MinEx Health & Safety Council

GUIDELINES FOR THE CONTROL OF DUST AND ASSOCIATED HAZARDS IN SURFACE MINES AND QUARRIES

Photo Newmont Mining Corporation Waihi

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NOTE: These guidelines have been superseded by the Health and safety at opencast mines, alluvial mines and quarries Good Practice Guidelines available on the MinEx website. However, this document contains information you may still find valuable.

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ACKNOWLEDGEMENT

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1.0 INTRODUCTION

A. Dust from mining and quarrying operations, if allowed to enter the atmosphere creates an uncomfortable working environment, causes excessive wear on machinery, reduces visibility and increasing the risk of accidents. It can also contribute to serious diseases such as pneumoconiosis; fibrosis and scarring of the lungs as a result of repeated inhalation of occupationally associated minerals, such as silica, asbestos, and coal dust.

B. The Resource Management Act 1991 applies legislation to the amount of dust that can be discharged to air, as “consent to discharge”, and should cover dust from all sources: drilling and blasting, road traffic within the quarry, and crushing and screening. Often mines and quarries are required to have regular sampling of dust on their boundaries, and this can be carried out using simple collection devices.

C. The Health and Safety in Employment Act 1992 applies legislation limiting the amount of dust people are exposed to on the site or in the vicinity of the site. All inhaled dust should be treated as a health hazard. Airborne dust is usually measured in two ways because of the different ways the dust affects the health of people.

D. Inspirable dust is the portion of dust that is taken through the mouth and nose when breathing and respirable dust corresponds to the fraction of total inspirable dust that is able to penetrate and deposit in the lower bronchioles and alveolar regions (Appendix 1)

E. Respirable dust consists of small particles (< 10 microns) that can cause particular health hazards to those exposed to them. They are the cause of diseases such as emphysema, and pneumoconiosis, which covers silicosis and asbestosis. Asbestosis has very special problems that are dealt with under the Asbestos Regulations. Silicosis has particular significance in the extractive industry, as the mineral is widespread in rocks.

F. This guideline will give practical information for the control of dust and will be mostly advisory.

G. Further guidance in workplace exposure levels for dust and contaminants can be found in Workplace Exposure Standards Effective From 2002 (WES book) ISBN 0-477-03660-0.

2.0 DUST CONTROL

A. The quantity of dust that enters the environment represents part of the risk of exposure for people who enter that environment. Reducing the quantity of dust that enters the environment reduces the risk of exposure. Dust control is the

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subject of this guideline. Areas in surface mines and quarries that generate dust are examined for methods to prevent dust generation there by reducing the risk of exposure.

3.0 DRILLING

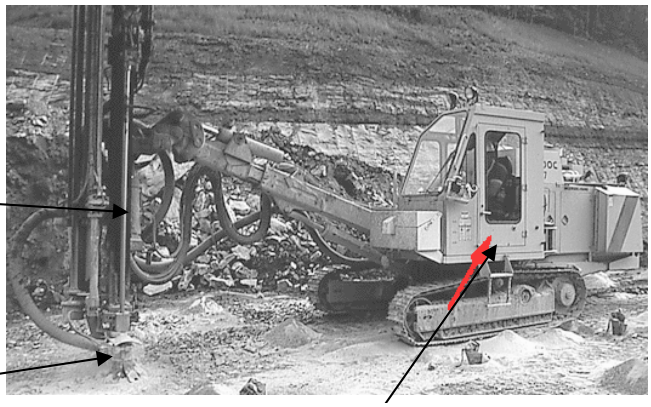
A. Drilling can be a major cause of dust problems within the quarry environment.

B. Drilling by the nature of the action required to drill holes can produce a lot of dust. Drilling rigs for hole diameters over 50 mm generally have their own dust collectors which suck the drill cuttings to a large cyclone separator on board, which dumps the larger cuttings (over 2-3 mm); the finer dust is collected on filter elements and dumped by intermittent reverse air pulses through the elements. Cyclones can be use in many other applications and present a very good method of capturing dust.

