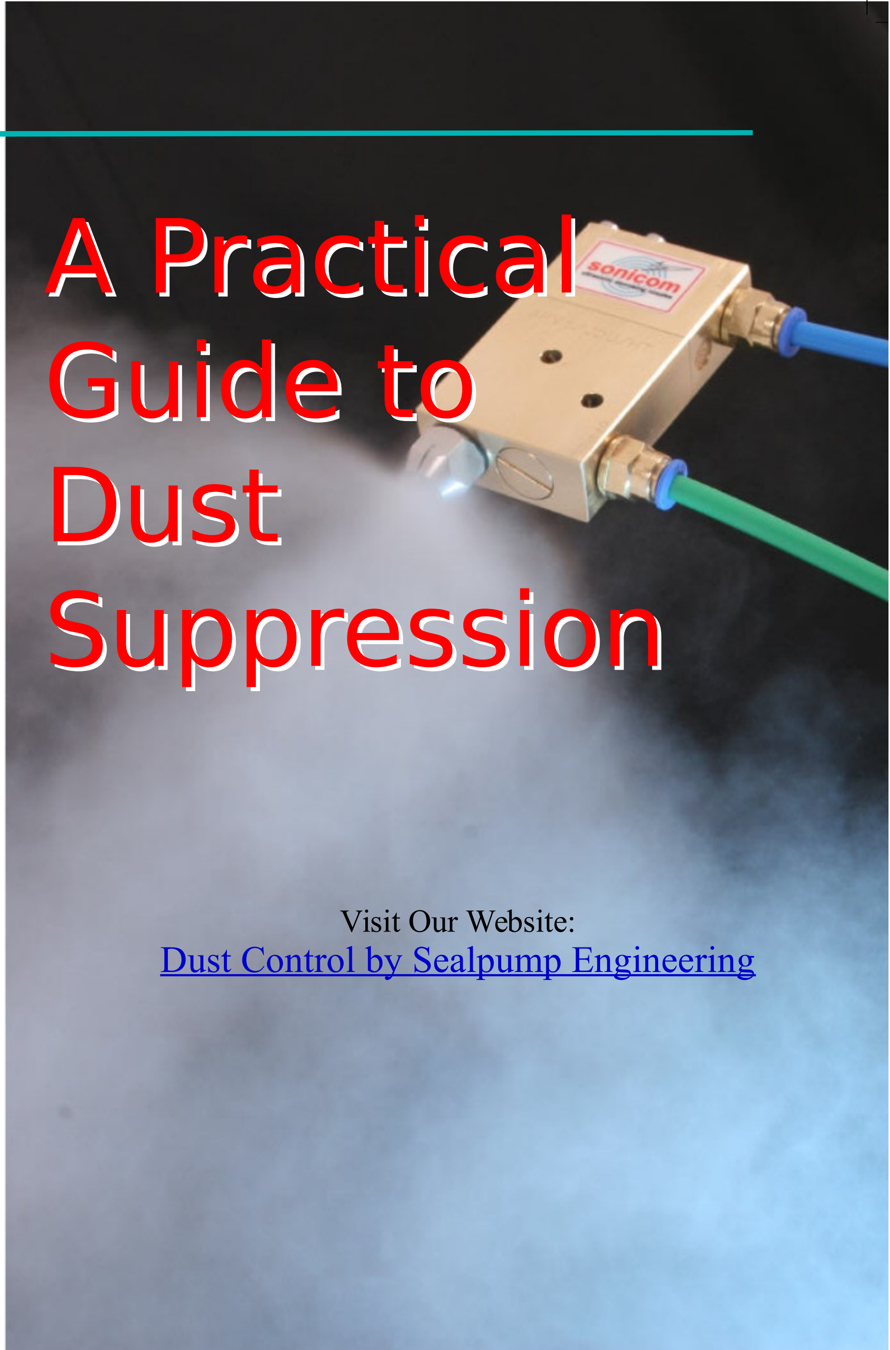
A Practical Guide to Dust Suppression



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Dust Control by Sealpump Engineering

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Preface

Any time a bulk solid material is altered or moved, it must be assumed that dust will be generated. Many times a dust cloud is visible; if a dust cloud is visible, there will also be non-visible respirable dust present. However, it cannot be assumed there is no material being emitted if there is no visible cloud.

