MSHA Handbook Series
Transmittal Sheet

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

Subject	Handbook Number	Release Number
Metal Nonmetal Health Inspection Procedures Handbook	PH06-IV-1(1)	Appendix 21D-7 Release 2 Chapter 22, Page 8

1. Explanation of Material Transmitted

This handbook provides guidance to MSHA inspectors in conducting sampling and monitoring procedures. It is intended articulate the Mine Safety and Health Administration's policy of what to sample, how to sample, how to use and maintain instruments, how to request laboratory analysis and how to keep adequate records of exposure assessment.

2. Action Required

1. MNM requests an addition of two new contaminant codes to be listed on Page 7 of Appendix 21D.

Remove the Page 7 currently in the handbook and replace it with the revised page 7.

2. MNM requests a revision of the existing final paragraph on Page 8 of Chapter 22.

Remove the Chapter 22, Page 8 currently in the handbook and replace it with the revised page 8.

3. Audience

All PPM Holders

Felix Quintana *02/22/07*

4. Approval Authority Date

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MSHA Handbook Series

U.S. Department of Labor
Mine Safety and Health Administration
Metal and Nonmetal Mine Safety and Health
October 2006

Handbook Number PH06-IV-1(1)

METAL AND NONMETAL HEALTH INSPECTION PROCEDURES

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PREFACE

This handbook sets forth procedures regarding health sampling and processing at mines inspected by the Mine Safety and Health Administration (MSHA). Express approval of the Administrator for Metal and Nonmetal Mine Safety and Health is needed to authorize any modifications to this manual. The procedures in this handbook replace previously issued directives on this subject. Compliance related instructions in the MSHA Program Policy Manual remain in effect.

Felix A. Quintana
Acting Administrator for
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INTRODUCTION TO HEALTH MANUAL

This handbook provides information and guidance needed to conduct an effective health inspection in accordance with the Federal Mine Safety and Health Act of 1977 (Mine Act).

Industrial hygiene involves the anticipation, recognition, evaluation, and control of health hazards in the work environment. When conducting the health portion of the mine inspection, inspectors should:

- identify potential hazards by examining mining operations, milling processes, and associated support functions (shop, laboratory, etc.), and observing the tasks performed by miners;
- evaluate the miners' exposures by conducting sampling, requesting analyses when appropriate, and interpreting results;
- evaluate the effectiveness of engineering and administrative controls, and of personal protective equipment programs;
- offer general advice regarding hazard-control measures or techniques to prevent miners' overexposure, although it is ultimately the mine operator’s responsibility to control exposures;
- provide assistance to management and labor in the recognition and control of work-place health hazards; and
- issue citations and orders following the policy and guidelines outlined in the Program Policy Manual (PPM).

A. **Authority**. This Health Inspection Procedures Handbook is derived from the Federal Mine Safety and Health Act of 1977, the subsequent regulations at 30 CFR Parts 56, 57, 58 and 62 (in particular Subpart D of Parts 56 and 57), and the Mine Safety and Health Administration (MSHA) directives system set forth in the Administration Policy and Procedures Manual (APPM), Volume II, Chapter 100.

B. **Purpose**. This Health Inspection Procedures Handbook establishes procedures for conducting the health portion of Metal/Nonmetal mine inspections.

C. **Responsibility**. Inspectors are required to follow these procedures unless specifically directed otherwise. Individual mine environments may warrant slight variations in procedures. In these cases, appropriate actions should be determined through consultations with the District Office, Metal and Nonmetal Health Division, and/or MSHA Technical Support. The Metal and Nonmetal Health Division is responsible for the contents of this handbook and subsequent updates.

D. **Directives Affected**. This handbook contains procedural instructions consistent with the Program Policy Manual and replaces the previous version (Metal and Nonmetal Health Inspection Procedures - MSHA Handbook Series No. PH90-IV-4).

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CHAPTER 1
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Chapter 1
BASICS OF INDUSTRIAL HYGIENE

I. Industrial Hygiene

Industrial Hygiene is the science and art of recognizing, evaluating, and controlling occupational health hazards. It uses scientific principles to evaluate the adverse effects of **chemical, physical and biological agents, and ergonomic stresses** on the body. That is, can these hazards injure or impair the health of miners?

II. Types of Health Hazards

A. **Chemical Hazards** - Chemicals may enter the body and poison or otherwise injure the body's organs or tissues. (This chapter includes an overview of chemical hazards and potential health effects. More information about certain topics can be found in Chapter 19 – Chemical Storage and Use.)

- **Organic chemicals** - are chemicals that have at least one carbon atom bonded to a hydrogen atom. Such chemicals are called hydrocarbons. The name "organic" was derived from chemicals like petroleum that are the result of decomposed organisms. This term does not mean "all natural." In fact, most known organic chemicals are man-made (plastics, solvents, pesticides, etc.). Organic chemicals may be very toxic. They are readily absorbed into the bloodstream through the skin and the eyes, and through the lungs and digestive system.

- **Inorganic chemicals** - are any chemicals that are not organic. That is, they do not have any carbon atoms bonded to a hydrogen atom. Water and many minerals are inorganic.

The permissible exposure levels for many of these chemicals are listed in the ***TLVs® Threshold Limit Values for Chemical Substances in Workroom Air Adopted by the ACGIH for 1973***. This is an important document for compliance determinations. It was published by the American Conference of Governmental Industrial Hygienists and has been incorporated by reference into MSHA health standards for metal and nonmetal mines at 30 CFR Parts 56/57.5001. The hazard represented by these chemicals or hazardous materials depends on many factors (*e.g.*, concentration, type, and length of exposure).

The ***NIOSH Pocket Guide to Chemical Hazards***[1] can be a helpful tool for MSHA inspectors in determining the toxicity of a substance. ***Material Safety Data Sheets (MSDS)*** are another resource for similar information.

1. **Asphyxiants** - suffocate by preventing the body from getting oxygen.

   - **Simple asphyxiants** - displace the oxygen in the environment Examples are carbon dioxide, methane, nitrogen and nitrous oxide.

   - **Chemical asphyxiants –** combine with hemoglobin to reduce the blood's capacity to transport oxygen, thereby preventing oxygen uptake at the cellular level. An example is carbon monoxide.

2. **Corrosives** - chemicals (very strong acids or caustics/alkalies) that causes visible destruction or permanent changes in tissue at the point of contact. Acidity or alkalinity of chemicals is measured on the **pH scale**, which ranges from 0.0 to 14.0, with 7.0 being neutral.

   a. **Acids** - pH lower than 7.0. The pH of corrosive acids is 0 to 2. Examples are battery and some laboratory acids.
   b. **Pure water** - pH of 7.0
   c. **Caustics or Alkalis** - pH higher than 7.0. The pH of corrosive caustics/alkalies is 12 to 14. Examples are drain cleaners and lye.

3. **Irritants** - a chemical that is non-corrosive, and causes reversible damage or inflammation in or on the body. An example is portland cement.

4. **Solvents –** substances that dissolve another material. Some solvents can damage fatty tissue and organs like the brain and central nervous system (CNS), liver, kidneys and bone marrow. Examples are water, acetone and paint thinners.

5. **Carcinogens** - cause cancer. Examples are asbestos, radon, some metals, and some solvents.

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[1] The ***NIOSH Pocket Guide to Chemical Hazards*** contains an index of synonyms for the most common chemicals in the workplace, information on the health effects of toxic chemicals, chemical incompatibilities, and required personal protective equipment (PPE).

6. **Organ toxins** – damage specific body organs (called **Target Organs)**, including the liver (hepatoxins), the kidneys (nephrotoxins) or the brain/central nervous system/nerve cells (neurotoxins). Examples are many solvents.

7. **Systemics** - substances that spread throughout the body, poisoning multiple body organs and systems. Examples include some solvents and heavy metals.

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8. **Sensitizers** (also called "allergenics") – some chemicals are skin sensitizers (causing an inflammation called "dermatitis"), while others are lung sensitizers (which may cause an "asthma-like" reaction). Still other chemicals may affect both the skin <u>and</u> lungs. Persons may respond to a sensitizer during their initial exposure, with respiratory tract irritation or bronchoconstriction, or they may experience little or no reaction during first exposure, but a small amount or concentration of the chemical during a subsequent exposure may elicit a dramatic reaction. Cross-reactivity may occur in some individuals, *i.e.* a sensitized person may react to other chemicals. Complete avoidance of certain chemicals may be necessary (*i.e.*, no occupational or non-occupational exposure).

9. **Reproductive Toxins, Teratogens and Mutagens -** cause sterility, birth defects, or mutations of future generations.

10. **Contaminants** - In Mine Safety and Health Administration (MSHA) standards, chemical health hazards are frequently called **contaminants**. Contaminants found in mining facilities occur naturally, as part of an ore body (such as silica, lead, etc.), or are man-made (such as processing chemicals or solvents). These contaminants are released into the environment through various mining and processing activities. They may be found as various **States of Matter**:

    a. **Aerosols** - are solid <u>or</u> liquid particles suspended in air or in another gas.

        1. **Dusts** are solid particles produced by drilling, crushing, grinding, chipping, or cutting.

            - **Respirable dusts** are particles suspended in the air with a size of less than 10 microns in diameter.

These dusts can penetrate to the deepest areas of the lungs. Examples are silica, coal, and metal ore dust.

- **Total dust** refers to airborne particles of any size that are suspended in air. Some total dusts can be toxic when inhaled. Examples are lead and uranium. Other total dusts are classified as "nuisance dusts." These are defined as those dusts listed in Appendix E of the ***TLVs*** $^{®}$ ***Threshold Limit Values for Chemical Substances in Workroom Air Adopted by the ACGIH for 1973***. They may cause toxic effects when inhaled in large quantities.

b. **Fumes** are microscopic particles formed when metal is melted and vaporizes (such as during welding, torch cutting, or smelting). When the heated metal vapor condenses, it forms a chemical compound of the metal and oxygen, called an oxide. Metal oxide fumes can be inhaled and may cause damage to various internal organs.

c. **Mists** are microscopic liquid droplets formed by splashing, foaming, or spraying. They are easily breathed, and some can be absorbed by the skin and the eyes. Acid mists can damage the lungs and skin. Examples are paint sprays and oil mists.

2. **Gases** are formless at room temperature and fill the shape of the space they are in. Under very high pressure or low temperature they change to liquids or solids. Gases are easily breathed and some are readily absorbed by the eyes. Examples are carbon dioxide or oxygen.

a. **Vapors** are gases that under ordinary conditions are liquids or solids. They can be easily breathed and absorbed by the eyes. Some organic chemical vapors can dissolve skin oils, be absorbed by the skin and enter the blood stream.

B. **Physical Hazards** – sometimes referred to as environmental factors, and often resulting from mechanical sources. Physical hazards can cause acute or chronic physical injury or death.

1. **Noise** – excessive noise for an extended time can damage or destroy the hearing cells of the inner ear, causing Noise Induced Hearing Loss.

2. **Thermal hazards –** a miner's health can be adversely affected if exposed to extremes of temperature or radiation, or if the body's metabolism is not properly regulated.

    a. **Heat stress –** occurs when the body's ability to cool itself is exceeded. This can result from high ambient temperature and/or excessive body heat production due to one's work load.

    b. **Hypothermia –** occurs when the body's core temperature falls due to exposure to cold and/or wet conditions. If not reversed, death can result.

    c. **Frostbite –** occurs when fluids near the body's surface freeze, creating ice crystals and damaging the skin. Areas most commonly affected are the hands and fingers, feet and toes, nose and ears.

3. **Radiation**

    a. **Ionizing –** gamma and X-rays can penetrate the skin and damage internal organs. Examples of sources are laboratory X-ray machines and storage level indicators.

    b. **Non-ionizing –** excessive exposure can burn and damage the skin or eyes. Examples of sources are lasers, infrared sensors and ultraviolet light generated by welding.

4. **Pressure extremes –** Rapid release of pressure can injure miners. Examples of extreme pressure containers are compressors and air receivers, compressed gas cylinders and aerosol cans.

C. **Biological Hazards** - an animal, plant, microscopic organism, virus, or product of a living organism can cause disease, poisoning, or allergic reactions.

1. **Bioaerosols –** bacteria, molds and fungi can cause mild or serious effects on miners' health. These small organisms can be found in the air, soil, water, solid surfaces and decaying matter.

2. **Bloodborne pathogens –** exposure to some viruses can cause serious health effects. Examples of viruses that may be in body fluids are hepatitis B and human immunodeficiency (HIV).

3. **Zoonotic diseases** – are those spread by animals and birds. Some may be injurious to miners. Examples are Histoplasmosis, Lyme disease, tick fever and Hantavirus.

D. **Ergonomic Hazards** - Improperly designed tools, equipment, and/or workplaces, or improper lifting techniques, repetitive motions, excessive force, extended periods of vibration and/or awkward or improper body positioning can damage muscles, tendons, spine, nerves or cardiovascular system.

III. Health Effects

Any chemical or physical agent when administered in sufficient quantities is capable of evoking adverse effects. The **dose**, or the amount of chemical or physical stress exposure over a given period of time, will elicit the degree of **response** of the miner. Defining or estimating the dose-response relationship is one important step in the risk assessment process.

Note: There is some variation in each miner's response to identical concentrations of chemicals or to exposure levels of physical agents. Exposure limits are designed to protect the "normal" person for a working lifetime from these health hazards. For persons with increased susceptibility, such as asthmatics, those with heart disease, or other pre-existing medical conditions, reactions may be more dramatic than for the general mining population. Adverse effects may occur at or even below the Permissible Exposure Level (PEL). Because estimates of risk may differ for such susceptible persons (miners), the measures taken to protect them from occupational hazards may need to be more carefully considered.

The effects of overexposure to health hazards can either be **acute** or **chronic**.

A. **Acute** effects result from short term or a single exposure and have immediate or almost immediate symptoms. Examples are metal fume fever, heat stroke, carbon monoxide poisoning, or a chemical burn.

B. **Chronic** effects result from long term exposure and often take years before the symptoms appear. They may cause a long-term illness or deterioration of health. Examples are silicosis, metal or solvent poisoning of the liver and brain, or noise induced hearing loss.

IV. Routes of Entry

Chemical or biological contaminants can enter the body by four different paths. These are called **routes of entry**:

A. **Inhalation (breathing)** - for example, silica dust, welding fumes, or solvent vapors.

B. **Ingestion (swallowing)** - for example, metal dusts, or solvents splashed in the mouth.

C. **Absorption (through skin or eyes) -** for example, mercury, hydrogen cyanide, and many processing chemicals.

D. **Injection (through a puncture or cut in the skin)** - allowing direct entry into the bloodstream.

V. Risk

Risk is the combination of the probability of sustaining bodily harm or impairment from exposure to a contaminant or a stressor and the severity of injury or illness should harm occur. Risk depends on the combined effects of the following factors:

A. The nature of the contaminant itself; for example, its chemical toxicity;

B. The amount or concentration of the material to which the miner is exposed;

C. The proximity of the miner to the source of the material;

D. The length of time of a miner’s exposure;

E. The route of entry into the miner (breathing, swallowing, absorbing, etc.);

F. Temperature (especially when heat stress or toxic chemicals are involved);

G. The individual miner’s tolerance or sensitivity to the contaminant; and

H. Other health hazards in the area that can damage the same part(s) of the body and have an *additive* or multiplicative effect, such as a combination of asbestos and smoking.

VI. Control Measures

The first step in controlling workplace hazards is to identify hazards and possible exposures. Consider where and how a substance is produced, handled, and stored, as well as its effects on miners' health. These factors influence how effectively the hazard(s) can be controlled and the type of the control(s) chosen.

A. **Controls** are devices, equipment, substances or procedures that either prevent health hazards from being generated or reduce or limit exposure to the hazard. Controls can be applied at three points: source (the origin of the hazard), path (the environment between source and miner), or the miner. Because each workplace is unique, one **type of control** or set of controls may not satisfy all conditions.

B. **Types of controls** are often grouped in what is termed a "hierarchy of controls." The types are listed in order of preference below except for the Noise and Diesel Particulate standards which do not place preference on the use of engineering controls over administrative controls:

1. **Engineering controls** involve modifying, repairing, or controlling an existing condition to reduce the health hazard; for example, redesigning a loading spout to reduce the dust. An engineering control may also involve substitution. Substitution replaces the offending machine, process, or contaminant with something less hazardous. Examples are the use of a quieter fan to replace a noisy fan, or the use of mineral spirits to replace benzene in parts cleaning applications.

2. **Administrative controls** limit the time a miner is exposed to a health hazard. Examples are establishing and enforcing policies, modifying job tasks, designating and avoiding high-risk areas, or rotating personnel so affected miners spend less time exposed to the health hazard. If not properly implemented, adhered to, or supervised, administrative controls have the potential to overexpose a greater number of miners.

VII. Personal Protective Equipment

Personal Protective Equipment (PPE) is worn by the miner to protect against health and safety hazards. When an overexposure has occurred, PPE must be used during the implementation of controls. PPE must also be worn when control measures have been exhausted and an overexposure still exists. Examples of PPE include ear plugs, respirators, goggles, protective outerwear, and gloves. Refer to Chapter 16.

VIII. Training

Training is important in industrial hygiene to communicate to miners the health hazards to which they may be exposed, how to recognize the hazards, the precautions needed to prevent or minimize exposure, and the importance of maintaining controls installed or implemented for the miners’ protection.

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CHAPTER 2
HEALTH INSPECTIONS

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Chapter 2
HEALTH INSPECTIONS

I. Establishing a Sampling Plan

Evaluating miners' exposures to contaminants is a required part of an inspector's health inspection. Since metal and nonmetal mines encompass a wide variety of mining techniques and environmental conditions, an inspector must utilize a strategy or sampling plan which addresses potential health hazards at each mine, especially targeting "high risk" occupations. When developing a sampling plan, the following must be considered:

- Type, nature, and source of contaminants at the mine;
- Miner's proximity to potential contaminant sources;
- Number of potentially exposed miners;
- Type of work being done, including routine and periodic tasks;
- Applicable exposure limits and other health-related standards; and
- Available sampling methods.

II. Health Inspection

A. Pre-Inspection Activities

Mines should be sampled in accordance with the current health inspection and sampling policy.

1. **Review the mine file**. This should include but is not limited to: Part 50 forms (7000-1) for past health-related injuries and illnesses; health hazard complaints and investigations; health sampling history; existing "P" codes; process flow sheets and associated Material Safety Data Sheets (MSDS); and previous or outstanding health citations and orders. Carefully review the health field notes associated with each overexposure. Note the activities of the miner(s) during the shift on which the initial overexposure occurred.

2. **Review relevant mandatory standards and enforcement policy**, based on hazards identified. For reference, a synopsis of contaminant-specific health-related standards is provided at the end of this chapter. See Table 2-1.

3. **As a general rule**, **consult your immediate supervisor** before seeking additional guidance. For additional information, contact inspectors, supervisors, industrial hygienists, health specialists, MSHA Technical Support, or the Metal and Nonmetal Health Division.

4. **Draw on your own experience** with other mines of this type and commodity. If possible, discuss the details with the last inspector who visited the mine.

B. On-Site Activities

Walk-around observations, discussions with miners, and direct-read area sampling can be used to determine which occupations are “high risk” and need to be sampled. When overexposures occur, whether on a previous inspection or from sampling conducted during the current inspection, expand the group of miners sampled in that occupation or area until you are certain that all miners at risk of overexposure have been identified and evaluated. To determine which hazards are present and which miners are “high risk”:

1. **Observe:**

    - **Proximity of miner to contaminants and tasks performed**. Miners working near or in direct contact with a hazard (such as welding fumes, process chemicals, or parts cleaning) are more likely to be at risk of an overexposure. Noise exposure may be greater for a miner working in or around multiple pieces of machinery than one working near a single noise source.

    - **Nature of operation and work practices**. Certain mineral processes may create hazardous environmental conditions which can affect miners’ health when physical or chemical changes occur during ore processing (kilns, dryers, chemical reagents, etc.). Hazards may be present in on-site laboratories that use and store chemicals. A substance used around a heat source (where heat intensifies chemical reactivity) may have a more toxic effect than if used in a cool atmosphere. Miners working in confined areas with little or no ventilation are more likely to be overexposed.

Insufficient housekeeping or improper clean-up methods (such as broom and shovel instead of a vacuum) may lead to increased exposures.

- **Warning signs, tags, and labels**. Areas, boxes, drums, bottles, etc., marked with warnings can be used as a guide in determining toxicity, proper handling procedures, required engineering controls, and necessary personal protective equipment (PPE). Review available MSDS for similar information. Miners working in or around these items should follow all precautions outlined and should be sampled accordingly. Review handling procedures and storage for compliance with applicable MSHA standards (refer to Chapter 19).

2. **Use your senses** - sight, smell, and hearing. *To protect your own health and safety, do not place yourself at risk of contaminant exposure. Call your supervisor or the District Office for guidance on proper handling, storage, use, and appropriate PPE for unfamiliar chemical substances.* Smoke or dust clouds may indicate sites where miners are at risk of particulate overexposures. Odd odors or bitter/sweet taste sensations may indicate the presence of fumes, gases, or vapors that may be toxic. When miners are unaware of these odors, it may be that long-term exposure to chemicals (e.g., hydrogen sulfide) has “numbed” their senses. A prickly sensation of the skin and nose linings may indicate the presence of acid mists or caustic dust. When sound levels consistently require miners to shout to be heard from only a few feet away, noise sampling should be considered.

3. **Screen with direct reading instruments**. A sound level meter can pinpoint noise sources and help identify miners for full-shift noise surveys. Direct-reading instantaneous dust or particle monitors, such as real-time aerosol monitors (RAM), can measure excessive dust concentrations, pinpoint leaks and problems with engineering controls, and indicate the best location for conducting personal monitoring. Multi-gas instruments or direct reading stain tubes can detect gases and vapors (such as gases from diesel exhaust or vapors from processing chemicals) which may create problems.

4. **Interview miners.** Since they work in the environment on a day-to-day basis, the miners' insights into problems are invaluable.
    - **Listen to miners' comments and complaints**. A miner's symptoms (headaches, nausea, skin rash, pains, etc.) can indicate the presence of potential contaminants.

    - **Ask miners on all shifts** to discuss specific work tasks and required personal protective equipment. If these tasks pose a high risk, the miners should be sampled accordingly.

    - **Talk to maintenance personnel** about precautions taken and PPE used when working in or around machinery which may pose significant health risks (baghouses, ball mills, kilns, etc.).

5. **Assess control measures.**

    - Are engineering controls in place and are they being maintained to minimize exposures? Are there additional controls that can be implemented?

    - Have administrative controls been established and are they being followed? Are miners knowledgeable regarding any administrative controls?

    - Is personal protective equipment (PPE) required? Is it being provided, worn, and maintained, and is training given on its use?

    - Where engineering controls are used, look for evidence that the mine operator is assessing the effectiveness of the controls during workplace examinations required by 30 CFR §§ 56/57.18002 and whether records are being kept.

    - Determine if the mine operator is conducting exposure monitoring and surveys to determine the adequacy of the control measures in accordance with 30 CFR §§ 56/57.5002 for air quality and with §62.110 for noise.

    - At mine sites where abrasive blasting or drilling is being conducted, check for compliance with 30 CFR §§ 58.610 and 58.620, respectively.

III. Sampling Protocol

If the pre-inspection review and the on-site assessment indicate that sampling is warranted, it becomes an integral part of the health inspection. Conditions within the work environment on the day of sampling must be similar to those experienced by the miner when sampling is not being done. Sample a sufficient number of miners to characterize the typical exposure levels of all affected occupations and areas during "normal" workshifts. In certain situations, such as when independent contractors are performing specialized tasks, samples should be collected.

A. Duration of Sampling

The duration of sample collection must be sufficient to compare a miner's exposure to the appropriate permissible exposure level (PEL). Permissible exposure levels are established by time-weighted average concentrations, short-term exposures, excursion limits, and ceiling values.

1. **Full-Shift Sampling**. Full-shift samples must be collected during the miner's entire workshift regardless of the number of hours worked. This is best accomplished by full-period, single-sample measurements (one full-shift sample) or full-period, consecutive sample measurements (multiple samples collected back-to-back throughout the shift).

   For some contaminants, **partial-period sampling** may be used to represent the full shift. For example, sampling can be done for 10 minutes every hour with a midget impinger (graphite, talc, mica, etc.) for an entire workshift or with one stain tube for a 15-minute interval each hour (carbon monoxide, sulfur dioxide, etc.) during the entire workshift.

2. **Short-Term Sampling**. Short-term samples may be collected during the miner's workshift. The representative sampling period should be at least as long as the time specified in the **short-term exposure limit (STEL)**. Many exposures are not continuous 8-hour daily exposures, but are short-term or intermittent exposures that may be addressed better by STELs. STELs for 5, 15, or 30 minutes for 142 substances are found in the regulations of the Pennsylvania Department of Health, Chapter 4, Article 432, revised January 25, 1968 (PA Rule). These PA Rule STELs are referenced in the *TLVs® Threshold Limit Values for Chemical Substances in Workroom Air Adopted by the ACGIH for 1973*, which is incorporated by reference into MSHA health standards (30 CFR §§ 56/57.5001).

The sampling times for these STELs vary from 5 to 30 minutes depending upon the contaminant. In general, when sampling a mixture of similar contaminants and toxicities, the sampling duration should correspond to the contaminant with the longest STEL time period. When sampling for specific contaminants, the duration should correspond to the listed time for the respective STEL. However, you need to ensure that the sample will provide enough contaminant for the Laboratory to analyze. Refer to Chapter 3, or contact the MSHA Laboratory.

Example I: A miner must not be exposed to greater than 400 ppm (parts per million) of Carbon Monoxide (CO) for any 15 minute period. It is not necessary to sample continuously during the period, but the sample must be representative of the time. CO detector tube readings taken every 5 minutes for the 15 minute period would be adequate.

Example II: A miner is performing routine arc welding on steel machinery for one hour. He or she must not be simultaneously exposed to an average concentration greater than 20 mg/m^3 of Iron Oxide for any 15-minute period, 0.1 mg/m^3 of Copper fume for 30 minutes, or 10 mg/m^3 Zinc Oxide for 30 minutes. It is not necessary to sample continuously for the maximum STEL time period (30 min.), but the sample must be representative of the welder’s actual work time. Therefore, taking two 15-minute samples in succession or multiple 5-minute samples would encompass all the listed times for the contaminant mixture and ensure that a large enough sample is obtained for analytical purposes.

3. **Sampling for Ceiling and Excursion Concentrations.** Samples to evaluate exposure to contaminants having **ceiling limits** or **excursion limits** must be taken only just long enough to determine the contaminant concentration and during periods of maximum contaminant concentrations. Ceiling limit concentrations are identified by a “C” in *TLVs® Threshold Limit Values for Chemical Substances in Workroom Air Adopted by the ACGIH for 1973*. Ceiling limits cannot be exceeded at any time during the workshift. Ceiling exposure limits have been established by the ACGIH for substances that are fast-acting. That is, for these contaminants, 15 minute exposures may result in intolerable irritation, chronic or irreversible tissue change, or narcosis of sufficient degree to increase accident proneness, impair self-rescue, or materially reduce work efficiency. <u>This does not mean that a sample must be taken for at least 15 minutes to determine whether a ceiling limit has been exceeded</u>. For ceiling limit concentrations, use direct-reading instruments or detector tubes so that immediate action can be taken to remove miners if a ceiling

limit has been exceeded. Excursion limits are maximum exposure concentrations established by the application of the ACGIH's Excursion Factors listed in Appendix D of the 1973 TLV Booklet which must not be exceeded at any time for those substances not bearing a "C" designation.

B. Types of Samples (Personal vs. Area Samples)

1. **Personal samples** are taken on or near the miner to determine exposure to the contaminant(s) present. These samples are taken with the sampling device or media attached to the miner or held in the **breathing zone** or **hearing zone** of the miner.

Breathing zone - 12-inch (30-centimeter) radius sphere of air space surrounding the miner's head. Air taken from this region represents the air the miner is breathing while working.

Hearing zone - the areas within 12 inches (30 centimeters) of the miner's ears. Noise samples taken in this region will be representative of the noise the miner actually experiences while working. Refer to Chapter 15 for the sampling protocol for noise.

2. **Area samples** are collected to determine the presence of potential contaminants in an area where miners work. These samples may be taken with or without miners being present.

C. Determination of a "Normal" Workshift

Observe and document the sampled miner's activities during the shift. Interview the miner and mine management to determine whether the observed activities and exposures are characteristic of a **"normal" workshift**.

1. The following are examples of the types of information that can be used to determine if activities are characteristic of a "normal" workshift: the number of truckloads of material processed by a crusher operator; the number of holes or vertical feet drilled by a driller; the number of trucks loaded by a shovel operator; the type of product and number of bags produced by a bagging machine operator; the number of pieces of equipment running during a production day; and indications operations have been modified.

2. A "normal" workshift at many operations may exhibit wide variations in working conditions and activities. Ask the miner if these are "usual" or "unusual" work conditions. Sample results are valid when collected on days that lie within the range of normal variations.

3. Sampling should be conducted among miners engaged in their "usual" activities under "normal" working conditions. However, it is quite common for a miner to engage in a variety of activities during a production cycle, day, week, or season. It is also common to experience variable production levels, equipment breakdowns, engineering control failures, poor maintenance or work practices, adverse weather conditions, and breakage and spills. These situations will not normally invalidate the sample.

4. Special effort should be made to sample non-routine maintenance operations when specific intermittent tasks involve health risks.

D. Refusal of the Miner to be Sampled

If a miner objects to wearing the sampling device, determine the reasons for the objection. Explain the need for the sampling. If you cannot obtain the cooperation of the miner and another miner performing the same job at the same location is available and cooperative, sample the cooperative miner. If the refusal is an attempt to impede or prevent an inspection, the inspector should attempt to complete any parts of the inspection that do not involve sampling, then contact his/her supervisor. In such cases, the supervisor is responsible for collecting all the facts, reducing them to writing, and contacting the district or assistant district manager. Consult the Program Policy Manual, Volume I, I.103-1, Assaulting, Intimidating or Impeding Inspectors, for current policy on actions to be taken in such circumstances.

E. Resampling

In most instances, you must resample to determine if the citation or order should be terminated. When resampling to terminate a citation or order, sample the job(s) being performed when the overexposure occurred. Where applicable, ensure that the same piece of equipment is being operated (e.g., front-end loader, packing machine, highwall drill) during a normal workshift.

If the citation or order resulted from an area sample, ensure that subsequent samples are taken in the same general area where the overexposure occurred and under similar conditions. However, if a sample was taken at a working face and the working face advanced considerably since the time of the initial sampling, resample at the new face area.

IV. Evaluation of Exposure

Once the sampling (personal or area) has been completed and results obtained, use the results to evaluate exposure. Determine compliance for the following contaminants by:

Dusts, fumes, mists, gases, and vapors -

- Calculating exposure concentration;
- Shift-weighted averaging;
- Applying error factors; and
- Calculating additive effects (if applicable).

