Wet Suppression System

The use of water as a means of dust suppression has been practiced for more than thirty years in both coal and non-coal mining operations. Water sprays, either directed by nozzles at transfer points, crusher exits and screening operations or applied manually by spray hose at muck piles (piles of rock from blasting) significantly reduce emissions.

System design is not guided by equations based on the physics of the situation, but rather on rules-of-thumb learned from many years of application experience. A wet suppression system as the name implies prevents or suppresses the tendency of the particles to become airborne. From the modest amount of water added (about 1/2 of 1% of weight of stone feed), it is obvious that an increase in density of a particle by means of retention of the water is not the sole mechanism for preventing emissions. The agglomeration of the small particles and the "sticking" of small particles to large pieces of stone is also involved. The precise mechanism of suppression is not as important as the fact that dust is suppressed when water is applied. As discussed later, water alone has poor wetting properties and a solution including a surfactant or surface active ingredient is usually applied. This substantially reduces (about 4:1) the amount of water that is required.

Application is made by spray heads mounted on a spray bar as in Figure 7. There are hundreds of different spray head designs when the combinations of flow, droplet size, coverage angle, spray crossections, etc. are considered. Droplets are generally formed by the water pressure on specially designed channels and exit orifices in the spray heads. Very small droplet sizes that rely on air atomization are practically never used. Different size and types of sprays are often used on different parts of the plant - the

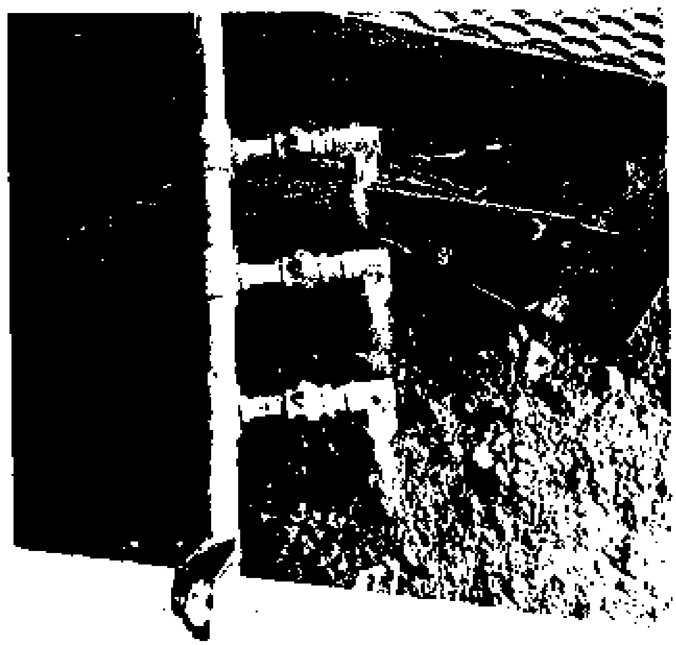


Figure 7

Typical Spray Bar Application

(Photo courtesy of Johnson March)

larger droplet types early in the production and the finer droplet size with the smaller size materials. Choice of spray heads are affected by production rate, stone size, and location ability. The spray bars on which the spray heads are mounted are located with sufficient clearance from the belt, screen, etc. to make sure that moving stone does not impact, trucks or other vehicles are not likely to hit it (as for instance in the loading area of the primary crusher) and so the unit can be observed and maintained with reasonable ease. Sprays are usually located about 3 to 6 feet from the contact point - splashing occurs if too close to the surface and the advantage of a fine spray will be lost, while if spray bars are too far from the surface, crosswinds will have more of a chance to deflect the spray away from its target. The designer usually examines the access problem, stone size and production rate in determining the number, type, and location of the spray positions in a process.

A good figure[5,6] for the amount of solution sprayed on the stone is 1.5 gallons per ton of plant production. If chemicals that reduce the surface tension of water are not used, this figure could be three or four times greater. The 1.5 gallons of solution per ton of production is not applied at one point, rather it is the sum of the solution distributed at various points throughout the plant. Figure 8 shows typical application points for such a system.

Plain water with a surface tension of 73 dynes per cm at 20°C does not exhibit good qualities of wetting, spreading and penetrating. Use of water as the sole spray materials therefore would require more gallons per ton of production than a solution containing a surfactant. When surfactan.