When silica, limestone, cement, coal, aggregate and other respirable dust particles ranging in diameter from 0.1 to roughly 70 microns are airborne, they become an occupational nuisance. As a source of physical discomfort, lost materials and wear on conveying pulleys, idlers, belting and motors: such dust is a significant factor in lowered productivity and added operating costs.

Conveyor transfer points are a prime source for fugitive material, both as spillage and as airborne dust. Depending on a number of factors, including the nature of the material carried on the conveyor, the height of drop onto the belt, the speeds and angles of unloading and loading belts, systems to capture or control airborne dust may be required at conveyor transfer points.

The first consideration is whether the volume of dust generated can be reduced. Although it is unlikely that dust can be completely eliminated, a change in system design or production technique will minimise the amount of dust produced. The less energy released by the falling stream of materials at the impact area, the less energy is imparted into the material and the fewer dust particles/fines will be driven off. Consequently, it is best to design conveyor layouts with low material drops. Since this may not always be possible, dust suppression control systems must be employed.

An important consideration is the use of well-designed, enclosed chutes, since material which is allowed to fall freely from one belt to another may allow a high concentration of dust to become airborne. In it's simplest form, dust control may involve nothing more than attention to the enclosure of the transfer point chutework or the use of water sprays to suppress the creation of dust.

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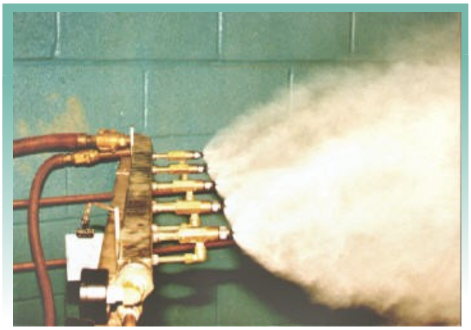


A Practical Guide to Dust Suppression

Dust Suppression is the application of water and/or chemicals, either to the body of material to prevent fines from being carried off into the air, or to the air above the material to return fugitive airborne fines to the material bed.

A significant advantage of dust suppression is that the material does not have to be handled again. The suppressed dust returns to the main body of conveyed material and the process without requiring additional material handling equipment.

There are a number of systems used for this purpose ranging from "garden hose" technology, through water and surfactant sprays, foam and fog generation systems. These various suppression technologies call for adding different volumes of moisture to the material. Fig 1 presents typical amounts of added moisture.

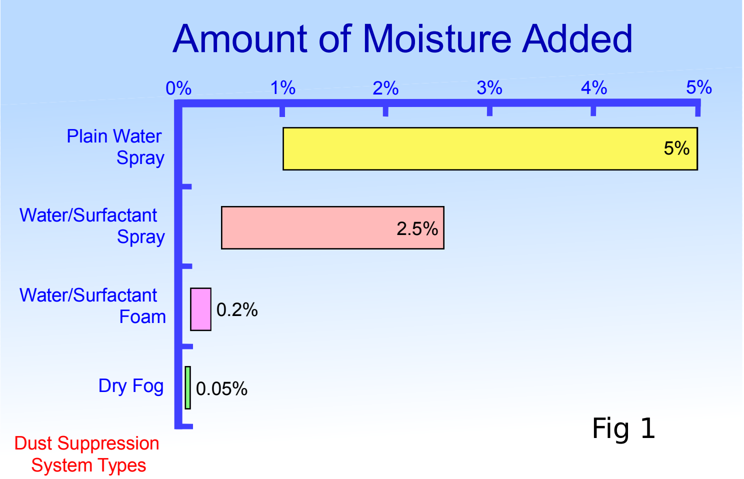


Fig 1

Water Suppression

Perhaps the oldest method for controlling fugitive dust is the application of water over the body of material. By wetting the fines, either as they lay in the material body or as they are being picked up into the air, the weight of each dust particle is increased so they are less likely to become airborne. The moisture also increases the cohesive force of the material body itself, creating larger, heavier groups of particles and making it more difficult for air movement to carry away the dust particles. This can be done by applying the water through a series of properly sized spray nozzles at a point where the material expands and takes in air, such as during discharge from the head drum in a transfer chute.

Water can also be applied to create a "curtain" around a transfer point, so any dust fines that become airborne come into contact with the water sprays surrounding the open area around the chute. The water droplets are expected to make contact with the dust fines, increasing their mass to remove them from the air stream.