Noise -

- Reading the personal noise dosimeter; or
- Reading the sound level meter; and
- Applying appropriate error factor.

Radiation -

- Reading the instrument;
- Applying time factor; and
- Applying the error factor.

A. Full-Shift Sampling

1. **Full-Shift Sampling**. Full-shift sampling is collecting one or more samples over an entire workshift. The total sampling time equals the full length of the shift.

   a. **Single sample**. Calculate sampling results on the basis of **480 minutes**, regardless of the actual sampling time. This "shift-weighting" for work schedules less than or greater than eight hours provides direct comparison with the 8-hour based exposure limits (TLVs).

   The general equation for calculating a shift-weighted average (SWA) or 8-hour equivalent time-weighted average (TWA_8) for dusts, fumes, and mists is:

$$\textbf{SWA in mg/m}^3 = \frac{\textbf{Total weight of contaminant in milligrams (mg)}}{\textbf{Flow rate in Liters per minute (Lpm) x 480 min x 0.001 m}^3\textbf{/L}}$$

where: mg/m^3 = milligrams per cubic meter
m^3/L = cubic meters per Liter

The following formula can be used for converting mg/m^3 to parts per million (ppm) for gases and vapors. Do not use this conversion formula for dusts, mists or fumes.

$$\text{ppm} = \frac{mg/m^3 \times 24.45}{MW}$$

where: MW = molecular weight of compound (gas or vapor)

The "shift weighting" of sampling results serves two functions:

- Contaminant concentrations during unsampled periods of an 8 hour shift are assumed to equal zero.
- Exposures for work schedules greater than 8 hours are proportionately adjusted to allow direct comparison with the 8-hour TLV.

   b. **Consecutive samples**. If the MSHA Laboratory notifies an inspector that a single full-shift sample (such as a filter cassette, charcoal tube, or passive badge) contains too much contaminant and cannot be analyzed for enforcement purposes, the inspector will have to resample the occupation using consecutive samples (two or more samples collected back-to-back). The laboratory may be able to analyze the original "overweight" sample for screening purposes only, but the sample is void and the results should not be entered into the MSHA Standardized Information System (MSIS).

Further, if sampling experience or observation causes the inspector to believe that a sample could be overloaded due to excessive concentrations of contaminant in the work environment, use consecutive sampling to cover the full shift.

By collecting consecutive samples, the total amount of contaminant is spread out over several samples. In calculating the SWA exposure concentration, add together the individual consecutive sample weights and use the total in the formula found in subparagraph 1.a. above. When consecutive sampling for asbestos, and results are reported as individual TWAs, use the formula given in the example below in 2. b., Method 2.

2. **Partial-Period Sampling**. Partial-period sampling is the collecting of one or more samples taken intermittently during a full shift to represent the entire full-shift exposure. The total actual sampling time will be less than the time of the full-shift. Partial-period sampling must be time-weighted **and** shift-weighted to evaluate exposure to contaminants with 8-hour TLVs. For example, MSHA uses partial-period sampling when collecting impinger or detector tube samples. When taking a series of grab samples periodically throughout a shift, each sample can serve the dual purpose of being part of the full-shift sampling process as well as a stand alone short-term sample. See Chapter 11, V., Sampling Strategy for Detector/ Diffusion Tube Sampling, and Chapter 13, VI, Sampling Procedures for Electronic Direct-Read Instruments (DRIs).

   a. **Time-Weighting**. Each sample must be individually time-weighted. (TWA = time-weighted average). This is done by the following equation:

$$\textbf{TWA in mg/m}^3 = \frac{\textbf{Weight of contaminant in milligrams (mg)}}{\textbf{Flow rate (Lpm) x actual sampling time x 0.001 m}^3\textbf{/L}}$$

Note: mg/m^3 TWA for gases and vapors can be converted to ppm using the formula in A.1.a above. Do not use this conversion formula for dusts, mists or fumes.

b. **Shift-Weighting**. Once the time-weighted average of each sample has been calculated, determine the time represented by that sample. This can be accomplished by either of the following two methods:

Method 1: If the miner's location and activities were relatively uniform during the shift (for example, a crusher operator or truck driver), then the one sample can represent the hour in which it was taken, regardless of the exact time it was taken. For example, if the sample were to be taken from 8:25 a.m. to 8:35 a.m., it could represent the hour covering 8:00 a.m. to 9:00 a.m. The next sample could be taken at 9:35 a.m. to represent the hour from 9:00 a.m. to 10:00 a.m., and so on.

Method 2: If the miner's shift was divided into work periods of two or more separate activities or locations (e.g., cleanup, bagging, reagent mixing, leach pad, mill), the time period represented by the sample can be time spent performing that task or in that location. If multiple samples were taken during a task or in specific locations, their weighted average can be used to represent that time. The total time represented by the samples must equal the entire shift.

The calculation of the shift-weighted average (SWA) is determined by the following formula:

$$\mathbf{SWA = (TWA_1 t_1 + TWA_2 t_2 + \ldots + TWA_n t_n) / 480\ min.}$$

where: TWA = Contaminant concentration measured;
t = Time period represented by sample in minutes; and
$t_1 + t_2 + \ldots t_n$ equals the total time of the full workshift.

Note: Do not mix TWA or time units of measure. The SWA and the multiple TWAs are in mg/m^3 or ppm; the units cannot be mixed.

B. Short-Term Exposure Limits (STEL)

1. **Full-Period Sampling**. When sample duration equals or exceeds time specified for the STEL (5, 15, or 30 minutes), use the actual sampling time to determine the exposure by using the following formula:
Short-term exposure concentration for STELs in mg/m^3 =

$$\frac{\textbf{Weight of contaminant in milligrams (mg)}}{\textbf{Flow rate (Lpm) x actual sampling time x 0.001 } \mathbf{m^3/L}}$$

Note: mg/m^3 STEL results for gases and vapors can be converted to ppm using the formula given in A.1.a above. Do not use this conversion formula for dusts, mists or fumes.

2. **Partial-Period Sampling**. When the partial-period sampling method is used (one or more samples taken intermittently) to represent the time specified for the STEL (5, 15, or 30 minutes), use the formula below to determine the exposure concentrations. Partial-period sampling would be conducted with detector tubes or direct read instruments.

SWA = $(TWA_1t_1 + TWA_2t_2 + \ldots + TWA_nt_n)$ / STEL time

where: TWA = Contaminant concentration measured by actual sampling;
t = Time period represented by sample; and
$t_1 + t_2 + \ldots t_n$ must equal the total of the STEL time.

Note: SWA and multiple TWAs are in mg/m^3 or ppm units. The units cannot be mixed.

C. Ceiling Limits and Excursion Limits

Ceiling limits and excursion limits must not be exceeded at any time. If the instantaneous sampling method is used, base compliance determinations on that reading. If a method is used that requires submitting the sample for expedited lab analysis, sample for at least as long a time as required to collect an amount of contaminant greater than the lab's detection limits. Determine the concentration by using the following formula:

Ceiling or Excursion Limit concentration in mg/m^3 =

$$\frac{\textbf{Weight of contaminant in milligrams (mg)}}{\textbf{Flow rate (Lpm) x actual sampling time (min) x 0.001 m}^3\textbf{/L}}$$

Note: Ceiling or Excursion Limit concentrations in mg/m^3 for gases and vapors can be converted to ppm using the formula given in A.1.a above. Do not use this conversion formula for dusts, mists or fumes.

D. Error Factors

Error factors are used to compensate for sampling and analytical errors associated with a specific method, as well as to ensure that the sample is over the exposure limit with a 95% confidence level. An up-to-date index of error factors for sampling methods listed in Chapter 3 will be maintained by the MSHA laboratory, applied in analytical computations, and shown on the laboratory report.

To calculate the error factor of a particular sampling instrument or method not listed in Chapter 3, use the manufacturer's specified **coefficient of variation (CV)** or **relative standard deviation (RSD)** number. Multiply the highest value listed by 1.65; then add one. The permissible exposure limit is then multiplied by the error factor. This result determines the limit concentration above which a miner's exposure would be considered citable.

Example:
The Dräger Detector Tube Handbook (11th edition) states that the hydrogen sulfide detector tube #6728821 has a relative standard deviation of ± 5 to 10 %. To determine the appropriate error factor, multiply the highest value by 1.65, which is then added to one.

Error Factor = (10% x 1.65) + 1
Error Factor = 1.17

E. Additive Effects

Inspectors must consider the effect on miners of exposure to multiple contaminants. When a miner is exposed to more than one airborne contaminant that produces the same effect on the body or on the same body site (target organ), they produce a combined effect. These exposures are said to be “additive.” There are many sources for finding the target organs and toxic effects of chemicals. The **NIOSH Pocket Guide to Chemical Hazards** and MSDSs are good sources of information. An extensive discussion of additive threshold limit values for mixtures is found on pages 42-51 of the ***TLVs® Threshold Limit Values for Chemical Substances in Workroom Air Adopted by the ACGIH for 1973***.

1. The general equation for calculating an additive exposure, where the contaminants have similar toxicological properties, is the sum of the individual contaminant to exposure limit ratios as follows:

$$\textbf{Additive Exposure} = \frac{C_1}{(TLV_1 \times EF_1)} + \frac{C_2}{(TLV_2 \times EF_2)} + \ldots + \frac{C_n}{(TLV_n \times EF_n)}$$

where: C = individual contaminant exposure concentration (in ppm or mg/m^3);
TLV = individual contaminant exposure limit (in ppm or mg/m^3); and
EF = error factor for contaminant sampling and analysis.

Express the individual contaminant concentration (C_1, C_2, etc.) and the corresponding exposure limit (TLV) in the same measurement units (e.g., ppm or mg/m^3). They must relate to the same exposure period (e.g., full-shift, short-term).

When the additive exposure is greater than (1.0), an overexposure is indicated.

Example:
A mineral processing facility uses a variety of chemicals in the plant and stores them in large open tanks throughout the facility. There are several tanks in one room. A miner's exposure was measured using an air sampling method with an error factor of 1.25. Although none of the exposures to the individual contaminants exceeded the associated TLVs, the concentrations of the four contaminants listed below were considered for additive effects[1]:

---

[1] The example of additive effects calculation and the discussion and examples of TLVs for liquid mixtures and airborne contaminants were excerpted (in part) from Jack Caravanos, DrPH, Quantitative Industrial Hygiene, 1991, pgs. 46-48.

- muriatic acid (hydrogen chloride), 2.8 mg/m^3 (TLV = 7.5 mg/m^3);
- nitric acid, 2.7 mg/m^3 (TLV = 5.2 mg/m^3);
- sulfuric acid, 0.2 mg/m^3 (TLV = 1.0 mg/m^3); and
- tributyl phosphate*, 1.7 mg/m^3 (TLV = 5.0 mg/m^3).

***** In this case, tributyl phosphate is <u>not</u> an acid gas, as are the other three contaminants, and does <u>not</u> have the same toxicological effects. Therefore, it is <u>not</u> included in the additive effects calculation which follows:

$$\text{Additive Exposure} = \frac{C_1}{(TLV_1 \times EF_1)} + \frac{C_2}{(TLV_2 \times EF_2)} + \ldots + \frac{C_n}{(TLV_n \times EF_n)}$$

$$= \frac{2.8}{(7.5 \times 1.25)} + \frac{2.7}{(5.2 \times 1.25)} + \frac{0.2}{(1.0 \times 1.25)}$$

$$= 0.2987 + 0.4154 + 0.1600$$

$$= 0.8741$$

The additive exposure of 0.8741 is less than 1.0, therefore, the TLV for the three similar contaminants (acid gases) has <u>not</u> been exceeded. This example illustrates that the miner's exposure to the contaminants, both individual <u>and</u> additive, would be in compliance.

2. Calculating TLVs for Liquid Mixtures.

For mixtures of <u>liquid</u> contaminants where the contaminants present have similar toxicological properties, it is an accepted practice to calculate a TLV for the mixture as a whole. The assumption is that the toxicological properties are additive in nature. The TLV of the liquid mixture is based on the percentage of each contaminant present and its respective TLV. The following formula can be used to calculate the combined TLV of the mix.

$$\mathbf{TLV_{mix}} = \frac{\mathbf{1}}{\dfrac{\mathbf{F_1}}{\mathbf{TLV_1 \times EF_1}} + \dfrac{\mathbf{F_2}}{\mathbf{TLV_2 \times EF_2}} + \dfrac{\mathbf{F_3}}{\mathbf{TLV_3 \times EF_3}} + \ldots + \dfrac{\mathbf{F_n}}{\mathbf{TLV_n \times EF_n}}}$$

where: F = the weight fraction of the contaminant in decimal percentage;
TLV = respective TLV of the contaminant in mg/m^3; and
EF = the associated error factor of the sampling method used.

Note: There are <u>no</u> air sampling concentration results involved in the calculation of the TLV for a liquid mixture.

Example:
What is the TLV in mg/m^3 of a solution containing 25% naphtha (TLV = 1370 mg/m^3), 15% toluene (TLV = 377 mg/m^3), and the remainder (60%) Stoddard solvent (TLV = 525 mg/m^3) when planning to sample using a charcoal tube. (Note: assume that for using a charcoal tube, the EF for naphtha = 1.15; the EF for toluene = 1.13; and the EF for Stoddard solvent = 1.11).

$$TLV_{mix} = \frac{1}{\dfrac{0.25}{1370 \times 1.15} + \dfrac{0.15}{377 \times 1.13} + \dfrac{0.60}{525 \times 1.11}}$$

$$= \frac{1}{0.0001586 + 0.0003521 + 0.001029}$$

$$= \frac{1}{0.001540}$$

$$= 649 \text{ mg/m}^3$$

The three-component solvent mixture will have an enforcement airborne TLV of 649 mg/m^3.

Table 2-1. Contaminants and Commonly Related Standards[2]

Contaminant	Commonly Related Standard(s)
1. Respirable Dust (Silica)	56/57.5001, 56/57.5002, 56/57.5005, 58.610, 58.620
2. Other Inhalation Hazards:	
Asbestos	56/57.5001(b), 56/57.5002, 56/57.5005, 56/57.15004, 56/57.15006, 56/57.16003, 56/57.16004, 56/57.20011, 56/57.20012, 56/57.20014
Other Mineral Fibers & Silicates	56/57.5001, 56/57.5002, 56/57.5005
Nuisance Particulates	56/57.5001, 56/57.5002, 56/57.5005
Mercury Vapor	56/57.5001, 56/57.5002, 56/57.5005, 56/57.20014
Welding Fumes	56/57.5001, 56/57.5002, 56/57.5005, 56/57.15007, 56/57.14213
Metal Dusts	56/57.5001, 56/57.5002, 56/57.5005, 56/57.20014
Caustic Dusts	56/57.5001, 56/57.5002, 56/57.5005, 56/57.20014
Chemical Vapors & Gases	56/57.5001, 56/57.5002, 56/57.5005, 56/57.5006, 56/57.15004, 56/57.15006, 56/57.20005, 56/57.20014
Radon Gas (underground)	57.5037 through 57.5047
3. Mixed Sound Levels	62.100 through 62.190
4. Diesel Exhaust:	
Gases	56/57.5001, 56/57.5002, 56/57.5005
Particulates	57.5060, 57.5061, 57.5062, 57.5065, 57.5066, 57.5067, 57.5070, 57.5071, 57.5075

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[2] This table is not intended to be an all-inclusive list of possible related standards. It is presented here only as a general reference.

Table 2-1. Contaminants and Commonly Related Standards

5. Hazardous Chemical Waste (Storage or Used As Fuel)	56/57.5001, 56/57.5002, 56/57.5005, 56/57.5006, 56/57.15001, 56/57.15004, 56/57.15006, 56/57.20011, 56/57.20012, 56/57.20014
6. Confined Spaces:	56/57.5001, 56/57.5002, 56/57.5005, 56/57.16002
Chemicals	56/57.5001, 56/57.5002, 56/57.5005
Oxygen Deficiency	57.5015, 57.8527, 57.8528
7. Radiation Hazards:	56/57.15006, 56/57.16003, 56/57.16004, 56/57.20011, 56/57.20012
Ionizing (Nuclear)	57.5037 through 57.5047
Non-ionizing (Electromagnetic)	none
8. Biological Hazards	56/57.20002, 56/57.20003, 56/57.20008, 56/57.20013, 56/57.20014
9. Heat Stress	56/57.15006, 56/57.20002
10. Corrosive & Toxic Chemicals (Eye & Skin Hazards)	56/57.15001, 56/57.15004, 56/57.15006, 56/57.20005
11. Ergonomic Hazards	none
12. General	56/57.18002, 56/57.18006, 56/57.20011

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CONTAMINANT INDEX

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Chapter 3
CONTAMINANT INDEX

Introduction

This chapter lists and describes common chemical contaminants that may be found in the mining environment. This is not an all-inclusive list. If other contaminants are identified at a mine site, contact your District Office for guidance.

The contaminants are listed alphabetically. Each contaminant listing contains information regarding chemical description, applicable exposure limits, contaminant code(s), analytical method(s), and sampling method(s). The information for each sampling method specifies the materials needed and their use. Once a method has been chosen, the inspector can refer to other chapters of this Handbook for further instructions. There may be alternate sampling methods other than those listed in this chapter which can be used for a particular contaminant. For assistance, contact the District Office.

The District, prior to any unusual non-routine or rush sampling, should contact the Technical Support Laboratory. The laboratory should be contacted in advance whenever a special analysis or expediting is needed, since the samples may have to be sent to an outside contract laboratory. The lab can provide advice or information and prepare for the samples. In these cases, arrangements may be made for special sampling equipment, media, or vials that can be sent from the laboratory directly to the inspector.

A list of abbreviations used in the descriptions of each contaminant is contained in Appendix A of this chapter. Because an individual chemical may have many different names, an alphabetized list of chemical synonyms with a cross-reference to each listed chemical is given in Appendix B.

SPECIAL NOTES:

Analyses

- Send ALL samples to the MSHA Laboratory in Pittsburgh as soon as possible after collection. If special mailing instructions include **“store and ship refrigerated”** or **“submit samples overnight to the MSHA Laboratory,”** notify the Laboratory that the samples are being sent and need to be processed as soon as they are received.

- **For expedited analysis**, coordinate shipment with the Laboratory so that the samples can be processed as soon as can be arranged. Send the samples via overnight service or express mail.

- **Controls and Blanks** are submitted to the MSHA Laboratory for quality assurance purposes: to determine if the collection media is contaminated from sample handling, storage, and shipping. In general, submit a control or blank for each set of like samples (five per Request for Laboratory Analysis (RLA) form). If multiple sample cassettes are needed for one exposure measurement, count each cassette as a separate sample and be sure there is one control or blank for each five samples. Also, prepare one control or blank for each type of analysis desired. For example, an "elemental" analysis of all 14 metals requires one blank, and a "calcium oxide" analysis would require its own separate blank. Separate controls or blanks must be submitted for each shift sampled. Controls or blanks must come from the same media lot or box used for the exposure sampling period. For example, this means that control sample cassettes must have the same pre-weighing date as the dust sample cassettes.

  Control Filter (submitted for respirable and total dust sampling): At no time may inlet or outlet plugs be removed from the control filter cassette. The respirable/total dust sample cassette may be submitted sealed in its original plastic wrapper.

  Blank (submitted for all other sampling media): For filter cassettes (asbestos, fibers, welding fumes, elemental dust, etc.), remove inlet and outlet plugs and then replace them. For other sampling media, open the sorbent tube, badge, or wipe filter paper and immediately seal it with the caps, cover, or container provided.

- **Bulk samples** taken are shipped separately from airborne contaminants exposure samples.

- **Error factors** will be supplied by the MSHA Laboratory when analyses are performed for compliance determination.

References

The following references were used in the preparation of this manual. These documents are periodically revised and updated, so later editions may be available from the publisher. Consult the current version of each reference.

- **Immediately Dangerous to Life or Health (IDLH)** concentration values are from the *NIOSH Chemical Listing and Documentation of Revised IDLH Values (as of 3/1/95)* [http://www.cdc.gov/niosh/idlh/intridl4.html, accessed from 11/27/2001 to 11/30/2001]. The NIOSH definition for an IDLH exposure condition, as stipulated in the *NIOSH Respirator Decision Logic* [DHHS (NIOSH) Publication No. 87-108, NTIS Publication No. PB-91-151183], is a condition "that poses a threat of exposure to airborne contaminants when that exposure is likely to cause death or immediate or delayed permanent adverse health effects or prevent escape from such an environment."

- Personal Protective Equipment (**PPE)** recommendations are from the *NIOSH Pocket Guide to Chemical Hazards* [DHHS (NIOSH) Publication No. 97-140, June 1997] and the *Recommendations for Chemical Protective Clothing: A Companion to the NIOSH Pocket Guide to Chemical Hazards* [NTIS No. PB98-137730, February 1998]. Consult these references for more complete information. MSHA standards require that PPE be appropriate to the hazard and exposure level of the affected miner.

Key to recommended protective clothing barriers:
(from the *Recommendations for Chemical Protective Clothing*)

Butyl = Butyl Rubber (Gloves, Suits, Boots)
Natural = Natural Rubber (Gloves)
Neoprene = Neoprene Rubber (Gloves, Suits, Boots)
Nitrile = Nitrile Rubber (Gloves, Suits, Boots)
PE = Polyethylene (Gloves, Suits, Boots)
PVA = Polyvinyl Alcohol (Gloves)
PVC = Polyvinyl Chloride (Gloves, Suits, Boots)
Teflon = Teflon™ (Gloves, Suits, Boots)
Viton = Viton™ (Gloves, Suits)
Saranex = Saranex™ coated suits
PE/EVAL = 4H™ and Silver Shield™ brand gloves
Barricade = Barricade™ coated suits
CPF3 = CPF3™ suits
Responder = Responder™ suits
Trellchem = Trellchem HPS™ suits
Tychem = Tychem 10000™ suits
8 hr = More than 8 hours of resistance to breakthrough $>0.1 g/cm^2/min$.
4 hr = At least 4 but less than 8 hours of resistance to breakthrough $>0.1 g/cm^2/min$.

Brand Names:

Neoprene is a tradename and Teflon™, Barricade™ and Tychem 10000™ are trademarks of the DuPont Company. Viton™ is a registered trademark of DuPont Dow Elastomers. Saranex is a tradename of the Dow Chemical Company. 4H is a trademark of the Safety 4 Company. Silver Shield is a trademark of the Siebe North Company. CPF3 and Responder are trademarks of the Kappler Company. Trellchem HPS is a trademark of the Trelleborg Company. Tyvek® is a registered trademark of DuPont for its brand of spun-bonded olefin. Recommendations for PPE usage are NOT valid for very thin natural rubber, Neoprene, nitrile, and PVC gloves (0.3 mm or less).

- Information on Dräger diffusion tubes and detector tubes comes from the "Dräger-VOICE 4.0 Hazardous substances database" http://voice.draeger.com/voice/owa/vn.com. Consult Dräger Safety's "Dräger-VOICE 4.0" online for Instructions for Use [to include: application; requirements; principle of reaction; ambient conditions (e.g., temperature, humidity, atmospheric pressure); prerequisites; duration and range of measurement; standard deviation; exposure limits; cross sensitivities / specificity; shelf life; disposal]. This information can be accessed by entering the name of the hazardous substance.

  NIOSH Manual of Analytical Methods (NMAM), 4th ed., DHHS (NIOSH) Publication 94-113 (August, 1994), Cassinelli, M.E. & O'Connor, P.F., Eds.

  (www.cdc.gov/niosh/nmampub.html **):** The NMAM is the result of part of the research activities of NIOSH relating to the determination of workplace contaminants. The NMAM is a collection of methods for sampling and analysis of contaminants in workplace air, and in the blood and urine of workers who are occupationally exposed. These methods have been developed specifically to have adequate sensitivity to detect the lowest concentrations as regulated by OSHA and recommended by NIOSH and sufficient range to measure concentrations exceeding safe levels of exposure.

  The methods have been developed or adapted by NIOSH or its contractors and have been evaluated according to established experimental protocol and evaluation criteria. The NMAM also includes chapters on quality assurance, strategies of sampling airborne substances, method development and discussions of some portable direct-reading instrumentation.

- The www.OSHA.gov web site site has an index of sampling and analytical methods. Chemicals that have either a validated or partially validated OSHA method are listed in alphabetical order. Some chemicals are listed by their common synonym. The index includes the method number, validation status, Chemical Abtract Series (CAS) number, analytical instrument and sampling device. There is information on protocols for methods evaluation, what is new in methods development at the OSHA Salt Lake Technical Center, and a listing of current projects. There are links to other OSHA information on chemical sampling information, hazardous and toxic substances, OSHA analytical studies and sampling and analysis.

Short Term Exposure Limits (STELs)

- The *TLVs® Threshold Limit Values for Chemical Substances in Workroom Air Adopted by ACGIH for 1973* did not list Short Term Exposure Limits (STELs) for substances. It did, however, provide in Appendix D, Permissible Excursions for Time-Weighted Average (TWA) Limits, pgs. 51-52, the instruction to consult the Pennsylvania Rules and Regulations, Chapter 4, Article 432, and "Acceptable Concentrations," ANSI, to find the appropriate excursions for 142 substances. [Note: The American National Standards Institute (ANSI) coordinated available information on various contaminants and established acceptable concentrations that were published as individual consensus standards.] MSHA enforces those excursions as 15-minute STELs. MSHA also enforces a STEL for asbestos given in 30 CFR §§56/57.5001(b).

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Acetic Acid - CH_3COOH

50 ppm IDLH (NIOSH, 1995)

Contaminant Codes:	**1973 ACGIH TLV:**	**1968 PA Rules STEL/Ceiling (C):**
433	10 ppm	40 ppm - 5 min.

CONTAMINANT INFORMATION

Synonyms: acetic acid (aqueous), ethanoic acid, glacial acetic acid (pure compound), methane carboxylic acid

Sources: used in mine laboratories

Description: colorless liquid or crystals, with sour, vinegar-like odor

Incompatibilities: strong oxidizers (especially chromic acid, sodium peroxide, nitric acid), strong caustics

Exposure: inhalation, skin and/or eye contact

Health Effects: irritation eyes, skin, nose, throat; eye, skin burns; skin sensitization; dental erosion; black skin, hyperkeratosis; conjunctivitis, lacrimation (discharge of tears); pharyngeal edema, chronic bronchitis

PPE: Respirator: Up to 50 ppm - any chemical cartridge respirator with a full facepiece and organic vapor cartridge(s) (APF = 50)

Skin: Prevent skin contact (conc. >10% in water);
8 hr: Butyl, Teflon, Viton, PE/EVAL, Responder, Tychem
4 hr: Neoprene, Barricade

Eyes: Prevent eye contact

Special Precautions: if 10-80% acid in water, Class II combustible liquid, vapor may explode if ignited in an enclosed area

LABORATORY INFORMATION

CAS Number: 64-19-7

Analytical Technique: detector/diffusion tube

Analytical Reference Method: NA

SAMPLING INFORMATION

Full Shift Sampling:

Sampling Strategy: see Chapter 11

Collection Media: Dräger diffusion tube #8101071

Note: up to 8 hours per tube (EF = 1.41).

Grab Sampling:

Sampling Strategy: see Chapter 11

Collection Media: Dräger detector tube #6722101, range 5 - 80 ppm (EF = 1.25).

Acetone - CH_3COCH_3

2,500 ppm IDLH (NIOSH, 1995),

based strictly on safety considerations (i.e., being 10% of the lower explosive limit of 2.5%)

Contaminant Codes:	1973 ACGIH TLV:	1973 ACGIH Excursion STEL/Ceiling (C):
243	1000 ppm	1250 ppm - 15 min.

CONTAMINANT INFORMATION

Synonyms: dimethyl ketone, ketone propane, 2-propanone, pyroacetic ether
Sources: solvent; used for paint and varnish removal
Description: colorless liquid, with fragrant mint-like odor
Incompatibilities: oxidizers, acids
Exposure: inhalation, skin or eye contact, ingestion
Health Effects: respiratory system, eyes, skin, central nervous system
PPE: Respirator: Recommendations - NIOSH: Up to 2500 ppm**:** (APF = 10) any chemical cartridge respirator with organic vapor cartridge(s**)**
Skin: Prevent skin contact;
8 hr: Butyl, PE/EVAL, Barricade, CPF3, Responder, Trellchem, Tychem
Eyes: Prevent eye contact

Special Precautions: Class IB combustible liquid, vapors may explode if ignited in an enclosed area

LABORATORY INFORMATION

CAS Number: 67-64-1
Analytical Technique: detector tube
Analytical Reference Method: NA

SAMPLING INFORMATION

Full Shift Sampling:
Sampling Strategy: see Chapter 11
Collection Media: Dräger diffusion tube #6728731
Note: up to 8 hours per tube. (EF = 1.33).

Grab Sampling:
Sampling Strategy: see Chapter 11
Collection Media: Dräger detector tube #22901, range 100 - 12000 ppm (EF = 1.33).

Alcohols (Screen)

Note: Profile sample when contaminants listed below are suspected. Analyses will quantify individual components. The results can be used for compliance with respective TLVs.

Organics Analyzed:

Group 1 Profile: Ethyl Alcohol (Ethanol), Isopropyl Alcohol (Isopropanol), tert-Butyl Alcohol.

Group 2 Profile: n-Butyl Alcohol, sec-Butyl Alcohol, n-Propyl Alcohol

SPECIAL INSTRUCTIONS

Specify group of three contaminants desired.

CONTAMINANT INFORMATION, Contaminant Codes, TLVs: see individual contaminants

LABORATORY INFORMATION

Analytical Technique: Gas Chromatograph (GC)/Flame Ionization Detector (FID)
Analytical Reference Method: OSHA 7/NIOSH 1400/1401

SAMPLING INFORMATION

Sampling Strategy: see Chapter 9
Collection Media: 100/50 mg: solid sorbent tube (coconut shell charcoal)
Sample Flow Rate: for a 100/50 mg tube, 0.01 - 0.05 Lpm. Must use a pump adaptor or arrange for low flow pumps.

Aluminum - Al
as Aluminum Oxide (Al_2O_3)

Contaminant Codes:	1973 ACGIH TLV:	1973 ACGIH Excursion STEL/Ceiling (C):
151 (aluminum oxide dust, as Al_2O_3)	10.0 mg/m^3	20.0 mg/m^3 - 15 min.
703 (aluminum oxide fume, as Al_2O_3)	10.0 mg/m^3	20.0 mg/m^3 - 15 min.
123 (nuisance dust)	10.0 mg/m^3	20.0 mg/m^3 - 15 min.