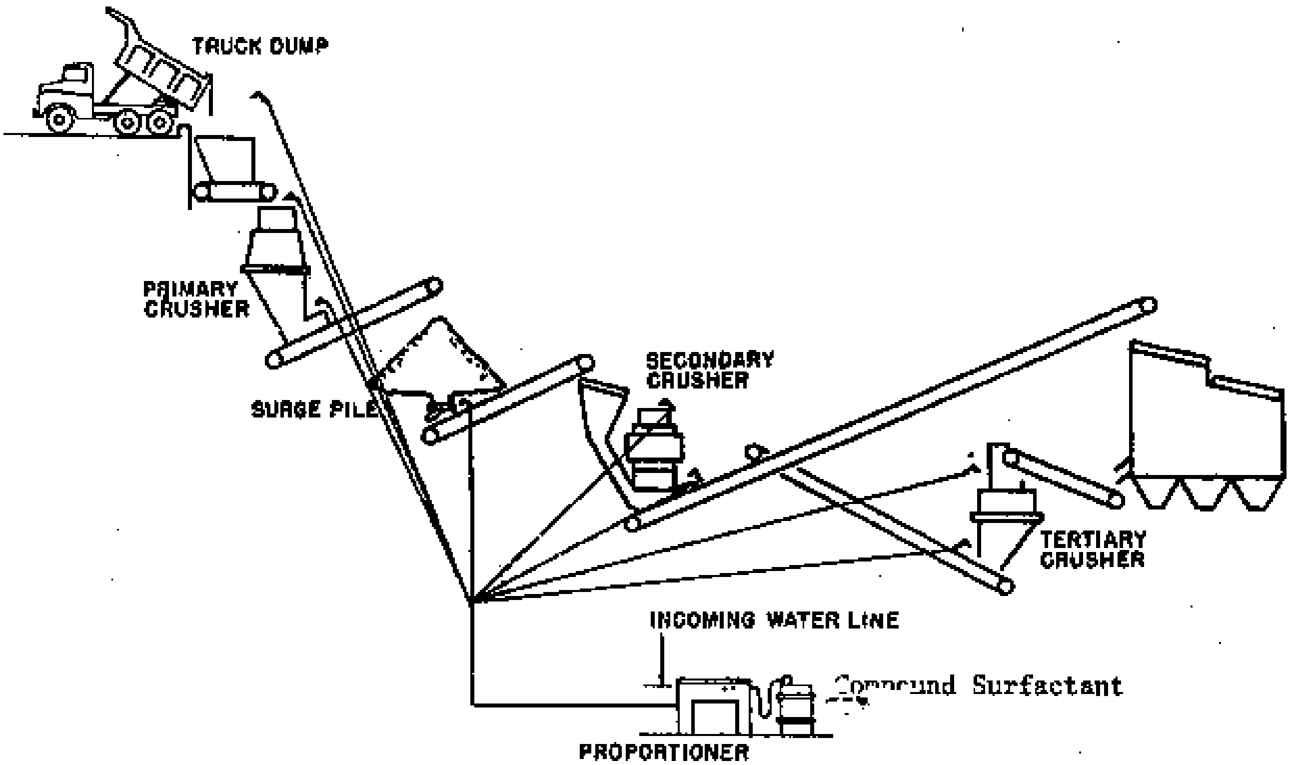


Figure 8

Typical Application Points for a Wet Suppression System in a Crushed Stone Plant are added, the surface tension of water is reduced to 20 to 30 dynes per cm which greatly enhances the dust suppression since the water is able to penetrate the dust particle creating a cementing action between dust particles so that the agglomerates thus formed are too heavy to become airborne.

"Wetting Agents" is a broad category which covers such items as emulsifiers, solubilizers, detergents, foams, penetrants, thickeners, etc. Dust control compounds, on the other hand, are carefully formulated blends in which one or more special surface active agents ("surfactants") have been incorporated. The molecules of these compounds are composed of two groups exhibiting differing solubility characteristics. One part, usually a long chain hydrophilic or water loving group is usually a sulfate, sulfonate, hydroxide, ethylene oxide, etc. The other group is a long chain hydrophobic or water hating group. When properly proportioned, these compounds effectively reduce the water surface tension.

Wet suppressent systems with surfactant solutions appear effective in dust control although there is no quantitative data to specify the degree of control attained. Figures 9 through 11 indicate the effectiveness of well designed wet suppression systems. Such systems, however, cannot be universally used for dust control. A spokesman[6] for one of the largest companies that makes and installs wet suppression systems stated that in their experience about 75% to 85% of crushed stone operations could use wet suppression systems. Some stone type and product size operations could not use the systems. In these cases, dry collection equipment is used or a combination wet suppression and dry collection.