C. Respiratory protection should only be used to control the dust exposures where other dust collection or suppression systems have not been able to reduce the dust to acceptable levels. See photo

D. When using hand held rock drills efforts should be made to control dust at source e.g. water injection or extraction. If control of dust at source is not practicable then respiratory protection should be used.

Dust Control on Drill Rig



4.0 MOBILE PLANT

A. Dust can be generated by trucks loading from bins, and carrying product to stockpiles, or by a loader working stockpiles and cleaning around plant. Specific problems with mobile machinery will be dealt with in the section on haulage and transport.

B. Methods to allay these dust problems may include:

   a. Installing plant sheltered from prevailing winds.
   b. Using water spray tankers on haul roads.
   c. (Caution: Do not use waste oil on haul roads, unless you have a permit to do so from your Regional Council. Waste oil leaching into the local environment would not be tolerated).

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d. Various emulsions are available that can be considered as "environmentally friendly" and have the added benefit that they can be used to stop wind erosion and slow water erosion of reinstated and stripped land. They are so effective that they can be used with seeding operations.

5.0 PLANT

A. Dust sources around the plant, apart from crushing and screening, include discharge into hoppers, long open chutes, and from conveyors and transfer points.

B. High discharge heights produce an air pressure blast effect and create turbulence, which carries dust into the air. This also causes particle fracture, and free fall allows the wind to pick up and carry the dust for a long distance from the discharge point.

C. Dust control methods include:
   a. Fog Suppression System .
   b. Dust extraction hoods and cyclones and/or bag filters.
   c. Conventional water sprays, whose performance can be enhanced with the addition of wetting agents that assist in water to dust particle contact, lessening the amount of water required. See photos for before treatment and with chemical added to water treatment.
   d. Locating plant so that it is sheltered from the prevailing wind and the introduction of plant shelterbelts

Before treatment

After dust suppression

source www.focusonaggregates.com

8.0 CRUSHERS

A. There are two basic methods of crushing, either compressive or impact. The main types within these categories are: Compressive; jaw crushers, single and double toggles, gyratory crushers, cone crushers, roll crushers, ball mills and rod mills.

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Impact; rotary or vertical shaft impactors (e.g. Barmac), hammer mills (fixed or swing hammers)

8.1 Compressive crushing

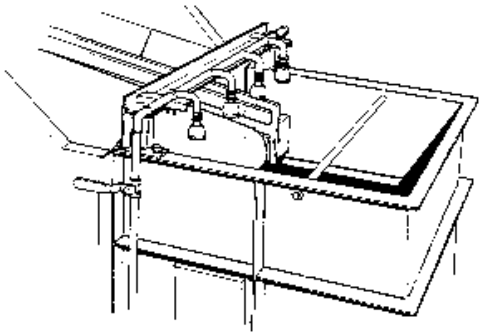
A. Compressive crushing produces dust but does not in itself produce a great deal of air movement, but rather the material passing through the crusher causes the dust from the process and the processed material to become airborne.

B. Excessive clearance under the crusher can cause a lot of dust generation in the same way as a high discharge point.

C. Dust control measures include:

   a. Dust can be reduced by providing a controlled fine water spray system that directs water onto the input material before it enters the crusher (be careful not to over water as this can cause further problems down the production process). (see diagram 1)

Diagram 1 Water spray system at a crusher



   b. Dust extractor hoods and cyclone collectors and/or bag filters. This is particularly suitable for use on the output chute or stone box under the crusher.
   c. Fog Suppression System is another method.

8.2 Impact Crushing

A. Impact-type crushers, for example hammer mills, act as powerful fans and not only produce dust from the impact of hammer on rock, but also blow the dust out.