CONTAMINANT INFORMATION

Synonyms: alundum, alumina, aluminum trioxide, corundum
Sources: *dust* - corundum
fume - welding, torch cutting, smelting
Description: white odorless crystalline powder
Incompatibilities: chlorine trifluoride, hot chlorinated rubber, acids, oxidizers
Exposure: inhalation, ingestion, skin and/or eye contact
Health Effects: skin and eye irritation, respiratory system (possible lung fibrosis)
PPE: Respirator: None specified
Skin: None specified
Eyes: None specified
Special Precautions: Combustible solid, finely divided dust is easily ignited and may cause explosions

LABORATORY INFORMATION

Metal Dust and Fume
CAS Numbers: 1344-28-1 (Al_2O_3)
Analytical Technique: Inductively Coupled Plasma (ICP)
Analytical Reference Method: MSHA P-3

SAMPLING INFORMATION

Full Shift Sampling:
Sampling Strategy: see Chapter 7
Collection Media: 37 mm, 0.8 µm mixed cellulose ester (MCE) filter
Sample Flow Rate: usual sampling is 1.7 Lpm for up to 9 hrs.

Ammonia - NH_3

300 ppm IDLH (NIOSH, 1995)

Contaminant Codes:	1973 ACGIH TLV:	1968 PA Rules STEL/Ceiling (C):
401	25 ppm	100 ppm - 30 min.

CONTAMINANT INFORMATION

Synonyms: ammonia gas, anhydrous ammonia, aqua ammonia, aqueous ammonia, liquid ammonia

Sources: fertilizers, nitric acid, explosives, plastics, gas/coke refinery, chemical reagents

Description: colorless gas or liquid, pungent odor (note: odor threshold is 47 ppm), corrosive, alkaline

Incompatibilities: strong oxidizers, acids, halogens, salts of silver & zinc, amides, isocyanates, aldehydes, nitro-compounds

Exposure: inhalation, ingestion, skin and/or eye contact

Health Effects: eye and skin irritation, respiratory inflammation, pulmonary edema, caustic burn (freeze burn by evaporation)

PPE: Respirator; Recommendations: NIOSH, Up to 250 ppm: (APF = 10) any chemical cartridge respirator with cartridge(s) providing protection against the compound of concern

Skin: Prevent contact; 8 hr: Butyl, Teflon™, Viton™, Responder, Trellchem, Tychem; 4 hr: Nitrile

Eyes: Prevent contact

Special Precautions: Severe eye and skin irritant; should be treated as a flammable gas. Vapor may explode if ignited in an enclosed area

LABORATORY INFORMATION

CAS Number: 7664-41-7

Analytical Technique: diffusion tube/detector tube

Analytical Reference Method: NA

SAMPLING INFORMATION

Full Shift Sampling:

Sampling Strategy: see Chapter 11

Collection Media: Dräger diffusion tube #8101301 -

Note: up to 8 hours per tube. (EF = 1.41).

Grab Sampling:

Sampling Strategy: see Chapter 11

Collection Media: Dräger detector tube #CH20501, range 5 to 700 ppm. (EF = 1.25).

Amorphous Silica - SiO_2

(Diatomaceous Earth)

3,000 mg/m^3 IDLH (NIOSH, 1995)

Contaminant Codes:	1973 ACGIH TLV:	1973 ACGIH Excursion STEL/Ceiling (C):
519 (enforcement)	20 mppcf (1.5 mg/m^3)	40 mppcf (3.0 mg/m^3) - 15 min.
519 (PEDS “screening”)	6.7 mg/m^3	13.3 mg/m^3 - 15 min.

CONTAMINANT INFORMATION

Synonyms: diatomaceous silica, diatomite, fused silica, infusorial earth, infusorial silica, kieselguhr, opaline silica, precipitated amorphous silica, silica gel, silicon dioxide (amorphous), tripolite
Sources: mining of diatomaceous earth
Description: particulates
Exposure: Inhalation, eyes
Incompatibilities: NA
Health Effects: eyes, respiratory system
PPE: Respirator: Recommendations - NIOSH: Up to 30 mg/m^3, (APF = 5), any dust and mist respirator
Skin: None specified
Eyes: None specified
Special Precautions: none reported

LABORATORY INFORMATION

CAS Number: 7631-86-9, 68855-54-9
Analytical Technique: x-ray diffraction
Analytical Reference Method: MSHA P-2/impinger method

SAMPLING INFORMATION

Screening, Full Shift Sampling: - Note: cannot be used for enforcement
Sampling Strategy: see Chapter 6
Collection Media: cyclone and filter [10 mm nylon cyclone and 37-mm diameter, 5-µm poly vinyl chloride (PVC) filter]
Sample Flow Rate: 1.7 Lpm

Enforcement, Full Shift - Partial Period Sampling: **-** Note: for compliance with TLV
Sampling Strategy: see Chapter 6
Collection Media: impinger
Sample Flow Rate: 2.8 Lpm

Special Instructions: Coordinate with MSHA Technical Support. Dust Division personnel will usually conduct impinger sampling with inspector escort.

Antimony & Compounds (as Sb)

50 mg/m^3 IDLH (NIOSH, 1995)

Contaminant Codes:	1973 ACGIH TLV:	1973 ACGIH Excursion STEL/Ceiling (C):
611 (dust)	0.5 mg/m^3 (500 µg/m^3)	1.5 mg/m^3 (1500 µg/m^3) - 15 min.
705 (fume)	0.5 mg/m^3 (500 µg/m^3)	1.5 mg/m^3 (1500 µg/m^3) - 15 min.
	(PEDS units of measure in parentheses)	

Antimony Hydride

Contaminant Codes:	1973 ACGIH TLV:	1973 ACGIH Excursion STEL/Ceiling (C):
311 stibine, SbH_3	0.1 ppm (100 ppb)	0.3 ppm (300 ppb) - 15 min.
	(PEDS units of measure in parentheses)	

CONTAMINANT INFORMATION

Synonyms: elemental**:** stibium
*compounds***:** antimonic..., antimonial..., antimonious..., antimonyl..., stibic..., stibo-, ...antimonate, powder of Algaroth, mercurious vitae.
*stibine***:** antimony hydride, antimony trihydride, hydrogen antimonide

Sources: coating metals, mining of ores of lead, stibnite, kermesite, cervantite, exitelite, senarmontite, valentinite, weisspiessglanz.

Description: *elemental:* silver-white, lustrous, hard, brittle metal or dark-gray lustrous powder (when tarnished by moist air)
compounds: vary

Incompatibilities: Hydrogen gas or acids (forms extremely toxic stibine), ammonium nitrate, halogens, potassium nitrate, potassium permanganate, potassium oxide, sodium nitrate, and oxidants

Exposure: inhalation, ingestion, skin or eyes

Health Effects: dermatitis, eye inflammation, cardiovascular system, nausea/diarrhea, and ulcers of the nose by contact (fumes or dust), systemic poisoning

PPE: Respirator: Recommendation: NIOSH, Up to 5 mg/m^3 (APF = 10) any dust and mist respirator except single-use and quarter-mask respirators

Skin: Prevent skin contact with a barrier that will prevent contamination from the dry chemical

Eyes: Prevent eye contact

Special Precautions: Can present a fire and explosion hazard when in the form of dust and vapors and exposed to flame or heat

LABORATORY INFORMATION

CAS Number: 7440-36-0 *(elemental)*

Analytical Technique: Inductively Coupled Plasma (ICP) or Graphite Furnace Atomic Absorption (GFAA)

Analytical Reference Method: OSHA 125

SAMPLING INFORMATION

Full Shift Sampling:

Sampling Strategy: see Chapter 7

Collection Media: 37 mm, 0.8 µm mixed cellulose ester (MCE) filter

Sample Flow Rate: usual sampling is 1.7 Lpm for up to 9 hrs.

Short Term Sampling:

Sampling Strategy: see Chapter 7

Sampling Duration: 30 min.

Collection Media: 37 mm, 0.8 µm mixed cellulose ester (MCE) filter

Sample Flow Rate: 1.7 Lpm

Special Instructions: **s**ubmit samples to MSHA Laboratory (contract laboratory analysis).

Arsenic and Compounds

5 mg/m^3 IDLH (NIOSH, 1995)

Contaminant Codes:	1973 ACGIH TLV:	1973 ACGIH Excursion STEL/Ceiling (C):
613 (dust)	0.5 mg/m^3 (500 µg/m^3)	1.5 mg/m^3 (1500 µg/m^3) - 15 min.
707 (fume)	0.5 mg/m^3 (500 µg/m^3)	1.5 mg/m^3 (1500 µg/m^3) - 15 min.

(PEDS units of measure in parentheses)

CONTAMINANT INFORMATION

Synonyms: *arsenic*: arsenia, arsenic salt, gray arsenic, metallic arsenic
arsenic acid: orthoarsenic acid, arsenic pentoxide
arsenic disulfide: realgar, red arsenic glass, red arsenic sulfide
arsenic trichloride: fuming liquid arsenic, arsenic (III) trichloride, arsenic chloride, arsenous chloride, caustic arsenic chloride
arsenic trioxide: arsenous acid, arsenous acid anhydride, arsenous oxide
arsenic trisulfide: arsenic yellow, king's gold, king's yellow, orpiment, yellow arsenic sulfide

Sources: used for hardening copper, lead, alloys; insecticides; by product in the smelting of copper, lead, cobalt, and gold ores

Description: *inorganic* - silver-gray or tin-white, brittle, odorless solid, may be yellow as condensed vapor
organic - varies by compounds

Incompatibilities: strong oxidizers, bromine azide, hydrogen gas

Exposure: inhalation, skin and/or eye contact, ingestion

Health Effects: liver, kidneys, bladder, skin, lungs, lymphatic system; cancer of these systems, inorganic forms more dangerous than organic.

PPE: Respirator: At concentrations above the NIOSH REL, 0.002 mg/m^3 [15-minute]: (APF = 10,000) any self-contained breathing apparatus that has a full facepiece and is operated in a pressure-demand or other positive-pressure mode.

Skin: Prevent skin contact; contact the manufacturer for recommendations
For organic compounds, recommendations regarding personal protective clothing vary depending upon the specific compound**.**

Eyes: Prevent eye contact

Special Precautions: Suspected carcinogen (National Toxicology Program); slight explosion hazard in the form of dust, when exposed to flame

LABORATORY INFORMATION
CAS Number: 7440-38-2
Analytical Technique: Inductively Coupled Plasma (ICP)
Analytical Reference Method: MSHA P-3

SAMPLING INFORMATION
Full Shift Sampling:
Sampling Strategy: see Chapter 7
Collection Media: 37 mm, 0.8 µm mixed cellulose ester (MCE) filter
Sample Flow Rate: usual sampling is 1.7 Lpm for up to 9 hrs.

Arsine - AsH_3

3 ppm IDLH (NIOSH, 1995)

Contaminant Codes:	1973 ACGIH TLV:	1973 ACGIH Excursion STEL/Ceiling (C):
313	0.05 ppm (50 ppb)	0.15 ppm (150 ppb) - 15 min.
	(PEDS units of measure in parentheses)	

CONTAMINANT INFORMATION

Synonyms: arsenic hydride, arsenic trihydride, arseniuretted hydrogen, arsenoushydride; hydrogen arsenide

Sources: water on metallic arsenide

Description: colorless gas; garlic-like odor

Incompatibilities: strong oxidizers, chlorine, nitric acid

Exposure: inhalation, skin and/or eye contact

Health Effects: blood, kidneys, liver

PPE: Respirator: At concentrations above the NIOSH REL, 0.002 mg/m^3 [15-minute]: (APF = 10,000) any self-contained breathing apparatus that has a full facepiece and is operated in a pressure-demand or other positive-pressure mode.

Skin: Frostbite; Prevent skin contact; Prevent possible skin freezing from direct liquid contact.

Eyes: Frostbite; Prevent contact. Use appropriate protection to prevent eye contact with the liquid.

Special Precautions: lung and lymphatic cancer; flammable gas

LABORATORY INFORMATION

CAS Number: 7784-42-1

Analytical Technique: detector tube

Analytical Reference Method: NA

SAMPLING INFORMATION

Grab Sampling:

Sampling Strategy: see Chapter 11

Collection Media: Dräger detector tube #CH25001, range 0.05 to 3.0 ppm (EF = 1.33).

Asbestos
(Fibers)

Contaminant Codes:	30 CFR §§56/57.5001(b) MSHA TLV:	30 CFR §§56/57.5001(b) MSHA STEL/Ceiling (C):
501	2.0 fibers/mL	10.0 fibers/mL - 15 min.

CONTAMINANT INFORMATION

Synonyms: actinolite, anthophyllite asbestos, chrysotile, crocidolite (riebeckite), amosite (cummingtonite-grunerite), and tremolite asbestos.

Sources: fireproofing, insulation, cement, commercial products, natural occurring mineral contaminant (can be found in serpentine, taconite wollastonite, vermiculite, some stone sand and gravels), depending on geology.

Description: fibrous; white or greenish (chrysotile), blue (crocidolite) or gray-green (amosite), odorless solid hydrated mineral silicates.

Incompatibilities: none reported

Exposure: inhalation, ingestion, clothing contamination

Health Effects: respiratory system; asbestosis, mesothelioma, lung cancer

PPE: Respirator: Recommendations: NIOSH, at concentrations above the NIOSH REL, which is 0.1 fiber per cubic centimeter of air (0.1 fiber/cc$^{)}$: (APF = 10,000) any self-contained breathing apparatus that has a full facepiece and is operated in a pressure-demand or other positive-pressure mode/(APF = 10,000) any supplied-air respirator that has a full facepiece and is operated in a pressure-demand or other positive-pressure mode in combination with an auxiliary self-contained positive-pressure breathing apparatus

Skin: Prevent skin contact, with a barrier that will prevent contamination from fibers.

Eyes: Prevent eye contact

Special Precautions: recognized human carcinogen

LABORATORY INFORMATION

CAS Numbers: Asbestos - 1332-21-4, Amosite - 12172-73-5, Chrysotile - 12001-29-5, Anthophyllite - 77536-67-5, Tremolite - 77536-68-6, Actinolite - 77536-66-4

Analytical Technique: Microscopy - Phase Contrast Microscope (PCM) for fibers unidentified, Transmission Electron Microscope (TEM) to confirm asbestos fiber minerology

Analytical Reference Method: Personal - NIOSH 7400 (PCM) & NIOSH 7402 (TEM)
Bulk Sample - OSHA 191, EPA 600/R93/116, EPA 600/M4-82-0

SAMPLING INFORMATION

Full Shift Sampling:

Sampling Strategy: see Chapter 8
Collection Media: 0.8 µm mixed cellulose ester (MCE) filter in 25 mm black cassette
Sample Flow Rate: 1.7 Lpm recommended
Air Collection Volume: Minimum - Maximum (L): 300 - 2400. [at least 200 recommended per consecutive sampling cassette.]

Short Term Sampling:

Sampling Strategy: see Chapter 8
Sample Duration: 15 - 30 minutes
Collection Media: 0.8 µm mixed cellulose ester (MCE) filter, 25 mm black cassette
Sample Flow Rate: 1.7 Lpm - 2.5 Lpm - up to maximum stable personal sampling pump capacity. [use lower range flow rates only in expected high fiber environments]

Grab Sampling:

Sampling Strategy: see Chapter 8
Collection Media: Bulk material or Core Sampler/Container, at least 1 to 10 grams.

Special Instructions: Ship in rigid container to MSHA Laboratory. Do not ship bulk and air samples together (contract laboratory analysis).

Use contaminant code 505 (no TLV) for unidentified fibers by PCM analysis only.
Use contaminant code 501 for asbestos identified fibers by TEM analysis.

Notes: For optimal filter loading without overloading, the initial flow rate setting or the sampling times may need to be adjusted. (See Chapter 8, V. Section F. 3., and 4.) Do not change pump flow rate after starting sampling sequence.

Barium (Soluble Compounds)

50 mg/m^3 IDLH (NIOSH, 1995)

Contaminant Codes:	1973 ACGIH TLV:	1973 ACGIH Excursion STEL/Ceiling (C):
641	0.5 mg/m^3 (500 µg/m^3)	1.5 mg/m^3 (1500 µg/m^3) - 15 min.
	(PEDS units of measure in parentheses)	

CONTAMINANT INFORMATION

Synonyms:	*soluble compounds* - barium carbonate, barium chlorate, barium cyanide, barium hydroxide, barium nitrate, barium oxide, barium perchlorate, barium permanganate, barium peroxide, barium sulfide
Sources:	electroplating, catalyst for organic reactions, barite and weathered ores, aluminum refining
Description:	appearance and odor varies by compound - soluble salts are white, green, or yellow powders, mostly alkaline
Incompatibilities:	varies by compound
Exposure:	inhalation, ingestion, skin and/or eye contact (caustic burns)
Health Effects:	eye and skin irritant, respiratory system, spasms, violent diarrhea/ vomiting, cardiac arrest
PPE: Respirator:	Varies by compound. e.g., respirator recommendations for barium nitrate: NIOSH/OSHA, Up to 5 mg/m^3, (APF=10) any dust and mist respirator except single-use and quarter-mask respirators
Skin:	Prevent skin contact; contact the manufacturer for recommendations.
Eyes:	Prevent eye contact.
Special Precautions:	Compounds may cause fire on contact with combustibles, containers may explode in fire

LABORATORY INFORMATION

CAS Numbers: Barium Nitrate - 10022-31-8

Analytical Technique: Inductively Coupled Plasma (ICP) 10022-31-8

Analytical Reference Method: OSHA ID 121

SAMPLING INFORMATION

Full Shift Sampling:

Sampling Strategy: see Chapter 7

Collection Media: 37 mm, 0.8 µm mixed cellulose ester (MCE) filter

Sample Flow Rate: usual sampling is 1.7 Lpm for up to 9 hrs.

Benzene - C_6H_6

500 ppm IDLH (NIOSH, 1995)

Contaminant Codes:	1973 ACGIH TLV:	1973 ACGIH Ceiling (C**):**
603	25 ppm (Skin)	25 ppm (C)

CONTAMINANT INFORMATION

Synonyms:	benzol, benzole, cyclohexatriene, phenyl hydride
Sources:	solvents, paint removers, gasoline
Description:	colorless liquid solvent; characteristic aromatic gasoline-like odor
Incompatibilities:	strong oxidizers, fluorides, perchlorates, nitric acid
Exposure:	inhalation, ingestion; 1973 TLV “Skin” notation - cutaneous, mucous membrane and eye absorption by direct contact.
Health Effects:	eye and skin irritant, respiratory system, blood, bone marrow, central nervous system, leukemia, carcinogen
PPE: Respirator:	Recommendations: NIOSH, at concentrations above the NIOSH REL, 0.1 ppm for 15 minutes: (APF = 10,000) any self-contained breathing apparatus that has a full facepiece and is operated in a pressure-demand or other positive-pressure mode
Skin:	Prevent skin contact; 8 hr: PVA, PE/EVAL, Barricade, CPF3, Responder, Tychem; 4 hr: Teflon, Viton
Eyes:	Prevent contact: goggles, safety glasses, face shield.
Special Precautions	Flammable liquid: vapor may explode if ignited; carcinogen

LABORATORY INFORMATION

CAS Number: 71-43-2

Analytical Technique: Gas Chromatograph (GC)/Flame Ionization Detector (FID)

Analytical Reference Method: OSHA 7/NIOSH 1501/3M

SAMPLING INFORMATION

Full Shift Sampling

Sampling Strategy: see Chapter 9

1. Collection Media: Passive monitor, 3M, 3500 series

Note: maximum 8-hour sample per badge

2. Collection Media: 100/50 mg: solid sorbent tube (coconut shell charcoal)

Sample Flow Rate: 0.01 - 0.2 Lpm, Must use a pump adaptor or arrange for low flow pumps.

Short Term Sampling:

Sampling Strategy: see Chapter 11

Collection Media: Dräger detector tube #6728561, range 0.5 -10 ppm (E.F. = 1.49)

Beryllium - Be

4 mg/m^3 (as Be) IDLH (NIOSH, 1995)

Contaminant Codes:	1973 ACGIH TLV:	1968 PA Rules STEL/Ceiling (C):
541 (dust)	0.002 mg/m^3 (2 µg/m^3)	0.025 mg/m^3 (25 µg/m^3) - 5 min.
709 (fumes)	0.002 mg/m^3 (2 µg/m^3)	0.025 mg/m^3 (25 µg/m^3) - 5 min.

(PEDS units of measure in parentheses)

CONTAMINANT INFORMATION

Synonyms: *beryllium*: beryllium metal, beryllium salts, glucinium
compounds: beryllium chloride, beryllium fluoride, beryllium nitrate, beryllium oxide, beryllium sulfate

Sources: hardening agent in alloys; ores of beryl, phenacite, chrysoberyl

Description: hard, brittle, gray-white metal

Incompatibilities: acids, caustics, chlorinated hydrocarbons, oxidizers, molten lithium

Exposure: inhalation, and/or eye contact, skin (depending on form)

Health Effects: eye and skin irritant, respiratory system, central nervous system, berylliosis.

PPE: Respirator: Recommendations: NIOSH, at concentrations above 0.0005 mg/m^3: (APF = 10,000) any self-contained breathing apparatus that has a full facepiece and is operated in a pressure-demand or other positive-pressure mode

Skin: Prevent contact; contact the manufacturer for recommendations

Eyes: Prevent contact

Special Precautions: Suspected carcinogen (National Toxicology Program); dust may explode if ignited in an enclosed area, poisonous gases released in fire

LABORATORY INFORMATION

CAS Number: 7440-41-7

Analytical Technique: Inductively Coupled Plasma (ICP)

Analytical Reference Method: MSHA P-3

SAMPLING INFORMATION

Full Shift Sampling:

Sampling Strategy: see Chapter 7

Collection Media: 37 mm, 0.8 µm mixed cellulose ester (MCE) filter

Sample Flow Rate: usual sampling is 1.7 Lpm for up to 9 hrs.

Short Term Sampling:
Sampling Strategy: see Chapter 7
Sample Duration: 30 min.
Collection Media: 37 mm, 0.8 µm mixed cellulose ester (MCE) filter
Sample Flow Rate: usual sampling is 1.7 Lpm

Wipe Sampling:
Sampling Strategy: see Chapter 14
Collection Media: Whatman Filter (41 or 42) or smear tabs, wetted with distilled water
Special Instructions: Seal wipe sample in plastic bag, jar, or vial.

Boron Oxide
2,000 mg/m^3 IDLH (NIOSH, 1995)

Contaminant Codes:	1973 ACGIH TLV:	1973 ACGIH Excursion STEL/Ceiling (C):
161	10.0 mg/m^3	20.0 mg/m^3 - 15 min.

CONTAMINANT INFORMATION

Synonyms: boracic acid anyhydride, boric anhydride, boric oxide, boron sesquioxide, boron trioxide, fused boric acid, orthoboric acid anhydride, sassolite
Sources: product of borax mines
Description: lumps of whitish, odorless crystals
Incompatabilities: water (reacts to form boric acid), hydroxide and carbonate solutions
Exposure: inhalation, ingestion, or eyes
Health Effects: irritates eyes, skin and respiratory system; circulatory collapse and heart fibrillation; affects central nervous system leading to convulsions and coma
PPE: Respirator: Recommendations: NIOSH, Up to 50 mg/m^3: (APF = 5) any dust and mist respirator
Skin: Prevent contact; contact the manufacturer for recommendations
Eyes: Prevent contact
Special Precautions: NA

LABORATORY INFORMATION

CAS Number: 1303-86-2
Analytical Technique: Inductively Coupled Plasma (ICP)
Analytical Reference Method: NIOSH 7300

SAMPLING INFORMATION

<u>Full Shift Sampling</u>:
Sampling Strategy: see Chapter 7
Collection Media: 37 mm, 0.8 µm mixed cellulose ester (MCE) filter
Sample Flow Rate: usual sampling is 1.7 Lpm for up to 9 hrs.

<u>Short Term Sampling</u>:
Sampling Strategy: see Chapter 7
Sampling Duration: 30 min.
Collection Media: 37 mm, 0.8 µm mixed cellulose ester (MCE) filter
Sample Flow Rate: usual sampling is 1.7 Lpm

<u>Special Instructions:</u> Submit samples to MSHA Laboratory (contract laboratory analysis).

Bromoform - $CHBr_3$

850 ppm IDLH (NIOSH, 1995)

Contaminant Codes:	1973 ACGIH TLV:	1973 ACGIH Excursion STEL/Ceiling (C):
995	0.5 ppm (Skin)	1.5 ppm - 15 min.

CONTAMINANT INFORMATION

Synonyms:	Methenyl tribromide, methyl tribromide, tribromomethane
Sources:	Separating minerals mixtures (process chemical)
Description:	Colorless to yellow liquid with chloroform-like odor
Incompatibilities:	Lithium, sodium, potassium, calcium, aluminum, zinc, magnesium, caustics
Exposure:	Inhalation, ingestion; 1973 TLV “Skin” notation - cutaneous, mucous membrane and eye absorption by direct contact.
Health Effects:	Central nervous system, respiratory system, liver, kidneys.
PPE: Respirator:	Recommendations: NIOSH/OSHA, Up to 12.5 ppm, (APF=25) Any supplied-air respirator operated in a continuous-flow mode/(APF=25) Any powered, air-purifying respirator with organic vapor cartridge(s)
Skin:	Prevent contact; 8 hr: PVA, Viton
Eyes:	Prevent contact
Special Precautions:	Store in the dark, decomposes when exposured to air and light producing **toxic and corrosive fumes including hydrogen bromide and bromine.**

LABORATORY INFORMATION

CAS Number: 75-25-2
Analytical Technique: Gas Chromatograph (GC)/Flame Ionization Detector (FID)
Analytical Reference Method: OSHA 7/NIOSH 1003/3M

SAMPLING INFORMATION

Full Shift Sampling:
Sampling Strategy: see Chapter 9
1. Collection Media: Passive monitor, 3M, 3500 series
Note: maximum 8-hour sample per badge
2. Collection Media: 100/50 mg: solid sorbent tube (coconut shell charcoal)
Sample Flow Rate: 0.01 - 0.2 Lpm, Must use a pump adaptor or arrange for low flow pumps.

BTEX (Profile)

Note: Profile sample when contaminants listed below are suspected. Analyses will quantify individual components. The results can be used for compliance with respective TLVs.

Organics Analyzed: Benzene, Toluene, Ethyl Benzene, Xylene

CONTAMINANT INFORMATION

See individual contaminants

LABORATORY INFORMATION

Analytical Technique: Gas Chromatograph (GC)/Flame Ionization Detector (FID)
Analytical Reference Method: OSHA 7/NIOSH 1501/3M

SAMPLING INFORMATION

Sampling Strategy: see Chapter 9
1. Collection Media: Passive monitor, 3M, 3500 series
Note: maximum 8-hour sample per badge
2. Collection Media: 100/50 mg: solid sorbent tube (coconut shell charcoal)
Sample Flow Rate: 0.01 - 0.2 Lpm, must use a pump adaptor or arrange for low flow pumps.

n-Butyl Acetate - $CH_3COO(CH_2)_3CH_3$
1,700 ppm IDLH (NIOSH, 1995),
based strictly on safety considerations (i.e., being 10% of the lower explosive limit of 1.7%)

Contaminant Codes:	1973 ACGIH TLV:	1973 ACGIH Excursion STEL/Ceiling (C):
995	150 ppm	187.5 ppm - 15 min.

CONTAMINANT INFORMATION

Synonyms:	Butyl acetate, butyl ethanoate, n-butyl ester of acetic acid
Sources:	Resins, lacquers, plastics
Description:	Colorless liquid, fruity odor
Incompatibilities:	Nitrates, strong oxidizers, alkalis (bases)
Exposure:	Inhalation, ingestion, skin and/or eye contact
Health Effects:	Eye and skin irritant, respiratory system, central nervous system
PPE: Respirator;	Recommendations: NIOSH/OSHA, Up to 1500 ppm: (APF = 10) any chemical cartridge respirator with organic vapor cartridge(s)
Skin:	Prevent contact; 8 hr: PE/EVAL, 4 hr: PVA, Teflon
Eyes:	Prevent contact
Special Precautions:	Vapor may explode if ignited in an enclosed area.

LABORATORY INFORMATION

CAS Number: 123-86- 4

Analytical Technique: Gas Chromatograph (GC)/Flame Ionization Detector (FID)

Analytical Reference Method: OSHA 7/NIOSH 1450/3M

SAMPLING INFORMATION

Full Shift Sampling:

Sampling Strategy: see Chapter 9

1. Collection Media: Passive monitor, 3M, 3500 series -

Note: maximum 8-hour sample per badge.

2. Collection Media: 100/50 mg or 400/200 mg: solid sorbent tube (coconut shell charcoal)

Sample Flow Rate: 100/50 mg: 0.01 - 0.2 Lpm; 400/200 mg: 0.05 - 0.2 Lpm. Must use a pump adaptor or arrange for low flow pumps.

Short Term Sampling:

Sampling Strategy: see Chapter 9

Sample Duration: 30 min.

Collection Media: 100/50 mg or 400/200 mg: solid sorbent tube (coconut shell charcoal)

Sample Flow Rate: 100/50 mg: 0.01 - 0.2 Lpm; 400/200 mg: 0.05 - 0.2 Lpm. Must use a pump adaptor or arrange for low flow pumps.

Special Instructions: Coordinate with Laboratory - Store and ship refrigerated.

n-Butyl Alcohol - $CH_3CH_2CH_2CH_2OH$

1,400 ppm IDLH (NIOSH, 1995),
based strictly on safety considerations (i.e., being 10% of the lower explosive limit of 1.4%)

Contaminant Codes:	1973 ACGIH TLV:	1973 ACGIH Excursion STEL/Ceiling (C):
245	100 ppm	150 ppm - 15 min.

CONTAMINANT INFORMATION

Synonyms: 1-butanol, butanol, butyl alcohol, butyric alcohol, butyl hydroxide, 1-hydroxybutane, NBA, n-butanol, n-propylcarbinol, propylcarbinol
Sources: solvents
Description: colorless liquid; strong, mildly, oily/alcoholic odor
Incompatibilities: strong oxidizers, mineral acids, alkali metals, halogens
Exposure: inhalation, absorption
Health Effects: respiratory system, central nervous system; eye and skin irritant (1999 TLV “Skin” notation - cutaneous, mucous membrane and eye absorption by direct contact).
PPE: Respirator: Recommendations: NIOSH, Up to 1400 ppm: (APF = 50) any chemical cartridge respirator with a full facepiece and organic vapor cartridge(s)
Skin: Prevent contact**;** 8 hr: Butyl, Teflon, Viton, PE/EVAL, Barricade, CPF3, Responder4 hr: Neoprene
Eyes: Prevent contact
Special Precautions: Protect eyes; Class IC flammable liquid, vapor may explode if ignited in an enclosed area.

LABORATORY INFORMATION

CAS Numbers: 71-36-3
Analytical Technique: Gas Chromatograph (GC)/Flame Ionization Detector (FID)
Analytical Reference Method: OSHA 7/NIOSH 1401/3M

SAMPLING INFORMATION

Full Shift Sampling:
Sampling Strategy: see Chapter 9
1. Collection Media: Passive monitor, 3M, 3500 series
Note: maximum 8-hour sample per badge
2. Collection Media: 100/50 mg or 400/200 mg: solid sorbent tube (coconut shell charcoal)
Sample Flow Rate: 100/50 mg: 0.01 - 0.2 Lpm, 400/200 mg: 0.05 - 0.2 Lpm, Must use a pump adaptor or arrange for low flow pumps.

