

**ATTACHMENT E**

**STANDARDS FOR PROCESS VENTS, EQUIPMENT LEAKS,  
AND AIR EMMISIONS STANDARDS**

**[270.A ((270.24) (270.25))]**

## SECTION E

### STANDARDS FOR PROCESS VENTS AND EQUIPMENT LEAKS

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## **E STANDARDS FOR PROCESS VENTS AND EQUIPMENT LEAKS**

### **E.1 Subpart AA**

#### **E.1.1 Applicability**

This compliance program is for air emission standards for process vents and equipment leaks for all vents associated with distillation, fractionation, thin-film evaporation solvents extraction, air or steam stripping operations that manage hazardous waste with organic concentrations, of at least ten (10) ppmw. This facility does not have any equipment that would be applicable to Subpart AA regulations.

### **E.2 Subpart BB**

#### **E.2.1 Applicability**

This compliance program for air emission standards for equipment leaks is to be implemented for all equipment that contains or contacts hazardous waste with organic concentrations of at least ten 10 % by weight. Many waste streams arriving at the facility are greater than 10% by weight total organics that are contacted by facility equipment. The facility appropriately considers itself to be subject to the regulations of 40 CFR 264 Subpart BB and has developed a program corresponding to the format of Subpart BB. The program is outlined to correspond to the format of 40 CFR 264, Subpart BB. For each piece of equipment specified in 40 CFR 264, Subpart BB, the program contains a procedure to ensure air emission standards are not exceeded as a result of equipment leaks. Leak detection for each piece of equipment will be handled as specified in the compliance program. Procedural requirements for leak detection outlined in 40 CFR.1054 (c), 264.1052, 264.1057, and 264.1058 are contained within the facilities compliance program. Inspections are logged on the facilities Equipment Identification Log (see figure E-1) and/or the facilities Inspection/Monitoring Log (see section E-2). Procedures for recording leaks are identified in the footnotes of the example Inspection Forms. Inspections occur monthly as specified by 40 CFR 264,

Subpart BB regulation.

#### E.2.2 Compliance

Compliance with the requirements of 40 CFR 264, Subpart BB, 40 CFR 61, Subpart B, and 40 CFR 60, Subpart BB will be attained by the measure described in this chapter. Standards in each corresponding part are referenced in parentheses.

#### E.2.3 Pumps in Light Liquid Service (264.1052) (60.482-2) (61.242-2)

There are currently no pumps at the facility that would be classified as pumps in contact with a waste stream where 20% or greater (by weight) of the waste stream is a combination of components that have a vapor pressure greater than .3 kilopascals (2.25 mmHg) at 20 C°. (or 68°F) (light liquid service). When such pump is installed, each pump would be inspected visually each calendar week for indications of liquids dripping from the pump seal, and monitored monthly to detect leaks by the method(s) specified in Section E.2.10.

A leak is detected when there are indications of liquids dripping from the pump seals or an instrument reading of 10,000 ppm or greater is measured.

When a leak is detected, it will be repaired as soon as practicable, but no later than fifteen (15) calendar days after it is detected, unless repairs must be delayed until the unit is shut down, or the pump is isolated from the unit and does not contain or contact hazardous waste.

A first attempt at repair will be made within five (5) calendar days after a leak is detected.

A pump may be designated for non detectable emissions if the following requirements are met:

1. It has no externally actuated shaft penetrating the pump housing.
2. It operates with no detectable emissions as indicated by an instrument reading of less

than 500 ppm above background as measured by the methods specified in 264.1063(c).

3. It is tested for compliance initially upon designation, annually, and as requested by the Director of ADEQ.

E.2.4 Compressors (264.1053) (60.482-3) (61.242.3)

Not Applicable. There are no compressors that contact hazardous waste at the facility.

E.2.5 Pressure Relief Devices in Gas/Vapor Service (264.1054) (60.482-4) (61.242-4)

Except during pressure releases, each pressure relief device in gas/vapor service will be operated with no detectable emissions, as indicated by an instrument reading of less than 500 ppm above background, as measured by the methods specified in 264.1063(c). The facility person is made aware of a pressure relief event through visual methods via required daily inspections.

After each pressure release, the pressure relief device will be returned to a condition of non detectable emissions as soon as practicable, but no later than five (5) calendar days after each pressure release unless repairs must be delayed until the unit is shut down, or the device is isolated from the unit and does not contain or contact hazardous waste.

No later than five (5) calendar days after a pressure release, the pressure relief device will be monitored to confirm the condition of no detectable emissions. Documented pressure releases and all monitoring associated Detectable Emissions Log (see Figure E-6) and will follow the no detectable emissions monitoring procedure in section E.2.10.

E.2.6 Sampling Connecting Systems (264.1055) (60.482-5) (61.242-5)

The facility only has inline sampling systems which are exempt from the requirements of this

section.

E.2.7 Open-ended valves or lines (264.1056) (60.482-6) (61.242-6)

Each open-ended valve or line is typically equipped with a cap, but a blind flange, plug, or second valve could be used to provide a system backup.

The cap, blind flange, plug, or second valve will seal the open end at all times except during use.

Each open-ended valve or line equipped with a second valve will be operated in a manner such that the valve on the waste stream end is closed before the second valve is closed.

In double block and bleed systems, the bleed valve or line may remain open during venting of the line between block valves, but will be equipped with a cap, plug, or second valve at all other times.

E.2.8 Valves in Gas/Vapor Service or in Light Service  
(264.1057) (60.482-7) (61.242-7)

Each valve in gas/vapor service or light liquid service will be monitored monthly to detect leaks by the method(s) specified in Section E.2.10, except that:

- a. Any valve for which a leak is not detected for two (2) successive months may be monitored the first month of every succeeding quarter, beginning with the next quarter until a leak is detected.
- b. If a leak is detected, the valve will be monitored monthly until a leak is not detected for two (2) successive months.
- c. An alternative monitoring method described below may be chosen.
  - (i) The facility may elect to have all valves within a hazardous waste management

unit comply with an alternative standard that allows no greater than two (2) percent of the valves to leak, by: (264.1061) (60.484-1) (61.243.1)

1. Notifying the Director of ADEQ or his/her designee of the decision to follow this standard and
2. Monitoring all valves subject to this requirement within one (1) week by the method(s) specified in Section 2.10.

The leak percentage will be determined by dividing the number of valves for which leaks are detected, by the total number of valves subject to this section within the hazardous waste unit. If it is decided to no longer use this method, the facility will notify the Director of ADEQ or his/her designee in writing.

(ii) The facility may elect to have all valves within a hazardous waste management unit comply with an alternative standard that allows monitoring periods to be skipped by: (264.1062) (60.483-2) (61.243-2)

1. Notifying the Director of ADEQ or his/her designee of the decision to follow the standard.
2. After two consecutive quarterly leak detection periods with less than one or equal to two (2) percent of the valves leaking, one quarterly leak detection period may be skipped.
3. After five consecutive quarterly leak detection periods with less than or equal to two (2) percent of the valves leaking, three quarterly leak detection periods may be skipped.
4. If greater than two (2) percent of the valves are leaking, the facility will return to monthly monitoring as in this section but may again elect to use this method after meeting the requirements of this section.

When a leak is detected, it will be repaired as soon as practical, but no later than fifteen (15) calendar days after it is detected, unless repairs must be delayed until the unit is shut down, and repaired prior to the end of shutdown. Delayed repair may extend beyond 15 days if the valve is



isolated from the unit and does not contain or contact hazardous waste or it is determined that emissions of purged material resulting from immediate repair are greater than the emissions likely to result from delay of the repair. When repair procedures are effected; the purged material is collected and destroyed or recovered in a control device. Delay of repairs beyond a hazardous waste management shutdown period may be allowed if valve assembly replacement is necessary during the hazardous waste management unit shutdown, valve assembly supplies have been depleted, and valve assembly supplies had been sufficiently stocked before supplies were depleted (264.1059) (60.482-9) (61.242-10).

A first attempt at repair will be made no later than five (5) calendar days after a leak is detected.

A valve may be designated for no detectable emissions if the following requirements are met:

1. It has no external actuating mechanism in contact with hazardous waste.
2. It is operated with emissions less than 500 ppm above background as determined by the method(s) specified in Section 2.10.
3. It is tested initially upon designation, annually, and as requested by the Director of ADEQ

A valve may be designated as unsafe-to-monitor if:

1. It is determined to be unsafe to monitor because monitoring personnel would be exposed to an immediate danger as a consequence of attempting to conduct monitoring as specified in this section.
2. The facility adheres to a written plan that requires monitoring of the valve as frequently as practicable during safe-to-monitor times,

A valve may be designated as difficult-to-monitor if:

1. It is determined that the valve cannot be monitored without elevating the monitoring personnel more than two (2) meters above a support surface.

2. The facility follows a written plan that requires monitoring of the valve at least once per calendar year.

Currently the facility does not have valves that qualify as “unsafe-to-monitor” or “difficult-to-monitor.”

E.2.9           Pumps and valves in Heavy Liquid Service, Pressure Relief Devices in Light Liquid or Heavy Liquid Service and Flanges and other Connectors  
(264.1058) (60.482-8) (61.242-8)

Each pump or valve in heavy liquid service, each pressure relief device in light or heavy liquid service, each flange or other connector will be monitored within five (5) days by the method specified in 264.1063(b) if evidence of a potential leak is found by visual, audible, olfactory, or any other detection method.

When a leak is detected, it will be repaired as soon as practicable, but no later than fifteen (15) calendar days after it is detected, unless repairs must be delayed until the unit is shut down, or it is isolated from the unit and does not contain or contact hazardous waste.

E.2.10           Test Methods and Procedures (264.1063) (60.485) (61.245)

Monitoring procedures will comply with Reference Method 21 in 40 CFR Part 60, and detection instruments will meet the performance criteria of Reference Method 21. Monitoring instrument will be calibrated before use on each day of use, using calibration gases of air with less than 10 ppm of hydrocarbon, and methane or n-hexane in air at a concentration of approximately (but less than) 10,000 ppm.

An alternative screening procedure (40 CFR 60, Appendix A, Reference Method 21, 4.3.3) based on the formation of bubbles in a soap solution that is sprayed on a potential leak source may be used for those sources which do not have continuously moving parts, which do not have surface temperatures greater than the boiling point or less than the freezing point of the soap solution, that

do not have open areas to the atmosphere that the soap solution cannot bridge, and that do not exhibit evidence of liquid leakage. A soap solution will be sprayed over potential leak sources. If no bubbles are formed, the source will be presumed to have no detectable leaks or emissions, as applicable. If any bubbles are observed, the instrument monitoring techniques will be used to determine if a leak exists, or if the source has detectable emissions, as applicable.

No detectable emissions monitoring procedures comply with Method 21 and are as follows:

1. Determine the background level around the component interface by moving the probe inlet randomly up wind or downwind at a distance of one to two meters. If interference exists, such as a nearby vent, the background level may be determined closer than 25 cm from the component interface.
2. Move the probe inlet to the surface of the component interface to determine the component interface reading.
3. Determine the arithmetical difference between the background level and the component interface reading.
4. If the arithmetical differences < 500 ppm, the equipment may be designated as having no detectable emissions. This information is entered into the Equipment with No Detectable Emissions Log.

#### E.2.11 Record Keeping (264.1064) (60.486) (61.246)

The facility operating record identifies each piece of equipment subject to this section by the hazardous waste unit it is associated with, the approximate location of the unit, the equipment ID number, the type of equipment, the hazardous waste physical state at the equipment, and the method of compliance with Subpart BB of Part 264 (example presented in Figures E-1 and E-2).

When a leak is detected, an inspection log and corresponding forms (Figure E-1 to E-5) will be maintained as part of the facility operating record, which will contain the following information:

1. Monitoring instrument identification and operator identification (See Figure E-1 or E-2)
2. Equipment identification number (see Figure E-2)
3. The date evidence of a potential leak was found (see Figure E-2)
4. The date the leak was detected (See Figure E-2)
5. The date of each repair (See Figure E-3)
6. Repair methods used in each repair attempt (See Figure E-3)
7. "Above 10,000" if the maximum instrument reading after each repair attempt is equal to or greater than 10,000 ppm (See Figure E-3)
8. "Repair delayed" and the reason for delay if a leak is not repaired within 15 calendar days after discovery (See Figure E-4)
9. The signature of the person whose decision it was that repair could not be affected without a hazard waste management unit shutdown, if applicable. (See Figure E-4)
10. The expected date of successful repair of the leak if not repaired within 15 calendar days. (See Figure E-4)
11. The date of successful repair of the leak (See Figure E-2 if written in "comments" section or Figure E-3 and/or E-4)

Design documentation and monitoring, operating, and inspection information for each close-vent system and control device required by Subpart BB will be recorded and kept-up-to-date in the facility operating record.

The following information pertaining to all equipment subject to the requirements of Subpart BB will be recorded in a log that is part of the facility operating record:

1. A list of equipment identification numbers (except welded fittings). (See Figure E-1

or E-2)

2. A list of identification numbers for equipment that is designated for no detectable emissions, with the designation signed by the facility manager. (See Figure E-7)
3. A list of identification numbers for pressure relief devices. (See Figure E-7)
4. The dates of each compliance test, the background level measured, and the maximum instrument reading recorded. (See Figure E-2)
5. A list of identification numbers for valves designated as difficult to monitor, an explanation for each stating the reason for the designation, and the planned schedule for monitoring each. To be developed if required.
6. For valves designated for skip-period leak detection and repair, a schedule of monitoring and the percent of valves found leaking. To be developed if this method is used.
7. For exemptions claimed, an up-do-date analysis and the supporting information and data used to determine that the equipment is not subject to the requirements of Subpart BB. To be developed if this method is used.

Records of equipment leak information and operating information will be kept a minimum of 3 years.

#### E.2.12 Reporting (264.1065) (60.487) (61.247)

If leaks from valves and pumps are repaired as described in this chapter, and control devices do not exceed or operate outside of design specifications for more than 24 hours, a report to the Director of ADEQ or his/her designee is not required.

If required, a semi-annual report will be sent to the Director of ADEQ or his/her designee, by the dates specified by the Director of ADEQ or his/her designee, which will include the following information:

1. The EPA ID number, name, and address of the facility.
2. For each month during the reporting period, the ID number of each valve or pump

for which a leak was not repaired as required by Subpart BB.

3. Dates of hazardous waste unit shutdown that occurred within the reporting period.
4. For each month during the reporting period, the dates when control devices exceeded or operated outside of the design specifications and were not corrected within 24 hours, the duration and cause of each violation, and any corrective measures taken.

#### E.2.13 Monitoring of Equipment Designated for Non Detectable Emissions or Difficult-To-Monitor

The facility does not have any equipment that qualifies as difficult or unsafe to monitor at this time. Equipment designated for “no detectable emissions”, “unsafe to monitor” or “as difficult-to-monitor” shall be inspected visually on a monthly basis. Potential leaks will be recorded and repaired according to the provisions of this chapter. After repairs are completed, the equipment will be monitored immediately for leaks and monthly thereafter until it can again meet the requirements for no detectable emissions. (Figure E-6)

Equipment designated for no detectable emissions or as difficult-to-monitor will be monitored at intervals not to exceed twelve months, providing that no leaks are detected.