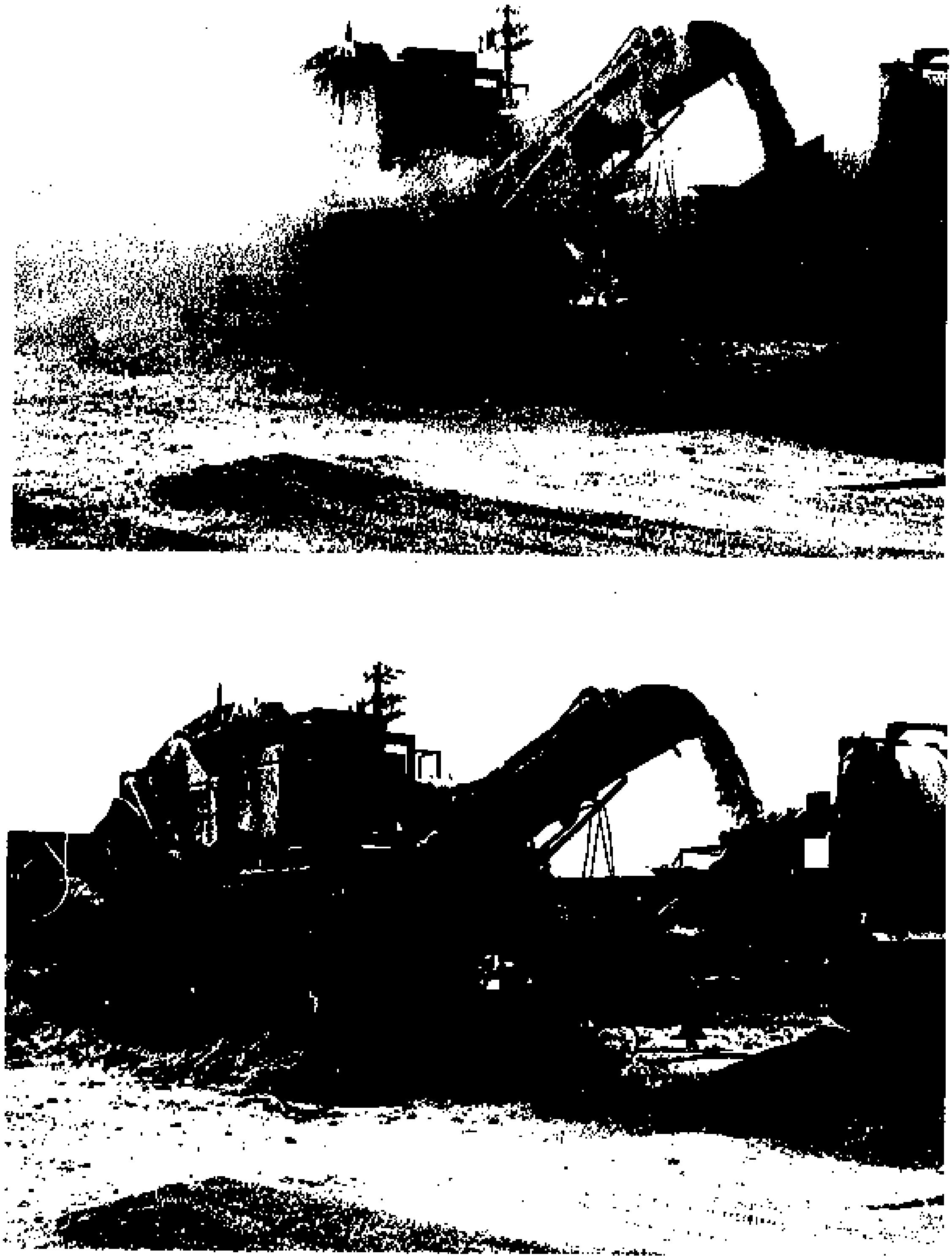
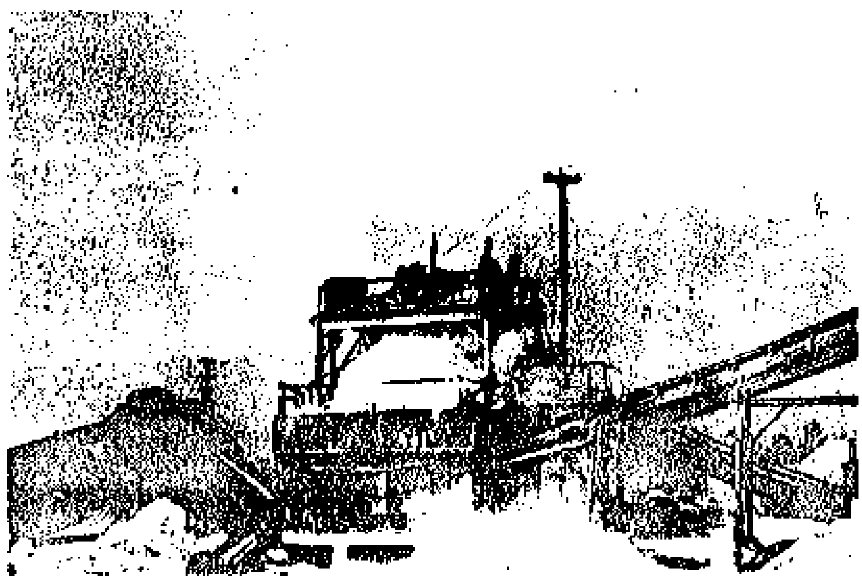


