Coal Dust / Iron Ore dust / Other Dusts

The most hazardous dust to human health is the type that is invisible to the human eye.

Respirable dust particle: < 4 microns in size
Inhalable dust particle: < 10 microns in size

Abstract

In this document, you will find a plain English guide to the effects of coal and iron ore dust exposure & how to provide a safe working environment on your site.

BEST PRACTICE FOR IRON ORE & COAL DUST ENVIRONMENTS

Enclosed cabins are an effective way to reduce dust exposure to workers.

Climate-controlled, environmentally sealed enclosures with pressurised systems manufactured with high efficiency filters (HEPA) will ensure operators are protected and their work environment is comfortable.

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The Surface of the Earth is composed of silicate minerals which are compounds of silicone dioxide found in combination with other elements such as iron, aluminium, gold, etc.

Iron ore workers are at risk of developing interstitial lung disease when exposed to high dust concentration over time as the process of extraction produces respirable / inhalable dust containing silica and other contaminants.

For coal workers, the hazards of processing coal are complex which include organic and inorganic contaminants with known carcinogenic substances, such as silica, cadmium, lead, kaolin, pyrite and polycyclic aromatic hydrocarbons.

It is up to the employer to implement effective engineering and administrative control measures.

Occupational lung disease is caused by inhaling high concentration amounts of fine respirable / inhalable particles over time.

Who is at risk?

Mine workers who are exposed to coal dust, rock dust, silica dust, diesel particulate matter and other fine airborne particles produced during mining and processing.

Worker exposed activities:

- Drilling
- Blasting
- Excavating / earth works
- Loading and tipping
- Transporting
- Crushing, conveying and screening
- Stockpiling

Atmospheric dust constitution and over-exposure which is directly related to lung disease:

• Hematite (iron oxide)	Siderosis
• Antimony (compounds)	Antimony Pneumoconiosis
• Barium (compounds)	Baritosis
• Tin (compounds)	Stannosis
• Asbestos	Asbestosis
• Silica	Silicosis

Some of these conditions are benign and may be associated with decreased lung function or minor health effects such as:

- Chronic bronchitis
- Bronchial asthma
- Pneumoconiosis

While Silicosis and Asbestosis are serious, debilitating forms of occupational lung disease.

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Common naturally occurring hazardous in the mining industry.

- Aluminium. Refining bauxite exposure to fluorides and smelting to polycyclic aromatic hydrocarbons which are carcinogens. Long term inhalation of aluminium powder is linked to pulmonary fibrosis. International Aluminium Institute, http://www.world-aluminium.org/.
- Arsenic. Ores processing at a refinery or smelters where it can be converted to arsenic trioxide and becomes readily bioavailable. Arsenic is a Group 1 human carcinogen IARC, http://www.iarc.fr/
- Asbestos. Naturally occurring in major nickel and gold deposits in Western Australia leading cause of lung disease. Airborne fibres may be present as minor/trace contaminant in dust produced in blasting, crushing and handling and processing coal and iron ore. Classified as Group 1 human carcinogen. IARC, http://www.iarc.fr/
- Cadmium. Smelting by-product and highly toxic and is classified as Group 1 carcinogen. International Cadmium Association, http://www.cadmium.org/.
- Coal dust. Contains crystalline silica which is leading cause of chronic obstructive pulmonary disease. (Stockpiles, due to reaction with oxygen, lead to oxidation releasing toxic gases, like carbon monoxide and sulphur dioxide). Silica is classified as Group 1 human carcinogen IARC, http://www.iarc.fr/
- Copper. Ore contains silica associated with high exposure to respirable crystalline silica. Other elements are arsenic and uranium.
- Iron ore. Typically, benign but when processing release dusts containing other substances, i.e.: silica, mineral fibres.
- Manganese. During mining, production of alloys, foundry. Long term exposure leads to severe neurotoxic symptoms. International Manganese Institute, http://www.manganese.org/.
- Mineral sands. Australia has vast deposits some of which contain radioactive material, thus making tailings slightly radioactive (thorium present in monazite) & dangerous if airborne dust is inhaled. http://www.minerals.org.au/file_upload/files/publications/3.1D_Download_Radiation_Workers_Handbook_1862009.pdf World Nuclear Association, *Occupational safety in uranium mining,* 2014, http://www.world-nuclear.org/information-library/safety-and-security/radiation-and-health/occupational-safety-in-uranium-mining.aspx. 22 ARPANSA, Radiation Protection Series Number 9, http://www.arpansa.gov.au/pubs/rps/rps9.pdf
- Silica. (RCS respirable crystalline silica) Silica is one of the most abundant minerals on the surface of the Earth. It is classified as a Group 1 human carcinogen. IARC, http://www.iarc.fr/
- Zinc. Inhaling large amount of zinc dust or fumes from smelting may lead to reversible short term disease - metal fume fever.