### E.3 Subpart CC

#### E.3.1 Applicability

This compliance program is for air emission standards for tanks and containers that manage hazardous waste that have average Volatile Organic (VO) concentration greater than 500 parts per million by weight (ppmw). The program is outlined to correspond to the format of 40 CFR 264 Subpart CC. For each piece of equipment specified in 40 CFR 264, Subpart CC, the program contains a procedure to ensure air emission standards are not exceeded as a result of equipment leaks. Leak detection for each piece of equipment will be handled as specified in the compliance program.

### E.3.2 Compliance

Compliance with the requirements of 40 CFR 264 Subpart CC will be attained by the measure described in this chapter. Standards in each corresponding part are referenced in parenthesis.

### E.3.3 Tanks (§264.1084)

The hazardous waste tanks, T101, 102, 103, 104, 301, and 303, are subject to the Subpart CC standards. Based on the maximum organic vapor pressure of the hazardous waste stored in these tanks, emissions from the tanks are subject to Tanks Level 1 controls. The control of air pollutant emissions from the tanks is performed through the design of the tank and the closed vent system vented to activated carbon as a control device; see Exhibit E-1 for the Activated Carbon Product Description. The tanks are exhausted continuously to a four (4) 55-gallon drum carbon adsorption system with a minimum control efficiency of 95% for Volatile Organic Compounds (VOC's). Controlled efficiency is calculated by using the method outlined in Exhibit E-4 and maintained through monthly monitoring of the Activated Carbon Adsorption system using guidelines established under EPA Test Method 21. After monitoring, if it has been determined that carbon change out is required, one carbon train (two canisters in series) will remain in service at all times during change out activities. The tanks are a fixed roof design, such that the roof is an integral part of the tank structure. The roof and its closure devices are designed to form a continuous barrier over the entire surface of the hazardous waste in the tank. Each opening in the fixed roof is equipped with a closure device designed to operate such that when the closure device is secured in the closed position there are no visible cracks, holes, or gaps, or other open spaces in the closure device or between the perimeter of the opening and the closure device, or the opening is connected by a closed vent system that is vented to the control device. Each closure device will be secured in the closed position except to provide access to the tank for performing routine inspection, maintenance, or other activities needed for normal operations or to remove accumulated sludge or other residues from the bottom of the tank. The fixed roof and its closure devices shall be visually inspected at least once every year to check for defects that could result in air pollution emissions.

Transfer of hazardous waste to a tank or from another tank shall be conducted using continuous hard piping or flexible hoses that do not allow exposure of the hazardous waste to the atmosphere. Exhibits E-2 and E-3 provide schematic flow diagrams and emissions control calculations.

#### E.3.4 Containers (§264.1086)

Air pollutant emissions shall be controlled from each container using Container Level 1 controls based upon a combination of the size and contents as outlined in Section 264.1086. One of several methods may be used to control emissions. One method is for containers containing hazardous waste to meet applicable U.S. Department of Transportation (DOT) regulations on packaging hazardous materials for transportation as specified in 49 CFR. Another is the container may be equipped with a cover and closure device that forms a continuous barrier over the container openings such that when the covers and closure device are secured in the closed position there are no visible holes, gaps, or other open spaces into the interior of the container.

All waste processed in the workstations are processed into D.O.T approved containers and therefore are subject to Container Level 1 Standards (40 CFR 264.1086 (c)(i)) or waste may also be pumped into one of the tanks located in the Tank Farm that subject to the facilities Subpart BB emissions control program. Waste contained in roll-off bins does not meet the definition of light-material-service and therefore only subject to the Container Level 1 Standard (40 CFR 264.1086 (a)(ii)).

All covers and closure devices for the containers shall be maintained in the closed position except for the following conditions:

- 1) Adding hazardous waste to the container.
- 2) Removing hazardous waste from the container.
- 3) When access inside the container is needed to perform routine activities.
- 4) Opening of a pressure relief device, which vents to the atmosphere for the purpose of maintaining the internal pressure of the container in accordance with the container design specifications.



- 5) The opening of a safety device to avoid an unsafe condition.

#### E.3.5 Closed vent systems and control devices (§264.1087)

This section applies to each closed vent system and control device installed and operated to control air emissions in accordance with standards of this subpart. The closed vent system shall route the gases, vapors, and fumes emitted from the hazardous waste in the waste management unit to a control device that meets the specified requirements. The closed vent system shall be designed to operate with no detectable emissions, as indicated by an instrument reading of less than 500 ppmv as determined by the procedure in §264.1033(l).

The control device shall be designed and operated to reduce the total organic content of the inlet vapor stream vented to the control device by at least 95% by weight or if an enclosed combustion device is used, the unit will be designed and operated in accordance with the specifications for a combustion device. Control device system malfunctions shall be corrected as soon as practicable after their occurrence in order to minimize excess emissions of air pollutants. The closed vent system shall be operated such that gases, vapors, or fumes are not actively vented to the control device during periods of planned maintenance or control system malfunctions except in cases when it is necessary to vent the gases, vapors, and/or fumes to avoid an unsafe condition or to implement malfunction corrective actions or planned maintenance actions. Periods of planned routine maintenance of the control device shall not exceed 240 hours per year.

#### E.3.6. Inspection and Monitoring Requirements (§264.1088)

Air emission control equipment shall be inspected and monitored to comply with this subpart in accordance with the applicable requirements specified in §264.1084 through §264.1087. A written plan and schedule shall be incorporated into the facility inspection plan under 40 CFR. §264.15.

#### E.3.7. Record Keeping Requirements (§264.1089)

The facility operating record will identify equipment subject to this requirement and the appropriate retention time for records in regard to this equipment and inspections. Records maintained for tanks shall include the following information:

- 1) A tank identification number
- 2) A record for each inspection including:
  - a) the date the inspection was conducted
  - b) for each defect detected during the inspection record the following information:
    - 1) the location of the defect,
    - 2) a description of the defect,
    - 3) the date of detection, and
    - 4) corrective action taken to repair the defect, and if applicable, if a delay is encountered, the reason for the delay and the expected completion date.
- 3.) The determination for the maximum organic vapor pressure of the hazardous waste in the tanks including the date and times the samples were collected, the analysis method used, and the analysis results.

For a design analysis the documentation shall include information prepared by the owner or provided by the control device manufacturer or vendor that describes the control device in accordance with 40 CFR 264.1035 (b)(4)(iii). If performance tests are used, then a performance test as specified in 40 CFR 264.1035(b)(3) shall be used and record all test results. Documentation shall be kept regarding the description and date of each modification that is made to the closed vent system.

A description of the planned routine maintenance that is anticipated for the upcoming 6 months and that which was actually performed over the previous 6 months including records of the management of the carbon removed from the carbon adsorption system. The total number of hours the control device did not operate appropriately shall also be recorded. The occurrence and duration of each malfunction of the control device system shall be recorded and actions taken during periods of

malfunction to restore the control device to its usual or normal manner of operation.

#### E.3.8 Reporting Requirements (§264.1090)

A written report shall be submitted to the Regional Administrator within 15 calendar days of the time of an occurrence when hazardous waste is managed in the tank using air emission controls in noncompliance with the conditions specified in §264.1084(b). The written report shall contain:

- The EPA identification number
- Facility name and address
- Description of the noncompliance event and the cause
- The dates of the noncompliance, and
- The actions taken to correct and prevent future noncompliance
- Signed and dated by an authorized individual.

A written report shall be submitted semiannually to the Regional Administrator describing each occurrence during the previous six months when a control device is operated continuously for 24 hours or longer in noncompliance with the applicable operating values defined in §264.1035(c)(4). If a control device and no period of 24 hours or longer that it operated in noncompliance with the operating values in a 6-month period, then a report is not required to be filed with the Regional Administrator.

**FIGURE E-1**  
**EXAMPLE EQUIPMENT IDENTIFICATION LOG**

**"EXAMPLE"**

Equipment Location:

Date: \_\_\_\_\_

Inspector:

[illegible]

Any equipment with evidence of leaks shall be monitored within 5 days and recorded on the Equipment Leak Repair Log. Valves (shaded areas) shall be inspected and recorded using the Valve Inspection/Monitoring Log.

tankid.log

<sup>1</sup> Method of Compliance:

- 1.) Visual, sound, smell, or other detection method.
- 2.) Monthly leak detection and repair.

**FIGURE E-2**  
**EXAMPLE INSPECTION/MONITORING LOG**

# **SUBPART BB & CC INSPECTION FORM** **HAZARDOUS WASTE TANKS and PUMP EQUIPMENT**

"EXAMPLE"

Instrument Name and Model: BACHARACH TLV				Inspector Name:			Inspection Date:		
Instrument Serial Number: ZB0501				Reviewer Name:			Review Date:		
				Check Time	Result				
Calibration Check Zero-Gas (Air):									
Calibration Check Mid-Gas (500 ppm Methane):									
Calibration Check High-Gas (10,000 PPM Methane):									
Id. #	Equipment Description	Equipment Location	Type of service Gas (G), Liquid (L), or Both (B)	Required Method of Compliance*	Visual Inspection Result	Monitored VOC (PPM)	Background VOC (PPM)	Corrective Action Required?	Comments
	TANK 101								
99	3" Valve and fittings to cap	bottom	L	1					
901	Manway	side	B	2					
902	Pressure relief device assy.	top	G	2, 3					
903	6" thief flange	top	G	2					
56	Thief hatch & flange	top	G	1, 3					
904	2" threaded coupling	top center	G	2					
905	2" threaded coupling and plug	top	G	2					
	TANK 102								
100	3" Valve and fittings to cap	bottom	L	1					
906	Manway	side	B	2					
907	Pressure relief device assy	top	G	2, 3					
908	6" thief flange	top	G	2					
55	Thief hatch & flange	top	G	1, 3					
909	2" threaded coupling	top center	G	2					
910	2" threaded coupling and plug	top	G	2					



Id. #	Equipment Description	Equipment Location	Type of service Gas (G), Liquid (L), or Both (B)	Required Method of Compliance*	Visual Inspection Result	Monitored VOC (PPM)	Background VOC (PPM)	Corrective Action Required?	Comments
	TANK 103								
32	3" Valve and fittings to cap	bottom	L	1					
911	Manway	side	B	2					
912	Pressure relief device assy	top	G	2, 3					
913	6" thief flange	top	G	2					
54	Thief hatch & flange	top	G	1, 3					
914	2" threaded coupling	top center	G	2					
915	2" threaded coupling and plug	top	G	2					
	TANK 104								
70	4" Valve and fittings to cap	bottom	L	1					
916	Bottom manway	side	B	2					
917	Top manway	side	B	2					
918	Pressure relief device and 6" flange	top edge	G	2, 3					
919	1/2" coupling and cap	top edge	G	2					
52	Thief hatch & flange	top	G	1, 3					
920	4" blind flange	top center	G	2					
921	4" blind flange	top edge	G	2					
922	4" flange for vapor recovery	top edge	G	2					



Id. #	Equipment Description	Equipment Location	Type of service Gas (G), Liquid (L), or Both (B)	Required Method of Compliance*	Visual Inspection Result	Monitored VOC (PPM)	Background VOC (PPM)	Corrective Action Required?	Comments
	TANK 301								
95	3" Valve and fittings to cap	bottom - east side	L	1					
96	3" Valve and fittings to cap	bottom - west side	L	1					
97	3" Valve and fittings to cap	bottom - west side	B	1					
98	3" Valve and fittings to cap	bottom - west side	B	1					
923	Manway	side	B	2					
63	Thief hatch and flange	top edge	G	1, 3					
924	8" Blind flange	top edge	G	2					
925	8" Pressure relief valve and flange	top edge	G	2, 3					
926	3" Blind flange	top edge	G	2					
927	¾" Coupling & plug	top edge	G	2					
928	4" Threaded coupling, 4x2 bushing, 2" nipple	top edge	G	2					
929	8" Blind flange	top center	G	2					
	TANK 302								
94	3" Valve and fittings to cap	bottom west side	L	1					
930	4" Plug	bottom east side	L	2					
931	Manway	side	B	2					
64	Thief hatch and flange	top edge	G	1, 3					
932	6" Plugged flange	top edge	G	2					
933	Pressure relief and flange	top edge	G	2					
934	4" Blind flange	top edge	G	2					
935	¾" Coupling and plug	top edge	G	2					
936	4" Threaded collar and plug	top edge	G	2					
937	2" welded pipe - vapor recovery	top edge	G	2					
938	8" Blind flange	top center	G	2					

Clean Harbors Arizona 1340 W. Lincoln Street, Phoenix, Arizona 85007 (EPA ID No: AZD049318009)

Id. #	Equipment Description	Equipment Location	Type of service Gas (G), Liquid (L), or Both (B)	Required Method of Compliance*	Visual Inspection Result	Monitored VOC (PPM)	Background VOC (PPM)	Corrective Action Required?	Comments
	TANK 303								
93	3" Valve and fittings to cap	bottom west	L	1					
92	3" Valve and fittings to cap	bottom east	L	1					
939	Manway	side	B	2					
65	Thief hatch and flange	top edge	G	1, 3					
940	8" Blind flange	top edge	G	2					
941	8" Pressure relief valve and flange	top edge	G	2, 3					
942	3" Blind flange	top edge	G	2					
943	4" Threaded coupling, 4x2 bushing, 2" nipple	top edge	G	2					
944	¾" coupling and plug	top edge	G	2					
945	8" Blind flange	top center	G	2					
	TANK 501								
91	3" Valve and fittings to cap	bottom west	L	1					
90	3" Valve and fittings to cap	bottom east	L	1					
946	Manway	side	B	2					
66	Thief hatch and flange	top edge	G	1, 3					
947	8" Blind flange	top edge	G	2					
948	8" Pressure relief valve and flange	top edge	G	2, 3					
949	3" Blind flange	top edge	G	2					
950	4" threaded coupling, 4x2 bushing, 2" nipple	top edge	G	2					
951	¾" coupling and plug	top edge	G	2					
952	8" Blind flange	top center	G	2					



Id. #	Equipment Description	Equipment Location	Type of service Gas (G), Liquid (L), or Both (B)	Required Method of Compliance*	Visual Inspection Result	Monitored VOC (PPM)	Background VOC (PPM)	Corrective Action Required?	Comments
	PUMPS and ASSOCIATED EQUIPMENT								
P1	2" Wilden	Tank farm	L	1					
P2	2" Wilden	Tank farm	L	1					
P3	3" Wilden	Tank farm	L	1					
P4	3" Wilden	Tank farm	L	1					
S1	Dual strainer basket	Tank farm	L	1					
S2	Single stainless strainer	Tank farm	L	1					
	COMPACTOR	Northwest corner of tank farm	G						
953	final discharge	Above Tank 104	G	1					

**\* = Required Method of Compliance:**

1 = Monthly leak detection and repair.

2 = Visual, sound, smell, or other detection method is acceptable. Check for drips, escaping gases, or bubbles indicating visual signs of leaks and record above.

3 = No detectable emissions.

**Leak Procedure:**

Leaks are defined as an instrument reading greater than 10,000 ppm or evidence from visual exam. If a leak is detected, the leak source shall be marked with a Leak Identification Number tag and the date the leak was detected. After the leak is repaired on valves, the valve must be monitored and remain free of leaks for two successive months. If a leak on a valve is not detected for two successive months, the valve must then be monitored the first month of every succeeding three month period thereafter, beginning with the next quarter unless a new leak is detected. If a new leak on the same valve is detected, the valve shall be repaired in the same manner and again monitored monthly until a leak is not detected for two (2) successive months. On other equipment, the tag may be removed after the leak is repaired with no additional monitoring required.