The most effective sprays come from low-velocity systems. High-velocity sprays can add energy to the air and the dust particles. This energy is counterproductive to the task of keeping (or returning) the dust with the material body. High velocity air movement can keep dust particles in suspension.

Water-based suppression systems can become more sophisticated as the engineering moves beyond "garden hose" technology in efforts to improve results. The effectiveness of water spray systems is dependent on the velocity of applied water, the size of the nozzle's orifice and the location of the spray nozzles. The techniques to improve plain water-spray dust suppression include a reduction of droplet size, an increase in droplet frequency, an increase of the droplet's velocity, or a decrease in the droplet's surface tension, making it easier to merge with dust particles.

The application of dust suppression water and/or chemicals at transfer points must be controlled automatically so that water is applied only when the conveyors are running and there is a material present. This can be accomplished with conveyor system interlocks and other sensors, including microwave (or similar) sensors that read both material on the belt and loaded belt movement.

Fig 2

Fig 2 shows a spray control valve capable of controlling the flow of any fluid by mechanically sensing belt movement without the need for an independent power supply. The valve can be positioned so that the wheel contacts the belt when it is loaded, therefore operating only when material is being conveyed. Fig 3.

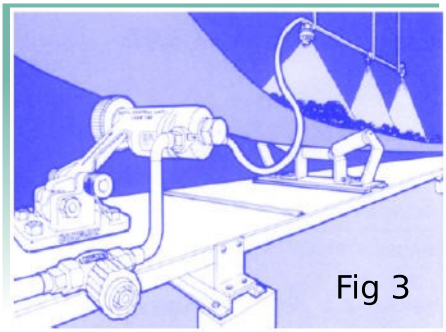


Fig 3

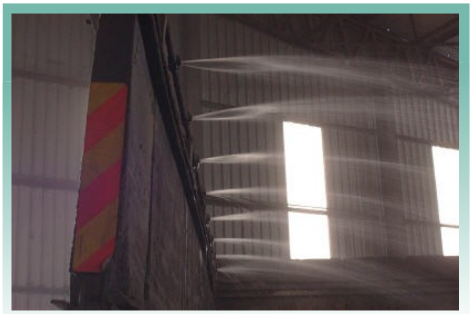
Plain water spray application systems are relatively simple to design and operate, and water has only a minimal residual effect. Water is generally inexpensive, it is usually easy to obtain; it is safe for the environment and for workers who come into contact with it.

Dust suppression systems utilising water are relatively simple systems that do not require the use of a costly elaborate enclosure or hoods. They are typically cheaper to install and use far less space than the dry collection systems. Changes can be made after startup with minimum expense and downtime. Unfortunately the application of water has several liabilities to be considered.

Dust Suppression over open rail track hoppers

With Water, Less is More

A plain water spray may appear to be the most inexpensive form of dust control available. The water is available almost free in many operations (such as mines), and it can be applied through low-technology systems. But this cost justification can



be a false equation. Many bulk solids are hydrophobic; they have a high surface tension and are adverse to combine with water. To achieve effective suppression, the amount of water is increased. Because the material does not mix well with water, there will be some particles that remain dry and others that become very wet, which can lead to material build-ups on chute walls, screens and conveyor belts.

When applying water to conveyor systems, a good axiom is “less is more”. For mineral handling in general, the addition of excess moisture prior to screening can cause material to adhere to a screen cloth, blinding the equipment. Excess water may promote belt slippage and increase the possibility of wet (and hence sticky) fines accumulating within chutes and around the transfer points. The addition of moisture can cause material to stick together, complicating the flow characteristics of the material being conveyed.

Problems occurring in plain water dust suppression systems include the possibility of excess moisture in the material, which can downgrade future performance in power generation or other thermal processing. Specifically, excess water addition to coal and coke used for boiler fuel results in a BTU penalty which can have a detrimental effect on utility heat rates. The more water added, the greater this penalty.

The Thermal Penalty for Added Moisture

There is a substantial performance penalty added to combustion and other thermal processes when the water content of the fuel is increased. In applications like coal-fired power plants and cement plants, water added to the material going into the thermal process must be "burned off" by the process. This can dramatically reduce the process efficiency and increase fuel costs.

