Dust — What You Can't See CAN Hurt You!

U. S. Department of Labor
Mine Safety and Health Administration
National Mine Health and Safety Academy

1999

Introduction

Black lung is, and has been, a problem for miners. Conditions have improved but the risk to miners remains. This booklet is part of the MSHA campaign to end black lung and silicosis, now and forever. Enforcement, new technology, and a better system of monitoring are all part of the effort. But an educated mining community, where every one of us takes the steps to prevent dust diseases, is the critical factor in eliminating black lung and silicosis mine by mine, section by section, and miner by miner.

> "Among other things, it is the purpose of this title to provide, to the greatest extent possible, that the working conditions in each underground coal mine are sufficiently free of respirable dust concentrations in the mine atmosphere to permit each miner the opportunity to work underground during the period of his entire adult working life without incurring any disability from pneumoconiosis or any other occupation-related disease during or at the end of such period."
>
> *Title II, Section 201(b) - Federal Mine Safety and Health Act of 1977*

Sources of Dust In Mining

Many miners are potentially exposed to the hazard of breathing respirable dust. Actual exposure is based on the concentration of dust in the air and the length of time spent in the dusty conditions.

Coal Mine Dust

Every time coal is broken from the seam, coal mine dust is generated. It's also released during blasting, drilling, or transportation. Continuous mining and longwall operations produce massive amounts of coal as well as coal mine dust, some of it respirable. Coal dust contains more than 50 different elements and their oxides, and its mineral content varies from seam to seam. Studies show that the hardness of coal plays a part in the amount of dust liberated in mining and influences the approaches used in dust control.

Sources of Coal Dust In Underground Coal Mines

The continuous miner, shuttle cars, and roof bolter are the major dust generation sources in a *continuous* mining operation. Feeder breakers, conveyors, and outby equipment also produce dust.

Longwall mining systems have been used overseas for many years, but made their first modern appearance in the U.S. in 1960 in a coal mine in southern West Virginia. Today, longwall mining accounts for approximately 40 percent of the coal produced in underground mines in the United States. A typical longwall system has five sources of dust. These sources are the shearer/plow, stage loader/crusher, roof supports, conveyors, and outby equipment. The shearer/plow and stage loader/crusher are the major dust sources on a longwall installation.

Sources of Coal Dust At Surface Coal Mines

At surface mines, drilling, blasting, and crushing are the major sources of coal dust. Operation of heavy equipment such as loaders, shovels, dozers, draglines, and haul trucks also produces dust. Dust on roadways and around stockpiles and loading operations is often a problem.

Silica Dust

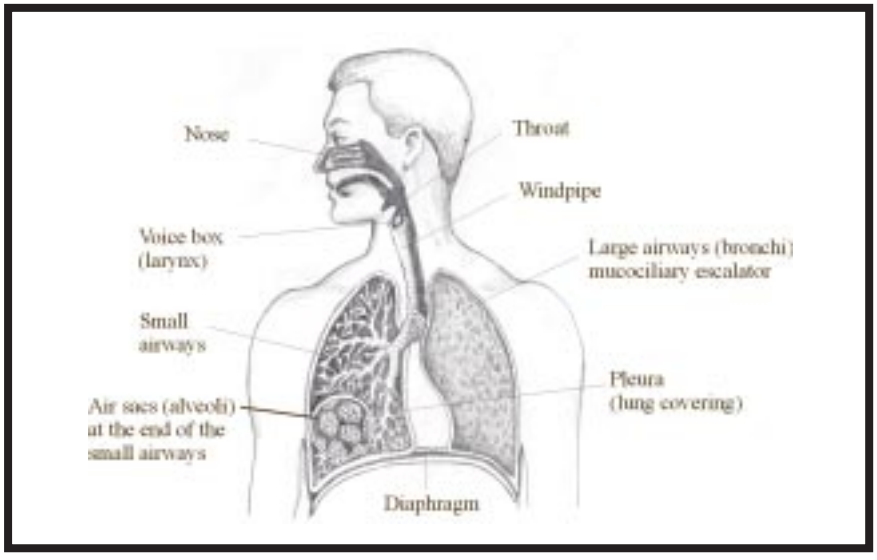
Each year, according to the Center for Disease Control/National Institute for Occupational Safety and Health (CDC/NIOSH), more than one million miners and other workers are exposed to dangerous levels of the disabling dust ***silica***. Silica, or silicon dioxide (SiO_2), the agent responsible for silicosis, is formed when oxygen combines with silicon. Silica exists in two primary forms — crystalline and noncrystalline (amorphous). Crystalline silica, also called free silica, is most commonly found in the form of quartz in nearly all mineral deposits. Quartz is found in common rocks such as granite, sandstone, limestone, shale, and traprock. It is the principal component of sand and occurs in many soils.