Figure 9
Before and After Applications of Wet Suppression on a Portable Plant
(Photo courtesy of Johnson March)



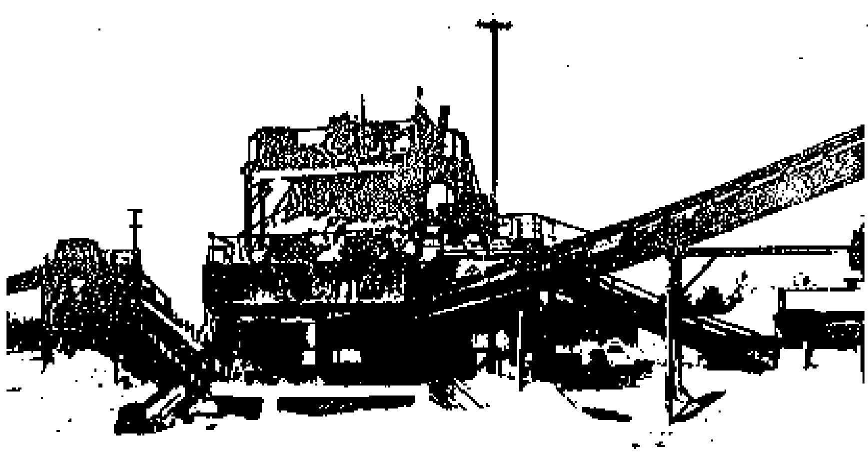


Figure 10
Before and After Wet Suppression on a Screening Operation
(Photo courtesy Johnson March)

