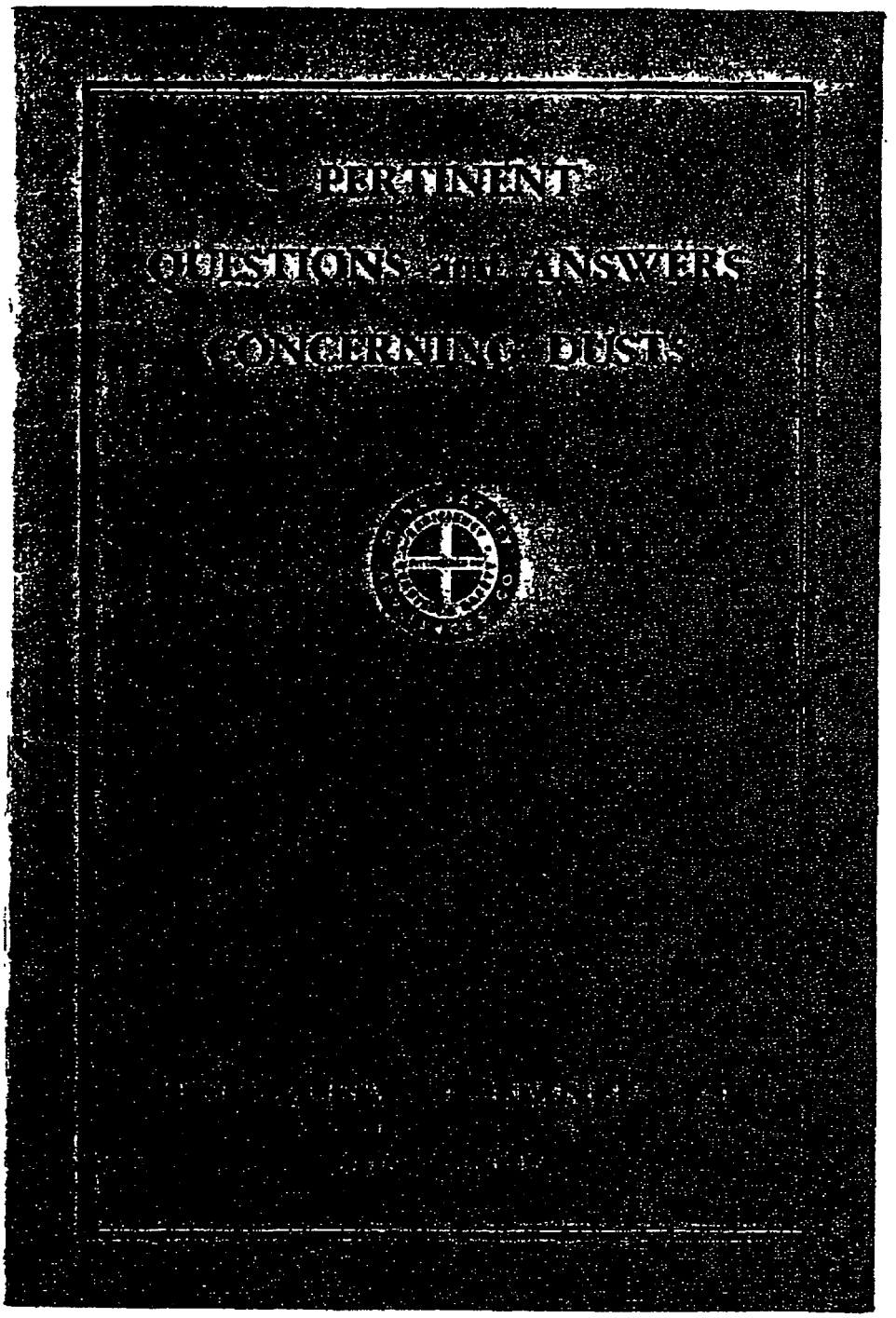
FILE NAME: Mine Safety Appliances (MSA)

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DOCUMENT DESCRIPTION: Book - Pertinent Questions & Answers Concerning Dusts

No. 1



SC 030709

Foreword

THERE is an increasingly wide and intense interest in harmful effects of breathing dusts, especially those that contain free silica and cause the disease of the lungs known as silicosis. Interest has been further stimulated by the work of Federal agencies and States in industrial hygiene, and by legislation that provides compensation for injury to health. As a result many persons in industry who are responsible for healthy working conditions have been confronted with the need of becoming acquainted with dust diseases, nature of dust, its composition, size of particles, and the amount that is harmful, and the means for preventing exposure and protecting workmen. Much has been said and published on these subjects, but it has been presented in terminology and language of a specialized, technical, and scientific nature that is either meaningless to most persons or creates a good deal of misunderstanding. Also, considerable confusion has arisen from the conflicting opinions and views that have been widely expressed.

In this booklet it is endeavored to present some of the questions that arise continually regarding the nature and effects of dusts, and to answer these questions in simple and insofar as possible non-technical language.

SC 030710

Pertinent Questions and Answers Concerning Dusts

1. **Q. What are the usual classifications of air-carried particles?**
   A. Air-carried particles are usually classified into three groups:
   1—Dusts
   2—Fumes
   3—Mists

2. **Q. What are dusts?**
   A. Dusts are mechanically generated particles resulting from such operations as drilling, blasting, crushing, and handling of rocks and minerals; sand-blasting; stone and granite cutting; grinding and polishing; and all similar operations and processes. The greater percentage of particles of air carried dusts are below one micron in size with an average between 0.5-0.7 microns.

3. **Q. What is a micron?**
   A. A micron is a unit of measurement, one micron being equal to about 1/25,000 of an inch or in other words it would require 25,000 particles each one micron in size laid end to end to measure one inch.

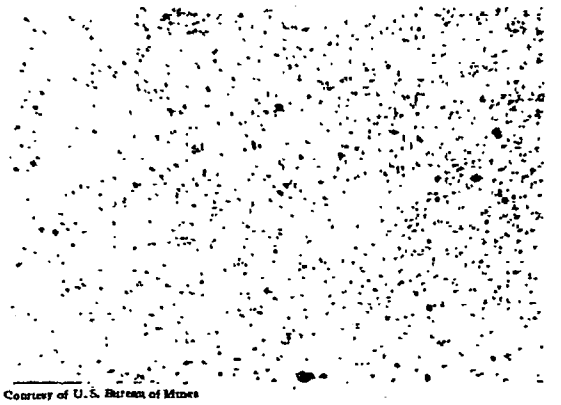
4. **Q. What is the smallest particle that can be seen by the naked eye?**
   A. The smallest particle visible to a person with average eyesight is about 100 microns in dimension. This is 1/250 of an inch.

5. **Q. How does this compare with the size of the average particle found in air-born industrial dusts?**
   A. This is one hundred and fifty to two hundred times the size of the average particle found in industrial atmospheres. In other words, the particles of dust of significance from the standpoint of health are only a small fraction of the size that is visible to the naked eye.

6. **Q. What range of particle sizes is important?**
   A. The particles below 5 microns are of most importance as dusts of larger size settle out of the air very quickly and are not likely to be breathed. In general the particles of dust found in industry are below one or two microns with as much as 50% below 0.5 or 0.7 micron. Under some conditions the size may be larger or smaller than this general size range.

7. **Q. What are fumes?**
   A. Fumes are particles produced in chemical and metallurgical processes, welding, and similar operations, or by the decomposition of chemicals by heat and combustion. The average particle size is less than that of dusts. Most fumes have an average particle size of 0.2-0.3 microns. The important harmful fumes are usually the fumes of metals or their compounds such as lead oxide, zinc oxide, and cadmium oxide. Owing to their small particle size, fumes are even more difficult to remove by filters than are mechanically generated dusts.

SC 030711



Courtesy of U.S. Bureau of Mines

10 7.5 5 3 2 1 .5

MICRONS

SILICEOUS DUST FROM MINE AIR

Magnified 100 times

The dust particles and dots shown in this illustration are magnified 100 times their actual size. If they were not magnified to this extent all of the particles and dots would be invisible. Even the largest or 10 micron size would be only one-tenth that which could be seen with the naked eye and the average particle would be less than one-hundredth the visible size. This illustrates that the smallest particle that can be seen with the naked eye is about 100 microns in dimension and that all air carried dust is invisible.

8. **Q. What are mists?**

   A. Mists are particles of liquids or mixtures of liquids and solids; in other words, wet particles. Their size depends upon the process by which they were generated. Good examples of mists are: the so-called "fogs" produced in spray coating with materials such as siliceous glazes or paints that contain lead, and the chromic acid mist produced during chromium plating.

9. **Q. What dusts are dangerous?**

   A. The effect of many industrial dusts on health is not known as yet since the physiological reactions of most dusts do not appear for some years, and the use of many dust producing compounds is relatively new. Most authorities agree that most dusts are harmful in some degree if breathed in sufficient concentration over a period of time. The safe course is to eliminate all dust down to the limits that are considered good engineering practice in dust control.

10. **Q. How are dusts classified in relation to their effects on health?**

    A. Dusts are usually classified into three groups:

    1—Toxic or poisonous dusts.
    2—Nuisance dusts.
    3—Fibrosis-producing dusts.

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11. **Q. What is a toxic dust?**

A. A toxic dust is usually considered to be the dust of a poisonous material, such as lead and arsenic or their compounds, that produces injury to organs such as the circulatory system, heart, liver, kidneys, brain, and nervous system. When a poisonous dust is inhaled and deposited in the lungs, it dissolves and is carried by the blood to all organs and tissues. It may also be deposited in the mouth and throat by inhalation or contamination with dirty hands, and later swallowed and enters the body through the digestive tract.

12. **Q. What is a nuisance dust?**

A. A nuisance dust is one that is often associated with an increase in respiratory diseases (such as, colds in the head, bronchitis, pneumonia, and tuberculosis). Many such dusts are discomforting and irritating to the worker and may be harmful. They do not produce toxic effects or form fibrous tissue in the lungs.

13. **Q. What is a fibrosis-producing dust?**

A. It is one that through its action in the lungs causes a disease of the normal lung tissue and a replacement of this vital tissue with fibrous (scar) tissue.

14. **Q. What is pneumoconiosis?**

A. It is a term applied to any lung disease arising from inhalation of dust.

15. **Q. What is silicosis?**

A. It is a disease of the lungs in which the normal lung tissue is replaced by fibrous (scar) tissue due to breathing air that contains free silica dust (silicon dioxide, SiO_2).

16. **Q. Can silicosis be produced by any substance other than free silica?**

A. Silicosis is a specific disease caused only by breathing free silica. However, there are indications that the presence of other kinds of dust and gases may influence the effect of silica in the lung.

17. **Q. What is miners' pthisis?**

A. It is a term used frequently to designate a condition of silicosis complicated by the presence of tuberculosis.

18. **Q. What is anthraco-silicosis (miner's asthma)?**

A. It is a chronic disease of the lungs in which the normal lung tissue is replaced by scar tissue caused by breathing excessive amounts of a mixture of silica dust along with coal dust.

19. **Q. What is asbestosis?**

A. It is a disease of the lungs in which the normal lung tissue is replaced by fibrous (scar) tissue due to breathing air that contains asbestos dust.

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20. **Q. What are the principal factors in determining the health hazard from air-carried dust?**

A. The following factors are usually important:

1—Chemical composition of the dust.

2—Amount of dust in the air.

3—Size of the dust particles.

4—Length of time of exposure.

21. **Q. What is meant by chemical composition of a dust?**

A. All materials such as rocks and minerals are not what might be termed pure chemical compounds, but are mixtures of several chemical compounds. The chemical composition is the kind and amounts of these various components. In the case of silica-bearing substances, the amount of silica present may vary from almost nothing to 100%. The amount of free silica present is obviously the important factor in the silicosis producing properties of a dust.

22. **Q. Is the chemical composition of the dust in the air the same as the substance that is being drilled, handled, crushed, or processed?**

A. As most dust producing substances dealt with in industry contain more than one mineral component, some of these components will crush or disintegrate more easily than others and thereby form a larger proportion of small particles. These smaller particles will tend to predominate in the air while other constituents being larger will settle out. For this reason, the composition of the dust in the air may vary greatly from the composition of the rock or mineral.

23. **Q. What is the importance of the chemical composition of a dust?**

A. The chemical composition reveals the harmful constituents and their amount, and constitutes the basis for judging the harmful qualities of the dust. This information is an important factor along with concentration and time of exposure in determining the hazard.

24. **Q. What are the important steps in determining the chemical composition of a dust?**

A. It is necessary to first obtain a sample that represents the dust in the air breathed, and then subject the sample to methods of analysis that are known to give accurate results for the constituents desired.

25. **Q. How can a representative sample of the dust in the air breathed be obtained?**

A. It can be obtained only by collecting the dust from the air. Samples of pieces of rock or settled dust do not necessarily bear any close relation in composition to the dust floating in the air.

26. **Q. How can a sample of sufficient size for chemical analysis be collected from the air?**

A. Collection from the air can be accomplished with dust collection devices such as the impinger, electrostatic precipitator or filter type of collectors.

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27. **Q. What methods are generally used for determination of the percent of free silica in dusts?**

A. 1—By observing the action of the small dust particles on light with the aid of a special type of microscope. This is known as the petrographic method.

2—By chemical analysis.

3—By observing the action of the particles on X-Rays.

28. **Q. What are the limitations of the petrographic method?**

A. It is impossible by this method to examine individual particles below one or two microns in size and since most of the air-carried dust is below this size range, one must rely on petrographic information obtained from particle sizes that are above those of primary significance.

29. **Q. What are the limitations of the chemical method?**

A. There is no known chemical method that is specific for free silica (SiO_2) when this constituent is present with silicates. However, by observing the difference in the rate at which silica dissolves in certain acids as compared with other constituents a rough estimate can be obtained for some dusts, but with others the method will be greatly in error.

30. **Q. What are the limitations of the X-Ray method?**

A. The X-Ray procedure can be used for making specific determinations of free silica in a very small sample such as 25 to 50 milligrams. The disadvantage of the method is that it requires very expensive apparatus.

31. **Q. What is meant by size of particle; how is it expressed?**

A. The size of the particle is its largest dimension, usually expressed in microns. It has been stated by authorities that if all dust below one micron in size could be eliminated, nearly all dust disease would be eliminated.

32. **Q. How can the size of dust particles be determined?**

A. The size of dust particles is measured by means of a microscope or by projection of the dust particles on a screen similar in general principle to ordinary lantern slide projection. The particles as seen in the microscope or projected are then measured.

33. **Q. How quickly does fine dust settle?**

A. It settles very slowly. In the table given below will be found the time in minutes estimated for silica dust of given sizes to fall one foot in still air.

Size in microns	Time in minutes to fall one foot
¼	590.
½	187.
1	54.
2	14.4
5	2.5

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34. **Q. Does absence of visible dust mean absence of fine dust?**

A. No. The operation may produce only fine dust or the visible dust may have disappeared owing to its rapid rate of settling, leaving the invisible but harmful dust in the air.

35. **Q. What is meant by dust concentration: how is it expressed?**

A. The concentration is the amount of dust suspended in a given volume of air. It is usually expressed in number of particles in a cubic foot of air, or millions of particles in a cubic meter of air, or in a cubic centimeter. It may also be expressed as the weight of dust in a given volume of air as milligrams in a cubic meter or grams in a cubic foot.

36. **Q. What is the relation among these units of quantity?**

A. Number of cubic feet times .02832 gives number of cubic meters (m^3).
Number of cubic meters times 35.31 gives number of cubic feet.
Number of cubic feet times 28,317 gives number of cubic centimeters (cc.)
Number of milligrams times .001 gives number of grams.
Number of grains times 64.80 gives number of milligrams.
Number of grains times .00229 gives ounces (avoirdupois).

37. **Q. How can the concentration in particles per cubic centimeter be converted to number of particles per cubic foot?**

A. Multiply the number of particles per cubic centimeter by a million and divide by 35.31 to get number of particles per cubic foot.

38. **Q. How many particles of air-carried dust are in one milligram weight of dust?**

A. It has been found that one milligram of silica dust of the size range present in industrial atmospheres contains about 200 to 300 million particles.

39. **Q. What apparatus and methods are generally used for determining dust concentrations?**

A. The impinger and electrostatic precipitator are the instruments generally used for this purpose. Details of the instruments and methods can be found in publications of the United States Bureau of Mines and the United States Public Health Service.

40. **Q. What is an impinger?**

A. It is a device by which air is drawn at a definite rate of flow and at high velocity through a small nozzle so directed as to strike the bottom of a glass flask which is partially filled with a liquid such as water, alcohol, or a mixture of these liquids. This high velocity action causes the dust particles to be "wetted" and retained in the liquid. Some of this liquid is then examined under a microscope and a count of the dust particles present is made.

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41. Q. What is an electrostatic precipitator?

A. It's a device by which air is drawn at a definite rate of flow through a high voltage electrical field so arranged as to cause any dust to be removed and deposited in a sampling tube. The dust collected can be determined either by counting the number of particles with a microscope or by weighing. It is an efficient method but requires a source of electrical energy. As with the impinger, the electrostatic precipitator collects the dust continuously from a comparatively large volume of air and thus provides a sample that represents average conditions. It may even be used to collect a sample that is large enough for chemical analysis.

42. Q. How can exposure be determined?

A. Since exposure is a term that involves concentration, particle size, chemical composition, and duration of time, it is necessary to determine all of these in order to properly evaluate the degree and extent of exposure. The time element requires an accurate job analysis in which is recorded the amount of time spent by a workman at his various operations. This record should then be associated with the dust concentration, particle size, and chemical composition of the dust at each operation and the average over all daily exposure determined.

For Example:

Summary of Dust Exposure of Leyner Drillers in a Granite Quarry

Activity	Average exposure in millions of particles per cubic foot.	Hours spent in each activity	Particle hrs. (millions per cubic foot)
Drilling	213.4	4	853.6
Changing drills	9.8	1	9.8
Watching drills	8.0	2	16.0
Broaching	6.0	¾	4.5
Blowing off holes	1085.0	¼	271.3
Total		8	1155.2

$\frac{1155.2 \text{ particle hours in millions per cubic foot}}{8 \text{ hr.}}$ 144.4 million particles per cubic foot. Average exposure throughout the day.

Table from U. S. Public Health Bulletin 217 by Bloomfield and Dallavalle

43. Q. What is a respirator?

A. Any personal protective device designed to prevent the wearer from inhaling the harmful constituents in his surrounding atmosphere is called a respirator.

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44. Q. How are the various types of respirators usually classified?

A. Respirators are classified as follows:

1. Air-supplied respirators.
2. Chemical filter respirators.
3. Mechanical filter respirators.

45. Q. What is a supplied-air or air-line respirator?

A. It is essentially a hose line through which air that is safe to breathe is conveyed to a facepiece worn by the workman. Air-line respirators are approved by the United States Bureau of Mines under schedule No. 19 The air may be supplied from the compressed air line although preferably it should come from a separate blower unit designed to furnish air free from distasteful or harmful impurities.

46. Q. What harmful or objectionable constituents might be present in high pressure air as produced by an ordinary reciprocating type of compressor?