For protection against radioactive dust tailings: uranium, thorium or radium the following is recommended.

Dust control is extremely important but weather will affect exposure to personnel via dust clouds. The same process applies with dust control measures. When executing activities such as exploration drilling and blast hole drilling, ore handling, crushing, pulverising and screening. Workers in enclosed cabins are protected if cabin integrity is very good, meaning that dust will not enter via leaks or gaps.

Then a high efficiency primary and return air (HEPA) filter are used within a pressurised system to supply clean air to the installed air conditioning system to effectively control the internal environment. This two-stage principle is best practice, sealing the cabin very well and then adding pressurised filtered air to effectively push out airborne contaminants.

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Particle size	Fall Velocity [cm/s]	Duration of fall from a height of 1 m [min]
0.1 micron	0.00006	500 hrs
1 micron	0.006	5 hrs
10microns	0.6	3 mins
50 microns	15	6 s

Table 1. Floating behaviour of dust particles (density 2g/m³) in air.

Exposure limits for coal dust in Australia: (TWA)

Queensland: 3.0 mg/m³ (containing < 5% quartz)

NSW: 2.5 mg/m³

US: 1.5 mg/m³

AIOH: 1.0 mg/m³ recommendation

Table 2. The different levels of coal dust exposure and the recommended limit by the Australian Institute of Occupational Hygienists.

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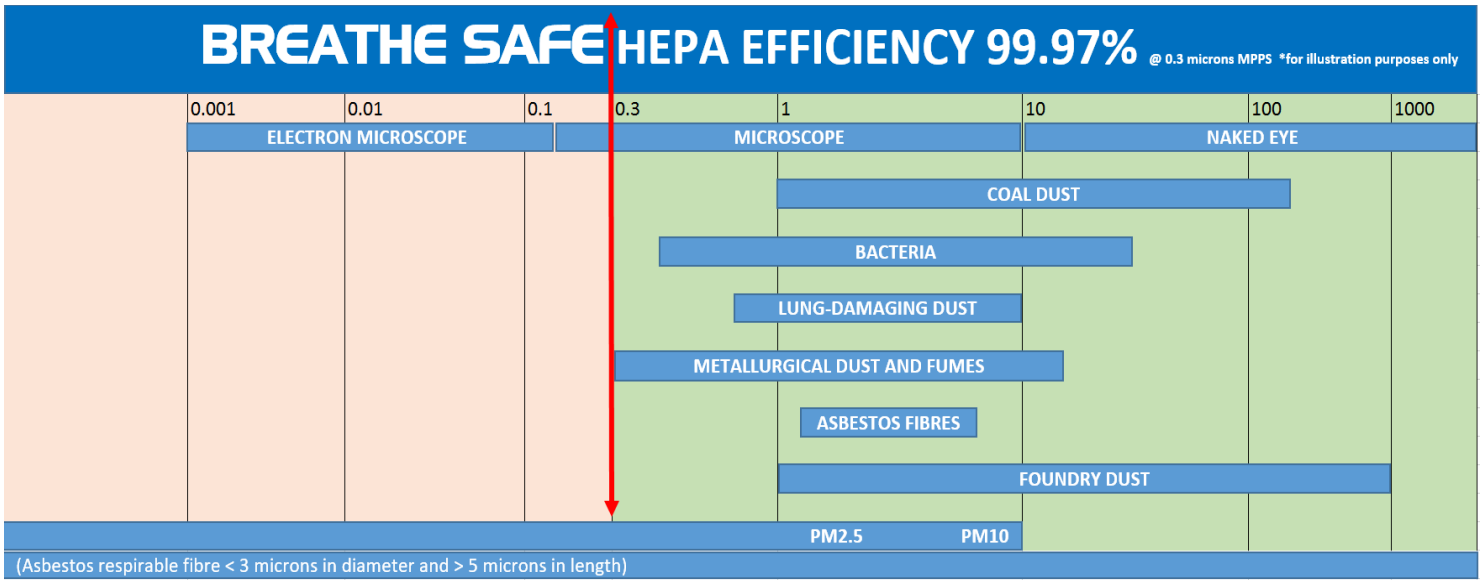

Table 3. HEPA filter media efficiency chart. (Asbestos respirable fibre < 3 microns in diameter and > 5 microns in length). *Illustration purposes only.