High silica exposures may occur when miners remove the overburden or tunnel through rock to get to the coal they want to mine.

Sources of Silica Dust in Coal Mines

What Dust Can Do To You

Dust Overwhelms the Body's Defense Systems



sneezed/blown/spit out or swallowed. Air then passes through the windpipe (***trachea***) into the bronchial tubes (***bronchi***). In these tubes a mucus blanket moistens the air, preventing the walls from drying out. It also traps particles that get past the nose and mouth. Special cells with whip-like projections (***cilia***) move the trapped particles up the larger air tubes to the mouth where they will be swallowed or spit out. The cilia and mucus blanket are called the ***mucociliary escalator***.

Particles that get past the mucociliary escalator are called ***respirable***, and are generally less than 10 microns (μ) in diameter. A micron is about one twenty- five thousandth of an inch. (Note: A human hair is about 40 microns in diameter.) These particles, which are invisible to the naked eye, move through smaller and smaller tubes called ***bronchioles***, finally ending in ***alveolar sacs*** and ***alveoli*** (air sacs). **Remember — when you see dust in the air, there's a lot more that's invisible and respirable!**

Exchange of oxygen and carbon dioxide takes place in our more than 300 million alveoli, which have walls so thin that gases can easily pass through. The entire blood volume of the body (approximately 5 liters) passes through the lungs each minute when we are resting. Special cells called ***macrophages***, which are part of the lungs' defenses, engulf some of the particles that make it to the alveoli. When there is too much dust the number of macrophages builds up to the point that they cannot pass out of the bronchioles to be cleared. Particles begin to build up in the air sacs interfering with the oxygen-carbon dioxide exchange. Eventually these respirable particles cause scarring (***fibrosis***) in the air sacs making it very hard to breathe. Diseases that cause this scarring are called ***pneumoconioses***.

What is Coal Workers' Pneumoconiosis (CWP)?[1]

According to CDC/NIOSH studies, from 1968-1992, almost 60,000 workers died of black lung and related complications. It is the most widespread disease caused by mineral dusts throughout the world.

[1] CWP is a medical term, black lung is a social term. These terms are often used interchangeably.

While black lung was not officially recognized in the United States until 1969 (with the passage of the Coal Act), it was diagnosed as long ago as 1831.

From MSHA
Part 50 Data .....

Reported Black Lung Cases
January 1992 – June 14, 1997
Total: 1,914

Major Occupations Affected	Number
Laborer/utility man/bullgang	304
Mechanic/repairman/helper	183
Roof bolter/helper	154
Continuous miner operator/ helper	136
Supervisory/management/ foreman	133
Shuttle car/tram operator	113
Belt/conveyor man/crew	101
Electrician/helper/wireman	93
Bulldozer/tractor operator	59
Truck driver	56
Scoop car/tram/load haul dump operator	51
Longwall jacksetter/swamper/ snaker/operator/helper	35
Other	486

Black lung/CWP is caused by the breathing in and buildup of respirable coal mine dust in the lungs. The Black Lung Benefits Reform Act of 1977 defines pneu-moconiosis as "a chronic dust disease of the lung and its sequelae, including respiratory and pulmonary impairments, arising out of coal mine employment."

CWP is a ***chronic*** disease which develops over years of exposure. It covers a wide range of illness including breathing and heart problems. It is usually diagnosed based on x-ray findings and a history of work in coal mines.