**Equipment Leak Repair Log:**

All leaks shall be reported on the Equipment Leak Repair Log. The first leak repair attempt must be made no later than five (5) calendar days after each leak is detected and shall be completely repaired within fifteen (15) calendar days.

**Id. #**

All identification numbers larger than 900 are used for identification purposes. When the identified equipment is found leaking, the appropriate identification number will be written on the leak repair tag.

**Inspection Schedule (Weekly and Monthly):**

Pumps shall be inspected weekly as required by Subpart BB §264.1052(a)(2). Weekly results are recorded on the RCRA Weekly Facility Inspection Reports. All listed equipment on this form shall be inspected monthly. Original and completed copies of all documents are maintained in the Conference Room.

## SUBPART BB & CC INSPECTION FORM VAPOR RECOVERY SYSTEM

Instrument Name and MODEL: BACHARACH TLV			Inspector Name:			Inspection Date:		
Instrument Serial Number: ZB0501			Reviewer Name:			Review Date:		
Calibration Check Zero-Gas (Air): Calibration Check Mid-Gas (500 ppm Methane): Calibration Check High-Gas (10,000 PPM Methane):			Check Time	Result				
Id. #	Equipment Description	Equipment Location	Required Method of Compliance*	Visual Inspection Result	Monitored VOC (PPM)	Background VOC (PPM)	Corrective Action Required?	Comments (Indicate MWO #)
700	4x2 Bushing	above tank 501	2					
701	2" Elbow	above tank 501	2					
702	2" Threaded union	above tank 501	2					
703	4x2 Bushing	above tank 303	2					
704	2" Tee	above tank 303	2					
705	2" Threaded union	above tank 303	2					
706	2" Tee	above tank 302	2					
708	2" Threaded union	above tank 302	2					
709	4x2 Bushing	connecting to tank 301	2					
710	2" Tee	above tank 301	2					
711	2" Threaded union	above tank 301	2					
712	2" Elbow	above tank 301	2					
713	2" Elbow	side of tank 301	2					
714	2" Threaded union	side of tank 301	2					
715	2" Elbow	side of tank 301	2					
716	2" Threaded union	above tank 101	2					
717	2" Tee	above tank 101	2					



Id. #	Equipment Description	Equipment Location	Required Method of Compliance*	Visual Inspection Result	Monitored VOC (PPM)	Background VOC (PPM)	Corrective Action Required?	Comments (Indicate MWO #)
718	2" Threaded union	above tank 102	2					
719	2" Tee	above tank 102	2					
720	2" Threaded union	above tank 103	2					
722	2" Tee	above tank 103	2					
723	4x2 Bushing	above tank 104	2					
724	2" Elbow	above tank 104	2					
725	2" Elbow	top side of tank 104	2					
726	2" Threaded union	side of tank 104	2					
727	2" Tee	side of tank 104 going to canisters	2					
728	2" Elbow	side of tank 104 going to canisters	2					
729	2" Tee	line from other tanks	2					
730	2" Tee	bottom side of tank 104	2					
71	2" Ball valve w/ cap	btm side of tank 104 for vent return.	1					
72	2" ball valve w/ cap	btm side of tank 104 for drain	1					
731	connecting hose to back pressure canister	beside tank 104	2					
732	back pressure canister	beside tank 104	2					
73	1" Ball valve w/ 2x1" bushing	top of back pressure canister	1					
733	hose from back pressure to carbon canister	beside tank 104	2					
734	Primary carbon canister	beside tank 104	2					
735	2" PVC bushing	out of primary canister	2					
736	2" PVC union	out of primary canister	2					
74	½" PVC sampling valve	between carbon canisters	1					
737	hose to secondary canister	between carbon canisters	2					
738	Secondary carbon canister	beside tank 104	2					
739	2" PVC bushing	out of secondary canister	2					
740	hose to riser	out of secondary canister	2					
741	final discharge	above tank 104	1					

\* = Required Method of Compliance:

1 = Monthly leak detection and repair.

2 = Visual, sound, smell, or other detection method is acceptable. Check for drips, escaping gases, or bubbles indicating visual signs of leaks and record above.

3 = No detectable emissions.

Leak Procedure:

Leaks are defined as an instrument reading greater than 10,000 ppm or evidence from visual exam. If a leak is detected, the leak source shall be marked with a Leak Identification Number tag and the date the leak was detected. After the leak is repaired on valves, the valve must be monitored and remain free of leaks for two successive months. If a leak on a valve is not detected for two successive months, the valve must then be monitored the first month of every succeeding three month period thereafter, beginning with the next quarter unless a new leak is detected. If a new leak on the same valve is detected, the valve shall be repaired in the same manner and again monitored monthly until a leak is not detected for two (2) successive months. On other equipment, the tag may be removed after the leak is repaired with no additional monitoring required.

Equipment Leak Repair Log:

All leaks shall be reported on the Equipment Leak Repair Log. The first leak repair attempt must be made no later than five (5) calendar days after each leak is detected and shall be completely repaired within fifteen (15) calendar days.

Id. #

All identification numbers larger than 700 are used for identification purposes. When the identified equipment is found leaking, the appropriate identification number will be written on the leak repair tag.

Type of service:

All monitoring points are not hazardous waste in gas or vapor physical state.

**FIGURE E-3**  
**EXAMPLE EQUIPMENT LEAK REPAIR LOG**

**CLEAN HARBORS ARIZONA, LLC**  
**40 CFR 265 Subpart BB/CC Equipment Leak Repair Log**

“EXAMPLE”

Equipment Id #	Date Leak Detected	Dates of Attempted Repairs	Repair Method	Monitor Results	Instrument Id #	Operator	Repair Comments

The Monitor reading after the repair attempt needs to be below 10,000 ppm before the leak is considered repaired.

A first attempt at repair shall be made no later than 5 calendar days after each leak is detected and shall be repaired within 15 calendar days.

If repairs are not made within the required 15 calendar days, a Delay of Repairs Log will be completed for the leaking equipment.

Leak.log



**FIGURE E-4**  
**EXAMPLE DELAY OF REPAIRS LOG**

**"EXAMPLE"**

[illegible]

delay.log

**FIGURE E-5**  
**EXAMPLE EQUIPMENT DIFFICULT TO MONITOR LOG**

"EXAMPLE" .

40 CFR 264 SUBPART BB EQUIPMENT DIFFICULT TO MONITOR LOG

[illegible]

### EXAMPLE

**FIGURE E-6**  
**EXAMPLE EQUIPMENT WITH NO DETECTABLE**  
**EMISSIONS LOG**

40 CFR 264 SUBPART BB EQUIPMENT WITH NO DETECTABLE EMISSIONS LOG  
FACILITY MANAGER SIGNATURE: \_\_\_\_\_

FACILITY MANAGER SIGNATURE:

[illegible]

### EXAMPLE

**FIGURE E-7**  
**EXAMPLE EQUIPMENT WITH NO DETECTABLE LIMITS IDENTIFICATION LOG**

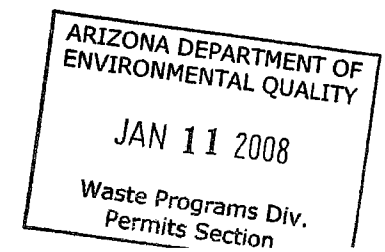
# SUBPART BB & CC "NO DETECTABLE LIMITS EQUIPMENT" IDENTIFICATION LOG

Id. #	Equipment Description	Equipment Location	Type of service Gas (G), Liquid (L), or Both (B)	Required Method of Compliance*	Comments
	TANK 101				
902	Pressure relief device assy.	top	G	2, 3	
	TANK 102				
907	Pressure relief device assy	top	G	2, 3	
	TANK 103				
912	Pressure relief device assy	top	G	2, 3	
	TANK 104				
918	Pressure relief device and 6" flange	top edge	G	2, 3	
	TANK 301				
925	8" Pressure relief valve and flange	top edge	G	2, 3	
	TANK 302				
	TANK 303				
941	8" Pressure relief valve and flange	top edge	G	2, 3	
	TANK 501				
948	8" Pressure relief valve and flange	top edge	G	2, 3	

Facility Manager: \_\_\_\_\_

\* = Required Method of Compliance:

2 = Visual, sound, smell, or other detection method is acceptable. Check for drips, escaping gases, or bubbles indicating visual signs of leaks and record above.  
3 = No detectable emissions.





**EXHIBIT E-1**  
**ACTIVATED CARBON PRODUCT DESCRIPTION**

# EI-410S

## Product Description

Envirotrol's EI-410S is a virgin coconut shell base carbon of 12x10 mesh. This coconut shell carbon provides superior hardness and minimum dust. EI-410S is typically used in HVAC and Odor Control applications.

Grade EI-410S is available in 1000 lb bulk sacks or in bulk. All other packaging is available at a premium. EI-410S is produced by steam activated process and is therefore excluded from IATA#395, IMCO Class 4.2 or UN1362, Freight Classification: NMFC #40560; UFC - #20460.

**WET ACTIVATED CARBON DEPLETES OXYGEN FROM AIR.**  
All precautions must be taken since dangerously low levels of oxygen may be encountered.

## Product Specifications

	EI-410S
Carbon Tetrachloride (Weight %), min:	60%
Iodine Number (mg.g), min:	1200
Hardness Number:	95
Moisture (as packed, weight %):	2.0%
Ash Content (max.):	3.0%
Apparent Density:	0.44 - 0.49

**\* Typical properties are for general information and are not to be construed as purchase specifications.**

The information and recommendations in this publication are, to the best of our knowledge, reliable. Suggestions made concerning uses or applications are only the opinion of Envirotrol Inc., and users should make their own tests to determine the suitability of these products for their own particular purposes. However, because of numerous factors affecting results, Envirotrol Inc., makes no warranty of any kind, expresses or implied, including those of merchantability and fitness for purpose, other than that the material conforms to its applicable current Standard Specifications. Statements herein, therefore, should not be construed as representations or warranties. The responsibility of Envirotrol for claims arising out of breach of warranty, negligence, strict liability, or otherwise is limited to the purchase price of the materials.

Statements concerning the use of the products or formulations described herein are not to be construed as recommending the infringement of any patent and no liability for infringement arising out of any such use is assumed.

Shipping Information: F.O.B. Points: Rochester, PA

Envirotrol, Inc.

# EI-410S



# EI-46 | EI-410

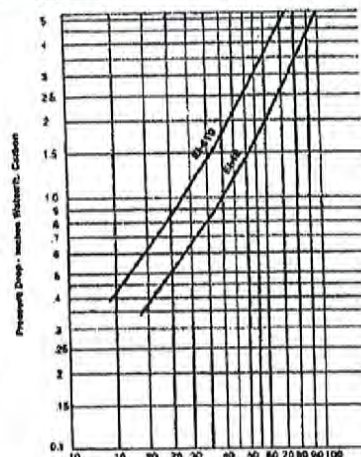
Envirotrol, Inc.

## Product Description

EI-46 and EI-410 grade virgin activated carbons are manufactured from select grades of bituminous coal, which are activated at high temperatures under rigidly controlled conditions. The resulting product is characterized by high internal surface area, offering superior gas phase adsorption properties for a broad spectrum of organic compounds.

EI-46 and EI-410 grade activated carbons are very hard and attrition resistant resulting in low dust and high durability during operation and reactivation. Typical applications for EI-46 and EI-410 include: solvent recovery, odor control, tank vent adsorbers, HVAC, VOC control, Soil Vapor Extraction, Air Stripper Off-Gas, and Sub Part CC Compliance.

Grades are available in 200 lb net weight fiber drums or in bulk sacks containing 1000 lbs. net each. They are produced by steam activated process and are therefore excluded from IATA#395, IMCO Class 4.2 or UN1362 Freight Classification: NMFC #40560; UFC - #20460



## WET ACTIVATED CARBON DEPLETES OXYGEN FROM AIR.

All precautions must be taken since dangerously low levels of oxygen may be encountered.

## Product Specifications

Carbon Tetrachloride Activity (base):

Hardness Number (min.):

Mean Particle Diameter (mm):

Moisture (as packed, weight %):

U.S. Standard Sieve Size:

Greater than 4 mesh (max.):

Less than 7 mesh (max.):

Less than 10 mesh (max.):

Apparent Density (dense packing, g/ml)

Total Surface Area (N<sub>2</sub> BET, m<sup>2</sup>/g):

Ignition Temperature (Deg. C):

EI-46

60%

95

3.0

2.0%

4x6

5%

10%

NA

.44-.50

1050-1150 m<sup>2</sup>/g

450

EI-410

60%

95

3.0

2.0%

4x10

5%

NA

4%

.44-.50

1050-1150 m<sup>2</sup>/g

450

The information and recommendations in this publication are, to the best of our knowledge, reliable. Suggestions made concerning uses or applications are only the opinion of Envirotrol Inc., and users should make their own tests to determine the suitability of these products for their own particular purposes. However, because of numerous factors affecting results, Envirotrol Inc., makes no warranty of any kind, expresses or implied, including those of merchantability and fitness for purpose, other than that the material conforms to its applicable current Standard Specifications. Statements herein, therefore, should not be construed as representations or warranties. The responsibility of Envirotrol for claims arising out of breach of warranty, negligence, strict liability, or otherwise is limited to the purchase price of the materials.

Statements concerning the use of the products or formulations described herein are not to be construed as recommending the infringement of any patent and no liability for infringement arising out of any such use is assumed.

Shipping Information: F.O.B. Points: Rochester, PA

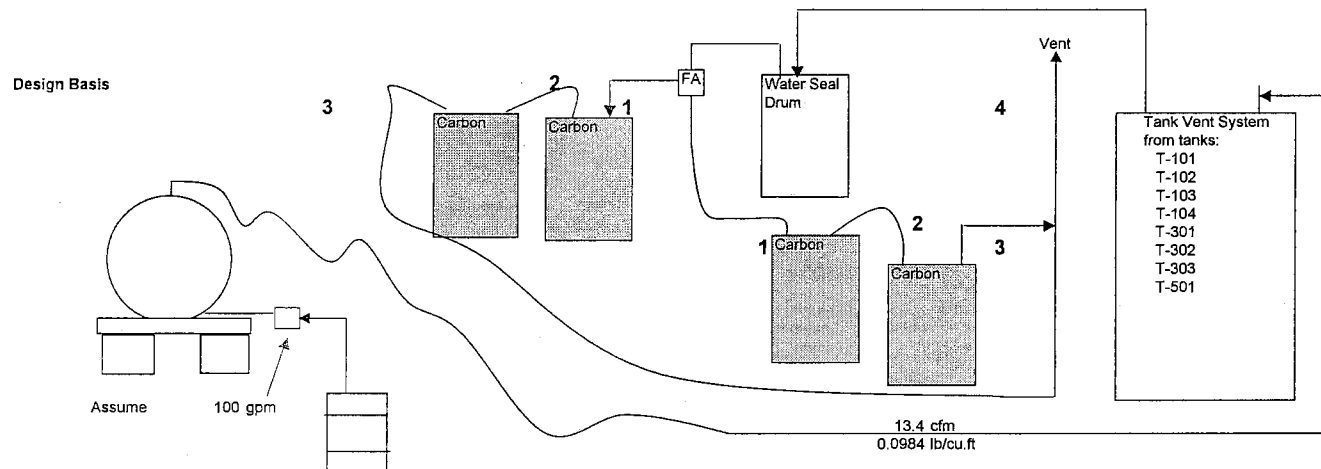
Envirotrol, Inc.

