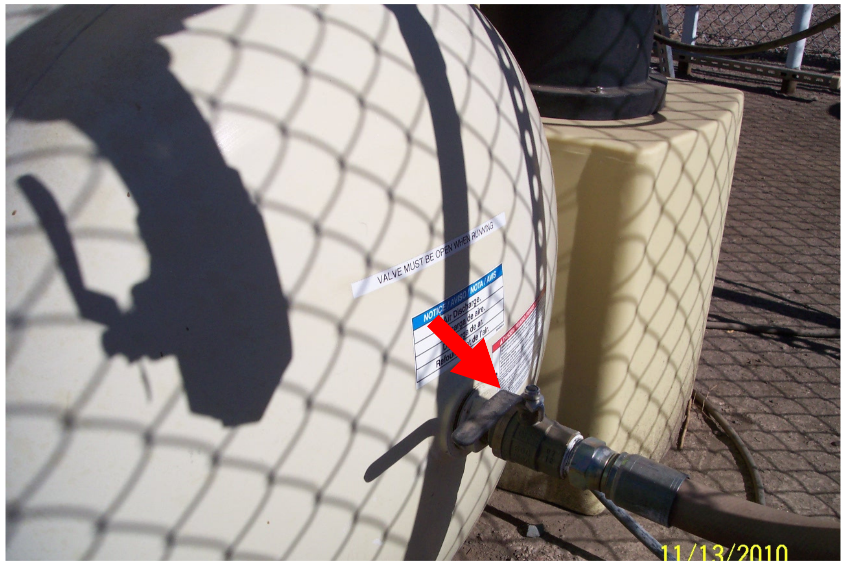


13. Viewing west and from left to right is the lead and lag vgac-vessels; note the arrow identifies the lead vgac outlet temperature gauge.

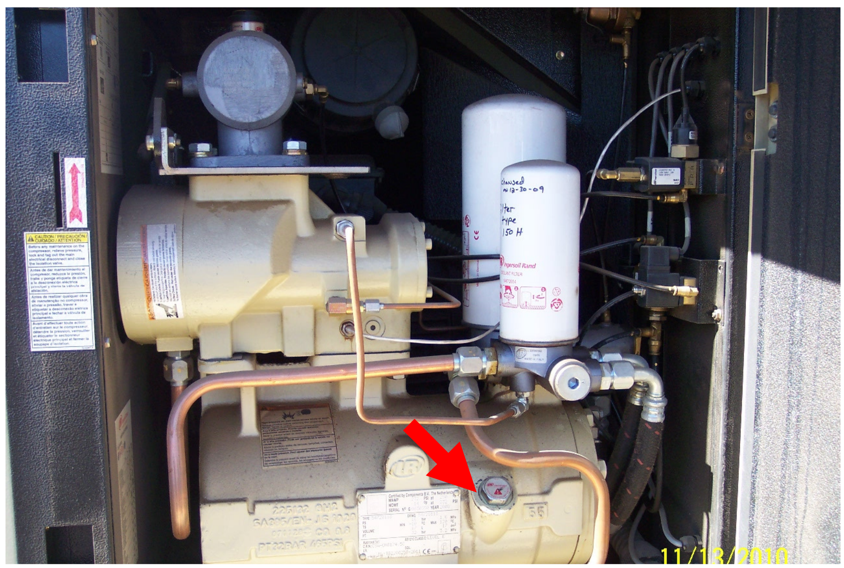
14. View east of the SVE-manifold; note valves from left to right are as follows: SVE-102, 105, 101, and 104.

15. View WSW of the AS-system's air-compressor unit and power-control-box; note the upper arrow identifies the unit's filters and the lower identifies the condensate separator module.

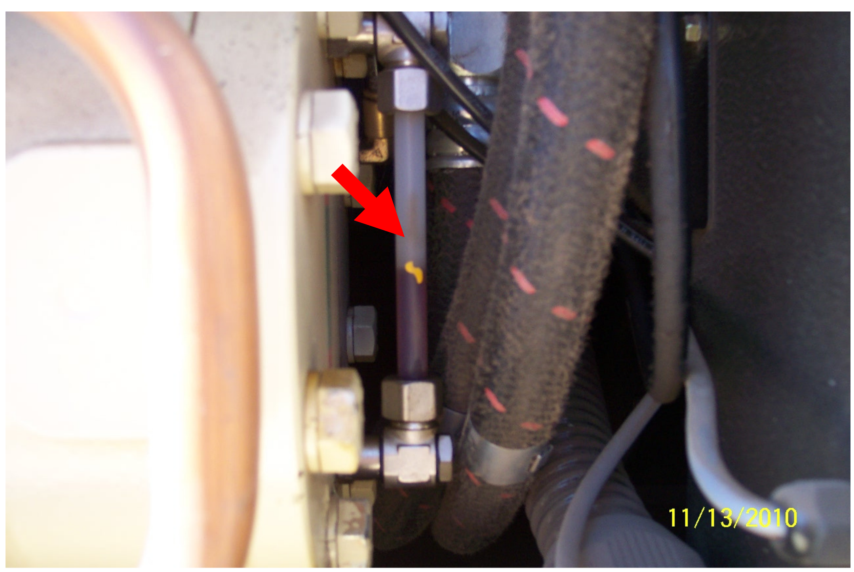
16. View ENE of the west end of the air compressor tank; note arrow indicates the air discharge valve that must be open when system is operating.



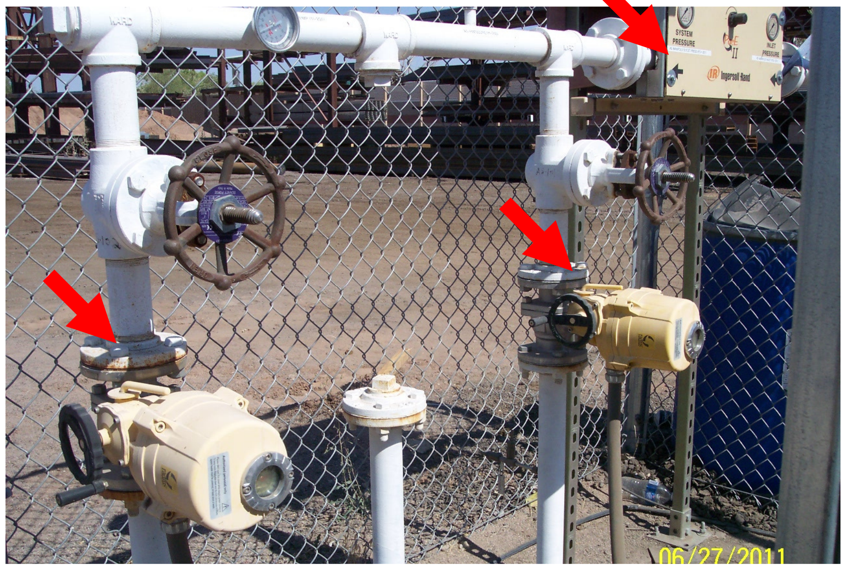
17. View west of the air unit's motor and filters; note arrow indicates locale for adding motor oil.



18. View east of the air unit's motor oil site glass located on the north end of the motor; note yellow mark indicates proper fluid level.

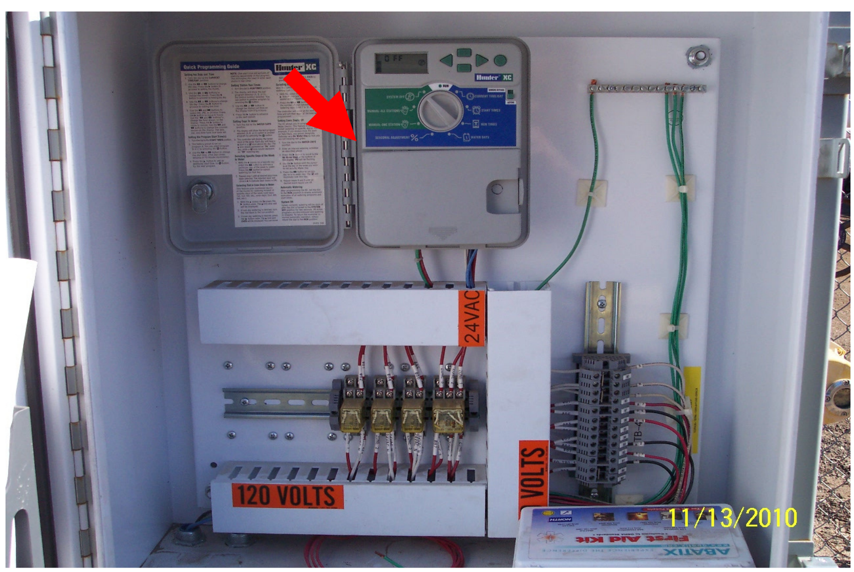


19. View southeast of the AS-manifold; note arrows identify components from left to right as: AS-102 motorized ball-valve, AS-101 motorized ball-valve, and air regulator-valve housing and controls.

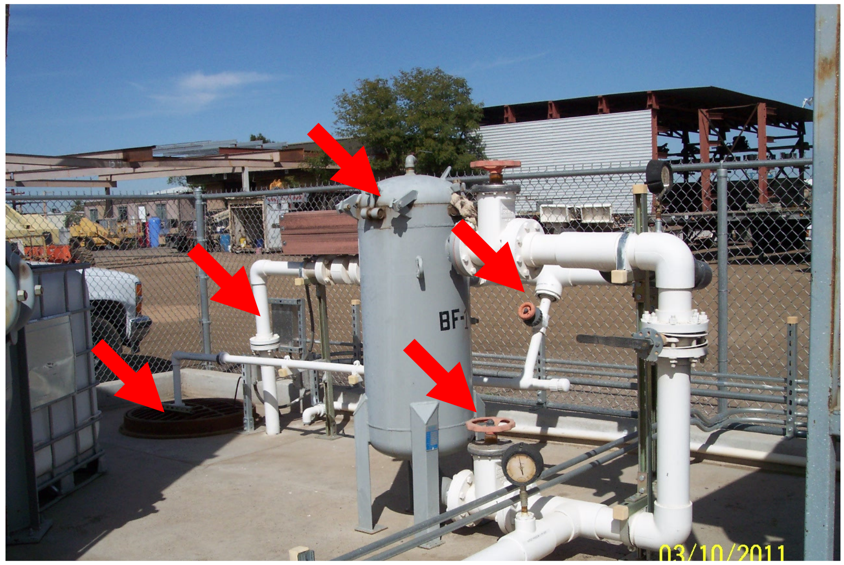


20. View east of the AS-control panel (ASPC) that contains relays and timer/controller-box.

21. View east inside AS-control panel (ASPC); note arrow identifies the controller for setting the on/off cycles for AS-101 & 102 motorized ball-valves.

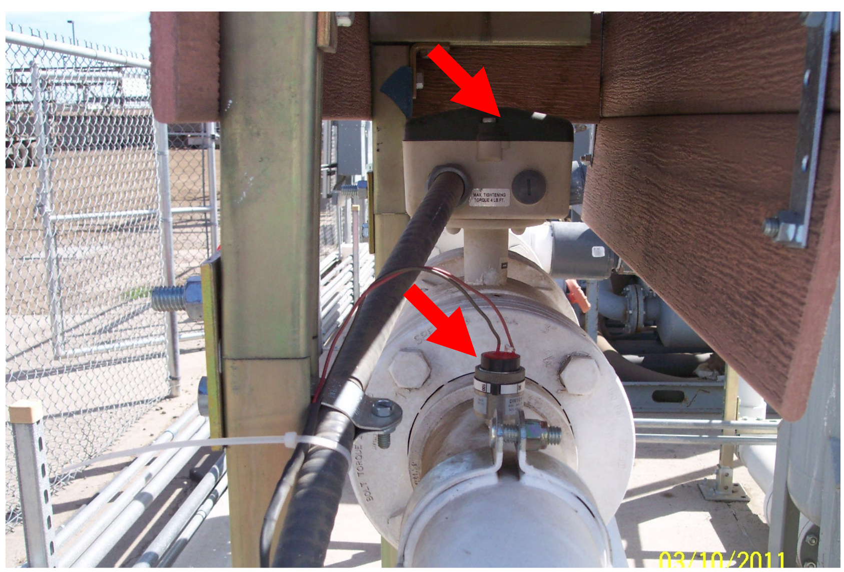


22. Located inside the NWC of compound indicated by red arrows from left to right clockwise are the: sump-vault, EW-101 pump influent piping, bag filter-1 (BF-1), sump-pump ball valve, and BF-1 outlet ball-valve and pressure-gauge.

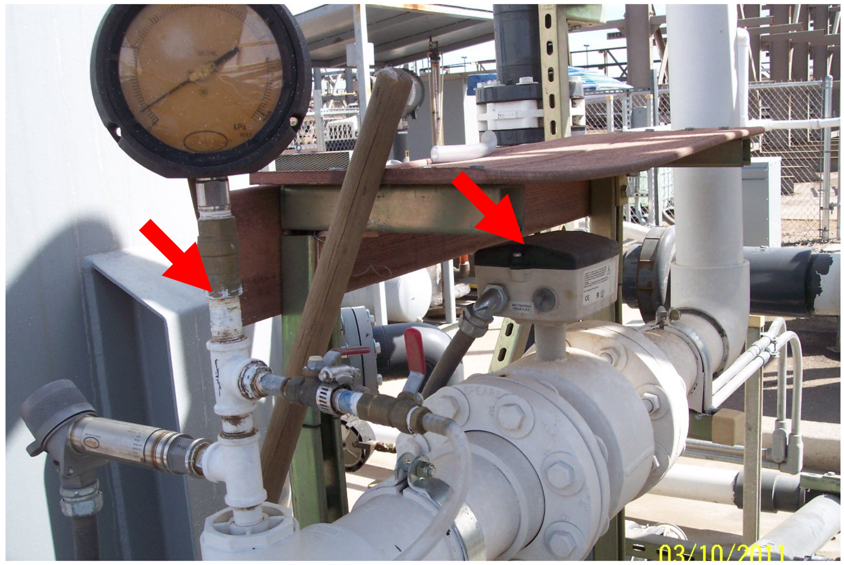


23. At NWC of compound, view west of GW-systems components from left to right as indicated by red arrows are: BF-1 inlet pressure-gauge, influent sample-port, and influent ball-valve.

24. View east from atop EW-101 influent piping indicated by red arrows front to back are the: GW-systems high-pressure shut-down switch and the influent flow-meter that is connected the Siemens digital meter inside CP-4. Note system shut-down pressure is set to 50-psi on the switch by rotating the metal dial.



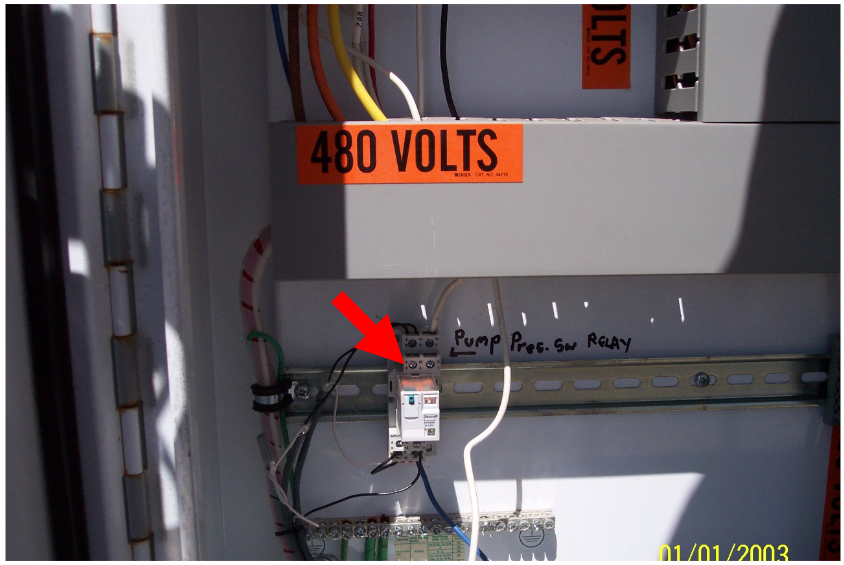
25. At effluent sample-port, view easterly as indicated by red arrows from left to right of: effluent pressure-gauge that is connected to Cell 682 unit inside CP-3, and the effluent flow-meter that is connected to the Siemens digital meter inside CP-4; see photos 6 and 10.



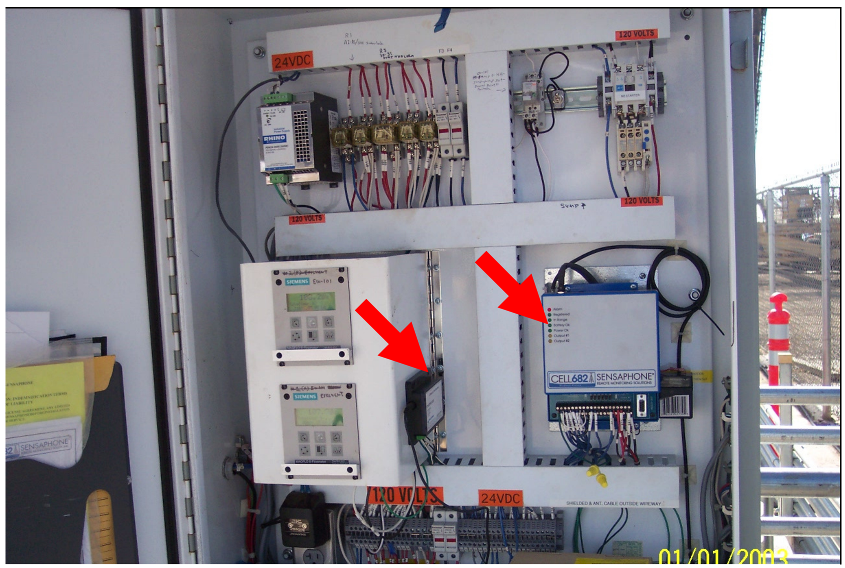
26. At NEC of compound, view west from left to right of CP-3 and CP-4. Note on the front of CP-3 from left to right indicated by red arrows is the GW-systems high-pressure shut-down reset switch and on/off control know for EW-101 pump. Note on front of CP-4 is the sump-pump on/off control knob indicated by red arrow.

27. View inside CP-4 of Siemens digital flow-meters; note EW-101 influent on top of GW-systems effluent meter.

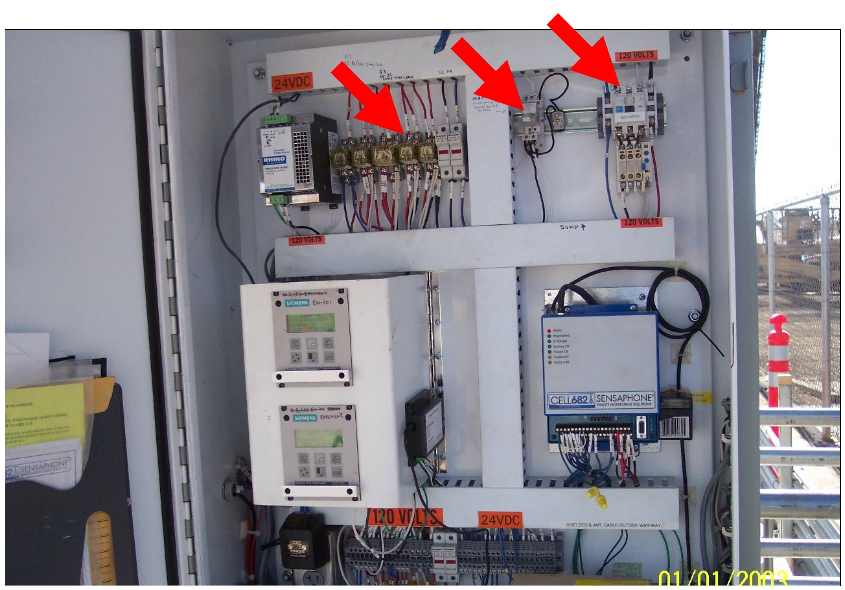
28. View inside CP-4 of the GW-systems high-pressure shut-down switch relay socket and relay, as indicated by red arrow.



29. View inside CP-4 from left to right as indicated by red arrows are: monarch quad processor connected to the Siemens digital meters that records the GW-systems influent and effluent flow-rates at 1-hour intervals, and the Cell 682 unit that enables the system to be connected to remotely.