Simple CWP shows up as small spots less than 10 millimeters (mm) on a chest x-ray. It is due to the collection of coal dust around the respiratory bronchioles, which contain alveoli. With continuing exposure more dust is deposited and lesions called ***macules*** are formed. These are typical of CWP. Coal macules are actually macrophages loaded with dust, mostly found around the respiratory bronchioles.

A miner with simple CWP may not seem sick, so x-rays and a detailed history of work in coal mines are important in making an

early diagnosis. If the disease is detected early and the worker removed to a less dusty atmosphere, lung damage may be halted. Recent studies, however, indicate that CWP can progress even after exposure has stopped. There is no cure for CWP. ***Prevention is the only answer!***

Complicated CWP occurs if the miner continues to be exposed to respirable coal mine dust, causing scar tissue to form in the lungs. On autopsy it appears as large black nodules and black lung tissue, while on an x-ray the disease appears as large spots. A miner with complicated CWP will feel short of breath on exertion and have a persistent cough. The miner may also be awakened by night sweats.

As the disease progresses, the shortness of breath gets much worse. Eventually the miner cannot work or perform simple everyday activities. Other symptoms include:

- chest pain
- coughing blood
- weight loss

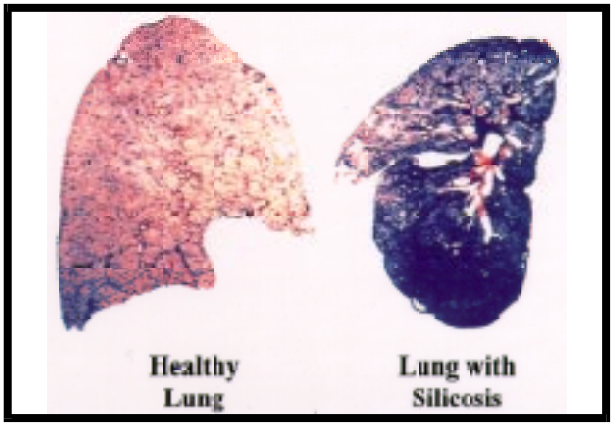
The heart becomes enlarged and heart failure is a likely result. The miner might also die from pneumonia or other infections that attack the weakened lungs.

Silicosis

Respirable crystalline silica dust (primarily quartz) is responsible for another pneumoconiosis called ***silicosis***.

At least 100,000 workers are at a high risk of developing the completely preventable disease ***silicosis***. More than 250 workers die with silicosis every year. A good occupational health program with a focus on control of silica dust and education can help us turn these statistics around.

Silicosis is a lung disease caused by breathing dust containing respirable silica particles. When these tiny particles reach the deep part of the lungs, they are engulfed by macrophages, which burst apart



because of the irritating effects of the silica. The silica builds up in the lungs and scar tissue forms, resulting in fibrosis. The lungs become stiff and must work harder to get the necessary oxygen from air. Even when a worker is removed from exposure, silicosis can continue to progress. As with black lung, prevention is absolutely necessary.

There are three types of silicosis: chronic, accelerated, and acute. ***Chronic*** silicosis is the most common form of the disease. It is caused by long-term exposure to crystalline silica at relatively low levels. It may not show up for 10 years or more. Early on, the miner may have no symptoms and the disease often won't show up on an x-ray. As the disease gets worse, the miner may feel short of breath or have a fever. Gradually, silicosis destroys breathing ability and makes miners more susceptible to other lung diseases. For example, workers with silicosis have higher rates of tuberculosis because the silicosis weakens the lungs' defenses against infection.

When the fibrosis spreads throughout the lungs restricting their function, the heart must work harder to move blood throughout the body. This can increase the risk of heart disease for miners with chronic silicosis.

Accelerated silicosis results from exposure to high concentrations of crystalline silica and develops 5 to 10 years after the initial exposure.

Acute silicosis can occur in miners exposed to very high dust levels, particularly among workers who produce finely ground silica – sandblasters, tunnelers, and rock drillers – especially if the material drilled is sandstone or other material with a high silica content. Unlike chronic silicosis, acute silicosis develops rapidly, usually after months (not years) of exposure. There are also historical reports of the disease developing after only weeks of intense exposure, with death resulting very quickly.