B. Dust control is the same treatment as for compressive crushing but another way to help cut down the dust being blown out of an impact type crusher is to cut down the quantity of air that is allowed to enter the hammer mill in the first place. A simple way to do that is to reduce the input aperture to the mill by using a series of rubber flaps or baffles.

C. For intermittent loading a control system would be needed, which starts water sprays at the feed point prior to stone entering the crusher and delays on the sprays at the discharge point after the crusher unloads.

D. Where practicable, stone boxes on process plants can direct and slow the fall of material onto conveyor belts, and thus the amount of dust generated at transfer points.

E. Main sources of suppressing crusher dust:

   a. Water sprays;

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b. Enclosed buildings;
c. Dust collector units that work on many principles;
d. Electrostatic precipitator.

F. Crushing often requires constant supervision; therefore some extra operator protection at this typically dusty process is almost always required.

G. In order to reduce dust contamination in crusher control rooms and operator's positions, these areas should be completely enclosed and ventilated with uncontaminated air to create a positive air pressure.

H. Thus it may be necessary to provide air conditioning so the operator has no need to open doors or windows.

I. Protection of the control room will, in addition to creating a healthier environment, protect the electrical equipment from dust contamination that may lead to malfunctioning.

9.0 SCREENING

A. Screening provides the most difficult dust control problem in quarry operations, particularly if dry screening is taking place. Very careful planning of screen layout has to be undertaken to take out the fine cut as early as possible to lessen the dust carried through the screening process, and allow the use of water to both clean chip and allay dust, as water is the cheapest form of dust suppression there is.

B. In order to control dust in dry screening, the conventional method is to place a hood over the total screen area with rubber curtains sealing to the screen sides.

C. To be effective the screens and discharge chutes should be sealed to the bins to prevent currents of air carrying fine dust away into the surrounding area, and the screen house building must be well sealed or dust will escape.

D. Desirable elements for effective control are enclosed screens; enclosed transfer points, covered conveyors and chutes, and sealed bins. In theory it is then only necessary to deal with dust-laden air in the controlled area. As an aid to creating these conditions, extensive use can be made of specially developed rubber sheet covering that can be removed for maintenance and the inevitable blockage.

E. A careful summary of what permanent sealing and what removable sealing can be done should be carried out before determining the degree of further dust control, which may need to be applied.

F. Ducting from each plant item and transfer point may be connected to a filter system. Each item can either have its own filter or be ducted through to a central collector, usually a cyclone or bag filter system, or an electrostatic precipitator. The electrostatic precipitator is very efficient, but is an expensive item to buy. They are usually used where there is a large amount of dust produced e.g. a lime or cement kiln.

G. Metal sheeting or rubber panels normally achieve the enclosure of equipment, plus rubber seals at the joints. The use of rubber sheeting panels has grown recently, as it is easily removed and replaced for maintenance purposes.

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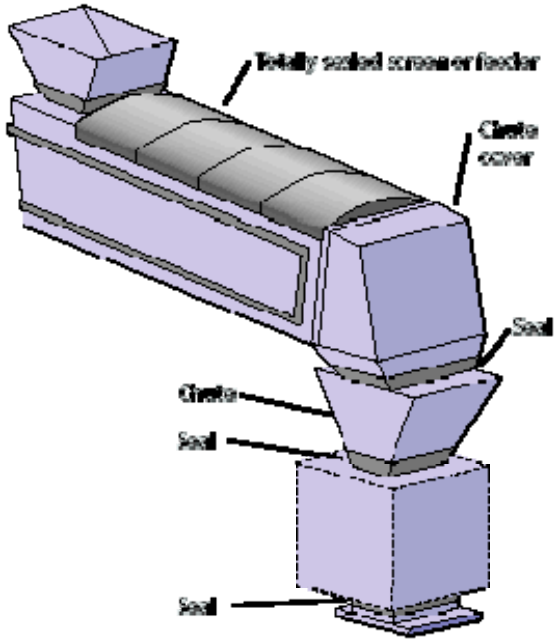
H. An important factor in the enclosure of a screen or the enclosing of any machinery is that adequate clearance must be allowed for moving parts, and account should be taken of potential temperature build-up in bearings and gearboxes. Further limitation on the discharge of dust can be achieved by the complete housing of the plant.