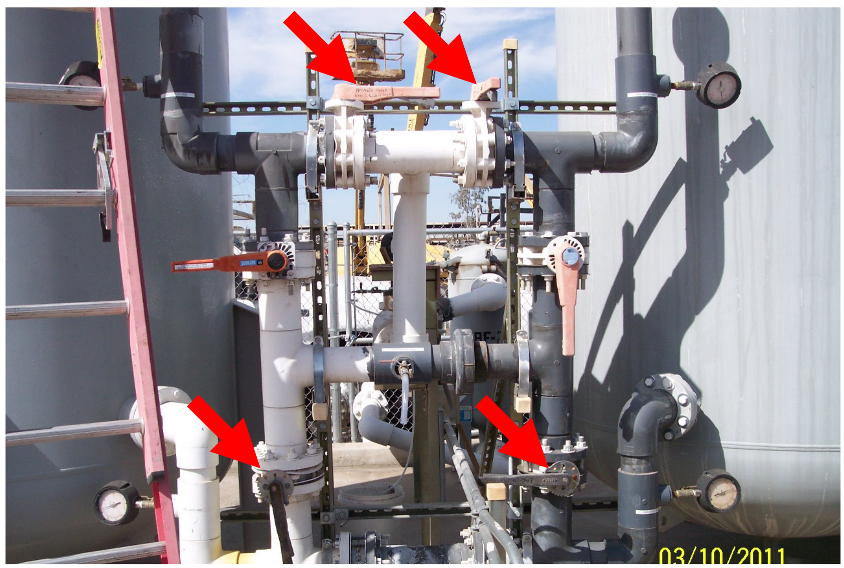


30. Same view inside CP-4 from left to right as indicated by red arrows are: relays 1 to 5, relay 6 (GW-systems sump-vault High-High water level shut down relay and momentary-contact reset toggle-switch that are connected to the float switches inside the sump-vault, and sump-pump motor starter.

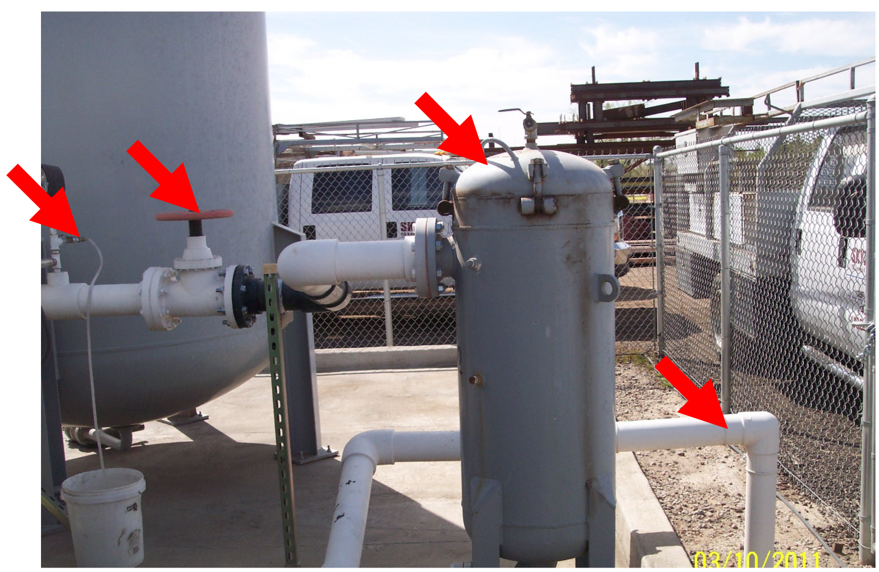


31. View west of lead and lag LGAC vessels and manifold; note red arrow indicates the air-pressure relief valve that is installed on the lag vessel.

32. Close-up view of LGAC vessels manifold; note lower red arrows indicate lead and lag inlet valves, and upper red arrows indicate lead and lag outlet valves along with associated pressure gauges.



33. At NWC inside compound, view south of GW-systems components as indicated by red arrows from left to right: effluent sample-port, effluent ball-valve, bag filter-2, and effluent discharge line.



34. At Badger-meter vault located approximately 100-feet south of the SWC of compound and inside Skyline Steel's south property boundary, viewing south inside vault; note SRP-gate valve and meter is located to the left and TOG-gate valve and meter to the right.

35. View west from the north side of the SRP-canal of the SRP and TOG-digital flow-meters panel that is located adjacent south of the Badger-meters vault.

36. View north from the south side of the SRP-canal toward the GW-systems effluent discharge point/outfall; note SRP-digital meter is located to the north indicated by red arrow.

APPENDIX F

INSTRUMENT CHARTS

ADEQ COOPER & COMMERCE ERA

PITOT TUBE FLOW RATE QUICK REFERENCE

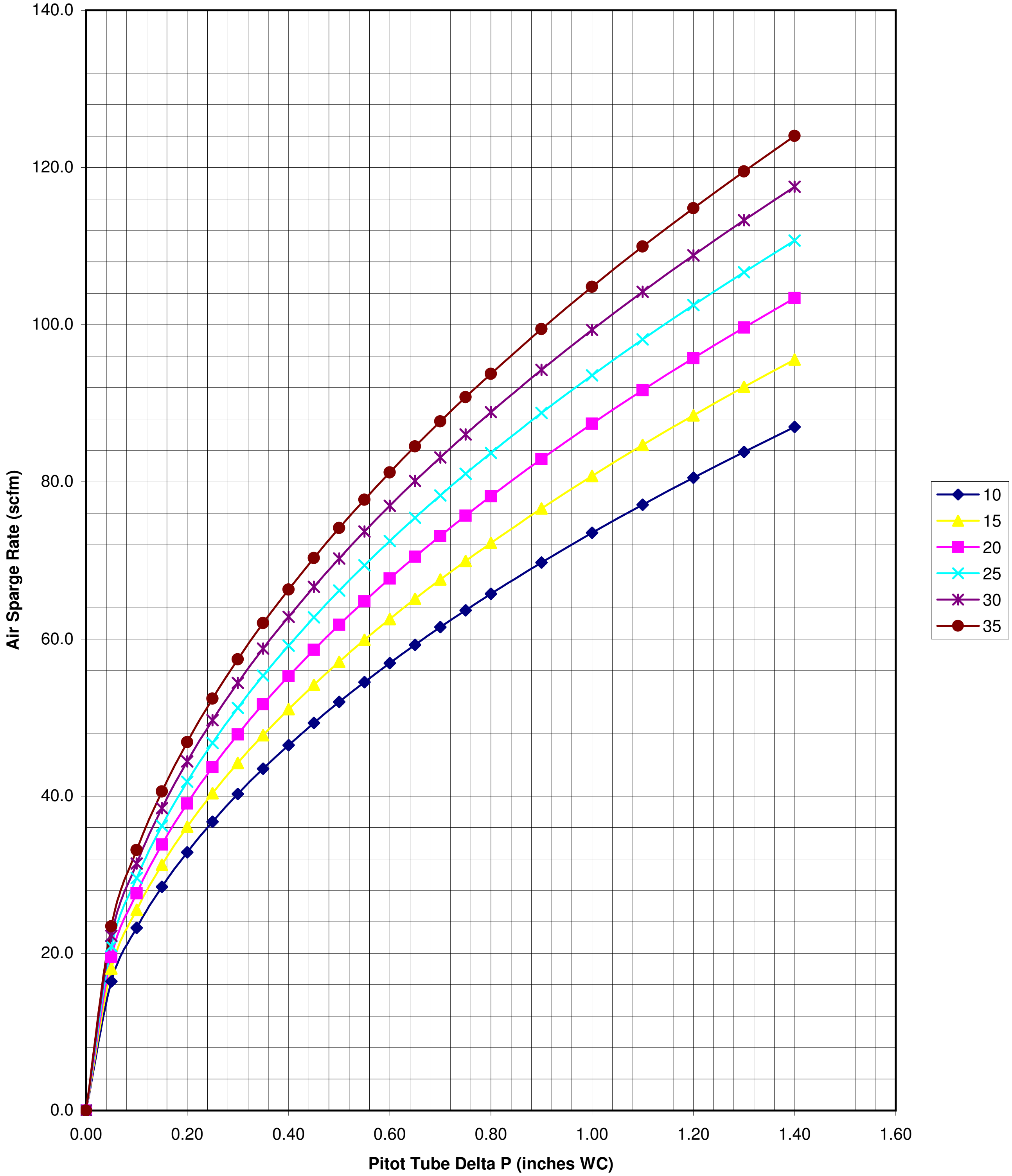
Pipe ID:	**2.067**	**inches**
Flow Coef:	**0.64**	
Gas Temp:	**90**	**F**
Gas SG:	**1.01**	**to dry air**

DWYER DS-300 AVERAGING PITOT TUBE FOR 2-INCH SCHEDULE 40 PIPE

Pitot Tube Delta P (inches WC)	Air Sparge Rates (scfm)					
	Line Pressure (psig)					
	10	15	20	25	30	35
0.00	0.0	0.0	0.0	0.0	0.0	0.0
0.05	16.4	18.1	19.5	20.9	22.2	23.4
0.10	23.2	25.5	27.6	29.6	31.4	33.1
0.15	28.5	31.3	33.8	36.2	38.5	40.6
0.20	32.9	36.1	39.1	41.8	44.4	46.9
0.25	36.8	40.4	43.7	46.8	49.7	52.4
0.30	40.3	44.2	47.9	51.2	54.4	57.4
0.35	43.5	47.8	51.7	55.3	58.8	62.0
0.40	46.5	51.1	55.3	59.2	62.8	66.3
0.45	49.3	54.2	58.6	62.8	66.6	70.3
0.50	52.0	57.1	61.8	66.2	70.2	74.1
0.55	54.5	59.9	64.8	69.4	73.7	77.7
0.60	56.9	62.5	67.7	72.5	77.0	81.2
0.65	59.3	65.1	70.5	75.4	80.1	84.5
0.70	61.5	67.6	73.1	78.3	83.1	87.7
0.75	63.7	69.9	75.7	81.0	86.0	90.8
0.80	65.7	72.2	78.2	83.7	88.9	93.7
0.90	69.7	76.6	82.9	88.8	94.2	99.4
1.00	73.5	80.7	87.4	93.6	99.3	104.8
1.10	77.1	84.7	91.7	98.1	104.2	109.9
1.20	80.5	88.5	95.7	102.5	108.8	114.8
1.30	83.8	92.1	99.6	106.7	113.3	119.5
1.40	87.0	95.5	103.4	110.7	117.5	124.0

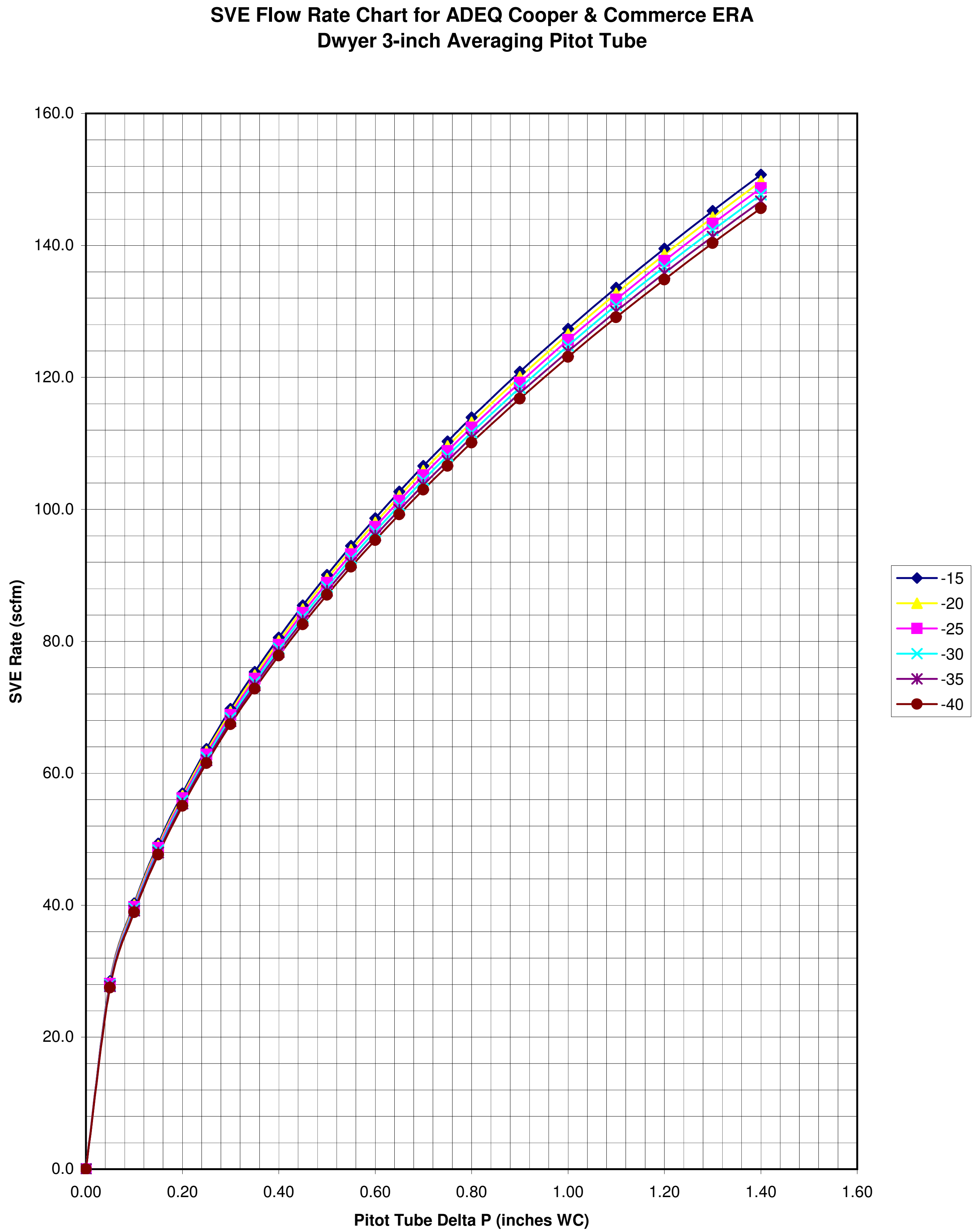
SG = specific gravity relative to dry air
ID = inside diameter

Air Sparge Flow Rate Chart for ADEQ Cooper & Commerce ERA
Dwyer 2-inch Averaging Pitot Tube



ADEQ COOPER & COMMERCE ERA						
PITOT TUBE FLOW RATE QUICK REFERENCE						
Pipe ID:	3.068	inches				
Flow Coef:	0.67					
Gas Temp:	90	F				
Gas SG:	1.01	to dry air				
DWYER DS-300 AVERAGING PITOT TUBE FOR 3-INCH SCHEDULE 40 PIPE						
Pitot Tube Delta P (inches WC)	SVE Rates (scfm)					
	Line Pressure (inches WC)					
	-15	-20	-25	-30	-35	-40
0.00	0.0	0.0	0.0	0.0	0.0	0.0
0.05	28.5	28.3	28.1	27.9	27.7	27.5
0.10	40.3	40.0	39.7	39.5	39.2	38.9
0.15	49.3	49.0	48.7	48.3	48.0	47.7
0.20	57.0	56.6	56.2	55.8	55.4	55.0
0.25	63.7	63.3	62.8	62.4	62.0	61.5
0.30	69.8	69.3	68.8	68.4	67.9	67.4
0.35	75.4	74.9	74.3	73.8	73.3	72.8
0.40	80.6	80.0	79.5	78.9	78.4	77.8
0.45	85.4	84.9	84.3	83.7	83.2	82.6
0.50	90.1	89.5	88.9	88.3	87.7	87.0
0.55	94.5	93.8	93.2	92.6	91.9	91.3
0.60	98.7	98.0	97.3	96.7	96.0	95.3
0.65	102.7	102.0	101.3	100.6	99.9	99.2
0.70	106.6	105.9	105.1	104.4	103.7	103.0
0.75	110.3	109.6	108.8	108.1	107.3	106.6
0.80	113.9	113.2	112.4	111.6	110.9	110.1
0.90	120.8	120.0	119.2	118.4	117.6	116.8
1.00	127.4	126.5	125.7	124.8	124.0	123.1
1.10	133.6	132.7	131.8	130.9	130.0	129.1
1.20	139.5	138.6	137.7	136.7	135.8	134.8
1.30	145.2	144.3	143.3	142.3	141.3	140.3
1.40	150.7	149.7	148.7	147.7	146.7	145.6

SG = specific gravity relative to dry air
ID = inside diameter


SVE Flow Rate Chart for ADEQ Cooper & Commerce ERA
Dwyer 3-inch Averaging Pitot Tube
SVE Rate (scfm)
Pitot Tube Delta P (inches WC)
0.0
20.0
40.0
60.0
80.0
100.0
120.0
140.0
160.0
0.00
0.20
0.40
0.60
0.80
1.00
1.20
1.40
1.60
-15
-20
-25
-30
-35
-40

ADEQ COOPER & COMMERCE ERA

PITOT TUBE FLOW RATE QUICK REFERENCE

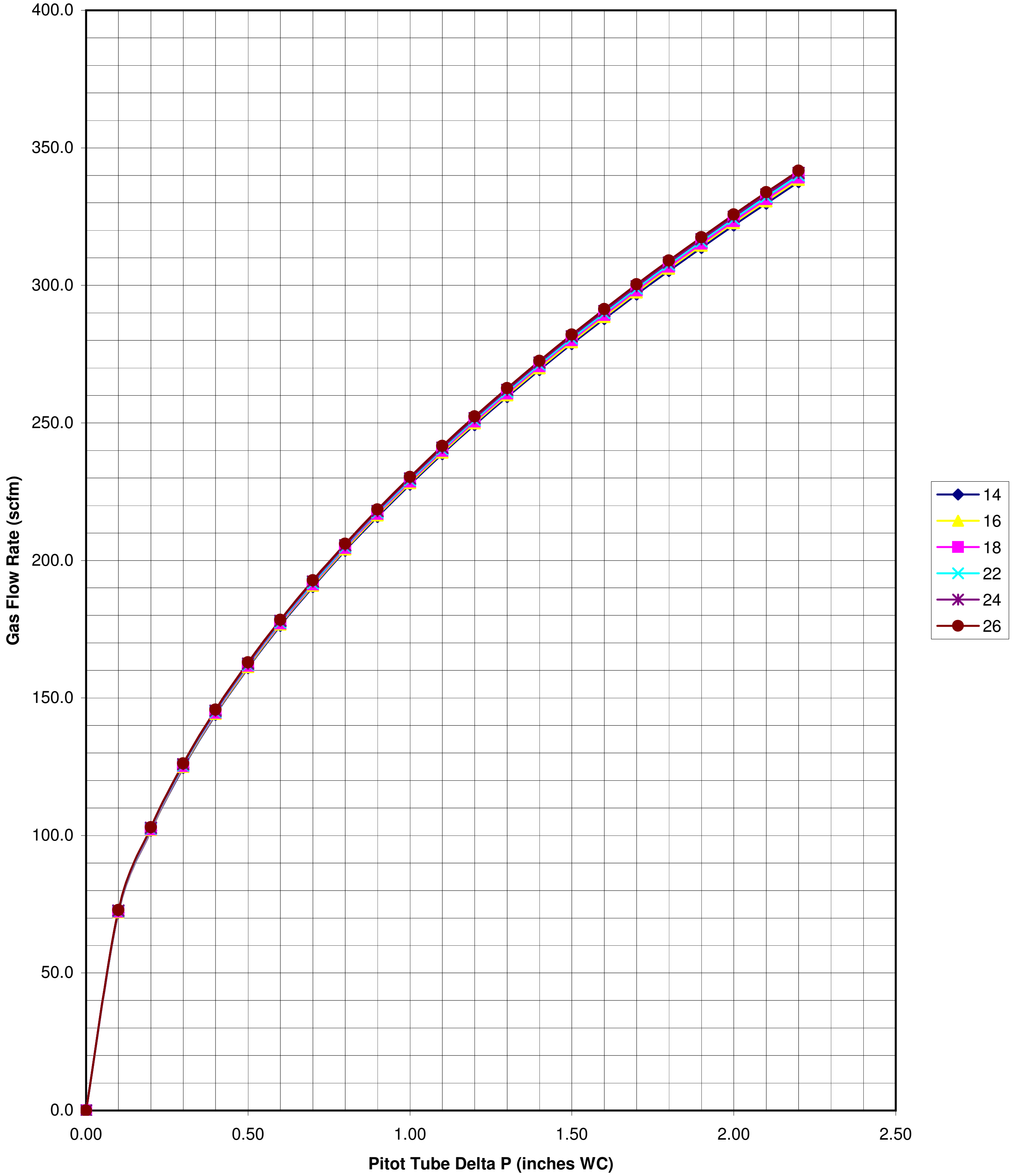
Pipe ID:	**4.026**	**inches**
Flow Coef:	**0.67**	
Gas Temp:	**90**	**F**
Gas SG:	**1.01**	**to dry air**