A. Air from this source may contain oil odors, mists of oil or water, particles of rust or dirt from the air receiver or air lines, and in case of improper compressor operation there may be burning of the lubricants with the formation of carbon monoxide.

47. Q. What precautions should be taken to lessen the danger from air contamination in the use of reciprocating type of air compressors?

A. Good maintenance and care in operation of the compressor, temperature indicators on the outlet side of compressor, and carbon monoxide detecting equipment or carbon monoxide alarms on the outlet side to give indication of the presence of any carbon monoxide. Individual compressor units so constructed as to make generation of harmful gases impossible are desirable sources of clean air for air-line respirators

48. Q. What is an abrasive mask?

A. An abrasive mask is essentially an air line respirator with a special hood for protection against high velocity particles in sand or shot blasting operations.

49. Q. What is a chemical filter respirator?

A. It is a respirator designed for removing gaseous constituents from the air breathed. The filtering materials in these respirators are usually granules that react with the harmful constituents and remove them. Chemical filter respirators are approved against light concentrations of organic vapors under U. S. Bureau of Mines schedule No. 23.

50. Q. What is a mechanical filter respirator?

A. A mechanical filter respirator is a device that removes by mechanical filtration the particles of harmful constituents from air that passes through it. These devices include dust, mist, and fume respirators. Each of these types of mechanical filter respirators is designed to protect the wearer against the particular kind of matter to be dealt with.

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51. Q. **What is a United States Bureau of Mines "approved" mechanical filter respirator?**

A. It is a respirator that has officially passed the rigid test requirements of the United States Bureau of Mines as outlined in that Bureau's Approval Schedule No. 21.

52. Q. **What are United States Bureau of Mines schedules No. 19, 21 and 23?**

A. They are publications that describe the requirements and tests that respirators must meet in order to obtain the approval of the Bureau of Mines. Free copies of these publications may be obtained upon request from the United States Bureau of Mines, Washington, D. C.

53. Q. **Who makes the approval tests?**

A. The Bureau of Mines makes the tests at its Pittsburgh Experiment Station where experienced personnel and complete laboratory facilities for dust investigations are available.

54. Q. **For what types of mechanical filter respirators does the Bureau of Mines schedule No. 21 provide approval requirements?**

A. Schedule No. 21 provides approval requirements for mechanical filter respirators for protection against mechanically generated dusts; fumes of various metals; and mists such as those from chromic acid and from spray coating in the absence of harmful vapors and gases. Combinations of these types may also be approved.

55. Q. **What are the general performance requirements that a mechanical filter dust respirator must give in order to obtain the approval of the Bureau of Mines?**

A. The general features of the performance requirements are:

1—Dust-tight fit of the facepiece.

2—Reduction of dust in the inhaled air below an amount that causes harm.

3—A resistance to breathing that is below that which produces discomfort.

4—A satisfactory degree of convenience, durability, and service.

56. Q. **What is the size of the dust particles used by the United States Bureau of Mines in the approval tests of mechanical filter respirators?**

A. The dust particles used in the tests are 95% below 1.78 microns and 50% below 0.6 micron. These size characteristics are very similar to those found in the atmospheres of mines and industrial plants.

57. Q. **What severe dust filtering and resistance performance must a mechanical filter dust respirator give to pass the approval test?**

A. Air that contains fifty milligrams per cubic meter (approximately 300 to 500 million particles per cubic foot) of dust of the small size

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specified by the Bureau of Mines is drawn through the respirator at a rate of 32 liters a minute, or at approximately the rate at which air is breathed by an average man doing work. The total amount of dust that leaks through the respirator in a 90 minute test period during which 2.88 cubic meters or 100 cubic feet of air are passed must not exceed 3.0 milligrams or 0.0001 ounces. The resistance to inhalation when tested with air flowing through the respirator at 85 liters a minute must at no time exceed 2 inches of water column. This resistance is below that which causes discomfort.

58. **Q. Are the Bureau of Mines approval requirements unnecessarily exacting and impractical?**

A. No. The approval requirements represent the minimum protection that a respirator should give in order to protect the wearer adequately

59. **Q. What are the most important features of a respirator?**

A. 1—Adequate respiratory protection.

2—Comfort and convenience.

3—Ease and cost of maintenance.

60. **Q. What is meant by the efficiency of a respirator: and what test facts concerning efficiency must be known to determine if a respirator gives adequate protection?**

A. The efficiency of a respirator is the percentage of the dust in the air that is retained on the filter. At least three very important facts should be known in order to determine if a respirator, that has a reported high efficiency, also gives adequate protection:

1—The dust concentration used in determining the efficiency figure.

2—That the particle size of the dust used in determining the efficiency represents the size of the dusts found in industrial atmospheres.

3—That the percentage inefficiency, or the amount of dust that leaks through, does not exceed that which is safe to breathe.

61. **Q. How does variation in particle size effect the reliability of an efficiency value of a respirator?**

A. The statement that a respirator is 98% efficient means little if the particle size range of the dust tested is not given because the difficulty in removing dust increases as the particle size decreases so that dusts below 1 to 2 microns are much more difficult to remove than the larger sizes, yet it is particles below 1 to 2 microns that predominate in industrial and mine atmospheres and produce the harmful effects. A respirator which would not effectively remove dust below 2 microns could be 98% efficient provided the test was made against concentrations that contain only a small amount of particles below 2 microns in size.

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62. Q. How is the reliability of an efficiency value as a measure of dust protection affected by the concentration of dust in the air?

A. A respirator may have high percentage efficiency and still leak enough dust through the filter to cause harm. For example, a respirator that is 97% efficient against a concentration of 500 million particles of dust per cubic foot of air (a not unusual case) would leak 15 million particles which is more than is considered a permissible amount of dust with a high silica content in the air breathed. The Bureau of Mines approval is given only to respirators that do not leak enough dust to bring the dust in the air breathed above permissible limits.

63. Q. What is meant by comfort and convenience?

A. The following factors are elements of comfort and convenience:

1—Resistance to breathing.

2—Degree of impediment and encumbrance to vision and normal performance of work.

64. Q. Should comfort and protection be considered separately?

A. No. Any acceptable respirator must give both adequate protection and an acceptable degree of comfort.

65. Q. What is meant by cost of maintenance?

A. The cost of maintenance is the expense involved in keeping the respirator in an efficient, comfortable, and clean working condition. Low cost of replacement of filters is an important element in this expense.

66. Q. What is meant by ease of maintenance?

A. By ease of maintenance is meant the ease with which a dust laden respirator can be restored to its initial high degree of efficiency and comfort through:

1—Servicing.

2—Replacement of filters.

3—Sterilization.

67. Q. How can respirators be sterilized?

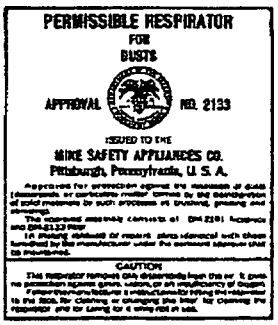
A. Scrub rubber and metal parts with soap and water. Rinse in warm water and immerse for 10 minutes in a solution of formalin made by placing one part of 40% formaldehyde solution into 9 parts of water. Instead of the formalin solution, 1 part of carbolic acid in 33 parts of water, or 1 part of Lysol in 50 parts of water, or 8 parts of denatured alcohol in 3 parts of water may be used.

All respirators should be thoroughly rinsed with water immediately after immersion in the sterilizing solution and put in a clean place to dry.

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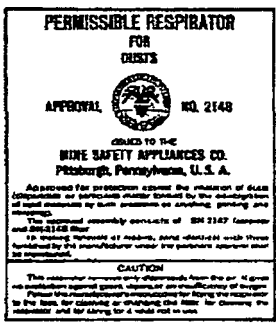
Mechanical Filter Respirators
For Protection from Dusts, Mists and Fumes
Manufactured by
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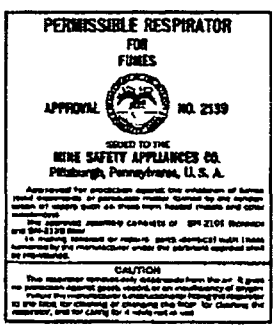
M.S.A. "COMFO" DUST RESPIRATOR With "Comfo" Cushion Facepiece




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M.S.A. "CLEAR-VUE" DUSTFOE RESPIRATOR



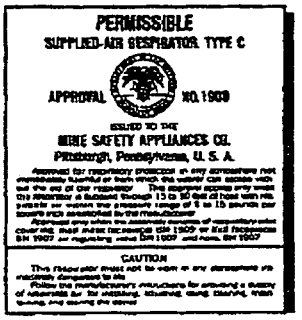

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M.S.A. "COMFO" METAL FUME RESPIRATOR

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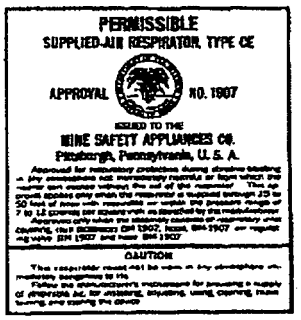
Air Line Respirator Equipment
Manufactured by
Mine Safety Appliances Company





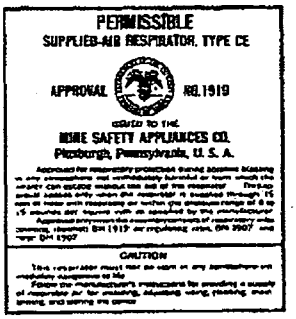
M.S.A. AIR LINE RESPIRATOR With "Comfo" Cushion Facepiece





M.S.A. ABRASIVE MASK





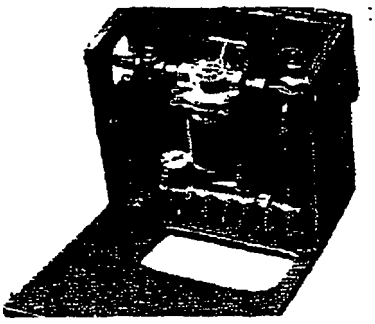
M.S.A. "BLASTFOE" ABRASIVE HELMET

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Accessory Equipment for Air Line Respirators

Manufactured by

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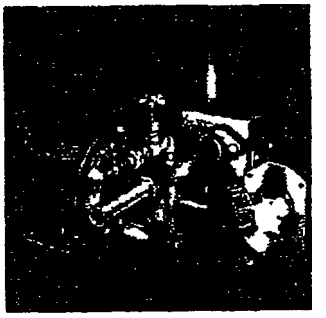


M.S.A. PORTABLE AIR FILTER AND REGULATOR

Entirely self-contained and readily portable, this unit removes oil mists, oil vapors, water, and pipe scale from compressed air, and provides effective protection against excessive and variable pressures in the air supply.

It is designed for attachment to the main compressed air lines and has a capacity of one to six take-off lines to supplied air masks and respirators.

The M.S.A. Portable Air Filter and Regulator is equipped with a chemical fill for efficient removal of odors and vapors, and a mechanical separator which removes oil, water and dirt from incoming compressed air. A built-in pressure regulator governs air pressure at a predetermined safe limit.



M.S.A. CLEANAIR BLOWER

M.S.A. CleanAir Blowers wash, cool, and humidify the air they supply—by utilizing a small, constant flow of water through the rotor chamber. The water also acts as a compression seal, eliminating all metal-to-metal contact. Since no lubrication is necessary for the operation of CleanAir Blowers, no oil or grease comes in contact with delivered air.

No auxiliary air filter or regulator is necessary with a CleanAir Blower.

M.S.A. CleanAir Blowers are furnished in a wide range of sizes to meet desired respiratory requirements.

SC 030724

Air Sampling Equipment for Dusts, Mists and Fumes

Manufactured by

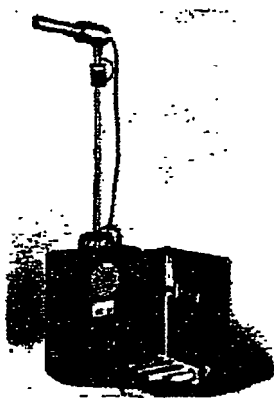
Mine Safety Appliances Company



M.S.A. MIDGET IMPINGER

The M.S.A. Midget Impinger samples at a rate of one-tenth of a cubic foot per minute and is operated by a hand-cranked, positive-acting 4 cylinder pump of ingenious design. This pump, in conjunction with a vacuum regulator, maintains an unfluctuating suction regardless of minor variations in the rate or smoothness of cranking. The apparatus is contained in a compact, sturdy carrying case complete with nine calibrated glass sampling tubes.

The light weight, small dimensions, and almost effortless operation of this modern instrument greatly broaden the field of dust sampling by the impinger method. Isolated locations, confined spaces, lack of electric current or compressed air presents no barriers to the M.S.A. Midget Impinger.



M.S.A. ELECTROSTATIC
Dust and Fume Sampler

This instrument, designed for quantitative sampling of dust, fume, and mist, employs the principle of precipitation with electrostatic precipitation. The unit is compact and easy to use for sampling from the general atmosphere or from stacks or ducts; it is the only efficient sampler for fumes, particularly lead fumes

Other features are large sampling volume of 2 cu. ft. per minute permitting accurate determinations of very low concentrations of atmospheric particulate matter; flow measurement with orifice and mechanical manometer —no liquids to spill; extension tube for sampling at breathing level with apparatus on the floor; and collection of samples in a special aluminum tube permitting determinations by weight, count or chemical analysis.

This precipitator operates on 110-120 volts, 60 cycle, alternating current. Case dimensions are 16 x 11¼ x 10¼ inches.

Printed in U.S.A.

SC 030725

NO. 5

PERTINENT QUESTIONS and ANSWERS CONCERNING DUSTS

MINE SAFETY APPLIANCES CO.
Braddock, Thomas and Meade Streets
PITTSBURGH 8, PA.

SC 030726

Foreword

THERE is an increasingly wide and intense interest in harmful effects of breathing dusts, especially those that contain free silica and cause the disease of the lungs known as silicosis. Interest has been further stimulated by the work of Federal agencies and States in industrial hygiene, and by legislation that provides compensation for injury to health. As a result many persons in industry who are responsible for healthy working conditions have been confronted with the need of becoming acquainted with dust diseases, nature of dust, its composition, size of particles, and the amount that is harmful, and the means for preventing exposure and protecting workmen. Much has been said and published on these subjects, but it has been presented in terminology and language of a specialized, technical, and scientific nature that is either meaningless to most persons or creates a good deal of misunderstanding. Also, considerable confusion has arisen from the conflicting opinions and views that have been widely expressed.

In this booklet it is endeavored to present some of the questions that arise continually regarding the nature and effects of dusts, and to answer these questions in simple and insofar as possible non-technical language.

SC 030727

Pertinent Questions and Answers Concerning Dusts

1. **Q. What are the usual classifications of air-carried particles?**
   A. Air-carried particles are usually classified into three groups:
   1—Dusts
   2—Fumes
   3—Mists

2. **Q. What are dusts?**
   A. Dusts are mechanically generated particles resulting from such operations as drilling, blasting, crushing, and handling of rocks and minerals; sand-blasting; stone and granite cutting; grinding and polishing; and all similar operations and processes. The greater percentage of particles of air carried dusts are below one micron in size with an average between 0.5-0.7 microns.

3. **Q. What is a micron?**
   A. A micron is a unit of measurement, one micron being equal to about 1/25,000 of an inch or in other words it would require 25,000 particles each one micron in size laid end to end to measure one inch.

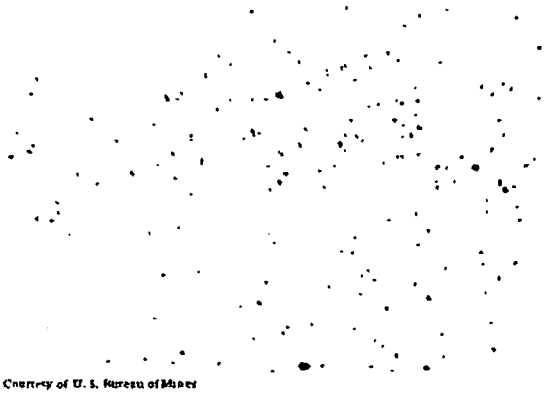
4. **Q. What is the smallest particle that can be seen by the naked eye?**
   A. The smallest particle visible to a person with average eyesight is about 100 microns in dimension. This is 1/250 of an inch.

5. **Q. How does this compare with the size of the average particle found in air-born industrial dusts?**
   A. This is one hundred and fifty to two hundred times the size of the average particle found in industrial atmospheres. In other words, the particles of dust of significance from the standpoint of health are only a small fraction of the size that is visible to the naked eye.

6. **Q. What range of particle sizes is important?**
   A. The particles below 5 microns are of most importance as dusts of larger size settle out of the air very quickly and are not likely to be breathed. In general the particles of dust found in industry are below one or two microns with as much as 50% below 0.5 or 0.7 micron. Under some conditions the size may be larger or smaller than this general size range

7. **Q. What are fumes?**
   A. Fumes are particles produced in chemical and metallurgical processes, welding, and similar operations, or by the decomposition of chemicals by heat and combustion. The average particle size is less than that of dusts. Most fumes have an average particle size of 0.2-0.3 microns. The important harmful fumes are usually the fumes of metals or their compounds such as lead oxide, zinc oxide, and cadmium oxide. Owing to their small particle size, fumes are even more difficult to remove by filters than are mechanically generated dusts.

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SILICEOUS DUST FROM MINE AIR

Magnified 100 times

The dust particles and dots shown in this illustration are magnified 100 times their actual size. If they were not magnified to this extent all of the particles and dots would be invisible. Even the largest of 10 micron size would be only one-tenth that which could be seen with the naked eye and the average particle would be less than one-hundredth the visible size. This illustrates that the smallest particle that can be seen with the naked eye is about 100 microns in dimension and that all air carried dust is invisible.

8. **Q. What are mists?**

   A. Mists are particles of liquids or mixtures of liquids and solids; in other words, wet particles. Their size depends upon the process by which they were generated. Good examples of mists are: the so-called "fogs" produced in spray coating with materials such as siliceous glazes or paints that contain lead, and the chromic acid mist produced during chromium plating.

9. **Q. What dusts are dangerous?**

   A. The effect of many industrial dusts on health is not known as yet since the physiological reactions of most dusts do not appear for some years, and the use of many dust producing compounds is relatively new. Most authorities agree that most dusts are harmful in some degree if breathed in sufficient concentration over a period of time. The safe course is to eliminate all dust down to the limits that are considered good engineering practice in dust control.

10. **Q. How are dusts classified in relation to their effects on health?**

    A. Dusts are usually classified into three groups:

       1—Toxic or poisonous dusts.
       2—Nuisance dusts.
       3—Fibrosis-producing dusts.

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11. **Q. What is a toxic dust?**

A. A toxic dust is usually considered to be the dust of a poisonous material, such as lead and arsenic or their compounds, that produces injury to organs such as the circulatory system, heart, liver, kidneys, brain, and nervous system. When a poisonous dust is inhaled and deposited in the lungs, it dissolves and is carried by the blood to all organs and tissues. It may also be deposited in the mouth and throat by inhalation or contamination with dirty hands, and later swallowed and enters the body through the digestive tract.