# EI-46 | EI-410

**EXHIBIT E-2**  
**EMISSION CONTROL CALCULATIONS**

# Clean Harbors Arizona, LLC

## Activated Carbon System Flow Rate and Emission Efficiency Calculations



Flow	6.68 cfm	1
	39 lbs/hr	
Temp	68 F	
Pressure	14.19 psia	
VOC	5.00 lbs./hr	

Flow	10.64 cfm	2
	35 lbs/hr	
Temp	68 F	
Pressure	14.15 psia	
VOC	0.25 lbs./hr	
VOC RE =	95	

Flow	10.67 cfm	3
	34 lbs/hr	
Temp	68 F	
Pressure	14.12 psia	
VOC	0.03 lbs./hr	
VOC RE =	90	

Flow	21 cfm	4
	69 lbs/hr	
Temp	68 F	
Pressure	14.12 psia	
VOC	0.03 lbs./hr	
OVERALL VOC RE	99.50	

Carbon Vessel Size	
Envirotron VMW-55	
Diameter	1.0 ft
Area	2.84 sq ft
Superficial velocity	2.8 ft/min
Height of Vessel	2.0 ft
Carbon	150 lbs
Carbon bed depth	8.4 ft
Carbon bed depth	2.3 ft
Pressure Drop	0.5 in. w.c. per ft
Total Pressure Drop	0.015 in. w.c.

FA= Flame Arrestor

ARIZONA DEPARTMENT OF  
ENVIRONMENTAL QUALITY

JAN 11 2008

Waste Programs Div.  
Permits Section

## Vapor Pressure Calculations

Flammable Liquid															
Vapor Pressure Calculations			Max. Liquid Surface Temperature		82 °F		27.7778 °C								
Basis:	100 lbs	Notes	Molecular Weight lb/lb-mole	Specific Gravity	weight percent.	lb moles	mole fract.	Antoine Constants for Vapor Pres			log P	Vapor Pressure mmHg	Partial Pressure mmHg	Partial Pressure psia	Partial Pressure kPa
								A	B	C					
toluene	Note 1		92.0	0.866	0.185	0.201	0.150	6.955	1344.800	219.480	1.516	32.793	4.926	0.095	0.657
xylene	Note 1		106.0	0.881	0.185	0.175	0.130	6.998	1474.679	213.690	0.891	7.778	1.014	0.020	0.135
acetone	Note 1		58.0	0.792	0.185	0.319	0.238	7.117	1210.595	229.664	2.415	259.859	61.918	1.198	8.255
Isopropyl Alcohol	Note 1		60.1	0.786	0.074	0.123	0.092	8.118	1580.920	219.610	1.727	53.364	4.909	0.095	0.654
Methanol	Note 1		32.0	0.791	0.074	0.231	0.173	7.898	1474.080	229.130	2.160	144.451	24.921	0.482	3.323
Methyl Ethyl Ketone	Note 1		72.1	0.805	0.037	0.051	0.038	6.974	1209.600	216.000	2.012	102.874	3.943	0.076	0.526
n-Butyl Acetate	Note 1		116.2	0.898	0.222	0.191	0.143	7.127	1430.418	210.745	1.130	13.494	1.926	0.037	0.257
n-Ethyl Acetate	Note 1		88.1		0.037	0.042	0.031	7.102	1244.950	217.880	2.034	108.135	3.393	0.066	0.452
water	Note 2		18.0		0.001	0.006	0.004	18.304	3816.440	-46.130	3.316	27.563	0.114	0.002	0.015
TOTAL					100.0%	1.34	1.00						107.064	2.071	14.274
Note 1	Vapor pressures calculated using values from Lange's Handbook of Chemistry using Antoine Coefficients for LOG P = A-B/(T+C) in mm Hg														
Note 2	Vapor pressure calculated using values from Properties of Gases and Liquids using Antoine Coefficients for LN P = A-B/(T+C) in mm Hg														

264.1084 Regulatory limit for the tank system is 76.6 kPa.

ARIZONA DEPARTMENT OF  
ENVIRONMENTAL QUALITY

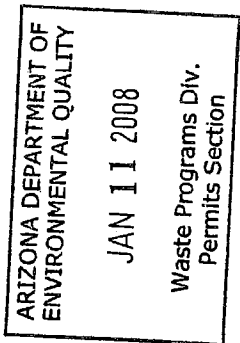
JAN 11 2008

Waste Programs Div.  
Permits Section

## Clean Harbors Arizona

### Waste Compact Flow Rate

Volume Displacement	8.12 ft <sup>3</sup>
Volume per year	14000 gallons
	1871.5 ft <sup>3</sup>
Flowrate	8.12 ft <sup>3</sup> /min



Carbon Vessel Size	
Envirotrol VPM-55	
Diameter	1.9 ft
Area	2.9 ft <sup>2</sup>
Superficial velocity	2.8 fpm
Height of Vessel	2.8 ft
Carbon	180 lbs.
Carbon	6.4 ft <sup>3</sup>
Carbon bed depth	2.2 ft
Pressure Drop	0.6 in wc. per filter
Total Pressure Drop	0.2 in wc.

**EXHIBIT E-3**  
**EMISSION CONTROL DESIGN**  
**EVALUATION, INSPECTION AND MONITORING**



**Estimated Maximum Vent Flow Rate & Potential Maximum Internal Tank Pressure**  
Phoenix facility

2/6/2009  
Rev 1 - 7/27/2009

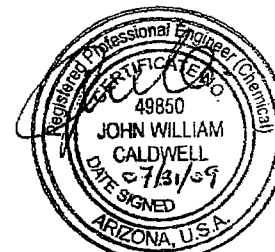
**A. Tank Data & Thermal Breathing Volume**

Tank No.	Description of Contents	Tank Capacity (gal)	Emissions Control	Thermal Out breathing volume in cubic feet per hour - Per API 2000
----------	-------------------------	---------------------	-------------------	--

<b>Tanks subject to RCRA regulation</b>				
101	RCRA Flammable & Non-flammable Liquid	2570	Yes	60
102	RCRA Flammable & Non-flammable Liquid	2570	Yes	60
103	RCRA Flammable & Non-flammable Liquid	2570	Yes	60
104	RCRA Flammable & Non-flammable Liquid	4530	Yes	125
301	RCRA Flammable Liquid	10250	Yes	250
302	RCRA Flammable & Non-flammable Liquid	10150	Yes	250
303	RCRA Flammable & Non-flammable Liquid	10150	Yes	250
501	RCRA Flammable & Non-flammable Liquid	10150	Yes	250
<b>Total all Tanks</b>		<b>52940</b>		<b>1305</b>

Therefore, Thermal Out breathing from all tanks in to vent header

= 1,305 CFH  
= 21.75 CFM (a)



okp.mcs 06/30/12

**Estimated Maximum Vent Flow Rate & Potential Maximum Internal Tank Pressure  
Phoenix facility**

2/6/2009

**B. Working loss - out breathing in to vent system**

**(1) Calculation Basis - Operational Data**

- (1) All tanks are connected to a common 2" header which is directed into a knock-out/back pressure/rinse drum and then into four carbon beds and exits through a stack.
- (2) Physical layout indicates that T- 501 is the farthest tank from the carbon beds.
- (3) Total length of the Vent line from T-501 to the knock out drum is 100 ft with 5 -90 degree elbows.  
This translate into an equivalent length of 130 ft of 2" pipe.
- (4) Facility utilizes vapor balancing during tanker-truck off loading, which reduces the outflow through the knock-out drum and carbon beds.
- (5) The vapor balancing connection is at the upstream side of the knock out drum. Facility utilizes a 73 feet of 2" flexible hose to connect tanker to the vent header connection at knock out drum.
- (6) Facility can at the most perform two tank filling activities at a time - one from tanker truck and one from drum pumping operation. Two independent double diaphragm pumps are utilized to perform these two activities. Pumps have nominal capacity of 80 GPM, however, the drum pumping is done at a slower pace by regulating the air flow to the pump to achieve an effective average rate of 10 GPM and the peak rate of 20 GPM.
- (7) The knock out drum is maintained to have 10" of water at all times. The vent pipe coming from the tanks is inserted into this water to the depth of 8". This will create an 8" of liquid back pressure into the tank header.
- (8) Each tank has a conservation vent and an emergency vent.  
Pressure setting for conservation vent = 1 psig  
Pressure setting for emergency vent = 2.5 psig
- (9) Flash point of liquid stored is less than 100 degrees F and boiling point is below 300 deg F for the API 2000 vent rate to be twice the liquid flow rate.
- (10) The total piping equivalent beyond knock-out drum is 30 feet of 2 inch pipe.

**(2) Assumptions for Pressure calculations**

- (1) For the maximum possible pressure/vent flow, it is assumed that a tanker truck is being pumped into T-501 and drum pumping is occurring into tank T-501, simultaneously. At the same time, all tanks are out breathing thermal loss at their maximum rate as indicated in the table.

**(3) Working - Out breathing flow**

No. of Simultaneous pumping operations	=	2	
Peak Flow rate of tanker truck off-load pump	=	80	GPM
Peak Flow rate of drum pump-off pump	=	20	GPM
Total combined Maximum pumping rate into the tanks	=	100	GPM

Per API 2000, the out breathing volume for transfer of liquids with flash point below 100 degrees F

Therefore working/outbreathing flow rate	=	GPM/3.5	
	=	28.57	CFM (b)

**Estimated Maximum Vent Flow Rate & Potential Maximum Internal Tank Pressure  
Phoenix facility**

2/6/2009

**C. Calculations for Maximum Internal Tank Pressure**

**(1) Flow distribution**

Due to vapor balancing, connection located at the knock-out drum inlet, vapor flow will split into two flows at that point. One going to tanker trailer in the amount equal to the volume being removed from the tanker, and, the remaining excess flow will go through knock-out drum, flame arrestor and carbon beds.

Total out breathing flow into the vent header = working displacement + Thermal displacement = (a) + (b)	=	50.32	CFM	(d)
Flow to the tanker truck = pump out rate @ 80 GPM	=	10.70	CFM	(e)
Therefore, net flow through knock-out drum and to the stack = (d) - (e)	=	39.63	CFM	(f)

**(2) Pressure drop**

**Flow Frictional pressure drop in vent pipe**

Pressure drop for the total outbreathing flow through the 130 feet of vent header, @ 0.1482 psi/100 feet per Crane Handbook

=	0.19	psi	(g)
---	------	-----	-----

**Knock-out Drum Resistance (pressure drop)**

Vent flow going through knock out drum needs to overcome 8" of water layer, which is

=	0.29	psi	(h)
---	------	-----	-----

**Flame Arrestor Resistance (pressure drop)**

Flow through flame arrestor = (f) x 60

Pressure drop from the curve for Protectoseal model 4952F - 2", for the total flow through the flame arrestor

=	2377.57	CFH	
=	3.5	inches of WC	
=	0.13	psi	(i)

**Carbon beds Resistance (pressure drop)**

Vapor flow from knock-out drum is split into two sets of carbon beds.

Therefore, flow through each carbon bed

Pressure drop from the curve for Ecosorb activated carbon drum model VSC200

=	19.81	CFM	
=	0.75	inches of WC	
=	0.027	psi	
=	0.054	psi	(k)

For two carbon beds in series, total pressure drop

**Estimated Maximum Vent Flow Rate & Potential Maximum Internal Tank Pressure  
Phoenix facility**

2/6/2009

Exit piping pressure drop  
Through 30 feet of pipe @0.13 psi/100 feet = 0.039 psi (l)

Total pressure drop through the knock out drum, carbon  
beds & vent - after the flow split, = (h)+(j)+(k)+(l) = 0.509 psi (m)

Total Required Maximum Internal Pressure of the  
tanks for the maximum vent flow = (g) + (m) = 0.70 psi (n)

The conservation vent pressure setting far exceeds  
the potential maximum internal pressure and is = 1 psi

Hence, under normal operation, vent flow will not be released through either conservation vent or emergency vent

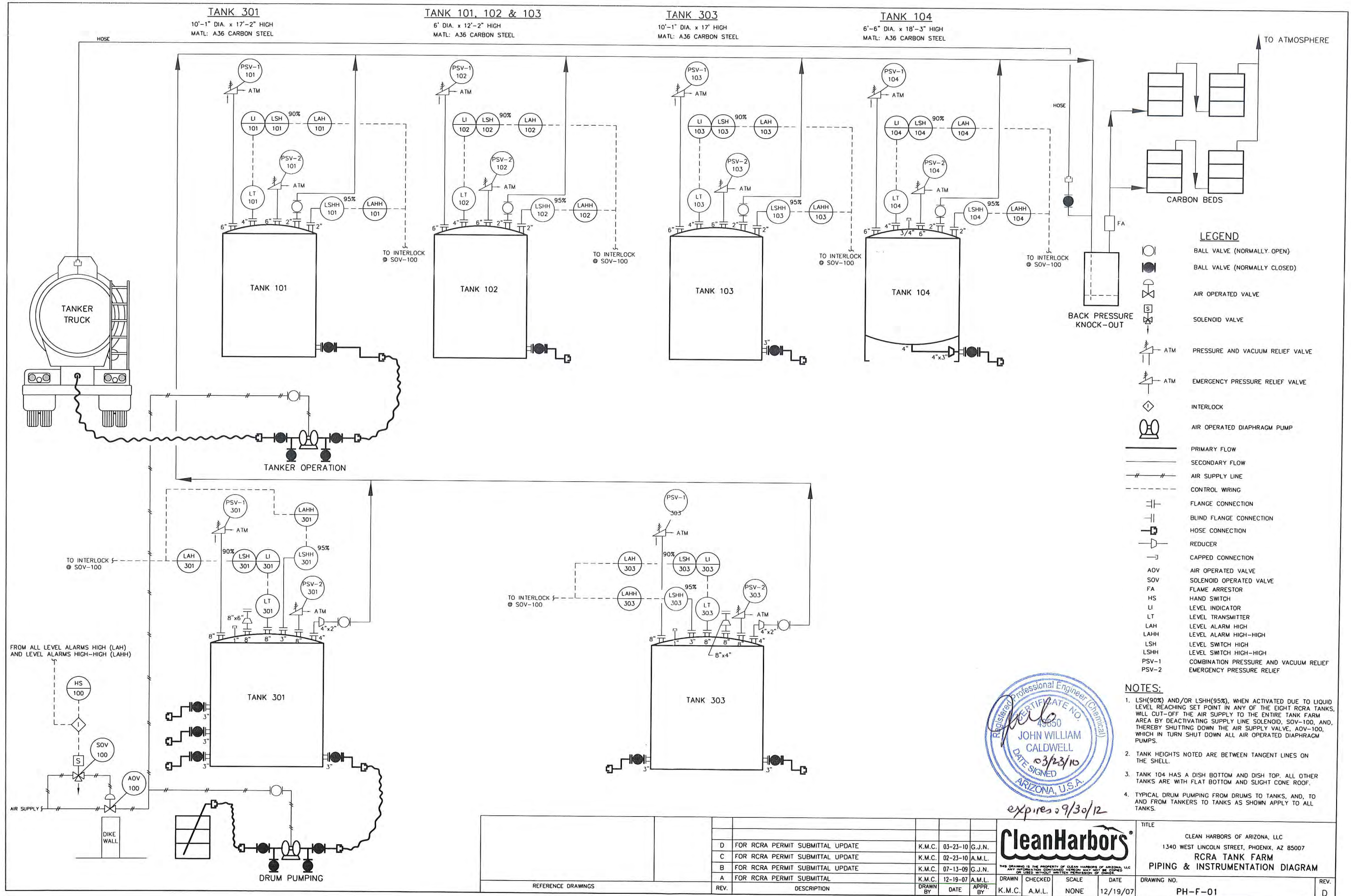
**D. Calculations for Pressure Drop through vapor balance**

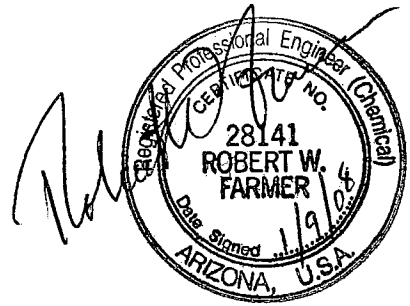
Hose length between tanker truck vapor balance  
connection and the branch connection at knock-out drum = 73 ft (p)  
Flow to the tanker truck = pump out rate@80 GPM = 10.70 CFM (e)  
Pressure drop through vapor balance line - 73 ft of 2"  
hose, @0.015 psi/100 ft per Crane Handbook = 0.01 psi (o)

Back pressure that must exist in tanker truck to equalize  
the pressure drop for a steady state condition = 0.69 psi (q)

Pressure drop (o) is far less than pressure drop (m)

Hence, initially, more flow would go to the tanker to equalize the pressure by creating the backpressure inside the tanker headspace which will reduce the forward flow through carbon beds. Therefore, the maximum total back pressure inside the storage tanks would be what has been calculated here, as represented by (n) above.