"...America's worst industrial disaster."

Silicosis first received widespread public attention in 1936 when more than 700 men died near the town of Gauley Bridge,West Virginia, as a result of breathing in silica dust. These men worked at tunneling through a mountain of almost pure silica, and even though the health effects of silica exposure had been documented for decades, no precautions against the dust exposures such as ventilation, wet drilling or respirator use were taken. The incident prompted a major congressional investigation in 1936.

What Increases the Risk of Developing Dust Diseases?

Miners who work in dusty conditions should consider themselves potentially exposed to respirable dust when there are:

- Inadequate dust control measures
- Inadequate respiratory protection

The National Institute for Occupational Safety and Health (NIOSH) also points out that efforts to prevent silicosis (as well as other dust diseases) may be inadequate if there is:

- Lack of awareness about the sources of dust exposure, the nature of silicosis, and the causes of the disease
- Lack of adequate medical screening and monitoring programs
- Lack of adequate air monitoring programs for respirable dust

It's too late for these miners...

“The old men; they have a hard time breathing ... I can see it in their faces.”

“Most of the people I know that had silicosis are no longer with us.”

“His lungs are done — the doctors can't do anything with them.”

“There's dust in my lungs — the doctor said working without protection would only make it worse.”

“It's affected my work — I take shortcuts whenever I can.”

“I can't hunt or walk like I used to.”

“I used to weigh 255, now I'm down to 165.”

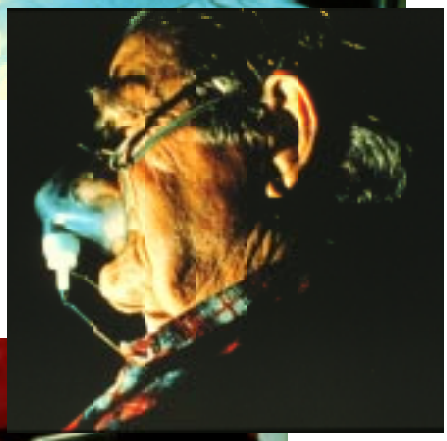
“It's worked on me and my family a lot. I can't do the things I want to for them.”

“People in their 30s and younger can get it.”

“It doesn't get any better; it just gets worse and it doesn't go away.”

But not for you!

Quotes taken from MSHA videotape, “What Does the Term Silicosis Mean to You?”



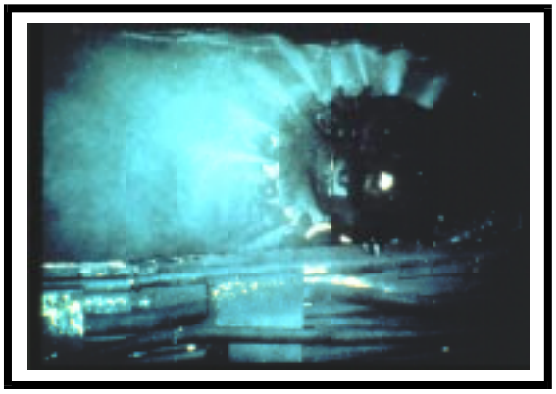
How Can Dust Exposures Be Prevented or Reduced?

The severity of black lung or silicosis is directly related to the amount of dust deposited in the lungs. Therefore, prevention depends on lim› iting the amount of dust breathed by miners. An effective prevention program requires:

- use of engineering controls to reduce worker exposures
- training of workers on the hazards of respirable coal mine dust and silica, control measures, and proper sampling procedures
- sampling of workplace air to determine dust levels and monitor the effectiveness of engineering controls
- respiratory protection program
- medical screening to identify miners who have early evidence of the development of respiratory diseases

Controls

As mining methods have changed and become more mechanized, dust controls have also changed. However, the major control meth› ods for dust in mining operations continue to be water, ventilation systems, and isolation of miners from the hazards through work prac› tices and use of remote control plus environmental cabs and control rooms in surface mining.