Short Term Sampling:
Sampling Strategy: see Chapter 9
Sample Duration: 30 min.
Collection Media: 100/50 mg or 400/200 mg: solid sorbent tube (coconut shell charcoal)
Sample Flow Rate: 100/50 mg: 0.01 - 0.2 Lpm; 400/200 mg: 0.05 - 0.2 Lpm. Must use a pump adaptor or arrange for low flow pumps.

Special Instructions: Coordinate with Laboratory - Store in freezer and ship on ice.

sec-Butyl Alcohol - $CH_3CH(OH)CH_2CH_3$
2,000 ppm IDLH (NIOSH, 1995)

Contaminant Codes:	1973 ACGIH TLV:	1973 ACGIH Excursion STEL/Ceiling (C):
995	150 ppm	187.5 ppm - 15 min.

CONTAMINANT INFORMATION

Synonyms: 2-butanol, butylene hydrate, ethylmethyl carbinol, 2-hydroxybutane, methyl ethyl carbinol

Sources: Cleaning materials, paint removers, lacquer solvent

Description: Colorless liquid; strong, pleasant odor

Incompatibilities: Strong oxidizers, organic peroxides, perchloric & permonosulfuric acids

Exposure: Inhalation, ingestion, skin and/or eye contact

Health Effects: Eye and skin irritant, respiratory system, central nervous system

PPE: Respirator: Recommendations: NIOSH/OSHA, Up to 1000 ppm: (APF = 10) any chemical cartridge respirator with organic vapor cartridge(s)

Skin: Prevent contact; 8 hr: PE/EVAL, 4 hr: Butyl, Nitrile

Eyes: Prevent contact

Special Precautions: flammable, vapor may explode if ignited in an enclosed area

LABORATORY INFORMATION

CAS Number: 78-92-2

Analytical Technique: Gas Chromatograph (GC)/Flame Ionization Detector (FID)

Analytical Reference Method: OSHA 7/NIOSH 1401/3M

SAMPLING INFORMATION

Full Shift Sampling:

Sampling Strategy: see Chapter 9

1. Collection Media: Passive monitor, 3M, 3500 series

Note: maximum 8-hour sample per badge

2. Collection Media: 100/50 mg or 400/200 mg: solid sorbent tube (coconut shell charcoal)

Sample Flow Rate: 100/50 mg: 0.01 - 0.2 Lpm; 400/200 mg: 0.05 - 0.2 Lpm. Must use a pump adaptor or arrange for low flow pumps.

Special Instructions: Coordinate with Laboratory - Store in freezer and ship on ice.

tert-Butyl Alcohol - $(CH_3)_3COH$

1,600 ppm IDLH (NIOSH, 1995)

Contaminant Codes:	1973 ACGIH TLV:	1973 ACGIH Excursion STEL/Ceiling (C):
995	100 ppm	150 ppm - 15 min.

CONTAMINANT INFORMATION

Synonyms:	2-methyl-2-propanol, TBA, t-butinol, trimethyl carbinol
Sources:	Lacquers, chemical intermediates, paint remover, gasoline octane booster
Description:	Colorless crystal or liquid; strong, pleasant odor (camphor-like)
Incompatibilities:	Strong oxidizers, organic peroxides, perchloric & permonosulfuric acids
Exposure:	Inhalation, absorption, ingestion, skin and/or eye contact
Health Effects:	Eye and skin irritant, respiratory system, central nervous system (narcosis)
PPE: Respirator:	Recommendations: NIOSH/OSHA, Up to 1600 ppm: (APF = 50) any chemical cartridge respirator with a full facepiece and organic vapor cartridge(s)
Skin:	Prevent contact; 8 hr: Butyl, PE/EVAL, Responder
Eyes:	Prevent contact
Special Precautions:	Flammable, vapor may explode if ignited in an enclosed area

LABORATORY INFORMATION

CAS Number: 75-65-0

Analytical Technique: Gas Chromatograph (GC)/Flame Ionization Detector (FID)

Analytical Reference Method: OSHA 7/NIOSH 1400

SAMPLING INFORMATION

<u>Full Shift Sampling</u>:

Sampling Strategy: see Chapter 9

Collection Media: 100/50 mg: solid sorbent tube (coconut shell charcoal)

Sample Flow Rate: 100/50 mg: 0.01 - 0.2 Lpm, Must use a pump adaptor or arrange for low flow pumps.

<u>Short Term Sampling</u>:

Sampling Strategy: see Chapter 9

Sample Duration: 30 min.

Collection Media: 100/50 mg: solid sorbent tube (coconut shell charcoal)

Sample Flow Rate: 100/50 mg: 0.01 - 0.2 Lpm; Must use a pump adaptor or arrange for low flow pumps.

<u>Special Instructions</u>: Coordinate with Laboratory - Store in freezer and ship on ice.

Cadmium - Cd (metal dust and soluble salts)

9 mg/m^3 (as Cd) dust, IDLH (NIOSH, 1995)

Cadmium Oxide fume, as Cd

9 mg/m^3 (as Cd) fume, IDLH (NIOSH, 1995)

Contaminant Codes:	1973 ACGIH TLV:	ANSI Z37.5-1970 STEL/Ceiling (C):
623 (metal dust)	0.2 mg/m^3 (200 µg/m^3)	0.6 mg/m^3 (600 µg/m^3) - (C)
	(PEDS units of measure in parentheses)	

Contaminant Codes:	1973 ACGIH TLV:	1973 ACGIH Ceiling (C):
711 (oxide fume, as Cd)	0.1 mg/m^3 (100 µg/m^3)	0.1 mg/m^3 (100 µg/m^3) - (C)
	(PEDS units of measure in parentheses)	

CONTAMINANT INFORMATION

Synonyms: *Cadmium compounds*: cadmium acetate, cadmium bromide, cadmium chloride, cadmium cyanide, cadmium fluoroborate, cadmium nitrate, cadmium sulfate

Sources: Electroplating, solder for aluminum, deoxidizer in nickel plating, pigments in enamels, welding rods/electrodes, ores of zinc, greenockite (CdS), otavite ($CdCO_3$)

Description: Appearance and odor varies by elemental sulfur, selenium, & tellurium

Incompatibilities: Strong oxidizers; elemental sulfur, selenium & tellurium

Exposure: Inhalation (as fume or dust), ingestion

Health Effects: Respiratory system, kidneys, prostate, blood

PPE: Respirator: Recommendations: NIOSH, At concentrations above 9 mg/m^3 (as Cd): (APF = 10,000) any self-contained breathing apparatus that has a full facepiece and is operated in a pressure-demand or other positive-pressure mode

Skin: None specified

Eyes: None specified

Special Precautions: Carcinogen (National Toxicology Program); poisonous gases may be produced in fire

LABORATORY INFORMATION

CAS Numbers: 7440-43-9 (Cd), 1306-19-0 (CdO), 10325-94-7 (CdN_2O_6), 10108-64-2 ($CdCl_2$)

Analytical Technique: Inductively Coupled Plasma (ICP)

Analytical Reference Method: OSHA 121/125

SAMPLING INFORMATION

<u>Full Shift Sampling</u>:

Sampling Strategy: see Chapter 7

Collection Media: 37 mm, 0.8 µm mixed cellulose ester (MCE) filter

Sample Flow Rate: usual sampling is 1.7 Lpm for up to 9 hrs.

<u>Short Term Sampling</u>:

Sampling Strategy: see Chapter 7

Sample Duration: 15 min.

Collection Media: 37 mm, 0.8 µm mixed cellulose ester (MCE) filter

Sample Flow Rate: usual sampling is 1.7 Lpm

<u>Wipe Sampling</u>:

Sampling Strategy: see Chapter 14

Collection Media: Whatman Filter (41 or 42) or smear tabs, wetted with distilled water

Special Instructions: Seal wipe sample in plastic bag, jar, or vial.

Calcium Arsenate

5 mg/m^3 (as As) IDLH (NIOSH, 1995)

Contaminant Codes:	1973 ACGIH TLV:	1973 ACGIH Excursion STEL/Ceiling (C):
995 $Ca_3(AsO_4)_2$	1 mg/m^3	N/A

CONTAMINANT INFORMATION

Synonyms:	*Calcium arsenate* [$Ca_3(AsO_4)_2$]: Pencal, cucumber dust, Tricalcium arsenate, Tricalcium ortho-arsenate
Sources:	Insecticides, herbicides
Description:	Colorless to white, odorless powder
Incompatibilities:	None reported [Note: Produces toxic fumes of arsenic when heated to decomposition]
Exposure:	inhalation, ingestion, skin and/or eye contact
Health Effects:	Eye irritant, respiratory system, liver, skin, central nervous system, lymphatic system, lymphatic and lung cancer
PPE: Respirator:	Recommendations: NIOSH, At concentrations above 0.002 mg/m^3 [15-minute]: (APF = 10,000) any self-contained breathing apparatus that has a full facepiece and is operated in a pressure-demand or other positive-pressure mode
Skin:	Prevent contact; contact the manufacturer for recommendations.
Eyes:	Prevent contact
Special Precautions:	Potential occupational carcinogen

LABORATORY INFORMATION

CAS Numbers: 7778-44-1

Analytical Technique: Inductively Coupled Plasma (ICP)

Analytical Reference Method: OSHA 121/125

SAMPLING INFORMATION

Full Shift Sampling:

Sampling Strategy: see Chapter 7

Collection Media: 37 mm, 0.8 µm mixed cellulose ester (MCE) filter

Sample Flow Rate: usual sampling is 1.7 Lpm for up to 9 hrs.

Wipe Sampling:

Sampling Strategy: see Chapter 14

Collection Media: Whatman Filter (41 or 42) or smear tabs, wetted with distilled water

Special Instructions: Seal wipe sample in plastic bag, jar, or vial.

Calcium Carbonate - $CaCO_3$

Contaminant Codes:	**1973 ACGIH TLV:**	**STEL/Ceiling (C):**
121, 123 ($CaCO_3$)	10.0 mg/m^3	N/A
523 ($CaCO_3$)	10 mg/m^3	N/A
if respirable fraction >1% quartz	% SiO_2 + 2	

Calcium Oxide - CaO

25 mg/m^3 (CaO) IDLH (NIOSH, 1995)

Contaminant Codes:	1973 ACGIH TLV:	1968 PA Rules STEL/Ceiling (C):
451 (CaO)	5.0 mg/m^3	10.0 mg/m^3 - 30 min.

CONTAMINANT INFORMATION

Synonyms:	*calcium oxide* [CaO]: - lime, burnt lime, calx, quick lime. [Note: Cement kiln dust (CKD) is predominantly CaO.] *calcium carbonate* [$CaCO_3$]: - limestone, chalk, marble, dolomite, aragonite, calcite, calcidia, calcium salt, carbonic acid, citrical, Paris white
Sources:	Manufacture of mortar, lubricants, drilling fluids, manufacture of steel, aluminum and magnesium; calcium carbonate-occurs naturally as limestone, chalk, marble, dolomite, aragonite, calcite, and oyster shells
Description:	Appearance and odor varies by compound (crystalline gray solid; white microcrystalline powder; crystals, white or grayish white lumps; granular powder
Incompatibilities:	*$CaCO_3$* - Acids, alum, ammonium salts, mercury & hydrogen, fluorine, magnesium *CaO* - Water (liberates heat), fluorine, ethanol. [Note: Reacts with water to form calcium hydroxide.]
Exposure:	Inhalation, ingestion, skin and/or eye contact
Health Effects:	*CaO* **-** Eye and skin corrosive; respiratory system irritant
PPE: Respirator:	*$CaCO_3$* - suitable for nuisance dusts if <1% quartz, suitable for silica if respirable fraction >1% quartz; *CaO*- Respirator Recommendations: NIOSH, Up to 10 mg/m^3: (APF = 5) any dust and mist respirator; up to 20 mg/m^3: (APF = 10) any dust and mist respirator except single-use and quarter-mask respirators

Skin: *CaO* - Prevent contact. Use any barrier, including clothing, that will prevent contact with the chemical, especially on wet or moist skin; practice good personal hygiene by washing after exposure.
$CaCO_3$ - to be determined, based on working conditions

Eyes: *CaO* - Prevent contact by wearing safety glasses or goggles. Promptly remove foreign material from the eyes and follow up with a medical check.

Special Precautions: Calcium oxide is a noncombustible solid that will support combustion by the liberation of oxygen.

LABORATORY INFORMATION
CAS Numbers: 1305-78-8 (CaO), 1317-65-3 ($CaCO_3$)
Analytical Technique: Inductively Coupled Plasma (ICP)
Analytical Reference Method: MSHA P-3

SAMPLING INFORMATION
Full Shift Sampling:
Sampling Strategy: see Chapter 7
Collection Media: $CaCO_3$: use a pre-weighed, 37-mm diameter, 5-µm pore size polyvinyl chloride (PVC) filter;
CaO: Prefer to a use 37-mm diameter .8 micron methyl cellulose ester (MCE) filter to sample for CaO (as Ca). [Note: a 37-mm diameter, 5-µm pore size polyvinyl chloride (PVC) filter can be used if an MCE filter is not available.]
Sample Flow Rate: usual sampling is 1.7 Lpm for up to 9 hrs.

Short Term Sampling:
Sampling Strategy: see Chapter 7
Sample Duration: 30 min.
Collection Media: $CaCO_3$: use a pre-weighed, 37-mm diameter, 5-µm pore size polyvinyl chloride (PVC) filter;
CaO: Prefer to use a 37-mm diameter .8 micron methyl cellulose ester (MCE) filter to sample for CaO (as Ca). [Note: a 37-mm diameter, 5-µm pore size polyvinyl chloride (PVC) filter can be used if an MCE filter is not available.]
Sample Flow Rate: usual sampling is 1.7 Lpm

Special Instructions: It is not necessary to take bulk samples.

Carbon Dioxide - CO_2

40,000 ppm IDLH (NIOSH, 1995)

Contaminant Codes:	1973 ACGIH TLV:	1973 ACGIH Excursion STEL/Ceiling (C):
105	0.5 % (5000 ppm)	1.5 % - 15 min.

CONTAMINANT INFORMATION

Synonyms: Carbonic acid gas, carbonic anhydride, carbonic gas, dry ice

Sources: Lime kiln operations, propellant in aerosols, confined spaces, coke burning

Description: Colorless, odorless gas, faint acid taste

Incompatibilities: Strong oxidizers, acids, halogens, salts of silver & zinc

Exposure: Inhalation, skin and/or eye contact (freeze burns from dry ice or compressed gas)

Health Effects: Respiratory system, cardiovascular system

PPE: Respirator: Recommendations: NIOSH/OSHA, Up to 40,000 ppm: (APF = 10) any supplied-air respirator/(APF = 50) any self-contained breathing apparatus with a full facepiece

Skin: Prevent contact. Frostbite is possible from contact with liquid.

Eyes: Prevent contact. Freezing is possible from contact with liquid.

Special Precautions: Simple asphyxiant; containers may explode in fire; dusts of various metals, such as magnesium, zirconium, titanium, aluminum, chromium & manganese are ignitable and explosive when suspended in carbon dioxide

LABORATORY INFORMATION

CAS Number: 124-38-9

Analytical Technique: diffusion tube/detector tube/Gas Chromatograph (GC)

SAMPLING INFORMATION

Full Shift Sampling:

Sampling Strategy: see Chapter 11

Collection Media: Dräger diffusion tube #8101381

Note: up to 8 hours per tube. (EF = 1.41).

Grab Sampling:

1. Sampling Strategy: see Chapter 11

Collection Media: Dräger detector tube #CH23501, range 0.1% to 6% (EF = 1.17).

2. Sampling Strategy: see Chapter 12

Collection Media: Evacuated 50 mL gas-sampling bottle or 10 mL vacutainer (EF = 1.11).

Various electronic direct-reading instruments are available. Consult the manufacturer's instructions and specifications to determine suitability for particular contaminants.

Special Instructions: 14 day holding time for vacuum samples and 7 day hold time for vacutainers. Submit sample as soon as possible to MSHA Laboratory.

Carbon Disulfide - CS_2
500 ppm IDLH (NIOSH, 1995)

Contaminant Codes:	1973 ACGIH TLV:	1968 PA Rules STEL/Ceiling (C):
631	20 ppm (Skin)	100 ppm - 30 min.

CONTAMINANT INFORMATION

Synonyms: Carbon bisulfide, carbon disulphide

Sources: Solvent for industrial hygiene samples in laboratories; solvent for resins, rubber, oils; insecticides

Description: Colorless to faint yellow liquid, sweet ether-like odor

Incompatibilities: Strong oxidizers; chemically active metals (sodium, potassium, zinc); azides; rust; halogens; amines

Exposure: Inhalation, ingestion, 1973 TLV “Skin” notation - cutaneous, mucous membrane and eye absorption by direct contact.

Health Effects: Respiratory system, skin, eyes, kidneys, liver, central nervous system, peripheral nervous system, reproductive system

PPE: Respirator: Recommendations: NIOSH -Up to 10 ppm**:** (APF = 10) Any chemical cartridge respirator with organic vapor cartridge(s)

Skin: Prevent contact; 8 hr: PVA, Viton, PE/EVAL, Barricade, Responder, Trellchem, Tychem; 4 hr: Teflon

Eyes: Prevent contact

Special Precautions: Class IB flammable liquid, vapors can be easily ignited, for example, by ordinary light bulb

LABORATORY INFORMATION

CAS Number: 75-15-0

Analytical Technique: Detector tube

Analytical Reference Method: NA

SAMPLING INFORMATION

Grab Sampling:

Sampling Strategy: see Chapter 11

Collection Media: Dräger detector tube #6728351, range 5 - 60 ppm (EF = 1.25).

Carbon Monoxide - CO

1,200 ppm IDLH (NIOSH, 1995)

Contaminant Codes:	1973 ACGIH TLV:	1968 PA Rules STEL/Ceiling (C):
111	50 ppm	400 ppm - 15 min.

CONTAMINANT INFORMATION

Synonyms: Carbon oxide, exhaust gas, flue gas, monoxide

Sources: Incomplete combustion of organic fuels, vehicle exhaust

Description: Colorless, odorless gas

Incompatibilities: Strong oxidizers, bromine trifluoride, chlorine trifluoride, lithium

Exposure: Inhalation, skin and/or eye contact, freeze burns from compressed gas

Health Effects: Cardiovascular system, lungs, blood, central nervous system

PPE: Respirator: Recommendations: NIOSH **-** Up to 1200 ppm: (APF = 50) any air-purifying, full-facepiece respirator (gas mask) with a chin-style, front or back-mounted canister providing protection against the compound of concern

Skin: Prevent contact.

Eyes: Prevent contact.

Special Precautions: Poisonous gas; flammable gas, containers may explode in fire

LABORATORY INFORMATION

CAS Number: 630-08-0

Analytical Technique: Diffusion tube/detector tube/Gas Chromatograph (GC)/DRI

SAMPLING INFORMATION

Full Shift Sampling:

Sampling Strategy: see Chapter 11

Collection Media: Dräger diffusion tube #6733191; range 50-600 ppm (1 hour), 25-300 ppm (2 hours), 10-120 ppm (5 hours), 6-75 ppm (8 hours); **Note:** up to 8 hours per tube. (EF = 1.41).

Grab Sampling:

1. Sampling Strategy: see Chapter 11

Collection Media: Dräger detector tube #CH25601, range 5 - 700 ppm (EF = 1.25).

2. Sampling Strategy: see Chapter 12

Collection Media: Evacuated 50 mL gas-sampling vacuum bottle (EF = 1.11).

3. Sampling Strategy: see Chapter 13

Collection Media: Electronic Direct Reading Instrument - TMX410 or TMX412 (EF = 1.25).

Various other electronic direct-reading instruments are available. Consult the manufacturer's instructions and specifications to determine suitability for particular contaminants.

Special Instructions: 14 day holding time for vacuum samples. Submit sample as soon as possible to MSHA Laboratory.

Carbon Tetrachloride* - CCl_4

*** Restricted use chemical as per 30 CFR §§ 56/57.5006**

200 ppm IDLH (NIOSH, 1995)

Contaminant Codes:	1973 ACGIH TLV:	1973 ACGIH Excursion STEL/Ceiling (C):
601	10 ppm (Skin)	20 ppm - 15 min.

CONTAMINANT INFORMATION

Synonyms:	Carbon chloride, carbon tet, Freon® 10, Halon® 104
Sources:	Solvents for oils, lacquers, resins, degreasing and cleaning agents
Description:	Clear, colorless liquid; sweetish odor
Incompatibilities:	Chemically active metals (sodium, potassium, fluorine, Al, Mg)
Exposure:	Inhalation, ingestion; 1973 TLV “Skin” notation - cutaneous, mucous membrane and eye absorption by direct contact.
Health Effects:	Central nervous system, eyes, lungs, liver, kidneys, skin
PPE: Respirator:	Recommendations: NIOSH **-** At concentrations above 2 ppm [60 min.]: (APF = 10,000) any self-contained breathing apparatus that has a full facepiece and is operated in a pressure-demand or other positive-pressure mode
Skin:	Prevent contact. 8 hr: PVA, Viton, PE/EVAL, Barricade, Responder 4 hr: Teflon
Eyes:	Prevent contact
Special Precautions:	Carcinogen (National Toxicology Program); avoid skin contact; poisonous vapors

LABORATORY INFORMATION

CAS Number: 56-23-5

Analytical Technique: Gas Chromatograph (GC)/Flame Ionization Detector (FID)

Analytical Reference Method: OSHA 7/NIOSH 1003/3M

SAMPLING INFORMATION

Full Shift Sampling:

Sampling Strategy: see Chapter 9

1. Collection Media: Passive monitor, 3M, 3500 series-

Note: 8-hour max sample/badge

2. Collection Media: 100/50 mg: solid sorbent tube (coconut shell charcoal)

Sample Flow Rate: 100/50 mg: 0.01 - 0.2 Lpm, Must use a pump adaptor or arrange for low flow pumps .

Short Term Sampling:
Sampling Strategy: see Chapter 9
Sampling Duration: 30 min.
Collection Media: 100/50 mg: solid sorbent tube (coconut shell charcoal)
Sample Flow Rate: 100/50 mg: 0.01 - 0.2 Lpm, Must use a pump adaptor or arrange for low flow pumps.

Chlorine - Cl_2

10 ppm IDLH (NIOSH, 1995)

Contaminant Codes:	1973 ACGIH TLV:	1968 PA Rules STEL/Ceiling (C):
485	1 ppm	3 ppm - 5 min.

CONTAMINANT INFORMATION

Synonyms:	Molecular chlorine
Sources:	Metal fluxing, bleaching agent, detinning and dezincing iron
Description:	Amber liquid or greenish-yellow gas; characteristic irritating (suffocating) odor
Incompatibilities:	Reacts explosively or forms explosive compounds with many common substances such as acetylene, ether, turpentine, ammonia, fuel gas, hydrogen and finely divided metals**,** combustible substances, finely divided metals, oxides
Exposure:	Inhalation, skin and/or eye contact
Health Effects:	Burns to eyes, skin, respiratory system (including pulmonary edema)
PPE: Respirator:	Recommendations: NIOSH, Up to 5 ppm: (APF = 10) any chemical cartridge respirator with cartridge(s) providing protection against the compound of concern
Skin:	Prevent contact. Frostbite-possible skin/tissue freezing from direct liquid contact
Eyes:	Prevent contact.
Special Precautions:	Poisonous vapors; strong irritant; may cause fire on contact with combustibles

LABORATORY INFORMATION

CAS Number: 7782-50-5
Analytical Technique: detector tube
Analytical Reference Method: NA

SAMPLING INFORMATION

Full Shift Sampling:

Sampling Strategy: see Chapter 11
Collection Media: Drager diffusion tube #6728421, range 0.13 to 2.5 - Note: Up to 8 hrs per tube. **(EF=1.25)**.

Grab Sampling:

Sampling Strategy: see Chapter 11
Collection Media: Dräger detector tube CH24301, range 0.2 - 3 ppm (EF = 1.25).

Chlorine Dioxide - ClO_2
5 ppm IDLH (NIOSH, 1995)

Contaminant Codes:	1973 ACGIH TLV:	1973 ACGIH Excursion STEL/Ceiling (C):
995	0.1 ppm	0.3 ppm - 15 min.

CONTAMINANT INFORMATION

Synonyms:	Chlorine oxide, chlorine peroxide
Sources:	Bactericide, bleaching agent, deodorizer
Description:	Yellow to red gas or a red-brown liquid, unpleasant chlorine odor
Incompatibilities:	Organic materials, heat, phosphorus, potassium hydroxide, sulfur, mercury, carbon monoxide
Exposure:	Inhalation, ingestion, skin and/or eye contact
Health Effects:	Eye, skin, respiratory system (including pulmonary edema)
PPE: Respirator:	Recommendations: NIOSH/OSHA, Up to 5 ppm: (APF = 50) any chemical cartridge respirator with a full facepiece and cartridge(s) providing protection against the compound of concern
Skin:	Prevent contact (liquid); contact the manufacturer for recommendations
Eyes:	Prevent contact (liquid).
Special Precautions:	Flammable gas/combustible liquid, unstable in light, powerful oxidizer.

LABORATORY INFORMATION

CAS Number: 10049-04-4
Analytical Technique: Dräger: detector tube
Analytical Reference Method: Dräger

SAMPLING INFORMATION

Grab Sampling:
Sampling Strategy: see Chapter 11
Collection Media: Dräger detector tube CH24301, range 0.1 - 1.5 ppm (EF = 1.25).
***Note:** Chlorine dioxide is indicated with approximately twice the sensitivity as chlorine, therefore divide the reading for chlorine by 2 to get the ClO_2 reading.

Chloroform - $CHCl_3$

500 ppm IDLH (NIOSH, 1995)

Contaminant Codes:	1973 ACGIH TLV:	1973 ACGIH Excursion STEL/Ceiling (C):
661	50 ppm	75 ppm - 15 min.

CONTAMINANT INFORMATION

Synonyms:	Methane trichloride, trichloromethane
Sources:	Refrigerants, aerosol propellants, solvents, resins
Description:	Colorless liquid; pleasant, sweet odor
Incompatibilities:	Caustics, chemically active metals (aluminum, magnesium, sodium, potassium)
Exposure:	Inhalation, absorption, ingestion, skin and/or eye contact
Health Effects:	Liver, kidneys, heart, eyes, skin, central nervous system
PPE: Respirator:	Recommendations: NIOSH, At concentrations above 2 ppm [60-minute]: (APF = 10,000) Any self-contained breathing apparatus that has a full facepiece and is operated in a pressure-demand or other positive-pressure mode
Skin:	Prevent contact; 8 hr: PVA, Viton, PE/EVAL, Barricade, Responder, Trellchem, Tychem; 4 hr: Teflon
Eyes:	Prevent contact
Special Precautions:	Suspected carcinogen (National Toxicology Program); strong irritant; when heated to decomposition, forms phosgene gas.

LABORATORY INFORMATION

CAS Number: 67-66-3

Analytical Technique: Gas Chromatograph (GC) / Flame Ionization Detector (FID)

Analytical Reference Method: OSHA 5/NIOSH 1003/3M

SAMPLING INFORMATION

Full Shift Sampling:

Sampling Strategy: see Chapter 9

1. Collection Media: Passive monitor, 3M, 3500 series

Note: maximum 8-hour sample per badge

2. Collection Media: 100/50 mg: solid sorbent tube (coconut shell charcoal)

Sample Flow Rate: 100/50 mg: 0.01 - 0.2 Lpm, Must use a pump adaptor or arrange for low flow pumps.

Short Term Sampling:
Sampling Strategy: see Chapter 9
Sampling Duration: 30 min.
Collection Media: 100/50 mg: solid sorbent tube (coconut shell charcoal)
Sample Flow Rate: 100/50 mg: 0.01 - 0.2 Lpm, Must use a pump adaptor or arrange for low flow pumps.

Chromic Acid and Chromates as CrO_3

15 mg/m^3 as Chromium(VI) IDLH (NIOSH, 1995)

Contaminant Codes:	1973 ACGIH TLV:	1973 ACGIH Excursion STEL/Ceiling (C):
543 (chromic acid and chromate dusts as CrO_3)	0.1 mg/m^3 (100 $\mu g/m^3$)	0.3 mg/m^3 (300 $\mu g/m^3$) - 15 min.
713 (fumes, chromate)	0.1 mg/m^3 (100 $\mu g/m^3$)	0.3 mg/m^3 (300 $\mu g/m^3$) - 15 min.

(PEDS units of measure in parentheses)

CONTAMINANT INFORMATION

Synonyms: Buttercup yellow, chromic acid salts, chromic anhydride, chromium trioxide, dichromates, polychromates, zinc yellow

Sources: Pigments/paints, corrosion inhibitors, stainless steel welding; ores of chromates (lead chromate, crocoite)

Description: CrO_3: Dark-red, odorless flakes or powder**,** appearance and odor varies by compound

Incompatibilities: Combustible, organic or other readily-oxidized material, e.g. paper, wood

Exposure: Inhalation, ingestion, skin and/or eye contact

Health Effects: Blood, respiratory system, liver, kidneys, eyes, skin

PPE: Respirator: Recommendations: NIOSH, At concentrations above 0.001 mg/m^3 TWA: (APF = 10,000) Any self-contained breathing apparatus that has a full facepiece and is operated in a pressure-demand or other positive-pressure mode

Skin: Prevent contact; As Chromic Acid - 8 hr: PE, PVC, Saranex; 4 hr: Butyl, Viton

Eyes: Prevent contact

Special Precautions: Carcinogen (National Toxicology Program); avoid skin contact

LABORATORY INFORMATION

CAS Number: 1333-82-0 (CrO_3)

Analytical Technique: Colorimetric

Analytical Reference Method: NIOSH 7600

SAMPLING INFORMATION

Full Shift Sampling:

Sampling Strategy: see Chapter 7

Collection Media: 5 µm poly vinyl chloride (PVC) filter, 37 mm

Sample Flow Rate: usual sampling is 1.7 Lpm for up to 9 hrs.

Special Instructions: Place filter into a glass vial after sampling (stable for only two weeks). Submit sample as soon as possible to MSHA Laboratory.

Chromium, Soluble Chromic, Chromous Salts as Cr

250 mg/m^3 [as Cr(II)] IDLH (NIOSH, 1995)
25 mg/m^3 [as Cr(III)] IDLH (NIOSH, 1995)

Chromium, Metal and Insoluble Salts

250 mg/m^3 (as Cr) IDLH (NIOSH, 1995)

Contaminant Codes:	1973 ACGIH TLV:	1973 ACGIH Excursion STEL/Ceiling (C):
545 (chromium, soluble chromic, chromous salts as Cr)		
	0.5 mg/m^3 (500 µg/m^3)	1.5 mg/m^3 (1,500 µg/m^3) - 15 min.
	(PEDS units of measure in parentheses)	
547 (Cr, metal and insoluble salts)		
	1.0 mg/m^3	3.0 mg/m^3 - 15 min.