It requires 3,064 kilojoules per litre (1,320 BTU per pound) to raise water from 21°C (70°F) to it's vaporization temperature of 149°C (300°F). It only takes 9.1 kg or 9.1 litres (20 pounds) of water to increase the moisture content of one tonne of material by one percent. As a gallon of water weighs approximately 4.5 kg (10 pounds), the addition of less than 2.0 gallons (9.1 litres) of water to a tonnne of material will raise the moisture content of a tonnne of material by 1 percent. Vaporizing this modest amount of water produces a heat loss of 27,850 kilojoules (26,400 BTU).

The thermal penalty typically created by the various dust suppression methods is displayed in Fig 4.

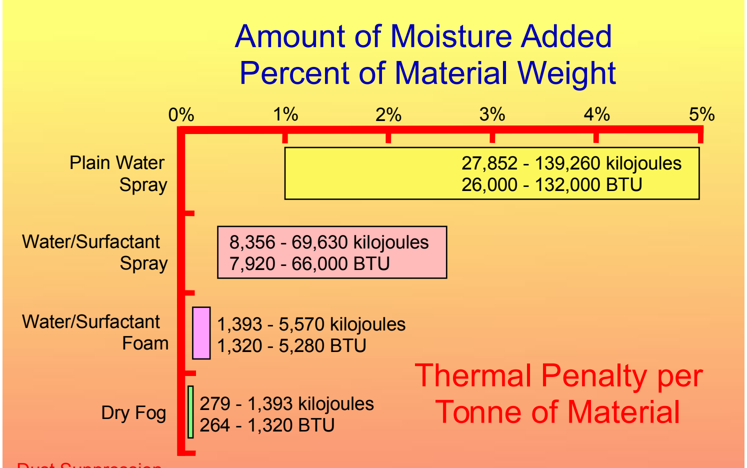


Fig 4

Because a "plain" water spray requires the highest volume of moisture for effective dust suppression, this method extracts the highest thermal penalty. While the use of a simple water spray for dust suppression may be a lower cost because the water is readily available and there is less "out-of-pocket" expense, the penalty for the addition of surplus moisture can be very costly indeed.

To prevent this problem, moisture addition must be minimised. Methods to improve dust suppression while limiting the addition water include the use of a "dry fog" or the addition of surfactant chemicals to water which is then applied as a spray or as a foam.

"Dry Fog" being added to coal over a conveyor head drum

Foam spray added to limestone at a crusher inlet

Ultrasonic Dry Fog Suppression Systems

"UltraFine Fog" fugitive dust suppression works like a combination of a wet scrubber and a fabric filter. The generated ultra-fine fogging blanket acts like a fabric filter in that a dust particle cannot pass through it without colliding with a droplet. Since the droplet consists of water, the dust particle does become somewhat wet as in a true flooded scrubber. This phenomenon can be called agglomeration and solving fugitive dust emission problems with ultra-fine water droplet atomisation begins with the theory of agglomeration. Agglomeration can be defined as the gathering of mass into a larger mass, or cluster.

Agglomeration probability is greatly increased between bodies of similar size. The agglomeration of these bodies produces a large enough mass to cause settling. For example, a dust particle of 5 microns will continue to follow the air stream around a water droplet of 200 microns, therefore, avoiding collision. With the dust particle and a water droplet of similar size, the air stream is not as great and collision occurs, causing agglomeration.

Fig 5 shows the aerodynamics of what can happen when the water droplets are larger than the dust particle.

Fig 5

Diagram illustrates the importance of droplet size for particle agglomeration. Airflow around the large water droplet (left) prevents the dust particle from contacting the droplet. However, the dust particle easily impacts the small droplet (right) triggering agglomeration.

Fog suppression is one method to optimise the application of water to dusty materials. These systems use special ultrasonic nozzles to produce extremely small water droplets (10 microns or less) in a dispersed mist. These droplets mix and agglomerate with dust particles of similar size, with the resulting larger combined particles falling back to the material body.

Compressed air passes through the nozzle's inner bore through a convergent/divergent section at high velocities and expands into a resonator cavity where it is reflected back to complement and amplify the primary shock wave. The result is an intensified field of sonic energy focused between the nozzle body and the resonator cap. Fig 6

Any liquid capable of being pumped into the shock wave is vigorously sheared into fine droplets by the acoustic field. Air bypassing the resonator carries the atomised droplets downstream in a soft plume shaped spray. In Fig 7 the droplets have low mass and low forward velocity with low impingement characteristics. Fine atomisation ensures uniform distribution of the liquid with minimum over spray and waste.