Prevention from engineering controls – Enclosed cabin for fixed and mobile plant - Hierarchy of risk controls with management examples:

RISK CONTROL	EXAMPLES
ELIMINATING THE RISK	May be unavoidable but isolate / chance process or remove personnel from exposure hazard.
ISOLATING THE HAZARD	Enclose process areas Dust suppression techniques at the source
ENGINEERING CONTROLS	Enclosed pressurised cabin with HEPA filters and pressure display. 20 to 60 pascals of overpressure. Recommended to extend cabin sealing components. (Higher pressure deforms seals). Review – daily / weekly inspections due to dust wears out controls quickly *Data logging – Internal pressure (Record keeping).
ADMINISTRATION CONTROLS	Training, signage, restricting time of exposure, staff rotation away from exposure to respirable dusts. Personnel to be aware of potentially harmful dust clouds Review maintenance – Coarse dust wears out components quickly. Last resort is personal protective equipment *Register of serial numbers for HEPA filters installed and replaced (Record keeping).

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To protect workers from high level exposure, they are required to wear RPE. Which should be the last resort.

Engineering controls overview for enclosed operator cabin:

- ✓ Enclosed pressurised cabin to EN15695 cat 4*
- ✓ Maintenance free Primary Pre-cleaner.
  - To remove coarse dusts.
- ✓ HEPA primary filter to remove dust from fresh air. (H13 tested to EN1822 / Serial number)
  - To remove respirable airborne particles 0.3 to 10 microns (HEPA efficiency rating)

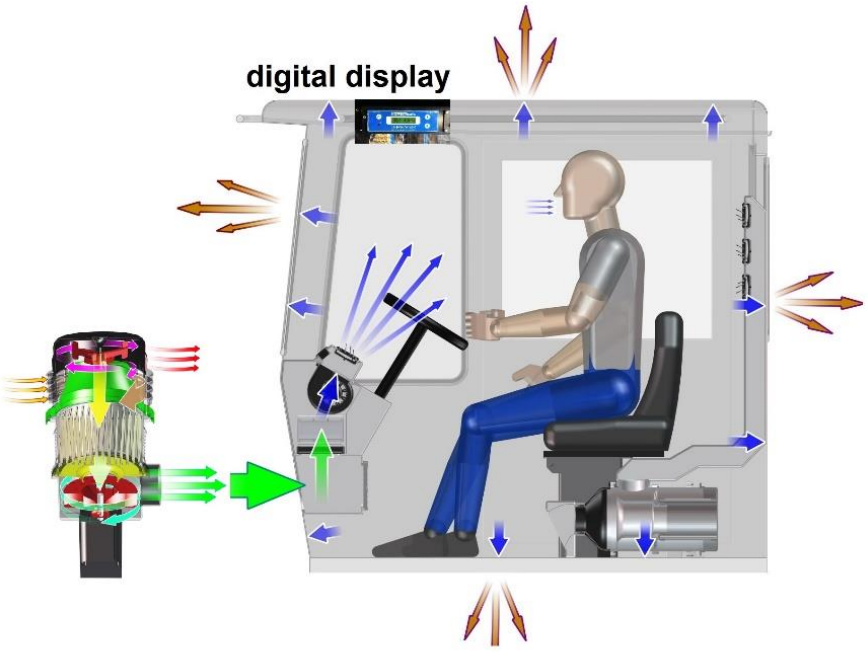
- ✓ HEPA return air filter
  - To remove any contaminate inside the cabin carried in when the operator enters & leaves the cabin
- ✓ Differential pressure Gauge (DPG) Display
  - To indicate pressurised cabin
- ✓ Alarm to indicate malfunction of system.
  - Possible Motor failure, clogged filter, Poor sealing, door or window not closed correctly
- ✓ Data logging
  - Provide documentation of chain of responsibility
- ✓ Remote monitoring (Data logging)

Breathe-Safe Category 3/4/5 Systems are design to replicate **clean room standards** by utilizing a 2 stage HEPA filters. (Primary and return air filter).

Stage 1 - Pre-cleaner - Removes coarse particles from fresh air

Stage 2 - Particulate HEPA Pre-filter - Removes fine dust particles to protect the operator with efficiency particle separation of 99.97%

Stage 3 – Return Air Filter – Removes particles from inside the cabin from shoes or clothes and ideally located at foot well or as close as possible to operator's feet.