CONTAMINANT INFORMATION

Synonyms: Chromic acetate hexahydrate, chromic anhydride, chromic nitrate, chromic oxide, chromic sulfate, chromium trioxide

Sources: Stainless and alloy steels, electroplating, corrosion inhibitors, green paints, ores of crocoite (lead chromate), chromite

Description: Appearance and odor varies by compound (bright blue or green crystals)

Incompatibilities: Chromium: Strong oxidizers (such as hydrogen peroxide), alkalis (varies according to compound)

Exposure: Inhalation, ingestion, skin and/or eye contact

Health Effects: Blood, respiratory system, liver, kidneys, eyes, skin

PPE: Respirator: Recommendations: NIOSH, up to 2.5 mg/m^3: (APF = 5) Any dust and mist respirator;

Skin: For metal, determine based on working conditions; all others - prevent contact**;** contact the manufacturer for recommendations for the specific compound

Eyes: For metal, determine based on working conditions; all others - prevent contact

Special Precautions: Hexavalent chromium is a carcinogen (IARC); chromium is a noncombustible solid in bulk form, but finely divided dust burns rapidly if heated in a flame.

LABORATORY INFORMATION

CAS Number: 7440-47-3 (chromium - Cr)
Analytical Technique: Inductively Coupled Plasma (ICP)
Analytical Reference Method: MSHA P-3

SAMPLING INFORMATION

Full Shift Sampling:
Sampling Strategy: see Chapter 7
Collection Media: 37 mm, 0.8 µm mixed cellulose ester (MCE) filter
Sample Flow Rate: usual sampling is 1.7 Lpm for up to 9 hrs.

Wipe Sampling:
Sampling Strategy: see Chapter 14
Sampling Media: Whatman Filter (41 or 42) or smear tabs, wetted with distilled water

Coal Dust (bituminous)

Contaminant Codes:	**1973 ACGIH TLV, see page 34** **MSHA TLV:**
531 (respirable dust < 1% quartz)	2.0 mg/m^3
523 (respirable dust > 1% quartz)	use Quartz formula

CONTAMINANT INFORMATION

Synonyms:	Bituminous coal, cannel coal, coking coal, fat coal, flaming coal, gas coal, parrot coal, soft coal
Sources:	Fuel for coal-fired kilns, dryers, boilers, etc., at cement and lime plants or other coal-fired operations
Description:	Very fine dark-brown to black solid particles
Incompatibilities:	N/A
Exposure:	Inhalation
Health Effects:	Respiratory system disorders including pneumoconiosis (black lung).
PPE: Respirator:	Any that are suitable for nuisance dusts if <1% quartz or suitable for silica if respirable fraction >1% quartz;
Skin:	Determine based on working conditions
Eyes:	Determine based on working conditions
Special Precautions:	Combustible; fire or explosion hazard in the presence of open flame

***LABORATORY INFORMATION*:**

See DUST, RESPIRABLE

SAMPLING INFORMATION

Full Shift Sampling:

Sampling Strategy: see Chapter 5

Collection Media: cyclone and filter [10mm nylon cyclone and 37-mm diameter 5 µm poly vinyl chloride (PVC) filter]

Sample Flow Rate: 1.7 Lpm.

Coal Tar Pitch Volatiles (benzene soluble fraction)

Anthracene, BaP, Phenanthrene, Acridine, Chrysene, Pyrene

80 mg/m^3 IDLH (NIOSH, 1995)

Contaminant Codes:	1973 ACGIH TLV:	1973 ACGIH Excursion STEL/Ceiling (C):
995	0.2 mg/m^3 (200 µg/m^3)	0.6 mg/m^3 (600 µg/m^3)
	(PEDS units of measure in parentheses)	

CONTAMINANT INFORMATION

Synonyms:	Anthracin, coal tar creosote (vapors), creosote volatiles, green oil,
Sources:	Sealing of tanks, fabrication of charcoal briquets; distillation residues of coal, petroleum (less asphalt), and other organic matter
Description:	Acrid, smoky-tasting vapors from translucent brown to black, oily liquid (creosote), composed mainly of aromatic (benzene-related) hydrocarbons
Incompatibilities:	Strong oxidizers
Exposure:	Inhalation, ingestion, skin and eye absorption
Health Effects:	Central nervous system, respiratory difficulty, hypothermia; skin or eye irritation, bladder, kidneys, skin cancer
PPE: Respirator:	Recommendations: NIOSH, At concentrations above TWA 0.1 mg/m^3 for the cyclohexane-extractable fraction or at any detectable concentration: (APF = 10,000); any self-contained breathing apparatus that has a full facepiece and is operated in a pressure-demand or other positive-pressure mode
Skin:	Prevent contact; contact the manufacturer for recommendations
Eyes:	Prevent contact
Special Precautions:	Flammable; confirmed carcinogen (BaP and chrysene fractions); nitric oxide byproduct when acridine is heated

LABORATORY INFORMATION

CAS Number: 65996-93-2

Analytical Technique: Gravimetric

Analytical Reference Method: OSHA 58

SAMPLING INFORMATION

<u>Full Shift Sampling</u>:

Sampling Strategy: see Chapter 7

Collection Media: Glass fiber filter

Sample Flow Rate: Usual sampling is 1.7 Lpm for up to 9 hrs.

Special Instructions: Place filter into glass vial and wrap with aluminum foil to protect from light. Submit samples to MSHA Laboratory (contract laboratory analysis).

Cobalt

$20\ mg/m^3$ (as Co) IDLH (NIOSH, 1995)

Contaminant Codes:	1973 ACGIH TLV:	1968 PA Rules STEL/Ceiling (C):
649 (dust)	$0.1\ mg/m^3$ ($100\ \mu g/m^3$)	$0.5\ mg/m^3$ ($500\ \mu g/m^3$) - 30 min.
715 (metal fume)	$0.1\ mg/m^3$ ($100\ \mu g/m^3$)	$0.5\ mg/m^3$ ($500\ \mu g/m^3$) – 30 min.
	(PEDS units of measure in parentheses)	

CONTAMINANT INFORMATION

Synonyms:	Cobalt metal dust, cobalt metal fumes
Sources:	Alloys, carbides, paint, electroplating; ores of cobaltite, linnaeite, smaltite, erythrite
Description:	Fume or dust; odorless, silver-gray to black solid
Incompatibilities:	Strong oxidizers, ammonium nitrate
Exposure:	Inhalation, ingestion, skin or eye contact
Health Effects:	Skin, respiratory system
PPE: Respirator:	Recommendations: NIOSH, up to $0.25\ mg/m^3$: (APF = 5) any dust and mist respirator; up to $0.5\ mg/m^3$: (APF = 10); any dust and mist respirator except single-use and quarter-mask respirators.
Skin:	Prevent skin contact
Eyes:	Prevent eye contact
Special Precautions:	Noncombustible solid in bulk form, but finely divided dust will burn at high temperatures.

LABORATORY INFORMATION

CAS Number: 7440-48-4

Analytical Technique: Inductively Coupled Plasma (ICP)

Analytical Reference Method: MSHA P-3

SAMPLING INFORMATION

<u>Full Shift Sampling</u>:

Sampling Strategy: see Chapter 7

Collection Media: 37 mm, 0.8 µm mixed cellulose ester (MCE) filter

Sample Flow Rate: Usual sampling is 1.7 Lpm for up to 9 hrs.

Short Term Sampling:
Sampling Strategy: see Chapter 7
Sampling Duration: 30 min.
Collection Media: 37 mm, 0.8 µm mixed cellulose ester (MCE) filter
Sample Flow Rate: Usual sampling is 1.7 Lpm.

Wipe Sampling:
Sampling Strategy: see Chapter 14
Collection Media: Whatman Filter (41 or 42) or smear tabs, wetted with distilled water

Copper - Cu

100 mg/m^3 (as Cu) IDLH (NIOSH, 1995)

Contaminant Codes:	1973 ACGIH TLV:	1973 ACGIH Excursion STEL/Ceiling (C):
171 (dust, mist)	1.0 mg/m^3	3.0 mg/m^3 - 15 min.

Contaminant Codes:	1973 ACGIH TLV:	1968 PA Rules STEL/Ceiling (C):
717 (fume)	0.1 mg/m^3 (100μg/m^3)	0.1 mg/m^3 (100μg/m^3) - 30 min.
	(PEDS units of measure in parentheses)	

CONTAMINANT INFORMATION

Synonyms:	Copper metal dusts, copper metal fumes; CuO fume: black copper oxide fume, copper monoxide fume, copper(II) oxide fume, cupric oxide fume
Sources:	Welding of copper containing metals; ores of copper, lead, zinc, chalcopyrite, chalcocite, bornite, tetrahedrite, enargite,
Description:	*Dusts and mists*: reddish, lustrous, malleable, odorless solid; *Fumes*: finely divided black particulate dispersed in air
Incompatibilities:	*Dusts and mists*: oxidizers, alkalis, sodium azide, acetylene; *CuO fume*: acetylene, zirconium
Exposure:	*Dusts and mists*: inhalation, ingestion, skin and/or eye contact; *Fumes*: inhalation, skin and/or eye contact
Health Effects:	*Dusts and mists*: irritation eyes, nose, pharynx; nasal septum perforation; metallic taste; dermatitis; in animals: lung, liver, kidney damage; anemia. *Fumes*: irritation eyes, upper respiratory system; metal fume fever: chills, muscle ache, nausea, fever, dry throat, cough, weakness, lassitude (weakness, exhaustion); metallic or sweet taste; discoloration skin, hair
PPE: Respirator:	*Dusts and mists*: NIOSH/OSHA: Up to 5 mg/m^3: (APF = 5) any dust and mist respirator; up to 10 mg/m^3: (APF = 10) any dust and mist respirator except single-use and quarter-mask respirators (if not present as a fume); up to 25 mg/m^3: (APF = 25) any powered, air-purifying respirator with a dust and mist filter; up to 50 mg/m^3: (APF = 50) any air-purifying, full-facepiece respirator with a high-efficiency particulate filter. *Fumes*: NIOSH/OSHA: Up to 1 mg/m^3: (APF = 10) any dust, mist, and fume respirator; up to 2.5 mg/m^3: (APF = 25) any powered, air-purifying respirator with a dust, mist, and fume filter; up to 5 mg/m^3: (APF = 50) any air-purifying, full-facepiece respirator with a high-efficiency particulate filter; (APF = 50) any powered, air-purifying respirator with a tight-fitting facepiece and a high-efficiency particulate filter

Skin: *Dusts and mists*: Prevent skin contact; contact the manufacturer for recommendations; fumes: no specific recommendation can be made; actual working conditions will determine the need and type of personal protective equipment.
Eyes: *Dusts and mists*: Prevent eye contact; fumes: no recommendation is made specifying the need for eye protection
Special Precautions: *Dusts*: noncombustible solid in bulk form, but powdered form may ignite; *CuO fume*: noncombustible solid

LABORATORY INFORMATION
CAS Number: Dusts and mists: 7440-50-8; fumes: 1317-38-0 (CuO), 1317-39-1 (Cu_2O)
Analytical Technique: Inductively coupled argon plasma, atomic emission spectroscopy
Analytical Reference Method: MSHA P-3

SAMPLING INFORMATION
Full Shift Sampling:
Sampling Strategy: see Chapter 7
Collection Media: 37 mm, 0.8 µm mixed cellulose ester (MCE) filter
Sample Flow Rate: Usual sampling is 1.7 Lpm for up to 9 hrs.

Short Term Sampling:
Sampling Strategy: see Chapter 7
Sampling Duration: Dusts and mists: 15 min.; fumes: 30 min.
Collection Media: 37-mm diameter, 0.8 µm pore size mixed cellulose ester (MCE) filter
Sample Flow Rate: Usual sampling is 1.7 Lpm.

Wipe Sampling:
Sampling Strategy: see Chapter 14
Collection Media: Whatman Filter (41 or 42) or smear tabs, wetted with distilled water

Cresol (all isomers) - $CH_3C_6H_4OH$
250 ppm IDLH (NIOSH, 1995)

Contaminant Codes:	1973 ACGIH TLV:	1973 ACGIH Excursion STEL/Ceiling (C):
447	5.0 ppm (Skin)	10 ppm - 15 min.

CONTAMINANT INFORMATION

Synonyms: O-cresol: ortho-cresol, 2-cresol, o-cresylic acid, 1-hydroxy-2-methylbenzene, 2-hydroxytoluene, 2-methyl phenol;
m-cresol: meta-cresol, 3-cresol, m-cresylic acid, 1-hydroxy-3-methylbenzene, 3-hydroxytoluene, 3-methyl phenol
p-cresol: para-cresol, 4-cresol, p-cresylic acid, 1-hydroxy-4-methylbenzene, 4-hydroxytoluene, 4-methyl phenol

Sources: Flotation agent, industrial solvents, fumigants

Description: O-cresol: white crystals with a sweet, tarry odor;
m-cresol: colorless to yellowish liquid with a sweet, tarry odor;
p-cresol: crystalline solid with a sweet, tarry odor

Incompatibilities: Strong oxidizers, acids

Exposure: Inhalation, skin absorption, ingestion, skin and/or eye contact

Health Effects: Irritation eyes, skin, mucous membrane; central nervous system effects: confusion, depressant/depression, respiratory failure; dyspnea (breathing difficulty), irregular/irregularities rapid respiratory, weakness pulse; eye, skin burns; dermatitis; lung, liver, kidney, pancreas damage

PPE: Respirator: Recommendations: NIOSH **-** Up to 23 ppm: (APF = 10) any chemical cartridge respirator with organic vapor cartridge(s) in combination with a dust and mist filter**;** up to 57.5 ppm: (APF = 25) any powered, air-purifying respirator with organic vapor cartridge(s) in combination with a dust and mist filter; up to 115 ppm**:** (APF = 50) any chemical cartridge respirator with a full facepiece and organic vapor cartridge(s) in combination with a high-efficiency particulate filter; (APF = 50) any powered, air-purifying respirator with a tight-fitting facepiece and a high-efficiency particulate filter

Skin: Prevent skin contact; o-cresol: Contact the manufacturer for recommendations; m-cresol: 4 hr: Neoprene, Teflon; p-cresol: 4 hr: PE/EVAL

Eyes: Prevent eye contact

Special Precautions: O-cresol: combustible solid; Class IIIA combustible liquid
m-cresol: Class IIIA combustible liquid
p-cresol: Combustible solid; Class IIIA combustible liquid

LABORATORY INFORMATION

CAS Number: 1319-77-3 (all isomers), 95-48-7 (o-), 108-39-4 (m-), 106-44-05 (p-)
Analytical Technique: NIOSH 2546 (IV): gas chromatography / flame ionization detection
Analytical Reference Method: NIOSH 2546 (IV)

SAMPLING INFORMATION

Special Instructions: XAD-7 tube required for contract lab analysis; flow rate and volume dependent upon method used. Call MSHA Laboratory for sampling parameters.

Grab Sampling:
Sampling Strategy: see Chapter 11
Collection Media: Dräger detector tube #8101641, Phenol 1/b, range 1 - 20 ppm (EF = 1.25).
Note: Temperature range must be 10°- 30° C (50°- 86° F). Detector tube is responsive to both phenol (which has the same TLV) and cresols. To determine m-cresol, multiply the indication by 0.8. Benzene, toluene, and other aromatics without the hydroxyl group are not indicated. Aliphatic hydrocarbons are not indicated.

Cristobalite - SiO_2 (Respirable)

25 mg/m^3 IDLH (NIOSH, 1995)

Contaminant Codes:	1973 ACGIH TLV:	1973 ACGIH Excursion STEL/Ceiling (C):
525	5 mg/m^3 % SiO_2 + 2	N/A

CONTAMINANT INFORMATION

Synonyms: Silica, volcanic sand, calcined diatomite

Sources: Kilns, clay fire brick, volcanic rock containing silica (especially lavas of Colorado)

Description: Colorless, odorless solid

Incompatibilities: Powerful oxidizers (e.g., fluorine, chlorine, trifluoride, manganese trioxide, oxygen difluoride, hydrogen peroxide); acetylene; ammonia

Exposure: Inhalation, skin and/or eye contact

Health Effects: Cough, dyspnea (breathing difficulty), wheezing; decreased pulmonary function, progressive respiratory symptoms (silicosis); irritation eyes; [potential occupational carcinogen]

PPE: Respirator: Recommendations: NIOSH - Up to 0.5 mg/m^3: (APF = 10) any air-purifying respirator with a high-efficiency particulate filter; Up to 1.25 mg/m^3: (APF = 25) any powered, air-purifying respirator with a high-efficiency particulate filter; Up to 2.5 mg/m^3: (APF = 50) any air-purifying, full-facepiece respirator with a high-efficiency particulate filter; (APF = 50) any powered, air-purifying respirator with a tight-fitting facepiece and a high-efficiency particulate filter

Skin: No specific recommendation can be made; actual working conditions will determine the need and type of personal protective equipment

Eyes: No recommendation is made specifying the need for eye protection

Special Precautions: Noncombustible solid

LABORATORY INFORMATION

CAS Number: 14464-46-1**;** 14808_60_7

Analytical Technique: X-ray diffraction

Analytical Reference Method: MSHA P-2

SAMPLING INFORMATION

<u>Full Shift Sampling</u>:

Sampling Strategy: see Chapter 5

Collection Media: MSHA P-2

Sample Flow Rate: Minimum - Maximum (Lpm): 1.7

Cyanide - CN

25 mg/m^3 (as CN) IDLH (NIOSH, 1995)

Contaminant Codes:	1973 ACGIH TLV:	1968 PA Rules STEL/Ceiling (C):
419	5.0 mg/m^3 (Skin)	5.0 mg/m^3 - 30 min.

CONTAMINANT INFORMATION

Synonyms:	Hydrogen cyanide (HCN): formonitrile, hydrocyanic acid, prussic acid; potassium cyanide (KCN): potassium salt of hydrocyanic acid sodium cyanide (NaCN): sodium salt of hydrocyanic acid
Sources:	Extraction of gold and silver, electroplating, coppering, bronzing, hardening of metals, pest fumigation
Description:	HCN: colorless or pale-blue liquid or gas (above 78°F) with a bitter, almond-like odor KCN: white, granular or crystalline solid with a faint, almond-like odor NaCN: white, granular or crystalline solid with a faint, almond-like odor
Incompatibilities:	HCN: amines, oxidizers, acids, sodium hydroxide, calcium hydroxide, sodium carbonate, water, caustics, ammonia; [note: can polymerize at 122-140°F.] KCN: strong oxidizers (e.g., acids, acid salts, chlorates, nitrates) NaCN: strong oxidizers (e.g., acids, acid salts, chlorates, nitrates)
Exposure:	HCN: inhalation, skin absorption, ingestion, skin and/or eye contact KCN: inhalation, skin absorption, ingestion, skin and/or eye contact NaCN: inhalation, skin absorption, ingestion, skin and/or eye contact
Health Effects:	HCN: asphyxia; weakness, headache, confusion; nausea, vomiting; increased rate and depth of respiration or respiration slow and gasping; thyroid, blood changes KCN: irritation eyes, skin, upper respiratory system; asphyxia; weakness, headache, confusion; nausea, vomiting; increased respiratory rate, slow gasping respiratory; thyroid, blood changes NaCN: irritation eyes, skin; asphyxia; weakness, headache, confusion; nausea, vomiting; increased respiratory rate; slow gasping respiration; thyroid, blood changes
PPE: Respirator:	HCN: NIOSH - Up to 47 ppm (51.7 mg/m^3): (APF = 10) any supplied-air respirator KCN: NIOSH/OSHA - Up to 25 mg/m^3: (APF = 10) any supplied-air respirator; (APF = 50) any self-contained breathing apparatus with a full facepiece

NaCN: NIOSH/OSHA - Up to 25 mg/m^3: (APF = 10) any supplied-air respirator; (APF = 50) Any self-contained breathing apparatus with a full facepiece

Skin: HCN: Prevent skin contact; 8 hr: Teflon; 4 hr: PE/EVAL, Responder, Tychem
KCN: Prevent skin contact; (solution <30% only) 8 hr: PE
NaCN: Prevent skin contact; (solution >70% only) 8 hr: Saranex, Barricade

Eyes: HCN: Prevent eye contact
KCN: Prevent eye contact
NaCN: Prevent eye contact

Special Precautions: HCN: Class IA flammable liquid; flammable gas
KCN: noncombustible solid; contact with acids releases highly flammable hydrogen cyanide
NaCN: noncombustible solid; contact with acids releases highly flammable hydrogen cyanide

LABORATORY INFORMATION

CAS Numbers: 57-12-5 (CN); 74-90-8 (HCN); 151-50-8 (KCN); 143-33-9 (NaCN)
Analytical Technique: HCN, KCN, NaCN: NIOSH 7904 (IV) - Ion-Specific Electrode (ISE)
Analytical Reference Method: NIOSH 7904 (IV)

SAMPLING INFORMATION

Full Shift Sampling:
Sampling Strategy: see Chapters 6 & 7
Collection Media: 37-mm diameter, 0.8-µm pore size polyvinyl chloride (PVC) filter, followed by glass midget bubbler containing 15 mL 0.1 N KOH
Sample Flow Rate: Minimum - Maximum (Lpm): 0.5-1.0
Air Collection Volume: Minimum - Maximum (L): 10-180

Short Term Sampling:
Sampling Strategy: see Chapters 6 & 7
Sampling Duration: 30 min.
Collection Media: 37-mm diameter, 0.8-µm pore size polyvinyl chloride (PVC) filter, followed by glass midget bubbler containing 15 mL 0.1 N KOH
Sample Flow Rate: Minimum - Maximum (Lpm): 0.5-1.0
Air Collection Volume: Minimum - Maximum (L): 10-180

Special Instructions: Quantitatively transfer the contents of the bubbler to a 20-mL vial. Close cap tightly and wrap with plastic tape to avoid sample loss during transit. Overnight samples to MSHA Laboratory for analysis. Analyze within 5 days. Particulate on filter may liberate HCN gas.

Cyclohexanone - $C_6H_{10}O$

700 ppm IDLH (NIOSH, 1995)

Contaminant Codes:	1973 ACGIH TLV:	1973 ACGIH Excursion STEL/Ceiling (C):
265	50 ppm	75 ppm - 15 min.

CONTAMINANT INFORMATION

Synonyms: Anone, cyclohexyl ketone, pimelic ketone

Sources: Metal degreaser

Description: Water-white to pale-yellow liquid with a peppermint- or acetone-like odor

Incompatibilities: Oxidizers, nitric acid

Exposure: Inhalation, skin absorption, ingestion, skin and/or eye contact

Health Effects: Irritation eyes, skin, mucous membrane; headache; narcosis, coma; dermatitis; in animals: liver, kidney damage

PPE: Respirator: Recommendations - NIOSH: Up to 625 ppm: (APF = 25) any supplied-air respirator operated in a continuous-flow mode (note: substance causes eye irritation or damage; eye protection needed); (APF = 25) any powered, air-purifying respirator with organic vapor cartridge(s) (note: substance causes eye irritation or damage; eye protection needed); Up to 700 ppm: (APF = 50) any chemical cartridge respirator with a full facepiece and organic vapor cartridge(s); (APF = 50) any air-purifying, full-facepiece respirator (gas mask) with a chin-style, front- or back-mounted organic vapor canister; (APF = 50) any powered, air-purifying respirator with a tight-fitting facepiece and organic vapor cartridge(s) (note: substance causes eye irritation or damage; eye protection needed); (APF = 50) any self-contained breathing apparatus with a full facepiece; (APF = 50) any supplied-air respirator with a full facepiece

Skin: Prevent skin contact; 8 hr: Butyl, PE/EVAL; 4 hr: PVA

Eyes: Prevent eye contact

Special Precautions: Class IIIA combustible liquid

LABORATORY INFORMATION

CAS Number: 108-94-1

Analytical Technique: 3M: Passive monitor; NIOSH 1300 (IV): gas chromatography (GC) / flame ionization detection (FID); OSHA 1: gas chromatography (GC) / flame ionization detection (FID)

Analytical Reference Method: 3M; NIOSH 1300 (IV); OSHA 1

SAMPLING INFORMATION

Full Shift Sampling:

Sampling Strategy: see Chapter 9

1. Collection Media: Passive monitor, 3M, 3500 series

Note: maximum 8-hour sample per badge

2. Collection Media: NIOSH 1300 (IV): 100/50 mg: solid sorbent tube (coconut shell charcoal)

Sample Flow Rate: Minimum - Maximum (Lpm): 0.01-0.2 Lpm; Must use a pump adaptor or arrange for low flow pumps.

Air Collection Volume: Minimum - Maximum (L): 1-10

3. Collection Media: OSHA 1: Chromosorb 106

Sample Flow Rate: Minimum - Maximum (Lpm): 0.05-0.2 Lpm; Must use a pump adaptor or arrange for low flow pumps.

Air Collection Volume (L): 10

Short Term Sampling:

Sampling Strategy: see Chapter 9

Sampling Duration: 15 min.

1. Collection Media: NIOSH 1300 (IV): 100/50 mg: solid sorbent tube (coconut shell charcoal)

Sample Flow Rate: Minimum - Maximum (Lpm): 0.01-0.2 Lpm; Must use a pump adaptor or arrange for low flow pumps.

Air Collection Volume: Minimum - Maximum (L): 1-10

2. Collection Media: OSHA 1: Chromosorb 106

Sample Flow Rate: Minimum - Maximum (Lpm): 0.05-0.2 Lpm; Must use a pump adaptor or arrange for low flow pumps.

Air Collection Volume (L): 10

1,2-Dichloroethane - $ClCH_2CH_2Cl$
(Ethylene Dichloride)
50 ppm IDLH (NIOSH, 1995)

Contaminant Codes:	1973 ACGIH TLV:	1973 ACGIH Excursion STEL/Ceiling (C):
263	50 ppm	75 ppm - 15 min.

CONTAMINANT INFORMATION

Synonyms:	Glycol dichloride; ethylene dichloride
Sources:	Degreaser compounds
Description:	Colorless liquid with a pleasant, chloroform-like odor; [note: decomposes slowly, becomes acidic & darkens in color.]
Incompatibilities:	Strong oxidizers & caustics; chemically-active metals (e.g., magnesium or aluminum powder, sodium, potassium; liquid ammonia; [note: decomposes to vinyl chloride & HCl above 1112°F.]
Exposure:	Inhalation, ingestion, skin absorption, skin and/or eye contact
Health Effects:	Irritation eyes, corneal opacity; central nervous system depressant / depression; nausea, vomiting; dermatitis; liver, kidney, cardiovascular system damage; [potential occupational carcinogen]
PPE: Respirator:	Recommendations: NIOSH - At any detectable concentration: (APF = 10,000) any self-contained breathing apparatus that has a full facepiece and is operated in a pressure-demand or other positive-pressure mode; (APF = 10,000) any supplied-air respirator that has a full facepiece and is operated in a pressure-demand or other positive-pressure mode in combination with an auxiliary self-contained positive-pressure breathing apparatus
Skin:	Prevent skin contact; 8 hr: Teflon, Viton, PE/EVAL, Barricade, CPF3, Responder, Tychem; 4 hr: PVA
Eyes:	Prevent eye contact
Special Precautions:	Class IB flammable liquid

LABORATORY INFORMATION

CAS Number: 107-06-2

Analytical Technique: NIOSH 1003 (IV): gas chromatography (GC) / flame ionization detection (FID); **OSHA** 3: gas chromatography (GC) / electron capture detection (ECD); 3M: passive monitor

Analytical Reference Method: NIOSH 1003 (IV); OSHA 3; 3M

SAMPLING INFORMATION

Full Shift Sampling:

Sampling Strategy: see Chapter 9

1. Collection Media: NIOSH 1003 (IV): 100/50 mg: solid sorbent tube (coconut shell charcoal)

Sample Flow Rate: Minimum - Maximum (Lpm): 0.01-0.2 Lpm; Must use a pump adaptor or arrange for low flow pumps.

Air Collection Volume: Minimum - Maximum (L): 1-50

2. Collection Media: OSHA 3: 100/50 mg: solid sorbent tube (coconut shell charcoal)

Sample Flow Rate (Lpm): 0.2 Lpm; Must use a pump adaptor or arrange for low flow pumps.

Air Collection Volume (L): 10

3. Collection Media: 3M: Passive monitor, 3M, 3500 series

Note: Maximum 8-hour sample per badge

Short Term Sampling:

Sampling Strategy: see Chapter 9

Sampling Duration: 15 min.

1. Collection Media: NIOSH 1003 (IV): 100/50 mg: solid sorbent tube (coconut shell charcoal)

Sample Flow Rate: Minimum - Maximum (Lpm): 0.01-0.2 Lpm; Must use a pump adaptor or arrange for low flow pumps.

Air Collection Volume: Minimum - Maximum (L): 1-50

2. Collection Media: OSHA 3: 100/50 mg: solid sorbent tube (coconut shell charcoal)

Sample Flow Rate (Lpm): 0.2 Lpm; Must use a pump adaptor or arrange for low flow pumps.

