Guidance for Controlling Silica Dust from Stone Crushing with Water Spray Technology

Stone crushing has long been associated with exposure to airborne crystalline silica dust to both workers and those residing in close proximity to these operations. Water spray dust control measures are effective at reducing levels of respirable crystalline silica dust. Studies have reported reductions in the range of 60% to 86% for respirable silica and dust in various applications including stone crushing, construction, mining, and manufacturing industries.

Health Effects of Crystalline Silica

Occupational exposure to respirable crystalline silica can cause silicosis, an irreversible and potentially fatal lung disease. Occupational silica exposure is also a risk factor for lung cancer, severe mycobacterial or fungal infections, such as pulmonary tuberculosis, chronic bronchitis and emphysema, and may be associated with renal disease and autoimmune diseases like scleroderma and rheumatoid arthritis. Freshly fractured crystalline silica particles are considered the most fibrogenic as they are capable of entering the gas-exchange regions of the lungs, thus increasing the importance for the control of respirable silica dust generated from stone crushing units.

Figure 1. Stone crushing operations create large quantities of respirable dust. Workers exposed to respirable silica dust have an increased risk of developing lung diseases such as silicosis or tuberculosis.

Engineering Controls

Reductions in respirable dust in stone crusher mills can be accomplished through engineering controls including process enclosures or containment, dust collection or local exhaust ventilation, and water spray systems. Water spray systems are generally thought to be the less expensive alternative and are therefore the focus of this guidance. However, additional measures may also be required to adequately lower silica exposure levels.

Water spray suppression techniques include the application of water, surfactants or foam at the crusher, conveyor feed and at other discharge points. Systems may be pressurized or rely on available water pressure. Wet methods can also control dust exposures downstream of the initial application if a high enough volume of water is applied to adhere to larger rock particles. Basic systems without pressurization and chemical additives are effective at significantly reducing respirable silica.

Water Spray System Design

The spray nozzle is the most important component of a water-spray system because it determines the physical characteristics of the spray, including droplet size, velocity, spray pattern and angle. In addition the available water pressure will dictate the selection of nozzles to achieve the desired spray characteristics. A general discussion of these factors is below, with specifics available from the manufacturer. Below is a general discussion of these factors, but product specific information must be obtained from the manufacturer.

Droplet and Orifice Size: Droplet size is the most important variable for proper dust control and is determined by the orifice size and available pressure. Droplet size decreases as operating pressure increases. The smallest droplets are generated by air atomizing nozzles using either compressed air or high-pressure water.

Droplet Velocity: Normally, higher droplet velocities are desirable for dust suppression control. Information on the droplet velocity, based on the available water pressure, can be obtained from the nozzle manufacturer.

Spray Pattern: Nozzles are categorized by the spray patterns they produce. The following table describes the different spay nozzles used in dust control.

Nozzle Selection & Characteristics

Solid-Cone	**Hollow-Cone**	**Flat-Spray**	**Air Atomizing/Fogging**
• Round spray pattern • High velocity over distance • Provide optimal surface area coverage for non-pressurized spray systems • Provide best coverage if water pressure available	• Circular ring spray pattern • Smaller droplets than other types of nozzles • Useful for operations with widely dispersed dust	• Rectangular, even spray pattern • Larger droplets • Useful for wetting rock material as it is being crushed	• Requires pressurized system • Very effective where airborne dust particles are very small • Nozzles can be located in close proximity to dust source

Spray Angle: The spray angle determines the width of the cone-shaped spray pattern produced by the nozzle. The appropriate spray angle needed to cover a specific surface area would depend on the distance the nozzle is placed from the material.

Flow Rate: The rate at which water flows through a nozzle depends on the operating pressure and orifice size. A pressurized system with a typical full-cone nozzle orifice diameter of 4 mm and an operating pressure of 80 psi (pounds per square inch) delivers a flow rate of 19 lpm (liters per minute). A non-pressurized system with the same nozzle orifice diameter delivers a flow rate of 5 lpm at 10 psi. Increased water pressure improves mist delivery and may allow for the installation of fewer nozzles to achieve the same dust reduction. It is also important not to apply too much water to the material as the finer particles can become muddy and sticky, which may cause equipment problems.

Number of Spray Nozzles

Depending on mill design and coverage area, a minimum of 8 – 11 nozzles are usually needed in small crushing units. The essential nozzle placements are given in the table below.

Essential Nozzle Locations	No. Nozzles
Top of crusher	1
Delivery point of crushing material	2–3
Each side of crushed material	1 pair
Vibrator/Rotary Screen (bottom)	1-2
Storage hopper	2–3

Additional nozzle locations may include: 1 at delivery point of raw materials and 1 at the bottom of the dust hopper.