## EMISSION CONTROL DESIGN

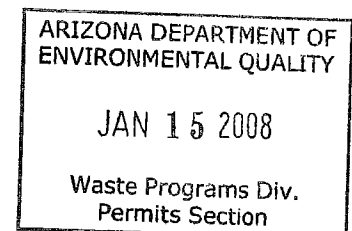
### EVALUATION, INSPECTIONS AND MONITORING

#### Item 66 a.

The spec sheets provided as Exhibit E-1 do not indicate the control efficiency of the carbon used for emissions control.

The size and configuration of the CHA storage tank emission control system are based on accepted principles of carbon adsorber system design to deliver very high control efficiency. Carbon canister beds arranged in series provide redundant capacity, and the control effectiveness can be monitored using a sampling point for effluent concentration in the piping between the two beds. In this design, the "upstream" bed would need to be almost fully loaded with adsorbed organic solvents before detectable solvents would be passed through to the second bed. The presence of the second "downstream" bed ensures that 95% control will be provided, since this bed will polish any "tail" of organic constituents that may escape the upstream bed as it approaches its capacity.

A piping and instrumentation diagram (P&I) is provided in Figure 66-1. There are four canisters in total, arranged in two parallel trains each with two canisters in series. The system plumbing is a combination of cemented PVC piping, and flexible rubber hose. Nominal 2-inch pipe and hose is used for plumbing from the tanks to the carbon canisters. The carbon canisters are 55-gallon size steel drums, each containing approximately 180 pounds of carbon, at a nominal bed depth of 2.3 feet. There is a distributor plate at the inlet end of each canister, to reduce the likelihood of channeling through the bed. Sampling locations, in the



form of threaded valves are installed at the outlet of the upstream and downstream beds of each pair of canisters.

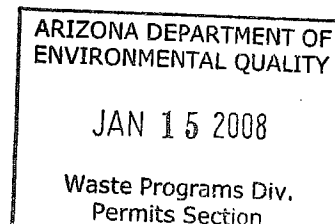
As illustrated in Figure 66-2, influent gases containing the contaminants begin to "load" the carbon in a fresh adsorber near the inlet to the first bed. As the carbon filters the organic molecules, the Mass Transfer Zone (MTZ) migrates through the bed. Downstream of the MTZ, there is virtually no organic left in the effluent stream. This material is polished out of the gases by the fresh, relatively unloaded carbon downstream of the MTZ. This is a different principle of control than other emission control devices, such as scrubbers, in which the efficiency is driven by an equilibrium end point and the absorbing media (usually water) is mixed between the gas inlet and outlet.

The reply to Item 66b provides the adsorbent capacity calculations to illustrate that the CHA carbon canisters contain sufficient adsorption capacity to provide 95% or higher control efficiency. This design analysis satisfies the requirements for carbon adsorber control systems listed in 40 CFR 264.1035(b)(4)(iii)(G). The inspection and monitoring of the organic vapor concentration between the two beds (see Item 66e) is also a conservative measure to ensure greater than 95% total control.

Item 66 b.

Demonstrate that carbon system has absorption capacity to manage percent-by-weight total organics in hazardous waste stream as required by 264.1064(b)(1)(iv). A 95% or greater efficiency is required per 264.1033(b) [as directed by 264.1060 via 264.1064(b)(4)].

A number of factors determine the adsorption working capacity of a carbon bed canister. One primary factor is the equilibrium capacity for a specific VOC constituent ( $w_e$ ), which is dependent on the adsorption potential of a given molecule, the representative concentration of that constituent in the gas to be treated, the range of working temperature, and the weight of carbon in the canister. The effective working capacity is then defined as a fraction of the equilibrium capacity. Estimation of equilibrium capacity is based on inspection



of adsorption isotherm correlations for the anticipated constituents. The fundamentals of this technique are presented in many engineering texts.

The isotherm data characterizing activated carbon produced from coconut shells was obtained from *Handbook of Separation Techniques for Chemical Engineers* (P.A. Schweitzer, 3<sup>rd</sup> Ed., McGraw-Hill, 1996, Ch. 3). The theoretical equations used for this evaluation were obtained from this text, and the *U.S. Army Corps of Engineers, Adsorption Design Guide* (No. 1110-1-2, Dept. of the Army, March 2001). A conservative estimation technique of carbon bed working capacity from the equilibrium capacity is provided in the *U.S. EPA Air Pollution Control Cost Manual, Section 3.1 VOC Capture Controls* (EPA/452/B-02-001, September 1999, Chapter 1 - Carbon Adsorbers). Key excerpts from these references are attached.

In the case of the CHA carbon canister systems, the amount of carbon provided is 720 total pounds in four separate canisters. To demonstrate the adequacy of these systems as a control device in accordance with 40 CFR 264.1064 (b)(1), one can estimate the carbon replacement interval in terms of the volume of liquid solvent transfer that will be effectively controlled prior to bed breakthrough.

Solvent vapors may be vented to the carbon canisters during periods when liquid is added to one of the controlled tanks. Also, thermal cycles during summer-peak daily temperature swings may contribute to vented emissions. However, such "breathing" emissions are only vented out of a tank under extreme conditions. A vacuum/pressure relief valve is installed at the top of each tank to ensure that pressure differential does not damage the tank. This vent is set to not release vapors to atmosphere until tank internal pressure exceeds 1.0 psig. The vacuum relief valve prevents the tank from collapsing by allowing atmospheric air to enter the tank when liquids are being removed from the tank.

When liquid solvent is pumped from drums or other portable containers, the volume of vapor vented to the carbon system is equal to the gallons of liquid added to the tank(s). For tank truck unloading the CHA system includes a vapor recovery line that returns displaced vapor from the CHA tanks back to the truck vessel, as illustrated in Figure 66-1.



The use of vapor recovery eliminates venting of solvent vapor to the canisters during truck unloading, which greatly extends carbon life. Solvent shipments received and unloaded from tanker trucks are normally in the range of 500 to 1,000 gallons per shipment and pumped at the rate of 50 to 100 gallons per minute. So, without vapor recovery the potential vapor volume treated by the carbon canisters is relatively large. However, in the CHA system these large volume transfers do not result in venting of vapor to the carbon canister. Instead, the liquid-gas displacement between vessels is equivalent and therefore virtually no vapors are being passed through the carbon.

For individual solvents, the vapor density in the tank headspace (assumed saturated at the tank temperature) can be calculated from pure component vapor pressure data. For comparison, vapor pressure data obtained from Perry's Chemical Engineers Handbook (5<sup>th</sup> ed. Table 3-8) for several solvents handled at CHA are plotted in Figure 66-3. For the example of m-xylene, the vapor density is calculated as follows:

$$\text{Vapor density (lb/ft}^3\text{)} = D_v = [P_v \text{ MW}] / R T$$

Where:

$P_v$  = pure component vapor pressure (= 15 mmHg @100 F for m-xylene)

MW = solvent molecular weight

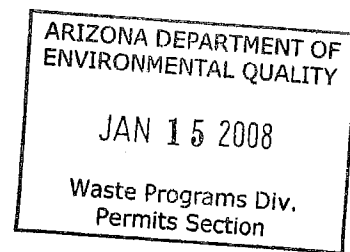
$R$  = gas constant (= 555 mmHg ft<sup>3</sup> / lbmole °R)

$T$  = tank temperature (°R)

For the example of m-xylene:

$$D_v = \frac{[15 \text{ mmHg} \times 106.16 \text{ lb/lbmole}]}{[555 \text{ mmHg ft}^3 / \text{lbmole } ^\circ\text{R} \times 560 ^\circ\text{R}]} = 0.0051 \text{ lb m-xylene/ft}^3$$

Information on carbon capacity for m-xylene was obtained from the *Handbook of Separation Techniques for Chemical Engineers*, Chapter 3, Table 1 and Figure 4 (copies attached). This reference indicates that equilibrium capacity,  $w_e = 0.43$  pounds m-xylene adsorbed per pound activated carbon. (For m-xylene,



parameter E is equal to 7 from Table 1, and from Figure 4 this E value corresponds to 0.5 mL xylene adsorbed per gram of carbon; unit conversions to pounds m-xylene per pound carbon are shown in Table 66-1.)

As described in Item 66a, the carbon adsorbs solvent vapor across a front that migrates from inlet to outlet, so that relatively fresh carbon is present near the canister outlet until breakthrough is approached. Selecting a working capacity that is below the equilibrium capacity makes allowance for this remaining carbon surface, and ensures the design will provide control efficiency above 95%. Based on the saturated vapor pressure data, inlet concentrations at the control device may range as high as 500,000 ppmv, so that corresponding outlet concentrations assuming 95% control (depending on constituent) range from 300 - 25,000 ppmv. The inspection threshold for breakthrough of 100 ppmv used at CHA is therefore more stringent than the 95% control efficiency standard.

Evaluating the carbon canister service life for intermittent use at CHA is not as straightforward for a continuous adsorption process. Normally, the service life is expressed as a "contact time" of the carbon in-service, treating a steady inlet flow and contaminant concentration. However, rearranging the conventional design equations allows the "contact volume" to be calculated for a given carbon quantity. Assuming a carbon working capacity of 50% of the equilibrium capacity allows a conservative estimate of canister service life in terms of the volume of vapor vented from the tanks. (*U.S. EPA Air Pollution Control Cost Manual, Sect. 3.1, Ch.1 , pg. 1-16*). In the case of the CHA system, the treated vapor volume will be equal to the liquid volume loaded from drums/totes not equipped with vapor recovery.

For the example of m-xylene:

$$\begin{aligned}\text{Working capacity} &= \frac{\text{lb carbon} \times \text{frac. working capacity} \times w_e (\text{lb solv i/lb/carbon})}{D_v (\text{lb/ft}^3)} \\ &= 720 \text{ lb carbon} \times 0.50 \times 0.434 / (0.00512 \text{ lb/ft}^3) \\ &= 30,500 \text{ ft}^3 \text{ treated vapor} \\ &= 228,000 \text{ gallons of liquid volume loaded}\end{aligned}$$

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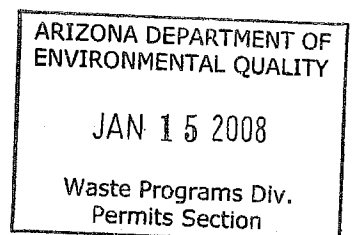
Similar calculations for other representative solvents received at CHA are presented in Table 66-1 (attached). Solvents with lower molecular weight and higher volatility tend to have the lower equilibrium carbon capacity. This suggests that either acetone or isopropyl alcohol is an appropriate "worst case" basis for evaluation of CHA canister working capacity. Tank-temperature also has a strong influence on the volume of vapor controlled, since at higher temperature the saturated vapor contains more mass of solvent per unit volume. The volume of solvent vapor controlled at ambient temperature of 70 °F is about three times the volume that will be controlled at 100 °F, as shown in Table 66-1. Ambient relative humidity is not a significant factor in this analysis, as the tanks and carbon canisters does not involve ambient air intake.

Even based on stringent design assumptions (100% IPA liquid and 100 °F continuous bed temperature) the current CHA carbon system (total 720 pounds of carbon) has an estimated working capacity of 24,400 gallons of vapor treated. With the use of vapor recovery for tank trucks, the net volume treated by the carbon canisters is small compared to the volume of solvent received at the Clean Harbors facility. In practice, most of the treated vapor volume would result from the unloading smaller-volume drums and totes. Given the pattern of actual received volume of solvent in the controlled tanks, and the conservative nature of this estimate, the CHA canisters can be operated for at least 12 months between change-outs.

Monitoring for bed breakthrough on a monthly basis is more frequent than 20% of the expected carbon working capacity timeframe, and therefore this schedule is viewed as compliant with the monitoring requirement in 40 CFR 1654.1033(h)(1). In addition, the total solvent received in the controlled tanks from drums/totes not equipped with vapor recovery may serve as a conservative indicator of the end of carbon canister service life.

Item 66 c.

Details on equations and assumptions used in Exhibit E-2 to demonstrate required control efficiency and to support designation of tanks as Level 1 are not stated. For example, calculations provided for maximum vapor pressure assume a maximum liquid surface temperature of 82 F; demonstrate/provide details as to why this assumption is appropriate.



Identification of the appropriate level of control for each tank is based on two criteria: 1) the theoretical (or actual) maximum vapor pressure for tank contents, and 2) the tank volume.

The emission control system for the regulated tanks consists of two sets of carbon canisters. Each set consists of two 55-gallon canisters in series. Because the tanks have piping to the common control device a single "worst case" vapor pressure can be assessed for the entire system.

As indicated in the table "Vapor Pressure Calculations" in Exhibit E-2 of the Part B application, the waste liquids contained in the tanks will typically consist of several organic solvent constituents. Based on the representative liquid profile, calculation of actual vapor pressure was presented in Exhibit E-2 at 82 °F (27.78 °C). This tank liquid temperature was selected since it is provided as the annual average in certain TANKS 4.09 cases for Phoenix, Arizona. The results showed a maximum vapor pressure of 14.27 kPa.

A more conservative "worst case" case for organic vapor pressure can be presented by assuming that 100 percent of the tank contents are the most volatile individual constituent (acetone), and that the tank liquid temperature is at a level that reflects peak summer conditions.

Vapor pressure from Antoine constants provided in Lange's Handbook of Chemistry (see reference in Exhibit E-2), assuming a summer tank liquid temperature of 115 °F (46.1 °C):

$$\text{Log } P_v = A - B / (C + T [^{\circ}\text{C}]) = 2.727$$

If the tank contains a single constituent, the tank partial pressure equals the vapor pressure:

$$P_v = P_i = 533.4 \text{ mmHg} = 71.1 \text{ kPa}$$

Even for the most volatile constituent at extreme summer conditions for the CHA facility, the organic partial pressure in the storage tanks does not exceed the Level 1 limiting threshold of 76.6 kPa for tanks having less than 75 m<sup>3</sup> volume. As stated in the Part B Application, each CHA tank has a maximum working volume of 37.8 m<sup>3</sup>.