DWYER DS-300 AVERAGING PITOT TUBE FOR 4-INCH SCHEDULE 40 PIPE

Pitot Tube Delta P (inches WC)	Combined SVE Rates (scfm)					
	Line Pressure (inches WC)					
	14	16	18	20	22	24
0.00	0.0	0.0	0.0	0.0	0.0	0.0
0.10	72.0	72.1	72.3	72.5	72.7	72.8
0.20	101.8	102.0	102.3	102.5	102.8	103.0
0.30	124.7	125.0	125.3	125.6	125.9	126.2
0.40	143.9	144.3	144.6	145.0	145.3	145.7
0.50	160.9	161.3	161.7	162.1	162.5	162.9
0.60	176.3	176.7	177.1	177.6	178.0	178.4
0.70	190.4	190.9	191.3	191.8	192.3	192.7
0.80	203.6	204.1	204.6	205.0	205.5	206.0
0.90	215.9	216.4	217.0	217.5	218.0	218.5
1.00	227.6	228.1	228.7	229.3	229.8	230.4
1.10	238.7	239.3	239.9	240.4	241.0	241.6
1.20	249.3	249.9	250.5	251.1	251.7	252.3
1.30	259.5	260.1	260.8	261.4	262.0	262.6
1.40	269.3	269.9	270.6	271.3	271.9	272.6
1.50	278.7	279.4	280.1	280.8	281.5	282.1
1.60	287.9	288.6	289.3	290.0	290.7	291.4
1.70	296.7	297.5	298.2	298.9	299.6	300.3
1.80	305.3	306.1	306.8	307.6	308.3	309.1
1.90	313.7	314.5	315.2	316.0	316.8	317.5
2.00	321.8	322.6	323.4	324.2	325.0	325.8
2.10	329.8	330.6	331.4	332.2	333.0	333.8
2.20	337.6	338.4	339.2	340.0	340.9	341.7

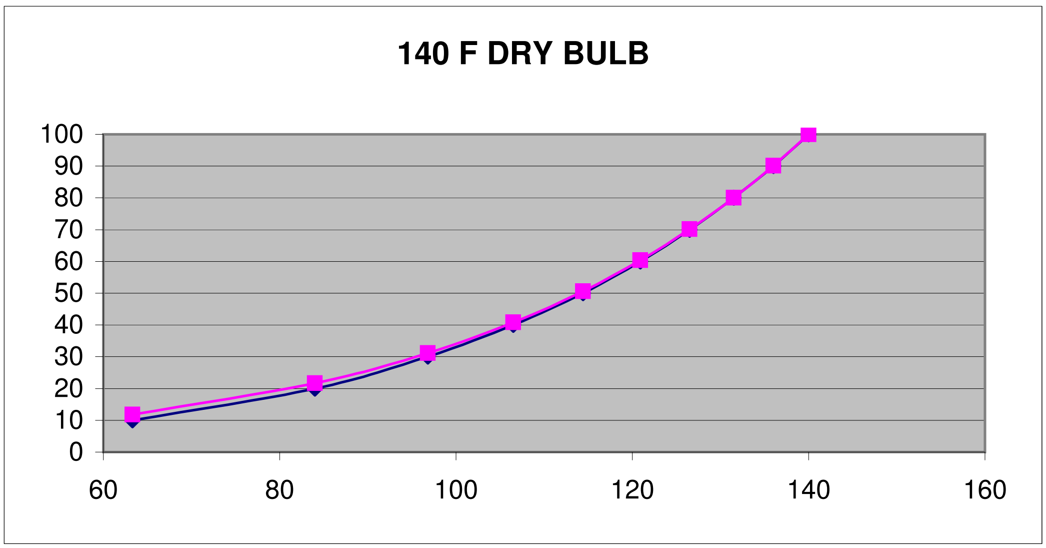
SG = specific gravity relative to dry air
ID = inside diameter

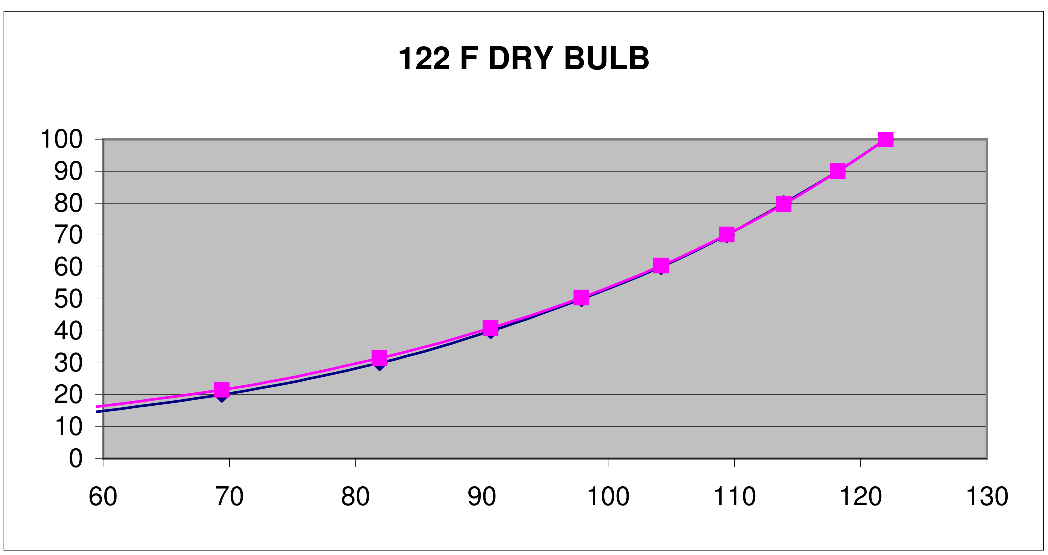
SVE Flow Rate Chart for ADEQ Cooper & Commerce ERA
Dwyer 4-inch Averaging Pitot Tube



RH FORMULA: $RH = 100 * [(Twb + 460) / (Tdb + 460)]^{(-0.0333 * T db + 20.267)}$

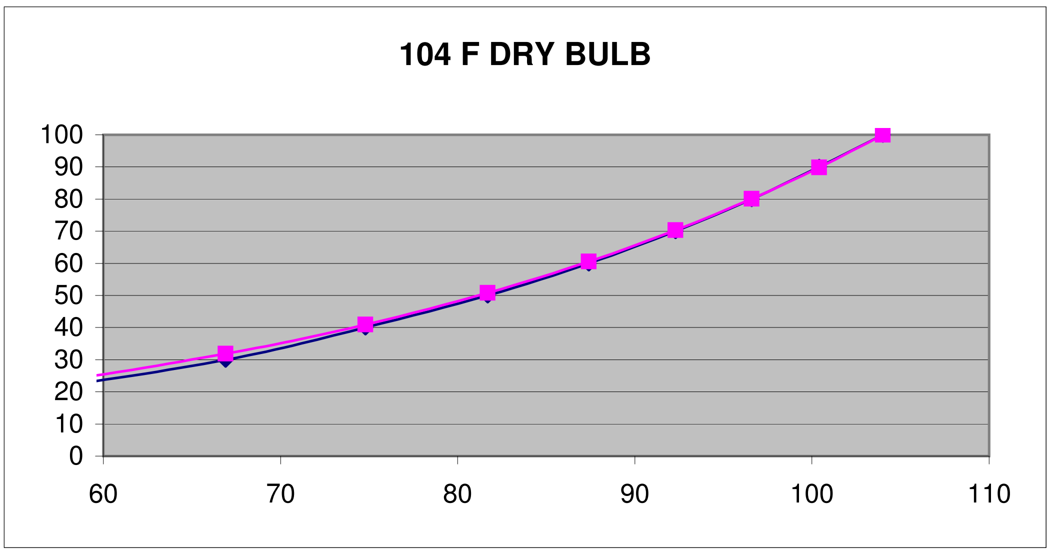
	DRY BULB TEMPERATURE (F)					
RH	**50**	**68**	**86**	**104**	**122**	**140**
10				36.9	50.2	63.3
20			40.5	55.0	69.4	84.0
30		35.4	50.9	66.9	81.9	96.8
40		**42.8**	**58.8**	**74.8**	**90.7**	**106.5**
50		**48.6**	**65.1**	**81.7**	**97.9**	**114.4**
60	**36.7**	**53.6**	**70.3**	**87.4**	**104.2**	**120.9**
70	**40.6**	**57.7**	**75.0**	**92.3**	**109.4**	**126.5**
80	**44.1**	**61.5**	**79.0**	**96.6**	**113.9**	**131.5**
90	**47.1**	**64.9**	**82.8**	**100.4**	**118.2**	**136.0**
100	**49.8**	**68.0**	**86.0**	**104.0**	**122.0**	**140.0**

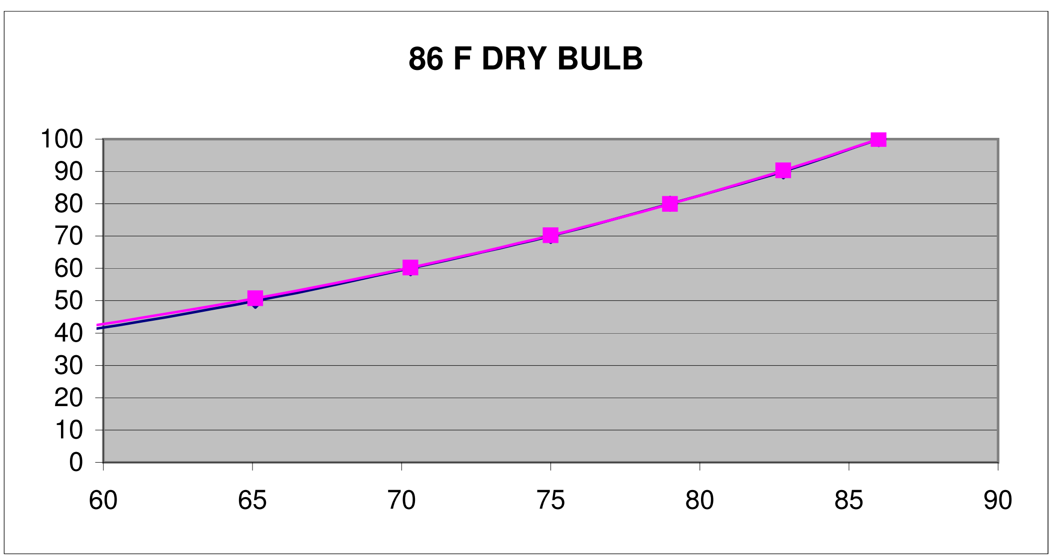




RH FORMULA: $RH = 100 * [(Twb + 460) / (Tdb + 460)]^{(-0.0333 * T db + 20.267)}$

	DRY BULB TEMPERATURE (F)					
RH	**50**	**68**	**86**	**104**	**122**	**140**
10				36.9	50.2	63.3
20			40.5	55.0	69.4	84.0
30		35.4	50.9	66.9	81.9	96.8
40		**42.8**	**58.8**	**74.8**	**90.7**	**106.5**
50		**48.6**	**65.1**	**81.7**	**97.9**	**114.4**
60	**36.7**	**53.6**	**70.3**	**87.4**	**104.2**	**120.9**
70	**40.6**	**57.7**	**75.0**	**92.3**	**109.4**	**126.5**
80	**44.1**	**61.5**	**79.0**	**96.6**	**113.9**	**131.5**
90	**47.1**	**64.9**	**82.8**	**100.4**	**118.2**	**136.0**
100	**49.8**	**68.0**	**86.0**	**104.0**	**122.0**	**140.0**





APPENDIX G

REMEDIAL SYSTEM PERMITS

JUL 0 9 REC'D

MARICOPA COUNTY AIR QUALITY DEPARTMENT

PERMITTING DIVISION
1001 N Central Ave, Suite 400
Phoenix, AZ 85004

ARIZONA DEPARTMENT OF ENVIRONMENTAL QUAL
C/O HYDRO GEO CHEM INC/RICH PETRUS
6340 E THOMAS RD STE 224
SCOTTSDALE, AZ 85251

Permit: 080020

Expiration: 07/31/13

ARIZONA DEPT OF ENVIRONMENTAL QUALITY
PORTABLE #2

ENCLOSED IS A COPY OF YOUR RECEIPT NUMBER AQ08006554 IN THE AMOUNT OF

$792.00 THAT WAS APPLIED TO: ***AIR***

NON-TITLE V

PERMIT APPLICATION

IF YOU HAVE ANY QUESTIONS PLEASE CALL (602) 506-6464 or 506-0422 **Application ID: 372638**

AIR QUALITY Department

ONE STOP SHOP

RECEIPT #: AQ08006554

TRANSACTION DATE: 07/03/2008
TRACKING #: AQ08001447 **TYPE:** Air Quality Fees
SITE ADDRESS:
PARCEL:
PERMIT NUMBER/APPLICATION ID #: 080020-372638
Project Name: PORTABLE # 2

TRANSACTION AMOUNT: 792.00
NOTATION: NTV ENGINEERS HOURS

TRANSACTION LIST

Type	Method	Description	Amount
Payment	Check	46754	792.00

RECEIPT ACCOUNT ITEM LIST

Item#	Description	Account Code	Tot Fee	Paid	Prv. Pmts	Cur. Pmts
7110	Non-V/Gen Engin	504-852-8550	992.00	992.00	200.00	792.00

MARICOPA COUNTY
AIR QUALITY
DEPARTMENT

AIR QUALITY DEPARTMENT
1001 North Central Avenue
Phoenix, AZ 85004

AIR QUALITY PERMIT

Permit Number: 080020
Revision:
Revised:

Issue Date: July 3, 2008
Renewal Date: July 31, 2013

Permittee Name: ARIZONA DEPARTMENT OF ENVIRONMENTAL QUAL
Mailing Address 6340 E THOMAS RD STE 224 SCOTTSDALE, AZ 85251
Business Name: ARIZONA DEPT OF ENVIRONMENTAL QUALITY
Facility Address: PORTABLE #2

The purpose of the letter is to inform you that the application for NEW Permit Revision, reference number 372638 has been approved and will be incorporated into Air Quality Permit 080020. The applicable Permit Conditions are enclosed with this letter.

If you have any questions, please give me a call at 506-6738.

Sincerely,

Todd Martin

SUPERVISOR, NON-TITLE V UNIT

PERMIT CONDITIONS

ARIZONA DEPARTMENT OF ENVIRONMENTAL QUALITY

Permit Number 080020

Date Issued: 07/03/2008
Revision:
Revision Date:

The numerical section references in this Permit are based on Maricopa County Air Pollution Control Rules and Regulations (Rules) in effect on the date of issuance of these Permit Conditions. In the event that these Rules are revised to change the content and numerical references during the term of this Permit, the revised Rules and numbering system will apply to this permit.

GENERAL CONDITIONS:

1. **Certification:**
   Any document which is required to be submitted by this Permit or the Rules shall contain certification by a responsible official of truth, accuracy and completeness. This certification shall state that, based on information and belief formed after reasonable inquiry, the statements and information in the document are true, accurate and complete.
   [Rule 100, §200.97; Rule 220, §301.5 and §302.14]

2. **Confidentiality Claims:**
   Except as provided for in Rule 100, any records, reports, or information obtained from the Permittee pursuant to the County Rules or this Permit shall be available to the public unless the Control Officer has notified the Permittee in writing and unless a person:

   a. Precisely identifies the information in the permit(s), records, or reports which is considered confidential.

   b. Provides sufficient supporting information to allow the Control Officer to evaluate whether such information satisfies the requirements related to trade secrets.

   A claim of confidentiality shall not excuse a person from providing any and all information required or requested by the Control Officer and shall not be a defense for failure to provide such information.
   [Rule 100, §200.110, §402 and Rule 200, §411]

3. **Controls:**
   Except as provided by the applicable Rules or these Permit Conditions, the Permittee shall not operate any equipment or process unless air pollution controls, required by either this Permit or the Rules, are in place, are operating without bypass, and are operating within their key system operating parameters, as identified in the approved Operation and Maintenance Plans, and in accordance with any other conditions specified in this Permit.

   This requirement to operate any required air pollution control equipment may be conditionally waived due to malfunction in an emergency situation provided that the Permittee fulfills the notification requirements in accordance with Rule 100, §501, and Rules 130 and 140.

   [Rule 100, §501, Rules 130 and 140]

The Permittee shall notify the Control Officer, in accordance with Rule 220, before making any additions, modifications or replacements to any required air pollution control equipment. This notification requirement does not apply to normal maintenance and repair activities.

[Rule 220, §404 and §405]

4. **Duty to Supplement or Correct Application:**

The Permittee who fails to submit any relevant facts or who has submitted incorrect information in a permit application shall, upon becoming aware of such failure or incorrect submittal, promptly submit such supplementary facts or corrected information. In addition, an applicant shall provide additional information as necessary to address any requirements that become applicable to the source after the date it filed a complete application but prior to release of a proposed permit.

[Rule 220, §301.5]

5. **Duty to Comply:**

The Permittee shall comply with all conditions of this Permit including all applicable requirements of Federal laws, Arizona laws, and Maricopa County Air Pollution Control Rules and Regulations.

[Rule 200, §308]

It shall not be a defense for the Permittee in an enforcement action that it would have been necessary to halt or reduce the permitted activity in order to maintain compliance with these Permit Conditions.

[Rule 220, §302.10]

6. **Fees:**

The Permittee shall pay, in a timely manner, an annual fee for this Permit as determined by the Control Officer in accordance with Rule 280.

[Rule 280, §302]

7. **Fugitive Dust:**

The Permittee shall take all reasonable precautions to minimize the emissions of fugitive dust in accordance with §300 of Rule 310.

[Rule 310, §300]

8. **Leased/Rented/Borrowed Equipment:**

If the Permittee leases, rents or lends any equipment covered by this Permit to a second party, the Permittee shall provide the second party with a copy of this Permit. It is the responsibility of the person using the equipment to make sure that the equipment is properly permitted and operated. If the Permittee does not provide the second party with a copy of this Permit, both the Permittee and the second party shall be responsible for operating the source in compliance with the Permit and for any violation thereof.

[Rule 200, §300]

9. **Malfunctions (Emergency Upsets) and Excess Emissions:**

Emergencies, malfunctions, and other excess emissions shall be reported as required by Rule 100, Section 500.

[Rule 100, §400 and §500; Rule 130, §400; Rule 140, §400 and §500]

10. **Material Containment:**

Materials including, but not limited to, solvents or other volatile compounds, paints, acids, alkalies, pesticides, fertilizer and manure shall be processed, stored, used and transported in such a manner and by such means that they will not unreasonably evaporate, leak, escape or be otherwise discharged into the ambient air so as to cause or contribute to air pollution.

[Rule 320, §302]

11. **Modifications:**

The Permittee shall notify the Control Officer, in accordance with Rule 220, of changes, replacements or additions to the source which are not covered by this Permit. [Rule 200, §312.3 and Rule 220, §400]

12. **Odors:**

The Permittee shall not emit gaseous or odorous air contaminants from equipment, operations or premises under his control in such quantities or concentrations as to cause air pollution.

[Rule 320, §300]

13. **Permit Term, Permit Transfer, and Permit Renewal:**

a. This Permit shall remain in effect for no more than 5 years.
[Rule 220, §402]

b. Except as provided in Rule 200, this Permit may be transferred to another person if the person who holds the permit gives notice to the Control Officer in writing at least 30 days before the proposed transfer and complies with the permit transfer requirements of Rule 200 and the administrative permit amendment procedures pursuant to Rule 220.
[Rule 200, §400 and Rule 220, §405.1]

c. The Permittee shall file an application for a permit renewal at least six months, but not more than 18 months, before the expiration date of this Permit. [Rule 220, §301.3a]

14. **Record Keeping:**

The Permittee shall maintain accurate records as required by these Permit Conditions and by Section 500 of all applicable Rules. These records shall be kept in a form, which allows easy verification of compliance with these Permit Conditions and any applicable Rules.