12. **Q. What is a nuisance dust?**

A. A nuisance dust is one that is often associated with an increase in respiratory diseases (such as, colds in the head, bronchitis, pneumonia, and tuberculosis) Many such dusts are discomforting and irritating to the worker and may be harmful. They do not produce toxic effects or form fibrous tissue in the lungs.

13. **Q. What is a fibrosis-producing dust?**

A. It is one that through its action in the lungs causes a disease of the normal lung tissue and a replacement of this vital tissue with fibrous (scar) tissue.

14. **Q. What is pneumoconiosis?**

A. It is a term applied to any lung disease arising from inhalation of dust.

15. **Q. What is silicosis?**

A. It is a disease of the lungs in which the normal lung tissue is replaced by fibrous (scar) tissue due to breathing air that contains free silica dust (silicon dioxide, SiO_2).

16. **Q. Can silicosis be produced by any substance other than free silica?**

A. *Silicosis is a specific disease caused only by breathing free silica.* However, there are indications that the presence of other kinds of dust and gases may influence the effect of silica in the lung.

17. **Q. What is miners' phthisis?**

A. It is a term used frequently to designate a condition of silicosis complicated by the presence of tuberculosis.

18. **Q. What is anthraco-silicosis (miner's asthma)?**

A. It is a chronic disease of the lungs in which the normal lung tissue is replaced by scar tissue caused by breathing excessive amounts of a mixture of silica dust along with coal dust.

19. **Q. What is asbestosis?**

A. It is a disease of the lungs in which the normal lung tissue is replaced by fibrous (scar) tissue due to breathing air that contains asbestos dust.

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20. **Q. What are the principal factors in determining the health hazard from air-carried dust?**

A. The following factors are usually important:

1—Chemical composition of the dust

2—Amount of dust in the air.

3—Size of the dust particles

4—Length of time of exposure.

21. **Q. What is meant by chemical composition of a dust?**

A. All materials such as rocks and minerals are not what might be termed pure chemical compounds, but are mixtures of several chemical compounds. The chemical composition is the kind and amounts of these various components. In the case of silica-bearing substances, the amount of silica present may vary from almost nothing to 100%. The amount of free silica present is obviously the important factor in the silicosis producing properties of a dust.

22. **Q. Is the chemical composition of the dust in the air the same as the substance that is being drilled, handled, crushed, or processed?**

A. As most dust producing substances dealt with in industry contain more than one mineral component, some of these components will crush or disintegrate more easily than others and thereby form a larger proportion of small particles. These smaller particles will tend to predominate in the air while other constituents being larger will settle out. For this reason, the composition of the dust in the air may vary greatly from the composition of the rock or mineral.

23. **Q. What is the importance of the chemical composition of a dust?**

A. The chemical composition reveals the harmful constituents and their amount, and constitutes the basis for judging the harmful qualities of the dust. This information is an important factor along with concentration and time of exposure in determining the hazard.

24. **Q. What are the important steps in determining the chemical composition of a dust?**

A. It is necessary to first obtain a sample that represents the dust in the air breathed, and then subject the sample to methods of analysis that are known to give accurate results for the constituents desired.

25. **Q. How can a representative sample of the dust in the air breathed be obtained?**

A. It can be obtained only by collecting the dust from the air. Samples of pieces of rock or settled dust do not necessarily bear any close relation in composition to the dust floating in the air.

26. **Q. How can a sample of sufficient size for chemical analysis be collected from the air?**

A. Collection from the air can be accomplished with dust collection devices such as the impinger, electrostatic precipitator or filter type of collectors.

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27. Q. **What methods are generally used for determination of the percent of free silica in dusts?**

A. 1—By observing the action of the small dust particles on light with the aid of a special type of microscope. This is known as the petrographic method.

2—By chemical analysis.

3—By observing the action of the particles on X-Rays.

28. Q. **What are the limitations of the petrographic method?**

A. It is impossible by this method to examine individual particles below one or two microns in size and since most of the air-carried dust is below this size range, one must rely on petrographic information obtained from particle sizes that are above those of primary significance.

29. Q. **What are the limitations of the chemical method?**

A. There is no known chemical method that is specific for free silica (SiO_2) when this constituent is present with silicates However, by observing the difference in the rate at which silica dissolves in certain acids as compared with other constituents a rough estimate can be obtained for some dusts, but with others the method will be greatly in error.

30. Q. **What are the limitations of the X-Ray method?**

A. The X-Ray procedure can be used for making specific determinations of free silica in a very small sample such as 25 to 50 milligrams The disadvantage of the method is that it requires very expensive apparatus.

31. Q. **What is meant by size of particle: how is it expressed?**

A. The size of the particle is its largest dimension, usually expressed in microns. *It has been stated by authorities that if all dust below one* micron in size could be eliminated, nearly all dust disease would be eliminated.

32. Q. ***How can the size of dust particles be determined?***

A. The size of dust particles is measured by means of a microscope or by projection of the dust particles on a screen similar in general principle to ordinary lantern slide projection. The particles as seen in the microscope or projected are then measured.

33. Q. **How quickly does fine dust settle?**

A. It settles very slowly. In the table given below will be found the time in minutes estimated for silica dust of given sizes to fall one foot in still air.

Size in microns	Time in minutes to fall one foot
¼	590
½	187.
1	54.
2	14.4
5	2.5

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34. **Q. Does absence of visible dust mean absence of fine dust?**

A. No. The operation may produce only fine dust or the visible dust may have disappeared owing to its rapid rate of settling, leaving the invisible but harmful dust in the air.

35. **Q. What is meant by dust concentration: how is it expressed?**

A. The concentration is the amount of dust suspended in a given volume of air. It is usually expressed in number of particles in a cubic foot of air, or millions of particles in a cubic meter of air, or in a cubic centimeter. It may also be expressed as the weight of dust in a given volume of air as milligrams in a cubic meter or grains in a cubic foot.

36. **Q. What is the relation among these units of quantity?**

A. Number of cubic feet times .02832 gives number of cubic meters (m^3).
Number of cubic meters times 35.31 gives number of cubic feet.
Number of cubic feet times 28,317 gives number of cubic centimeters (cc.)
Number of milligrams times .001 gives number of grams.
Number of grains times 64.80 gives number of milligrams.
Number of grains times .00229 gives ounces (avoirdupois).

37. **Q. How can the concentration in particles per cubic centimeter be converted to number of particles per cubic foot?**

A. Multiply the number of particles per cubic centimeter by a million and divide by 35.31 to get number of particles per cubic foot.

38. **Q. How many particles of air-carried dust are in one milligram weight of dust?**

A. It has been found that one milligram of silica dust of the size range present in industrial atmospheres contains about 200 to 300 million particles.

39. **Q. What apparatus and methods are generally used for determining dust concentrations?**

A. The impinger and electrostatic precipitator are the instruments generally used for this purpose. Details of the instruments and methods can be found in publications of the United States Bureau of Mines and the United States Public Health Service.

40. **Q. What is an impinger?**

A. It is a device by which air is drawn at a definite rate of flow and at high velocity through a small nozzle so directed as to strike the bottom of a glass flask which is partially filled with a liquid such as water, alcohol, or a mixture of these liquids. This high velocity action causes the dust particles to be "wetted" and retained in the liquid. Some of this liquid is then examined under a microscope and a count of the dust particles present is made.

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41. **Q. What is an electrostatic precipitator?**

A. It's a device by which air is drawn at a definite rate of flow through a high voltage electrical field so arranged as to cause any dust to be removed and deposited in a sampling tube. The dust collected can be determined either by counting the number of particles with a microscope or by weighing. It is an efficient method but requires a source of electrical energy. As with the impinger, the electrostatic precipitator collects the dust continuously from a comparatively large volume of air and thus provides a sample that represents average conditions. It may even be used to collect a sample that is large enough for chemical analysis.

42. **Q. How can exposure be determined?**

A. Since exposure is a term that involves concentration, particle size, chemical composition, and duration of time, it is necessary to determine all of these in order to properly evaluate the degree and extent of exposure. The time element requires an accurate job analysis in which is recorded the amount of time spent by a workman at his various operations. This record should then be associated with the dust concentration, particle size, and chemical composition of the dust at each operation and the average over all daily exposure determined.

For Example:

Summary of Dust Exposure of Leyner Drillers in a Granite Quarry

Activity	Average exposure in millions of particles per cubic foot.	Hours spent in each activity	Particle hrs. (millions per cubic foot)
Drilling	213.4	4	853.6
Changing drills	9.8	1	9.8
Watching drills	8.0	2	16.0
Broaching	6.0	¾	4.5
Blowing off holes	1085.0	¼	271.3
Total		8	1155.2

1155.2 particle hours in millions per cubic foot / 8 hr. = 144.4 million particles per cubic foot. Average exposure throughout the day.

Table from U. S. Public Health Bulletin 217 by Bloomfield and Dallavalle

43. **Q. What is a respirator?**

A. Any personal protective device designed to prevent the wearer from inhaling the harmful constituents in his surrounding atmosphere is called a respirator.

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44. Q. How are the various types of respirators usually classified?

A. Respirators are classified as follows:

1. Air-supplied respirators.
2. Chemical filter respirators.
3. Mechanical filter respirators.

45. Q. What is a supplied-air or air-line respirator?

A. It is essentially a hose line through which air that is safe to breathe is conveyed to a facepiece worn by the workman. Air-line respirators are approved by the United States Bureau of Mines under schedule No 19 The air may be supplied from the compressed air line although preferably it should come from a separate blower unit designed to furnish air free from distasteful or harmful impurities

46. Q. What harmful or objectionable constituents might be present in high pressure air as produced by an ordinary reciprocating type of compressor?

A. Air from this source may contain oil odors, mists of oil or water, particles of rust or dirt from the air receiver or air lines, and in case of improper compressor operation there may be burning of the lubricants with the formation of carbon monoxide.

47. Q. What precautions should be taken to lessen the danger from air contamination in the use of reciprocating type of air compressors?

A. Good maintenance and care in operation of the compressor, temperature indicators on the outlet side of compressor, and carbon monoxide detecting equipment or carbon monoxide alarms on the outlet side to give indication of the presence of any carbon monoxide. Individual compressor units so constructed as to make generation of harmful gases impossible are desirable sources of clean air for air-line respirators

48. Q. What is an abrasive mask?

A. An abrasive mask is essentially an air line respirator with a special hood for protection against high velocity particles in sand or shot blasting operations.

49. Q. What is a chemical filter respirator?

A. It is a respirator designed for removing gaseous constituents from the air breathed. The filtering materials in these respirators are usually granules that react with the harmful constituents and remove them. Chemical filter respirators are approved against light concentrations of organic vapors under U. S. Bureau of Mines schedule No 23.

50. Q. What is a mechanical filter respirator?

A. A mechanical filter respirator is a device that removes by mechanical filtration the particles of harmful constituents from air that passes through it. These devices include dust, mist, and fume respirators. Each of these types of mechanical filter respirators is designed to protect the wearer against the particular kind of matter to be dealt with.

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51. **Q. What is a United States Bureau of Mines "approved" mechanical filter respirator?**

A. It is a respirator that has officially passed the rigid test requirements of the United States Bureau of Mines as outlined in that Bureau's Approval Schedule No. 21.

52. **Q. What are United States Bureau of Mines schedules No. 19, 21 and 23?**

A. They are publications that describe the requirements and tests that respirators must meet in order to obtain the approval of the Bureau of Mines. Free copies of these publications may be obtained upon request from the United States Bureau of Mines, Washington, D. C.

53. **Q. Who makes the approval tests?**

A. The Bureau of Mines makes the tests at its Pittsburgh Experiment Station where experienced personnel and complete laboratory facilities for dust investigations are available.

54. **Q. For what types of mechanical filter respirators does the Bureau of Mines schedule No. 21 provide approval requirements?**

A. Schedule No. 21 provides approval requirements for mechanical filter respirators for protection against mechanically generated dusts; fumes of various metals; and mists such as those from chromic acid and from spray coating in the absence of harmful vapors and gases. Combinations of these types may also be approved.

55. **Q. What are the general performance requirements that a mechanical filter dust respirator must give in order to obtain the approval of the Bureau of Mines?**

A. The general features of the performance requirements are:

1—Dust-tight fit of the facepiece.

2—Reduction of dust in the inhaled air below an amount that causes harm.

3—A resistance to breathing that is below that which produces discomfort.

4—A satisfactory degree of convenience, durability, and service.

56. **Q. What is the size of the dust particles used by the United States Bureau of Mines in the approval tests of mechanical filter respirators?**

A. The dust particles used in the tests are 95% below 1.78 microns and 50% below 0.6 micron. These size characteristics are very similar to those found in the atmospheres of mines and industrial plants.

57. **Q. What severe dust filtering and resistance performance must a mechanical filter dust respirator give to pass the approval test?**

A. Air that contains fifty milligrams per cubic meter (approximately 300 to 500 million particles per cubic foot) of dust of the small size

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specified by the Bureau of Mines is drawn through the respirator at a rate of 32 liters a minute, or at approximately the rate at which air is breathed by an average man doing work. The total amount of dust that leaks through the respirator in a 90 minute test period during which 2.88 cubic meters or 100 cubic feet of air are passed must not exceed 3.0 milligrams or 0.0001 ounces. The resistance to inhalation when tested with air flowing through the respirator at 85 liters a minute must at no time exceed 2 inches of water column. This resistance is below that which causes discomfort.

58. Q. Are the Bureau of Mines approval requirements unnecessarily exacting and impractical?

A. No. The approval requirements represent the minimum protection that a respirator should give in order to protect the wearer adequately.

59. Q. What are the most important features of a respirator?

A. 1—Adequate respiratory protection.

2—Comfort and convenience.

3—Ease and cost of maintenance.

60. Q. What is meant by the efficiency of a respirator; and what test facts concerning efficiency must be known to determine if a respirator gives adequate protection?

A. The efficiency of a respirator is the percentage of the dust in the air that is retained on the filter. At least three very important facts should be known in order to determine if a respirator, that has a reported high efficiency, also gives adequate protection:

1—The dust concentration used in determining the efficiency figure.

2—That the particle size of the dust used in determining the efficiency represents the size of the dusts found in industrial atmospheres.

3—That the percentage inefficiency, or the amount of dust that leaks through, does not exceed that which is safe to breathe.

61. Q. How does variation in particle size effect the reliability of an efficiency value of a respirator?

A. The statement that a respirator is 98% efficient means little if the particle size range of the dust tested is not given because the difficulty in removing dust increases as the particle size decreases so that dusts below 1 to 2 microns are much more difficult to remove than the larger sizes, yet it is particles below 1 to 2 microns that predominate in industrial and mine atmospheres and produce the harmful effects. A respirator which would not effectively remove dust below 2 microns could be 98% efficient provided the test was made against concentrations that contain only a small amount of particles below 2 microns in size.

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62. Q. **How is the reliability of an efficiency value as a measure of dust protection affected by the concentration of dust in the air?**

A. A respirator may have high percentage efficiency and still leak enough dust through the filter to cause harm. For example, a respirator that is 97% efficient against a concentration of 500 million particles of dust per cubic foot of air (a not unusual case) would leak 15 million particles which is more than is considered a permissible amount of dust with a high silica content in the air breathed. The Bureau of Mines approval is given only to respirators that do not leak enough dust to bring the dust in the air breathed above permissible limits.

63. Q. **What is meant by comfort and convenience?**

A. The following factors are elements of comfort and convenience:

1—Resistance to breathing.

2—Degree of impediment and encumbrance to vision and normal performance of work.

64. Q. **Should comfort and protection be considered separately?**

A. No Any acceptable respirator must give both adequate protection and an acceptable degree of comfort.

65. Q. **What is meant by cost of maintenance?**

A. The cost of maintenance is the expense involved in keeping the respirator in an efficient, comfortable, and clean working condition. Low cost of replacement of filters is an important element in this expense.

66. Q. **What is meant by ease of maintenance?**

A. By ease of maintenance is meant the ease with which a dust laden respirator can be restored to its initial high degree of efficiency and comfort through:

1—Servicing.

2—Replacement of filters.

3—Sterilization.

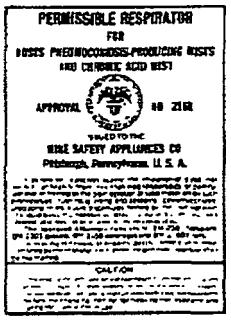
67. Q. **How can respirators be sterilized?**

A. M.S.A. Cleaner-Sanitizer powder when mixed with warm water makes an effective cleaner and sanitizer for respirators. Just mix one package (one ounce) to a gallon of warm (about 120° F) water and immerse soiled respirator in this solution. Scrub gently with soft brush until respirator is clean. Rinse in plain warm water and air dry.

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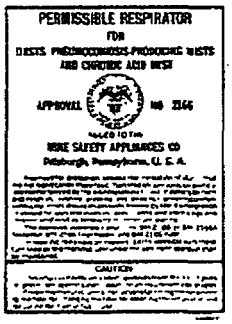
Mechanical Filter Respirators
For Protection from Dusts, Mists and Fumes
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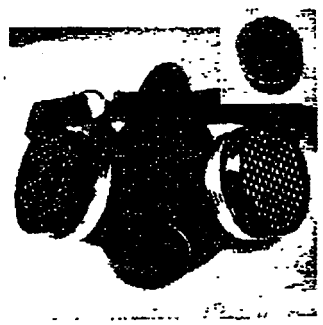


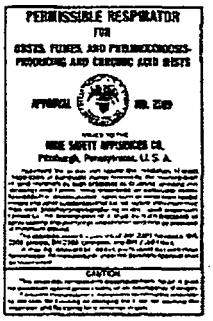
M-S-A "COMFO" DUST RESPIRATOR With Type F Filters





M-S-A DUSTFOE RESPIRATOR



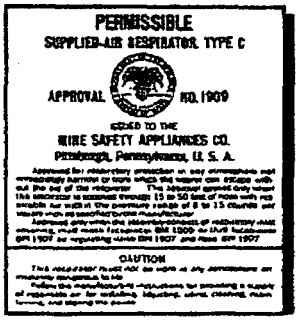


M-S-A "COMFO" RESPIRATOR With Type S Filters

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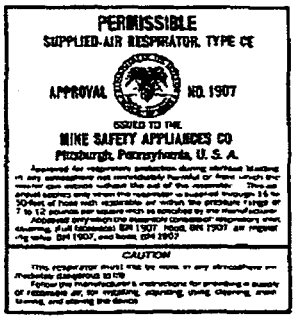
Air Line Respirator Equipment
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Mine Safety Appliances Company





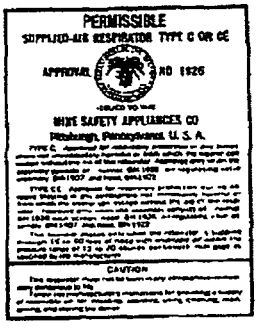
M.S.A. AIR LINE RESPIRATOR With "Comfo" Cushion Facepiece





M.S.A. ABRASIVE MASK





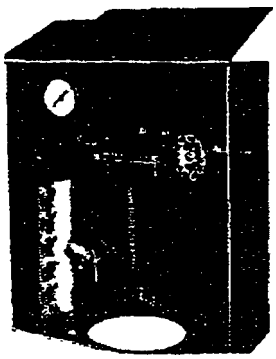
M.S.A. "BLASTFOE" ABRASIVE HELMET

SC 030740

Accessory Equipment for Air Line Respirators

Manufactured by

Mine Safety Appliances Company



M.S.A. PORTABLE AIR FILTER AND REGULATOR

Entirely self-contained and readily portable, this unit removes oil mists, oil vapors, water, and pipe scale from compressed air, and provides effective protection against excessive and variable pressures in the air supply.