Water

- **Prevent** dust from being generated by introducing water during drilling or roof bolting.
- **Wet** materials as they are cut and removed to prevent dust from becoming airborne — e.g., by controlling the airflow patterns at and near the face to minimize dust rollback, and by dust knockdown (airborne capture or scrubbing of airborne dust from the air).
- **Enclos**e crushers and transfer points and add water sprays to reduce major dust sources in outby areas.
- **Water** haul roads.
- **Use** dust collectors such as scrubbers on continuous miners and longwall shears.

Ventilation

- **Improve** the quality and quantity of face ventilation.
- **Increase** ventilating air if the air current is below optimal rates.
- **Install** curtains to increase forward air velocity over the operator and prevent dust rollback.
- **Put** passive barriers over the dust cloud at the longwall face which separates the air into two separate splits.
- **Use** dust collectors on roof bolters or change roof bolting system.
- **Keep** the bolter upwind of the miner.
- In longwall operations, **utilize** a shearer-clearer that uses the air moving qualities of normal water sprays to confine the dust cloud and move it away from the operator.
- In longwall operations, **use** homotropal ventilation (coursing the air in the same direction as material transport), and **use** the tail entry as an auxiliary intake.

Other Controls

- **Use** remote controls and locate operator upwind of the dust source — commonly used in continuous and longwall mining systems.
- **Install** environmental cabs on surface equipment.
- **Modify** cutting sequences to keep workers upwind of face.
- **Improve** design of bits — studies by NIOSH show that changing bits can reduce the amount of dust produced; also **maintain** bits in good condition.
- **Increase** depth of the cut on longwall.
- On conventional and continuous mining sections, **mine** in seam (prevents taking top and bottom thus reducing potential silica exposure).
- **Maintain** dust scrubber ductwork, sprays, filters, sump, and air velocity.

Training

Miners need to be informed about the hazards they are potentially exposed to through formal and informal training, provision of written materials, or through posting of bulletins, MSHA Alerts, fact sheets, and warning signs.

Training should include measures workers can take to protect themselves and information on legal requirements for sampling, on-shift examinations, controls, etc.

Sampling Program

The two reasons for monitoring the workplace are:

- to measure the level of a particular contaminant to which workers may be exposed, and
- to determine the effectiveness of any control measures in place.

To ensure this, samples must represent actual exposures. The current respirable dust control program requires that MSHA and the mine op› erator do monitoring, but the operator has primary responsibility for demonstrating that all miners work in an environment that is free of excessive levels of respirable dust. A brief description of the key ele› ments of the program follows.

Operator's Sampling

Each mine operator is required to collect a prescribed number of full-shift respirable dust samples on a bimonthly basis and submit them to MSHA for processing and analysis to de› termine compliance with the respirable dust standard. These samples are required to be col› lected by certified persons — individuals who have passed a written examination administered by MSHA. After samples have been collected, certified persons are required to fill out the dust data card provided by the manufacturer with each filter cassette. They identify the mine, describe the type of sample taken, report the production level during sampling, and include their signature and certification number.

Wearing a dust pump is important! Sampling determines an individual miner's exposure and also provides information important to other miners in the area.

The sampling device is required to be operated "portal to portal." That is, the device stays with the miner during the entire shift or for eight hours, whichever time is less. Sampling must also be conducted with approved sampling equipment that is properly calibrated and maintained by persons certified to perform that task. The equipment must be examined by a certified person prior to the beginning of the sampling shift, at least once during the second hour of sampling, and again during the last hour.

Underground coal mine operators are required to collect and submit two different types of respirable dust samples on a bimonthly basis:

Designated Occupation (DO) samples and Designated Area (DA) samples. A Designated Occupation is the work position that has been determined by MSHA to have the greatest respirable dust concentra› tion. If such occupations are in compliance, then others exposed to lower concentrations will also be in compliance with the standard.

During each bimonthly period, mine operators are required to collect and submit five DO samples for each mining unit. An operator who is found to be in violation is issued a citation and must take steps to re› duce the dust level.