Air Collection Volume (L): 10

Dust (Mineral), Respirable

Contaminant Codes:	1973 ACGIH TLV:	1973 ACGIH Excursion STEL/Ceiling (C):
523 (quartz dust, respirable fraction, > 1% quartz)	$\frac{10}{\%\ \text{resp quartz} + 2}$ mg/m^3	N/A
521 (quartz not analyzed)	N/A	N/A
131 (unlisted particulate, respirable fraction, < 1% quartz)	N/A	N/A
121 (listed nuisance dust, respirable fraction, < 1% quartz)	10 mg/m^3	N/A

CONTAMINANT INFORMATION

Description: Dust particulate less than 10 microns

Sources: Mining and mineral processing at operations producing materials containing silica

Exposure: Inhalation, skin and/or eye contact

Health Effects: Crystalline silica: cough, dyspnea (breathing difficulty), wheezing; decreased pulmonary function, progressive respiratory symptoms (silicosis); irritation eyes; [potential occupational carcinogen]

PPE: Respirator: Recommendations - NIOSH:
crystalline silica: Up to 0.5 mg/m^3: (APF = 10) any air-purifying respirator with a high-efficiency particulate filter; up to 1.25 mg/m^3: (APF = 25) any powered, air-purifying respirator with a high-efficiency particulate filter; up to 2.5 mg/m^3: (APF = 50) any air-purifying, full-facepiece respirator with a high-efficiency particulate filter; (APF = 50) any powered, air-purifying respirator with a tight-fitting facepiece and a high-efficiency particulate filter; up to 25 mg/m^3: (APF = 1000) any supplied-air respirator operated in a pressure-demand or other positive-pressure mode

Skin: No specific recommendation can be made; actual working conditions will determine the need and type of personal protective equipment

Eyes: No recommendation is made specifying the need for eye protection

Special Precautions: Noncombustible solid

LABORATORY INFORMATION
CAS Number: 14808-60-7 (quartz, crystalline silica)
Analytical Technique: X-ray diffraction spectrometry
Analytical Reference Method: MSHA P-2

SAMPLING INFORMATION
Full Shift Sampling:
Sampling Strategy: see Chapter 5
Collection Media: Cyclone and filter [10-mm nylon cyclone and pre-weighed 37-mm diameter, 5 µm pore size polyvinyl chloride (PVC) filter]
Sample Flow Rate (Lpm): 1.7

Dust, Total*

Contaminant Codes:	1973 ACGIH TLV:	1973 ACGIH Excursion STEL/Ceiling (C):
123 (listed nuisance dust, total particulate, < 1% quartz)	10 mg/m^3	N/A
133 (unlisted particulate, total particulate, < 1% quartz)	N/A	N/A

***Note: No quartz analysis performed.**

CONTAMINANT INFORMATION

Synonyms:	Nuisance dust; alundum (Al_2O_3), calcium carbonate, cellulose (paper fiber), portland cement, corundum (Al_2O_3); emery, glass [fibrous (<5-7 µm in diameter) or dust], glycerin mist, graphite (synthetic), gypsum, vegetable oil mists (except castor, cashew nut, or similar irritant oils), kaolin, limestone, magnesite, marble, pentaerythritol, plaster of Paris, rouge, silicon carbide, starch, sucrose, tin oxide, titanium dioxide
Sources:	Mining and mineral processing at operations producing materials contained in Appendix E of the ***TLVs® Threshold Limit Values for Chemical Substances in Workroom Air Adopted by the ACGIH for 1973***
Description:	When toxic impurities are not present (e.g. quartz < 1%), Appendix E listed contaminants include: alundum (Al_2O_3); calcium carbonate; cellulose (paper fiber); portland cement; corundum (Al_2O_3); emery; glass [fibrous (<5-7 µm in diameter) or dust]; glycerin mist; graphite (synthetic); gypsum; vegetable oil mists (except castor, cashew nut, or similar irritant oils); kaolin; limestone; magnesite; marble; pentaerythritol; plaster of Paris rouge; silicon carbide; starch; sucrose; tin oxide; and titanium dioxide
Incompatibilities:	N/A
Exposure:	Inhalation, skin and/or eye contact
Health Effects:	These dusts can cause significant toxic effects when inhaled in large quantities
PPE: Respirator:	Recommendations - Minimum N-95 if no oil particles are present in work environment minimum R-95 if oil particles are present

Skin: Portland cement: prevent contact. Use any barrier, including clothing, that will prevent contact with the chemical, especially on wet or moist skin; practice good personal hygiene by washing after exposure. For other substances, no specific recommendation can be made; actual working conditions will determine the need and type of personal protective equipment.

Eyes: Portland cement: wear safety glasses or goggles; remove foreign material promptly and follow up with medical check. For other substances, no specific recommendation is made regarding eye protection

Special Precautions: See above

LABORATORY INFORMATION

CAS Number: Varies according to contaminant

Analytical Technique: NIOSH 0500 (IV) [particulates not otherwise regulated, total]: gravimetric (filter weight)

Analytical Reference Method: MSHA P-19

SAMPLING INFORMATION

Full Shift Sampling:

Sampling Strategy: see Chapter 5

Collection Media: Filter [pre-weighed 37-mm diameter, 5 µm pore size polyvinyl chloride (PVC) filter, no cyclone]

Sample Flow Rate (Lpm): 1.7

Air Collection Volume: Dependent on dust levels and shift length see chapter 5.

Special Instructions: Under special circumstances and with laboratory permission, dust samples collected on the total dust PVC filters can be analyzed for metal elements.

Elemental Profile
(Metal Dusts and Fumes)

Metals Analyzed: Aluminum, arsenic, beryllium, cadmium, calcium, chromium, cobalt, copper, iron, lead, lithium, magnesium, manganese, molybdenum, nickel, phosphorus, platinum, selenium, silver, sodium, tellurium, thallium, titanium, vanadium, yttrium, zinc, zirconium

CONTAMINANT INFORMATION**:** Varies by element

LABORATORY INFORMATION

Analytical Technique: Inductively coupled argon plasma, atomic emission spectroscopy (ICAP-AES); NIOSH 7300 (IV).

Analytical Reference Method: MSHA P-3

SAMPLING INFORMATION

Full Shift Sampling:

Sampling Strategy: see Chapter 7

Collection Media: 37-mm diameter, 0.8-µm pore size mixed cellulose ester (MCE) filter

Sample Flow Rate (Lpm): 1.7

Air Collection Volume: Minimum - Maximum (L): varies by element

Special Instructions: Under special circumstances, the 37-mm diameter polyvinyl chloride (PVC) filter pre-weighed dust cassettes can be used. Contact Lab for permission. **Note**: There are 16 individual elements that can be selectively analyzed, however the standard profile is a 14-metal elemental profile that does not include aluminum and titanium.

Ethyl Acetate - $CH_3COOCH_2H_5$

2,000 ppm IDLH (NIOSH, 1995),

based strictly on safety considerations (i.e., being 10% of the lower explosive limit of 2.0%)

Contaminant Codes:	1973 ACGIH TLV:	1973 ACGIH Excursion STEL/Ceiling (C):
995	400 ppm	500 ppm - 15 min.

CONTAMINANT INFORMATION

Synonyms: Acetic ester, acetic ether, ethyl ester of acetic acid, ethyl ethanoate

Sources: Solvents

Description: Colorless liquid with an ether-like, fruity odor

Incompatibilities: Nitrates, strong oxidizers, alkalis & acids

Exposure: Inhalation, ingestion, skin and/or eye contact

Health Effects: Irritation eyes, skin, nose, throat; narcosis; dermatitis

PPE: Respirator: Recommendations - NIOSH/OSHA: Up to 2000 ppm: (APF = 25) any supplied-air respirator operated in a continuous-flow mode (note: substance causes eye irritation or damage, eye protection needed); (APF = 25) any powered, air-purifying respirator with organic vapor cartridge(s) (note: substance causes eye irritation or damage, eye protection needed); (APF = 50) any chemical cartridge respirator with a full facepiece and organic vapor cartridge(s); (APF = 50) any air-purifying, full-facepiece respirator (gas mask) with a chin-style, front- or back-mounted organic vapor canister; (APF = 50) any self-contained breathing apparatus with a full facepiece; (APF = 50) any supplied-air respirator with a full facepiece

Skin: Prevent skin contact; 8 hr: PE/EVAL, Barricade, CPF3, Responder, Trellchem, Tychem; 4 hr: PVA, Teflon

Eyes: Prevent eye contact

Special Precautions: Class IB flammable liquid

LABORATORY INFORMATION

CAS Number: 141-78-6

Analytical Technique: NIOSH 1457 (IV): gas chromatography (GC) / flame ionization detector (FID); **OSHA** 7: gas chromatography (GC) / flame ionization detector (FID); 3M: passive monitor

Analytical Reference Method: NIOSH 1457 (IV); OSHA 7; 3M

SAMPLING INFORMATION

Full Shift Sampling:

Sampling Strategy: see Chapter 9

1. Collection Media: NIOSH 1457 (IV): 100/50 mg: solid sorbent tube (coconut shell charcoal)

Sample Flow Rate: Minimum - Maximum (Lpm): 0.01-0.2 Lpm, Must use a pump adaptor or arrange for low flow pumps.

Air Collection Volume: Minimum - Maximum (L): 0.1-10

2. Collection Media: OSHA 7: 100/50 mg: solid sorbent tube (coconut shell charcoal)

Sample Flow Rate: Minimum - Maximum (Lpm): 0.01-0.2 Lpm, Must use a pump adaptor or arrange for low flow pumps.

Air Collection Volume (L): 6

3. Collection Media: 3M: Passive monitor, 3M, 3500 series

Note: maximum 8-hour sample per badge

Short Term Sampling:

Sampling Strategy: see Chapter 9

Sampling Duration: 15 min.

1. Collection Media: NIOSH 1457 (IV): 100/50 mg: solid sorbent tube (coconut shell charcoal)

Sample Flow Rate: Minimum - Maximum (Lpm): 0.01-0.2 Lpm, Must use a pump adaptor or arrange for low flow pumps.

Air Collection Volume: Minimum - Maximum (L): 0.1-10

2. Collection Media: OSHA 7: 100/50 mg: solid sorbent tube (coconut shell charcoal)

Sample Flow Rate: Minimum - Maximum (Lpm): 0.01-0.2 Lpm, Must use a pump adaptor or arrange for low flow pumps.

Air Collection Volume (L): 6

Special Instructions: Coordinate with Laboratory - Ship on ice; sample stable six days refrigerated. Overnight sample to MSHA laboratory.

Ethyl Alcohol - CH_3CH_2OH

3,300 ppm IDLH **(NIOSH**, 1995),

based strictly on safety considerations (i.e., being 10% of the lower explosive limit of 3.3%)

Contaminant Codes:	1973 ACGIH TLV:	1973 ACGIH Excursion STEL/Ceiling (C):
247	1000 ppm	1250 ppm - 15 min.

CONTAMINANT INFORMATION

Synonyms:	Alcohol, cologne spirit, ethanol, EtOH, grain alcohol
Sources:	Solvents
Description:	Clear, colorless liquid with a weak, ethereal, vinous odor
Incompatibilities:	Strong oxidizers, potassium dioxide, bromine pentafluoride, acetyl bromide, acetyl chloride, platinum, sodium
Exposure:	Inhalation, ingestion, skin and/or eye contact
Health Effects:	Irritation eyes, skin, nose; headache, drowsiness, fatigue, narcosis; cough; liver damage; anemia; reproductive, teratogenic effects
PPE: Respirator:	Recommendations - NIOSH/OSHA: Up to 3,300 ppm: (APF = 10) any supplied-air respirator; (APF = 50) any self-contained breathing apparatus with a full facepiece
Skin:	Prevent skin contact; 8 hr: Butyl, Viton, PE/EVAL; 4 hr: Neoprene, Teflon
Eyes:	Prevent eye contact
Special Precautions:	Class IB flammable liquid

LABORATORY INFORMATION

CAS Number: 64-17-5

Analytical Technique: NIOSH 1400 (IV): gas chromatography (GC) / flame ionization detector (FID); **OSHA** 100: gas chromatography (GC) / flame ionization detector (FID)

Reference Method: NIOSH 1400 (IV); OSHA 100

SAMPLING INFORMATION

Full Shift Sampling:

Sampling Strategy: see Chapter 9

1. Collection Media: NIOSH 1400 (IV): 100/50 mg: solid sorbent tube (coconut shell charcoal)

Sample Flow Rate: Minimum - Maximum (Lpm): 0.01-0.05 Lpm; Must use a pump adaptor or arrange for low flow pumps.

Air Collection Volume: Minimum - Maximum (L): 0.1-1

2. Collection Media: OSHA 100: 400/200 mg Anasorb 747
Sample Flow Rate (Lpm): 0.05 Lpm; Must use a pump adaptor or arrange for low flow pumps.
Air Collection Volume (L): 12

<u>Short Term Sampling</u>:
Sampling Strategy: see Chapter 9
Sampling Duration: 15 min.
1. Collection Media: NIOSH 1400 (IV): 100/50 mg: solid sorbent tube (coconut shell charcoal)
Sample Flow Rate: Minimum - Maximum (Lpm): 0.01-0.05 Lpm; Must use a pump adaptor or arrange for low flow pumps.
Air Collection Volume: Minimum - Maximum (L): 0.1-1
2. Collection Media: OSHA 100: 400/200 mg Anasorb 747
Sample Flow Rate (Lpm): 0.05 Lpm; Must use a pump adaptor or arrange for low flow pumps.
Air Collection Volume (L): 0.75

<u>Special Instructions</u>: Coordinate with MSHA Laboratory. Store in freezer and ship on ice.

Ethyl Benzene - $CH_3CH_2C_6H_5$

800 ppm IDLH (NIOSH, 1995),

based strictly on safety considerations (i.e., being 10% of the lower explosive limit of 0.8%)

Contaminant Codes:	1973 ACGIH TLV:	1973 ACGIH Excursion STEL/Ceiling (C):
267	100 ppm	150 ppm - 15 min.

CONTAMINANT INFORMATION

Synonyms:	Ethylbenzol, phenylethane
Sources:	Solvents
Description:	Colorless liquid with an aromatic odor
Incompatibilities:	Strong oxidizers
Exposure:	Inhalation, ingestion, skin and/or eye contact
Health Effects:	Irritation eyes, skin, mucous membrane; headache; dermatitis; narcosis, coma
PPE: Respirator:	Recommendations - NIOSH/OSHA: Up to 800 ppm: (APF = 10) any chemical cartridge respirator with organic vapor cartridge(s) (note: substance reported to cause eye irritation or damage, may require eye protection); (APF = 50) any air-purifying, full-facepiece respirator (gas mask) with a chin-style, front- or back-mounted organic vapor canister; (APF = 25) any powered, air-purifying respirator with organic vapor cartridge(s) (note: substance reported to cause eye irritation or damage; may require eye protection); (APF = 10) any supplied-air respirator (note: substance reported to cause eye irritation or damage; may require eye protection); (APF = 50) any self-contained breathing apparatus with a full facepiece
Skin:	Prevent skin contact; 8 hr: Viton, Barricade, Responder, Tychem; 4 hr: Teflon
Eyes:	Prevent eye contact
Special Precautions:	Class IB flammable liquid

LABORATORY INFORMATION

CAS Number: 100-41-4

Analytical Technique: NIOSH 1501 (IV): gas chromatography (GC) / flame ionization detector (FID); 3M: passive monitor

Analytical Reference Method: NIOSH 1501 (IV); 3M

SAMPLING INFORMATION

<u>Full Shift Sampling</u>:
Sampling Strategy: see Chapter 9
1. Collection Media: NIOSH 1501 (IV): 100/50 mg: solid sorbent tube (coconut shell charcoal)
Sample Flow Rate: Minimum - Maximum (Lpm): 0.01-0.2 Lpm; Must use a pump adaptor or arrange for low flow pumps.
Air Collection Volume: Minimum - Maximum (L): 1-24
2. Collection Media: 3M: Passive monitor, 3M, 3500 series
Note: maximum 8-hour sample per badge

<u>Short Term Sampling</u>:
Sampling Strategy: see Chapter 9
Sampling Duration: 15 min.
Collection Media: NIOSH 1501 (IV): 100/50 mg: solid sorbent tube (coconut shell charcoal)
Sample Flow Rate: Minimum - Maximum (Lpm): 0.01-0.2 Lpm; Must use a pump adaptor or arrange for low flow pumps.
Air Collection Volume: Minimum - Maximum (L): 1-24

Fluorine - F_2

25 ppm IDLH (NIOSH, 1995)

Fluorides (as F)

250 ppm (as F) IDLH (NIOSH, 1995)

Contaminant Codes:	1973 ACGIH TLV:	1968 PA Rules STEL/Ceiling (C):
487 (F_2, fluorine gas)	1.0 ppm	0.5 ppm - 5 min.
719 (fluoride fume)	2.5 mg/m^3	10.0 mg/m^3 - 30 min.
417 (fluoride dust, as F)	2.5 mg/m^3	10.0 mg/m^3 - 30 min.

CONTAMINANT INFORMATION

Synonyms: Fluorine gas (F_2): fluorine-19

Sources: Fluoride dust: metallic ores & mining of fluorspar, florspar, apatite
fluoride fume: welding fumes (flux emissions)

Description: Fluorine gas: pale-yellow to greenish gas with a pungent, irritating odor

Incompatibilities: Fluorine gas: water, nitric acid, oxidizers, organic compounds; [note: reacts violently with all combustible materials, except the metal containers in which it is shipped; reacts with H_2O to form hydrofluoric acid.]

Exposure: Fluorine gas: inhalation, skin and/or eye contact

Health Effects: Fluorine gas: irritation eyes, nose, respiratory system; laryngeal spasm, bronchitis spasm; pulmonary edema; eye, skin burns; in animals: liver, kidney damage

PE: Respirator: Recommendations - NIOSH/OSHA: Up to 1 ppm: (APF = 10) any supplied-air respirator (note: substance reported to cause eye irritation or damage; may require eye protection); up to 2.5 ppm: (APF = 25) any supplied-air respirator operated in a continuous-flow mode (note: substance reported to cause eye irritation or damage; may require eye protection); up to 5 ppm: (APF = 50) any self-contained breathing apparatus with a full facepiece; (APF = 50) any supplied-air respirator with a full facepiece; up to 25 ppm: (APF = 2000) any supplied-air respirator that has a full facepiece and is operated in a pressure-demand or other positive-pressure mode

Skin: Fluorine: Prevent skin contact (liquid); 8 hr: Barricade, Responder

Eyes: Fluorine: Prevent eye contact (liquid)

Special Precautions: Fluorine gas: nonflammable gas, but an extremely strong oxidizer

LABORATORY INFORMATION

CAS Number: 7782-41-4 (fluorine gas as F_2); 7664-39-3 (fluoride as HF)

Analytical Technique: NIOSH 7902 (IV) [fluorides, aerosol and gas]: ion-specific electrode (ISE); Dräger: detector tube

Analytical Reference Method: NIOSH 7902 (IV) [fluorides as F, aerosol and gas]; Dräger

SAMPLING INFORMATION

Full Shift Sampling:

Sampling Strategy: see Chapter 9

Collection Media: Fluorides, aerosol and gas: filter and treated pad [37-mm diameter, 0.8-µm pore size mixed cellulose ester (MCE) filter with Na_2CO_3-treated cellulose pad]

Sample Flow Rate (Lpm): 1.7

Air Collection Volume: Minimum - Maximum (L): 12-800

Short Term Sampling:

Sampling Strategy: see Chapter 9

Sampling Duration: F_2, fluorine gas: 15 min.; fluoride fume, fluoride dust: 30 min.

Collection Media: Fluorides, aerosol and gas: filter and treated pad [37-mm diameter, 0.8-µm pore size mixed cellulose ester (MCE) filter with Na_2CO_3-treated cellulose pad]

Sample Flow Rate (Lpm): 1.7

Air Collection Volume: Minimum - Maximum (L): 12-800

Special Instructions: For total and gaseous forms, a treated filter is required. Contact MSHA Laboratory for media and sampling instructions.

Grab Sampling:

Sampling Strategy: see Chapter 11

Collection Media: fluorine: Dräger detector tube, #8101491, range 0.05-40 ppm (EF = 1.33)

Formaldehyde - HCHO

20 ppm IDLH (NIOSH, 1995)

Contaminant Codes:	1973 ACGIH TLV:	1973 ACGIH Excursion STEL/Ceiling (**C):**
441	2.0 ppm	2.0 ppm (C)

CONTAMINANT INFORMATION

Synonyms:	Methanal, methyl aldehyde, methylene oxide, formalin (aqueous 30-60% w/v formaldehyde), formic aldehyde
Sources:	Adhesives, disinfectants, carpet off-gassing, rosin-core soldering
Description:	Nearly colorless gas with a pungent, suffocating odor
Incompatibilities:	Strong oxidizers, alkalis & acids; phenols; urea; [note: pure formaldehyde has a tendency to polymerize; reacts with HCl to form bis-Chloromethyl ether.]
Exposure:	Inhalation, skin and/or eye contact
Health Effects:	Irritation eyes, nose, throat, respiratory system; lacrimation (discharge of tears); cough; bronchitis spasm; [potential occupational carcinogen]
PPE: Respirator:	Recommendations - NIOSH: At any detectable concentration: (APF = 10,000) any self-contained breathing apparatus that has a full facepiece and is operated in a pressure-demand or other positive-pressure mode; (APF = 10,000) any supplied-air respirator that has a full facepiece and is operated in a pressure-demand or other positive-pressure mode in combination with an auxiliary self-contained positive-pressure breathing apparatus
Skin:	Formaldehyde: Prevent skin contact; contact the manufacturer for recommendations. Formalin: Prevent skin contact; 8 hr: Butyl, Nitrile, Viton, Saranex, Barricade, CPF3; 4 hr: Teflon, PE/EVAL, Responder
Eyes:	Prevent eye contact
Special Precautions:	Flammable gas

LABORATORY INFORMATION

CAS Number: 50-00-0

Analytical Technique: NIOSH 2016 (IV): high-pressure liquid chromatography (HPLC) / ultraviolet detection (UVD); NIOSH 2541 (IV): gas chromatography (GC) / flame ionization detection (FID); NIOSH 3500 (IV): visible absorption spectrometry; 3M: passive monitor / OSHA ID-205: visible absorption spectrometry (UV spectrophotometer at 580 nm); Dräger: detector tube

Analytical Reference Method: NIOSH 2016 (IV); NIOSH 2541 (IV); NIOSH 3500 (IV); 3M / OSHA ID-205; Dräger

SAMPLING INFORMATION

Full Shift Sampling:

Sampling Strategy: see Chapter 9

Collection Media:

1. NIOSH 2016 (IV): 2,4-dinitrophenylhydrazine (DNPH)-coated silica gel tube [i.e., plastic holder containing 0.35 g of 500-1000 µm silica gel coated with 0.9 mg DNPH];

2. NIOSH 2541 (IV): Solid sorbent tube [i.e., 120/60 mg 10% 2-(hydroxymethyl) piperidine-coated XAD-2]

3. NIOSH 3500 (IV): Filter + impingers [i.e., 37-mm diameter, 1-3-µm pore size polytetrafluoroethylene (PTFE) filter, followed by 2 midget impingers (each containing 20 mL 1% sodium bisulfite solution)]

4. 3M / OSHA ID-205: Passive monitor, 3M, 3721 [bisulfite impregnated paper]

Note: monitor has 18-month shelf life when stored at room temperature and in an environment free of formaldehyde; maximum 8-hour sample per badge

Sample Flow Rate: Minimum - Maximum (Lpm):

1. NIOSH 2016 (IV): 0.1-1.5

2. NIOSH 2541 (IV): 0.01-0.10; Must use a pump adaptor or arrange for low flow pumps.

3. NIOSH 3500 (IV): 0.2-1

Air Collection Volume: Minimum - Maximum (L):

1. NIOSH 2016 (IV): 1-15

2. NIOSH 2541 (IV): 1-36

3. NIOSH 3500 (IV): 1-100

Short Term Sampling:

Sampling Strategy: see Chapter 9.

Sampling Duration: 15 min.

Collection Media:

1. NIOSH 2016 (IV): 2,4-dinitrophenylhydrazine (DNPH)-coated silica gel tube [i.e., plastic holder containing 0.35 g of 500-1000 µm silica gel coated with 0.9 mg DNPH];

2. NIOSH 2541 (IV): solid sorbent tube [i.e., 120/60 mg 10% 2-(hydroxymethyl) piperidine-coated XAD-2]

3. NIOSH 3500 (IV): Filter + impingers [i.e., 37-mm diameter, 1-3-µm pore size polytetrafluoroethylene (PTFE) filter, followed by 2 midget impingers (each containing 20 mL 1% sodium bisulfite solution)]
Sample Flow Rate: Minimum - Maximum (Lpm):
1. NIOSH 2016 (IV): 0.1-1.5
2. NIOSH 2541 (IV): 0.01-0.10 Lpm, Must use a pump adaptor or arrange for low flow pumps.
3. NIOSH 3500 (IV): 0.2-1
Air Collection Volume: Minimum - Maximum (L):
1. NIOSH 2016 (IV): 1-15
2. NIOSH 2541 (IV): 1-36
3. NIOSH 3500 (IV): 1-100

Special Instructions:
1. NIOSH 2016 (IV): Coordinate with MSHA laboratory. Ship on ice via overnight express carrier. Samples are stable for 14 days at 4^{o}C.
2. NIOSH 2541 (IV): N/A
3. NIOSH 3500 (IV): Coordinate with MSHA laboratory. Transfer samples to low-density polyethylene bottles before shipping.

Grab Sampling:
Sampling Strategy: see Chapter 11
Collection Media: Dräger detector tube, #6733081, range 0.04-25 ppm (EF = 1.49).

Gas (Profile)

Gases Analyzed: Carbon Monoxide*, Carbon Dioxide**,** Oxygen, Methane and Nitrogen Dioxide

CONTAMINANT INFORMATION
see individual contaminants

LABORATORY INFORMATION
CAS Number: see individual contaminants
Analytical Technique: Gas Chromatography (GC)/DRI
Analytical Reference Method: Gas Chromatography

SAMPLING INFORMATION
Grab Sampling:
Sampling Strategy: See chapter 12
Collection Media: 50 mL vacuum bottle or 10 mL vacutainer (EF = 1.11).
* **Note:** for inclusion of carbon monoxide, use 50 mL vacuum bottle
Sample Flow Rate: Minimum - Maximum (Lpm): N/A
Air Collection Volume: Minimum - Maximum (L): 10 mL - 50 mL

Grab Sampling:
Sampling Strategy: see Chapter 13
Collection Media: Direct Reading Instrument TMX412 (EF = 1.25): for carbon monoxide (CO), oxygen (O_2), nitrogen dioxide (NO_2), sulfur dioxide (SO_2), methane (CH_4/combustibles - LEL%).
Various other electronic direct-reading instruments are available. Consult the manufacturer's instructions and specifications to determine suitability for particular contaminants.

Special Instructions:
There is a 14-day holding time for vacuum samples and a 7-day hold time for vacutainers. Submit sample as soon as possible to MSHA laboratory.

Gasoline

Contaminant Codes: TLVs: STEL/Ceiling (C):

**** NOTE:** Lab must perform qualitative analysis first to determine the applicable TLV according to analytically determined composition.

CONTAMINANT INFORMATION

Synonyms: Motor fuel, motor spirits, natural gasoline, petrol
Sources: Fuel, diluent, solvent
Description: Clear liquid with a characteristic odor
Incompatibilities: Strong oxidizers (e.g., peroxides, nitric acid, perchlorates)
Exposure: Inhalation, skin absorption, ingestion, skin and/or eye contact
Health Effects: Irritation eyes, skin, mucous membrane; dermatitis; headache, fatigue, blurred vision, dizziness, slurred speech, confusion, convulsions; chemical pneumonia (aspiration of liquid); possible liver, kidney damage; [potential occupational carcinogen]
PPE: Respirator: Recommendations - NIOSH: At any detectable concentration: (APF = 10,000) any self-contained breathing apparatus that has a full facepiece and is operated in a pressure-demand or other positive-pressure mode; (APF = 10,000) any supplied-air respirator that has a full facepiece and is operated in a pressure-demand or other positive-pressure mode in combination with an auxiliary self-contained positive-pressure breathing apparatus
Skin: Prevent skin contact; 8 hr: Nitrile, Viton, Barricade;
4 hr: PVA, PE/EVAL, Responder
Eyes: Prevent eye contact
Special Precautions: Class IB flammable liquid

LABORATORY INFORMATION

CAS Number: 8006-61-9
Analytical Technique: NIOSH 1550 (IV): gas chromatography (GC) / flame ionization detector (FID); 3M: passive monitor
Analytical Reference Method: NIOSH 1550 (IV); 3M

SAMPLING INFORMATION

Full Shift Sampling:
Sampling Strategy: see Chapter 9
1. Collection Media: 100/50 mg: solid sorbent tube (coconut shell charcoal)
Sample Flow Rate: Minimum - Maximum (Lpm): 0.01-0.2, Must use a pump adaptor or arrange for low flow pumps.
Air Collection Volume: Minimum - Maximum (L): 1.3-20
2. Collection Media: Passive monitor, 3M, 3500 series
Note: Maximum 8-hour sample per badge.

Short Term Sampling:
Sampling Strategy: see Chapter 9
Sampling Duration: 30 min.
Collection Media: 100/50 mg: solid sorbent tube (coconut shell charcoal)
Sample Flow Rate: Minimum - Maximum (Lpm): 0.01-0.2, Must use a pump adaptor or arrange for low flow pumps.
Air Collection Volume: Minimum - Maximum (L): 1.3-20

Special Instructions: Samples are stable for only one week at room temperature. Ship samples to MSHA laboratory via overnight carrier.

Graphite (natural) - C
1,250 mg/m^3 (as C) IDLH (NIOSH, 1995)

Contaminant Codes:	1973 ACGIH TLV:	1973 ACGIH Excursion STEL/Ceiling (C):
517 (< 1 % quartz)	15 mppcf (1.9 mg/m^3)	30 mppcf (3.8 mg/m^3) - 15 min.
	(PEDS “screening” units of measure in parentheses)	

CONTAMINANT INFORMATION

Synonyms:	Black lead, mineral carbon, plumbago, silver graphite, stove black
Sources:	Graphite mines or processing plants, lubricants, polishing compounds, electroplating
Description:	Steel gray to black, greasy feeling, odorless solid
Incompatibilities:	Very strong oxidizers (*e.g.*, fluorine, chlorine trifluoride, potassium peroxide)
Exposure:	Inhalation, skin and/or eye contact
Health Effects:	cough, dyspnea (breathing difficulty), black sputum, decreased pulmonary function, lung fibrosis
PPE: Respirator:	Recommendations - NIOSH: Up to 12.5 mg/m^3: (APF = 5) any dust respirator; up to 25 mg/m^3: (APF = 10) any dust respirator except single-use and quarter-mask respirators/(APF = 10) any supplied-air respirator; up to 62.5 mg/m^3: (APF = 25) any powered, air-purifying respirator with a dust filter; (APF = 25) any supplied-air respirator operated in a continuous-flow mode; up to 125 mg/m^3: (APF = 50) any air-purifying, full-facepiece respirator with a high-efficiency particulate filter; (APF = 50) any powered, air-purifying respirator with a tight-fitting facepiece and a high-efficiency particulate filter; (APF = 50) any supplied-air respirator that has a tight-fitting facepiece and is operated in a continuous-flow mode; (APF = 50) any self-contained breathing apparatus with a full facepiece; (APF = 50) any supplied-air respirator with a full facepiece; up to 1250 mg/m^3: (APF = 2000) any supplied-air respirator that has a full facepiece and is operated in a pressure-demand or other positive-pressure mode
Skin:	No specific recommendation can be made; actual working conditions will determine the need and type of personal protective equipment
Eyes:	No recommendation is made specifying the need for eye protection
Special Precautions:	Combustible solid

LABORATORY INFORMATION

CAS number: 7782-42-5

Analytical Technique:
1. X-ray diffraction
2. Mineral Dust: impinger method
Analytical Reference Method: MSHA p-2; impinger method

SAMPLING INFORMATION
Full Shift Sampling: Screening - **Note:** cannot be used for enforcement
Sampling Strategy: See chapter 6
MSHA P-2
Collection Media: Cyclone and filter [10-mm nylon cyclone and 37-mm diameter, 5-µm pore size polyvinyl chloride (PVC) filter]
Sample Flow Rate (Lpm): 1.7

Full Shift - Partial Period Sampling: Enforcement - **Note:** for compliance with TLV
Sampling Strategy: see Chapter 6
Collection Media: Impinger
Sample Flow Rate (Lpm): 2.8
Air Collection Volume (L): 168

Special Instructions: Coordinate with MSHA Technical Support. Dust Division personnel will conduct impinger sampling with inspector escort.

n-Heptane -$CH_3[CH_2]_5CH_3$
750 ppm IDLH (NIOSH, 1995)

Contaminant Codes:	1973 ACGIH TLV:	1973 ACGIH Excursion STEL/Ceiling (C):
995	500 ppm	625 ppm - 15 min.