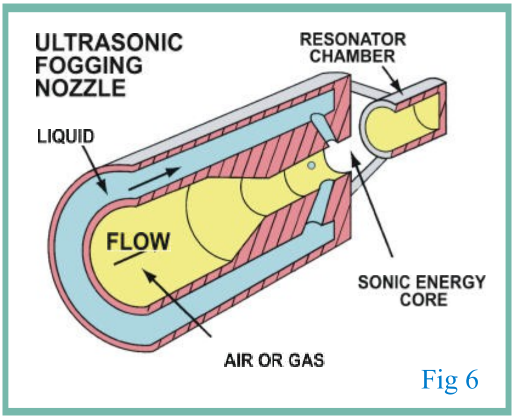


Fig 6

Ultrasonic atomising nozzles operate at very low liquid pressures and have large orifices. The large orifices and low pressures virtually eliminate orifice wear and prevent deterioration of the quality of atomisation while greatly extending useful nozzle life.

The plume leaving the fog system nozzles is so fine it will not freeze, but the water supply system itself can freeze if drain or heating elements are not provided.


Fig 7

Mist Suppression Systems

Atomisation is designed to reduce the surface tension of the water droplets, while increasing the number of droplets in a given area and eliminating the need for the addition of surfactants or other additives. The low level of water added through the fog/mist systems - typically at 0.01% to 0.05% by weight of the material - generally will not degrade the performance of the material.

There are two methods of producing atomised water mist.

Two-Fluid Atomisation (Fig 8)
One method produces mist from water and compressed air by passing them together through a two-fluid nozzle. Here the external air supply is the vehicle that fractures the water supply into the droplet mist to capture the dust. The supply of compressed air to this system provides an additional expense for the installation and operation of this system. The cost of producing the compressed air must also be considered in the economics of the system.

Fig 8

Single-Fluid Atomisation (Fig 9)
This system uses an ultra-fine stream of water pumped at high pressure through single-fluid atomising nozzles. It does not require compressed air or an additional power source other than the electricity to run it's pump. Single-fluid nozzles use hydraulic atomisation to generate the mist. Water is forced under pressure through a small orifice that shatters the water droplets into microscopic particles. The energy created by the high-pressure is used to atomise the water droplets, rather than increase water velocity, thereby minimising displaced air. By eliminating the compressed air requirement, single-fluid nozzles simplify installation and reduce operating costs. To keep nozzles clear, any suspended solids must be removed from the water. However, the low volume of water applied to the material makes this relatively easy to accomplish with good filtration.

Fig 9

Placement and Position of Nozzles

The placement of the fogging nozzles is the most important aspect to producing effective results with no wetting of material. The fog should be generated and contained in a properly designed shrouding. This eliminates dissipation due to wind and also produces the treatment time necessary to suppress the dust. The fog is generated above the dust problem area, not on the material. As the airborne dust enters the confine, UltraFine Fog agglomeration occurs and the dust is suppressed in situ.