All records shall be kept for the time as specified. All records required to demonstrate that each required air pollution control device is being operated properly shall be retained for five years.

All records required by this Permit should be made available for inspection upon request by a representative of the Control Officer.

Upon request, the Permittee shall furnish to the Control Officer copies of records required to be kept by this Permit.

[Rule 100, §504; Rule 220, §302.7; and §500 of All Applicable Rules]

15. **Reopening For Cause:**
This Permit shall be reopened or revised prior to expiration under any of the following conditions:

a. Either the Control Officer or the Administrator of the United States Environmental Protection Agency (Administrator) determines that this Permit contains a material mistake or that inaccurate statements were made in establishing the emission standards or other terms or conditions of this Permit Revision, or

b. Either the Control Officer or Administrator determines that this Permit must be revised or revoked to assure compliance with the applicable requirements.

[Rule 200, §402]

16. **Reporting:**
If notified, the Permittee shall submit an annual emissions inventory report to the Control Officer. The report shall summarize the activities and air pollution emissions from the facility during the previous calendar year in accordance with §505 of Rule 100. The report shall be filed on a form supplied by the Control Officer and shall be due by April 30 or 90 days after the Control Officer makes the forms available, whichever is later.

The Permittee shall furnish to the Control Officer, within a reasonable time, any information that the Control Officer may request in writing to determine whether cause exists for revising or revoking and reissuing this Permit or to determine compliance with this Permit.

Upon request, the Permittee shall furnish to the Control Officer copies of records required to be kept by this Permit.

The Permittee shall file any additional reports required by the Control Officer in a complete and timely manner.

[Rule 100, §501 and §505; Rule 220, §302.8 and §302.13]

17. **Right to Entry:**

The authorized representative of the Control Officer, upon presentation of credentials, shall be permitted:

a. To enter upon the premises where the source is located or emission-related activity is conducted, or where records are required to be kept under the conditions of this Permit and,

b. To have access to and copy, at reasonable times, any records that are required to be kept under the conditions of this Permit, and

c. To inspect, at reasonable times, any source(s), equipment (including monitoring and air pollution control equipment), practices or operations regulated or required under the Permit, and

d. To sample or monitor, at reasonable times, substances or parameters for the purpose of assuring compliance with the Permit or other applicable requirements, and

e. To record any inspection by use of written, electronic, magnetic, and photographic media.

No claim of confidentiality for trade secrets or commercial information available to the Permittee under Arizona Revised Statutes (ARS) 49-487 or Rule 200 §400 can limit the scope of or otherwise interfere with an on-site inspection by a representative of the Control Officer. However, a claim of confidentiality may be made on any information gathered during the inspection to the extent identified in ARS 49-487 or Rule 200 §400. [Rule 100, §200.110 and §402; Rule 200, §411; Rule 220, §302.17-21]

18. **Rights and Privileges:**

This Permit does not convey any property rights nor exclusive privileges of any sort. [Rule 220, §302.12]

19. **Severability:**

The provisions of this Permit are severable, and, if any provision of this Permit is held invalid, the remainder of this Permit shall not be affected thereby. [Rule 220, §302.9]

20. **Start-up Notification:**

If a performance test is required, the Permittee shall give written notification to the Department, Attention: Compliance Division Manager, at least 7 days but no more than 30 days before the initial start-up of any new pollution abatement equipment or process that requires a test. Start-up of the subject equipment or process, shall be defined as the earliest occurrence of one of the following dates:

a. The date that achieved maximum (or permitted) capacity occurs; or

b. The date that a marketable product has been produced; or

c. The date that achieved sustained product manufacturing occurs; or

d. The date that the production line(s) or processes, exhausted to the air pollution abatement equipment that require the test, have been qualified to produce product that meets customer requirements.

This startup notification does not apply to processes or equipment recognized by the Control Officer as being trivial or insignificant activities.
[Rule 270, §400]

SPECIFIC CONDITIONS:

SOIL REMEDIATION

21. **Allowable Emissions:**
The Permittee shall not allow emissions into the atmosphere to exceed any of the following limits:

	Daily Emission Limits	Monthly Emission Limits	Twelve Month Rolling Total Emission Limits
ANY SINGLE HAZARDOUS AIR POLLUTANT (HAP)	14 lbs		4,957.00 lbs
TOTAL HAZARDOUS AIR POLLUTANTS (HAPS)	14 lbs		4,957.00 lbs
VOLATILE ORGANIC COMPOUNDS (VOCS)	24 lbs		8,567.00 lbs

Upon the request of the Department, the Permittee shall calculate a daily emission rate by dividing the monthly emissions by the number of days of operation for that month.

[Rule 220, §302.2]

22. **Definitions:**
For the purposes of these Permit Conditions, breakthrough shall be defined as follows:

a. Less than a 90% VOC removal efficiency; or,

b. A VOC concentration at the outlet of the carbon canisters greater than 10 ppmv measured as methane when the inlet to the canisters is less than three (3) pounds per day.

23. **Control Parameters:**

Exhaust from the soil vapor extraction (SVE) system shall be vented to a vapor phase granular activated carbon (VGAC) vessel. The SVE shall not be operated unless the VGAC system is operating within the parameters listed in this section.

a. The VOC removal efficiency of the VGAC system shall be at least 90%.

b. The testing Results required below by Permit Condition 25, together with the other relevant factors such as temperature, humidity, and working capacity of the particular carbon shall be used to estimate the time the system can operate before breakthrough occurs. The Permittee shall replace the carbon canisters before the calculated breakthrough time is reached as well as anytime breakthrough is discovered. Before the carbon canister replacement schedule can be extended, a new breakthrough time period must first be established through testing. This replacement schedule does not relieve the Permittee from the requirements of assuring a removal efficiency of at least 90%.

c. The Permittee shall replace the carbon canisters before the calculated breakthrough time is reached as well as anytime breakthrough is discovered. Before the carbon canister replacement schedule can be extended, a new breakthrough time period must be established through testing. This replacement schedule does not relieve the Permittee from the requirements of assuring a VOC removal efficiency of at least 90%.

d. If the Permittee wishes to replace only the first of two canisters operating in series, it must be demonstrated through testing that breakthrough has not occurred on the first canister. When only the first canister is replaced, the remaining canister will be moved to the front position before operation is resumed.

e. The VOC inlet concentration to the VGAC system shall not exceed 2100 parts per million by volume (ppmv).

f. The flow rate through the SVE and VGAC system shall not exceed 300 standard cubic feet per minute (scfm).

g. The VGAC system shall not contain a valve or any other device which will either dilute or restrict the flow of the soil gasses unless the position of the device can be measured and controlled. If a device is installed, its position must be measured and recorded any time a test sample is taken which will be used to calculate either the mass flow rate of VOCs into the atmosphere or the removal efficiency of the control device.

h. If uncontrolled VOC emissions exceed three (3) pounds per day, then the removal efficiency of the VGAC system shall be at least 90%. If uncontrolled VOC emissions less than three (3) pounds per day, then the outlet concentration of the VGAC system shall be less than or equal to 10 ppmv measured as methane.

[Rule 220, §302.2]

24. **Operations and Maintenance Plans:**

The Permittee shall submit an approvable Operation and Maintenance (O&M) Plan for the VGAC system to the Department within 45 days of the initial issuance or the renewal of this permit in accordance with the Department guidelines unless the required O&M plan has been submitted within the last 12 months.

The Operation and Maintenance (O&M) will include, at a minimum, calibration of the instrumentation, and any other maintenance required of the system. The Control Officer's written approval of this plan shall be required for compliance to be achieved. The Permittee shall monitor, operate and maintain the equipment in accordance with the device's approved O&M Plan.

If any control device is found to be operating outside a specified range, the Permittee shall immediately take corrective action to bring the device back into the specified operating range or shut down the device and the associated equipment vented to it.

If a pattern of excursions, as determined by the Department or the Permittee, of operation outside the specified operating range develops, the Permittee shall submit for Department approval a Corrective Action Plan to bring the devices back into the specified operating range. The Plan shall be submitted to the Department, Attn: Compliance Division Manager, within 30 days of the determination of the existence of excursions.

[Rule 220 § 302.4]

25. **Testing:**

a. Within four (4) hours of starting up the soil vapor extraction (SVE) system, the Permittee shall measure the mass flow rate and concentration of VOC's entering the first carbon bed.

b. If the SVE system contains a valve or any other device which could cause either the dilution or the restriction of the soil gases entering the carbon canisters, its position must be measured and recorded anytime a test sample is taken which is used to calculate the expected time until breakthrough.

c. Within thirty (30) days after the completion of any required testing, the Permittee shall notify the Department in writing of the test results including the expected operating time until breakthrough.

[Rule 270, §401]

26. **Record Keeping:**
The Permittee shall maintain the following records for a period of at least five years from

the date of the records. These records shall be made available for immediate inspection by Department personnel upon request:

a. Accurate records shall be maintained of all VGAC system maintenance.

b. The Permittee shall maintain accurate records on site of the position of any flow dilution or restriction devices.

c. The Permittee shall keep a log of the cumulative hours of operation of the SVE system.

d. The required replacement interval for the carbon canisters and the date and cumulative operating time when the last canister replacement was made.

e. Records of the O&M Plan's key system operating parameters. Account for any periods of operation when the control device was not operating.

f. The Permittee shall file a report with the Maricopa County Air Quality Department (MCAQD) detailing the results of all required emissions testing within 30 days of the date of the test. The report shall include a record of all maintenance performed on the VGAC system during the same thirty (30) days.

g. The Permittee shall notify the Department in writing of the removal of the equipment from the site within 30 days.

[Rule 220, §501]

27. **Portable Sources:**

a. The Permittee shall obtain a permit from the Maricopa County Air Quality Department Control Officer (Control Officer) for a portable source which will operate for the duration of its permit solely in Maricopa County and is subject to Sections 410.2, 410.3, and 410.4 of Rule 200. A portable source with a current State of Arizona permit need not obtain a Maricopa County permit but is subject to Sections 410.3, 410.4, and 410.5 of Rule 200. Any permit for a portable source shall contain conditions that will assure compliance with all applicable requirements at all authorized locations.

b. An owner or operator of a portable source which has a Maricopa County permit but proposes to operate outside of Maricopa County shall obtain a permit from the Arizona Department of Environmental Quality Director (Director). Upon issuance of a permit by the Director, the Control Officer shall terminate the Maricopa County permit for that source. If the owner or operator relocates the portable source in Maricopa County, the owner or operator shall notify the Control Officer, as required by Section 410.4 of Rule 200, of the relocation of the portable source. Whenever the owner or operator of a portable source operates a portable source in Maricopa County, such owner or operator shall comply with all regulatory requirements.

c. An owner of a portable source which requires a permit under Rule 200 shall obtain the permit prior to renting or leasing said portable source. This permit shall be provided by the owner to the renter or lessee, and the renter or lessee shall be bound by the permit provisions. In the event a copy of the permit is not provided to the renter or lessee, both the owner and the renter or lessee shall be responsible for the operation of the portable source in compliance with these permit conditions and any violations thereof.

d. A portable source may be transported from one location to another within or across Maricopa County boundaries provided the owner or operator of such portable source notifies the Director and any Control Officer who has jurisdiction over the geographic area that includes the new location of the portable source by certified mail at least ten working days before the portable source is transported to the new location. The notification required under this rule shall include:

   i. A description of the portable source to be transported including the Maricopa County permit number or the State of Arizona permit number for such portable source;

   ii. A description of the present location;

   iii. A descriptio n of the location to which the portable source is to be transported, including the availability of all utilities, such as water and electricity, necessary for the proper operation of all control equipment;

   iv. The date on which the portable source is to be moved;

   v. The date on which operation of the portable source will begin at the new location; and

   vi. The duration of operation at the new location.

e. An owner or operator of a portable source with a current State of Arizona permit that moves such portable source into Maricopa County shall notify the Control Officer that such portable source is being transported to a new location and shall include in such notification a copy of the State of Arizona permit and a copy of any conditions imposed by the State of Arizona permit. The source shall be subject to all regulatory requirements of these rules.

[Rule 220, §410]

Equipment List

ARIZONA DEPT OF ENVIRONMENTAL QUALITY
Permit Number 080020

Date Issued: 07/03/08
Revision:
Date: 06/10/08

Equipment Description	Rated Capacity	Quantity Exist/Future
CARBON ADSORPTION UNIT - VGAC SYSTEM - VAPOR PHASEGRANULATED ACTIVATED CARBON - SIEMENS VENT SCRUB 2000		2 / 0
EQUIPMENT - SVE SYSTEM - VACUUM BLOWER-20 HP MOTOR	300.00 CFM	/
EQUIPMENT - CONSVE SYSTEM- DENSATE SEPARATOR/CONDENSATE TRANSFER PUMP	55.00 GALLON(S)	/

STATEMENT OF BASIS FOR MODIFICATION OF AZPDES PERMIT NO. AZ0025801

Pursuant to A.C.C. R18-9-B906, on April 24, 2006, ADEQ received an application from the Arizona Department of Environmental Quality (Cooper & Commerce WQARF Site) to modify AZPDES Permit No. AZ0025801 which became effective on November 24, 2008. The request would remove the Domestic Water Source (DWS) use from the requirements in this permit.

The receiving water for the Cooper & Commerce WQARF Site Outfall 001 is Salt River Project's (SRP) Lateral Canal 5-9.5 tributary to the Western Canal which in the Middle Gila River Basin.

This facility is located at 619 W. Commerce Avenue, Gilbert, Arizona in Maricopa County and has a design flow of 0.432 MGD. In order to contain groundwater contaminated with tetrachloroethene (PCE), the WQARF project will withdraw groundwater from one well and treat it in an above ground activated carbon treatment facility prior to discharge to SRP's Lateral 5-9.5. Another well may be added in the future. This is a new treatment plant which is not yet operational. Construction began in 2008 and has not yet been completed. The treated groundwater will be discharged from the Cooper and Commerce WQARF Site treatment system to SRP's Lateral 5-9.5 at approximately North Cooper Road and West Commerce Avenue through Outfall 001 located in the Middle Gila River Basin at latitude 33°21'25.8"N, longitude 111°48'09.3"W. This facility plans on having a continuous discharge except a connection to the Town of Gilbert WWTP may be established for periods of canal dry up. The AZPDES permit has authorized the discharge of treated groundwater to SRP's Lateral 5-9.5.

The designated use, as applied in the current permit, for the Western Canal is Agricultural Livestock Watering (AgL), Agricultural Irrigation (AgI) and Domestic Water Source (DWS).

ADEQ Surface Water Permits Unit has received a request from the ADEQ Remedial Projects Unit to appropriately assign the correct designated uses to this receiving water based on new information provided by SRP. It was understood at the time the permit was drafted that the DWS use was to be applied to this facility because the discharge occurs upstream of the South Tempe Water Treatment Plant located along the Western Canal. However, SRP confirms that the South Tempe Water Treatment Plant can only receive water from the Tempe Canal. The location of the South Tempe WTP intake is on the Tempe Canal upstream of the junction of lateral 5-9.5 and the Western Canal. There are no drinking water treatment plants downstream of the Cooper & Commerce WQARF Site discharge.

Permit Limitations and Monitoring Requirements: The table that follows summarizes parameters that are limited in the draft permit modification and the rationale for that decision. Also included are some parameters that require monitoring without any limitations or that have not been included in the permit at all and the basis for that decision. The corresponding monitoring requirements are shown for each parameter.

Parameter	Lowest Standard/ Designated Use	Maximum Reported Daily Value	No. of Samples	Estimated Maximum Value	RP determination	Proposed Monitoring Requirement/ Rationale
Flow	- - -	- - -	- - -	- - -	- - -	It is proposed that discharge flow be monitored on a continual basis using a flow meter.
pH	Minimum: 6.5 Maximum: 9.0 AgL A.A.C.R 18-11-109(B)	7.2 to 8.0	NA	NA	Limit is always included.	pH is to be monitored weekly using a discrete sample of the effluent. 40 CFR Part 136 specifies that grab samples must be collected for pH.
Antimony	No Applicable Standard	0.54 ug/L	1	7.13 ug/L	No RP	Monitoring required 1x/6 months and an assessment level is set.
Arsenic	200 ug/L/ Ag/L	19 ug/L	1	250.8 ug/L	RP Indeterminate Limited data	Monitoring required 1x/6 months and an assessment level is set.
Beryllium	No Applicable Standard	<0.50 ug/L	1	3.3 ug/L	No RP	Monitoring required 1x/6 months and an assessment level is set.
Boron	1000 ug/L/ Ag/l	610 ug/L	1	8052 ug/L	RP Exists	Monitoring required 1x/6 months and a limit is set.
Cadmium	50 ug/L/ Ag/l Ag/L	0.9 ug/L	1	11.88 ug/L	No RP	Monitoring required 1x/6 months and an assessment level is set.
Chromium (total)	1000 ug/L/ Ag/l Ag/L	<2.3 ug/L	1	15.18 ug/L	No RP	Monitoring required 1x/6 months and an assessment level is set.
Chromium VI	No Applicable Standard	No Data	0	NA	No RP	Monitoring required 1x/6 months and an assessment level is set.
Chloroform	5 ug/l best professional judgment technology based standard	0.086 ug/L	1	NA	Not applicable	A technology-based limit using BPJ is set with monitoring required quarterly.
Copper	500 ug/L/ AgL	<3.5ug/L	1	23.1 ug/L	No RP	Monitoring required 1x/6 months and an assessment level is set.
Cyanide	No Applicable Standard	No Data	0	NA	No RP	Monitoring required 1x/6 months and an assessment level is set.
Lead	100 ug/L / Ag/L	<2.4 ug/L	1	15.84 ug/L	No RP	Monitoring required 1x/6 months and an assessment level is set.
Mercury	No Applicable Standard	<0.044 ug/L	1	0.29 ug/L	No RP	Monitoring required 1x/6 months and an assessment level is set.
Nickel	No Applicable Standard	<9.8 ug/L	1	64.68 ug/L	No RP	Monitoring required 1x/6 months and an assessment level is set.
Selenium	20 ug/L/ Agl	<9.2 ug/L	1	60.72 ug/L	RP Indeterminate Limited data	Monitoring required 1x/6 months and an assessment level is set.
Silver	No Applicable Standard	<2.5 ug/L	1	16.5 ug/L	No RP	Monitoring required 1x/6 months and an assessment level is set.
Tetrachloroethene	5 ug/l best professional judgment technology based standard	680 ug/L	1	Not applicable	Not applicable	A technology-based limit using BPJ is set with monitoring required quarterly.
Thallium	No Applicable Standard	<0.09 ug/L	1	0.594 ug/L	No RP	Monitoring required 1x/6 months and an assessment level is set.
Trichloroethene	5 ug/l best professional judgment technology based standard	0.45 ug/L	1	Not applicable	Not applicable	A technology-based limit using BPJ is set with monitoring required quarterly.
Zinc	10000 ug/L/ Agl	26 ug/L	1	171.6 ug/L	No RP	Monitoring required 1x/6 months and an assessment level is set.

ADEQ has reviewed the request and proposes to modify the permit as follows:

Due to the removal of the domestic water source (DWS) standard, monitoring parameters for the WQARF Site have been revised in the permit as shown in Part I.B Table 2 below. The following parameters have been removed because they do not have surface water quality standards under the AgI and AgL designated uses: antimony, beryllium, chromium IV, cyanide, mercury, nickel, silver, and thallium. Effluent characterization testing will; however, be required for these and other parameters as indicated in Table 3.a.