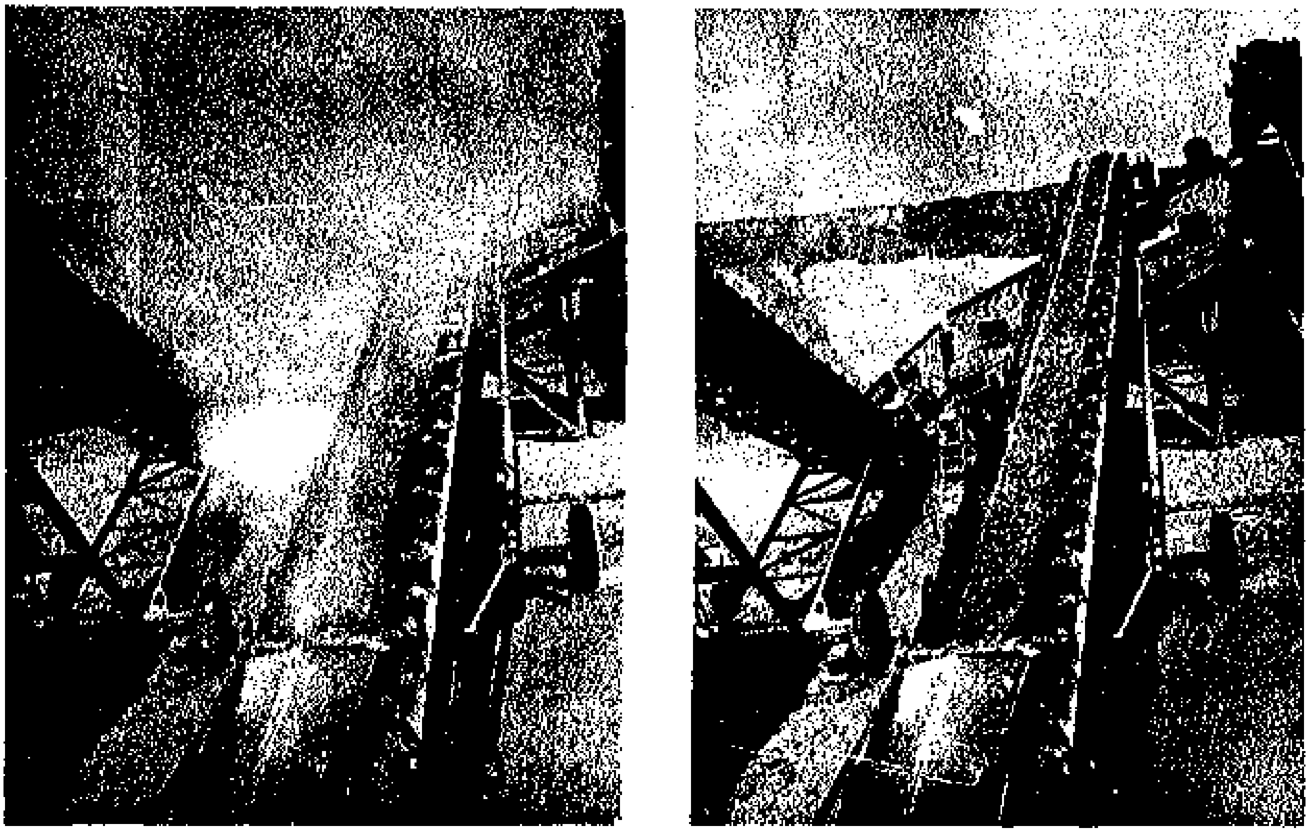


Figure 11

Before and After Wet Suppression on a Portable Crusher-Screening Operation
(Photo courtesy of Johnson March)

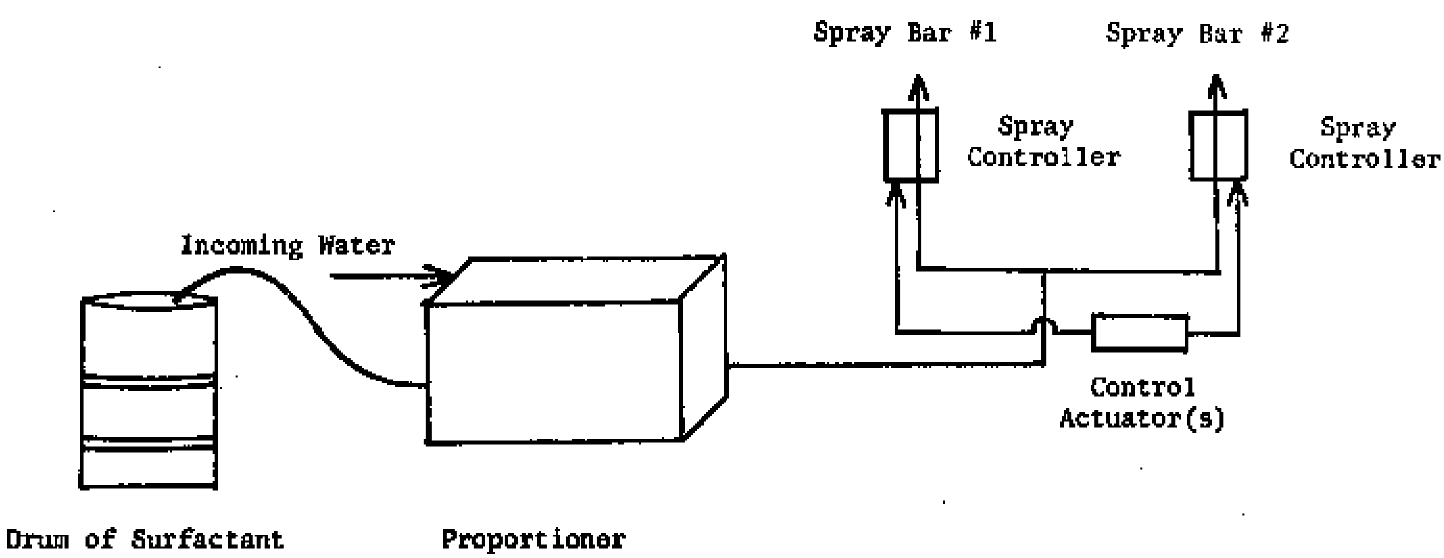
In the initial process stages of production, i.e. primary crushing and screening and secondary crushing and screening, problems associated with wet suppression are minimal. However, when used to control dust at tertiary crushing and screening where small product sizes and screen openings are encountered, problems may arise. The wetted dust tends to blind the openings in fine screens. In agricultural limestone where very fine material is required in a dry state, the addition of water is not practical. Many states also have what is known as a wash out test specification on certain grades of stone. This test is designed to measure and thereby control the amount of -200 mesh (74 microns) particles in the product. A given amount of product is washed in a prescribed fashion and the amount of particles passing a 200 mesh screen weighed. If the weight of these particles exceeds a certain amount of the product weight (usually 1% to 2%), the lot from which the sample was taken is rejected. If the stone is to be used for certain types of concrete products, both the fines and any surfactant remains may have to be washed out of the stone before it is acceptable. This requires an additional plant operation with the need for more water, on the order of several hundred gallons per ton of product processed. The water residue would then have to be treated for solids removal before discharge to surface waters. If discharge is to municipal facilities, a charge based quantity discharge and a surcharge based on solids content may be levied. If the plant discharges into a municipal system that was constructed or upgraded with a government grant under the Federal Water Pollution Control Act, the plant would be assessed both a User Charge and an Industrial Cost Recovery Charge.