It is designed for attachment to the main compressed air lines and has a capacity of one to six take-off lines to supplied air masks and respirators.

The M S A. Portable Air Filter and Regulator is equipped with a chemical fill for efficient removal of odors and vapors, and a mechanical separator which removes oil, water and dirt from incoming compressed air. A built-in pressure regulator governs air pressure at a predetermined safe limit.



M.S.A. CLEANAIR BLOWER

M.S.A. CleanAir Blowers wash, cool, and humidify the air they supply—by utilizing a small, constant flow of water through the rotor chamber. The water also acts as a compression seal, eliminating all metal-to-metal contact. Since no lubrication is necessary for the operation of CleanAir Blowers, no oil or grease comes in contact with delivered air.

No auxiliary air filter or regulator is necessary with a CleanAir Blower.

M S.A. CleanAir Blowers are furnished in a wide range of sizes to meet desired respiratory requirements.

SC 030741

Air Sampling Equipment for Dusts, Mists and Fumes

Manufactured by

Mine Safety Appliances Company



M.S.A. MIDGET IMPINGER

The M.S.A. Midget Impinger samples at a rate of one-tenth of a cubic foot per minute and is operated by a hand-cranked, positive-acting 4 cylinder pump of ingenious design. This pump, in conjunction with a vacuum regulator, maintains an unfluctuating suction regardless of minor variations in the rate or smoothness of cranking. The apparatus is contained in a compact, sturdy carrying case complete with nine calibrated glass sampling tubes.

The light weight, small dimensions, and almost effortless operation of this modern instrument greatly broaden the field of dust sampling by the impinger method. Isolated locations, confined spaces, lack of electric current or compressed air presents no barriers to the M.S.A. Midget Impinger.



M.S.A. ELECTROSTATIC
Dust and Fume Sampler

This instrument, designed for quantitative sampling of dust, fume, and mist, employs the principle of preionization with electrostatic precipitation. The unit is compact and easy to use for sampling from the general atmosphere or from stacks or ducts; it is the only efficient sampler for fumes, particularly lead fumes.

Other features are large sampling volume of 2 cu. ft. per minute permitting accurate determinations of very low concentrations of atmospheric particulate matter; flow measurement with orifice and mechanical manometer --no liquids to spill; extension tube for sampling at breathing level with apparatus on the floor; and collection of samples in a special aluminum tube permitting determinations *by weight, count or chemical analysis.*

This precipitator operates on 110-120 volts, 60 cycle, alternating current. Case dimensions are 16 x 11¼ x 10¼ inches.

Booklet No 1000-2

Printed in U. S. A. 565

SC 030742

Exc. 2

PERTINENT QUESTIONS and ANSWERS CONCERNING DUSTS

MINE SAFETY APPLIANCES CO.
Braddock, Thomas and Meade Streets
PITTSBURGH, PA.

SC 030743

Foreword

THERE is an increasingly wide and intense interest in harmful effects of breathing dusts, especially those that contain free silica and cause the disease of the lungs known as silicosis. Interest has been further stimulated by the work of Federal agencies and States in industrial hygiene, and by legislation that provides compensation for injury to health. As a result many persons in industry who are responsible for healthy working conditions have been rather suddenly confronted with the need of becoming acquainted with dust diseases, nature of dust, its composition, size of particles, and the amount that is harmful, and the means for preventing exposure and protecting workmen. Much has been said and published on these subjects, but it has been presented in terminology and language of a specialized, technical, and scientific nature that is either meaningless to most persons or creates a good deal of misunderstanding. Also, considerable confusion has arisen from the conflicting opinions and views that have been widely expressed.

In this booklet it is endeavored to present some of the questions that arise continually regarding the nature and effects of dusts, and to answer these questions in simple and insofar as possible non-technical language.

J. T. RYAN,
Mine Safety Appliances Co.

SC 030744

Pertinent Questions and Answers Concerning Dusts

1. Q. **What are the usual classifications of air-carried particles?**
   A. Air-carried particles are usually classified into three groups:
      1—Dusts
      2—Fumes
      3—Mists

2. Q. **What are dusts?**
   A. Dusts are mechanically generated particles resulting from such operations as drilling, blasting, crushing, and handling of rocks and minerals: sand-blasting; stone and granite cutting; grinding and polishing; and all similar operations and processes. The particle sizes of air-carried dusts are usually below one micron with an average size of 0.5-0.7 microns.

3. Q. **What is a micron?**
   A. A micron is a unit of measurement, one micron being equal to about 1/25,000 of an inch or in other words it would require 25,000 particles each one micron in size laid end to end to measure one inch.

4. Q. **What is the smallest particle that can be seen by the naked eye?**
   A. The smallest particle visible to a person with average eyesight is about 100 microns in dimension. This is 1/250 of an inch.

5. Q. **How does this compare with the size of the average particle found in air-born industrial dusts?**
   A. This is one hundred and fifty to two hundred times the size of the average particle found in industrial atmospheres. In other words, the particles of dust of significance from the standpoint of health are only a small fraction of the size that is visible to the naked eye.

6. Q. **What range of particle sizes is important?**
   A. The particles below 5 microns are of most importance as dusts of larger size settle out of the air very quickly and are not likely to be breathed. In general the particles of dust found in industry are below one or two microns with as much as 50% below 0.5 or 0.7 micron. Under some conditions the size may be larger or smaller than this general size range.

7. Q. **What are fumes?**
   A. Fumes are particles produced in chemical and metallurgical processes, welding, and similar operations, or by the decomposition of chemicals by heat and combustion. The average particle size is less than that of dusts. Most fumes have an average particle size of 0.2-0.3 microns. The important harmful fumes are usually the fumes of metals or their compounds such as lead oxide, zinc oxide, and cadmium oxide. Owing to their small particle size, fumes are even more difficult to remove by filters than are mechanically generated dusts.

SC 030745



Courtesy of U.S. Bureau of Mines

10 7.5 5 3 2 1 .5

MICRONS

SILICIOUS DUST FROM MINE AIR

Magnified 100 times

The dust particles and dots shown in this illustration are magnified 100 times their actual size. If they were not magnified to this extent all of the particles and dots would be invisible. Even the largest or 10 micron size would be only one-tenth that which could be seen with the naked eye and the average particle would be less than one-hundredth the visible size. This illustrates that the smallest particle that can be seen with the naked eye is about 100 microns in dimension and that all air carried dust is invisible.

8. **Q. What are mists?**

   A. Mists are particles of liquids or mixtures of liquids and solids; in other words, wet particles. Their size depends upon the process by which they were generated. Good examples of mists are: the so-called "fogs" produced in spray coating with materials such as siliceous glazes or paints that contain lead, and the chromic acid mist produced during chromium plating.

9. **Q. What dusts are dangerous?**

   A. The effect of many industrial dusts on health is not known as yet since the physiological reactions of most dusts do not appear for some years, and the use of many dust producing compounds is relatively new. Most authorities agree that most dusts are dangerous in some degree if breathed in sufficient concentration over a period of time. The safe course is to eliminate all dust down to the limits that are considered good engineering practice in dust control.

10. **Q. How are dusts classified in relation to their effects on health?**

    A. Dusts are usually classified into three groups:

    1—Toxic or poisonous dusts.
    2—Nuisance dusts.
    3—Fibrosis-producing dusts.

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11. Q. **What is a toxic dust?**

A. A toxic dust is usually considered to be the dust of a poisonous material, such as lead and arsenic or their compounds, that produces injury to organs such as the circulatory system, heart, liver, kidneys, brain, and nervous system. When a poisonous dust is inhaled and deposited in the lungs, it dissolves and is carried by the blood to all organs and tissues. It may also be deposited in the mouth and throat by inhalation or contamination with dirty hands, and later swallowed and enters the body through the digestive tract.

12. Q. **What is a nuisance dust?**

A. A nuisance dust is one that is often associated with an increase in respiratory diseases (such as, colds in the head, bronchitis, pneumonia, and tuberculosis). Many such dusts are discomforting to the worker and may be dangerous. They do not produce toxic effects or form fibrous tissue in the lungs.

13. Q. **What is a fibrosis-producing dust?**

A. It is one that through its action in the lungs causes a disease of the normal lung tissue and a replacement of this vital tissue with fibrous (scar) tissue.

14. Q. **What is pneumoconiosis?**

A. It is a term applied to any lung disease arising from inhalation of dust.

15. Q. **What is silicosis?**

A. It is a disease of the lungs in which the normal lung tissue is replaced by fibrous (scar) tissue due to breathing air that contains free silica dust (silicon dioxide, SiO_2).

16. Q. **Can silicosis be produced by any substance other than free silica?**

A. Silicosis is a specific disease caused only by breathing free silica. However, there are indications that the presence of other kinds of dust and gases may influence the effect of silica in the lung.

17. Q. **What is miners' phthisis?**

A. It is a term used frequently to designate a condition of silicosis complicated by the presence of tuberculosis.

18. Q. **What is anthraco-silicosis (miner's asthma)?**

A. It is a chronic disease of the lungs in which the normal lung tissue is replaced by scar tissue caused by breathing excessive amounts of a mixture of silica dust along with coal dust.

19. Q. **What is asbestosis?**

A. It is a disease of the lungs in which the normal lung tissue is replaced by fibrous (scar) tissue due to breathing air that contains asbestos dust.

20. Q. **What are the principal factors in determining the health hazard from air-carried dust?**

A. The following factors are usually important:

1—Chemical composition of the dust.

2—Amount of dust in the air.

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3—Size of the dust particles.
4—Length of time of exposure.
5—An understanding and interpretation of these factors in terms of the effect of dust on persons.

21. **Q. What is meant by chemical composition of α dust?**
A. All materials such as rocks and minerals are not what might be termed pure chemical compounds, but are mixtures of several chemical compounds. The chemical composition is the kind and amounts of these various components. In the case of silica-bearing substances, the amount of silica present may vary from almost nothing to 100%. The amount of silica present is obviously the important factor in the silicosis producing properties of a dust.

22. **Q. Is the chemical composition of the dust in the air the same as the substance that is being drilled, handled, crushed, or processed?**
A. As most dust producing substances dealt with in industry contain more than one mineral component, some of these components will crush or disintegrate more easily than others and thereby form a larger proportion of small particles. These smaller particles will tend to predominate in the air while other constituents being larger will settle out. For this reason, the composition of the dust in the air may vary greatly from the composition of the rock or mineral.

23. **Q. What is the importance of the chemical composition of α dust?**
A. The chemical composition reveals the harmful constituents and their amount, and constitutes the basis for judging the harmful qualities of the dust. This information is an important factor along with concentration and time of exposure in determining the hazard.

24. **Q. What are the important steps in determining the chemical composition of α dust?**
A. It is necessary to first obtain a sample that represents the dust in the air breathed, and then subject the sample to methods of analysis that are known to give accurate results for the constituents desired.

25. **Q. How can a representative sample of the dust in the air breathed be obtained?**
A. It can be obtained only by collecting the dust from the air. Samples of pieces of rock or settled dust do not necessarily bear any close relation in composition to the dust floating in the air.

26. **Q. How can a sample of sufficient size for chemical analysis be collected from the air?**
A. Collection from the air can be accomplished by long and continuous operation of dust collection devices such as the impinger, electrical or electrostatic precipitators or filter bag type of collectors.

27. **Q. What methods are generally used for determination of the percent of free silica in dusts?**
A. 1—By observing the action of the small dust particles on light with the aid of a special type of microscope. This is known as the petrographic method.
2—By chemical analysis.
3—By observing the action of the particles on X-Rays.

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28. **Q. What are the limitations of the petrographic method?**

A. It is impossible by this method to examine individual particles below one or two microns in size and since most of the air-carried dust is below this size range, one must rely on petrographic information obtained from particle sizes that are above those of primary significance.

29. **Q. What are the limitations of the chemical method?**

A. There is no known chemical method that is specific for free silica (SiO_2) when this constituent is present with silicates. However, by observing the difference in the rate at which silica dissolves in certain acids as compared with other constituents a rough estimate can be obtained for some dusts, but with others the method will be greatly in error.

30. **Q. What are the limitations of the X-Ray method?**

A. The X-Ray procedure can be used for making specific determinations of free silica in a very small sample such as 25 to 50 milligrams. The disadvantage of the method is that it requires very expensive apparatus.

31. **Q. What is meant by size of particle; how is it expressed?**

A. The size of the particle is its largest dimension, usually expressed in microns. It has been stated by authorities that if all dust below one micron in size could be eliminated, nearly all dust disease would be eliminated.

32. **Q. How can the size of dust particles be determined?**

A. The size of dust particles is measured by means of a microscope or by projection of the dust particles on a screen similar in general principle to ordinary lantern slide projection. The particles as seen in the microscope or projected are then measured.

33. **Q. How quickly does fine dust settle?**

A. It settles very slowly. In the table given below will be found the time in minutes estimated for silica dust of given sizes to fall one foot in still air.

Size in microns	Time in minutes to fall one foot
¼	590.
½	187.
1	54.
2	14.4
5	2.5

34. **Q. Does absence of visible dust mean absence of fine dust?**

A. No. The operation may produce only fine dust or the visible dust may have disappeared owing to its rapid rate of settling, leaving the invisible but harmful dust in the air.

35. **Q. What is meant by dust concentration; how is it expressed?**

A. The concentration is the amount of dust suspended in a given volume of air. It is usually expressed in number of particles in a cubic foot of air, or millions of particles in a cubic meter of air, or in a cubic

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centimeter. It may also be expressed as the weight of dust in a given volume of air as milligrams in a cubic meter or grains in a cubic foot.

36. Q. **What is the relation among these units of quantity?**
A. Number of cubic feet times .02832 gives number of cubic meters (m^3).
Number of cubic meters times 35.31 gives number of cubic feet.
Number of cubic feet times 28,317 gives number of cubic centimeters (cc.)
Number of milligrams times .001 gives number of grams.
Number of grains times 64.80 gives number of milligrams.
Number of grains times 00229 gives ounces (avoirdupois)

37. Q. **How can the concentration in particles per cubic centimeter be converted to number of particles per cubic foot?**
A. Multiply the number of particles per cubic centimeter by a million and divide by 35.31 to get number of particles per cubic foot.

38. Q. **How many particles of air-carried dust are in one milligram weight of dust?**
A. It has been found that one milligram of silica dust of the size range present in industrial atmospheres contains about 200 to 300 million particles.

39. Q. **What apparatus and methods are generally used for determining dust concentrations?**
A. The impinger, konimeter, and electrical precipitator are the instruments generally used for this purpose. Details of the instruments and methods can be found in publications of the United States Bureau of Mines and the United States Public Health Service.

40. Q. **What is an impinger?**
A. It is a device by which air is drawn at a definite rate of flow and at high velocity through a small nozzle so directed as to strike a glass plate immersed in liquid such as water, alcohol, or a mixture of these liquids. This high velocity action causes the dust particles to be "wetted" and retained in the liquid. Some of this liquid is then examined under a microscope and a count of the dust particles present is made. It is a rather bulky instrument, requires training in use, care in handling, but has acceptable accuracy. It is the instrument most commonly used at present in the United States for dust determinations. It can be used for determining the number of dust particles of any kind of dust not soluble in the liquid in which it is collected. It can be used for soluble dusts by evaporating the solution, thus leaving the dust as residue. The soluble dust may also be determined by chemical means. As the impinger apparatus collects the dust from a rather large volume of air taken continuously over a considerable period of time, the results are more representative of average conditions than those obtained by the use of an instrument that collects instantaneous or grab samples.

41. Q. **What is a konimeter?**
A. It is a device by which a small sample of air, usually 5 cc., is drawn through a small nozzle and directed in the form of a jet onto a glass plate coated with vaseline or microscope jelly. By this means dust

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particles are deposited on the plate. With one design of konimeter the number of particles of dust are counted with a microscope directly attached to the instrument; with another type these samples are taken to the laboratory for counting with an ordinary microscope. The konimeter takes an instantaneous or grab sample rather than a continuous sample as taken by the impinger or electrical precipitator. It is a rapid method and requires very little sampling skill. For obtaining average dust concentrations over a period of time it is necessary to make a series of konimeter determinations and average the results.

42. Q. What is an electrical precipitator?

A. It's a device by which air is drawn at a definite rate of flow through a high voltage electrical field so arranged as to cause any dust to be removed and deposited on a foil or paper. The dust collected can be determined either by counting the number of particles with a microscope or by weighing. It is an efficient method but requires a source of electrical energy. As with the impinger, the electrical precipitator collects the dust continuously from a comparatively large volume of air and thus provides a sample that represents average conditions. It may even be used to collect a sample that is large enough for chemical analysis.

43. Q. How can exposure be determined?

A. Since exposure is a term that involves concentration, particle size, chemical composition, and duration of time, it is necessary to determine all of these in order to properly evaluate the degree and extent of exposure. The time element requires an accurate job analysis in which is recorded the amount of time spent by a workman at his various operations. This record should then be associated with the dust concentration, particle size, and chemical composition of the dust at each operation and the average over all daily exposure determined.

For Example:
Summary of Dust Exposure of Leyner Drillers in a Granite Quarry

Activity	Average exposure in millions of particles per cubic foot.	Hours spent in each activity	Particle hrs. (millions per cubic foot)
Drilling	213.4	4	853.6
Changing drills	9.8	1	9.8
Watching drills	8.0	2	16 0
Broaching	6.0	¾	4.5
Blowing off holes	1085 0	¼	271.3
Total		8	1155 2

$$\frac{1155.2 \text{ particle hours in millions per cubic foot}}{8 \text{ hr.}} = 144.4 \text{ million particles per cubic foot. Average exposure throughout the day.}$$

Table from U. S. Public Health Bulletin 217 by Bloomfield and Dallavalle.

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44. **Q. What is a respirator?**

A. Any personal protective device designed to prevent the wearer from inhaling the harmful constituents in his surrounding atmosphere is called a respirator.

45. **Q. What is a supplied-air or air-line respirator?**

A. It is essentially a hose line through which air that is safe to breathe is conveyed to a facepiece worn by the workman. The air may be supplied from the compressed air line although preferably it should come from a separate blower unit designed to furnish air free from distasteful or harmful impurities.

46. **Q. What harmful or objectionable constituents might be present in high pressure air as produced by an ordinary reciprocating type of compressor?**

A. Air from this source may contain oil odors, mists of oil or water, particles of rust or dirt from the air receiver or air lines, and in case of improper compressor operation there may be burning of the lubricants with the formation of carbon monoxide.