1. For Part I.A, Table 1, limits for Outfall 001 remain the same.

2. For Part I.B, Table 2, Trace Substance Monitoring Parameters for Outfall 001 are as follows:

TABLE 2: Trace Substance Monitoring Requirements

Parameter	ASSESSMENT LEVELS (1) ~~(3)~~ Concentration (µg/L)		Monitoring Requirements (2)	
	Monthly Average	Daily Maximum	Monitoring Frequency	Sample Type
Arsenic	200	292	1x/6 months	Discrete
~~Cadmium~~	~~50.0~~	~~72.9~~	~~1x/6 months~~	~~Discrete~~
~~Copper~~	~~500~~	~~729~~	~~1x/6 months~~	~~Discrete~~
~~Chromium (Total)~~	~~1000~~	~~1460~~	~~1x/6 months~~	~~Discrete~~
~~Cyanide~~	~~200~~	~~292~~	~~1x/6 months~~	~~Discrete~~
~~Lead~~	~~100~~	~~146~~	~~1x/6 months~~	~~Discrete~~
~~Mercury~~	~~10.0~~	~~14.6~~	~~1x/6 months~~	~~Discrete~~
Selenium	20.0	29.2	1x/6 months	Discrete
~~Zinc~~	~~10,000~~	~~14,600~~	~~1x/6 months~~	~~Discrete~~
Hardness ($CaCO_3$)	Report	Report	1x/6 months	Discrete

Footnotes:
(1) Concentration values are calculated based on Arizona Water Quality Standards. Monitoring and reporting required.
(2) All metals effluent Assessment Levels are for total recoverable metals, except for Chromium VI, for which the assessment levels listed are dissolved.
(3) ~~If total chromium exceeds 2100 ug/L, the permittee must conduct sampling for chromium VI for the remainder of the permit. Otherwise, monitoring for chromium VI is not required.~~

3. For Part I.B, Table 3.b, Effluent Characterization Testing for Selected Volatile Organic Compounds, sampling frequency has been changed to quarterly monitoring due to removal of the DWS designated use.

These changes are considered a major modification. This proposed modification will be public noticed for a 30 day comment period prior to issuance of the final permit decision.

ADEQ Inventory No. 106037
LTF No. 43998

Permit No. AZ0025801

AUTHORIZATION TO DISCHARGE UNDER THE ARIZONA POLLUTANT DISCHARGE ELIMINATION SYSTEM

In compliance with the provisions of Arizona Revised Statutes (A.R.S.) Title 49, Chapter 2, Article 3.1; the Federal Water Pollution Control Act, (33 USC § 1251 et. seq., as amended), and Arizona Administrative Code (A.A.C.) Title 18, Chapter 9, Articles 9 and 10, and amendments thereto,

Cooper & Commerce WQARF Site
1110 West Washington Street
Phoenix, Arizona 85007

is authorized to discharge treated groundwater from the remediation system located at 619 West Commerce Avenue, Gilbert, Arizona to the Salt River Project's Lateral 5-9.5 which is tributary to the Western Canal in the Middle Gila River Basin at:

Outfall No.	Latitude	Longitude	Legal
001	33° 21' 25.8" N	111° 48' 09.3" W	Township 1S, Range 5E, Section 12

in accordance with effluent limitations, monitoring requirements and other conditions set forth herein, and in the attached "Standard AZPDES Permit Conditions," dated February 2, 2004.

This permit became effective on November 24, 2008.

The permit modification shall become effective on June 29, 2009.

This permit and the authorization to discharge shall expire at midnight, November 23, 2013.

24th day of November, 2008.
Joan Card, Director
Water Quality Division
Department of Environmental Quality

Modification is signed 29 day of June, 2009.

Henry Darwin, Acting Director
Water Quality Division
Department of Environmental Quality

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PART I. EFFLUENT LIMITATIONS AND MONITORING REQUIREMENTS

A. The permittee shall limit and monitor discharges from outfall 001 as specified in Table 1 which follows. These requirements are based on a design capacity of 1635 m^3/day (0.432 MGD).

TABLE 1: Effluent Limitations and Monitoring Requirements

Parameter	Maximum Allowable Discharge Limitations				Monitoring Requirement	
	Mass Limits		Concentration Limits			
	Daily Maximum		Daily Maximum		Monitoring Frequency	Sample Type
Discharge Flow (MGD)	REPORT (1)		REPORT (1)		Continuous (report monthly)	Metered
Boron	AML (2)	MDL (2)	AML	MDL	1x/6 months	Discrete
	1635 g/day	2385 g/day	1000 ug/L	1460 ug/L		
Chloroform	11.9 g/day		5 ug/L		1x/Quarter	Discrete
Tetrachloroethene	11.9 g/day		5 ug/L		1x/Quarter	Discrete
Trichloroethene	11.9 g/day		5 ug/L		1x/Quarter	Discrete
pH (3)	Not less than 6.5 standard units (S.U.) nor greater than 9.0 S.U.				1x/week	Discrete

Footnotes:
(1) Monitoring and reporting required. No limit set at this time.
(2) AML and MDL are acronyms for average monthly limit and maximum daily limit, respectively.
(3) pH must be measured at the time of sampling and does not require use of a certified laboratory.

B. Trace Substance Monitoring

The permittee shall monitor discharges from outfall 001 as specified in Table 2. Data results above the Assessment Levels (ALs) listed in Table 2 do not constitute a permit violation, but may trigger evaluation of Reasonable Potential by ADEQ. The permittee shall use an approved analytical method with a Method Detection Limit (MDL) lower than the AL values per Part II.A.5.

TABLE 2: Trace Substance Monitoring Requirements

Parameter	ASSESSMENT LEVELS (1)		Monitoring Requirements (2)	
	Concentration (µg/L)			
	Monthly Average	Daily Maximum	Monitoring Frequency	Sample Type
Arsenic	200	292	1x/6 months	Discrete
Selenium	20.0	29.2	1x/6 months	Discrete
Hardness ($CaCO_3$)	Report	Report	1x/6 months	Discrete

Footnotes:
(1) Concentration values are calculated based on Arizona Water Quality Standards. Monitoring and reporting required.
(2) All metals effluent Assessment Levels are for total recoverable metals.

TABLE 3.a: Effluent Characterization Testing - Selected Metals (Total Recoverable)

Parameter	Reporting Units	Monitoring Requirements	
		Monitoring Frequency (1)	Sample Type
Antimony	ug/L	Once /year 2,3,4	Discrete
Arsenic	ug/L	Once /year 2,3,4	Discrete
Beryllium	ug/L	Once /year 2,3,4	Discrete
Cadmium	ug/L	Once /year 2,3,4	Discrete
Chromium	ug/L	Once /year 2,3,4	Discrete
Chromium VI	ug/L	Once /year 2,3,4	Discrete
Copper	ug/L	Once /year 2,3,4	Discrete
Lead	ug/L	Once /year 2,3,4	Discrete
Mercury	ug/L	Once /year 2,3,4	Discrete
Nickel	ug/L	Once /year 2,3,4	Discrete
Selenium	ug/L	Once /year 2,3,4	Discrete
Silver	ug/L	Once /year 2,3,4	Discrete
Thallium	ug/L	Once /year 2,3,4	Discrete
Zinc	ug/L	Once /year 2,3,4	Discrete
Cyanide	ug/L	Once /year 2,3,4	Discrete
Hardness ($CaCO_3$)	mg/L	Once /year 2,3,4	Discrete

(1) If more frequent monitoring of any of these parameters is required by another part of this permit, those sampling results may be used to satisfy Table 3.b. requirements.

TABLE 3.b: Effluent Characterization Testing - Selected Volatile Organic Compounds

Parameter	Reporting Units	Monitoring Requirements	
		Monitoring Frequency (1)	Sample Type
Acrolein	ug/L	1x/Quarter	Discrete
Acrylonitrile	ug/L	1x/Quarter	Discrete
Benzene	ug/L	1x/Quarter	Discrete
Bromoform	ug/L	1x/Quarter	Discrete
Carbon tetrachloride	ug/L	1x/Quarter	Discrete
Chlorobenzene	ug/L	1x/Quarter	Discrete
Chlorodibromomethane	ug/L	1x/Quarter	Discrete
Chloroethane	ug/L	1x/Quarter	Discrete
2-chloroethylvinyl ether	ug/L	1x/Quarter	Discrete
Chloroform	ug/L	1x/Quarter	Discrete
Dichlorobromomethane	ug/L	1x/Quarter	Discrete
1,1-dichloroethane	ug/L	1x/Quarter	Discrete
1,2-dichloroethane	ug/L	1x/Quarter	Discrete

Trans-1,2-dichloroethylene	ug/L	1x/Quarter	Discrete
1,1-dichloroethylene	ug/L	1x/Quarter	Discrete
1,2-dichloropropane	ug/L	1x/Quarter	Discrete
1,3-dichloropropylene	ug/L	1x/Quarter	Discrete
Ethylbenzene	ug/L	1x/Quarter	Discrete
Methyl bromide	ug/L	1x/Quarter	Discrete
Methyl chloride	ug/L	1x/Quarter	Discrete
Methylene chloride	ug/L	1x/Quarter	Discrete
1,1,2,2-tetrachloroethane	ug/L	1x/Quarter	Discrete
Tetrachloroethylene	ug/L	1x/Quarter	Discrete
Toluene	ug/L	1x/Quarter	Discrete
1,1,1-trichloroethane	ug/L	1x/Quarter	Discrete
1,1,2-trichloroethane	ug/L	1x/Quarter	Discrete
Trichloroethylene	ug/L	1x/Quarter	Discrete
Vinyl chloride	ug/L	1x/Quarter	Discrete

C. The discharge shall be free from pollutants in amounts or combinations that:

1. Settle to form bottom deposits that inhibit or prohibit the habitation, growth or propagation of aquatic life;
2. Cause objectionable odor in the area in which the surface water is located;
3. Cause off-taste or odor in drinking water;
4. Cause off-flavor in aquatic organisms;
5. Are toxic to humans, animals, plants or other organisms;
6. Cause the growth of algae or aquatic plants that inhibit or prohibit the habitation, growth or propagation of other aquatic life or that impair recreational uses;
7. Change the color of the surface water from natural background levels of color.

D. The discharge shall be free from oil, grease and other pollutants that float as debris, foam, or scum; or that cause a film or iridescent appearance on the surface of the water; or that cause a deposit on a shoreline, bank or aquatic vegetation.

E. Samples taken in compliance with the monitoring requirements specified above shall be taken after the treatment process and prior to mixing with the receiving waters.

PART II. MONITORING AND REPORTING

A. Sample Collection and Analysis

1. Quality Assurance (QA) Manual
The permittee shall keep a QA Manual at the facility that describes the sample collection and analyses processes. If the facility collects samples or conducts sample analyses in-house, the permittee shall develop the QA Manual. If a third party collects and/or analyzes samples on behalf of the permittee, the permittee shall obtain a copy. The QA Manual shall be available for review by ADEQ/ADHS upon request. The permittee is responsible for the quality and accuracy of all data required under this permit. The QA Manual shall be updated as necessary, and shall describe the following:

   a. Project Management, including roles and responsibilities of the participants; purpose of sample collection; matrix to be sampled; the analytes or compounds being measured; applicable regulatory or permit-specific limits or Assessment Levels; and personnel qualification requirements for collecting samples.

   b. Sample collection procedures; equipment used; the type and number of samples to be collected including QA/QC samples (i.e., background samples, duplicates, and equipment or field blanks); preservatives and holding times for the samples (see methods under 40 CFR 136 or 9 A.A.C. 14, Article 6 or any condition within this permit that specifies a particular test method.)

   c. Approved analytical method(s) to be used; Method Detection Limits (MDLs) and Minimum Levels (MLs) to be reported; required quality control (QC) results to be reported (e.g., matrix spike recoveries, duplicate relative percent differences, blank contamination, laboratory control sample recoveries, surrogate spike recoveries, etc.) and acceptance criteria; and corrective actions to be taken by the permittee or the laboratory as a result of problems identified during QC checks.

   d. How the permittee will: perform data review; report results to ADEQ; resolve data quality issues; and identify limitations on the use of the data.

2. Sample collection, preservation and handling shall be performed as described in 40 CFR 136 including the referenced Editions of *Standard Methods for the Examination of Water and Wastewater*. Where collection, preservation and handling procedures are not described in 40 CFR 136, the procedures specified under 9 A.A.C. 14, Article 6 methods for wastewater samples shall be used. (The permittee shall outline the proper procedures in the QA Manual, and samples taken to meet the monitoring requirements in this permit must conform to these procedures whether collection and handling is performed directly by the permittee or contracted to a third-party.)

3. All samples collected for monitoring must be analyzed:

   a. by a laboratory that is licensed by the ADHS Office of Laboratory Licensure and Certification, and that has demonstrated proficiency within the last 12 months for each parameter to be sampled under the terms of this permit, under R9-14-609. This requirement does not apply to parameters that must be analyzed for at the time of sampling and which are therefore exempt under A.A.C. R 9-14-602. These parameters include flow, dissolved oxygen, pH, temperature, and total residual chlorine.

b. using a method specified in this permit. If no test procedure is specified within this permit, then the permittee shall analyze the pollutant using:
   i. a test procedure listed in 40 CFR 136;
   ii. an alternative test procedure approved by the EPA as provided in 40 CFR 136;
   iii. a test procedure listed in 40 CFR 136, with modifications allowed by the EPA and approved as a method alteration by the ADHS under A.A.C. R9-14-610(B); or
   iv. If a test procedure for a pollutant is not available under subparagraphs (3)(b)(i) through (3)(b)(iii), a test procedure listed in A.A.C. R9-14-612 or approved under A.A.C. R9-14-610(B) for wastewater may be used, except the use of Hach Methods is not allowed unless otherwise specified in this permit. If there is no approved wastewater method for a parameter, any other method identified in 9 A.A.C. 14, Article 6 that will achieve appropriate detection limits may be used to analyze that parameter.

c. For results to be considered valid, all analytical work shall meet quality control standards specified in the approved methods.

4. The permittee shall use an analytical method with a Method Detection Limit (MDL, as defined in Appendix A of this permit) that is lower than the effluent limitations, Assessment Levels, Action Levels, or water quality criteria specified in this permit. **If all method-specific MDLs are higher than the limits specified in this permit, the permittee shall use the approved analytical method with the lowest method-specific MDL.**

5. The permittee shall use a standard calibration where the lowest standard point is equal to or less than the Minimum Level (ML) as defined under 40 CFR 136. When a method-specific ML is not available 40 CFR 136, the *interim* ML (see Appendix A- definitions) is to be used for calibration.

   When neither a ML nor MDL is promulgated under 40 CFR 136, the Laboratory ML, (as defined in Appendix A) shall be used for calibration.

6. In accordance with 40 CFR 122.45(c), effluent analyses for all metals, with the exception of chromium VI, shall be measured as "total recoverable metals". Effluent levels in this permit are for total recoverable metals, except for Chromium VI, for which the levels listed are dissolved.

B. Reporting of Monitoring Results

1. The permittee shall report monitoring results on Discharge Monitoring Report (DMR) forms supplied by ADEQ, to the extent that the results reported may be entered on the forms. The permittee shall submit results of all monitoring required by this permit in a format that will allow direct comparison with the limitations and requirements of this permit. If no discharge occurs during the reporting period, the permittee shall specify "No discharge" on the DMR. The results of effluent characterization monitoring required by Tables 1 through 3 taken at a representative sample point do not have to be submitted on DMRs if the samples are collected

when the facility is not discharging. These sample results must be submitted as an attachment to the DMRs that indicate "No discharge".

The permittee shall submit (see Appendix A- definitions) DMRs by the 28th day of the month following the end of any given monitoring period. For example, if the monitoring period ends January 31st, the permittee shall submit the DMR by February 28th. The permittee shall submit original copies of these and all other reports required in this Part, signed by an authorized representative, to ADEQ at the following address:

ADEQ Water Quality Compliance Section
Data Unit Mailcode: 5415B-1
1110 W. Washington
Phoenix, AZ 85007

For each month, a copy of the **AZPDES Discharge Flow Record** (found in Appendix B) is to be completed and submitted with the DMR for that month, along with copies of the original lab results for all parameters monitored during the reporting period.

2. The permittee shall participate in the annual NPDES DMR/QA study and submit the results of this study to ADEQ and ADHS for all laboratories used in monitoring compliance with this permit.

3. For the purposes of reporting, the permittee shall use the reporting threshold equivalent to the method-specific ML. If there is no method-specific ML promulgated, the laboratory's ML shall be used.

4. For parameters with Daily Maximum Limits or Daily Maximum Assessment Levels specified in this permit, the permittee shall review the results of all samples collected during the reporting period and report:

For Daily Maximum Limits/Assessment Levels	**The Permittee shall Report on the DMR**
When the maximum value of any analytical result is greater than the ML (e.g., method-specific ML if one exists, or if not, the laboratory's ML)	The maximum value of all analytical results
When the maximum value detected is greater than or equal to the laboratory's MDL, but less than the ML;	*NODI (Q)*(1)
When the maximum value is less than the laboratory's MDL.	*NODI (B)* (2)

(1) NODI(Q) means Not Quantifiable
(2) NODI(B) means Below Detection

5. For parameters with Monthly Average Limits or Monthly Average Assessment Levels specified in this permit, the permittee shall review the results of all samples collected during the reporting period and report:

For Monthly Average Limits/Assessment Levels		The Permittee shall Report on the DMR
If only one sample is collected during the reporting period (monthly, quarterly, annually, etc.) (In this case, the sample result is the monthly average.)	When the value detected is greater than the ML (e.g., method-specific ML if one exists, or if not, the laboratory's ML)	the analytical result
	When the value detected is greater than or equal to the laboratory's MDL, but less than the ML;	*NODI (Q)*[(1)]
	When the value is less than the laboratory's MDL.	*NODI (B)* [(2)]
If more than one sample is collected during the reporting period	All samples collected in the same calendar month must be averaged. ▪ When all results are greater than the ML, all values are averaged ▪ When calculating monthly averages where some samples have non-numeric results, substitute the laboratory's MDL for NODI(Q) and substitute "0" for NODI(B).	the highest monthly average which occurred during the reporting period

(1) NODI(Q) means Not Quantifiable
(2) NODI(B) means Below Detection

6. If the information below is not provided on the laboratory reports required in Part II.B.1, the permittee shall attach a report to each DMR that includes the following for all analytical results during the reporting period:

   a. The analytical result.

   b. The number or title of the approved analytical method, preparation and analytical procedure utilized by the laboratory and method-specific MDL or method-specific ML of the analytical method for the pollutant. When no method-specific ML exists, the laboratory derived ML shall be reported.

   c. The levels at which any results are reported as either *NODI(B)* or *NODI(Q)*.

   d. Any applicable data qualifiers using Arizona Data Qualifiers Revision 3.0 (9/27/07).

C. Twenty-four Hour Reporting of Noncompliance

The permittee shall orally report any noncompliance which may endanger the environment or human health within 24 hours from the time the permittee becomes aware of the event to:

ADEQ 24 hour hotline at 602-771-2330

The permittee shall also notify the Water Quality Compliance Section Manager at (602) 771-2209 by phone call or voice mail by 9 a.m. on the first business day following the noncompliance. The permittee shall also notify the Water Quality Compliance Section in writing within 5 days of the noncompliance event. The permittee shall include in the written notification a description of the noncompliance and its cause; the period of noncompliance, including dates and times, and, if the noncompliance has not been corrected, the time it is expected to continue; and steps taken or planned to reduce, eliminate, and prevent reoccurrence of the noncompliance.

D. Monitoring Records

The permittee shall retain the following monitoring information:

1. Date, exact location and time of sampling or measurements performed, preservatives used;

2. Individual(s) who performed the sampling or measurements;

3. Date(s) the analyses were performed;

4. Laboratory(s) which performed the analyses;

5. Analytical techniques or methods used;

6. Chain of custody forms;

7. Any comments, case narrative or summary of results produced by the laboratory. These comments should identify and discuss QA/QC analyses performed concurrently during sample analyses and should specify whether analyses met project requirements and 40 CFR 136. The summary of results must include information on initial and continuing calibration, surrogate analyses, blanks, duplicates, laboratory control samples, matrix spike and matrix spike duplicate results, sample receipt condition, holding times and preservation.

8. Summary of data interpretation and any corrective action taken by the permittee.

9. Effluent Limitations or Assessment Levels for analytes/compound being analyzed.

III. SPECIAL CONDITIONS

REOPENER

This permit may be modified per the provisions of A.A.C. R18-9-B906, and R18-9-A905 which incorporates 40 CFR Part 122. This permit may be reopened based on newly available information; to add conditions or limits to address demonstrated effluent toxicity; to implement any EPA-approved new Arizona water quality standard; or to re-evaluate reasonable potential (RP), if Assessment Levels in this permit are exceeded.