CONTAMINANT INFORMATION

Synonyms:	Eptane, normal-heptane
Sources:	Solvent, testing gasoline engines (knocking)
Description:	Colorless liquid with a gasoline-like odor
Incompatibilities:	Strong oxidizers
Exposure:	Inhalation, ingestion, skin and/or eye contact
Health Effects:	Lightheadedness, giddiness, stupor, vertigo (an illusion of movement), loss of coordination, loss of appetite, nausea, dermatitis, chemical pneumonia (aspiration of liquid), unconsciousness
PPE: Respirator:	Recommendations **-** NIOSH: up to 750 ppm: (APF = 10) any chemical cartridge respirator with organic vapor cartridge(s); (APF = 50) any air-purifying, full-facepiece respirator (gas mask) with a chin-style, front- or back-mounted organic vapor canister; (APF = 25) any powered, air-purifying respirator with organic vapor cartridge(s); (APF = 10) any supplied-air respirator; (APF = 50) any self-contained breathing apparatus with a full facepiece
Skin:	Prevent skin contact; 8 hr: Nitrile, Viton, PE/EVAL
Eyes:	Prevent eye contact
Special Precautions:	Class IB flammable liquid

LABORATORY INFORMATION

CAS Number: 142-82-5

Analytical Technique: NIOSH 1500 (IV): gas chromatography (GC) / flame ionization detector (FID); **OSHA** 7: gas chromatography (GC) / flame ionization detector (FID); 3M: passive monitor

Analytical Reference Method: NIOSH 1500 (IV); OSHA 7; 3M

SAMPLING INFORMATION

Full Shift Sampling:

Sampling Strategy: see Chapter 9

1. NIOSH 1500 (IV):

Collection Media: 100/50 mg: solid sorbent tube (coconut shell charcoal)

Sample Flow Rate: Minimum - Maximum (Lpm): 0.01-0.2; Must use a pump adaptor or arrange for low flow pumps.

Air Collection Volume (L): 4

2. OSHA 7:

Collection Media: 100/50 mg: solid sorbent tube (coconut shell charcoal)

Sample Flow Rate: Minimum - Maximum (Lpm): 0.01-0.2; Must use a pump adaptor or arrange for low flow pumps.

Air Collection Volume (L): 4

3. 3M:

Collection Media: Passive monitor, 3M, 3500 series

Note: maximum 8-hour sample per badge

Short Term Sampling:

Sampling Strategy: see Chapter 9

Sampling Duration: 15 min.

1. NIOSH 1500 (IV):

Collection Media: 100/50 mg: solid sorbent tube (coconut shell charcoal)

Sample Flow Rate: Minimum - Maximum (Lpm): 0.01-0.2; Must use a pump adaptor or arrange for low flow pumps.

Air Collection Volume (L): 3

2. OSHA 7:

Collection Media: 100/50 mg: solid sorbent tube (coconut shell charcoal)

Sample Flow Rate: Minimum - Maximum (Lpm): 0.01-0.2; Must use a pump adaptor or arrange for low flow pumps.

Air Collection Volume (L): 3

Special Instructions: N/A

n-Hexane - $CH_3(CH_2)_4CH_3$

1,100 ppm IDLH (NIOSH, 1995), based strictly on safety considerations (i.e., being 10% of the lower explosive limit of 1.1%)

Contaminant Codes:	1973 ACGIH TLV:	1973 ACGIH Excursion STEL/Ceiling (C):
659	500 ppm	625 ppm - 15 min.

CONTAMINANT INFORMATION

Synonyms:	Hexane, hexyl hydride, normal-hexane
Sources:	Solvents, glues, mineral analytical laboratories, ligroine (VM&P naphtha)
Description:	Colorless liquid with a gasoline-like odor
Incompatibilities:	Strong oxidizers
Exposure:	Inhalation, ingestion, skin and/or eye contact
Health Effects:	Irritation eyes, nose; lightheadedness; nausea, headache; peripheral neuropathy: numbness in extremities, muscle weakness; dermatitis; giddiness; chemical pneumonia (aspiration of liquid)
PPE: Respirator:	Recommendations - NIOSH: Up to 500 ppm: (APF = 10) any supplied-air respirator (note: substance reported to cause eye irritation or damage; may require eye protection); up to 1100 ppm: (APF = 25) any supplied-air respirator operated in a continuous-flow mode (note: substance reported to cause eye irritation or damage; may require eye protection); (APF = 50) any self-contained breathing apparatus with a full facepiece; (APF = 50) any supplied-air respirator with a full facepiece
Skin:	Prevent skin contact; 8 hr: Nitrile, PVA, Teflon, Viton, PE/EVAL, CPF3, Responder, Trellchem, Tychem; 4 hr: Barricade
Eyes:	Prevent eye contact
Special Precautions:	Class IB flammable liquid

LABORATORY INFORMATION

CAS Number: 110-54-3

Analytical Technique: NIOSH 1500 (IV): gas chromatography (GC) / flame ionization detector (FID); OSHA 7: gas chromatography (GC) / flame ionization detector (FID); 3M: passive monitor

Analytical Reference Method: NIOSH 1500 (IV); OSHA 7; 3M

SAMPLING INFORMATION

Full Shift Sampling:

Sampling Strategy: see Chapter 9

1. NIOSH 1500 (IV):

Collection Media: 100/50 mg: solid sorbent tube (coconut shell charcoal)

Sample Flow Rate: Minimum - Maximum (Lpm): 0.01-0.2; Must use a pump adaptor or arrange for low flow pumps.

Air Collection Volume (L): 4

2. OSHA 7:

Collection Media: 100/50 mg: solid sorbent tube (coconut shell charcoal)

Sample Flow Rate: Minimum - Maximum (Lpm): 0.01-0.2; Must use a pump adaptor or arrange for low flow pumps.

Air Collection Volume (L): 4

3. 3M:

Collection Media: Passive monitor, 3M, 3500 series

Note: maximum 8-hour sample per badge

Short Term Sampling:

Sampling Strategy: see Chapter 9

Sampling Duration: 15 min.

1. NIOSH 1500 (IV):

Collection Media: 100/50 mg: solid sorbent tube (coconut shell charcoal)

Sample Flow Rate: Minimum - Maximum (Lpm): 0.01-0.2; Must use a pump adaptor or arrange for low flow pumps.

Air Collection Volume (L): 3

2. OSHA 7:

Collection Media: 100/50 mg: solid sorbent tube (coconut shell charcoal)

Sample Flow Rate: Minimum - Maximum (Lpm): 0.01-0.2; Must use a pump adaptor or arrange for low flow pumps.

Air Collection Volume (L): 3

Special Instructions: N/A

Hexone (Methyl Isobutyl Ketone) - $CH_3COCH_2CH(CH_3)_2$

500 ppm IDLH (NIOSH, 1995)

Contaminant Codes:	1973 ACGIH TLV:	1973 ACGIH Excursion STEL/Ceiling (C):
249	100 ppm	125 ppm - 15 min.

CONTAMINANT INFORMATION

Synonyms:	Isobutyl methyl ketone, methyl isobutyl ketone, 4-methyl 2-pentanone, MIBK
Sources:	Paints, glues, solvents, forgum, resins
Description:	Colorless liquid with a pleasant odor
Incompatibilities:	Strong oxidizers, potassium tert-butoxide
Exposure:	Inhalation, ingestion, skin and/or eye contact
Health Effects:	Irritation eyes, skin, mucous membrane; headache, narcosis, coma, Dermatitis, in animals: liver, kidney damage
PPE: Respirator:	Recommendations - NIOSH: Up to 500 ppm: (APF = 10) any chemical cartridge respirator with organic vapor cartridge(s) (note: substance reported to cause eye irritation or damage; may require eye protection); (APF = 50) any air-purifying, full-facepiece respirator (gas mask) with a chin-style, front- or back-mounted organic vapor canister; (APF = 50) any powered, air-purifying respirator with a tight-fitting facepiece and organic vapor cartridge(s) (note: substance reported to cause eye irritation or damage; may require eye protection); (APF = 10) any supplied-air respirator (note: substance reported to cause eye irritation or damage; may require eye protection); (APF = 50) any self-contained breathing apparatus with a full facepiece
Skin:	Prevent skin contact; contact the manufacturer for recommendations
Eyes:	Prevent eye contact
Special Precautions:	Class IB flammable liquid

LABORATORY INFORMATION

CAS Number: 108-10-1

Analytical Technique: NIOSH 1300 (IV): gas chromatography (GC) / flame ionization detection (FID); **OSHA** 1004: gas chromatography (GC) / flame ionization detection (FID); 3M: passive monitor

Analytical Reference Method: NIOSH 1300 (IV); OSHA 1004; 3M

SAMPLING INFORMATION

Full Shift Sampling:

Sampling Strategy: see Chapter 9

1. 3M:

Collection Media: Passive monitor, 3M, 3500 series

Note: Maximum 8-hour sample per badge

2. NIOSH 1300 (IV):

Collection Media: 100/50 mg: solid sorbent tube (coconut shell charcoal)

Sample Flow Rate: Minimum - Maximum (Lpm): 0.01-0.2; Must use a pump adaptor or arrange for low flow pumps.

Air Collection Volume: Minimum - Maximum (L): 1-10

3. OSHA 1004:

Collection Media: 150/75 mg Anasorb carbon molecular sieve (CMS) sampling tubes

Sample Flow Rate (Lpm): 0.05; Must use a pump adaptor or arrange for low flow pumps.

Air Collection Volume (L): 12

Short Term Sampling:

Sampling Strategy: see Chapter 9

Sampling Duration: 15 min.

1. NIOSH 1300 (IV):

Collection Media: 100/50 mg: solid sorbent tube (coconut shell charcoal)

Sample Flow Rate: Minimum - Maximum (Lpm): 0.01-0.2; Must use a pump adaptor or arrange for low flow pumps.

Air Collection Volume: Minimum - Maximum (L): 1-10

2. OSHA 1004:

Collection Media: 150/75 mg Anasorb carbon molecular sieve (CMS) sampling tubes

Sample Flow Rate (Lpm): 0.05; Must use a pump adaptor or arrange for low flow pumps.

Air Collection Volume (L): 0.75

Special Instructions: NIOSH 1300 (IV): Coordinate with MSHA Laboratory. Samples must be refrigerated. Ship on ice via overnight express carrier.

Hydrocarbons, Total (Screen)
[as n-Hexane - $CH_3(CH_2)_4CH_3$]

1,100 ppm (as n-Hexane) IDLH (NIOSH, 1995),
based strictly on safety considerations (i.e., being 10% of the lower explosive limit of 1.1%)

Contaminant Codes:	1973 ACGIH TLV:	1973 ACGIH Excursion STEL/Ceiling (C):
659	500 ppm	625 ppm - 15 min.

Note: “Screening” sample for field application when contaminants listed below are suspected. Analyses will quantify as n-Hexane. The results can be used for compliance with n-Hexane TLV.

Organics Analyzed: Fuels, including**:** gasoline, kerosene, diesel fuel, fuel oil

LABORATORY INFORMATION
CAS Number: 110-54-3 (n-hexane)
Analytical Technique: NIOSH 1500 (IV): gas chromatography (GC) / flame ionization detector (FID)
Analytical Reference Method: NIOSH 1500 (IV)

SAMPLING INFORMATION
Full Shift Sampling:
Sampling Strategy: see Chapter 9
Collection Media: 100/50 mg: solid sorbent tube (coconut shell charcoal)
Sample Flow Rate: Minimum - Maximum (Lpm): 100/50 mg: 0.01-0.2; must use a pump adaptor or arrange for low flow pumps.
Air Collection Volume (L): 4

Short Term Sampling:
Sampling Strategy: see Chapter 9
Sampling Duration: 15 min.
Collection Media: 100/50 mg: solid sorbent tube (coconut shell charcoal)
Sample Flow Rate: Minimum - Maximum (Lpm): 100/50 mg: 0.01-0.2; Must use a pump adaptor or arrange for low flow pumps.
Air Collection Volume (L): 3

Special Instructions: N/A

Grab Sampling:
Sampling Strategy: see Chapter 11
Collection Media: Dräger detector tubes:
A. Hexane: #6728391, range 50-3,000 ppm (EF = 1.33).
B. Hydrocarbons: #CH26101, range 0.1-0.8 vol. (% butane) and 0.5-1.3 vol. (% propane) (EF = 1.66).
C. Hydrocarbons: #CH25401, range 2-23 mg/L (EF = 1.66).
D. Petroleum hydrocarbons: #8101691, range 10-300 ppm (n-octane) (EF = 1.41).
E. Petroleum hydrocarbons: #6730201, range 100-2,500 ppm (n-octane) (EF = 1.25).

Hydrogen Chloride - HCl
50 ppm IDLH (NIOSH, 1995)

Contaminant Codes:	1973 ACGIH TLV:	1973 ACGIH Excursion STEL/Ceiling (C):
413	5.0 ppm	5.0 ppm - (C)

CONTAMINANT INFORMATION

Synonyms:	Anhydrous hydrogen chloride, aqueous hydrogen chloride, hydrochloric acid, muriatic acid
Sources:	Used in mine laboratories; ore processing of manganese, radium, vanadium, tantalum, tin, and tungsten; formed during fires involving polyvinyl chloride (PVC)
Description:	Colorless to slightly yellow gas with a pungent, irritating odor
Incompatibilities:	Hydroxides, amines, alkalis, copper, brass, zinc; [note: hydrochloric acid is highly corrosive to most metals.]
Exposure:	Inhalation, ingestion (solution), skin and/or eye contact
Health Effects:	Irritation nose, throat, larynx; cough, choking; pulmonary edema; contact dermatitis, eye, skin; acid burns
PPE: Respirator:	Recommendations - NIOSH/OSHA: Up to 50 ppm: (APF = 10) any chemical cartridge respirator with cartridge(s) providing protection against the compound of concern (note: substance reported to cause eye irritation or damage; may require eye protection); (APF = 50) any air-purifying, full-facepiece respirator (gas mask) with a chin-style, front- or back-mounted canister providing protection against the compound of concern; (APF = 25) any powered, air-purifying respirator with cartridge(s) providing protection against the compound of concern (note: substance reported to cause eye irritation or damage; may require eye protection); (APF = 10) any supplied-air respirator (note: substance reported to cause eye irritation or damage; may require eye protection); (APF = 50) any self-contained breathing apparatus with a full facepiece
Skin:	Prevent skin contact with concentrate or solution; 8 hr: Butyl, Teflon, Saranex, Barricade, Responder, Trellchem, Tychem; 4 hr: Neoprene, PVC; wear appropriate personal protective clothing to prevent skin contact with the liquid or from contact with vessels containing the liquid.
Eyes:	Prevent eye contact.
Special Precautions:	Nonflammable gas

LABORATORY INFORMATION

CAS Number: 7647-01-0

Analytical Technique: NIOSH 7903 (IV): ion chromatography; Dräger: detector tube

Analytical Reference Method: NIOSH 7903 (IV); Dräger

SAMPLING INFORMATION

Full Shift Sampling:

Sampling Strategy: see Chapter 9

Collection Media: 400/200 mg: solid sorbent tube (washed silica gel, with glass fiber filter plug)

Sample Flow Rate: Minimum - Maximum (Lpm): 0.2-0.5

Air Collection Volume: Minimum - Maximum (L): 3-100

Short Term Sampling:

Sampling Strategy: see Chapter 9

Sampling Duration: 15 min.

Collection Media: 400/200 mg: solid sorbent tube (washed silica gel, with glass fiber filter plug)

Sample Flow Rate: Minimum - Maximum (Lpm): 0.2-0.5

Air Collection Volume: Minimum - Maximum (L): 3-100

Special Instructions: N/A

Grab Sampling:

Sampling Strategy: see Chapter 11

Collection Media: Dräger detector tube, #CH29501, range 1-10 ppm (EF = 1.25); Dräger detector tube, #6728181, range 50-5,000 ppm (EF = 1.25).

Hydrogen Cyanide - HCN

50 ppm IDLH (NIOSH, 1995)

Contaminant Codes:	1973 ACGIH TLV:	1968 PA Rules STEL/Ceiling (C):
309	10 ppm (Skin)	20 ppm - 30 min.

CONTAMINANT INFORMATION

Synonyms: Formonitrile, hydrocyanic acid, prussic acid

Sources: Nitrates; processing of gold, silver, and copper ores from decomposing metal cyanides with hydrochloric acid

Description: Colorless or pale-blue liquid or gas (above 78°F) with a bitter, almond-like odor

Incompatibilities: Amines, oxidizers, acids, sodium hydroxide, calcium hydroxide, sodium carbonate, water, caustics, ammonia; [note: can polymerize at 122-140°F.]

Exposure: Inhalation, skin absorption, ingestion, skin and/or eye contact

Health Effects: Asphyxia; weakness, headache, confusion; nausea, vomiting; increased rate and depth of respiration or respiration slow and gasping; thyroid, blood changes

PPE: Respirator: Recommendations - NIOSH: Up to 47 ppm: (APF = 10) any supplied-air respirator; up to 50 ppm: (APF = 25) any supplied-air respirator operated in a continuous-flow mode; (APF = 50) any self-contained breathing apparatus with a full facepiece; (APF = 50) any supplied-air respirator with a full facepiece

Skin: Prevent skin contact; 8 hr: Teflon; 4 hr: PE/EVAL, Responder, Tychem

Eyes: Prevent eye contact

Special Precautions: Class IA flammable liquid; flammable gas

LABORATORY INFORMATION

CAS Number: 74-90-8

Analytical Technique: NIOSH 6010 (IV): spectrophotometry, visible absorption; NIOSH 7904 (IV): ion-specific electrode (ISE); Dräger: diffusion tube; Dräger: detector tube

Analytical Reference Method: NIOSH 6010 (IV); NIOSH 7904 (IV); Dräger: Dräger

SAMPLING INFORMATION

<u>Full Shift Sampling</u>:

Sampling Strategy: see Chapters 9 & 11

Collection Media:

1. NIOSH 6010 (IV): 600/200 mg: solid sorbent tube (soda lime)

2. NIOSH 7904 (IV): 37-mm diameter, 0.8-µm pore size polyvinyl chloride (PVC) filter, followed by glass midget bubbler containing 15 mL 0.1 N KOH

3. Dräger diffusion tube, #6733221; 20-200 ppm (1 hour), 10-100 ppm (2 hours), 5-50 ppm (4 hours), 2.5-25 ppm (8 hours); (EF = 1.25); **Note:** up to 8 hours per tube.

Sample Flow Rate: Minimum - Maximum (Lpm):

1. NIOSH 6010 (IV): 0.05-0.2 Lpm. Must use a pump adaptor or arrange for low flow pumps .

2. NIOSH 7904 (IV): 0.5-1.0

Air Collection Volume: Minimum - Maximum (L):

1. NIOSH 6010 (IV): 2-90

2. NIOSH 7904 (IV): 10-180

<u>Short Term Sampling</u>:

Sampling Strategy: see Chapters 9 & 11

Sampling Duration: 30 min.

Collection Media:

1. NIOSH 6010 (IV): 600/200 mg: solid sorbent tube (soda lime)

2. NIOSH 7904 (IV): 37-mm diameter, 0.8-µm pore size polyvinyl chloride (PVC) filter, followed by glass midget bubbler containing 15 mL 0.1 N potassium hydroxide (KOH)

Sample Flow Rate: Minimum - Maximum (Lpm):

1. NIOSH 6010 (IV): 0.05-0.2 Lpm. Must use a pump adaptor or arrange for low flow pumps.

2. NIOSH 7904 (IV): 0.5-1.0

Air Collection Volume: Minimum - Maximum (L):

1. NIOSH 6010 (IV): 2-90

2. NIOSH 7904 (IV): 10-180

<u>Special Instructions</u>: NIOSH 7904 (IV): Quantitatively transfer the contents of the bubbler to a 20-mL vial. Close cap tightly and wrap with plastic tape to avoid sample loss during transit. Overnight sample to MSHA laboratory for analysis. Analyze within 5 days. Particulate on filter may liberate HCN gas.

<u>Grab Sampling</u>:

Sampling Strategy: see Chapter 11

Collection Media: Dräger detector tube, #CH25701, range 1-150 ppm (EF = 1.25**)**.

Hydrogen Fluoride - HF
30 ppm (as F) IDLH (NIOSH, 1995)

Contaminant Codes:	1973 ACGIH TLV:	1968 PA Rules STEL/Ceiling (C):
415	3.0 ppm	3.0 ppm - 15 min.

CONTAMINANT INFORMATION

Synonyms:	Anhydrous hydrogen fluoride; aqueous hydrogen fluoride (i.e., hydrofluoric acid); HF-A
Sources:	High octane gasolines, removal of sand from metal casings, removing oxides from metals, processing graphite ore, dissolving ores
Description:	Colorless gas or fuming liquid (below 67°F) with a strong, irritating odor
Incompatibilities:	Metals, water, or steam; [note: corrosive to metals; will attack glass and concrete]
Exposure:	Inhalation, skin absorption (liquid), ingestion (solution), skin and/or eye contact
Health Effects:	Irritation eyes, skin, nose, throat; pulmonary edema; eye, skin burns; rhinitis; bronchitis; bone changes
PPE: Respirator:	Recommendations - NIOSH/OSHA: Up to 30 ppm: (APF = 10) any chemical cartridge respirator with cartridge(s) providing protection against the compound of concern (note: substance reported to cause eye irritation or damage; may require eye protection); (APF = 25) any powered, air-purifying respirator with cartridge(s) providing protection against the compound of concern (note: substance reported to cause eye irritation or damage; may require eye protection); (APF = 50) any air-purifying, full-facepiece respirator (gas mask) with a chin-style, front- or back-mounted canister providing protection against the compound of concern; (APF = 10) any supplied-air respirator (note: substance reported to cause eye irritation or damage; may require eye protection); (APF = 50) any self-contained breathing apparatus with a full facepiece
Skin:	Prevent skin contact (liquid); 8 hr: Tychem; 4 hr: Teflon
Eyes:	Prevent eye contact (liquid)
Special Precautions:	nonflammable gas

LABORATORY INFORMATION

CAS Number: 7664-39-3

Analytical Technique: NIOSH 7903 (IV) [acids, inorganic]: ion chromatography; NIOSH 7902 (IV) [fluorides, aerosol and gas]: ion-specific electrode (ISE); NIOSH 7906 (IV) [fluorides, aerosol and gas]: ion chromatography / conductivity; Dräger: detector tube

Analytical Reference Method: NIOSH 7903 (IV) [acids, inorganic]; NIOSH 7902 (IV) [fluorides as F, aerosol and gas]; NIOSH 7906 (IV) [fluorides, aerosol and gas]; Dräger

SAMPLING INFORMATION

Full Shift Sampling:

Sampling Strategy: see Chapter 9

Collection Media:

1. NIOSH 7903 (IV): 400/200 mg: solid sorbent tube (washed silica gel, with glass fiber filter plug)

2. NIOSH 7902 (IV): filter and treated pad [37-mm diameter, 0.8-µm pore size mixed cellulose ester (MCE) filter with Na_2CO_3-treated cellulose pad]

3. NIOSH 7906 (IV): filter and treated pad [37-mm diameter, 0.8-µm pore size mixed cellulose ester (MCE) filter with Na_2CO_3-treated cellulose pad]

Sample Flow Rate: Minimum - Maximum (Lpm):

1. NIOSH 7903 (IV): 0.2-0.5

2. NIOSH 7902 (IV): 1.7

3. NIOSH 7906 (IV): 1.7

Air Collection Volume: Minimum - Maximum (L):

1. NIOSH 7903 (IV): 3-100

2. NIOSH 7902 (IV): 12-800

3. NIOSH 7906 (IV): 1-800

Short Term Sampling:

Sampling Strategy: see Chapter 9

Sampling Duration: 15 min.

Collection Media:

1. NIOSH 7903 (IV): 400/200 mg: solid sorbent tube (washed silica gel, with glass fiber filter plug)

2. NIOSH 7902 (IV): filter and treated pad [37-mm diameter, 0.8-µm pore size mixed cellulose ester (MCE) filter with Na_2CO_3-treated cellulose pad]

3. NIOSH 7906 (IV): filter and treated pad [37-mm diameter, 0.8-µm pore size mixed cellulose ester (MCE) filter with Na_2CO_3-treated cellulose pad]

Sample Flow Rate: Minimum - Maximum (Lpm):
1. NIOSH 7903 (IV): 0.2-0.5
2. NIOSH 7902 (IV): 1.7
3. NIOSH 7906 (IV): 1.7
Air Collection Volume: Minimum - Maximum (L):
1. NIOSH 7903 (IV): 3-100
2. NIOSH 7902 (IV): 12-800
3. NIOSH 7906 (IV): 1-800

Special Instructions: N/A

Grab Sampling:
Sampling Strategy: see Chapter 11
Collection Media:
a. Hydrogen fluoride: Dräger detector tube, #8103251, range 0.5-90 ppm (EF = ?); or Dräger detector tube, #CH30301, range 1.5-15 ppm (EF = 1.33)
b. Fluorine: Dräger detector tube, #8101491, range 0.05-40 ppm (EF = 1.33)

Hydrogen Peroxide - H_2O_2

75 ppm IDLH (NIOSH, 1995)

Contaminant Codes:	1973 ACGIH TLV:	1973 ACGIH Excursion STEL/Ceiling (C):
995	1.0 ppm	3.0 ppm - 15 min.

CONTAMINANT INFORMATION

Synonyms: High-strength hydrogen peroxide; hydrogen dioxide; hydrogen peroxide (aqueous); hydroperoxide; peroxide

Sources: Oxidizing agent, bleaching agent, metal cleaning (when combined with sodium hydroxide)

Description: Colorless liquid with a slightly sharp odor

Incompatibilities: Oxidizable materials, iron, copper, brass, bronze, chromium, zinc, lead, silver, manganese; [**Note:** contact with combustible material may result in **SPONTANEOUS combustion**]

Exposure: Inhalation, ingestion, skin and/or eye contact

Health Effects: Irritation eyes, nose, throat; corneal ulcer; erythema (skin redness), vesiculation skin; bleaching hair

PPE: Respirator: Recommendations **-** NIOSH/OSHA**:** Up to 10 ppm: (APF = 10) any supplied-air respirator (note: substance reported to cause eye irritation or damage; may require eye protection); up to 25 ppm: (APF = 25) any supplied-air respirator operated in a continuous-flow mode (note: substance reported to cause eye irritation or damage; may require eye protection); up to 50 ppm: (APF = 50) any self-contained breathing apparatus with a full facepiece; (APF = 50) any supplied-air respirator with a full facepiece; up to 75 ppm: (APF = 2000) any supplied-air respirator that has a full facepiece and is operated in a pressure-demand or other positive-pressure mode

Skin: Prevent skin contact (solution 30%-70%); 8 hr: Butyl, Natural, Nitrile, PE, Viton, CPF3, Responder, Tychem; 4 hr: PVC, PE/EVAL

Eyes: Prevent eye contact

Special Precautions: Noncombustible liquid; powerful oxidizer

LABORATORY INFORMATION

CAS Number: 7722-84-1

Analytical Technique: Dräger detector tube

Analytical Reference Method: Dräger

Special Instructions: N/A

SAMPLING INFORMATION

Grab Sampling:
Sampling Strategy: see Chapter 11
Collection Media: Dräger detector tube, #8101041, range 0.1-3 ppm (EF = 1.25).

Hydrogen Sulfide - H_2S
100 ppm IDLH (NIOSH, 1995)

Contaminant Codes:	1973 ACGIH TLV:	1968 PA Rules STEL/Ceiling (C):
305	10 ppm	20 ppm - 5 min.

CONTAMINANT INFORMATION

Synonyms: Sewer gas, hydrosulfuric acid, sulfuretted hydrogen; hepatic gas; stink damp

Sources: By-product of petroleum products; naturally occurs in coal, volcanic gases and sulfur springs. Evolves from bacterial or anerobic decomposition of organic substances and from a variety of industrial operations. Can accumulate in confined spaces and man holes.

Description: Colorless gas with a strong odor of rotten eggs; [note: an insidious poison because the sense of smell becomes rapidly fatigued & can NOT be relied upon to warn of the continued presence of H_2S]

Incompatibilities: Strong oxidizers, strong nitric acid, metals

Exposure: Inhalation, skin and/or eye contact

Health Effects: Irritation eyes, respiratory system; apnea, coma, convulsions; conjunctivitis, eye pain, lacrimation (discharge of tears), photophobia (abnormal visual intolerance to light), corneal vesiculation; dizziness, headache, fatigue, irritability, insomnia; gastrointestinal disturbance; liquids: skin irritation, erythema, frostbite

PPE: Respirator: Recommendations **-** NIOSH: Up to 100 ppm: (APF = 25) any powered, air-purifying respirator with cartridge(s) providing protection against the compound of concern; (APF = 50) any air-purifying, full-facepiece respirator (gas mask) with a chin-style, front- or back-mounted canister providing protection against the compound of concern; (APF = 10) any supplied-air respirator (note: substance reported to cause eye irritation or damage; may require eye protection); (APF = 50) any self-contained breathing apparatus with a full facepiece

Skin: Prevent skin contact / frostbite possible; 8 hr: Tychem; 4 hr: Teflon; wear appropriate personal protective clothing to prevent the skin from becoming frozen from contact with the evaporating liquid or from contact with vessels containing the liquid.

Eyes: Prevent eye contact; wear appropriate eye protection to prevent direct eye contact.