A potential problem is occasionally noted relative to a tendency of the surfactant material to cause air voids in concrete and bituminous mixes. No data could be found to identify this as a practical problem on a national basis. Several producers in the Pennsylvania-New York border refrain from using surfactants in their wet suppression systems, but no national pattern or test evidence was uncovered.

System Configuration

The method of suppression described above requires a series of spray bars and nozzles, a supply of surfactant which is proportioned and mixed with the water, a set of connecting pipes, pumps to force the water to the spray heads, and appropriate filters. A method of automatically turning on the system only when material is being produced is required, as is winterizing equipment when the system is to be employed in below-freezing weather.

The system is shown below in schematic with only two spray bars to demonstrate the equipment involved.



The function of the proportioner shown in Figure 12 is to filter the input water if necessary, add surfactant from a drum at the rate of one part to 1000 parts water or more, and develop a pump head of about 150 psi. This pressure is typically used at the truck dump at the front end of the crusher and reduced to about 60 psi at the other spray bars by means of pressure regulators.

The control actuators automatically detect presence of stone on the conveyor and transmit the signal to the spray controllers. The actuators operate on a variety of principles including mechanical displacement of the conveyor belt, weight, electrical interlock with the conveyor drive motors, by measuring the current load to drive motors, and for fine or light weight materials that cause little conveyor deflection or motor drag, by a device mounted on top of the conveyor that is deflected by material on the conveyor.

A spray jet controller is mounted before each spray jet header and consists of a filter and a method of governing the flow of the mixed solution supplied by the proportioner.

Maintenance

According to a report prepared for the U.S. Bureau of Mines by MSA Research Corporation in April, 1974[7], adequate maintenance of dust control systems in non-coal mining and ore processing operations seems to be the exception, rather than the rule. The report contained results of visits to 50 mines and 51 mills (processing plants) of which seven were crushed stone.

Figure 12

Proportioner, Main Pump and Surfactant Drum
(Photo courtesy of Johnson March)

Where wet suppression systems were employed spray bars were found where the nozzles were either completely clogged or clogged to the point where they were ineffective. In most cases, this problem was due to inadequately maintained water line filters. The report was generally critical of the state of maintenance of control equipment which was reported in a poor state of repair in relation to general plant.

As with any dust control device, a wet suppression system must be adequately maintained to keep its efficiency at peak levels. The principal source of trouble is in foreign material blocking the liquid flow. If the system operates on city water the filters can go for months without serious effects whereas if the water is from wells, rivers, or ponds more maintenance will be involved. Although the system details vary from manufacturer to manufacturer there are generally three filters, one at the proportioner, one at each spray controller, and one in each spray. The main filter in the proportioner demands the most attention because it is first to "see" the conditions of the supply water. One manufacturer[8] suggests the following maintenance procedures. After some experience is gained with the system the maintenance schedule can be adjusted. For instance if the strainer baskets remain clean after several weekly checks this procedure could be extended. On the other hand, the strainer basket in the proportioner might need more frequent attention if the input water has a high amount of solids.

DAILY MAINTENANCE

1. At time of start-up of Proportioner

   a. Check pump discharge pressure.

   b. Check operation of level control valve.

   c. Check operation of surfactant pump.

   d. Check level of surfactant compact in drum.

   e. Check operation of Inlet Water Filter.