Diagram 2 Enclosed screens with chute covers



Source Metso Minerals

9.1 Conclusion

A. In order to minimise dust, plant operating constraints may include the elimination of open ground storage of finer graded materials.

B. Main suppression areas of screening airborne dust:
   a. Fine mist water sprays;
   b. Enclosed building;
   c. Dust collection units;
   d. Cladding or full enclosure of screen areas.

10.0 STOCKPILING (DUST SUPPRESSION)

A. Generally all sand, aggregate and road base products that are stockpiled on site have an initial water content, which helps suppress dust generated from such sources as the wind. However when products are stored for long periods in high temperatures and low humidity, stockpiles may need to be treated for dust suppression.

B. Wind is a major carrier of dust. Vegetation e.g. shelter belt, grown around dumps and stockpiles can reduce wind velocities hence dust.

C. Dust from stockpile sources can be contained in an enclosure, the use of plastic or other material cover, compaction of the surface and the use of water or sprays, trees and careful citing of stockpiles.

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D. In summary, care and planning of sites for plant, haul roads and stockpiles will help in reducing problems with nuisance dust. For existing plants, care must be taken to ensure the dust suppression system used fits in with the products produced and is easily used and maintained. See photo

Dust suppression on stockpiles

11.0 HAULAGE, TRANSPORT AND OVERBURDEN STRIPPING OPERATIONS

A. Dust in large volumes is inevitably generated as a result of overburden removal by haulage and transport operations, if precautions are not taken to allay dust at the source.

B. Air filtration systems on some mobile machines often only remove dust of the inspirable sizes leaving the invisible but potentially hazardous respirable dust in circulation – often in heavy concentrations.

C. Causes of dust from these operations are:
   a. Liberation of dust by wind.
   b. Dust raised by passage of tyres or tracks of vehicles (directly related to speed of vehicle).
   c. Dust liberated by excavation or disturbance of material.
   d. Dust raised by exhausts of vehicles.
   e. Dust raised by engine cooling fans of vehicles.

11.1 Methods of control

A. Formulation and implementation of sound management plans for all operations likely to create dust.

B. Planting plenty of trees or hedges as shelterbelts to eliminate or minimise wind disturbance.

C. Planning operations to maximise the benefit of wind breaks.

D. Disturbed areas such as those caused by stripping off grass and topsoil should be kept to a minimum.

E. Haul roads and standing areas should be sealed or concreted where possible.

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F. Use water sprays or water carts to settle dust. Care must be taken to ensure that the water used is free from pollution by noxious matter. There are additives available that reduce the volume of water used, and increase its effectiveness, but approval to use them should be obtained from the local territorial authority. Ensure permission from Regional Council is obtained before spraying emulsion on haul roads.