APPENDIX A PART A: ACRONYMS

A.A.C.	Arizona Administrative Code
ADEQ	Arizona Department of Environmental Quality
ADHS	Arizona Department of Health Services
AZPDES	Arizona Pollutant Discharge Elimination System
A.R.S.	Arizona Revised Statutes
CFR	Code of Federal Regulations
CFU	colony forming units
Director	The Director of ADEQ or any authorized representative thereof
DMR	Discharge Monitoring Report
EPA	The U.S. Environmental Protection Agency
kg/day	kilograms per day
MGD	million gallons per day
mg/L	milligrams per Liter, also equal to parts per million (ppm)
MPN	Most Probable Number
NPDES	National Pollutant Discharge Elimination System
QA	quality assurance
ug/L	micrograms per Liter, also equal to parts per billion (ppb)

APPENDIX A PART B: DEFINITIONS

DAILY MAXIMUM CONCENTRATION LIMIT means the maximum allowable discharge of a pollutant in a calendar day as measured on any single discrete sample or composite sample.

DAILY MAXIMUM MASS LIMIT means the maximum allowable total mass of a pollutant discharged in a calendar day.

DISCRETE or GRAB SAMPLE means an individual **sample of at least 100 mL** collected from a single location~~,~~ or over a period of time not exceeding 15 minutes.

HARDNESS means the sum of the calcium and magnesium concentrations, expressed as calcium carbonate ($CaCO_3$) in milligrams per liter.

HYPOTHESIS TESTING is a statistical technique (e.g., Dunnetts test) that determines what concentration is statistically different from the control. Endpoints determined from hypothesis testing are NOEC and LOEC. The two hypotheses commonly tested in WET are:

- Null hypothesis (H_0): The effluent is not toxic.
- Alternative hypothesis (H_a): The effluent is toxic.

INTERIM ML If a promulgated method-specific ML is not available, then an interim ML must be calculated. The interim ML is equal to 3.18 times the promulgated method-specific MDL rounded to the nearest multiple of 1, 2, 5, 10, 20, 50, etc.

LABORATORY ML, is to be calculated when neither an ML or MDL are promulgated under 40 CFR 136 or 9 A.A.C. 14, Article 6. A laboratory ML should be calculated by multiplying the best estimate of detection by a factor or 3.18 and rounding the value to the nearest multiple of 1, 2, 5, 10, 20, 50, etc. When a range of detection is given, the lower end value of the range of detection should be used to calculate the ML.

METHOD DETECTION LIMIT (MDL) is the minimum concentration of an analyte that can be detected with 99% confidence that the analyte concentration is greater than zero, as defined under 40 CFR 136 or 9 A.A.C. 14, Article 6 methods. The procedure for determination of a laboratory MDL is prescribed under 9 A.A.C. 14, Article 6 methods or by 40 CFR Part 136, Appendix B (1998).

METHOD SPECIFIC ML is the promulgated method-specific ML contained in 40 CFR 136 or 9 A.A.C.14, Article 6 (as "Minimum Levels") and must be used if available.

MINIMUM LEVEL (ML) is the concentration at which the entire analytical system gives a recognizable signal and acceptable calibration point. The ML is the concentration in a sample that is equivalent to the concentration of the lowest calibration standard analyzed by a specific analytical procedure, assuming that all of the method-specified sample weights, volumes, and processing steps have been followed (as defined in EPA's draft *National Guidance for the Permitting, Monitoring, and*

Enforcement of Water Quality-Based Effluent Limitations Set Below Analytical Detection/Quantitative Levels, March 22, 1994).

MIXING ZONE is an area where an effluent discharge undergoes initial dilution and may be extended to cover the secondary mixing in the ambient water body. A mixing zone is an allocated impact zone where water quality criteria can be exceeded as long as acutely toxic conditions are prevented.

MONTHLY OR WEEKLY AVERAGE CONCENTRATION LIMIT, other than for bacteriological testing, means the highest allowable average calculated as an arithmetic mean of consecutive measurements made during calendar month or week, respectively. The "monthly or weekly average concentration limit" for *E. coli* bacteria means the highest allowable average calculated as the geometric mean of a minimum of four (4) measurements made during a calendar month or week, respectively. The geometric mean is the nth root of the product of n numbers. For either method (CFU or MPN), when data is reported as "0" or non-detect then input a "1" into the calculation for the geometric mean.

MONTHLY OR WEEKLY AVERAGE MASS LIMITATION means the highest allowable value that shall be obtained by taking the total mass discharged during a calendar month or week, respectively, divided by the number of days in the period that the facility was discharging. Where less than daily sampling is required by this permit, the monthly or weekly average value shall be determined by the summation of all the measured discharges by mass divided by the number of days during the month or week, respectively, when the measurements were made.

MONTHLY MEDIAN means the middle value in a data set consisting of measurements collected during one calendar month ordered from smallest to largest. If the number of values in the ordered data set is even, the middle two values are averaged. Ex. The median of (1, 3, 4) is 3. The median of (1, 3, 4, 5) is 3.5. If there is only one value in the data set, then that value is the median.

SIGNIFICANT DIFFERENCE is defined as statistically significant difference (e.g., 95% confidence level) in the means of two distributions of sampling results.

SUBMIT, as used in this permit, means post-marked, documented by other mailing receipt, or hand-delivered to ADEQ.

APPENDIX B

AZPDES Discharge Flow Record

Cooper & Commerce WQARF Site - AZ0025801

Discharge to the Salt River Project's Lateral 9.5 in the Middle Gila River Basin At:

Outfall No.:

Location:

Month: **Year:**

DATE	Flow Duration (1) (Total hours per day)	Flow Rate(2) (Total MGD per day)
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		
11		
12		
13		
14		
15		
16		
17		
18		
19		
20		
21		
22		
23		
24		
25		
26		
27		
28		
29		
30		
31		

Comment:

footnotes:

(1) Total time of discharge in hours per day. If actual time is not available, use an estimate of flow duration.

(2) Report flow discharged in MGD. If no discharge occurs on any given day, report 'ND' for the flow for that day

Signature of Authorized Representative:

____

APPENDIX C

STANDARD AZPDES PERMIT CONDITIONS & NOTIFICATIONS

(Updated as of February 2, 2004)

1. Duty to Reapply [R18-9-B904(C)]
Unless the Permittee permanently ceases the discharging activity covered by this permit, the Permittee shall submit a new application 180 days before the existing permit expires.

2. Applications [R18-9-A905(A)(1)(c) which incorporates 40 CFR 122.22]

   a. All applications shall be signed as follows:

      1) For a corporation: by a responsible corporate officer. For the purpose of this section, a responsible corporate officer means:

         A) A president, secretary, treasurer, or vice-president of the corporation in charge of a principle business function, or any other person who performs similar policy- or decision-making functions for the corporation, or

         B) The manager of one or more manufacturing, production, or operating facilities, provided, the manager is authorized to make management decisions which govern the operation of the regulated facility including having the explicit or implicit duty of making major capital investment recommendations, and initiating and directing other comprehensive measures to assure long term environmental compliance with environmental laws and regulations; the manager can ensure that the necessary systems are established or actions taken to gather complete and accurate information for permit application requirements; and where authority to sign documents has been assigned or delegated to the manager in accordance with corporate procedures;

      2) For a partnership or sole proprietorship: by a general partner or the proprietor, respectively; or

      3) For a municipality, State, Federal, or other public agency: By either a principal executive officer or ranking elected official. For purposes of this section, a principal executive officer of a Federal agency includes: (i) The chief executive officer having responsibility for the overall operations of a principal geographic unit of the agency (e.g., Regional Administrators of EPA).

   b. All reports required by permits and other information requested by the Director shall be signed by a person described in paragraph (a) of this Section, or by a duly authorized representative of that person. A person is a duly authorized representative only if:

      1) The authorization is made in writing by a person described in paragraph (a) of this section;

      2) The authorization specifies either an individual or a position having responsibility for the overall operation of the regulated facility, such as the position of plant manager, operator of a well or a well field, superintendent, position of equivalent responsibility, or an individual or position having overall responsibility for environmental matters for the company. (A duly authorized representative may thus be either a named individual or any individual occupying a named position.) and,

      3) The written authorization is submitted to the Director.

   c. Changes to Authorization. If an authorization under paragraph (b) of this section is no longer accurate because a different individual or position has responsibility for the overall operation of the facility, a new authorization satisfying the requirements of paragraph (b) of this section must be submitted to the Director prior to or together with any reports, information, or applications to be signed by an authorized representative.

   d. Certification. Any person signing a document under paragraph (a) or (b) of this section shall make the following certification:

I certify under penalty of law, that this document and all attachments were prepared under my direction or supervision in accordance with a system designed to assure that qualified personnel properly gathered and evaluated the information submitted. Based on my inquiry of the person or persons who manage the system, or those persons directly responsible for gathering information, the information submitted is, to the best of my knowledge and belief, true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment for knowing violations.

3. Duty to Comply [R18-9-A905(A)(3)(a) which incorporates 40 CFR 122.41(a)(i) and A.R.S. §49- 262, 263.01, and 263.02.]

   a. The Permittee shall comply with all conditions of this permit and any standard and prohibition required under A.R.S. Title 49, Chapter 2, Article 3.1 and A.A.C. Title 18, Chapter 9, Articles 9 and 10. Any permit noncompliance constitutes a violation of the Clean Water Act; A.R.S. Title 49, Chapter 2, Article 3.1; and A.A.C. Title 18, Chapter 9, Articles 9 and 10, and is grounds for enforcement action, permit termination, revocation and reissuance, or modification, or denial of a permit renewal application.

   b. The issuance of this permit does not waive any federal, state, county, or local regulations or permit requirements with which a person discharging under this permit is required to comply.

   c. The Permittee shall comply with the effluent standards or prohibitions established under section 307(a) of the Clean Water Act for toxic pollutants and with standards for sewage sludge use or disposal established under section 405(d) of the Clean Water Act within the time provided in the regulation that establish these standards or prohibitions, even if the permit has not yet been modified to incorporate the requirement.

   d. Civil Penalties. A.R.S. § 49-262(C) provides that any person who violates any provision of A.R.S. Title 49, Chapter 2, Article 3.1 or a rule, permit, discharge limitation or order issued or adopted under A.R.S. Title 49, Chapter 2, Article 3.1 is subject to a civil penalty not to exceed $25,000 per day per violation.

   e. Criminal Penalties. Any a person who violates a condition of this permit, or violates a provision under A.R.S. Title 49, Chapter 2, Article 3.1, or A.A.C. Title 18, Chapter 9, Articles 9 and 10 is subject to the enforcement actions established under A.R.S. Title 49, Chapter 2, Article 4, which may include the possibility of fines and/or imprisonment.

4. Need to Halt or Reduce Activity Not a Defense [R18-9-A905(A)(3)(a) which incorporates 40 CFR 122.41(c)]

   It shall not be a defense for a Permittee in an enforcement action that it would have been necessary to halt or reduce the permitted activity in order to maintain compliance with the conditions of this permit.

5. Duty to Mitigate [R18-9-A905(A)(3)(a) which incorporates 40 CFR 122.41(d)]

   The Permittee shall take all reasonable steps to minimize or prevent any discharge or sludge use or disposal in violation of this permit which has a reasonable likelihood of adversely affecting human health or the environment.

6. Proper Operation and Maintenance [R18-9-A905(A)(3)(a) which incorporates 40 CFR 122.41(e)]

   The Permittee shall at all times properly operate and maintain all facilities and systems of treatment and control (and related appurtenances) which are installed or used by the Permittee to achieve compliance with the conditions of this permit. Proper operation and maintenance also includes adequate laboratory controls and appropriate quality assurance procedures. This provision requires the operation of back-up or auxiliary facilities or similar systems which are installed by a Permittee only when the operation is necessary to achieve compliance with the conditions of the permit.

7. Permit Actions [R18-9-A905(A)(3)(a) which incorporates 40 CFR 122.41(f)]

This permit may be modified, revoked and reissued, or terminated for cause. The filing of a request by the Permittee for a permit modification, revocation and reissuance, or termination, or a notification of planned changes or anticipated noncompliance does not stay any permit condition.

8. Property Rights [R18-9-A905(A)(3)(a) which incorporates 40 CFR 122.41(g)]

This permit does not convey any property rights of any sort, or any exclusive privilege.

9. Duty to Provide Information [R18-9-A905(A)(3)(a) which incorporates 40 CFR 122.41(h)]

The Permittee shall furnish to the Director, within a reasonable time, any information which the Director may request to determine whether cause exists for modifying, revoking and reissuing, or terminating this permit or to determine compliance with this permit. The Permittee shall also furnish to the Director upon request, copies of records required to be kept by this permit.

10. Inspection and Entry [R18-9-A905(A)(3)(a) which incorporates 40 CFR 122.41(i)]

The Permittee shall allow the Director, or an authorized representative, upon the presentation of credentials and such other documents as may be required by law, to:

a. Enter upon the Permittee's premises where a regulated facility or activity is located or conducted, or where records must be kept under the conditions of this permit;

b. Have access to and copy, at reasonable times, any records that must be kept under the terms of the permit;

c. Inspect at reasonable times any facilities, equipment (including monitoring equipment or control equipment), practices or operations regulated or required under this permit; and

d. Sample or monitor at reasonable times, for the purposes of assuring permit compliance or as otherwise authorized by A.R.S. Title 49, Chapter 2, Article 3.1, and A.A.C. Title 18, Chapter 9, Articles 9 and 10, any substances or parameters at any location.

11. Monitoring and Records [R18-9-A905(A)(3)(a) which incorporates 40 CFR 122.41(j)]

a. Samples and measurements taken for the purpose of monitoring shall be representative of the monitored activity.

b. The Permittee shall retain records of all monitoring information, including all calibration and maintenance records and all original strip chart recordings for continuous monitoring instrumentation, copies of all reports required by this permit, and records of all data used to complete the application for this permit, for a period of at least 3 years from the date of the sample, measurement, report or application, except for records of monitoring information required by this permit related to the Permittee's sewage sludge use and disposal activities, which shall be retained for a period of at least five years (or longer as required by 40 CFR Part 503). This period may be extended by request of the Director at any time.

c. Records of monitoring information shall include:

1) The date, exact place and time of sampling or measurements;

2) The individual(s) who performed the sampling or measurements;

3) The date(s) the analyses were performed;

4) The individual(s) who performed the analyses;

5) The analytical techniques or methods used; and

6) The results of such analyses.

d. Monitoring must be conducted according to test procedures specified in this permit. If a test procedure is not specified in the permit, then monitoring must be conducted according to test procedures approved under A.A.C. R18-9-A905(B) including those under 40 CFR Part 136 unless otherwise specified in 40 CFR Part 503 (for sludge).

e. The Clean Water Act provides that any person who falsifies, tampers with, or knowingly renders inaccurate any monitoring device or method required to be maintained in this permit shall, upon conviction, be punished by a fine of not more than $10,000 per violation, or by imprisonment for not more than two years per violation, or by both for first conviction. For a second conviction, such a person is subject to a fine of not more than $20,000 per day of violation, or imprisonment for not more than four years, or both.

Any person who falsifies, tampers with, or knowingly renders inaccurate any monitoring device or method required to be maintained in this permit is subject to the enforcement actions established under A.R.S. Title 49, Chapter 2, Article 4, which includes the possibility of fines and/or imprisonment.

12. Signatory Requirement [R18-9-A905(A)(3)(a) which incorporates 40 CFR 122.41(k)]

a. All applications, reports, or information submitted to the Director shall be signed and certified. (See 40 CFR 122.22 incorporated at R18-9-A905(A)(1)(c))

b. The CLEAN WATER ACT provides that any person who knowingly makes any false statement, representation, or certification in any record or other document submitted or required to be maintained under this permit, including monitoring reports or reports of compliance or non-compliance shall, upon conviction, be punished by a fine of not more than $10,000 per violation, or by imprisonment for not more than two years per violation, or by both for a first conviction. For a second conviction, such a person is subject to a fine of not more than $20,000 per day of violation, or imprisonment of not more than four years, or both.

13. Reporting Requirements [R18-9-A905(A)(3)(a) which incorporates 40 CFR 122.41(l)]

a. Planned changes. The Permittee shall give notice to the Director as soon as possible of any planned physical alterations of additions to the permitted facility. Notice is required only when:

1) The alteration or addition to a permitted facility may meet one of the criteria for determining whether a facility is a new source in 40 CFR 122.29(b) (incorporated by reference at R18-9-A905(A)(1)(e)); or

2) The alteration or addition could significantly change the nature or increase the quantity of pollutants discharged. This notification applies to pollutants which are subject neither to effluent limitations in the permit, nor to notification requirements under 40 CFR 122.42(a)(1) (incorporated by reference at R18-9-A905(A)(3)(b)).

3) The alteration or addition results in a significant change in the Permittee's sludge use or disposal practices, and such alteration, addition, or change may justify the application of permit conditions that are different from or absent in the existing permit including notification of additional use or disposal sites not reported during the permit application process or not reported pursuant to an approved land application plan.

b. Anticipated noncompliance. The Permittee shall give advance notice to the Director of any planned changes in the permitted facility or activity which may result in noncompliance with permit requirements.

c. Transfers. (R18-9-B905) This permit is not transferable to any person except after notice to the Director. The Director may require modification or revocation and reissuance of the permit to change the name of the Permittee and incorporate such other requirements as may be necessary under Arizona Revised Statutes and the Clean Water Act.

d. Monitoring reports. Monitoring results shall be reported at the intervals specified elsewhere in this permit.

1) Monitoring results must be reported on a Discharge Monitoring Report (DMR) or forms provided or specified by the Director for reporting results of monitoring of sludge use or disposal practices.

2) If the Permittee monitors any pollutant more frequently than required by the permit, then the results of this monitoring shall be included in the calculation and reporting of the data submitted in the DMR, or sludge reporting form specified by the Director.

3) Calculations for all limitations which require averaging of measurements shall utilize an arithmetic mean unless otherwise specified by the Director in the permit.

e. Compliance schedules. Reports of compliance or noncompliance with, or any progress reports on, interim and final requirements contained in any compliance schedule of this permit shall be submitted no later than 14 days following each schedule date.

f. Twenty-four hour reporting.

1) The Permittee shall report any noncompliance which may endanger human health or the environment. Any information shall be provided orally within 24 hours from the time the Permittee becomes aware of the circumstances. A written submission shall also be provided within five days of the time the Permittee becomes aware of the circumstances. The written submission shall contain a description of the noncompliance and its cause; the period of noncompliance, including exact dates and times, and if the noncompliance has not been corrected, the anticipated time it is expected to continue; and steps taken or planned to reduce, eliminate, and prevent recurrence of the noncompliance.

2) The following shall be included as information which must be reported within 24 hours under this paragraph.

a) Any unanticipated bypass which exceeds any effluent limitation in the permit. (See 40 CFR 122.41(g) which is incorporated by reference at R18-9-A905(A)(3)(a))

b) Any upset which exceeds any effluent limitation in the permit.

c) Violation of a maximum daily discharge limitation for any of the pollutants listed by the Director in the permit to be reported within 24 hours. (See 40 CFR 122.44(g) which is incorporated by reference at R18-9-A905(A)(3)(d))

g. Other noncompliance. The Permittee shall report all instances of noncompliance not reported under paragraphs (d), (e), and (f) of this section, at the time monitoring reports are submitted. The reports shall contain the information listed in paragraph (f) of this section.

h. Other information. Where the Permittee becomes aware that it failed to submit any relevant facts in a permit application, or submitted incorrect information in a permit application or in any report to the Director, it shall promptly submit such facts or information.

14. Bypass [R18-9-A905(A)(3)(a) which incorporates 40 CFR 122.41(m)]

a. Definitions

1) "Bypass" means the intentional diversion of waste streams from any portion of a treatment facility.

2) "Severe property damage" means substantial physical damage to property, damage to the treatment facilities which causes them to become inoperable, or substantial and permanent loss of natural resources which can reasonably be expected to occur in the

absence of a bypass. Severe property damage does not mean economic loss caused by delays in production.

b. Bypass not exceeding limitations. The Permittee may allow any bypass to occur which does not cause effluent limitations to be exceeded, but only if it also is for essential maintenance to assure efficient operation. These bypasses are not subject to the provision of paragraphs (c) and (d) of this section.

c. Notice.

1) Anticipated bypass. If the Permittee knows in advance of the need for a bypass, it shall submit prior notice, if possible at least ten days before the date of bypass.
2) Unanticipated bypass. The Permittee shall submit notice of an unanticipated bypass as required in paragraph (f)(2) of section 13 (24-hour notice).

d. Prohibition of bypass.