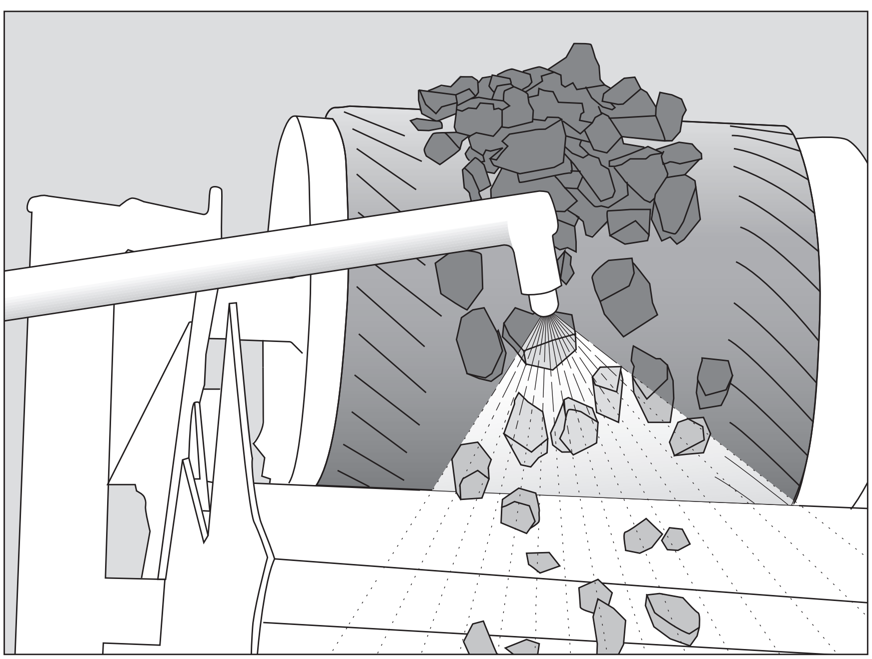

Figure 2. Spray nozzles help reduce the formation of respirable dust.

Placement of Nozzles

Nozzles should be placed upstream of transfer point where dust emissions are produced and located to allow maximum time for water droplets interaction with airborne dust. Distance to crushing material depends on nozzle type, spray angle and water pressure (see Figures 3 and 4).