The operator is also required to collect samples from each Designated Area. These locations are selected so that the environment where miners normally work or travel is monitored for compliance with the applicable dust standard. Operators are required to collect and submit one sample from each DA during each bimonthly period; if any of these samples exceed the applicable respirable dust standard, MSHA notifies the operator of this finding.

The operator's approved ventilation system and methane and dust control plan is required to identify the specific locations in the mine where area samples are to be taken.

In addition, mine operators are required to collect and submit a bi› monthly sample from every "Part 90" miner they employ. If any of these samples exceed the applicable standard of 1.0 mg/m^3, the operator is required to submit additional samples collected on five consecutive production shifts or days, which are used by MSHA to make a compliance determination.

Operators must transmit all samples collected to MSHA within twenty-four hours after the end of the sampling shift, and each sample transmitted to MSHA must be accompanied by a properly completed dust data card.

After MSHA has processed the samples, the operator is provided with a respirable dust sample data report, which contains the results of every sample submitted. The operator is required to post this

report on the mine bulletin board for a period of thirty-one days to provide miners ready access to current information on respirable dust conditions in the mine. If a miner jots down the filter cassette number when wearing a dust pump, he or she can check out the posted sam› pling results for the pump they were wearing.

Operators are also required to report to MSHA in writing any changes in the operating status of the mine, mining unit, or designated area that affects the sampling requirements, within three working days after the change occurs.

MSHA's Sampling Program

Regulations require mine operators to maintain dust concentrations at or below the applicable standard in the mine. MSHA conducts dust sampling at a variety of underground and surface locations to determine if the mine atmosphere meets the established stand› ards. Many samples collected by MSHA are analyzed for both coal mine and silica dust.

Underground

MSHA collects respirable dust samples on each active working sec› tion four (4) times each year. The occupations typically sampled in› clude such jobs as continuous miner operator, longwall shear op› erator, roof bolter, etc. One occupation on each section has been se› lected by MSHA as the Designated Occupation (DO) which is the oc› cupation MSHA has determined is most likely exposed to the highest dust levels. MSHA also collects samples from areas outby the active section, such as belt transfer points, rotary dumps, and crushers, to determine that respirable dust concentrations are main› tained at or below the applicable standard. Many of these outby areas are selected as Designated Area (DA) sample points which must be monitored by the mine operator's sampling as well.

Surface

MSHA collects respirable dust samples at each active surface mine and surface facility two (2) times each year. The occupations

typically sampled include such jobs as highwall drill operator, bulldozer operator, end loader operator, etc. Some areas have been se› lected as a Designated Work Position (DWP) which is a surface area MSHA has determined is most likely exposed to high dust levels. These DWP sample points must be monitored by the mine operator's sampling as well. Sampling is conducted during dry periods to accurately determine the dust concentrations to which miners are normally exposed.

Surface facilities (except preparation plants) and surface areas of underground mines with no active designated work positions and fewer than 20 employees are sampled by MSHA annually.

Request for Inspection

Under Section 103(g) of the Act, at any time any person may, and is encouraged to, notify MSHA of any violation of the Act or safety or health standards — for example, potential overexposure to dust — or of an imminent danger. Notice may be given by telephone, letter, or word of mouth to any MSHA inspector or office. If circumstances warrant, MSHA will then inspect the mine to see whether or not the violation or danger actually exists.

Sampling Equipment

Exposure levels should be monitored using approved equipment that selectively collects a sample of the respirable fraction of the dust in the breathing zone of the worker. Routine monitoring is crucial if operators are to identify major sources of respirable dust exposure. Ongoing monitoring of the workplace air also helps the operator determine if engineering and work practice controls are effective.

The sampling setup for monitoring respirable dust consists of:

- a sampling pump
- a filter cassette
- sampling head assembly with a cyclone
- tubing and clips

The pump has a rechargeable battery and maintains air flow at a predetermined rate of 2.0 liters per minute. There are a number of personal sampling pumps on the market. They have similar construction and operate in a similar manner. Basically, air is drawn through the sampling train, first through the 10 mm cyclone (size selector) where nonrespirable particles are separated out as the air spins through the cyclone, then through the filter where respirable particles are deposited.