1) Bypass is prohibited, and the Director may take enforcement action against a Permittee for bypass, unless:

a) Bypass was unavoidable to prevent loss of life, personal injury, or severe property damage;

b) There were no feasible alternatives to the bypass, such as the use of auxiliary treatment facilities, retention of untreated wastes, or maintenance during normal periods of equipment down time. This condition is not satisfied if adequate back-up equipment should have been installed in the exercise of reasonable engineering judgement to prevent a bypass which occurred during normal periods of equipment downtime or preventive maintenance; and

c) The Permittee submitted notices as required under paragraph (c) of this section.

2) The Director may approve an anticipated bypass, after considering its adverse effects, if the Director determines that it will meet the three conditions listed above in paragraph (d)(1) of this section.

15. Upset [A.R.S.§§49-255(8) and 255.01(E), R18-9-A905(A)(3)(a) which incorporates 40 CFR 122.41(n)]

a. Definition. "Upset" means an exceptional incident in which there is unintentional and temporary noncompliance with technology-based permit effluent limitations because of factors beyond the reasonable control of the Permittee. An upset does not include noncompliance to the extent caused by operational error, improperly designed treatment facilities, inadequate treatment facilities, lack of preventative maintenance, or careless or improper operation.

b. Effect of an upset. An upset constitutes an affirmative defense to an action brought for noncompliance with such technology-based permit effluent limitations if the requirements of paragraph (c) of this section are met. No determination made during administrative review of claims that noncompliance was caused by upset, and before an action for noncompliance, is final administrative action subject to judicial review.

c. Conditions necessary for a demonstration of upset. A Permittee who wishes to establish the affirmative defenses of upset shall demonstrate, through properly signed, contemporaneous operating logs, or other relevant evidence that:

1) An upset occurred and that the Permittee can identify the cause(s) of the upset;

2) The permitted facility was at the time being properly operated; and

3) The Permittee submitted notice of the upset as required in paragraph (f)(2) of Section 13 (24-hour notice).

4) The Permittee has taken appropriate measure including all reasonable steps to minimize or prevent any discharge or sewage sludge use or disposal that is in violation of the permit and that has a reasonable likelihood of adversely affecting human health or the environment per A.R.S. § 49-255.01(E)(1)(d)

d. Burden of proof. In any enforcement proceeding the Permittee seeking to establish the occurrence of an upset has the burden of proof.

16. Existing Manufacturing, Commercial, Mining, and Silvicultural Dischargers [R18-9-A905(A)(3)(b) which incorporates 40 CFR 122.42(a)]

In addition to the reporting requirements under 40 CFR 122.41(l) (which is incorporated at R18-9-A905(A)(3)(a)), all existing manufacturing, commercial, mining, and silvicultural dischargers must notify the Director as soon as they know or have reason to believe:

a. That any activity has occurred or will occur which would result in the discharge, on a routine or frequent basis, of any toxic pollutant which is not limited in the permit, if that discharge will exceed the highest of the following "notification levels":

1) One hundred micrograms per liter (100 µg/l);

2) Two hundred micrograms per liter (200 µg/l) for acrolein and acrylonitrile; five hundred micrograms per liter (500 µg/l) for 2,4-dinitrophenol and for 2-methyl-4,6-dinitrophenol; and one milligram per liter (1 mg/l) for antimony;

3) Five times the maximum concentration value reported for that pollutant in the permit application in accordance with 40 CFR 122.21(g)(7) (which is incorporated at R18-9-A905(A)(1)(b)); or

4) The level established by the Director in accordance with 40 CFR 122.44(f) (which is incorporated at R18-9-A905(A)(3)(d)).

b. That any activity has occurred or will occur which would result in any discharge, on a nonroutine or infrequent basis, of a toxic pollutant which is not limited in the permit, if that discharge will exceed the highest of the following "notification levels":

1) Five hundred micrograms per liter (500 µg/l);

2) One milligram per liter (1 mg/l) for antimony;

3) Ten (10) times the maximum concentration value reported for that pollutant in the permit application in accordance with 40 CFR 122.21(g)(7)(which is incorporated at R18-9-A905(A)(1)(b));

4) The level established by the Director in accordance with 40 CFR 122.44(f) (which is incorporated at R18-9-A905(A)(3)(d)).

17. Publicly Owned Treatment Works [R18-9-A905(A)(3)(b) which incorporates 40 CFR 122.42(b)]

This section applies only to publicly owned treatment works as defined at ARS § 49-255(5).

a. All POTW's must provide adequate notice to the Director of the following:

1) Any new introduction of pollutants into the POTW from an indirect discharger which would be subject to section 301 or 306 of the CLEAN WATER ACT if it were directly discharging those pollutants; and

2) Any substantial change in the volume or character of pollutants being introduced into that POTW by a source introducing pollutants into the POTW at the time of issuance of the permit.

3) For the purposes of this paragraph, adequate notice shall include information on (i) the quality and quantity of effluent introduced into the POTW, and (ii) any anticipated impact of the change on the quantity or quality of effluent to be discharge from the POTW.

b. Publicly owned treatment works may not receive hazardous waste by truck, rail, or dedicated pipe except as provided under 40 CFR 270. Hazardous wastes are defined at 40 CFR 261 and include any mixture containing any waste listed under 40 CFR 261.31 - 261.33. The Domestic Sewage Exclusion (40 CFR 261.4) applies only to wastes mixed with domestic sewage in a sewer leading to a publicly owned treatment works and not to mixtures of hazardous wastes and sewage or septage delivered to the treatment plant by truck.

18. Reopener Clause [R18-9-A905(A)(3)(d) which incorporates 40 CFR 122.44(c)]

This permit shall be modified or revoked and reissued to incorporate any applicable effluent standard or limitation or standard for sewage sludge use or disposal under sections 301(b)(2)(C), and (D), 304(b)(2), 307(a)(2) and 405(d) which is promulgated or approved after the permit is issued if that effluent or sludge standard or limitation is more stringent than any effluent limitation in the permit, or controls a pollutant or sludge use or disposal practice not limited in the permit.

19. Privately Owned Treatment Works [R18-9-A905(A)(3)(d) which incorporates 40 CFR 122.44]

This section applies only to privately owned treatment works as defined at 40 CFR 122.2.

a. Materials authorized to be disposed of into the privately owned treatment works and collection system are typical domestic sewage. Unauthorized material are hazardous waste (as defined at 40 CFR Part 261), motor oil, gasoline, paints, varnishes, solvents, pesticides, fertilizers, industrial wastes, or other materials not generally associated with toilet flushing or personal hygiene, laundry, or food preparation, unless specifically listed under "Authorized Non-domestic Sewer Dischargers" elsewhere in this permit.

b. It is the Permittee's responsibility to inform users of the privately owned treatment works and collection system of the prohibition against unauthorized materials and to ensure compliance with the prohibition. The Permittee must have the authority and capability to sample all discharges to the collection system, including any from septic haulers or other unsewered dischargers, and shall take and analyze such samples for conventional, toxic, or hazardous pollutants when instructed by the permitting authority. The Permittee must provide adequate security to prevent unauthorized discharges to the collection system.

c. Should a user of the privately owned treatment works desire authorization to discharge non-domestic wastes, the Permittee shall submit a request for permit modification and an application, pursuant to 40 CFR 122.44(m), describing the proposed discharge. The application shall, to the extent possible, be submitted using ADEQ Forms 1 and 2C, unless another format is requested by the permitting authority. If the privately owned treatment works or collection system user is different from the Permittee, and the Permittee agrees to allow the non-domestic discharge, the user shall submit the application and the Permittee shall submit the permit modification request. The application and request for modification shall be submitted at least 6 months before authorization to discharge non-domestic wastes to the privately owned treatment works or collection system is desired.

20. Transfers by Modification [R18-9-B905]

Except as provided in section 21, a permit may be transferred by the Permittee to a new owner or operator only if the permit has been modified or revoked and reissued, or a minor modification made under R18-9-B906, to identify the new Permittee and incorporate such other requirements as may be necessary.

21. Automatic Transfers [R18-9-B905]

An alternative to transfers under section 20, any AZPDES permit may be automatically transferred to a new Permittee if:

a. The current Permittee notifies the Director at least 30 days in advance of the proposed transfer date;

b. The notice includes a written agreement between the existing and new Permittee containing a specific date for transfer of permit responsibility, coverage, and liability between them; and

c. The Director does not notify the existing Permittee and the proposed new Permittee of his or her intent to modify or revoke and reissue the permit. A modification under this subparagraph may also be a minor modification under R18-9-B906(B).

22. Minor Modification of Permits [R18-9-B906(B)]

Upon the consent of the Permittee, the Director may modify a permit to make the corrections or allowances for changes in the permitted activity listed in this section, without following public notice procedures under R18-9-A907 or A908. Minor modifications may only:

a. Correct typographical errors;

b. Update a permit condition that changed as a result of updating an Arizona water quality standard;

c. Require more frequent monitoring or reporting by the Permittee;

d. Change an interim compliance date in a schedule of compliance, provided the new date is not more than 120 days after the date specified in the existing permit and does not interfere with attainment of the final compliance date requirement;

e. Allow for a change in ownership or operational control of a facility where the Director determines that no other change in their permit is necessary, provided that a written agreement containing a specific date for transfer of permit responsibility, coverage, and liability between the current and new Permittee has been submitted to the Director.

f. Change the construction schedule for a discharger which is a new source. No such change shall affect a discharger's obligation prior to discharge under 40 CFR 122.29 (which is incorporated by reference in R18-9-A905(A)(1)(e)).

g. Delete a point source outfall when the discharge from that outfall is terminated and does not result in discharge of pollutants from other outfalls except in accordance with the permit limits.

h. Incorporate conditions of a POTW pretreatment program that has been approved in accordance with the procedures in 40 CFR 403.11 and 403.18 as enforceable conditions of the POTW's permit.

i. Annex an area by a municipality.

23. <u>Termination of Permits</u> [R-9-B906(C)]

The following are causes for terminating a permit during its term, or for denying a permit renewal application:

a. Noncompliance by the Permittee with any condition of the permit;

b. The Permittee's failure in the application or during the permit issuance process to disclose fully all relevant facts, or the Permittee's misrepresentation of any relevant facts at any time;

c. A determination that the permitted activity endangers human health or the environment and can only by regulated to acceptable levels by permit modification or termination; or

d. A change in any condition that requires either a temporary or a permanent reduction or elimination of any discharge controlled by the permit (for example, a plant closure or termination of discharge by connection to a POTW).

24. Availability of Reports [Pursuant to A.R.S § 49-205]

Except for data determined to be confidential under A.R.S § 49-205(A), all reports prepared in accordance with the terms of this permit shall be available for public inspection at ADEQ offices. As required by A.R.S. § 49-205(B) and (C), permit applications, permits, and effluent data shall not be considered confidential.

25. Removed Substances [Pursuant to Clean Water Act Section 301]

Solids, sludges, filter backwash, or other pollutants removed in the course of treatment or control of wastewaters shall be disposed of in a manner such as to prevent any pollutant from such materials from entering navigable waters.

26. Severability [Pursuant to A.R.S § 49-324(E)]

The provisions of this permit are severable, and if any provision of this permit, or the application of any provision of this permit to any circumstance, is held invalid, the application of such provision to other circumstances, and remainder of this permit, shall not be affected thereby.

27. Civil and Criminal Liability [Pursuant to A.R.S § 49-262, 263.01, and 263.02]

Except as provided in permit conditions on "Bypass" (Section 14) and "Upset" (Section 15), nothing in this permit shall be construed to relieve the Permittee from civil or criminal penalties for noncompliance.

28. Oil and Hazardous Substance Liability [Pursuant to Clean Water Act Section 311]

Nothing in this permit shall be construed to preclude the institution of any legal action or relieve the Permittee from any responsibilities, liabilities, or penalties to which the Permittee is or may be subject under Section 311 of the Clean Water Act.

29. State or Tribal Law [Pursuant to R18-9-A904(C)]

Nothing in this permit shall be construed to preclude the institution of any legal action or relieve the operator from any responsibilities, liabilities, or penalties established pursuant to any applicable State or Tribal law or regulation under authority preserved by Section 510 of the Clean Water Act.

ARIZONA DEPARTMENT OF WATER RESOURCES

PERMIT TO WITHDRAW

POOR QUALITY GROUNDWATER

PURSUANT TO A.R.S. § 45-516

PERMIT NO. 59-217080.0000

STATE OF ARIZONA)
)ss.
COUNTY OF MARICOPA)

This is to certify that Application No. 59-217080.0000 meets the requirements of Title 45, Chapter 2, Article 7, Arizona Revised Statutes for a Permit to Withdraw Poor Quality Groundwater. The Director hereby grants a permit to withdraw poor quality groundwater pursuant to Arizona Revised Statutes § 45-516, subject to the following limitations and conditions:

Permit Limitations

Permittee: Arizona Department of Environmental Quality
1110 West Washington Street
Phoenix, AZ 85007

Active Management Area:	Phoenix
Sub-basin:	East Salt River Valley
Maximum Amount of Groundwater to be Withdrawn:	250 acre-feet per annum
Authorized Point of Withdrawal:	Well Registration No. 55-211538, located in the SE ¼ SW ¼ NW ¼ Section 12 T1S R5E
Authorized Use of Groundwater:	Discharge into the SRP Western Canal and/or the Neely Water Reclamation Facility for reclaimed use.
Authorized Place of Use for Groundwater Withdrawn:	Section 12, Township 1 South, Range 5 East GSRB&M
Effective Date of Permit:	July 16, 2008
Expiration Date of Permit:	July 16, 2018

Permit Conditions

1. Poor quality groundwater shall be withdrawn by the Permittee pursuant to remedial actions being performed at the Cooper and Commerce Water Quality Assurance Revolving Fund site and described in the Cooper and Commerce Sampling Plan (Plan). The Plan and subsequent modifications are collectively referred to as the "Remediation Documents", which are incorporated in and made a part of this permit.

2. For the purpose of this permit, poor quality groundwater is defined as groundwater that does not meet the state of Arizona Aquifer Water Quality Standards (AWQSs). For the purposes of this permit, the AWQSs are indicators that the groundwater is of poor quality and do not constitute a remediation standard.

3. The issuance of this permit does not constitute endorsement of the assertions or findings of investigations and studies submitted by the Permittee as part of its applications, nor as part of its other efforts to delineate the area and extent of contamination or to delineate contamination source or responsibility.

4. This permit shall terminate when the activities performed pursuant to the remediation documents end. If the activities being performed will extend beyond the expiration date of this permit, the Permittee may submit an application to renew this permit within six (6) months prior to the date of the expiration of this permit.

5. Monitoring Requirements:

   a. Groundwater Withdrawal Monitoring:

      The Permittee shall measure the volume of groundwater withdrawn from the extraction well (ADWR registration number 55-211538) with an approved water measuring device and method consistent with A.A.C. R12-15-903.

   b. Water Measuring Device Accuracy and Failures:

      The water quantity measuring devices and methods shall quantify flow accurately pursuant to A.A.C. R12-15-905. If any water quantity measurement device fails to perform its designated function for more than seventy-two (72) hours, the Permittee shall notify ADWR in writing and shall repair or replace the measuring device as described in A.A.C. R12-15-906.

   c. Groundwater Quality Monitoring:

      The Permittee shall perform groundwater quality monitoring as described in the remediation documents and that allows ADWR to determine that the groundwater withdrawn, because of its quality, has no other beneficial use. The Permittee shall notify ADWR of any changes to the groundwater quality data collection plan pursuant to the remediation documents.

6. Reporting Schedule

   The Permittee shall submit an "Annual Water Withdrawal and Use Report" as required under A.R.S. § 45-632, together with supplemental data reports described below, no later than March 31 following the end of each completed annual reporting period. The first reporting period shall be from the effective date of this permit through December 31, 2008. Subsequent reporting periods shall be from January 1 through December 31. Annual reports must be submitted regardless of whether groundwater has been withdrawn. If no groundwater is withdrawn during the reporting period, the Permittee shall indicate that fact on the annual report and in the supplemental data report. The Permittee shall send one (1) copy of all annual and supplemental data reports to the Arizona Department of Water Resources, Phoenix Active Management Area, 3550 North Central Avenue, Phoenix, Arizona 85012.

7. Supplemental Data Reporting Requirements

   The Permittee shall submit all monitoring data and analyses in the supplemental data reports as specified below. The supplemental data reports shall include:

a. Site Map:

The data reports shall include a site map showing the location of all monitoring points and relevant facility features such as extraction wells, injection wells, monitor wells, and water measurement devices. The site map shall include a contour of the known extent of groundwater contamination above the AWQS. The data reports shall include the map data in electronic format such as an ARCMap (ESRI) shape files or AutoCAD used to generate the contour map.

b. Groundwater Withdrawal Data:

The data reports shall quantify all groundwater withdrawals from the well referenced above for the reporting period. The groundwater extraction data shall indicate the well registration number, the Permittee's well identifier, beginning and ending flowmeter readings, and the volume of groundwater withdrawn in gallons and acre-feet.

c. Water Quality Monitoring Data:

The data reports shall summarize the groundwater quality data collected from the extraction well pursuant to the remediation documents. The complete site water quality data shall be uploaded into the ADEQ Groundwater Quality database. If the data are not uploaded into the ADEQ Groundwater Quality database, copies of the laboratory and supporting quality control documentation shall be included in the data reports as an appendix.

8. General Provisions:

a. The issuance of this permit does not waive compliance with any federal, state, county or local government statutes, rules or permits.

b. All ADWR agency notifications, other than annual and supplemental data reports, shall be addressed to the Arizona Department of Water Resources, Records Management Unit, 3550 North Central Avenue, Phoenix, Arizona 85012.

WITNESS my hand and seal of office this 16th day of July, 2008.

Sandra Fabritz-Whitney

Sandy Fabritz-Whitney, Assistant Director

ANNUAL REPORT INSERT

Persons holding groundwater rights in Active Management Areas as of December 31 of each year are required to file an annual water withdrawal and use report (annual report) for that calendar year. This annual report must be filed no later than March 31 of the following year, and must account for water withdrawn and used for the entire calendar year. Persons with more than one right must file a separate annual report for each right. Annual report forms are mailed in early January. Failure to receive the proper forms does not relieve a person from the requirement to file.

If you own an Irrigation Grandfathered Right which obtains all water from an irrigation district, that district may file an annual report on your behalf. Check with your irrigation district to determine whether they intend to file on your behalf.

MEASURING DEVICES

All water pumped from non-exempt wells in Active Management Areas must be measured with a device approved by the Department. In general, the methods include: 1) installation of an in-line or "totalizing" meter (two discharge measurements must be taken annually but results need not be submitted unless the meter malfunctions); 2) a minimum of two well discharge rate measurements per year to be used in conjunction with energy consumption measurements (this method may not be used if the energy meter serves uses other than the well); and 3) a minimum of two discharge rate measurements per year to be used in conjunction with an approved hour meter. A copy of the measuring rules may be obtained upon request from the AMA offices listed below.

Devices must be installed and maintained to insure that measurement error does not exceed 10%. The pump and discharge system on a well must be so constructed to allow the Department, with its own devices, to check the accuracy of the installed device.

Persons withdrawing groundwater pursuant to an Irrigation Grandfathered Right and one or more Non-Irrigation Rights or Withdrawal Permits must use a sufficient number of devices to allow for the separate measurement of the amount withdrawn pursuant to the Irrigation Grandfathered Right.

If a device malfunctions for a period of more than 72 hours, the malfunction must be reported to the Department within seven days of discovery of the malfunction. Repair or replacement of the device must be made within 30 days or as soon as practicable. Measuring device malfunction reports may be obtained from your Active Management Area office.

Exceptions to the measurement requirement are made only for persons holding Type 2 Non-Irrigation Grandfathered Rights or General Industrial Use Permits with aggregate allotments of ten acre-feet or less. Persons with such rights may estimate annual withdrawals.

RECORD KEEPING

Records of annual water withdrawal, delivery and use calculations must be maintained for at least three years. In the event that you are selected for a records audit, you will be asked to provide this information.

FEES

Withdrawal fees are assessed for each acre foot of water annually withdrawn from wells associated with groundwater rights. This fee is annually set by the Director of the Department each October for the following calendar year. These fees must be included with annual report filings.

Annual reports not filed by the March 31 deadline are subject to late filing penalties of $25.00 for each month or portion of a month that the annual report has not been filed up to a maximum of $150.00. In addition, late payment fees of 10% per month to a maximum of 60% are assessed for any withdrawal fees not paid by March 31.