47. **Q. What precautions should be taken to lessen the danger from air contamination in the use of reciprocating type of air compressors?**

A. Good maintenance and care in operation of the compressor, temperature indicators on the outlet side of compressor, and carbon monoxide detecting equipment or carbon monoxide alarms on the outlet side to give indication of the presence of any carbon monoxide. Individual compressor units so constructed as to make generation of harmful gases impossible are desirable sources of clean air for air-line respirators. The M.S.A. Clean Air Blower is designed to fill this need.

48. **Q. What is a chemical filter respirator?**

A. It is a respirator designed for removing gaseous constituents from the air breathed. The filtering materials in these respirators are usually granules that react with the harmful constituents and remove them.

49. **Q. What is a mechanical filter respirator?**

A. A mechanical filter respirator is a device that removes by mechanical filtration the particles of harmful constituents from air that passes through it. These devices include dust, mist, and fume respirators. Each of these types of mechanical filter respirators is designed to protect the wearer against the particular kind of matter to be dealt with.

50. **Q. What is a United States Bureau of Mines "approved" mechanical filter respirator?**

A. It is a respirator that has officially passed the rigid test requirements of the United States Bureau of Mines as outlined in that Bureau's Approval Schedule No. 21.

51. **Q. What is United States Bureau of Mines schedule No. 21?**

A. It is a publication that describes the requirements and tests that a respirator must meet in order to obtain the approval of the Bureau of

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Mines. Free copies of this publication may be obtained upon request from the United States Bureau of Mines, Washington, D. C.

52. Q. For what types of mechanical filter respirators does the Bureau of Mines schedule No. 21 provide approval requirements?

A. Schedule No 21 provides approval requirements for mechanical filter respirators for protection against mechanically generated dusts (known as Type A respirator): fumes of various metals (Type B). and mists such as those from chromic acid and from spray coating in the absence of harmful vapors and gases (Type C) Combinations of these types may also be approved.

53. Q. Who makes the approval tests?

A. The Bureau of Mines makes the tests at its Pittsburgh Experiment Station where experienced personnel and complete laboratory facilities for dust investigations are available

54. Q. What are the general performance requirements that a mechanical filter dust respirator must give in order to obtain the approval of the Bureau of Mines?

A. The general features of the performance requirements are:

1—Dust-tight fit of the facepiece.

2—Reduction of dust in the inhaled air below an amount that causes harm.

3—A resistance to breathing that is below that which produces discomfort.

4—A satisfactory degree of convenience, durability, and service.



Coal Miner wearing COMFO RESPIRATOR

SC 030753

55. **Q. What is the size of the dust particles used by the United States Bureau of Mines in the approval tests of respirators?**

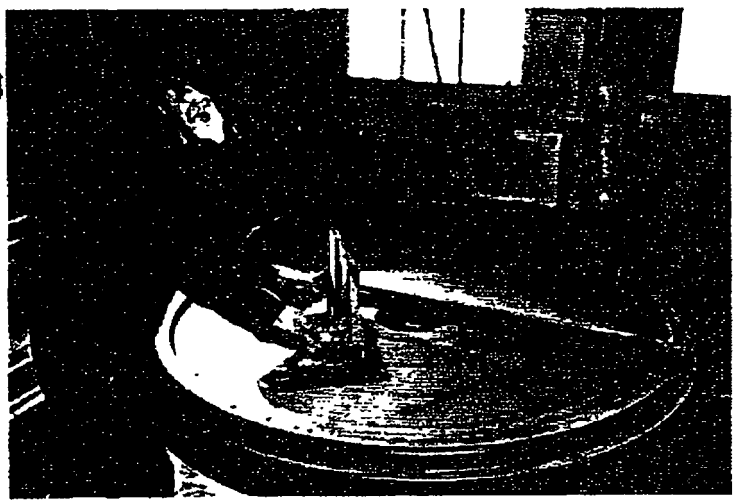
A. The dust particles used in the tests are 95% below 1.78 microns and 50% below 0.6 micron. These size characteristics are very similar to those found in the atmospheres of mines and industrial plants.

56. **Q. What severe dust filtering and resistance performance must a mechanical filter dust respirator give to pass the approval test?**

A. Air that contains fifty milligrams per cubic meter (approximately 300 to 500 million particles per cubic foot) of dust of the small size specified by the Bureau of Mines is drawn through the respirator at a rate of 32 liters a minute, or at approximately the rate at which air is breathed by an average man doing work. The total amount of dust that leaks through the respirator in a 90 minute test period during which 2.88 cubic meters or 100 cubic feet of air are passed must not exceed 3.0 milligrams or 0.0001 ounces. The resistance to inhalation when tested with air flowing through the respirator at 85 liters a minute must at no time exceed 2 inches of water column. This resistance is below that which causes discomfort.

57. **Q. Are the Bureau of Mines approval requirements unnecessarily exacting and impractical?**

A. No. The approval requirements in schedule No. 21 represent the minimum protection that a respirator should give in order to protect the wearer adequately.



M S A Comfo Respirator used during grinding operations

SC 030754

58. **Q. What are the most important features of a respirator?**

A. 1—Adequate respiratory protection.
2—Comfort and convenience.
3—Ease and cost of maintenance.

59. **Q. What is the Comfo Respirator?**

A. It is a particular type of respirator manufactured by the Mine Safety Appliances Company that is approved by the U S Bureau of Mines It was the first respirator to pass this Bureau's approval tests. It has filters of specially treated cellulose for removing the dusts of very small size that are present in industrial atmospheres. The filters are protected from damage or contamination by a metal covering and are attached to both sides of an all rubber facepiece. It has a large filtering area and low resistance to breathing.

60. **Q. How does the Comfo Respirator meet the requirements for adequate respiratory protection?**

A. The protection afforded by the Comfo Respirator is certified by the United States Bureau of Mines approval which it carries as a result of having successfully passed the approval tests against dusts of a particle size 95% of which are less than 1 78 microns and 50% less than 0 60 microns. This is the range of particle sizes usually found for mine and industrial dusts.

61. **Q. What is meant by the efficiency of a respirator and what test facts concerning efficiency must be known to determine if a respirator gives adequate protection?**

A. The efficiency of a respirator is the percentage of the dust in the air that is retained on the filter. At least three very important facts should be known in order to determine if a respirator, that has a reported high efficiency, also gives adequate protection:

1—The dust concentration used in determining the efficiency figure

2—That the particle size of the dust used in determining the efficiency represents the size of the dusts found in industrial atmospheres

3—That the percentage inefficiency, or the amount of dust that leaks through, does not exceed that which is safe to breathe.

62. **Q. How does variation in particle size effect the reliability of an efficiency value of a respirator?**

A. The statement that a respirator is 98% efficient means little if the particle size range of the dust tested is not given because the difficulty in removing dust increases as the particle size decreases so that dusts below 1 to 2 microns are much more difficult to remove than the larger sizes, yet it is particles below 1 to 2 microns that predominate in industrial and mine atmospheres and produce the harmful effects. A respirator which would not effectively remove dust below 2 microns could be 98% efficient provided the test was made against concentrations that contain only a small amount of particles below 2 microns in size.

SC 030755

63. Q. How is the reliability of an efficiency value as a measure of dust protection affected by the concentration of dust in the air?

A. A respirator may have high percentage efficiency and still leak enough dust through the filter to cause harm. For example, a respirator that is 97% efficient against a concentration of 500 million particles of dust per cubic foot of air (a not unusual case) would leak 15 million particles which is more than is considered a permissible amount of dust with a high silica content in the air breathed. The Bureau of Mines approval is given only to respirators that do not leak enough dust to bring the dust in the air breathed above permissible limits.

64. Q. What is meant by comfort and convenience?

A. The following factors are elements of comfort and convenience

1—Resistance to breathing.

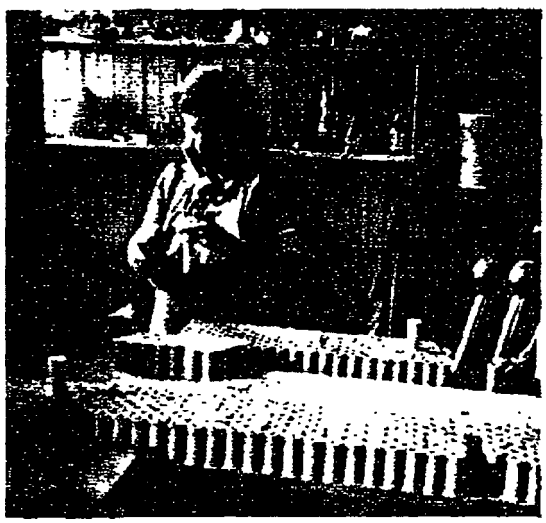
2—Degree of impediment and encumbrance to vision and normal performance of work.

65. Q. Should comfort and protection be considered separately?

A. No. Any acceptable respirator must give both adequate protection and an acceptable degree of comfort.

66. Q. How does the Comfo Respirator meet the comfort requirement?

A. The comfort of the Comfo Respirator is assured by its low breathing resistance, light weight, and lack of encumbrance to the wearer's vision and movement



M S A. Comfo Respirator worn by worker in ceramic plant

SC 030756

67. Q. **What is meant by cost of maintenance?**

A. The cost of maintenance is the expense involved in keeping the respirator in an efficient, comfortable, and clean working condition. Low cost of replacement of filters is an important element in this expense.

68. Q. **How does the Comfo Respirator meet the low maintenance cost requirements?**

A. The low maintenance cost of the Comfo Respirator is given by the low cost of the replaceable filters and the short time required for replacement.

69. Q. **What is meant by ease of maintenance?**

A. By ease of maintenance is meant the ease with which a dust laden respirator can be restored to its initial high degree of efficiency and comfort through.

1—Servicing.

2—Replacement of filters

3—Sterilization.

70. Q. **How does the Comfo Respirator meet this requirement for ease of maintenance?**

A. The low cost of Comfo Respirator filters permits discarding of the dust laden filter and replacement with new filters. This avoids the cleaning of filters and provides a new and clean filter with the initial high degree of protection and comfort.

71. Q. **How can respirators be sterilized?**

A. Scrub rubber and metal parts with soap and water. Rinse in warm water and immerse for 10 minutes in a solution of formalin made by placing one part of 40% formaldehyde solution into 9 parts of water. Instead of the formalin solution, 1 part of carbolic acid in 33 parts of water, or 1 part of Lysol in 50 parts of water, or 8 parts of denatured alcohol in 3 parts of water may be used.
All respirators should be thoroughly rinsed with water immediately after immersion in the sterilizing solution and put in a clean place to dry.

72. Q. **How does the Comfo Respirator permit easy and thorough sterilization and cleaning of all parts?**

A. Owing to the low cost of filters, these parts can be discarded and the entire remaining part of the respirator thoroughly washed and sterilized. After replacement of new filters the respirator is in its original clean and efficient condition. This permits daily sterilization of all parts and avoids the growth of bacteria and danger of contamination from parts that cannot be completely sterilized.

73. Q. **How does the Comfo Respirator meet the requirements of industries for respiratory protection?**

A. The Comfo Respirator is certified by the United States Bureau of Mines Approval as giving adequate respiratory protection; it is comfortable and convenient; it is easily maintained and the cost of filter replacement is low.

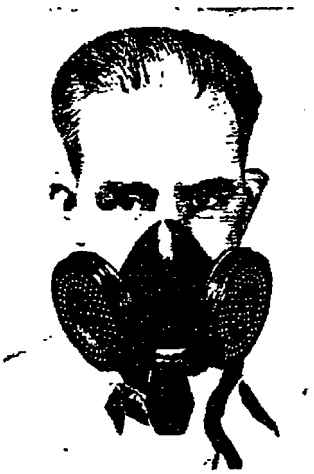
SC 030757

Equipment for Protection from Dusts

Manufactured by

Mine Safety Appliances Company

M.S.A. COMFO RESPIRATOR



The M.S.A. Comfo Dust and Mist Respirator is a mechanical filter type respirator that was developed to protect workmen from breathing dust such as silica, coal, iron, asbestos, and other similar air carried particles of the very small sizes found in industrial atmospheres. It will also protect against the harmful liquid mist produced in chromium plating and the mist of vitreous enamels. This respirator has been officially approved by the U. S. Bureau of Mines, Approval No. 2101.

The M.S.A. Comfo Lead Dust Respirator is identical in design with the Dust and Mist Respirator except the cellulose filters are specially treated for filtering out lead dusts of small particle sizes. It is officially approved by the U. S. Bureau of Mines, Approval No. 2107.

M.S.A. AIR LINE RESPIRATOR



The M.S.A. Air Line Respirator provides protection from gases, vapors, dusts, and fumes by providing the wearer with an adequate supply of air for breathing requirements. Both the M.S.A. Air Line Respirator and the M.S.A. Abrasive Mask (shown later) have free-wheeling control valves to insure against accidental bumping and changing of air flow, and a quick release connection in case the air supply fails or becomes unusable for any reason.

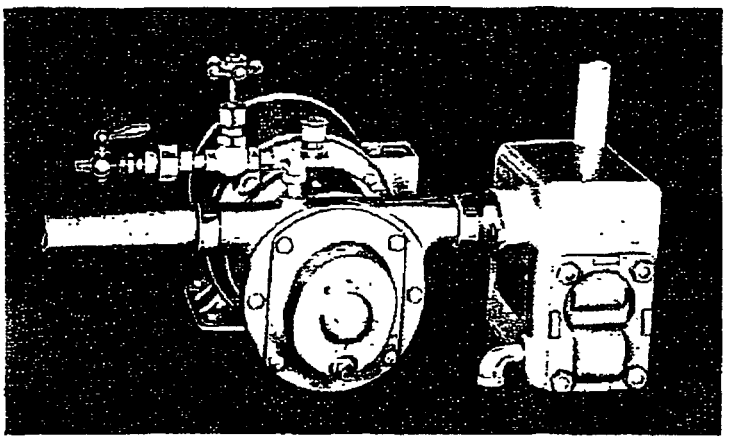
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M.S.A. ABRASIVE MASK



The M.S.A. Abrasive Mask is a light, comfortable, fresh air supplied unit designed for respiratory protection from the high concentrations of fine dust produced by abrasive blasting with sand or shot, and for protection of the head and shoulders from impact and abrasion by the high velocity rebounding particles. It gives protection from dusts, fumes, gases, and vapors.

M.S.A. CLEAN AIR BLOWER



The M.S.A. Clean Air Blower is specially designed for supplying air that is cool, clean, humidified, and free from obnoxious or harmful gases to air line respirators, sand blast hoods, and helmets. It is a rotary type in which water is used as a compressor seal, cooling medium, humidifier, air washer, and dust remover. There is no internal lubrication and no contact of the air with oil, grease, or contaminating agents.

PRINTED IN U. S. A.

SC 030759

PERTINENT QUESTIONS and ANSWERS CONCERNING DUSTS



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M664q
no. 5

SC 030760

Foreword

THERE is an increasingly wide and intense interest in harmful effects of breathing dusts, especially those that contain free silica and cause the disease of the lungs known as silicosis. Interest has been further stimulated by the work of Federal agencies and States in industrial hygiene, and by legislation that provides compensation for injury to health. As a result many persons in industry who are responsible for healthy working conditions have been rather suddenly confronted with the need of becoming acquainted with dust diseases, nature of dust, its composition, size of particles, and the amount that is harmful, and the means for preventing exposure and protecting workmen. Much has been said and published on these subjects, but it has been presented in terminology and language of a specialized, technical, and scientific nature that is either meaningless to most persons or creates a good deal of misunderstanding. Also, considerable confusion has arisen from the conflicting opinions and views that have been widely expressed.

In this booklet it is endeavored to present some of the questions that arise continually regarding the nature and effects of dusts, and to answer these questions in simple and insofar as possible non-technical language.

J. T. RYAN,
Mine Safety Appliances Co.

SC 030761

Pertinent Questions and Answers Concerning Dusts

1. **Q. What are the usual classifications of air-carried particles?**
   A. Air-carried particles are usually classified into three groups:
   1—Dusts
   2—Fumes
   3—Mists

2. **Q. What are dusts?**
   A. Dusts are mechanically generated particles resulting from such operations as drilling, blasting, crushing, and handling of rocks and minerals: sand-blasting; stone and granite cutting; grinding and polishing; and all similar operations and processes. The particle sizes of air-carried dusts are usually below one micron with an average size of 0.5-0.7 microns.

3. **Q. What is a micron?**
   A. A micron is a unit of measurement, one micron being equal to about 1/25,000 of an inch or in other words it would require 25,000 particles each one micron in size laid end to end to measure one inch.

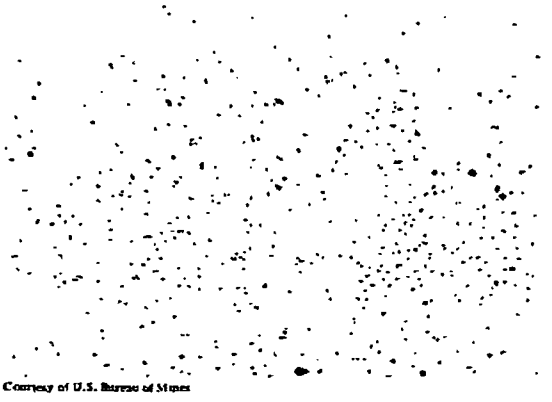
4. **Q. What is the smallest particle that can be seen by the naked eye?**
   A. The smallest particle visible to a person with average eyesight is about 100 microns in dimension. This is 1/250 of an inch.

5. **Q. How does this compare with the size of the average particle found in air-born industrial dusts?**
   A. This is one hundred and fifty to two hundred times the size of the average particle found in industrial atmospheres. In other words, the particles of dust of significance from the standpoint of health are only a small fraction of the size that is visible to the naked eye.

6. **Q. What range of particle sizes is important?**
   A. The particles below 5 microns are of most importance as dusts of larger size settle out of the air very quickly and are not likely to be breathed. In general the particles of dust found in industry are below one or two microns with as much as 50% below 0.5 or 0.7 micron. Under some conditions the size may be larger or smaller than this general size range.

7. **Q. What are fumes?**
   A. Fumes are particles produced in chemical and metallurgical processes, welding, and similar operations, or by the decomposition of chemicals by heat and combustion. The average particle size is less than that of dusts. Most fumes have an average particle size of 0.2-0.3 microns. The important harmful fumes are usually the fumes of metals or their compounds such as lead oxide, zinc oxide, and cadmium oxide. Owing to their small particle size, fumes are even more difficult to remove by filters than are mechanically generated dusts.

SC 030762



Courtesy of U.S. Bureau of Mines

10 7.5 5 3 2 1 .5

MICRONS

SILICIOUS DUST FROM MINE AIR

Magnified 100 times

The dust particles and dots shown in this illustration are magnified 100 times their actual size. If they were not magnified to this extent all of the particles and dots would be invisible. Even the largest or 10 micron size would be only one-tenth that which could be seen with the naked eye and the average particle would be less than one-hundredth the visible size. This illustrates that the smallest particle that can be seen with the naked eye is about 100 microns in dimension and that all air carried dust is invisible.

8. **Q. What are mists?**

   A. Mists are particles of liquids or mixtures of liquids and solids; in other words, wet particles. Their size depends upon the process by which they were generated. Good examples of mists are: the so-called "fogs" produced in spray coating with materials such as siliceous glazes or paints that contain lead, and the chromic acid mist produced during chromium plating.