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Item 66 d.

State what waste stream is used in Exhibit E-2's Antoine Equation and why this is appropriate.

The waste stream constituent profile used in the vapor pressure calculation in Exhibit E-2 is a representative composite of tank contents throughout the Clean Harbors system. Clean Harbors conducted an in-house study at various locations throughout the company and arrived at an average percentage of constituents in the flammable liquid storage tanks. There is no single composition profile that can represent the waste included in the tanks since the composition changes with the addition of any new waste stream. However, the selection of composition profile is not important in determining the appropriate level of control for these tanks. As illustrated in the reply for Item 66c, the Level 1 control threshold is not exceeded even if the most volatile constituent present in the CHA waste stream (acetone) is assumed to comprise the entire waste stream at an extreme summer liquid temperature of 115 °F.

Item 66 e.

Provide an emission controls system written inspection and monitoring plan (and schedule) for carbon changeout/system as referenced in Sec E.3.6 (40 CFR 270.27(a)(5) and (6)).

An example Inspection and Monitoring Log is provided as Figure E-2 in the Part B application. The use of this form satisfies the inspection and monitoring requirements contained in the MCAQD Operation and Maintenance Plan for the carbon canister adsorption units. The primary inspection procedures consist of:

- Monthly sampling of organic vapor concentration between canisters at the control system vent using a portable analyzer that is consistent with Reference Method 21 sampling technique.
- On a monthly basis, at the time of the organic vapor sampling, the canisters, valves, fittings, piping and other equipment that are contacted by waste vapors are visually inspected for physical integrity and presence of breaks or leaks.

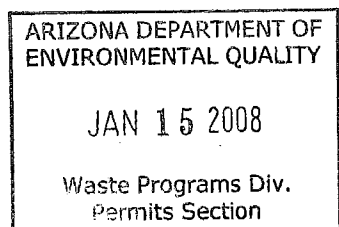
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- The location of each connection is identified such that a maintenance person can return to the specific item to perform repairs if required.
- On an annual basis, organic vapor monitoring is conducted at joints and connections in the piping from the tanks to the carbon control device, as required by monitoring provisions in 40 CFR 264.1034 (b).

Any hazardous waste tanks containing waste or organic vapors including the emission control system connections to these tanks will be inspected monthly. An inspection form is completed for each inspection and sampling event, in a format that complies with 40 CFR 264/265, Subparts BB and CC, an example is provided in Figure E-2. Repairs of leaks found by visual inspection or monitoring are to be performed promptly.



**Table 66-1**  
**Carbon Working Capacity Calculations**  
**Clean Harbors - Arizona**

	Acetone <sup>2</sup>	Toluene	m-Xylene	IPA
Specific Gravity	0.792	0.866	0.867	0.789
Molecular Weight	58.08	92.13	106.16	60.09
Molar Density (gmol/mL)	0.0136	0.0094	0.0082	0.0131
E (Fig 4)		9	7	11
Equilibrium Point - mL ads/g Carbon		0.3	0.5	0.2
lb Adsorbed/lb Carbon	0.300	0.260	0.434	0.158
Reference <sup>3</sup>	Fig 10	Tbl 1-Fig 4	Tbl 1-Fig 4	Tbl 1-Fig 4
<u>Vapor Press. (mmHg)</u>				
@ 70 F	180	20	5	30
@ 100F	380	50	15	90
<u>Vapor Molar Density (lbmole/ft<sup>3</sup>)</u>				
@ 70 F	0.00061	0.00007	0.00002	0.00010
@ 100F	0.00122	0.00016	0.000048	0.00029
<u>Vapor Density (lb solv/ft<sup>3</sup>)</u>				
@ 70 F	0.036	0.006	0.002	0.006
@ 100F	0.071	0.015	0.00512	0.017
<b><u>Solvent Liquid Volume</u></b>				
<b><u>Controlled <sup>1</sup> (Gallons)</u></b>				
@ 70 F	<b>22728</b>	<b>111673</b>	<b>646842</b>	<b>69330</b>
@ 100F	<b>11375</b>	<b>47198</b>	<b>227819</b>	<b>24418</b>

1 - Assume tank headspace is saturated with respect to the individual solvent, at tank temperature.

Working capacity = 50% equilibrium capacity, 720 pounds of total carbon.

2 - For bed capacity evaluation, acetone is a "limiting case"

However, acetone is not a regulated air pollutant

3 - Equilibrium data from:

Handbook of Separation Techniques for Chemical Engineers, Schweitzer, 1996.

Table 1 - Figure 4, pages 3-10, 3-11 (equilibrium carbon capacity)

Figure 10, page 3-14 (acetone isotherm)

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TANK 101, 102 &amp; 103

8" DIA. x 12'-2" HIGH  
MATL: A36 CARBON STEEL

TANK 302, 303 &amp; 501

10'-1" DIA. x 17' HIGH  
MATL: A36 CARBON STEEL

TANK 104

6'-8" DIA. x 18'-3" HIGH  
MATL: A36 CARBON STEEL

TANK 301

10'-1" DIA. x 17'-2" HIGH  
MATL: A36 CARBON STEEL

FIGURE 00-1

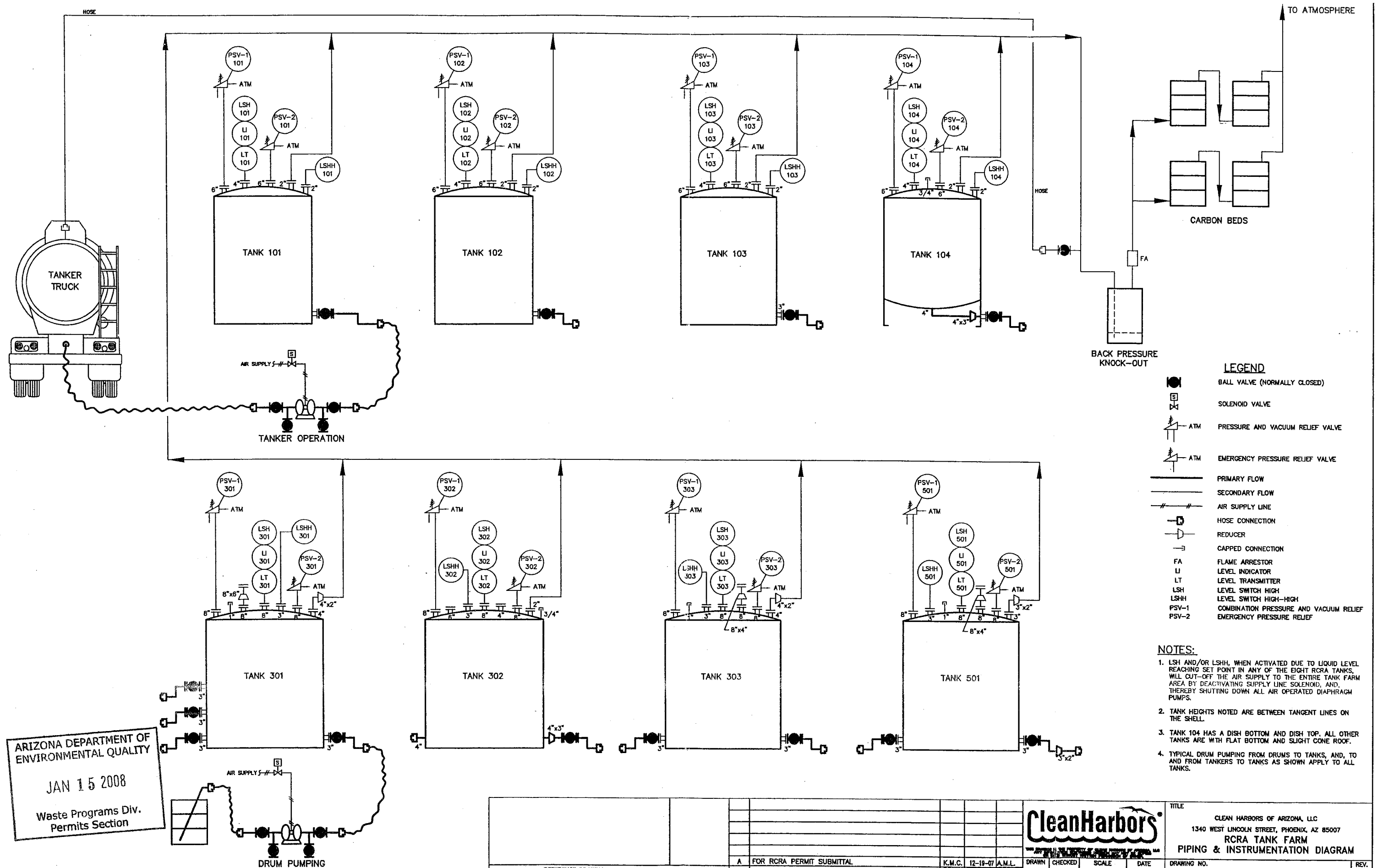
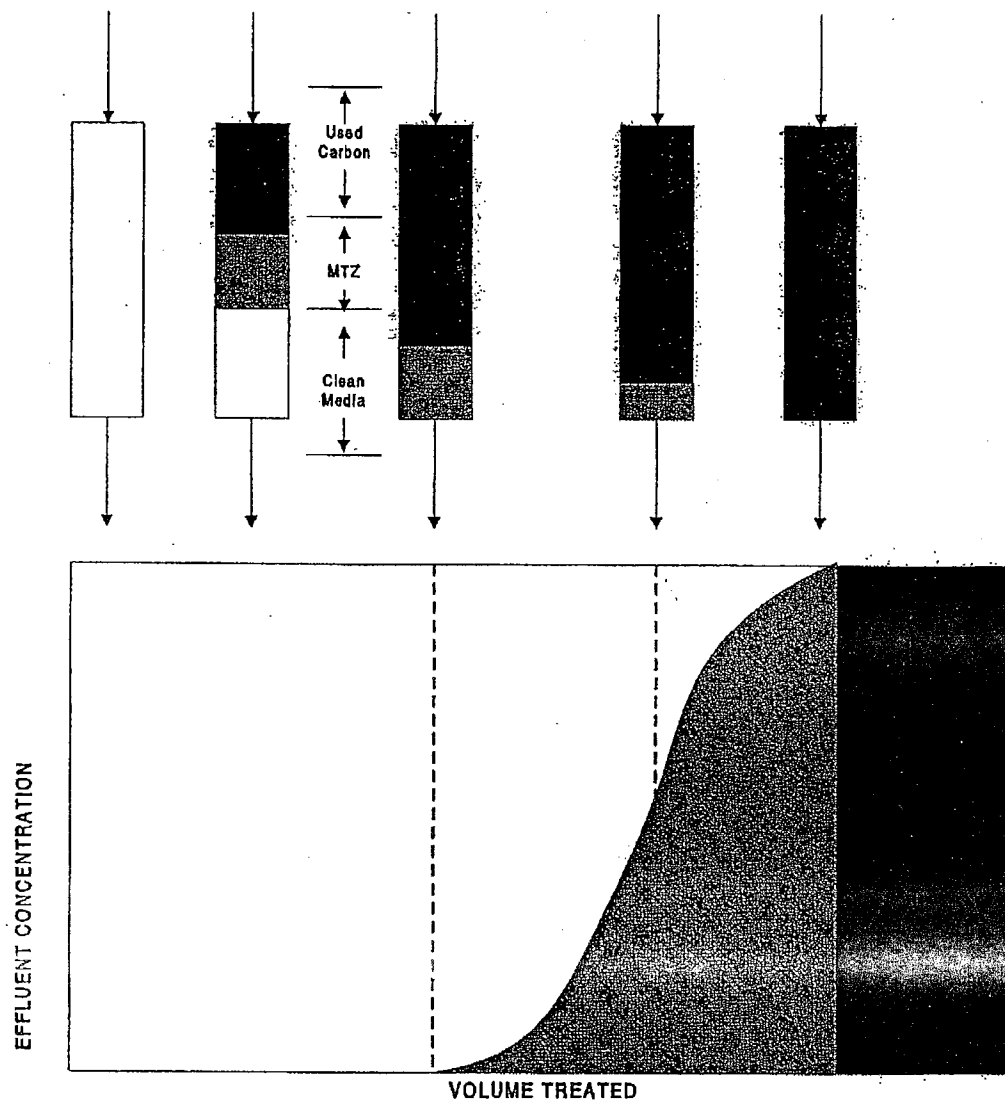
PIPING AND INSTRUMENTATION DIAGRAM FOR CHA STORAGE TANKS AND  
CARBON ADSORBER CONTROL SYSTEM

FIGURE 66-2

ILLUSTRATION OF ADSORPTION MASS TRANSFER ZONE AND  
BREAKTHROUGH - SINGLE BED

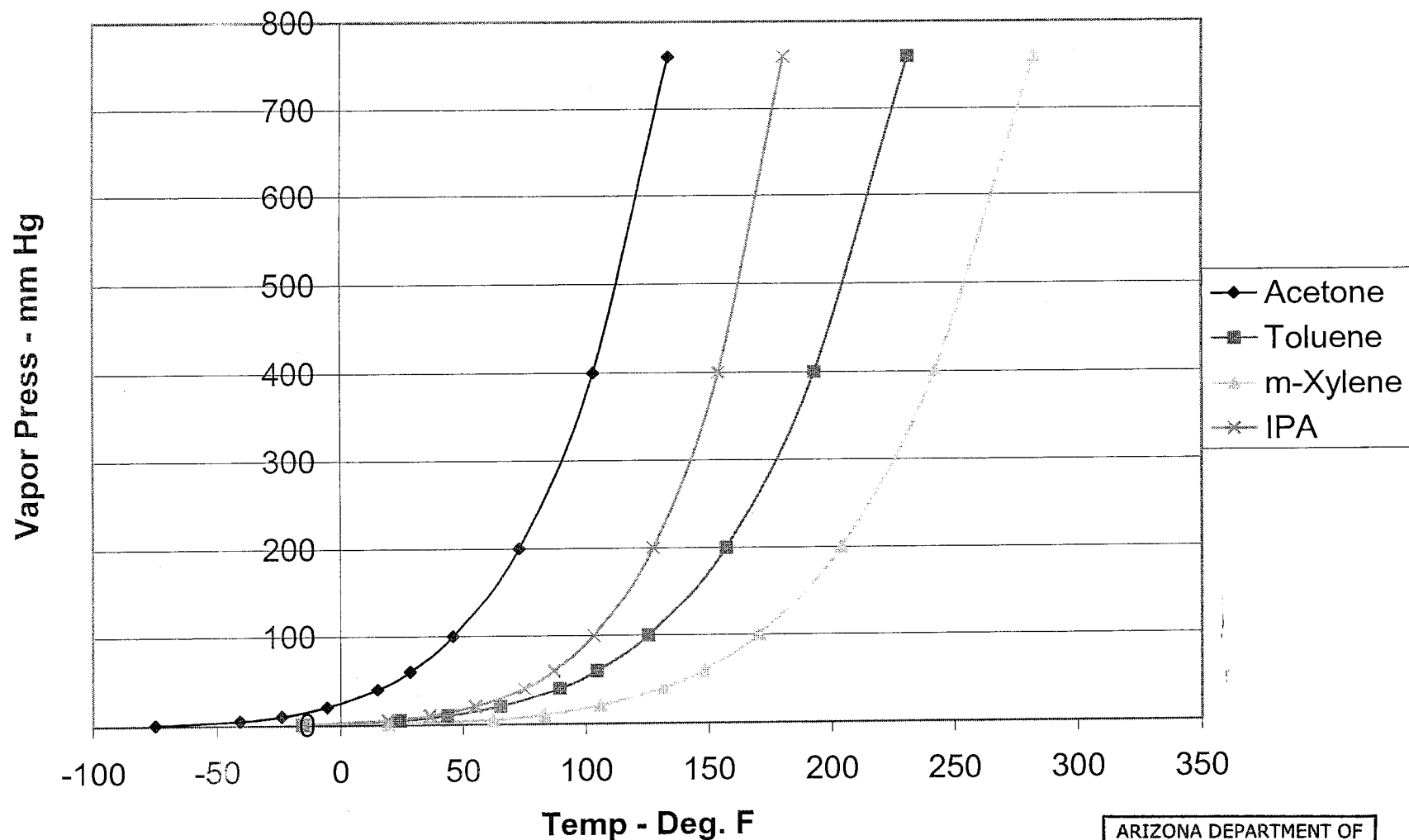


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**Figure 66 - 3**  
**Vapor Pressure Data - CHA Solvents**



Source: Perry's Chemical Engineering Handbook, 5th Ed. Table 3-8.