CHANGES IN OWNERSHIP

The Department must be notified if the person named in the Certificate changes his or her mailing address, conveys ownership of all or a part of the land to another person or wishes to convert the irrigation right to a non-irrigation right. Forms and information relative to these matters are available upon request or on our website at www.water.az.gov.

ASSISTANCE

For further information, contact your local Active Management Area office: Phoenix 602-771-8585; Prescott 928-778-7202; Pinal 520-836-4857; Tucson 520-770-3800; Santa Cruz 520-761-1814.

APPENDIX H

ABBREVIATED QAPP

ABBREVIATED QAPP FORM

1. Title and Approval Page

Cooper and Commerce ERA
Water Quality Assurance Revolving Fund Registry Site
Soil Vapor Extraction System Operation and Groundwater Maintenance

Prepared for:

Arizona Department of Environmental Quality

Prepared by:

Hydro Geo Chem, Inc.

April 30, 2010

ADEQ Project Manager Signature	
	Name/Date Scott d. Goodwin, R.G.
ADEQ Project QA Officer Signature	
	Name/Date
Hydro Geo Chem Project Manager Signature	
	Name/Date Christopher L. Jacquemin, P.E.
Hydro Geo Chem QA Officer Signature	
	Name/Date James G. Peck, P.E.

2. Table of Contents

List sections with page numbers, figures, tables, references, and appendices (attach pages).

3. Distribution List

Names and telephone numbers of those receiving copies of this QAPP. Attach additional page, if necessary.

i. Scott D. Goodwin, R.G., Project Manager (ADEQ) 602-771-4452

ii. Richard Olm, P.E., Project Engineer (ADEQ)

iii. Christopher L. Jacquemin, P.E., Project Manager (Hydro Geo Chem) 480-421-1501 x145

iv. James G. Peck, P.E., Project Engineer and Quality Assurance Officer (Hydro Geo Chem) 480-421-1501 x147

v. Tracy Dutton, Laboratory Quality Assurance Officer (Test America) 602-437-0330

vi. Carlene McCutcheon, Laboratory Project Manager (Test America) 602-437-3340

4. Project/Task Organization

List key project personnel and their corresponding responsibilities.

Name	Project Title/Responsibility
	Advisory Panel (contact)
Scott D. Goodwin, R.G.	Project Manager (ADEQ)
Christopher L. Jacquemin, P.E.	Project Manager (Hydro Geo Chem)
James G. Peck, P.E.	QA Officer (Hydro Geo Chem)
Neil J. Babb, G.I.T.	Field/Sampling Leader
Carlene McCutcheon	Laboratory Manager/Leader (Test America)

5. Problem Definition/Background

A. Problem Statement

The purpose of this abbreviated QAPP is to assure collection of the appropriate information needed to support the evaluation of remedial activities for the Cooper and Commerce WQARF Registry Site. The evaluation will include sampling of soil-gas for volatile organic compounds.

B. Intended Usage of Data

Data collected in accordance with this abbreviated QAPP is intended to provide technically accurate and legally defensible information to the ADEQ in the evaluation of the SVE system installed at the Cooper and Commerce Site.

6. Project/Task Description

A. General Overview of Project

The Site is located in Gilbert, Arizona, within the Cooper and Commerce WQARF project area. Previous investigations at the Site by ADEQ have focused on determining the type and distribution of VOCs in soils and groundwater beneath the Site. A groundwater extraction system has been constructed at the Site to remediate groundwater and maintain hydraulic control of a groundwater PCE plume.

VOCs of concern in the subsurface include PCE, dichloroethylene, trichloroethylene (TCE), 1,1,1-trichloroethane, and benzene. PCE, which occurs in both vadose zone soils and in groundwater beneath the Site, is the primary VOC of concern.

The operation and maintenance of the SVE system is intended to achieve soil remedial goals within the least duration possible, projected by HGC to be within two years. The primary soil remediation goal is to remove PCE from subsurface soil to levels that no longer present a threat to groundwater quality beneath the site. Achievement of this goal will also satisfy a secondary goal of reducing the presence of PCE in subsurface soil to levels that are less than the respective Arizona non-residential (and residential) soil remediation level (SRL), currently established at 13 milligrams per kilogram (mg/kg).

B. Project Timetable

Activity	Projected Start Date	Anticipated Date of Completion
Finalize SVE construction	May 1, 2010	June 30, 2010
System Startup & Debug System	July 1, 2010	July 11, 2010
System Operation	July 1, 2010	October 14, 2010
Maricopa County Initial Report	November 5, 2010	November 16, 2010
First quarterly O&M Report	January 1, 2011	February 1, 2011
Second quarterly O&M Report	April 1, 2011	May 1, 2011
Third quarterly O&M Report	July 1, 2011	August 1, 2011
Fourth quarterly and Annual O&M Report	October 1, 2011	November 1, 2011

7. Measurement Quality Objectives

A. Data Precision, Accuracy, Measurement Range

Matrix	Parameter	Measurement Range	Accuracy	Precision
Soil gas	VOCs TO-15	≥ 1.5 mg/m^3	75-125%	± 25%

B. Data Representativeness

Evaluate whether measurements are made and physical samples collected in such a manner that the resulting data appropriately reflect the environment or condition being measured or studied.

C. Data Comparability

Compare sample collection and handling methods. All samples for each matrix type and parameter list will be collected using identical methods.

D. Data Completeness

Parameter	No. Valid Samples Anticipated	No. Valid Samples Collected & Analyzed	Percent Complete
VOCs in Soil gas, TO-15	20		

8. Training Requirements and Certification

A. Training Logistical Arrangements

Type of Volunteer Training	Frequency of Training/Certification
Field Personnel	1 time, OSHA 40-hour HAZWOPER
Field Personnel	Annual 8-hour OSHA HAZWOPER refresher
Field Personnel	HASP review and acknowledgement
Analytical Laboratories	Arizona DHS environmental laboratory certification
Siemens Water Technologies	Waste hauling permit

B. Description of Training and Trainer Qualifications

9. Documentation and Records

Field sampling documentation will include, at a minimum:

- Weekly field notes and activity records;
- Site photographs;
- Sampling collection and handling records (field notes);
- Site HASP acknowledgement signature form;
- Site visitor log;
- Soil vapor sampling forms;
- COC forms;
- Sample receipt records, including sample tags and shipping bills;
- Analytical logs;
- Test method raw data and QC sample records;
- Standard reference material and/or proficiency test sample data;
- Instrument, equipment, and model calibration information; and
- Computer documentation such as model input and output files resulting from code and database test procedures.

10. Sampling Process Design

A. Rationale for Selection of Sampling Sites

Two sampling sites are identified for soil gas sample collection. One sampling site is at the discharge of the Vacuum Blower for monitoring of PCE mass recovery rates. The other sampling site is just upstream of the first carbon vessel as required by the air quality permit.

B. Sample Design Logistics

	Type of Sample/ Parameter	Number of Samples	Sampling Frequency	Sampling Period
Biological	N/A			
Physical	N/A			
Chemical	Soil gas/VOCs	1	Once a week	During first 3 months
	Soil gas/VOCs	1	Once a month	After first 3 months

11. Sampling Method Requirements

Parameter	Sampling Equipment	Sampling Method
VOCs in soil gas	Summa canister	EPA Method TO-15
VOCs in soil gas	PID	PID
VOCs in groundwater	VOA's	EPA Method 8260B, Metals and Chromium 6 (C6)

12. Sample Handling and Custody Procedures

All samples collected will be labeled in a consistent, clear, and accurate way for proper identification in the field and for tracking in the laboratory. The samples will have pre-assigned, identifiable, and unique numbers. All sample labels will contain the following information: station location, date of collection, analytical parameter(s), sample matrix, sampler's initials, and method of preservation (if applicable).

Upon collection, samples will be considered to be in the sampler's custody. Samples will be accompanied to the laboratory by a COC (Chain of Custody) form. The COC form, which will be completed by the field technician, will include the job number, sample identification, date and time of sample collection, and type of analysis requested.

13. Analytical Methods Requirements

Soil-gas VOCs: Test America's fixed base laboratory will perform analysis of soil gas samples by EPA Method TO-15 (full list). The maximum holding time before analysis is 14 days. Samples of soil gas are collected by gas-tight glass syringe from each canister. The sub-samples are then injected directly into a GC. Concentrations are then determined through calibration with standards, continuing standards, and spikes.

14. Quality Control Requirements

A. Field QC Checks

- One field duplicate for every 20 soil-gas samples
- One equipment blank for every 20 samples.

B. Laboratory QC Checks

Each laboratory will prepare and analyze method blanks, matrix spike/matrix spike duplicate samples, and surrogate samples consistent with laboratory quality control protocols established in each laboratory's quality assurance plan.

C. Data Analysis QC Checks

Each laboratory will review and evaluate project data consistent with the laboratory's quality assurance plan. This will include data verification, data review, and data reporting protocols. The HGC QA Officer will review all laboratory reports for analytical data consistent with project objectives identified in this abbreviated QAPP.

15. Instrument/Equipment Testing, Inspection, and Maintenance Requirements

See Quality Assurance Plans for individual laboratories.

16. Instrument Calibration and Frequency

Equipment Type	Calibration Frequency	Standard or Calibration Instrument Used
Field instrumentation	Initial, every 12 hours	See laboratory QAP
Fixed-base laboratory	Per method	See laboratory QAP.

17. Inspection/Acceptance Requirements

All supplies and consumables must be received in their original packaging and visually inspected by the field technician for defects and/or tampering. Where applicable, laboratory or vendor calibration sheets will be reviewed and placed in the job file.

18. Data Acquisition Requirements

Historic information regarding previous site investigations may be referenced in investigation decision-making. Information may be collected from ADEQ, environmental consultants, and/or analytical laboratories. Any historical data used will meet minimum qualifications established by this QAPP, or will be qualified as non-direct measurements and only relied upon as background information.

19. Data Management

Data measured by field instruments will be recorded in field logbooks and/or on required field forms. The field data will be reviewed by the Project or Field Manager to evaluate completeness of the field records and appropriateness of the field methods employed. Laboratory data will be retained in hard copy and in electronic format.

20. Assessment and Response Actions

Evaluations and audits of both field and laboratory activities may be conducted to verify that sampling and analysis are performed in accordance with the procedures established in this QAPP. Either the project QA/QC officer or project manager may perform performance evaluation or system audits.

Field audits are not required, but may be performed in the event significant discrepancies are identified that warrant evaluation of field practices.

Laboratory evaluations consist of sending evaluation samples (i.e., split sampling) to laboratories to check laboratory precision and accuracy. Audits of all field and laboratory notebooks may be made on a periodic basis to assure compliance with the work plan and QAPP. ADEQ may elect, at their discretion, to inspect and/or assess any field activities performed during this project.

21. Reports

Upon receipt of any laboratory reports, the project QA/QC officer will verify that results are reported for all critical analyses samples submitted, that the laboratories meet RLs, and that the laboratories meet the QA/QC requirements laid out in their SOPs or in the standard methods. QA reports that outline any irregularities or problems with the data will be included in the semi-annual and final reports.

22. Data Review, Validation, and Verification

Data validation refers to a thorough review of 100% of all the data generated listed as validation deliverables in accordance with EPA Region IX's laboratory documentation requirements for data validation. This level of review requires that data documentation consistent with EPA Level IV be received from the laboratory. This level of review will not be performed unless laboratory/data quality issues arise that are deemed significant. If laboratory/data quality issues do arise and an EPA Level IV package is deemed necessary, 100% of the affected data will undergo data validation, as described.

Data verification refers to all other levels of review (other than validation). It is anticipated that 99% of the analytical data collected for this project will undergo data verification procedures.

23. Validation and Verification Methods

Data will be reviewed using analytical method specifications and, where applicable, the general criteria derived from the QA Program EPA Region IX's laboratory documentation requirements for data validation. The data verification/validation task will be performed and documented by the QA officer. The ADEQ QA unit will validate data at the ADEQ project manager's request.

24. Reconciliation with DQO's

The QA officer will determine whether the DQOs for the analytical data have been met, review the data according to the SOPs for data review, and apply applicable data validation flags, if required.

APPENDIX I

FORMS

ADEQ COOPER AND COMMERCE AS SYSTEM	
EXTRAORDINARY MAINTENANCE RECORD	
Follow applicable maintenance shutdown and restart procedure in Section 11.2. Conduct extraordinary maintenance as described in Section 12.2. Describe actual work performed.	
Operator:	Date:
CONTROL PANEL (CP-2 and CP-4)	
AIR COMPRESSOR AC-1	
AIR RECEIVER T-1	
AS MANIFOLD	
OTHER	

ADEQ COOPER AND COMMERCE SVE SYSTEM
EXTRAORDINARY MAINTENANCE RECORD
Follow applicable maintenance shutdown and restart procedure in Section 11.1. Conduct extraordinary maintenance as described in Section 12.1. Describe actual work performed.
Operator: Date:
CONTROL PANEL (CP-1 and CP-4)
CONDENSATE SEPARATOR AND CONDENSATE HOLDING TANK
VACUUM BLOWER, MOTOR, AND BELT DRIVE; DISCHARGE FAN
AIR DILUTION BLOWER, MOTOR, AND BELT DRIVE
CARBON CANISTER CHANGE-OUTS (VGAC-1 and VGAC-2)
SVE MANIFOLD (AS/SVE-101, AS/SVE-102, VP-104 and SVE-105)

ADEQ COOPER AND COMMERCE GROUNDWATER SYSTEM	
EXTRAORDINARY MAINTENANCE RECORD	
Follow applicable maintenance shutdown and restart procedure in Section 11.3. Conduct extraordinary maintenance as described in Section 12.3. Describe actual work performed.	
Operator:	**Date:**
CONTROL PANEL (CP-3 and CP-4)	
GROUNDWATER EXTRACTION WELL EW-101 AND PUMP	
BAG FILTERS BF-1 AND BF-2	
LIQUID PHASE CARBON VESSELS (LGAC-1 AND LGAC-2)	
BADGER METERS (SRP AND TOWN OF GILBERT)	

ADEQ COOPER & COMMERCE WQARF SITE	
FAILURE RESPONSE AND TROUBLESHOOTING RECORD	
Follow applicable troubleshooting and normalization procedure in Section 7. Describe actual work performed.	
Operator:	**Date:**
OPERATING STATUS UPON ARRIVAL	
OPERATING STATUS UPON ATTEMPT TO RESTART	
TROUBLESHOOTING AND NORMALIZATION PROCEDURE PERFORMED	

SVE/AS System Preventive Maintenance Checklist
Cooper and Commerce WQARF Site

Maintenance Task	Recommended Frequency	Date Completed	Initials	Comments
1. Inspect vacuum blower for unusual vibration, noise, or heat	Weekly			
2. Inspect local control panel for proper function	Weekly			
3. Check condensate level in condensate separator and verify proper operation of condensate transfer pump.	Weekly			
4. Check condition of vacuum blower belts and lubricate blower bearings	Monthly			
5. Inspect process piping and instrumentation for any damage or weathered condition	Monthly			
6. Clean or replace inlet particulate filter to vacuum blower	Monthly			
7. Grease sve motor bearings	Bi-Monthly			
8. Replace sve motor oil	Once Every Other Month			
9. Check air sparge compressor coolant level and add coolant as needed.	Monthly			
10. Check VGAC canisters and vacuum blower discharge piping for any process gas leaks	Monthly			

SVE AND AS OPERATION LOG SHEET
ADEQ COOPER AND COMMERCE ERA

Date:	Time:	Operator:	
SVE SYSTEM			
Flow Rates	**Pitot Tube Delta P (in WC)**	**Soil Gas Temperature at TI-101 (F)**	**Approximate Flow Rate (scfm)**
SVE Rate at AS/SVE-101 (FE-101)			
SVE Rate at AS/SVE-102 (FE-102)			
SVE Rate at VP-104 (FE-104)			
SVE Rate at SVE-105 (FE-105)			
Monitoring Point	**Pressure (in WC)**	**PID Reading (ppmv)**	**Isolation Valve Position (%)**
AS/SVE-101 Lateral at Manifold			
AS/SVE-102 Lateral at Manifold			
VP-104 Lateral at Manifold			
SVE-105 Lateral at Manifold			
AS/SVE-101 Well Head			
AS/SVE-102 Well Head			
SVE Manifold			
Vacuum Blower Intake			
Vacuum Blower Discharge			
AS SYSTEM			
	Control Timer Settings		
AS Well	**On-Time (hours)**	**Start Time**	**Number of Start Times**
AS/SVE-101			
AS/SVE-102			
Flow Rates	**Pitot Tube Delta P (in WC)**	**Air Temperature at TI-201 (F)**	**Approximate Flow Rate (scfm)**
AS Rate at AS/SVE-101 (FE-201)			
AS Rate at AS/SVE-102 (FE-202)			
Monitoring Point	**Pressure (in PSIG) at AS/SVE-101**	**Pressure (in PSIG) at AS/SVE-102**	
PCV-201 Inlet			
PCV-201 Oulet			
T-1 Air Receiver (PI-201)			
AS Manifold (PI-202)			
COMMENTS			

VGAC ADSORBERS OPERATION LOG SHEET
ADEQ COOPER AND COMMERCE ERA

Date of site visit:	Time:	Operator:

Flow Rate	Pitot Tube Delta P (in WC)	Calculated Flow Rate (scfm)	Normal Flow Rate (scfm)	Air Dilution Valve Setting
Process Gas to Lead VGAC (FE-104)			up to 300	% open

Note: Stack gas flow rate same as process gas flow rate to Lead VGAC.

Operating Time Meter Reading
hours

Pressures	Measured (in WC)
Lead VGAC-In	
Lead VGAC-Out	
Lag VGAC-In	
Lag VGAC-Out	
Intake Filter Pressure Drop	

Differential Pressures	Calculated (in WC)	Normal (in WC)
Lead VGAC Pressure Drop		varies
Lag VGAC Pressure Drop		varies

PID Readings (VOC Concs)	Measured (ppmv)	Normal (ppmv)	
Lead VGAC-In		varies	
Lead VGAC-Out		varies	Notify engineer if not zero value.
Lag VGAC-Out		up to 10% of Lead VGAC-In Reading	

Dry Bulb Temperatures	Measured (F)	Normal (F)
Lead VGAC In		varies
Lead VGAC Out		varies

Wet Bulb Temperatures	Measured (F)
Lead VGAC In	

Lead VGAC Canister Status		
Cumulative SVE System Operation		hours
Date of Last Carbon Change-Out		
Projected Breakthrough Period*		days
Net Operating Time		days
Projected Breakthrough Date		

Relative Humidity	Calculated (% Sat)
Lead VGAC In	

* Obtain from Engineer.

COMMENTS

GROUNDWATER OPERATION LOG SHEET
ADEQ COOPER AND COMMERCE ERA

Date:	Time:	Operator:

GROUNDWATER EXTRACTION / TREATMENT SYSTEM

Time:	Monitoring Point	Total Quantity Water Discharged (Siemens) (kgals)	Approximate Flow Rate (Siemens) (gpm)	EW-101 Transducer Depth of Submergence (Cell682) (ft)
	EW-101			
	Effluent			

Time:	Cell682 Parameters	SVE Pressure (psi)	GW Effluent Pressure (psi)	EW-101 Pump (Time)	EW-101 Pump OFF (Time)

Time:	Monitoring Point	Total Quantity Water Discharged (kgals)	Approximate Flow Rate (gpm)
	SRP Lateral 9.5 (Badger Meter)		
	Town of Gilbert Sewer (Badger Meter)		
	SRP Lateral 9.5 (Digital Meter)		
	Town of Gilbert Sewer (Digital Meter)		

Time:	Monitoring Point	Temperature	pH	
	Effluent			Range: 6.5-9.0

Time:	Monitoring Point	Pressure Reading (in psig)	Differential Pressure	Calculated (in psig)
	Inlet Bag Filter BF-1 (PI-301)		Bag Filter Pressure Drop	
	Outlet Bag Filter BF-1 (PI-302)			
	If pressure differential for BF-1 exceeds 15 psi, bags needs to be replaced.			
	Lead-In (PI-304)		Lead LGAC Pressure Drop	
	Lead-Out (PI-303)			
	Lag-In (PI-306)		Lag LGAC Pressure Drop	
	Lag-Out (PI-305)			
	Effluent Port			

COMMENTS