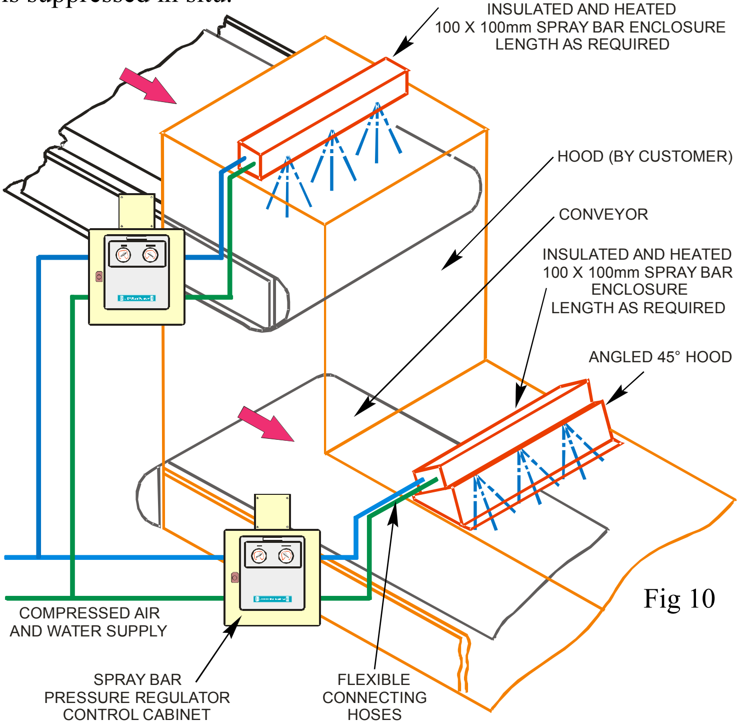


Fig 10

A simple system schematic is shown in Fig 10. In this picture two spray bars are mounted on the covers. They are heat traced and insulated assemblies. The enclosure has a quick release cover, which makes it easy to service the nozzles as required. This picture also shows the regulator control cabinets, which are used to regulate the air and water pressures and would also include solenoid valves linked into the conveyor drives, along with the flex hoses used to connect the two fluids.

Typical conveyor transfer point and crusher shrouding along with location of the nozzles are shown in Fig 11 and Fig 12 respectively.

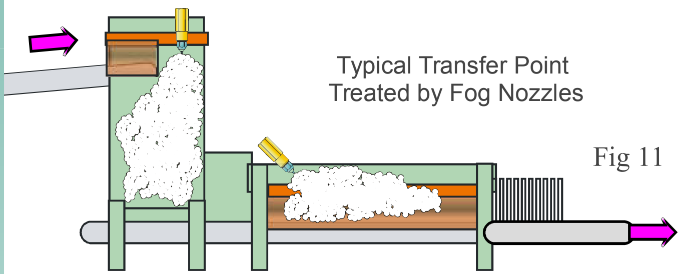


Fig 11

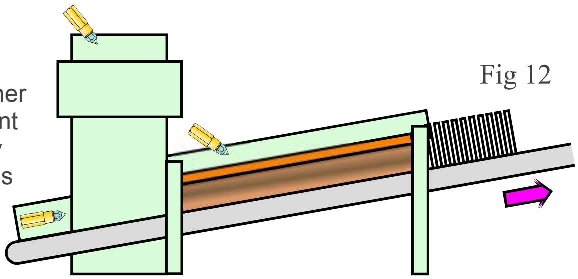


Fig 12

A general rule of thumb is that the height of the conveyor cover be approximately 1 metre above the product level on the belt and the cover length 3 times the belt speed (m/s). The basic principles involved for location of the nozzles are as follows:-

- Nozzle spray pattern must not directly impinge upon any surface.
- Nozzles should be mounted in order to maximise the ability to fill the shrouding.
- The fog should avoid direct contact with the material being suppressed.
- Nozzles must be protected or shielded to avoid damage from falling material.
- Nozzles should be mounted to minimise exposure to a heavy-laden dust air stream. This will void erosion of the nozzle components.
- Spray pattern of nozzles should be generated so that all the fugitive dust emissions are forced to pass through the blanket of fog.

Pros & Cons of Fog and Mist Systems

Fog systems provide highly effective dust capture combined with economical capital and operating costs.

A well designed fogging system can provide excellent control of dust at the point of application without the need for chemical additives. This is especially important for processes such as wood chip transport destined for fine paper making. Many mills are very concerned over the application of any chemical that might negatively affect the pulp or degrade the quality of the finished paper.

Since fog systems only add water, they protect the integrity of the customer process. Total moisture addition to the bulk material can be realistically less than 0.1%. This makes fog suppression systems attractive in industries that cannot tolerate excess moisture, such as cement and lime production.

Mains water is typically required for fog suppression systems, so filtration to remove suspended solids from the water supply is required. As high pressure misting nozzles have a very small orifice to produce droplets, the water used for this operation must be treated to be free of particulate and suspended solids. Nozzles can clog if the water treatment system is not serviced at required intervals.

Another consideration prior to choosing a fogging device is the air volume and velocity at the open area surrounding the transfer point or chute. For truly effective performance, fog dust suppression systems require tight enclosure of the transfer point that minimises turbulent, high-velocity air movement through the system. Since the fog droplets are very small, both the fog droplets and the dust can be carried out of the treatment area onto surrounding equipment by high-velocity air exiting the chute.