9. **Q. What dusts are dangerous?**

   A. The effect of many industrial dusts on health is not known as yet since the physiological reactions of most dusts do not appear for some years, and the use of many dust producing compounds is relatively new. Most authorities agree that most dusts are dangerous in some degree if breathed in sufficient concentration over a period of time. The safe course is to eliminate all dust down to the limits that are considered good engineering practice in dust control.

10. **Q. How are dusts classified in relation to their effects on health?**

    A. Dusts are usually classified into three groups:

    1—Toxic or poisonous dusts.
    2—Nuisance dusts.
    3—Fibrosis-producing dusts.

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11. **Q. What is a toxic dust?**

A. A toxic dust is usually considered to be the dust of a poisonous material, such as lead and arsenic or their compounds, that produces injury to organs such as the circulatory system, heart, liver, kidneys, brain, and nervous system. When a poisonous dust is inhaled and deposited in the lungs, it dissolves and is carried by the blood to all organs and tissues. It may also be deposited in the mouth and throat by inhalation or contamination with dirty hands, and later swallowed and enters the body through the digestive tract.

12. **Q. What is a nuisance dust?**

A. A nuisance dust is one that is often associated with an increase in respiratory diseases (such as, colds in the head, bronchitis, pneumonia, and tuberculosis). Many such dusts are discomforting to the worker and may be dangerous. They do not produce toxic effects or form fibrous tissue in the lungs.

13. **Q. What is a fibrosis-producing dust?**

A. It is one that through its action in the lungs causes a disease of the normal lung tissue and a replacement of this vital tissue with fibrous (scar) tissue.

14. **Q. What is pneumoconiosis?**

A. It is a term applied to any lung disease arising from inhalation of dust.

15. **Q. What is silicosis?**

A. It is a disease of the lungs in which the normal lung tissue is replaced by fibrous (scar) tissue due to breathing air that contains free silica dust (silicon dioxide, SiO_2).

16. **Q. Can silicosis be produced by any substance other than free silica?**

A. Silicosis is a specific disease caused only by breathing free silica. However, there are indications that the presence of other kinds of dust and gases may influence the effect of silica in the lung.

17. **Q. What is miners' pthisis?**

A. It is a term used frequently to designate a condition of silicosis complicated by the presence of tuberculosis.

18. **Q. What is anthraco-silicosis (miner's asthma)?**

A. It is a chronic disease of the lungs in which the normal lung tissue is replaced by scar tissue caused by breathing excessive amounts of a mixture of silica dust along with coal dust.

19. **Q. What is asbestosis?**

A. It is a disease of the lungs in which the normal lung tissue is replaced by fibrous (scar) tissue due to breathing air that contains asbestos dust.

20. **Q. What are the principal factors in determining the health hazard from air-carried dust?**

A. The following factors are usually important:

1—Chemical composition of the dust.

2—Amount of dust in the air.

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3—Size of the dust particles.
4—Length of time of exposure.
5—An understanding and interpretation of these factors in terms of the effect of dust on persons.

21. **Q. What is meant by chemical composition of α dust?**
A. All materials such as rocks and minerals are not what might be termed pure chemical compounds, but are mixtures of several chemical compounds. The chemical composition is the kind and amounts of these various components. In the case of silica-bearing substances, the amount of silica present may vary from almost nothing to 100%. The amount of silica present is obviously the important factor in the silicosis producing properties of a dust.

22. **Q. Is the chemical composition of the dust in the air the same as the substance that is being drilled, handled, crushed, or processed?**
A. As most dust producing substances dealt with in industry contain more than one mineral component, some of these components will crush or disintegrate more easily than others and thereby form a larger proportion of small particles. These smaller particles will tend to predominate in the air while other constituents being larger will settle out. For this reason, the composition of the dust in the air may vary greatly from the composition of the rock or mineral.

23. **Q. What is the importance of the chemical composition of α dust?**
A. The chemical composition reveals the harmful constituents and their amount, and constitutes the basis for judging the harmful qualities of the dust. This information is an important factor along with concentration and time of exposure in determining the hazard.

24. **Q. What are the important steps in determining the chemical composition of α dust?**
A. It is necessary to first obtain a sample that represents the dust in the air breathed, and then subject the sample to methods of analysis that are known to give accurate results for the constituents desired.

25. **Q. How can α representative sample of the dust in the air breathed be obtained?**
A. It can be obtained only by collecting the dust from the air. Samples of pieces of rock or settled dust do not necessarily bear any close relation in composition to the dust floating in the air.

26. **Q. How can α sample of sufficient size for chemical analysis be collected from the air?**
A. Collection from the air can be accomplished by long and continuous operation of dust collection devices such as the impinger, electrical or electrostatic precipitators or filter bag type of collectors.

27. **Q. What methods are generally used for determination of the percent of free silica in dusts?**
A. 1—By observing the action of the small dust particles on light with the aid of a special type of microscope. This is known as the petrographic method.
2—By chemical analysis.
3—By observing the action of the particles on X-Rays.

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28. Q. **What are the limitations of the petrographic method?**

A. It is impossible by this method to examine individual particles below one or two microns in size and since most of the air-carried dust is below this size range, one must rely on petrographic information obtained from particle sizes that are above those of primary significance.

29. Q. **What are the limitations of the chemical method?**

A. There is no known chemical method that is specific for free silica (SiO_2) when this constituent is present with silicates. However, by observing the difference in the rate at which silica dissolves in certain acids as compared with other constituents a rough estimate can be obtained for some dusts, but with others the method will be greatly in error.

30. Q. **What are the limitations of the X-Ray method?**

A. The X-Ray procedure can be used for making specific determinations of free silica in a very small sample such as 25 to 50 milligrams. The disadvantage of the method is that it requires very expensive apparatus.

31. Q. **What is meant by size of particle: how is it expressed?**

A. The size of the particle is its largest dimension, usually expressed in microns. It has been stated by authorities that if all dust below one micron in size could be eliminated, nearly all dust disease would be eliminated.

32. Q. **How can the size of dust particles be determined?**

A. The size of dust particles is measured by means of a microscope or by projection of the dust particles on a screen similar in general principle to ordinary lantern slide projection. The particles as seen in the microscope or projected are then measured.

33. Q. **How quickly does fine dust settle?**

A. It settles very slowly. In the table given below will be found the time in minutes estimated for silica dust of given sizes to fall one foot in still air.

Size in microns	Time in minutes to fall one foot
1/4	590.
1/2	187.
1	54.
2	14.4
5	2.5

34. Q. **Does absence of visible dust mean absence of fine dust?**

A. No. The operation may produce only fine dust or the visible dust may have disappeared owing to its rapid rate of settling, leaving the invisible but harmful dust in the air.

35. Q. **What is meant by dust concentration: how is it expressed?**

A. The concentration is the amount of dust suspended in a given volume of air. It is usually expressed in number of particles in a cubic foot of air, or millions of particles in a cubic meter of air, or in a cubic

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centimeter. It may also be expressed as the weight of dust in a given volume of air as milligrams in a cubic meter or grains in a cubic foot.

36. Q. **What is the relation among these units of quantity?**
A. Number of cubic feet times .02832 gives number of cubic meters (m^3).
Number of cubic meters times 35.31 gives number of cubic feet.
Number of cubic feet times 28,317 gives number of cubic centimeters (cc.)
Number of milligrams times .001 gives number of grams.
Number of grains times 64.80 gives number of milligrams.
Number of grains times .00229 gives ounces (avoirdupois).

37. Q. **How can the concentration in particles per cubic centimeter be converted to number of particles per cubic foot?**
A. Multiply the number of particles per cubic centimeter by a million and divide by 35.31 to get number of particles per cubic foot.

38. Q. **How many particles of air-carried dust are in one milligram weight of dust?**
A. It has been found that one milligram of silica dust of the size range present in industrial atmospheres contains about 200 to 300 million particles.

39. Q. **What apparatus and methods are generally used for determining dust concentrations?**
A. The impinger, konimeter, and electrical precipitator are the instruments generally used for this purpose. Details of the instruments and methods can be found in publications of the United States Bureau of Mines and the United States Public Health Service.

40. Q. **What is an impinger?**
A. It is a device by which air is drawn at a definite rate of flow and at high velocity through a small nozzle so directed as to strike a glass plate immersed in liquid such as water, alcohol, or a mixture of these liquids. This high velocity action causes the dust particles to be "wetted" and retained in the liquid. Some of this liquid is then examined under a microscope and a count of the dust particles present is made. It is a rather bulky instrument, requires training in use, care in handling, but has acceptable accuracy. It is the instrument most commonly used at present in the United States for dust determinations. It can be used for determining the number of dust particles of any kind of dust not soluble in the liquid in which it is collected. It can be used for soluble dusts by evaporating the solution, thus leaving the dust as residue. The soluble dust may also be determined by chemical means. As the impinger apparatus collects the dust from a rather large volume of air taken continuously over a considerable period of time, the results are more representative of average conditions than those obtained by the use of an instrument that collects instantaneous or grab samples.

41. Q. **What is a konimeter?**
A. It is a device by which a small sample of air, usually 5 cc., is drawn through a small nozzle and directed in the form of a jet onto a glass plate coated with vaseline or microscope jelly. By this means dust

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particles are deposited on the plate. With one design of konimeter the number of particles of dust are counted with a microscope directly attached to the instrument; with another type these samples are taken to the laboratory for counting with an ordinary microscope. The konimeter takes an instantaneous or grab sample rather than a continuous sample as taken by the impinger or electrical precipitator. It is a rapid method and requires very little sampling skill. For obtaining average dust concentrations over a period of time it is necessary to make a series of konimeter determinations and average the results.

42. **Q. What is an electrical precipitator?**

A. It's a device by which air is drawn at a definite rate of flow through a high voltage electrical field so arranged as to cause any dust to be removed and deposited on a foil or paper. The dust collected can be determined either by counting the number of particles with a microscope or by weighing. It is an efficient method but requires a source of electrical energy. As with the impinger, the electrical precipitator collects the dust continuously from a comparatively large volume of air and thus provides a sample that represents average conditions. It may even be used to collect a sample that is large enough for chemical analysis.

43. **Q. How can exposure be determined?**

A. Since exposure is a term that involves concentration, particle size, chemical composition, and duration of time, it is necessary to determine all of these in order to properly evaluate the degree and extent of exposure. The time element requires an accurate job analysis in which is recorded the amount of time spent by a workman at his various operations. This record should then be associated with the dust concentration, particle size, and chemical composition of the dust at each operation and the average over all daily exposure determined.

For Example:

Summary of Dust Exposure of Leyner Drillers in a Granite Quarry

Activity	Average exposure in millions of particles per cubic foot	Hours spent in each activity	Particle hrs. (millions per cubic foot)
Drilling	213.4	4	853.6
Changing drills	9.8	1	9.8
Watching drills	8.0	2	16.0
Broaching	6.0	¾	4.5
Blowing off holes	1085.0	¼	271.3
Total		8	1155.2

$$\frac{1155.2 \text{ particle hours in millions per cubic foot}}{8 \text{ hr.}} = 144.4 \text{ million particles per cubic foot. Average exposure throughout the day.}$$

Table from U. S. Public Health Bulletin 217 by Bloomfield and Dallavalle.

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44. **Q. What is a respirator?**

A. Any personal protective device designed to prevent the wearer from inhaling the harmful constituents in his surrounding atmosphere is called a respirator.

45. **Q. What is a supplied-air or air-line respirator?**

A. It is essentially a hose line through which air that is safe to breathe is conveyed to a facepiece worn by the workman. The air may be supplied from the compressed air line although preferably it should come from a separate blower unit designed to furnish air free from distasteful or harmful impurities.

46. **Q. What harmful or objectionable constituents might be present in high pressure air as produced by an ordinary reciprocating type of compressor?**

A. Air from this source may contain oil odors, mists of oil or water, particles of rust or dirt from the air receiver or air lines, and in case of improper compressor operation there may be burning of the lubricants with the formation of carbon monoxide.

47. **Q. What precautions should be taken to lessen the danger from air contamination in the use of reciprocating type of air compressors?**

A. Good maintenance and care in operation of the compressor, temperature indicators on the outlet side of compressor, and carbon monoxide detecting equipment or carbon monoxide alarms on the outlet side to give indication of the presence of any carbon monoxide. Individual compressor units so constructed as to make generation of harmful gases impossible are desirable sources of clean air for air-line respirators. The M.S.A. Clean Air Blower is designed to fill this need.

48. **Q. What is a chemical filter respirator?**

A. It is a respirator designed for removing gaseous constituents from the air breathed. The filtering materials in these respirators are usually granules that react with the harmful constituents and remove them.

49. **Q. What is a mechanical filter respirator?**

A. A mechanical filter respirator is a device that removes by mechanical filtration the particles of harmful constituents from air that passes through it. These devices include dust, mist, and fume respirators. Each of these types of mechanical filter respirators is designed to protect the wearer against the particular kind of matter to be dealt with.

50. **Q. What is a United States Bureau of Mines "approved" mechanical filter respirator?**

A. It is a respirator that has officially passed the rigid test requirements of the United States Bureau of Mines as outlined in that Bureau's Approval Schedule No. 21.

51. **Q. What is United States Bureau of Mines schedule No. 21?**

A. It is a publication that describes the requirements and tests that a respirator must meet in order to obtain the approval of the Bureau of

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Mines. Free copies of this publication may be obtained upon request from the United States Bureau of Mines, Washington, D. C.

52. Q. **For what types of mechanical filter respirators does the Bureau of Mines schedule No. 21 provide approval requirements?**

A. Schedule No. 21 provides approval requirements for mechanical filter respirators for protection against mechanically generated dusts (known as Type A respirator); fumes of various metals (Type B); and mists such as those from chromic acid and from spray coating in the absence of harmful vapors and gases (Type C). Combinations of these types may also be approved.

53. Q. **Who makes the approval tests?**

A. The Bureau of Mines makes the tests at its Pittsburgh Experiment Station where experienced personnel and complete laboratory facilities for dust investigations are available.

54. Q. **What are the general performance requirements that a mechanical filter dust respirator must give in order to obtain the approval of the Bureau of Mines?**

A. The general features of the performance requirements are:

1—Dust-tight fit of the facepiece.

2—Reduction of dust in the inhaled air below an amount that causes harm.

3—A resistance to breathing that is below that which produces discomfort.

4—A satisfactory degree of convenience, durability, and service.



Coal Miner wearing COMFO RESPIRATOR

SC 030770

55. Q. **What is the size of the dust particles used by the United States Bureau of Mines in the approval tests of respirators?**

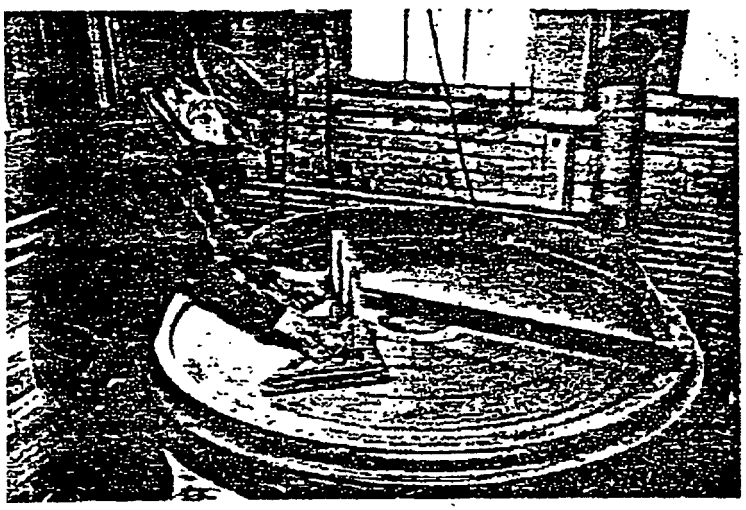
A. The dust particles used in the tests are 95% below 1.78 microns and 50% below 0.6 micron. These size characteristics are very similar to those found in the atmospheres of mines and industrial plants.

56. Q. **What severe dust filtering and resistance performance must a mechanical filter dust respirator give to pass the approval test?**

A. Air that contains fifty milligrams per cubic meter (approximately 300 to 500 million particles per cubic foot) of dust of the small size specified by the Bureau of Mines is drawn through the respirator at a rate of 32 liters a minute, or at approximately the rate at which air is breathed by an average man doing work. The total amount of dust that leaks through the respirator in a 90 minute test period during which 2.83 cubic meters or 100 cubic feet of air are passed must not exceed 3.0 milligrams or 0.0001 ounces. The resistance to inhalation when tested with air flowing through the respirator at 85 liters a minute must at no time exceed 2 inches of water column. This resistance is below that which causes discomfort.

57. Q. **Are the Bureau of Mines approval requirements unnecessarily exacting and impractical?**

A. No. The approval requirements in schedule No. 21 represent the minimum protection that a respirator should give in order to protect the wearer adequately.



M.S.A. Comfo Respirator used during grinding operations

SC 030771

58. **Q. What are the most important features of a respirator?**

A. 1—Adequate respiratory protection.
2—Comfort and convenience.
3—Ease and cost of maintenance.

59. **Q. What is the Comfo Respirator?**

A. It is a particular type of respirator manufactured by the Mine Safety Appliances Company that is approved by the U. S. Bureau of Mines. It was the first respirator to pass this Bureau's approval tests. It has filters of specially treated cellulose for removing the dusts of very small size that are present in industrial atmospheres. The filters are protected from damage or contamination by a metal covering and are attached to both sides of an all rubber facepiece. It has a large filtering area and low resistance to breathing.

60. **Q. How does the Comfo Respirator meet the requirements for adequate respiratory protection?**

A. The protection afforded by the Comfo Respirator is certified by the United States Bureau of Mines approval which it carries as a result of having successfully passed the approval tests against dusts of a particle size 95% of which are less than 1.78 microns and 50% less than 0.60 microns. This is the range of particle sizes usually found for mine and industrial dusts.

61. **Q. What is meant by the efficiency of a respirator; and what test facts concerning efficiency must be known to determine if a respirator gives adequate protection?**

A. The efficiency of a respirator is the percentage of the dust in the air that is retained on the filter. At least three very important facts should be known in order to determine if a respirator, that has a reported high efficiency, also gives adequate protection:

1—The dust concentration used in determining the efficiency figure.

2—That the particle size of the dust used in determining the efficiency represents the size of the dusts found in industrial atmospheres.

3—That the percentage inefficiency, or the amount of dust that leaks through, does not exceed that which is safe to breathe.

62. **Q. How does variation in particle size effect the reliability of an efficiency value of a respirator?**

A. The statement that a respirator is 98% efficient means little if the particle size range of the dust tested is not given because the difficulty in removing dust increases as the particle size decreases so that dusts below 1 to 2 microns are much more difficult to remove than the larger sizes, yet it is particles below 1 to 2 microns that predominate in industrial and mine atmospheres and produce the harmful effects. A respirator which would not effectively remove dust below 2 microns could be 98% efficient provided the test was made against concentrations that contain only a small amount of particles below 2 microns in size.