Roadway dust suppression

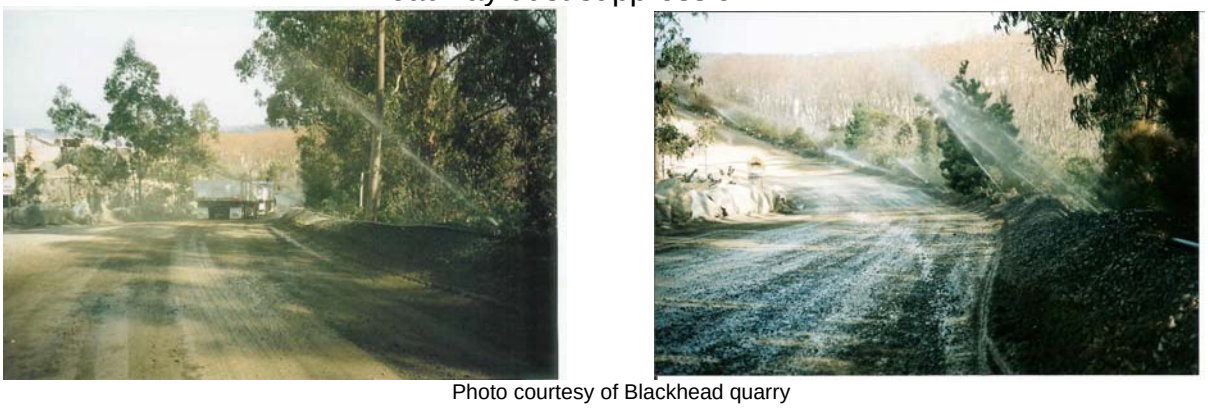

Photo courtesy of Blackhead quarry

G. Speed restrictions should be imposed and enforced.

H. Cabs of machines should be swept or vacuumed regularly to remove accumulated dust.

I. Exhaust pipes of vehicles should be directed so that they do not raise dust.

J. Engine cooling fans of vehicles should be shrouded so that they do not raise dust.

K. Hard surfaced haul roads or standing areas should be washed down and swept to remove accumulated dust.

12.0 HEALTH HAZARDS FROM DUST

12.1 Introduction

A. Rock dust is a significant hazard in the mining and quarrying industry. As well being a general nuisance it can cause visibility problems, eye damage and result in serious lung disease.

B. Pneumoconiosis is the name of a group of lung diseases caused by inhalation of airborne dust. Examples are silicosis, caused by breathing in silica dust, and asbestosis from asbestos dust.

C. Because the effect of dust exposure on a person's health will probably not be apparent for many years, the hazard is often underestimated. By the time symptoms such as shortness of breath appear, permanent and sometimes life threatening damage has already occurred.

D. Major factors which directly affect development of pneumoconiosis are:

   a. Dust particle size and shape.
   b. Composition of the dust.
   c. Concentration of particles.
   d. Duration of the exposure.

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12.2 Particle size and shape

A. Dust is solid matter, disintegrated into a fine state. Individual particle size is measured in microns diameter. In typical quarry dust, particle sizes would range from less than 1 micron to over 100 microns. Particles that cause silicosis are less than 7 microns in diameter – far too small to be seen by the human eye.

B. The size of dust particles controls where in the respiratory system inhaled dust will be deposited. Larger particles are trapped before they get to the lungs by mucous and small hairs that line the respiratory passages. This natural dust filter is very efficient but only partly successful in preventing tiny particles from penetrating deep into the alveolar region of the lungs where damage occurs. (See appendix 1).

C. **Respirable dust** is that fraction of airborne dust that is small enough to be able to penetrate deep into the alveolar region of the lungs.

D. **Inspirable dust** is all dust contained in the air which enters the mouth and nose as we breath in - including the respirable fraction.

E. These two terms are important when considering sampling methods. When sampling for respirable dust a miniature cyclone is used to remove particles over 7 microns in diameter.

12.3 Composition of rock dust

A. Workplace exposure standards (WES) vary according to the dust type. Silicosis results from inhaling respirable silica dust in its crystalline forms - quartz or free silica and a large variety of rock, sands and clays that are quarried in New Zealand contain a significant percentage of free silica.

B. Asbestos is not common in New Zealand quarries but it occurs in some ultramafic rocks, notably serpentine and dunite. The asbestos may not be visible so tests for asbestos fibre should be made before undertaking dust creating work with these rock types.

C. Rock dusts can be classified into two broad groups, fibrogenic and inert.

D. Fibrogenic dusts include both quartz and asbestos and are a serious health hazard. Exposure to high concentrations causes fibrosis – a thickening of the lung walls leading to development of scar tissue. This scar tissue restricts the vital exchange of oxygen and carbon dioxide in the blood causing breathing to become laboured which in turn places a strain on the heart. In addition to causing fibrosis, asbestos and quartz are carcinogens.