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$$E_i = RT \ln \frac{P_0}{P_s}$$

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where  $P_s$  = equilibrium vapor pressure in the gas phase  
 $P_0$  = vapor pressure in the adsorbed phase

The value  $\phi_i$  corresponding to  $E_i$  is  $x/d_T$  where  $x$  is the weight of the adsorbed film and  $d_T$  is the density of the liquid at temperature  $T$ . The Polanyi equation is very important in chemical engineering design calculations because of its ability to predict isotherms for any gas, given a single isotherm for one gas on the same solid. Dubinin et al.<sup>13-16</sup> published a large number of adsorption correlation results using the Polanyi equation. Lewis et al.<sup>17</sup> improved the Polanyi-Dubinin method by substituting fugacity in place of pressure and replacing  $V$ , the molar volume of the liquid at temperature  $T$ , by  $V^1$ , the molar volume of the liquid at a temperature where its vapor pressure is equal to the equilibrium pressure  $p$ .

The Polanyi potential theory of adsorption basically describes the volume filling of micropores in a typical adsorbent structure. The theory is valid primarily below the critical temperature of the adsorbate. The applicability of this theory to industrial adsorbents is expressed by the equation

$$W = W_0 \exp(-kE^2) \quad (14)$$

where  $W$  = volume of the adsorbate as liquid

$W_0$  = volume of adsorbent filled when  $E$  decreases to zero, which in most cases is the total pore volume of the adsorbent.

$k$  = constant

The plot of  $W/W_0$  against  $E$ , the characteristic curve representing the relationship between volume of the available adsorption volume and the adsorption potential, is basically a statistical relationship expressing the fraction of the pore volume filled at different adsorption potential  $E$  values.

The filled volume of the adsorbent is

$$W = av_m \quad (15)$$

where  $a$  = constant and

$v_m$  = molar volume of the adsorbate

Equation (12) indicated the temperature invariance of the adsorption potential, and

$$\frac{E_1}{E_2} = \beta \approx \frac{v_{m1}}{v_{m2}} \approx \frac{|P_1|}{|P_2|} \quad (16)$$

where  $\beta$  = the affinity coefficient or the relative molar work of vapor adsorption compared with a standard substance (often for benzene = 1.0), and

$|P|$  = parachor for the bulk liquid phase

Therefore, with these equations it is possible to calculate the adsorption isotherm of nearly every substance at any temperature from a single measured adsorption isotherm at one temperature.

A typical potential curve is shown on Fig. 3 for W.R. Grace 13X molecular sieve, and a generalized form is shown on Fig. 4 in conjunction with Table 1 for 1000 to 1100 m<sup>2</sup>/g steam-activated coconut-shell carbon (Nusorb CC 1000 grade). The  $E$  values of Table 1 are given for 20% of the ACGIH threshold limit values.

Langmuir<sup>18</sup> presented an ideal monolayer adsorption isotherm

$$V = \frac{V_m b p}{1 + b p} \quad (17)$$

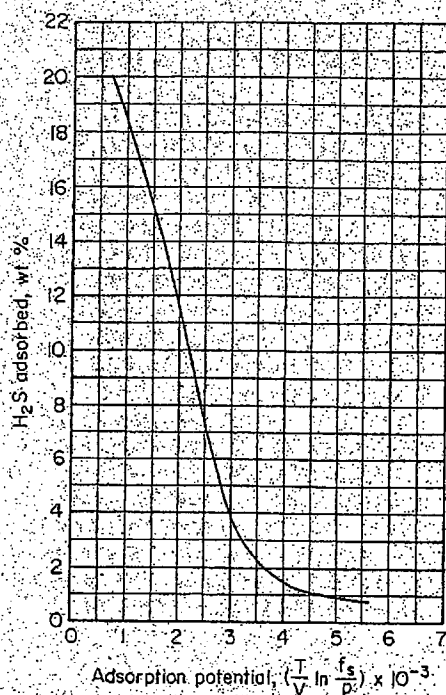


FIG. 3 Potential curve for  $H_2S$  on 13x molecular sieve.

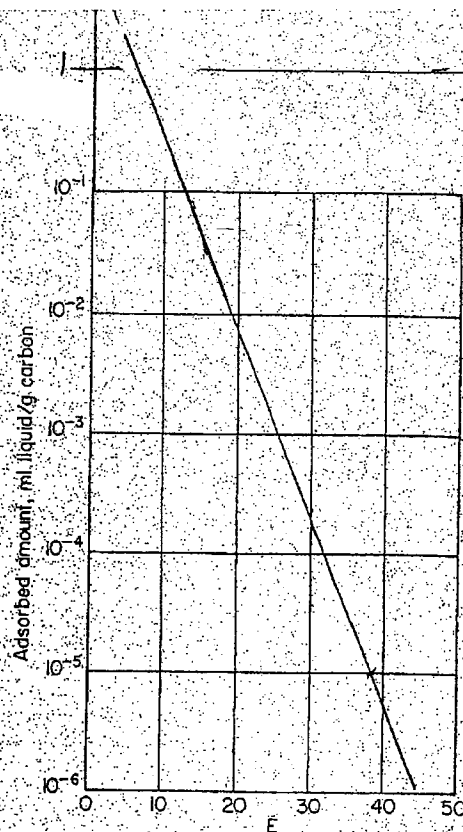


FIG. 4 Experimental characteristic curve for 1000 to 1100  $m^2/g$  coconut-shell activated carbon.

where  $V$  = volume of gas (0°C, 760 mmHg) adsorbed per unit mass of adsorbent

$V_m$  = volume of gas (0°C, 760 mmHg) adsorbed per unit of adsorbent with a layer one molecule thick

$b$  = empirical constant in reciprocal pressure unit which has limited practical application

Brunauer, Emmett, and Teller<sup>19</sup> expanded the Langmuir isotherm to include multilayer adsorption

$$V = \frac{V_m C x}{(1 - x)[1 + (C - 1)x]} \quad (18)$$

where  $V_m$  and  $C$  are empirical constants and  $x = p/p_s$ . The constant  $C$  is derived from the heat of adsorption and  $V_m$  represents the volume of gas required to cover the surface with a monomolecular layer.

Although the BET equation has limitations (such as the assumption that the heat of adsorption is constant over the entire surface coverage of the monolayer and that the monolayer is completed before the formation of the secondary layer begins, with a heat of adsorption equaling that of the heat of liquefaction), it is very useful because it permits the numerical determination of surface area. Knowing the area occupied by a single molecule of the adsorbent and the number of molecules needed to form a monolayer, it is possible to express the surface area of the adsorbent in  $cm^2/g$  or  $m^2/g$ .

Surface areas of commonly used adsorbents determined in this manner are:

Activated alumina:	50 to 250 $m^2/g$
Silica gel:	200 to 600 $m^2/g$
Molecular sieve:	800 to 1000 $m^2/g$
Activated carbon:	500 to 2000 $m^2/g$

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Adsorption isotherms are most commonly used to select the adsorbent or even the adsorption process as a unit operation for the adsorptive separation of gases.

TABLE 1 E Values for Use With Potential Plot, Fig. 4

(E values are for 20% of the ACGIH threshold limit values)

Contaminant	E	Contaminant	E
Acetone	18	Formaldehyde	75
Acetaldehyde	27	Hydrogen	418
Acetylene	48	Hydrogen chloride	81
Allyl alcohol	23	Hydrogen fluoride	166
Ammonia	54	1-Hexene	10
Amyl alcohol	7	n-Hexane	10
Benzene	16	Hexamethylcyclotrisiloxane	5
n-Butane	17	Hydrogen sulfide	63
Butene-1	19	Isopropyl alcohol	15
cis-Butene-2	18	Isobutyl alcohol	11
trans-Butene-2	19	Methylene chloride	22
n-Butyl alcohol	10	Methyl chloroform	12
Butraldehyde	11	Methyl ethyl ketone	14
Butyric acid	8	Methyl isopropyl ketone	10
Carbon disulfide	22	Methyl alcohol	31
Carbon monoxide	110	3-Methyl pentane	10
Chlorine	55	Methane	43
Chloroacetone	13	Monomethylhydrazine	20
Chlorobenzene	9	Methyl mercaptan	35
Chloropropane	16	Nitric oxide	107
Cyclohexane	11	Nitrogen tetroxide	32
Cyclohexanol	8	Nitrous oxide	42
Cyanamide	18	Propylene	28
1,1-Dimethylcyclohexane	7	Isopentane	13
trans-1,2-Dimethylcyclohexane	7	n-Pentane	13
2,2-Dimethylbutane	10	Propane	24
1,4-Dioxane	16	n-Propylacetate	9
Dimethylhydrazine	23	Propyl mercaptan	13
Ethyl alcohol	20	Phenol	9
Ethyl acetate	12	Sulfur dioxide	49
Ethylene dichloride	17	Toluene	9
Ethylene	42	Trichloroethylene	13
Ethylene glycol	7	Tetrachloroethylene	10
trans-1, me-3, ethylcyclohexane	6	1,1,3-Trimethylcyclohexane	6
Ethyl sulfide	10	Tetrafluoroethylene	30
Ethyl mercaptan	23	Freon-21	23
Freon-11	22	Valeric acid	4
Freon-12	22	Vinyl chloride	27
Freon-22	28	Vinylidene chloride	19
Freon-23	40	m-Xylene	7
Freon-114	14	o-Xylene	8
Freon-114 unsymmetrical	16	p-Xylene	7
Freon-125	25		

If the adsorption isotherm shape is Type I, II, or IV, adsorption can be used to separate the adsorbate from the carrier gas. If it is Type III or V, adsorption will probably not be economical for the separation.

The shape of the adsorption isotherm for each temperature is a function of both the properties of the adsorbate and the adsorbent. As an example, Figs. 5 and 6 show CO<sub>2</sub> and N<sub>2</sub>O adsorption isotherms on the same 1800 m<sup>2</sup>/g coconut-shell carbon. These are pure-gas isotherms where concentration is expressed as absolute adsorbate pressure. The CO<sub>2</sub> adsorption at low temperature shows significant hysteresis (higher sorption capacity on desorption than on adsorption). As the temperature increases the hysteresis loop diminishes, and above 169 K the adsorption is reversible. The saturation adsorption is constant in the reversible range but increases with the development of hysteresis toward low temperatures. The adsorption of N<sub>2</sub>O on the same carbon shows that hysteresis is much smaller and occurs in a different shape at low and high temperatures. Also at high temperatures a rise in the saturation capacity is observed.

Figure 7 shows the CO<sub>2</sub> adsorption isotherm on a structurally different 1400 m<sup>2</sup>/g coal carbon, which obviously has larger pore diameters also. The low-temperature hysteresis loop disappears with increasing

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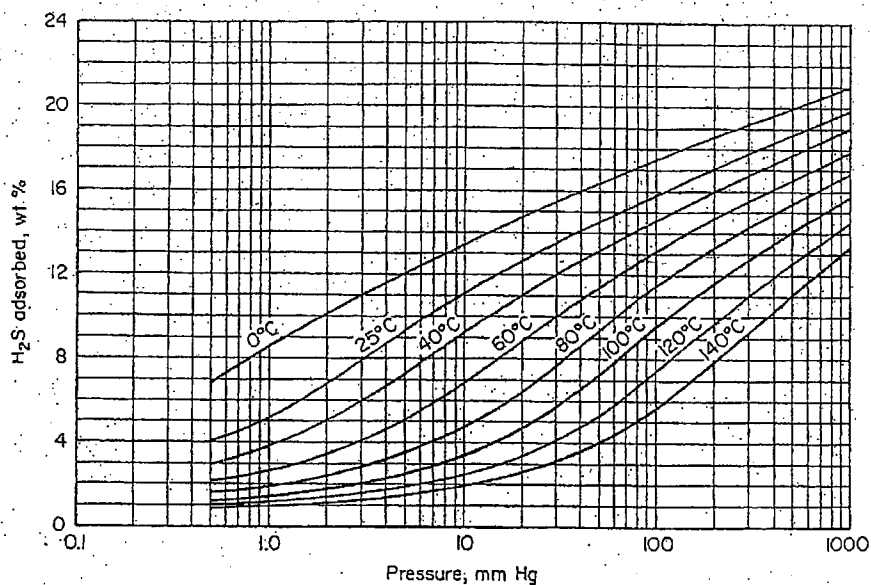


FIG. 8 Hydrogen sulfide adsorption isotherms on 13x molecular sieves.

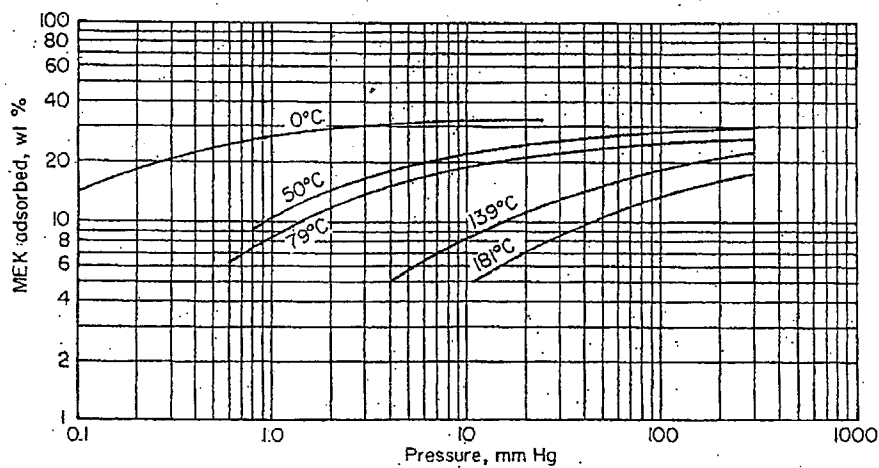


FIG. 9 Methyl ethyl ketone adsorption isotherms on Union Carbide 45 carbon.