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63. Q. **How is the reliability of an efficiency value as a measure of dust protection affected by the concentration of dust in the air?**

A. A respirator may have high percentage efficiency and still leak enough dust through the filter to cause harm. For example, a respirator that is 97% efficient against a concentration of 500 million particles of dust per cubic foot of air (a not unusual case) would leak 15 million particles which is more than is considered a permissible amount of dust with a high silica content in the air breathed. The Bureau of Mines approval is given only to respirators that do not leak enough dust to bring the dust in the air breathed above permissible limits.

64. Q. **What is meant by comfort and convenience?**

A. The following factors are elements of comfort and convenience:

1—Resistance to breathing

2—Degree of impediment and encumbrance to vision and normal performance of work.

65. Q. **Should comfort and protection be considered separately?**

A. No. Any acceptable respirator must give both adequate protection and an acceptable degree of comfort.

66. Q. **How does the Comfo Respirator meet the comfort requirement?**

A. The comfort of the Comfo Respirator is assured by its low breathing resistance, light weight, and lack of encumbrance to the wearer's vision and movement.



M.S.A. Comfo Respirator worn by worker in ceramic plant

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67. **Q. What is meant by cost of maintenance?**

A. The cost of maintenance is the expense involved in keeping the respirator in an efficient, comfortable, and clean working condition. Low cost of replacement of filters is an important element in this expense.

68. **Q. How does the Comfo Respirator meet the low maintenance cost requirements?**

A. The low maintenance cost of the Comfo Respirator is given by the low cost of the replaceable filters and the short time required for replacement.

69. **Q. What is meant by ease of maintenance?**

A. By ease of maintenance is meant the ease with which a dust laden respirator can be restored to its initial high degree of efficiency and comfort through:

1—Servicing.

2—Replacement of filters.

3—Sterilization.

70. **Q. How does the Comfo Respirator meet this requirement for ease of maintenance?**

A. The low cost of Comfo Respirator filters permits discarding of the dust laden filter and replacement with new filters. This avoids the cleaning of filters and provides a new and clean filter with the initial high degree of protection and comfort.

71. **Q. How can respirators be sterilized?**

A. Scrub rubber and metal parts with soap and water. Rinse in warm water and immerse for 10 minutes in a solution of formalin made by placing one part of 40% formaldehyde solution into 9 parts of water. Instead of the formalin solution, 1 part of carbolic acid in 33 parts of water, or 1 part of Lysol in 50 parts of water, or 8 parts of denatured alcohol in 3 parts of water may be used.
All respirators should be thoroughly rinsed with water immediately after immersion in the sterilizing solution and put in a clean place to dry.

72. **Q. How does the Comfo Respirator permit easy and thorough sterilization and cleaning of all parts?**

A. Owing to the low cost of filters, these parts can be discarded and the entire remaining part of the respirator thoroughly washed and sterilized. After replacement of new filters the respirator is in its original clean and efficient condition. This permits daily sterilization of all parts and avoids the growth of bacteria and danger of contamination from parts that cannot be completely sterilized.

73. **Q. How does the Comfo Respirator meet the requirements of industries for respiratory protection?**

A. The Comfo Respirator is certified by the United States Bureau of Mines Approval as giving adequate respiratory protection; it is comfortable and convenient; it is easily maintained and the cost of filter replacement is low.

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Equipment for Protection from Dusts
Manufactured by
Mine Safety Appliances Company

M.S.A. COMFO RESPIRATOR



The M.S.A. Comfo Dust and Mist Respirator is a mechanical filter type respirator that was developed to protect workmen from breathing dust such as silica, coal, iron, asbestos, and other similar air carried particles of the very small sizes found in industrial atmospheres. It will also protect against the harmful liquid mist produced in chromium plating and the mist of vitreous enamels. This respirator has been officially approved by the U. S. Bureau of Mines, Approval No. 2101.

The M.S.A. Comfo Lead Dust Respirator is identical in design with the Dust and Mist Respirator except the cellulose filters are specially treated for filtering out lead dusts of small particle sizes. It is officially approved by the U. S. Bureau of Mines, Approval No. 2107.

M.S.A. AIR LINE RESPIRATOR



The M.S.A. Air Line Respirator provides protection from gases, vapors, dusts, and fumes by providing the wearer with an adequate supply of air for breathing requirements. Both the M.S.A. Air Line Respirator and the M.S.A. Abrasive Mask (shown later) have free-wheeling control valves to insure against accidental bumping and changing of air flow, and a quick release connection in case the air supply fails or becomes unusable for any reason.

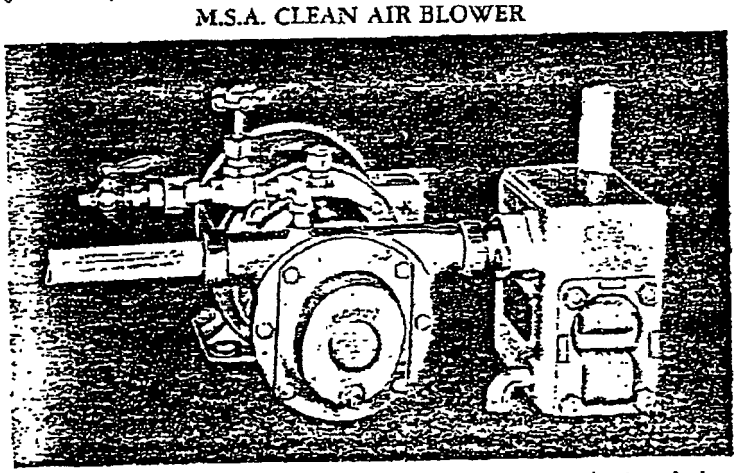
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M.S.A. ABRASIVE MASK



The M S A. Abrasive Mask is a light, comfortable, fresh air supplied unit designed for respiratory protection from the high concentrations of fine dust produced by abrasive blasting with sand or shot, and for protection of the head and shoulders from impact and abrasion by the high velocity rebounding particles. It gives protection from dusts, fumes, gases, and vapors.

M.S.A. CLEAN AIR BLOWER



The M.S A. Clean Air Blower is specially designed for supplying air that is cool, clean, humidified, and free from obnoxious or harmful gases to air line respirators, sand blast hoods, and helmets. It is a rotary type in which water is used as a compressor seal, cooling medium, humidifier, air washer, and dust remover. There is no internal lubrication and no contact of the air with oil, grease, or contaminating agents.

PRINTED IN U. S. A.

SC 030776

No. 6.

PERTINENT QUESTIONS and ANSWERS CONCERNING DUSTS

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Foreword

THERE is an increasingly wide and intense interest in harmful effects of breathing dusts, especially those that contain free silica and cause the disease of the lungs known as silicosis. Interest has been further stimulated by the work of Federal agencies and States in industrial hygiene, and by legislation that provides compensation for injury to health. As a result many persons in industry who are responsible for healthy working conditions have been confronted with the need of becoming acquainted with dust diseases, nature of dust, its composition, size of particles, and the amount that is harmful, and the means for preventing exposure and protecting workmen. Much has been said and published on these subjects, but it has been presented in terminology and language of a specialized, technical, and scientific nature that is either meaningless to most persons or creates a good deal of misunderstanding. Also, considerable confusion has arisen from the conflicting opinions and views that have been widely expressed.

In this booklet it is endeavored to present some of the questions that arise continually regarding the nature and effects of dusts, and to answer these questions in simple and insofar as possible non-technical language.

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Pertinent Questions and Answers Concerning Dusts

1. Q. **What are the usual classifications of air-carried particles?**
   A. Air-carried particles are usually classified into three groups:
   1—Dusts
   2—Fumes
   3—Mists

2. Q. **What are dusts?**
   A. Dusts are mechanically generated particles resulting from such operations as drilling, blasting, crushing, and handling of rocks and minerals; sand-blasting; stone and granite cutting; grinding and polishing; and all similar operations and processes. The greater percentage of particles of air carried dusts are below one micron in size with an average between 0.5-0.7 microns.

3. Q. **What is a micron?**
   A. A micron is a unit of measurement, one micron being equal to about 1/25,000 of an inch or in other words it would require 25,000 particles each one micron in size laid end to end to measure one inch.

4. Q. **What is the smallest particle that can be seen by the naked eye?**
   A. The smallest particle visible to a person with average eyesight is about 100 microns in dimension. This is 1/250 of an inch.

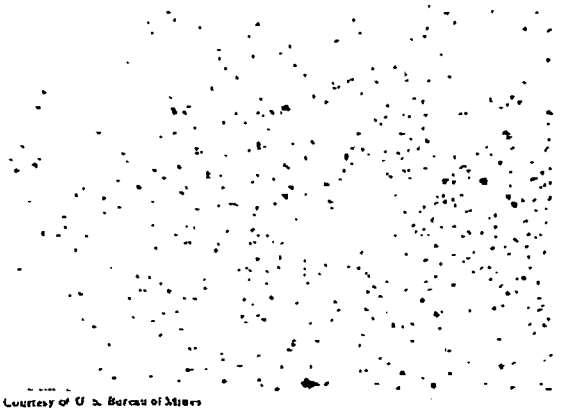
5. Q. **How does this compare with the size of the average particle found in air-born industrial dusts?**
   A. This is one hundred and fifty to two hundred times the size of the average particle found in industrial atmospheres. In other words, the particles of dust of significance from the standpoint of health are only a small fraction of the size that is visible to the naked eye.

6. Q. **What range of particle sizes is important?**
   A. The particles below 5 microns are of most importance as dusts of larger size settle out of the air very quickly and are not likely to be breathed. In general the particles of dust found in industry are below one or two microns with as much as 50% below 0.5 or 0.7 micron. Under some conditions the size may be larger or smaller than this general size range.

7. Q. **What are fumes?**
   A. Fumes are particles produced in chemical and metallurgical processes, welding, and similar operations, or by the decomposition of chemicals by heat and combustion. The average particle size is less than that of dusts. Most fumes have an average particle size of 0.2-0.3 microns. The important harmful fumes are usually the fumes of metals or their compounds such as lead oxide, zinc oxide, and cadmium oxide. Owing to their small particle size, fumes are even more difficult to remove by filters than are mechanically generated dusts.



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Courtesy of U. S. Bureau of Mines

10 7.5 5 3 2 1 .5

MICRONS

SILICEOUS DUST FROM MINE AIR

Magnified 100 times

The dust particles and dots shown in this illustration are magnified 100 times their actual size. If they were not magnified to this extent all of the particles and dots would be invisible. Even the largest or 10 micron size would be only one-tenth that which could be seen with the naked eye and the average particle would be less than one-hundredth the visible size. This illustrates that the smallest particle that can be seen with the naked eye is about 100 microns in dimension and that all air carried dust is invisible.

8. **Q. What are mists?**

   A. Mists are particles of liquids or mixtures of liquids and solids; in other words, wet particles. Their size depends upon the process by which they were generated. Good examples of mists are: the so-called "fogs" produced in spray coating with materials such as siliceous glazes or paints that contain lead, and the chromic acid mist produced during chromium plating.

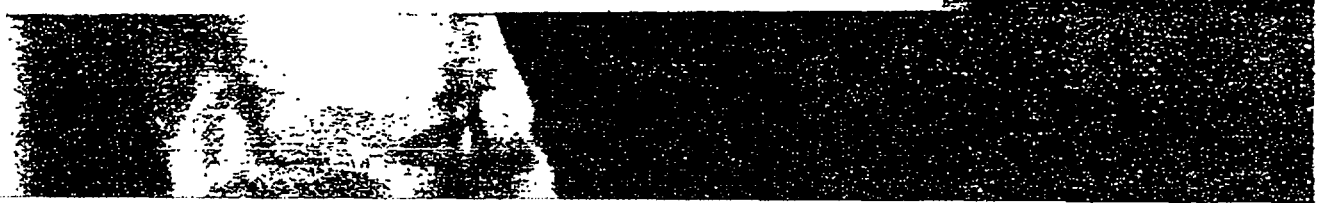
9. **Q. What dusts are dangerous?**

   A. The effect of many industrial dusts on health is not known as yet since the physiological reactions of most dusts do not appear for some years, and the use of many dust producing compounds is relatively new. Most authorities agree that most dusts are harmful in some degree if breathed in sufficient concentration over a period of time. The safe course is to eliminate all dust down to the limits that are considered good engineering practice in dust control.

10. **Q. How are dusts classified in relation to their effects on health?**

    A. Dusts are usually classified into three groups:

    1—Toxic or poisonous dusts.
    2—Nuisance dusts.
    3—Fibrosis-producing dusts.



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11. Q. **What is a toxic dust?**

A. A toxic dust is usually considered to be the dust of a poisonous material, such as lead and arsenic or their compounds, that produces injury to organs such as the circulatory system, heart, liver, kidneys, brain, and nervous system. When a poisonous dust is inhaled and deposited in the lungs, it dissolves and is carried by the blood to all organs and tissues. It may also be deposited in the mouth and throat by inhalation or contamination with dirty hands, and later swallowed and enters the body through the digestive tract.

12. Q. **What is a nuisance dust?**

A. A nuisance dust is one that is often associated with an increase in respiratory diseases (such as, colds in the head, bronchitis, pneumonia, and tuberculosis). Many such dusts are discomforting and irritating to the worker and may be harmful. They do not produce toxic effects or form fibrous tissue in the lungs.

13. Q. **What is a fibrosis-producing dust?**

A. It is one that through its action in the lungs causes a disease of the normal lung tissue and a replacement of this vital tissue with fibrous (scar) tissue.

14. Q. **What is pneumoconiosis?**

A. It is a term applied to any lung disease arising from inhalation of dust.

15. Q. **What is silicosis?**

A. It is a disease of the lungs in which the normal lung tissue is replaced by fibrous (scar) tissue due to breathing air that contains free silica dust (silicon dioxide, SiO_2).

16. Q. **Can silicosis be produced by any substance other than free silica?**

A. Silicosis is a specific disease caused only by breathing free silica. However, there are indications that the presence of other kinds of dust and gases may influence the effect of silica in the lung.

17. Q. **What is miners' pthisis?**

A. It is a term used frequently to designate a condition of silicosis complicated by the presence of tuberculosis.

18. Q. **What is anthraco-silicosis (miner's asthma)?**

A. It is a chronic disease of the lungs in which the normal lung tissue is replaced by scar tissue caused by breathing excessive amounts of a mixture of silica dust along with coal dust.

19. Q. **What is asbestosis?**

A. It is a disease of the lungs in which the normal lung tissue is replaced by fibrous (scar) tissue due to breathing air that contains asbestos dust.

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20. **Q. What are the principal factors in determining the health hazard from air-carried dust?**

A. The following factors are usually important:

1—Chemical composition of the dust.

2—Amount of dust in the air.

3—Size of the dust particles.

4—Length of time of exposure.

21. **Q. What is meant by chemical composition of a dust?**

A. All materials such as rocks and minerals are not what might be termed pure chemical compounds, but are mixtures of several chemical compounds. The chemical composition is the kind and amounts of these various components. In the case of silica-bearing substances, the amount of silica present may vary from almost nothing to 100%. The amount of free silica present is obviously the important factor in the silicosis producing properties of a dust.

22. **Q. Is the chemical composition of the dust in the air the same as the substance that is being drilled, handled, crushed, or processed?**

A. As most dust producing substances dealt with in industry contain more than one mineral component, some of these components will crush or disintegrate more easily than others and thereby form a larger proportion of small particles. These smaller particles will tend to predominate in the air while other constituents being larger will settle out. For this reason, the composition of the dust in the air may vary greatly from the composition of the rock or mineral.

23. **Q. What is the importance of the chemical composition of a dust?**

A. The chemical composition reveals the harmful constituents and their amount, and constitutes the basis for judging the harmful qualities of the dust. This information is an important factor along with concentration and time of exposure in determining the hazard.

24. **Q. What are the important steps in determining the chemical composition of a dust?**

A. It is necessary to first obtain a sample that represents the dust in the air breathed, and then subject the sample to methods of analysis that are known to give accurate results for the constituents desired.

25. **Q. How can a representative sample of the dust in the air breathed be obtained?**

A. It can be obtained only by collecting the dust from the air. Samples of pieces of rock or settled dust do not necessarily bear any close relation in composition to the dust floating in the air.

26. **Q. How can a sample of sufficient size for chemical analysis be collected from the air?**

A. Collection from the air can be accomplished with dust collection devices such as the impinger, electrostatic precipitator or filter type of collectors.

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27. **Q. What methods are generally used for determination of the percent of free silica in dusts?**

A. 1—By observing the action of the small dust particles on light with the aid of a special type of microscope. This is known as the petrographic method.

2—By chemical analysis.

3—By observing the action of the particles on X-Rays.

28. **Q. What are the limitations of the petrographic method?**

A. It is impossible by this method to examine individual particles below one or two microns in size and since most of the air-carried dust is below this size range, one must rely on petrographic information obtained from particle sizes that are above those of primary significance.

29. **Q. What are the limitations of the chemical method?**

A. There is no known chemical method that is specific for free silica (SiO_2) when this constituent is present with silicates. However, by observing the difference in the rate at which silica dissolves in certain acids as compared with other constituents a rough estimate can be obtained for some dusts, but with others the method will be greatly in error.

30. **Q. What are the limitations of the X-Ray method?**

A. The X-Ray procedure can be used for making specific determinations of free silica in a very small sample such as 25 to 50 milligrams. The disadvantage of the method is that it requires very expensive apparatus.

31. **Q. What is meant by size of particle; how is it expressed?**

A. The size of the particle is its largest dimension, usually expressed in microns. It has been stated by authorities that if all dust below one micron in size could be eliminated, nearly all dust disease would be eliminated.

32. **Q. How can the size of dust particles be determined?**

A. The size of dust particles is measured by means of a microscope or by projection of the dust particles on a screen similar in general principle to ordinary lantern slide projection. The particles as seen in the microscope or projected are then measured.

33. **Q. How quickly does fine dust settle?**

A. It settles very slowly. In the table given below will be found the time in minutes estimated for silica dust of given sizes to fall one foot in still air.

Size in microns	Time in minutes to fall one foot
¼	590
½	187.
1	54.
2	14.4
5	2.5

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34. Q. **Does absence of visible dust mean absence of fine dust?**

A. No. The operation may produce only fine dust or the visible dust may have disappeared owing to its rapid rate of settling, leaving the invisible but harmful dust in the air.

35. Q. **What is meant by dust concentration: how is it expressed?**

A. The concentration is the amount of dust suspended in a given volume of air. It is usually expressed in number of particles in a cubic foot of air, or millions of particles in a cubic meter of air, or in a cubic centimeter. It may also be expressed as the weight of dust in a given volume of air as milligrams in a cubic meter or grains in a cubic foot.

36. Q. **What is the relation among these units of quantity?**

A. Number of cubic feet times .02832 gives number of cubic meters (m^3)
Number of cubic meters times 35.31 gives number of cubic feet.
Number of cubic feet times 28,317 gives number of cubic centimeters (cc.)
Number of milligrams times .001 gives number of grams.
Number of grains times 64.80 gives number of milligrams.
Number of grains times .00229 gives ounces (avoirdupois)

37. Q. **How can the concentration in particles per cubic centimeter be converted to number of particles per cubic foot?**

A. Multiply the number of particles per cubic centimeter by a million and divide by 35.31 to get number of particles per cubic foot.