E. Inert rock dust with a free silica content of less than 1% is often perceived as harmless because it causes no significant scar tissue development in the lungs. However, extensive exposure to concentrations in excess of the body's natural clearing ability will cause damage and will create a favourable environment for disease.

12.4 Measuring Dust Levels

A. The concentration of airborne dust is measured by gravimetric sampling – usually with a personal sampling unit. This consists of a lightweight portable air pump that draws a measured quantity of air through a pre-weighed membrane filter on which

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the dust is collected. The mass of dust deposited on the filter and the quantity of air pumped is measured and a result calculated - expressed in milligrams of dust per cubic meter of air (mg/m^3). Samples should be taken over periods of several hours under typical average working conditions.

B. For respirable dust sampling, a miniature cyclone is used to remove +7 micron particles.

C. The free silica content of dust deposited on the filter can be measured in a laboratory using x-ray diffraction.

D. Detailed sampling procedures are set out in Standards Australia publications **AS 2985** and **AS 3640**. They are for respirable and inspirable dusts respectively.

12.5 Exposure Limits

A. Potential lung damage is directly related to the dust concentration in the air and the duration of exposure. For most rock dusts an 8-hour time weighted average (TWA) is used for the Workplace Exposure Standards (WES).

B. Some examples of current Workplace Dust Exposure Standards:

a. Respirable silica (crystalline quartz) 0.2 mg/m^3
b. Inspirable particulates, containing less than 1% free silica 10.0 mg/m^3
c. Respirable particulates, containing less than 1% free silica 3.0 mg/m^3
d. Respirable coal 3.0 mg/m^3
e. Coal containing respirable crystalline quartz respirable quartz 0.15 mg/m^3

Note: These exposure limits do not define clear lines between safe and unsafe exposure. In some countries the WES for respirable quartz has been reduced to 0.05 mg/m^3 and this would be a more appropriate maximum limit for the Industry to aim at.

C. Asbestos dust sample results are expressed in number of fibres per millilitre of air (f/ml).
Refer to the Health and Safety in Employment (Asbestos) Regulations 1998.

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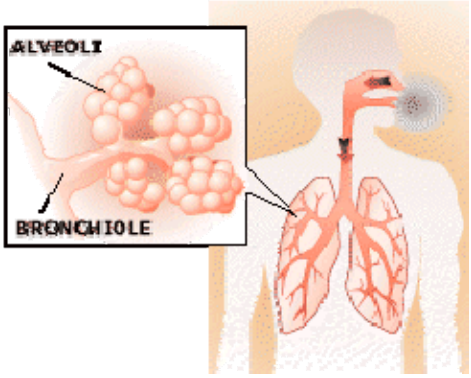
APPENDIX 1

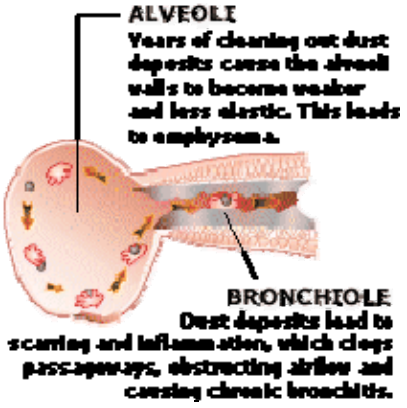
Only the smallest dust particles make it past the nose, mouth and throat to the alveoli deep in the lungs.

1. The alveoli, or air sacs, are responsible for exchanging gases with the blood. They are located at the ends of each bronchiole.



2. Macrophages, a type of blood cell, collect foreign particles and carry them to where they can be coughed out or swallowed.

3. If too much dust is inhaled over an extended period of time, some particles and dust-laden macrophages collect permanently in the lungs.



Sources: MSHA Informational Service.

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