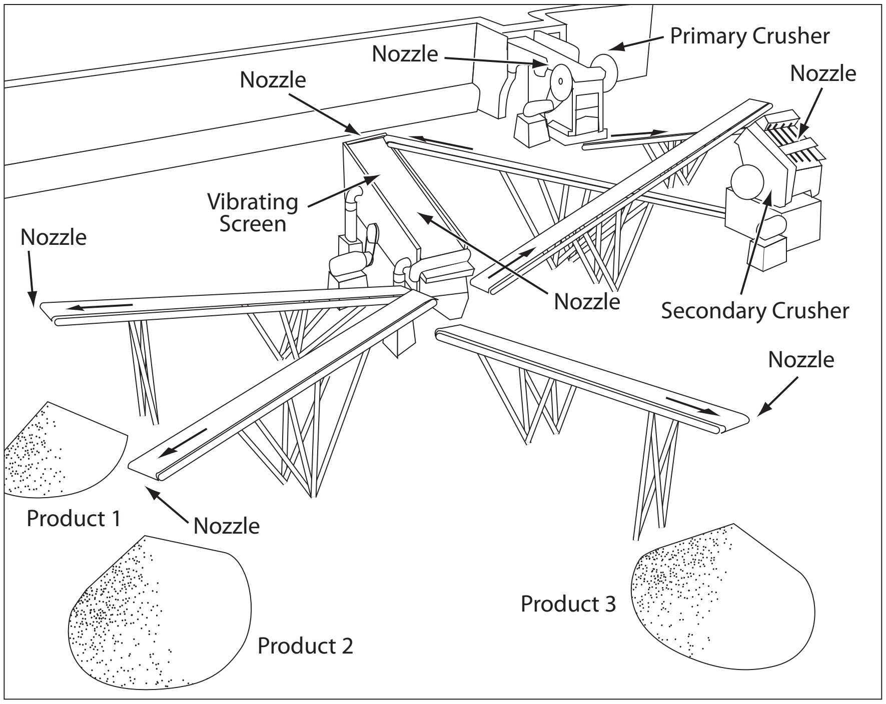

Figure 3

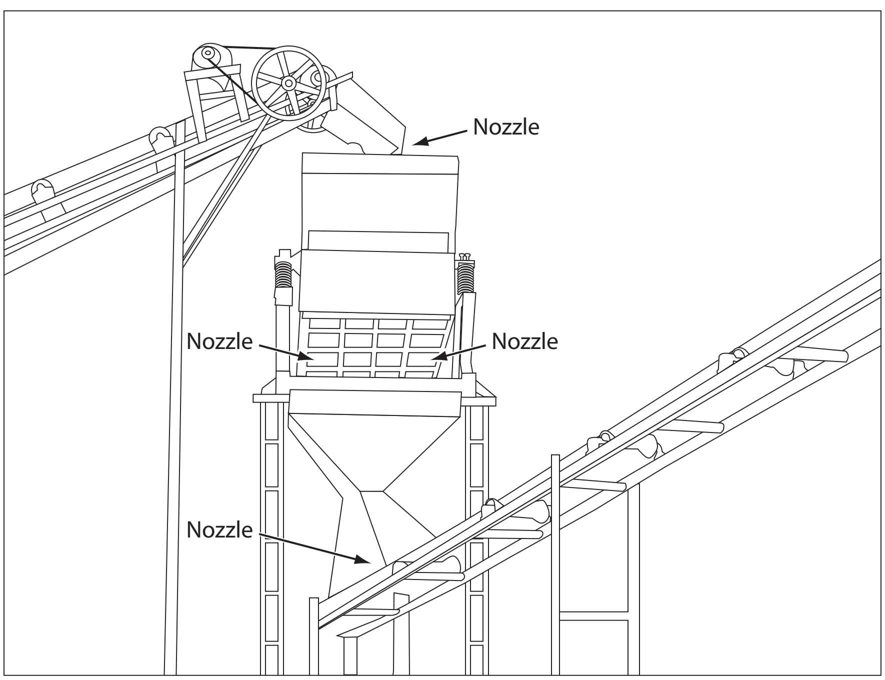

Figure 4

Water Consumption

A typical nozzle consumes 5 to 20 lpm of water (per nozzle) depending on pressure, with total water use dependent on the crusher unit size and number of nozzles needed.

Water Quality

Spray systems can rely on a variety of water sources that do not have to meet drinking water quality. In some cases, in-line filtration may be needed to avoid clogging nozzles.

For nonpotable water sources, careful consideration should be taken with respects to microbiological contaminants in the water, as they may constitute an inhalation hazard. Contaminants may include bacteria such as *Legionella* and *Mycobacterium,* viruses such as Hepatitis A or Hepatitis E, or even protozoa or helminths such as *Giardia* and *Schistosoma*.

Road Sprinklers

Sprinklers may be used to stop the spread of dust previously settled on the roadways and on waste materials. Road sprinklers are intended to reduce the amount of fugitive airborne dust generated by wind or vehicles. Commercially available spray equipment can be used without regard to nozzle orifice size. However such systems typically consume considerably more water than the fine mist nozzles, but they may also be operated intermittently.

Figure 5. Dust being released during the loading of fine waste materials.

Figure 6. Sprinkler systems along roadways help to reduce dust created by trucks entering and leaving the facility.

Estimated Costs for Water Spray System

Costs for purchasing and installing this equipment will vary and largely depend on the availability of water. Equipment costs for pressurized systems or those using chemical surfactants are higher than nonpressurized water spray equipment and will also have higher operating costs. Rainwater harvesting and other sources of reclaimed water can also lower operating costs.

Below are some examples of the cost for equipment and installation of dust suppression technology at two different stone crusher units. The cost for a site with 21 spray nozzles and a crusher capacity of 35 tonnes per hour (tph), and another site with 30 spray nozzles and a crusher capacity of 50 tph is approximately $2,120 and $2,815 respectively (Table 1). Smaller systems can be purchased and installed for approximately half these costs.

Table 1. Cost Estimate for Dust Suppression Technology Unit[1]

Description	Total Site A	Total Site B[2]
Well Bore Drilling Cost	$900	$1,400
Well Depth (meters)	60	91
Well pump (electric) cost	$300	$420
Water Storage Tank cost	$120	$120
Water Consumption per Day	3500 L/day	5000 L/day
Spray Equipments cost	$800	$875
Number of Nozzles	21	30
Crusher Capacity	35 tonnes/hr	50 tonnes/hr
Motor and Pump capacity (water)	1.5 H.P. (6500 lph -50 m head)	2 H.P. (7500 lph -60 m head)
Total Costs (USD)	$2,120	$2,815

[1]All cost are approximated in US dollars.

[2]Consists of two crusher units sharing one well.

Note

The above information has been provided as a general guideline for implementing a water spray system. However, the silica content of rock varies greatly and other environmental conditions such as temperature and humidity will impact the effectiveness. It is recommended that stone crusher mill operators consult with water spray specialists to properly design a system suited for their dust control needs.

Limitations

Although water spray systems are very cost-effective in significantly reducing the risk of silica dust exposure in stone crusher units, they do not eliminate the risk of silicosis or other related disease among exposed workers. Additional engineering controls and respiratory protection, may be required depending upon the crystalline silica content in the stone.

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