This type of system works well where the area to be treated is not large. A potential drawback of a fogging application is that treatment is site specific. That is, dust control is achieved only at the point of application. Several fogging devices may be required for a conveyor system with multiple transfer points.

Adding Chemicals to Water

To improve the wetting characteristics of water and also reduce overall water usage and minimise the drawbacks associated with excessive moisture addition, it is a common practice to "enhance" the water by adding chemical surfactants. The purpose of the surfactant addition is to improve the dust suppressant performance of the water.

If dust from coal, petroleum coke or other similar materials falls onto a pool of water on the ground, the dust particles can lay on top of the water. If undisturbed, this dust can remain on the surface of the pool for hours. This phenomenon takes place because these materials are hydrophobic; they do not mix well with water. It is not possible or practical to alter the nature of the dust particles to give them greater affinity for water. Therefore chemicals are added to alter the water molecules, so they attract or at least join with the dust fines which they contact.

By adding chemicals (usually surfactants - surface acting agents) the surface tension of the water is reduced, allowing the dust fines to become wet. To understand surface tension, imagine a drop of water lying on a smooth, flat surface. It will usually form a liquid bubble with well-defined sides. It is the surface tension of the water that prevents the droplet walls from collapsing and spreading as a thin water sheet. A drop of water that has been mixed with a surfactant such as dishwashing soap, for example, will not form a liquid bubble on the same surface because its surface tension has been drastically reduced. The "walls" on the side of the droplet cannot support the weight of the droplet, because the forces holding the walls together have been altered. This is the reason surfactant technology is applied to dust control. If the water droplets no longer have a surface that is a barrier to contact with the dust fines, then random collisions between droplets of treated water and dust will result in wetting of the fines.

Location, Location, Location

In fog, foam, water and water/chemical spray applications, the sites chosen for nozzle placement and suppressant delivery patterns are as important as the selection of material to be applied. Even the best designed program will fail if the suppressant material is not delivered to the correct location to allow intimate mixing with the dust fines.

The success of the suppression effort relies on the proper mixing together of the material and the suppressant at the transfer point. When applying dust control, whether the suppressant is simply water or a surfactant/water mix as a spray or foam, it is best to locate the suppression system as close to the beginning of the transfer point as possible. That way, the forces of the moving material fold the suppressant into the material body as it moves through the transfer point.

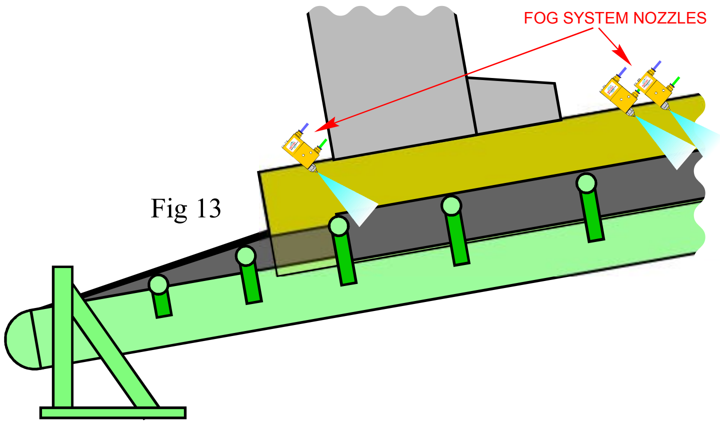


Fig 13

The installation of fog systems is a little different in that fog systems are designed to treat the air above the material, rather than the material body itself. Therefore, the application point for the fog mist is generally near the end of the transfer point Fig 13. This allows the material load to settle and any pickups for active or passive dust collection systems to remove dust-laden air without the risk of binding the filtration media with moistened dust particles. Fog generation nozzles are installed to cover the full width of the conveyor's skirted area. It is recommended that skirtboard height be at least 800mm to allow the plume of the nozzle output to reach optimum coverage.

Other Dust Suppression Equipment

Sprinklers: Used mainly where wetting is required over a wide area such as roadways and open yards. They are limited by the throw achievable from each head and rely on good water pressure and flow. Sizes are selected according to the application and the units can be set to spray full or part circle patterns. This ensures maximum areas are covered with the minimum of over lap between spray heads. Water consumption varies typically between 0.3 and 95 m^3/hr.