2. Visually check spray pattern and direction of all spray jets. Clean and adjust as necessary.

WEEKLY MAINTENANCE

1. Clean strainer basket in each Flow Controller.

2. Clean strainer basket in the Proportioner.

3. Check operation of all Automatic Spray Controls.

GENERAL

1. Lubricate all equipment requiring lubrication, including wheels on Automatic Spray Controls, when other plant equipment is lubricated.

2. Before first freezing weather, check all heating equipment. (Winterizing is accomplished by wrapping electrical heating tape around pipes much the same as in winterizing residential.)

More detailed information is usually contained in the System and Equipment Operation and Maintenance Instructions generally furnished by the vendors with the equipment.

Portable Plant Applications

Spray systems are readily installed in portable plants, and by the use of flexible connections from the proportioner to the spray headers, can accomodate changes in plant layout. In cold weather there is a problem in winterizing such installations by using heating tape because of the flexible nature of the hose and its heat transfer characteristics compared to metal piping.

In areas where arid conditions are encountered, there are special problems on water needs for the system which must be considered in setting up the plant. As noted previously, if a surfactant is used, the total water needs for a plant would be about 1.5 gallons per ton of product. If a surfactant is not used, water requirements would be 4 to 5 gallons of water per ton of production.

There are several regions of the country which have arid conditions and where portable plants are extensively used. Eastern Oregon, for example, is one such region of low precipitation and with high reliance on portable plants.

Stone crushing operations in this region might obtain water from three sources; ground water (wells or old quarries that have intercepted the water table), surface water (rivers, streams, lakes, ponds, etc.), or tank truck. Water wells may be constructed when a plant is to remain in one location for a period of time or if the plant returns periodically to the location. This, of course, means that sufficient ground water supplies must be available to meet the plant's needs, and because ground water occurs sporadically in Oregon, well drilling is relatively uncommon. The cost of drilling a well is about \$20 to \$25 per foot plus \$15 per foot for casing (steel). Water when available via wells occurs within 100 to 300 feet of the surface which would cost between \$3400 (drilled to 100' and cased to 75') and \$10,000 (drilled to 300' and cased to 225').

Surface water supplies can be used when they are available. A plant could purchase water from the owner of a farm pond. In other instances, a stream may be temporarily dammed to serve as a source of water for the crushing operation. The cost of water is about \$10 per 1000 gallons or about \$0.01/gallon. This is the prevailing cost of water in both Eastern and Western Oregon according to Oregon sources.[10]

When neither ground water nor surface water supplies are available to a stone crushing operation, water can be supplied by tank truck. These tank trucks can be purchased or rented by the crushing plant. Crushed stone plants with their own water trucks, are frequently of the "home-made" variety. That is, a tank will be mounted on the bed of an old truck and used for hauling water. The cost is less than half of a new truck. The cost of purchasing a new tank truck can be from about \$22,000 for a 4,000 gallon truck to \$43,000 for a 10,000 gallon truck (either diesel or gasoline engine powered). The operating cost of one of these trucks is about \$0.02/ton of product (this includes labor, rent, fuel and servicing).

Another way of approaching the cost is to use rental figures set forth in a state's method of adjusting highway construction contract figures for unanticipated additional work. In Oregon, for example, according to Oregon highway personnel[9] when the state requires supplemental work done and desires to use a contractor's equipment, there is a set payment schedule on what is known as a "force account". This schedule shows that on a weekly basis the contractor would be paid an amount of $399.65 + 15% for overhead and profit for the use of a diesel powered gravity type sprinkling truck (the closest to a water truck on the schedule). Assuming profit at 1/2 of the 15% figure, the weekly cost would be $430 or $10.75 per hour prorated over a 40-hour week. This figure includes all expenses, including fuel and oil, but excludes labor. Labor at $12.35 per hour including markup is, according to contacts with Oregon highway personnel, a realistic labor rate to drive the water haul truck to and from a pick-up point. Since only about 2 hours per day would be spent in driving the truck, the hourly prorated amount would be 2/8 of $12.35 or $3.09. The total hourly cost would be $10.75 + $3.09, or $13.84. For a 300 ton per hour plant (one that could be supplied by one 4,000 gallon truck on one trip per day) the cost per ton capacity would be $13.84 ÷ 300 tons or 4.61¢ per ton. To this must be added the cost of the water.