38. Q. **How many particles of air-carried dust are in one milligram weight of dust?**

A. It has been found that one milligram of silica dust of the size range present in industrial atmospheres contains about 200 to 300 million particles.

39. Q. **What apparatus and methods are generally used for determining dust concentrations?**

A. The impinger and electrostatic precipitator are the instruments generally used for this purpose. Details of the instruments and methods can be found in publications of the United States Bureau of Mines and the United States Public Health Service.

40. Q. **What is an impinger?**

A. It is a device by which air is drawn at a definite rate of flow and at high velocity through a small nozzle so directed as to strike the bottom of a glass flask which is partially filled with a liquid such as water, alcohol, or a mixture of these liquids. This high velocity action causes the dust particles to be "wetted" and retained in the liquid. Some of this liquid is then examined under a microscope and a count of the dust particles present is made.

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41. **Q. What is an electrostatic precipitator?**

A. It's a device by which air is drawn at a definite rate of flow through a high voltage electrical field so arranged as to cause any dust to be removed and deposited in a sampling tube. The dust collected can be determined either by counting the number of particles with a microscope or by weighing. It is an efficient method but requires a source of electrical energy. As with the impinger, the electrostatic precipitator collects the dust continuously from a comparatively large volume of air and thus provides a sample that represents average conditions. It may even be used to collect a sample that is large enough for chemical analysis.

42. **Q. How can exposure be determined?**

A. Since exposure is a term that involves concentration, particle size, chemical composition, and duration of time, it is necessary to determine all of these in order to properly evaluate the degree and extent of exposure. The time element requires an accurate job analysis in which is recorded the amount of time spent by a workman at his various operations. This record should, then be associated with the dust concentration, particle size, and chemical composition of the dust at each operation and the average over all daily exposure determined.

For Example:

Summary of Dust Exposure of Leyner Drillers in a Granite Quarry

Activity	Average exposure in millions of particles per cubic foot.	Hours spent in each activity	Particle hrs. (millions per cubic foot)
Drilling	213.4	4	853.6
Changing drills	9.8	1	9.8
Watching drills	8.0	2	16.0
Broaching	6.0	¾	4.5
Blowing off holes	1085.0	¼	271.3
Total		8	1155.2

1155.2 particle hours in millions per cubic foot / 8 hr. = 144.4 million particles per cubic foot. Average exposure throughout the day.

Table from U. S. Public Health Bulletin 217 by Bloomfield and Dallavalle

43. **Q. What is a respirator?**

A. Any personal protective device designed to prevent the wearer from inhaling the harmful constituents in his surrounding atmosphere is called a respirator.

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44. **Q. How are the various types of respirators usually classified?**

A. Respirators are classified as follows:

1. Air-supplied respirators.
2. Chemical filter respirators
3. Mechanical filter respirators.

45. **Q. What is a supplied-air or air-line respirator?**

A. It is essentially a hose line through which air that is safe to breathe is conveyed to a facepiece worn by the workman. Air-line respirators are approved by the United States Bureau of Mines under schedule No. 19. The air may be supplied from the compressed air line although preferably it should come from a separate blower unit designed to furnish air free from distasteful or harmful impurities.

46. **Q. What harmful or objectionable constituents might be present in high pressure air as produced by an ordinary reciprocating type of compressor?**

A. Air from this source may contain oil odors, mists of oil or water, particles of rust or dirt from the air receiver or air lines, and in case of improper compressor operation there may be burning of the lubricants with the formation of carbon monoxide.

47. **Q. What precautions should be taken to lessen the danger from air contamination in the use of reciprocating type of air compressors?**

A. Good maintenance and care in operation of the compressor, temperature indicators on the outlet side of compressor, and carbon monoxide detecting equipment or carbon monoxide alarms on the outlet side to give indication of the presence of any carbon monoxide. Individual compressor units so constructed as to make generation of harmful gases impossible are desirable sources of clean air for air-line respirators.

48. **Q. What is an abrasive mask?**

A. An abrasive mask is essentially an air line respirator with a special hood for protection against high velocity particles in sand or shot blasting operations.

49. **Q. What is a chemical filter respirator?**

A. It is a respirator designed for removing gaseous constituents from the air breathed. The filtering materials in these respirators are usually granules that react with the harmful constituents and remove them. Chemical filter respirators are approved against light concentrations of organic vapors under U. S. Bureau of Mines schedule No. 23.

50. **Q. What is a mechanical filter respirator?**

A. A mechanical filter respirator is a device that removes by mechanical filtration the particles of harmful constituents from air that passes through it. These devices include dust, mist, and fume respirators. Each of these types of mechanical filter respirators is designed to protect the wearer against the particular kind of matter to be dealt with.

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51. Q. **What is a United States Bureau of Mines "approved" mechanical filter respirator?**

A. It is a respirator that has officially passed the rigid test requirements of the United States Bureau of Mines as outlined in that Bureau's Approval Schedule No. 21.

52. Q. **What are United States Bureau of Mines schedules No. 19, 21 and 23?**

A. They are publications that describe the requirements and tests that respirators must meet in order to obtain the approval of the Bureau of Mines. Free copies of these publications may be obtained upon request from the United States Bureau of Mines, Washington, D. C

53. Q. **Who makes the approval tests?**

A. The Bureau of Mines makes the tests at its Pittsburgh Experiment Station where experienced personnel and complete laboratory facilities for dust investigations are available.

54. Q. **For what types of mechanical filter respirators does the Bureau of Mines schedule No. 21 provide approval requirements?**

A. Schedule No. 21 provides approval requirements for mechanical filter respirators for protection against mechanically generated dusts; fumes of various metals, and mists such as those from chromic acid and from spray coating in the absence of harmful vapors and gases. Combinations of these types may also be approved.

55. Q. **What are the general performance requirements that a mechanical filter dust respirator must give in order to obtain the approval of the Bureau of Mines?**

A. The general features of the performance requirements are:

1—Dust-tight fit of the facepiece.

2—Reduction of dust in the inhaled air below an amount that causes harm.

3—A resistance to breathing that is below that which produces discomfort.

4—A satisfactory degree of convenience, durability, and service.

56. Q. **What is the size of the dust particles used by the United States Bureau of Mines in the approval tests of mechanical filter respirators?**

A. The dust particles used in the tests are 95% below 1.78 microns and 50% below 0.6 micron. These size characteristics are very similar to those found in the atmospheres of mines and industrial plants.

57. Q. **What severe dust filtering and resistance performance must a mechanical filter dust respirator give to pass the approval test?**

A. Air that contains fifty milligrams per cubic meter (approximately 300 to 500 million particles per cubic foot) of dust of the small size

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specified by the Bureau of Mines is drawn through the respirator at a rate of 32 liters a minute, or at approximately the rate at which air is breathed by an average man doing work. The total amount of dust that leaks through the respirator in a 90 minute test period during which 2.88 cubic meters or 100 cubic feet of air are passed must not exceed 3.0 milligrams or 0.0001 ounces. The resistance to inhalation when tested with air flowing through the respirator at 85 liters a minute must at no time exceed 2 inches of water column. This resistance is below that which causes discomfort.

58. **Q. Are the Bureau of Mines approval requirements unnecessarily exacting and impractical?**

A. No The approval requirements represent the minimum protection that a respirator should give in order to protect the wearer adequately

59. **Q. What are the most important features of a respirator?**

A. 1—Adequate respiratory protection

2—Comfort and convenience.

3—Ease and cost of maintenance.

60. **Q. What is meant by the efficiency of a respirator; and what test facts concerning efficiency must be known to determine if a respirator gives adequate protection?**

A. The efficiency of a respirator is the percentage of the dust in the air that is retained on the filter. At least three very important facts should be known in order to determine if a respirator, that has a reported high efficiency, also gives adequate protection:

1—The dust concentration used in determining the efficiency figure.

2—That the particle size of the dust used in determining the efficiency represents the size of the dusts found in industrial atmospheres

3—That the percentage inefficiency, or the amount of dust that leaks through, does not exceed that which is safe to breathe

61. **Q. How does variation in particle size effect the reliability of an efficiency value of a respirator?**

A. The statement that a respirator is 98% efficient means little if the particle size range of the dust tested is not given because the difficulty in removing dust increases as the particle size decreases so that dusts below 1 to 2 microns are much more difficult to remove than the larger sizes, yet it is particles below 1 to 2 microns that predominate in industrial and mine atmospheres and produce the harmful effects A respirator which would not effectively remove dust below 2 microns could be 98% efficient provided the test was made against concentrations that contain only a small amount of particles below 2 microns in size.

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62. Q. **How is the reliability of an efficiency value as a measure of dust protection affected by the concentration of dust in the air?**

A. A respirator may have high percentage efficiency and still leak enough dust through the filter to cause harm. For example, a respirator that is 97% efficient against a concentration of 500 million particles of dust per cubic foot of air (a not unusual case) would leak 15 million particles which is more than is considered a permissible amount of dust with a high silica content in the air breathed. The Bureau of Mines approval is given only to respirators that do not leak enough dust to bring the dust in the air breathed above permissible limits.

63. Q. **What is meant by comfort and convenience?**

A. The following factors are elements of comfort and convenience:

1—Resistance to breathing.

2—Degree of impediment and encumbrance to vision and normal performance of work.

64. Q. **Should comfort and protection be considered separately?**

A. No. Any acceptable respirator must give both adequate protection and an acceptable degree of comfort.

65. Q. **What is meant by cost of maintenance?**

A. The cost of maintenance is the expense involved in keeping the respirator in an efficient, comfortable, and clean working condition. Low cost of replacement of filters is an important element in this expense.

66. Q. **What is meant by ease of maintenance?**

A. By ease of maintenance is meant the ease with which a dust laden respirator can be restored to its initial high degree of efficiency and comfort through:

1—Servicing.

2—Replacement of filters.

3—Sterilization.

67. Q. **How can respirators be sterilized?**

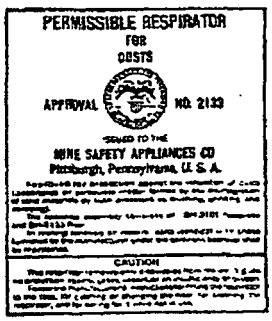
A. Scrub rubber and metal parts with soap and water. Rinse in warm water and immerse for 10 minutes in a solution of formalin made by placing one part of 40% formaldehyde solution into 9 parts of water. Instead of the formalin solution, 1 part of carbolic acid in 33 parts of water, or 1 part of Lysol in 50 parts of water, or 8 parts of denatured alcohol in 3 parts of water may be used.

All respirators should be thoroughly rinsed with water immediately after immersion in the sterilizing solution and put in a clean place to dry.

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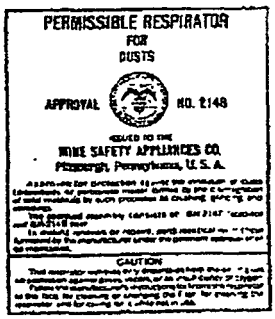
Mechanical Filter Respirators
For Protection from Dusts, Mists and Fumes
Manufactured by
Mine Safety Appliances Company





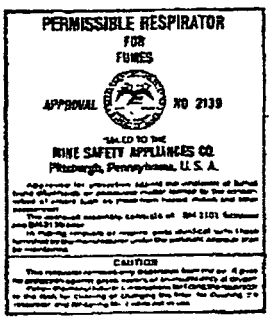
M.S.A. "COMFO" DUST RESPIRATOR With "Comfo" Cushion Facepiece



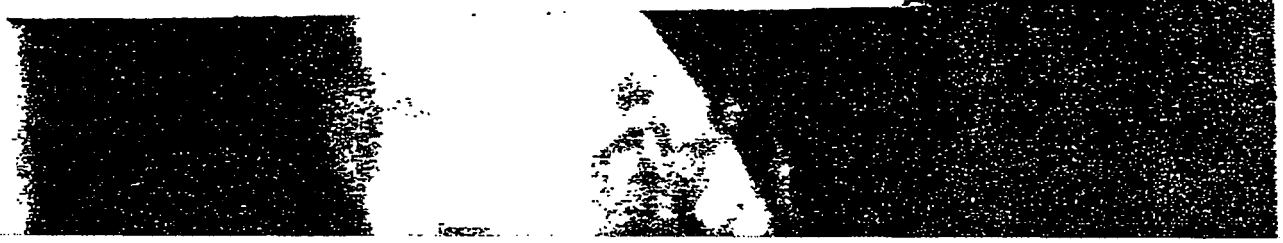


M.S.A. "CLEAR-VUE" DUSTFOE RESPIRATOR





M.S.A. "COMFO" METAL FUME RESPIRATOR



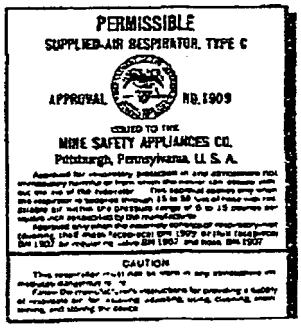
SC 030790

Air Line Respirator Equipment

Manufactured by

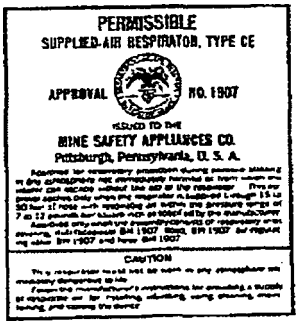
Mine Safety Appliances Company





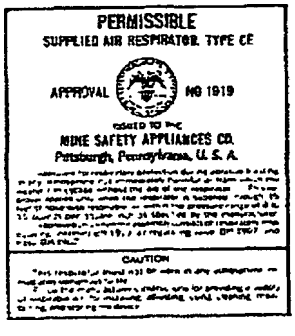
M.S.A. AIR LINE RESPIRATOR With "Comfo" Cushion Facepiece





M.S.A. ABRASIVE MASK





M.S.A. "BLASTFOE" ABRASIVE HELMET

SC 030791

Air Sampling Equipment for Dusts, Mists and Fumes

Manufactured by

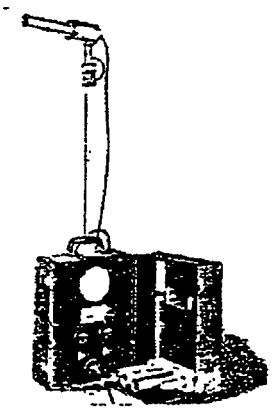
Mine Safety Appliances Company



M.S.A. MIDGET IMPINGER

The M.S.A. Midget Impinger samples at a rate of one-tenth of a cubic foot per minute and is operated by a hand cranked, positive-acting 4 cylinder pump of ingenious design. This pump, in conjunction with a vacuum regulator, maintains an unfluctuating suction regardless of minor variations in the rate or smoothness of cranking. The apparatus is contained in a compact, sturdy carrying case complete with nine calibrated glass sampling tubes.

The light weight, small dimensions, and almost effortless operation of this modern instrument greatly broaden the field of dust sampling by the impinger method. Isolated locations, confined spaces, lack of electric current or compressed air presents no barriers to the M.S.A. Midget Impinger.



M.S.A. ELECTROSTATIC
Dust and Fume Sampler

This instrument, designed for quantitative sampling of dust, fume, and mist, employs the principle of preionization with electrostatic precipitation. The unit is compact and easy to use for sampling from the general atmosphere or from stacks or ducts. It is the only efficient sampler for fumes, particularly lead fumes.

Other features are large sampling volume of 2 cu. ft. per minute permitting accurate determinations of very low concentrations of atmospheric particulate matter; flow measurement with orifice and mechanical manometer —no liquids to spill; extension tube for sampling at breathing level with apparatus on the floor; and collection of samples in a special aluminum tube permitting determinations by weight, count or chemical analysis.

This precipitator operates on 110-120 volts, 60 cycle, alternating current. Case dimensions are 16 x 11¼ x 10¼ inches.

Printed in U.S.A.

SC 030792

Castleman File on: MSA Doc # 17

wc = with cover letter or memo If DATE = 0, undated

DATE = 1944

__ article __ adv ___ abstract __ letter to editor from:

__ peer reviewed journal __ trade journal
__ newspaper ___ magazine __ company journal

__ published __ conference __ presentation __ report

__ Federal Fegister notice __ NSC Transactions

__ unpublished report __ of asbestos inspection

__ government __ inspection __ report __ hearing

__ book ___ excerpt ___ chapter __ testimony

__ letter __ memo __ notes of __ call __ meeting

__ warning labels __ patent __ sales data

__ sales literature __ recommended practices

meeting ___agenda ___ minutes __attendees

legal __ affidavit __ depo OR __ testimony of _____

legal _____

__ Notes of ___ BC or _____

__ Other _____

Castleman File on: ~~OIL / API~~ MSA Doc # 18

wc = with cover letter or memo If DATE = 0, undated

DATE = 0

__ article __ adv ___ abstract __ letter to editor from:

__ peer reviewed journal __ trade journal
__ newspaper ___ magazine __ company journal

__ published __ conference __ presentation __ report

__ Federal Fegister notice __ NSC Transactions

__ unpublished report __ of asbestos inspection

__ government __ inspection __ report __ hearing

__ book ___ excerpt ___ chapter __ testimony

__ letter __ memo __ notes of __ call __ meeting

__ warning labels __ patent __ sales data

__ sales literature __ recommended practices

meeting ___agenda ___ minutes __attendees

legal __ affidavit __ depo OR __ testimony of _____

legal _____

__ Notes of ___ BC or _____

__ V Other Cost of technical proc 55
latest is from 1951

Castleman File on: ~~OIL PAPI~~ MSA Doc # 19

wc = with cover letter or memo If DATE = 0, undated

DATE = 0

__ article __ adv ___ abstract __ letter to editor from:

__ peer reviewed journal __ trade journal
__ newspaper ___ magazine __ company journal

__ published __ conference __ presentation __ report

__ Federal Fegister notice __ NSC Transactions

__ unpublished report __ of asbestos inspection

__ government __ inspection __ report __ hearing

__ book ___ excerpt ___ chapter __ testimony Pertinent Q&A Concerning Dusts

__ letter __ memo __ notes of __ call __ meeting

__ warning labels __ patent __ sales data

__ sales literature __ recommended practices

meeting ___agenda ___ minutes __attendees

legal __ affidavit __ depo OR __ testimony of _____

legal _____

__ Notes of ___ BC or _____

__ Other _____

Castleman File on: ~~ON / APT~~ MSA Doc # 20

wc = with cover letter or memo If DATE = 0, undated

DATE = 2006

__ article __ adv ___ abstract __ letter to editor from:

__ peer reviewed journal __ trade journal
__ newspaper ___ magazine __ company journal

__ published __ conference __ presentation __ report

__ Federal Fegister notice __ NSC Transactions

__ unpublished report __ of asbestos inspection

__ government __ inspection __ report __ hearing

__ book ___ excerpt ___ chapter __ testimony

__ letter __ memo __ notes of __ call __ meeting

__ warning labels __ patent __ sales data

__ sales literature __ recommended practices

meeting ___agenda ___ minutes __attendees

legal __ affidavit ✓ depo OR __ testimony of Seibel

legal _____

__ Notes of ___ BC or _____

__ Other _____