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***An international EU standard in effect with enclosed cabins is EN 15695 for applications required to protect the operator from dusts, gases and pesticides in the agricultural sector. The standard is expected, in future, to extend to the construction sector.**

Mobile Equipment with Enclosed Cabins

The Operators cabin should have the following features: (Exceeds EN15695 in qualifying cabin)

Cabin Pressuriser

Filtered fresh air cabin pressuriser capable of maintaining 25Pa of cabin pressure through the service life of the HEPA filter with a minimum of 30 cubic meters per hour of fresh air to ensure there is no CO2 build up. The filter must be HEPA with a minimum efficiency of H13 and be tested after manufacture as per EN1822.

Cabin Sealing

Cabin sealing must be to a standard where the cabin pressure can be maintained at 25Pa over for the service life of the filter

Differential Pressure Gauge

A DPG must be installed in the cabin to ensure the system is working correctly and to warn the operator of a fault.

Return air filter HEPA

A Return air filter with a minimum efficiency of H13 (tested to EN1822) should be installed in the HVAC system to ensure that particles in the cabin are captured & not recirculated.

The return air filter is best located close to operators' feet to trap contaminants from shoes or clothes.

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Engineering control design and notes:

US studies found: [1][2]

*An enclosed cabin which **has been environmentally sealed** and is equipped with pressurisation and with air conditioning has a protection factor of 52.*

*An enclosed cabin which has only an air conditioning system (HVAC) installed but the cabin is **not sealed** or pressurised returned a protection factor of 0. A cabin with the above configuration creates a higher risk of exposure. It is understood that contaminants are carried into the cabin by wind & by the worker (on shoes & clothes) then HVAC system dries out contaminant. Then by normal body movement particles become airborne inside the cabin and the worker inhales these particles.*

- Where Respirable Crystalline Silica (RCS), Asbestos, elongated mineral particles (EMP) or Hazardous fibres are present use only HEPA filters with a minimum efficiency of H13 tested after manufacture as per EN1822. MERV 16 type filters may not have the same efficiency and should not be used on these sites.
- In high risk areas, it is recommended that door & window alarm switches are installed to warn of any external contamination.
- HEPA filters cannot be cleaned as HEPA media is easily damaged.
- For underground mines, it is recommended that a brushless pressuriser motor is used (Spark free operation).

Important notes on effective dust control:

- International trials* have determined that the optimum protection factor is achieved if the cabin pressure is maintained between 20 Pa & 30 Pa of cabin pressure. We recommend that systems maintain a cabin pressure of 25 Pa throughout the service life of the system whenever the machine ignition is turned on.
- A primary HEPA filter has a serial number with test date. This is a record which can be maintained each time the filter is replaced.
- A data recorder to maintain an electronic register showing that positive pressure has been maintained over the service life of each filter and the machine's service life if required.
- A real time positive pressure display D.P.G. to show the system is working correctly. (Recommended accuracy of less than 2 Pa)
- An alarm / warning device to advise operator if the system is not working correctly.
    - Message on display if there is a fault saying "Low Cabin Pressure" with a, Warning light & Optional warning buzzer
- A pre-cleaner is required to protect the filter from coarse silica dusts – Recommend centrifugal type as daily maintenance is not required.

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- An air volume system delivering a minimum of 30 cubic meters per hour of fresh air to prevent respiratory acidosis is needed. (This prevents excessive CO2 Build up in the body and/or Hypoxia-lack of sufficient oxygen within the cabin).
- Workers should keep doors and windows closed always.

Service maintenance

- Personnel to wear RPE/PPE when handling old filters and/or when any HVAC maintenance is to be carried out
- Check that the cabin pressurisation system is working when the ignition is turned on and maintains a minimum level of 25Pa of cabin pressure
- Abrasive dusts can wear out equipment quickly. Plan and carry out regular checks of the critical parts.
- Vacuum clean the vehicle cab at least once a week. Use a Type H vacuum cleaner fitted with a certified HEPA filter
- Change HEPA filters as advised by the manufacturer.
- Qualified personnel to inspect & test the system every 6 months.
- Down load & archive data from the data recorder.
- Caution: Never use a brush or compressed air to carry out maintenance or to clean cabin

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Refences

[1] Cecala AB, Organiscak JA, Heitbrink WA, Zimmer JA, Fisher T, Gresh RE, et al. [2002a]. Reducing enclosed cab drill operators' respirable dust exposure at surface coal operations with a retrofitted filtration and pressurization system

[2] Cecala AB, Organiscak JA, et al. [2016a] Air cleaning performance of a new environmentally controlled primary crusher operator booth. https://www.cdc.gov/niosh/mining/UserFiles/works/pdfs accessed Aug. 2016

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