Despite the fact that there is a considerable difference in precipitation between eastern and western Oregon, adequate water supplies are available if trucking is done and the prevailing rate of about $10 per 1000 gallons of water holds in both regions[10]. The water cost, assuming 1.5 gallons per ton of product would add 1.5¢ to the trucking cost for a total of 6.11¢ (4.61¢ + 1.5¢) per ton of stone crushed for a 300 ton per hour plant. For a 600 ton per hour plant the cost is 4.45¢ (see Table 3) per ton added.

Therefore, the trucking cost alone more than doubles per ton control costs by wet suppression of a plant required to haul water over a plant which is not required to haul water. This cost of control, however, viewed in relation to product cost and market posture of the industry is not unreasonable. While operations using wet suppressent methods in arid regions will experience higher operating costs, the inelastic nature of the market and the strong effect transportation exerts on price indicates that such costs can be passed through with negligible change in product demand.

A portable 300 ton per hour plant using a wet suppression system would experience control costs of 9.84¢ (see Table 3) per ton if water had to be hauled. The price of crushed stone FOB quarry is on the order of $2.50 per ton. It varies according to location of the quarry and size stone produced. The average price of 1975 stone received by one state depot in Pennsylvania in response to competitive bids was $2.41 for 2A stone, and 2.73¢ for 1B. Oregon reported[9] an average FOB price from four cities (Eugene, Grant's Pass, Albany, and Portland) of $2.37 for 3/4" stone. The control cost is 4.2% of this average product cost. This 4.2% pass-through increase would not affect the overall demand for stone because the price of stone has little effect on the price of its major uses. This can be seen from data submitted by the crushed stone industry in 1973 to the Cost of Living Council which concluded that a 10% increase in stone price would have had little effect on its users.

Table 3

MODEL WET SUPPRESSION COSTS

FOR PROCESS PORTIONS OF CRUSHED STONE PLANTS[1]

Capital Costs for Installed System

	Small Plant 300 Tons/Hr.		Large Plant 600 Tons/Hr.	
Wet Suppression Equipment	$58,643		$69,108	
Annualized Capital Costs (12.50% of Capital)		$ 7,330		$ 8,639
Operating & Maintenance[2]				
Electricity @ .04/KWH	$ 115		$ 288	
Maintenance Operation & Supplies	$14,048		$22,398	
Total Annualized O&M		$14,163		$22,686
Total Annualized Cost (Capital + O&M)		$21,493		$31,325
Cost/Ton (excluding water hauling & water costs in arid regions)		3.73¢		2.72¢
Added Cost/Ton for water & hauling in arid regions		6.11¢		4.45¢

1. Basic data obtained from: Evans, Robert J., "Methods and Costs of Dust Control in Stone Crushing Operations", Bureau of Mines, U.S. Dept. of Interior, IC 8669, September 13, 1974, adjusted as follows:
   (a) Electrical operating costs increased from $.015KWH to $.040/KWH
   (b) Operating time increased from 40% to 80%
   (c) Capital costs and maintenance material adjusted to June 1977 by Wholesale Price Index for General Purpose Machinery & Equipment (33% June 1974 to June 1977)
   (d) Operating and Maintenance labor adjusted to June 1977 rates by use of U.S. Dept. of Commerce Survey of Current Business Conditions for Private, Non Agricultural Businesses (24.3% from June 1974 to June 1977)

2. (a) Supplies do not include water costs.
   (b) Surfactant costs adjusted from $2.60 per gallon to $5.00 per gallon to reflect current prices.

At that time the average price of a cubic yard of concrete in place was $125. The average price of the stone at the quarry was $1.73 per ton; FOB delivered it cost approximately $3.00. This was less than 1.4% and 2.5%, respectively, of the price of the concrete. Thus a 10% increase in the price of the stone at the quarry would have a negligible effect on the per yard cost of concrete in place, increasing the price by $.17. The effect of a 10% increase in the price of stone would have about a $7 increase in the price of a $30,000 home; a $500,000 building would be increased by $180, a $400,000 per mile highway by $640 per mile and a $360,000 school building by $140.

Transportation costs make the industry one of local competition with the notable exceptions of some stone sources with access to cheap water transportation. Stone transportation costs range roughly from 12 to 19¢ per mile for truck transportation, so that proximity to market is the major competitive determinate when yard prices are several dollars per ton. Because of the demand inelasticity and this high impact of transportation costs for the finished stone on-site delivered price, one would expect negligible decrease in demand for stone with the addition of the control costs, and a good ability of a producer to recover the cost by price adjustments.

Control Costs

Typical control costs for two size plants using wet suppression techniques are shown in Table 3. To these figures must be added the water costs developed above if the plant is in an arid region. (Oregon figures used in the table).