After sampling (usually for a full shift) the filter cassette is analyzed at the MSHA laboratory to determine the concentration of respirable dust and the por- tion that is crystalline silica.

Note that only sampling systems approved for coal dust sampling can be used to sample for respirable coal mine dust, and they must be operated, calibrated, and maintained by certified persons.

When sampling is conducted, you want to show that respirable coal mine dust and silica levels are at a minimum lower than the MSHA permissible exposure limit.

For respirable coal mine dust, the allowable standard is 2.0 milligrams of dust per cubic meter of air (2.0 mg/m^3), or 1 mg/m^3 for Part 90 miners and within 200 feet outby the working faces of each section in the intake airway. When the dust contains more than 5% silica the applicable standard is determined by the formula:

$$\frac{10\ mg/m^3}{\%\ quartz}$$

(Example — 10% quartz would result in the following: 10 mg/m^3 divided by 10% quartz = 1.0 mg/m^3. The applicable standard would be 1.0 mg/m^3.)

Respiratory Protection

MSHA regulations require that mine operators make available to miners approved respirators when any area is found to exceed the applicable respirable dust standard. The respirators must be suitable for use in the type and concentrations of dust present in the subject area. Use of respirators by miners is not permitted as a means of control — that is, the mine operator must institute effective engi neering controls to maintain the working environment at or below the applicable respirable dust standard. Miners are encouraged to make use of all means available to provide the best protection from exposure to respirable dust. This includes the proper use of personal respi ratory protection.

MSHA regulations require that respirators be approved by NIOSH, and that whenever respiratory protective equipment is used the employer must have a program that is consistent with the require ments of ANSI (American National Standards Institute) Z88.2-1969 — Practices for Respiratory Protection.

What Are My Rights?

Miners have the right to:

- Work in an environment where dust levels are kept at or below the legal limits required by MSHA.
- Expect that all necessary dust controls are in place, used, and properly maintained in all mining situations.
- Be trained on the hazards of all respirable dusts potentially found in their workplace, specific dust controls in effect, and sampling requirements.
- Be provided with appropriate, approved respirators whenever exposed to excessive amounts of dust.
- Request an MSHA inspection, including dust sampling, when excessive dust levels are suspected.
- Expect compliance with the MSHA-approved methane and dust control section of the ventilation plan during each working shift for underground coal mines.
- Review the operator's ventilation plan posted on the mine bulletin board.
- Review coal dust sampling results which must be posted on the mine bulletin board for at least 31 days.
- Receive a free chest x-ray if working in an underground coal mine.
- Transfer to a less dusty job if working as an underground coal miner when a chest x-ray shows evidence of pneumoconiosis (black lung or silicosis).

What Are the Operator's Responsibilities?

The operator must:

- Continuously keep dust levels at or below the legal limits required by MSHA.
- Provide environmental hazard training to all miners.
- Make available appropriate, approved respiratory equipment to all miners exposed to excessive levels of dust.
- When respirators are required, establish a respiratory protection program in keeping with ANSI Z88.2-1969 Practices for Respiratory Protection.
- Comply with all provisions of the MSHA-approved coal dust control plan.
- Train miners on the reason for taking dust measurements, the reason for placing dust control plans in effect, and the need for MSHA health regulations.
- Sample, every other month, all underground coal mines and designated occupations at many surface operations.
- Report, within 3 working days, any changes in operational status that affects coal dust sampling.
- Not open, tamper with, or alter any coal dust sample required by MSHA.
- Post coal dust sample results for at least 31 days on the mine bulletin board.
- Conduct on-shift examinations for compliance with MSHA-approved dust control measures at underground coal mines.
- Provide working underground coal miners the opportunity for voluntary free chest x-rays.
- Report to MSHA within 10 working days after being notified or otherwise learning that a miner has an occupational lung disease, or for which an award of compensation has been made.

ACKNOWLEDGMENT

"Dust & You — The Menace Remains," issued by RJB Mining, Great Britain, was used as a model for this publication. We acknowledge RJB Mining for their contribution to the field of mining health and safety.