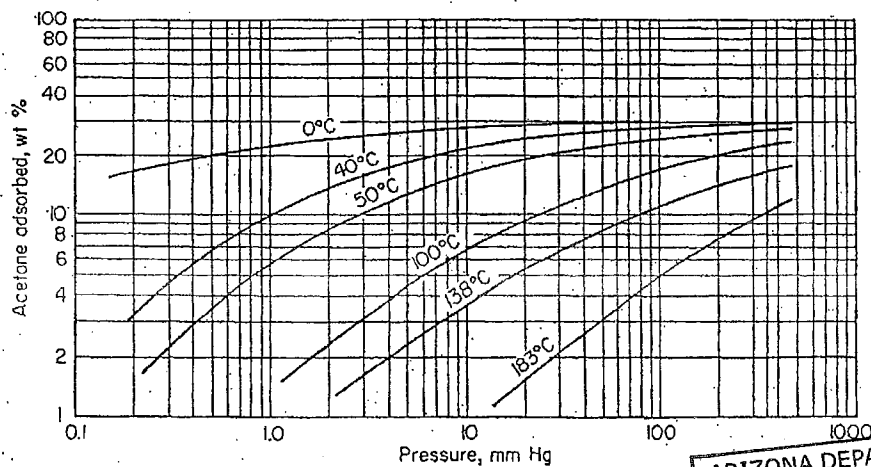


FIG. 10 Acetone adsorption isotherms on Union Carbide 45 carbon.

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1 Mar 2001

Engineering and Design  
ADSORPTION DESIGN GUIDE

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**2-5. Dynamic Operation Testing.** The following parameters must be considered when designing a pilot scale evaluation.

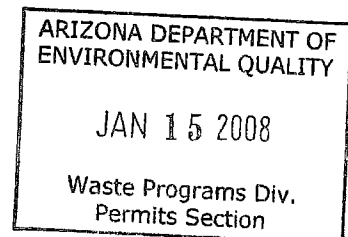
*a. Breakthrough Curves.* The breakthrough curve can be defined as the "S" shaped curve that typically results when the effluent adsorbate concentration is plotted against time or volume. Breakthrough curves can be constructed for full scale, dynamic, or pilot testing. The breakthrough point is the point on the breakthrough curve where the effluent adsorbate concentration reaches its maximum allowable concentration, which often corresponds to the treatment goal. The treatment goal is usually based on regulatory or risk based numbers (see Figure 2-4).

*b. Mass Transfer Zone.* The mass transfer zone (MTZ) is the area within the adsorbate bed where adsorbate is actually being adsorbed on the adsorbent. The MTZ typically moves from the influent end toward the effluent end of the adsorbent bed during operation. That is, as the adsorbent near the influent becomes saturated (spent) with adsorbate, the zone of active adsorption moves toward the effluent end of the bed where the adsorbate is not yet saturated. The MTZ is sometimes called the adsorption zone or critical bed depth. The MTZ is generally a band, between the spent carbon and the fresh carbon, where adsorbate is removed and the dissolved adsorbate concentration ranges from  $C_0$  to  $C_e$ .

(1) The length of the MTZ can be defined as  $L_{MTZ}$ . When  $L_{MTZ}$  = bed depth, it becomes  $L_{CRIT}$ , or the theoretical minimum bed depth necessary to obtain the desired removal.

(2) As adsorption capacity is used up in the initial MTZ, the MTZ advances down the bed until the adsorbate begins to appear in the effluent. The concentration gradually increases until it equals the influent concentration. In cases where there are some very strongly adsorbed components, in addition to a mixture of less strongly adsorbed components, the effluent concentration very seldom reaches the influent concentration because only the components with the faster rate of movement through the adsorber are in the breakthrough curve. The MTZ is illustrated in Figure 2-5.

(3) Adsorption capacity is influenced by many factors, such as flow rate, temperature, and pH (liquid phase). The adsorption column may be considered exhausted when the effluent adsorbate concentration equals 95–100% of the influent concentration. This is illustrated in Figure 2-5.



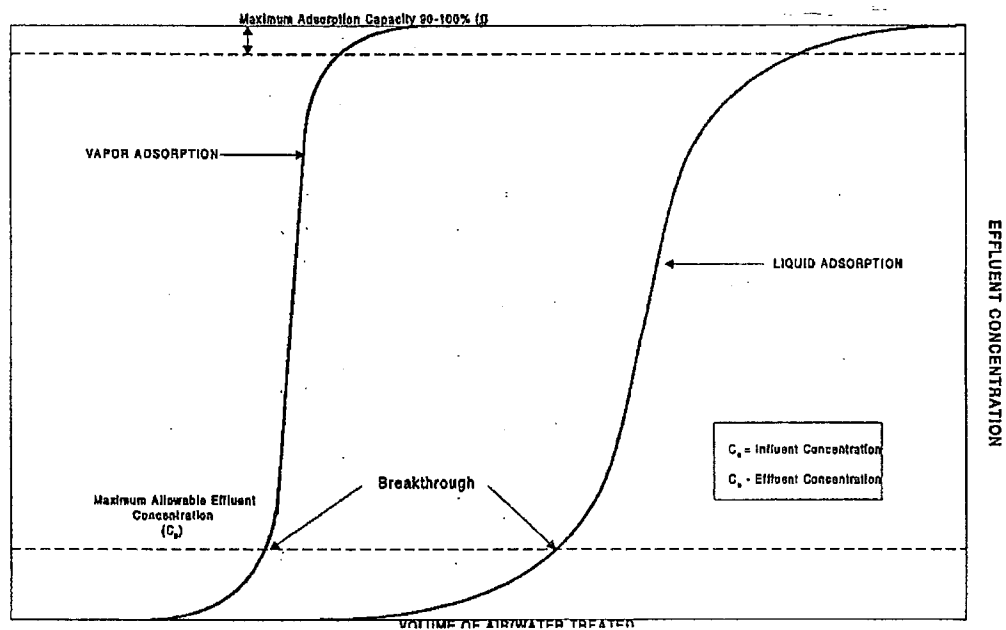


Figure 2-4. Comparison of idealized vapor and liquid breakthrough curves.

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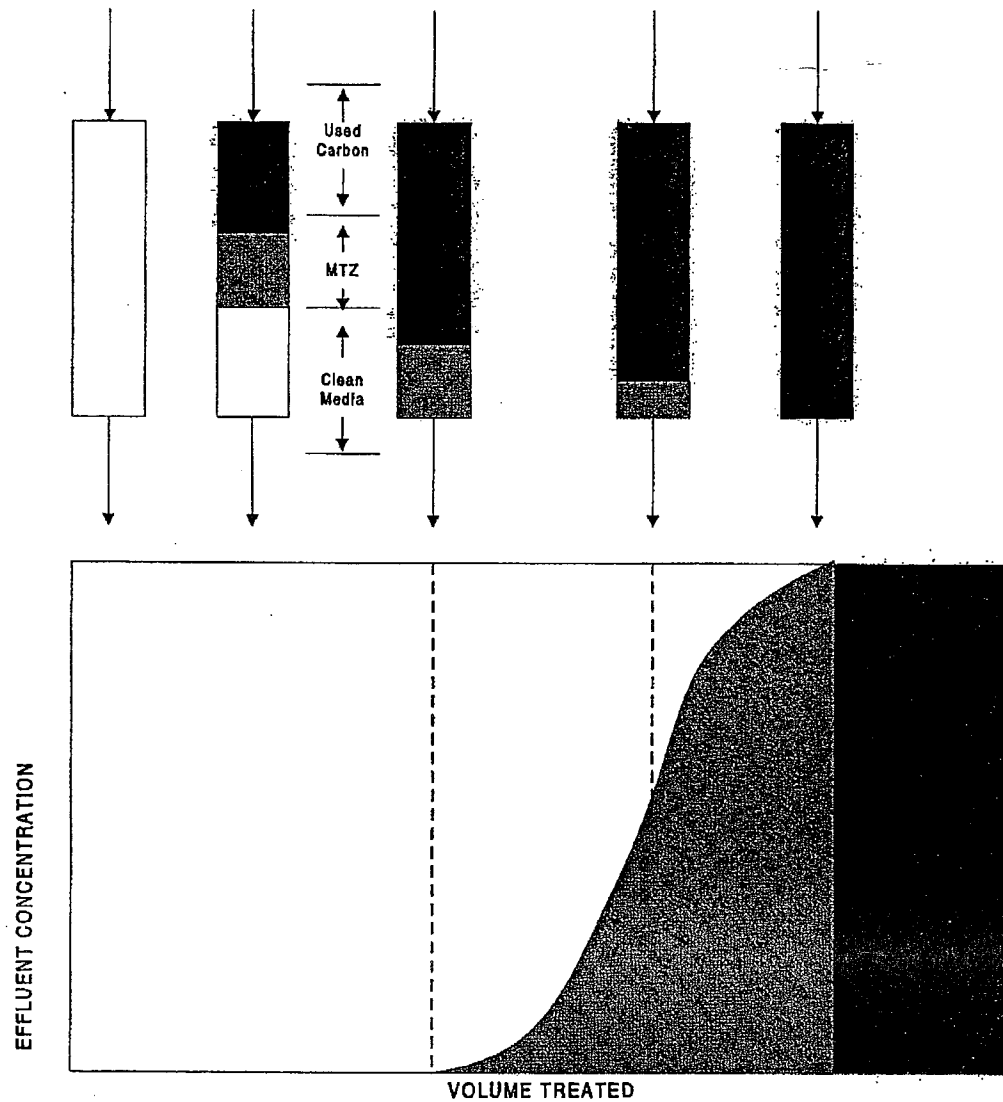


Figure 2-5. Adsorption column mass transfer zone and idealized breakthrough zone.

# Chapter 1

## Carbon Adsorbers

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### 1.2.3 Estimating Carbon Requirement

#### 1.2.3.1 Overview of Carbon Estimation Procedures

Obtaining the carbon requirement ( $M_c$  or  $M_q$ ) is not as straightforward as determining the other adsorber design parameters. When estimating the carbon charge, the sophistication of the approach used depends on the data and calculational tools available.

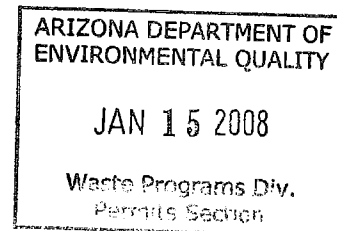
One approach for obtaining the carbon requirement is a rigorous one which considers the unsteady-state energy and mass transfer phenomena occurring in the adsorbent bed. Such a procedure necessarily involves a number of assumptions in formulating and solving the problem. Such a procedure is beyond the scope of this Manual at the present time, although ongoing work in the Agency is addressing this approach.

In preparing this section of the Manual, we have adopted a rule-of-thumb procedure for estimating the carbon requirement. This procedure, while approximate in nature, appears to have the acceptance of vendors and field personnel. It is sometimes employed by adsorber vendors to make rough estimates of carbon requirement and is relatively simple and easy to use. It normally yields results incorporating a safety margin, the size of which depends on the bed depth (short beds would have less of a safety margin than deep beds), the effectiveness of regeneration, the particular adsorbate and the presence or absence of impurities in the stream being treated.

#### 1.2.3.2 Carbon Estimation Procedure Used in Manual

The rule-of-thumb carbon estimation procedure is based on the "working capacity" ( $W_c$ , lb VOC/lb carbon). This is the difference per unit mass of carbon between the amount of VOC on the carbon at the end of the adsorption cycle and the amount remaining on the carbon at the end of the desorption cycle. It should not be confused with the "equilibrium capacity" ( $W_e$ ), defined above in Section 1.1.3. Recall that the equilibrium capacity measures the capacity of virgin activated carbon when the VOC has been in contact with it (at a constant temperature and partial pressure) long enough to reach equilibrium. In adsorber design, it would not be feasible to allow the bed to reach equilibrium. If it were, the outlet concentration would rapidly increase beyond the allowable outlet (or "breakthrough") concentration until the outlet concentration reached the inlet concentration. During this period the adsorber would be violating the emission limit. With non-regenerable (cannister) type systems, placing multiple vessels in a series can substantially decrease concerns of breakthrough.

The working capacity is some fraction of the equilibrium capacity. Like the equilibrium adsorptivity, the working capacity depends upon the temperature, the VOC partial pressure, and the VOC composition. The working capacity also depends on the flow rate and the carbon bed parameters.





The working capacity, along with the adsorption time and VOC inlet loading, is used to compute the carbon requirement for a canister adsorber or for an intermittently operated fixed-bed adsorber as follows:

$$M_{c_i} = \frac{m_{voc}}{w_c} \theta_A \quad (1.13)$$

where

$m_{voc}$  = VOC inlet loading (lb/h)

Combining this with Equations 1.10 and 1.11 yields the general equation for estimating the system total carbon charge for a continuously operated system:

$$M_c = \frac{m_{voc}}{w_c} \theta_A \left( 1 + \frac{N_D}{N_A} \right) \quad (1.14)$$

Values for  $w_c$  may be obtained from knowledge of operating units. If no value for  $w_c$  is available for the VOC (or VOC mixture) in question, the working capacity may be estimated at 50% of the equilibrium capacity, as follows:

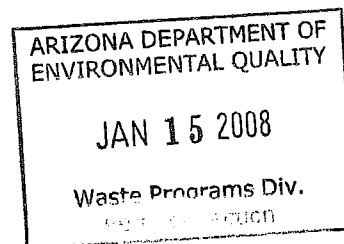
$$w_c \approx 0.5w_{e(max)} \quad (1.15)$$

where

$w_{e(max)}$  = the equilibrium capacity (lb VOC/lb carbon) taken at the adsorber inlet (i.e., the point of maximum VOC concentration).

(Note: To be conservative, this 50% figure should be lowered if short desorption cycles, very high vapor pressure constituents, high moisture contents significant amounts of impurities, or difficult-to-desorb VOCs are involved. Furthermore, the presence of strongly adsorbed impurities in the inlet VOC stream may significantly shorten carbon life.)

As Equation 1.14 shows, the carbon requirement is directly proportional to the adsorption time. This would tend to indicate that a system could be designed with a shorter adsorption time to minimize the carbon requirement (and equipment cost). There is a trade-off here not readily apparent from Equation 1.14, however. Certainly, a shorter adsorption time would require less carbon. But, it would also mean that a carbon bed would have to be desorbed more frequently. This would mean that the regeneration steam would have to be supplied to the bed(s) more frequently to remove (in the long run) the same amount of VOC. Further, each time the bed is regenerated



**EXHIBIT E-4**  
**PROCEDURE FOR CALCULATING CARBON EFFICIENCY AND CARBON**  
**REPLACEMENT**

### **CALCULATING CARBON EFFICIENCY**

The efficiency of each carbon canister should be monitored on a monthly basis to determine that the canister is functioning at the manufacturer's specification of 95%.

Volatile Organic Concentrations (VOC's) are measured using a Flame Ionization Detector (FID), or Photo Ionization Detector (PID). In order to verify control efficiency, monitoring will occur at the inlet to the carbon system and at the outlet of the system. The control efficiency is calculated based on the differential between the two monitoring points.

### **PROCEDURE FOR CARBON REPLACEMENT**

Breakthrough is discovered if the carbon efficiency is less than 95%. Once discovered, the first carbon unit shall be replaced within 24 hours of breakthrough. Service shall be completed by removing the primary canister and replacing it with the secondary canister, and then installing a new canister in the secondary position. This will ensure full utilization of all carbon beds. One spare canister may be kept on-site to ensure that replacement can be completed as required.