Rain Guns: Dust suppression rain guns have been specifically designed to provide immediate and efficient dampening/wetting over large areas with minimal water consumption.

A high frequency drive mechanism provides a fine water curtain and gives excellent water distribution with minimum maintenance. Units can be self adjusting and range from 12 to 150 m^3/hr with spray trajectories up to 120 metres.

Sprinklers and rain guns can be used together to achieve an overall suppression effect over areas of concern and provide the best possible results with budget costs and water conservation in mind.

Water Spray Nozzle Systems: Such systems provide immediate dampening of general material handling processes and site boundaries. The nozzle design ensures a cone spray pattern is achieved at pressures from 1 to 8 Bar.

These types of nozzle systems are a low cost option for material handling processes/site boundaries where wetting is not a problem. Nozzles are available in various materials including plastic, stainless steel and brass with flow volumes ranging from 0.3 lts/min up to 90 lts/min per nozzle.

Fog Cannon:

When vast open spaces require dust suppression and a semi permanent system is not a practical option, the solution may lie with the introduction of a fog cannon to the site.

These huge mobile and expensive units can utilise up to 60 hydraulic spray nozzles mounted circumferentially around the outlet head of a large fan assisted barrel. The concentration of nozzle spray together with the high flow of air from the fan, throws the droplets many metres towards the source of the dust activity. The droplets scatter in a plume of relatively soft spray and can capture fugitive dust before it becomes airborne and a major problem.

CONVERSION TABLES

Multiply	by	to obtain
Area		
cm^2	0.0010764	ft^2
cm^2	0.1550003	inch^2
ft^2	0.09290304	m^2
ft^2	929.0304	cm^2
ft^2	92903.04	mm^2
inch^2	0.0006452	m^2
inch^2	6.4516	cm^2
inch^2	645.16	mm^2
m^2	1.19599	yard^2
m^2	10.7639	ft^2
m^2	1550.003	inch^2
mm^2	0.00001076391	ft^2
mm^2	0.00155	inch^2
yard^2	0.8361274	m^2

Multiply	by	to obtain
Flow		
ft^3/min	1.699	m^3/hr
ft^3/min	0.0283	m^3/min
ft^3/min	0.000472	m^3/sec
ft^3/min	1699	lt/hr
ft^3/min	28.317	lt/min
ft^3/min	0.4719	lt/sec
ft^3/min	0.4719	dm^3/sec
lt/min	0.22	Imp gal/min
lt/min	0.264172	US gal/min
lt/min	0.035315	ft^3/min
lt/min	0.000589	ft^3/sec
lt/sec	0.22	Imp gal/sec
lt/sec	0.264172	US gal/sec
lt/sec	2.11888	ft^3/min
lt/sec	0.035315	ft^3/sec
lt/sec	0.06	m^3/min
lt/sec	0.001	m^3/sec
m^3/sec	2118.88	ft^3/min
m^3/sec	35.31	ft^3/sec
m^3/sec	13198.15	Imp gal/min

Multiply	by	to obtain
Pressure		
bar	14.50377	lbf/inch^2
bar	1.02	Kgf/cm^2
bar	100,000.0	N/m^2 (Pa)
bar	750.1	mm Hg
bar	29.53	inch Hg
bar	0.9871668	atm
lbf/inch^2	0.06894757	bar
lbf/inch^2	0.07030697	Kgf/cm^2
lbf/inch^2	6894.757	N/m^2 (Pa)
lbf/inch^2	51.71	mm Hg
lbf/inch^2	2.036	inch Hg
lbf/inch^2	0.0680461	atm

Multiply	by	to obtain
Volume		
cm^3	0.0610234	inch^3
ft^3	0.02831685	m^3
ft^3	28.31685	litre
Imp gal	0.004546092	m^3
Imp gal	4.546092	litre
Imp gal	1.20032	US gal
Imp gal	0.16054	ft^3
inch^3	16387.06	mm^3
inch^3	16.38706	cm^3
inch^3	0.000016387	m^3
litre	0.001	m^3
litre	0.2199692	Imp gal
litre	0.03531466	ft^3
litre	61.0234	inch^3
m^3	219.9692	Imp gal
m^3	35.31466	ft^3
m^3	1000.0	litre
m^3	61023.4	inch^3
mm^3	0.000061024	inch^3

1 micron	equals	0.00004 inch
1 micron	equals	0.001mm