Special Precautions: Flammable gas

LABORATORY INFORMATION

CAS Number: 7783-06-4
Analytical Technique: Dräger: diffusion tube; NIOSH 6013 (IV): ion chromatography / conductivity detector; Dräger: detector tube
Analytical Reference Method: Dräger; NIOSH 6013 (IV); Dräger

SAMPLING INFORMATION
Full Shift Sampling:
Sampling Strategy: see Chapters 9 and 11
1. Dräger
Collection Media: Dräger diffusion tube, #6733091; range 10-300 ppm (1 hour), 5-150 ppm (2 hours), 2.5-75 ppm (4 hours), 1.3-40 ppm (8 hours); **Note:** Up to 8 hours per tube. (EF = 1.41).
2. NIOSH 6013 (IV):
Collection Media: filter [25-mm diameter, 0.45-µm pore size Zefluor polytetrafluoroethylene (PTFE) prefilter] + solid sorbent tube (400/200 mg coconut shell charcoal)
Sample Flow Rate: Minimum - Maximum (Lpm): 0.1-0.2 (Must use a pump adaptor or arrange for low flow pumps.); 0.2-1.5
Air Collection Volume: Minimum - Maximum (L): 1.2-40

Short Term Sampling:
Sampling Strategy: see Chapter 9
Sampling Duration: 15 min.
NIOSH 6013 (IV):
Collection Media: filter [25-mm diameter, 0.45-µm pore size Zefluor polytetrafluoroethylene (PTFE) prefilter] + solid sorbent tube (400/200 mg coconut shell charcoal)
Sample Flow Rate: Minimum - Maximum (Lpm): 0.1-0.2 (Must use a pump adaptor or arrange for low flow pumps.); 0.2-1.5
Air Collection Volume: Minimum - Maximum (L): 1.2-40

Special Instructions: N/A

Grab Sampling:
Sampling Strategy: see Chapter 11
Collection Media: Dräger detector tube, #6728041, range 0.05-150 ppm (EF = 1.49); Dräger detector tube, #8101991, range 0.2-6 ppm (EF = 1.33); Dräger detector tube, #8101461, range 0.2-50 ppm (EF = 1.17); Dräger detector tube, #8101961, range 1-60 ppm (EF = 1.17); Dräger detector tube, #6719001, range 1-200 ppm (EF = 1.17); Dräger detector tube, #8101831, range 1-200 ppm (EF = 1.25); Dräger detector tube, #6728821, range 2-200 ppm (EF = 1.17); Dräger detector tube, #CH29801, range 5-600 ppm (EF = 1.17); Dräger detector tube, #CH29101, range 10-2,000 ppm (EF = 1.17); Dräger detector tube, #CH28101, range 0.02-7 vol. % (EF = 1.17); Dräger detector tube, #8101211, range 0.2-40 vol. % (EF = 1.17).

Iron Oxide (dusts & fumes) - Fe_2O_3

2,500 mg/m^3 (as Fe) IDLH (NIOSH, 1995)

Iron Salts (Soluble) as Fe

Contaminant Codes:	1973 ACGIH TLV:	1973 ACGIH Excursion STEL/Ceiling (C):
175 (dust - Soluble salts as Fe)	1.0 mg/m^3	3.0 mg/m^3 - 15 min.
721 (fume - Fe_2O_3)	10.0 mg/m^3	20.0 mg/m^3 - 15 min.

CONTAMINANT INFORMATION

Synonyms: *Iron oxide*: ferric oxide, iron(III) oxide
iron(II) sulfate [$FeSO_4$]: ferrous sulfate
iron(II) chloride [$FeCl_2$]: ferrous chloride
iron(III) nitrate [$Fe(NO_3)_3$]: ferric nitrate
iron(III) sulfate [$Fe_2(SO_4)_2$]: ferric sulfate
iron(III) chloride [$FeCl_3$]: ferric chloride

Sources: *Iron oxide*: result of welding and silver finishing; ores of hematite and magnetite
iron(II) sulfate: preparation of iron compounds, electroplating, reducing agent in chemical processes; ores of melanterite, siderotil, terisite
iron(II) chloride: reducing agent in metallurgy
iron(III) nitrate: corrosion inhibitor; ores of hematite, maghemite
iron(III) sulfate: preparation of iron compounds, etching aluminum
iron(III) chloride: processing silver and copper ores, catalyst in organic reactives

Description: *Iron oxide*: reddish-brown solid
iron salts: appearance and odor vary depending upon the specific soluble iron salt

Incompatibilities: *Iron oxide*: calcium hypochlorite
iron salts: vary depending upon the specific soluble iron salt

Exposure: *Iron oxide*: inhalation
iron salts: inhalation, ingestion, skin and/or eye contact

Health Effects: *Iron oxide*: benign pneumoconiosis with X-ray shadows indistinguishable from fibrotic pneumoconiosis (siderosis)
iron salts: irritation eyes, skin, mucous membrane; abdominal pain, diarrhea, vomiting; possible liver damage

PPE: Respirator: *Iron oxide***:** NIOSH: Up to 50 mg/m^3: (APF = 10) any dust, mist, and fume respirator; (APF = 10) any supplied-air respirator; up to 125 mg/m^3: (APF = 25) any supplied-air respirator operated in a continuous-flow mode; (APF = 25) any powered, air-purifying respirator with a dust, mist, and fume filter; up to 250 mg/m^3: (APF = 50) any air-purifying, full-facepiece respirator with a high-efficiency particulate filter; (APF = 50) any supplied-air respirator that has a tight-fitting facepiece and is operated in a continuous-flow mode; (APF = 50) any powered, air-purifying respirator with a tight-fitting facepiece and a high-efficiency particulate filter; (APF = 50) any self-contained breathing apparatus with a full facepiece; (APF = 50) any supplied-air respirator with a full facepiece; up to 2,500 mg/m^3: (APF = 1000) any supplied-air respirator operated in a pressure-demand or other positive-pressure mode

iron salts: N/A

Skin: *Iron oxide*: no specific recommendation can be made; actual working conditions will determine the need and type of personal protective equipment

*iron salts***:** Prevent skin contact; contact the manufacturer for recommendations for the specific compound

Eyes: *Iron oxide*: no recommendation is made specifying the need for eye protection

iron salts: Prevent eye contact

Special Precautions: Noncombustible solid

LABORATORY INFORMATION

CAS Numbers: 1309-37-1 [FeO_2], 7439-89-6 [Fe], 7720-78-7 [$FeSO_4$], 7758-94-3 [$FeCl_2$], 10421-48-4 [$Fe(NO_3)_3$], 10028-22-5 [$Fe_2(SO_4)_2$], 7705-08-0 [$FeCl_3$]

Analytical Technique: Inductively coupled argon plasma, atomic emission spectroscopy

Analytical Reference Method: MSHA P-3

SAMPLING INFORMATION

Full Shift Sampling:

Sampling Strategy: see Chapter 7

Collection Media: 37-mm diameter, 0.8-µm pore size mixed cellulose ester (MCE) filter

Sample Flow Rate (Lpm): 1.7

Short Term Sampling:
Sampling Strategy: see Chapter 7
Sampling Duration: 15 min.
Collection Media: 37-mm (or 25-mm) diameter, 0.8-µm pore size mixed cellulose ester (MCE) filter
Sample Flow Rate (Lpm): 1.7

Special Instructions: N/A

Wipe Sampling:
Sampling Strategy: see Chapter 14
Collection Media: Whatman Filter (No. 41 or 42), moistened with distilled water
Special Instructions: Seal wipe sample in plastic bag, vial, or jar.

Isopropyl Alcohol - $(CH_3)_2CHOH$

2,000 ppm IDLH (NIOSH, 1995),
based strictly on safety considerations (i.e., being 10% of the lower explosive limit of 2.0%)

Contaminant Codes:	1973 ACGIH TLV:	1973 ACGIH Excursion STEL/Ceiling (C):
995	400 ppm	500 ppm - 15 min.

CONTAMINANT INFORMATION

Synonyms: Rubbing alcohol, dimethyl carbinol, IPA, isopropanol, 2-propanol, sec-propyl alcohol,

Sources: Solvents

Description: Colorless liquid with the odor of rubbing alcohol

Incompatibilities: Strong oxidizers, acetaldehyde, chlorine, ethylene oxide, acids, isocyanates **Exposure:** Inhalation, ingestion, skin and/or eye contact

Health Effects: Irritation: eyes, nose, throat; drowsiness; dizziness; headache; dry cracking skin

PPE: Respirator: Recommendations - NIOSH/OSHA: Up to 2000 ppm: (APF = 25) any supplied-air respirator operated in a continuous-flow mode (note: substance causes eye irritation or damage; eye protection needed); (APF = 50) any chemical cartridge respirator with a full facepiece and organic vapor cartridge(s); (APF = 50) any air-purifying, full-facepiece respirator (gas mask) with a chin-style, front- or back-mounted organic vapor canister; (APF = 25) any powered, air-purifying respirator with organic vapor cartridge(s) (note: substance causes eye irritation or damage; eye protection needed); (APF = 50) any self-contained breathing apparatus with a full facepiece; (APF = 50) any supplied-air respirator with a full facepiece

Skin: Prevent skin contact; 8 hr: Butyl, Nitrile, Viton, PE/EVAL, CPF3, Responder; 4 hr: Neoprene, Teflon

Eyes: Prevent eye contact

Special Precautions: Class IB flammable liquid

LABORATORY INFORMATION

CAS Number: 67-63-0

Analytical Technique: NIOSH 1400 (IV): gas chromatography (GC) / flame ionization detector (FID); OSHA 109: gas chromatography (GC) / flame ionization detector (FID)

Reference Method: NIOSH 1400 (IV); OSHA 109

SAMPLING INFORMATION

<u>Full Shift Sampling</u>:

Sampling Strategy: see Chapter 9

1. Collection Media: NIOSH 1400 (IV): 100/50 mg: solid sorbent tube (coconut shell charcoal)

Sample Flow Rate: Minimum - Maximum (Lpm): 0.01-0.05 Lpm; Must use a pump adaptor or arrange for low flow pumps.

Air Collection Volume: Minimum - Maximum (L): 0.3-3

2. Collection Media: OSHA 109: 400/200 mg Anasorb 747

Sample Flow Rate (Lpm): 0.05-0.2 Lpm; Must use a pump adaptor or arrange for low flow pumps.

Air Collection Volume (L): 18

<u>Short Term Sampling</u>:

Sampling Strategy: see Chapter 9

Sampling Duration: 15 min.

1. Collection Media: NIOSH 1400 (IV): 100/50 mg: solid sorbent tube (coconut shell charcoal)

Sample Flow Rate: Minimum - Maximum (Lpm): 0.01-0.05 Lpm; Must use a pump adaptor or arrange for low flow pumps.

Air Collection Volume: Minimum - Maximum (L): 0.3-3

2. Collection Media: OSHA 109: 400/200 mg Anasorb 747

Sample Flow Rate (Lpm): 0.05-0.2 Lpm; Must use a pump adaptor or arrange for low flow pumps.

Air Collection Volume (L): 18

<u>Special Instructions</u>: NIOSH 1400 (IV): Coordinate with MSHA Laboratory. Store samples in freezer and ship on ice.

Kerosene

Contaminant Codes:	1973 ACGIH TLV:	1973 ACGIH Excursion STEL/Ceiling (C):

**** NOTE:** Lab must perform qualitative analysis first to determine the applicable TLV according to analytically determined composition.

CONTAMINANT INFORMATION

Synonyms: Fuel oil no. 1, range oil [note: a refined petroleum solvent, which typically is 25% normal paraffins, 11% branched paraffins, 30% monocycloparaffins, 12% dicycloparaffins, 1% tricycloparaffins, 16% mononuclear aromatics & 5% dinuclear aromatics]

Sources: Degreaser/cleaner; portable heater fuel

Description: Colorless to yellowish, oily liquid with a strong, characteristic odor

Incompatibilities: Strong oxidizers

Exposure: Inhalation, ingestion, skin and/or eye contact

Health Effects: Irritation: eyes, skin, nose, throat; burning sensation in chest; headache, nausea, weakness, restlessness, incoordination, confusion, drowsiness; vomiting, diarrhea; dermatitis; chemical pneumonia – if liquid aspiration

PPE: Respirator: Recommendations - NIOSH: Up to 1000 mg/m^3: (APF = 10) any chemical cartridge respirator with organic vapor cartridge(s); (APF = 10) any supplied-air respirator; Up to 2500 mg/m^3: (APF = 25) any supplied-air respirator operated in a continuous-flow mode; (APF = 25) any powered, air-purifying respirator with organic vapor cartridge(s); up to 5000 mg/m^3: (APF = 50) any chemical cartridge respirator with a full facepiece and organic vapor cartridge(s); (APF = 50) any air-purifying, full-facepiece respirator (gas mask) with a chin-style, front- or back-mounted organic vapor canister; (APF = 50) any powered, air-purifying respirator with a tight-fitting facepiece and organic vapor cartridge(s); (APF = 50) any self-contained breathing apparatus with a full facepiece; (APF = 50) any supplied-air respirator with a full facepiece

Skin: Prevent skin contact; 8 hr: Nitrile, PE, Viton; 4 hr: Neoprene, PVA, PVC, Barricade, Responder

Eyes: Prevent eye contact

Special Precautions: Class II combustible liquid

LABORATORY INFORMATION

CAS Number: 8008-20-6

Analytical Technique: NIOSH 1550 (IV): gas chromatography (GC) / flame ionization detector (FID)

Analytical Reference Method: NIOSH 1550 (IV)

SAMPLING INFORMATION

Full Shift Sampling:

Sampling Strategy: see Chapter 9

Collection Media: 100/50 mg: solid sorbent tube (coconut shell charcoal)

Sample Flow Rate: Minimum - Maximum (Lpm): 0.01-0.2 Lpm; Must use a pump adaptor or arrange for low flow pumps.

Air Collection Volume: Minimum - Maximum (L): 1.3-20

Special Instructions: Stable at least one week at room temperature. Submit a 5-10 mL bulk sample separately. Submit samples via overnight carrier to MSHA laboratory.

Lead - Pb
(Inorganic fumes and dusts)
100 mg/m^3 (as Pb) IDLH (NIOSH, 1995)

Contaminant Codes:	1973 ACGIH TLV:	1973 ACGIH Excursion STEL/Ceiling (C):
635 (dust)	0.15 mg/m^3 (150 $\mu g/m^3$)	0.45 mg/m^3 (450 $\mu g/m^3$) - 15 min.
723 (fume)	0.15 mg/m^3 (150 $\mu g/m^3$)	0.45 mg/m^3(450 $\mu g/m^3$) - 15 min.

(PEDS units of measure in parentheses)

CONTAMINANT INFORMATION

Synonyms: Lead metal, plumbum

Sources: Welding fume, paint, metallurgy; ores of galena (PbS), anglesite ($PbSO_4$), cerrusite ($PbCO_3$), mimetite, pyromorphite, schultanite, cottunite, plattnerite, wulfenite, lanarkite, altaite, mineral red, Paris red

Description: Heavy, ductile, soft, gray solid

Incompatibilities: Strong oxidizers, hydrogen peroxide, acids

Exposure: Inhalation, ingestion, skin and/or eye contact

Health Effects: Weakness, lassitude (weakness, exhaustion), insomnia; facial pallor; anorexia, weight loss, malnutrition; constipation, abdominal pain, colic; anemia; gingival lead line; tremor; paralysis wrist, ankles; encephalopathy; kidney disease; irritation eyes; hypotension

PPE: Respirator: Recommendations - OSHA: Up to 0.5 mg/m^3: (APF = 10) any air-purifying respirator with a high-efficiency particulate filter; (APF = 10) any supplied-air respirator; up to 1.25 mg/m^3: (APF = 25) any supplied-air respirator operated in a continuous-flow mode; (APF = 25) any powered, air-purifying respirator with a high-efficiency particulate filter; up to 2.5 mg/m^3: (APF = 50) any air-purifying, full-facepiece respirator with a high-efficiency particulate filter; (APF = 50) any supplied-air respirator that has a tight-fitting facepiece and is operated in a continuous-flow mode; (APF = 50) any powered, air-purifying respirator with a tight-fitting facepiece and a high-efficiency particulate filter; (APF = 50) any self-contained breathing apparatus with a full facepiece; (APF = 50) any supplied-air respirator with a full facepiece; up to 50 mg/m^3: (APF = 1000) any supplied-air respirator operated in a pressure-demand or other positive-pressure mode; up to 100 mg/m^3: (APF = 2000) any supplied-air respirator that has a full facepiece and is operated in a pressure-demand or other positive-pressure mode

Skin: Prevent skin contact; use any barrier that will prevent contact contamination from the dust
Eyes: Prevent eye contact
Special Precautions: Noncombustible solid in bulk form

LABORATORY INFORMATION
CAS Number: 7439-92-1
Analytical Technique: Inductively coupled argon plasma, atomic emission spectroscopy
Analytical Reference Method: MSHA P-3

SAMPLING INFORMATION
Full Shift Sampling:
Sampling Strategy: see Chapter 7
Collection Media: 37-mm diameter, 0.8-μm pore size mixed cellulose ester (MCE) filter
Sample Flow Rate (Lpm): 1.7

Short Term Sampling:
Sampling Strategy: see Chapter 7
Sampling Duration: 15 min.
Collection Media: 37-mm diameter, 0.8-μm pore size mixed cellulose ester (MCE) filter
Sample Flow Rate (Lpm): 1.7

Special Instructions: N/A

Wipe Sampling:
Sampling Strategy: see Chapter 14
Collection Media: Whatman Filter (No. 41 or 42), moistened with distilled water
Special Instructions: Seal wipe sample in plastic bag, vial, or jar.

Magnesium Oxide Fume - MgO

750 mg/m^3 IDLH (NIOSH, 1995)

Contaminant Codes:	1973 ACGIH TLV:	1973 ACGIH Excursion STEL/Ceiling (C):
725 (fume)	10 mg/m^3	20 mg/m^3 - 15 min.

CONTAMINANT INFORMATION

Synonyms: Magnesia fume

Sources: Welding fumes, fire brick, magnesia cements

Description: Finely divided white particulate dispersed in air

Incompatibilities: Chlorine trifluoride, phosphorus pentachloride

Exposure: Inhalation, skin and/or eye contact

Health Effects: Irritation: eyes, nose; metal fume fever: cough, chest pain, flu-like fever

PPE: Respirator: Recommendations - OSHA: Up to 150 mg/m^3: (APF = 10) any dust, mist, and fume respirator; (APF = 10) any supplied-air respirator; up to 375 mg/m^3: (APF = 25) any supplied-air respirator operated in a continuous-flow mode; (APF = 25) any powered, air-purifying respirator with a dust, mist, and fume filter; up to 750 mg/m^3: (APF = 50) any air-purifying, full-facepiece respirator with a high-efficiency particulate filter; (APF = 50) any powered, air-purifying respirator with a tight-fitting facepiece and a high-efficiency particulate filter (note: substance reported to cause eye irritation or damage; may require eye protection); (APF = 50) any self-contained breathing apparatus with a full facepiece; (APF = 50) any supplied-air respirator with a full facepiece

Skin: No specific recommendation can be made; actual working conditions will determine the need and type of personal protective equipment

Eyes: No recommendation is made specifying the need for eye protection

Special Precautions: Noncombustible solid

LABORATORY INFORMATION

CAS Number: 1309-48-4

Analytical Technique: Inductively coupled argon plasma, atomic emission spectroscopy

Analytical Reference Method: MSHA P-3

SAMPLING INFORMATION

Full Shift Sampling:

Sampling Strategy: see Chapter 7
Collection Media: 37-mm diameter, 0.8-µm pore size mixed cellulose ester (MCE) filter
Sample Flow Rate (Lpm): 1.7

Short Term Sampling:

Sampling Strategy: see Chapter 7
Sampling Duration: 15 min.
Collection Media: 37-mm diameter, 0.8-µm pore size mixed cellulose ester (MCE) filter
Sample Flow Rate (Lpm): 1.7

Special Instructions: N/A

Manganese - Mn
(Compounds and Fume)
500 mg/m^3 (as Mn) IDLH (NIOSH, 1995)

Contaminant Codes:	1973 ACGIH TLV:	1973 ACGIH Excursion STEL/Ceiling (C):
647 (dust)	5.0 mg/m^3	5.0 mg/m^3 (C)
727 (fume)	5.0 mg/m^3	5.0 mg/m^3 (C)

CONTAMINANT INFORMATION

Synonyms: Manganese metal: colloidal manganese, manganese-55

Sources: Manufacture of alloys, welding rods; mining and processing of manganese ores - pyrolusite, manganese oxide (MnO), braunite, haussmanite, manganite, manganosite, rhodocrosite, manganomanganic oxide

Description: Ustrous, brittle, silvery solid

Incompatibilities: Oxidizers; [note: will react with water or steam to produce hydrogen]

Exposure: Inhalation, ingestion

Health Effects: Parkinson's; asthenia, insomnia, mental confusion; metal fume fever: dry throat, cough, chest tightness, dyspnea (breathing difficulty), rales, flu-like fever; low-back pain; vomiting; malaise (vague feeling of discomfort); fatigue; kidney damage

PPE: Respirator: Recommendations - NIOSH: Up to 10 mg/m^3: (APF = 10) any dust and mist respirator except single-use and quarter-mask respirators (note: if not present as a fume); (APF = 10) any supplied-air respirator; Up to 25 mg/m^3: (APF = 25) any supplied-air respirator operated in a continuous-flow mode; (APF = 25) any powered, air-purifying respirator with a dust and mist filter (note: if not present as a fume); up to 50 mg/m^3: (APF = 50) any air-purifying, full-facepiece respirator with a high-efficiency particulate filter; (APF = 50) any supplied-air respirator that has a tight-fitting facepiece and is operated in a continuous-flow mode; (APF = 50) any powered, air-purifying respirator with a tight-fitting facepiece and a high-efficiency particulate filter; (APF = 50) any self-contained breathing apparatus with a full facepiece; (APF = 50) any supplied-air respirator with a full facepiece; up to 500 mg/m^3: (APF = 1000) any supplied-air respirator operated in a pressure-demand or other positive-pressure mode

Skin: No specific recommendation can be made; actual working conditions will determine the need and type of personal protective equipment

Eyes: No recommendation is made specifying the need for eye protection

Special Precautions: Metal: combustible solid

LABORATORY INFORMATION

CAS Number: 7439-96-5
Analytical Technique: Inductively coupled argon plasma, atomic emission spectroscopy
Analytical Reference Method: MSHA P-3

SAMPLING INFORMATION
Full Shift Sampling:
Sampling Strategy: see Chapter 7
Collection Media: 37-mm diameter, 0.8-hm pore size mixed cellulose ester (MCE) filter
Sample Flow Rate (Lpm): 1.7

Short Term Sampling:
Sampling Strategy: see Chapter 7
Sampling Duration: 15 min.
Collection Media: 37-mm diameter, 0.8-hm pore size mixed cellulose ester (MCE) filter
Sample Flow Rate (Lpm): 1.7

Special Instructions: N/A

Wipe Sampling:
Sampling Strategy: see Chapter 14
Collection Media: Whatman Filter (No. 41 or 42), moistened with distilled water
Special Instructions: Seal wipe sample in plastic bag, vial, or jar.

Mercury - Hg

10 mg/m^3 [except (organo) alkyls compounds] (as Hg) IDLH (NIOSH, 1995)
2 mg/m^3 [(organo) alkyls compounds] (as Hg) IDLH (NIOSH, 1995)

Contaminant Codes:	1973 ACGIH TLV:	1973 ACGIH Excursion STEL/Ceiling (C):
625 [dusts & vapors, except (organo) alkyl compounds]	0.05 mg/m^3 (50 µg/m^3)	0.15 mg/m^3 (150 µg/m^3) - 15 min.
729 [fume, except (organo) alkyl compounds]	0.05 mg/m^3 (50 µg/m^3)	0.15 mg/m^3 (150 µg/m^3) - 15 min.
	(PEDS units of measure in parentheses)	
995 [(organo) alkyl compounds]*	0.01 mg/m^3 (Skin)	0.03 mg/m^3 - 15 min.

***Note: If (organo) alkyl compounds of mercury are encountered,**
use EXTREME CAUTION and contact the District Office for guidance.

CONTAMINANT INFORMATION

Synonyms:	*Metal*: Colloidal mercury, metallic mercury, quicksilver *(organo) alkyl*: synonyms vary depending upon the specific compound
Sources:	*Metal*: Measurement control systems, amalgams, lab reagent, gold and silver mining; ores of cinnabar, red sulfide, and vermillion *(organo) alkyl*: pesticide, antibacterial agent, explosives (mercury fulminate), reagents
Description:	*Metal*: Silver-white, heavy, odorless liquid *(organo) alkyl*: appearance and odor vary depending upon the specific compound
Incompatibilities:	*Metal*: Acetylene, ammonia, chlorine dioxide, azides, calcium (amalgam formation), sodium carbide, lithium, rubidium, copper *(organo) alkyl*: strong oxidizers (*e.g.*, chlorine)
Exposure:	*Metal*: Inhalation, skin absorption, ingestion, skin and/or eye contact *(organo) alkyl*: inhalation, skin absorption, ingestion, skin and/or eye contact

Health Effects: *Metal*: Irritation: eyes, skin; cough, chest pain, dyspnea (breathing difficulty), bronchitis pneumonitis; tremor, insomnia, irritability, indecision, headache, fatigue, weakness; stomatitis, salivation; gastrointestinal disturbance, anorexia, weight loss; proteinuria
(organo) alkyl: paresthesia; ataxia, dysarthria; vision, hearing disturbance; spasticity, jerking limbs; dizziness; salivation; lacrimation (discharge of tears); nausea, vomiting, diarrhea, constipation; skin burns; emotional disturbance; kidney injury; possible teratogenic effects

PPE: Respirator: *Mercury vapor*: Recommendations - NIOSH: Up to 0.5 mg/m^3: (APF = 10) any chemical cartridge respirator with cartridge(s) providing protection against the compound of concern [note: end of service life indicator (ESLI) required]; up to 1.25 mg/m^3: (APF = 25) any powered, air-purifying respirator with cartridge(s) [or canister] providing protection against the compound of concern [note: end of service life indicator (ESLI) required]; up to 2.5 mg/m^3: (APF = 50) any chemical cartridge respirator with a full facepiece and cartridge(s) providing protection against the compound of concern [note: end of service life indicator (ESLI) required]; (APF = 50) any air-purifying, full-facepiece respirator (gas mask) with a chin-style, front- or back-mounted canister providing protection against the compound of concern [note: end of service life indicator (ESLI) required]; (APF = 50) any supplied-air respirator that has a tight-fitting facepiece and is operated in a continuous-flow mode; (APF = 50) any powered, air-purifying respirator with a tight-fitting facepiece and cartridge(s) [or canister] providing protection against the compound of concern [note: end of service life indicator (ESLI) required]; (APF = 50) any self-contained breathing apparatus with a full facepiece; (APF = 50) any supplied-air respirator with a full facepiece; up to 10 mg/m^3: (APF = 1000) any supplied-air respirator operated in a pressure-demand or other positive-pressure mode
other non (organo) alkyl mercury compounds: Recommendations - NIOSH / OSHA: Up to 1 mg/m^3: (APF = 10) any chemical cartridge respirator with cartridge(s) providing protection against the compound of concern [note: end of service life indicator (ESLI) required]; (APF = 10) any supplied-air respirator; up to 2.5 mg/m^3: (APF = 25) any supplied-air respirator operated in a continuous-flow mode; (APF = 25) any powered, air-purifying respirator with cartridge(s) [or canister] providing protection against the compound of concern [note: end of service life indicator (ESLI) required]; up to 5 mg/m^3: (APF = 50) any chemical cartridge respirator with a full facepiece and cartridge(s) providing protection against the compound of concern [note: end of service life indicator (ESLI) required]; APF = 50) any air-purifying, full-facepiece respirator (gas mask) with a chin-style, front- or back-mounted canister providing

protection against the compound of concern [note: end of service life indicator (ESLI) required]; (APF = 50) any supplied-air respirator that has a tight-fitting facepiece and is operated in a continuous-flow mode; (APF = 50) any powered, air-purifying respirator with a tight-fitting facepiece and cartridge(s) [or canister] providing protection against the compound of concern [note: end of service life indicator (ESLI) required]; (APF = 50) any self-contained breathing apparatus with a full facepiece; (APF = 50) any supplied-air respirator with a full facepiece; up to 10 mg/m^3: (APF = 1000) any supplied-air respirator operated in a pressure-demand or other positive-pressure mode

(organo) alkyl: Recommendations - NIOSH/OSHA: Up to 0.1 mg/m^3: (APF = 10) any supplied-air respirator; up to 0.25 mg/m^3: (APF = 25) any supplied-air respirator operated in a continuous-flow mode; up to 0.5 mg/m^3: (APF = 50) any supplied-air respirator that has a tight-fitting facepiece and is operated in a continuous-flow mode; (APF = 50) any self-contained breathing apparatus with a full facepiece; (APF = 50) any supplied-air respirator with a full facepiece; up to 2 mg/m^3: (APF = 1000) any supplied-air respirator operated in a pressure-demand or other positive-pressure mode

Skin: Prevent skin contact; contact the manufacturer for recommendations for the specific compound

Eyes: *Non (organo) alkyl mercury compounds / particulate*: No recommendation is made specifying the need for eye protection

(organo) alkyl: Prevent eye contact

Special Precautions: *Metal*: Noncombustible liquid

(organo) alkyl: properties vary depending upon the specific compound

LABORATORY INFORMATION

CAS Number: 7439-97-6

Analytical Technique:

mercury vapor: OSHA ID-140: cold vapor - atomic absorption spectrophotometer (CV-AAS); Assay Technology: passive monitor; Dräger: detector tube; directing reading instrument

other non (organo) alkyl mercury compounds / particulate: OSHA ID-145: cold vapor - atomic absorption spectrophotometer (CV-AAS)

(organo) alkyl: none available

Analytical Reference Method: OSHA ID-145; OSHA ID-140; Assay Technology; Dräger; Jerome Mercury Vapor Analyzer

SAMPLING INFORMATION

Full Shift Sampling:

Sampling Strategy: see Chapters 7 & 9

1. OSHA ID-140: [*mercury vapor*]

Collection Media: 200 mg Hydrar (or hopcalite) sorbent tube
Sample Flow Rate (Lpm): 0.2; Must use a pump adaptor or arrange for low flow pumps.
Air Collection Volume: Minimum - Maximum (L): 3-100
2. Assay Technology: [*mercury vapor*]
Collection Media: Assay Technology Mercury Vapor Monitor Badge, #X593; **Note:** maximum 8-hour sample per badge
3. OSHA ID-145: [*other non (organo) alkyl mercury compounds / particulate*]
Collection Media: 37-mm diameter, 0.8-µm pore size mixed cellulose ester (MCE) filter
Sample Flow Rate (Lpm): 2.0
Air Collection Volume (L): 10

<u>Short Term Sampling</u>:
Sampling Strategy: see Chapter 7 & 9
Sampling Duration: 15 min.
1. OSHA ID-140: [*mercury vapor*]
Collection Media: 200 mg Hydrar (or hopcalite) sorbent tube
Sample Flow Rate (Lpm): 0.2; Must use a pump adaptor or arrange for low flow pumps.
Air Collection Volume: Minimum - Maximum (L): 3-100
2. OSHA ID-145: [*other non (organo) alkyl mercury compounds / particulate*]
Collection Media: 37-mm diameter, 0.8-µm pore size mixed cellulose ester (MCE) filter
Sample Flow Rate (Lpm): 2.0
Air Collection Volume (L): 10

<u>Special Instructions</u>: Submit samples to MSHA Laboratory for contract laboratory analysis.

<u>Wipe Sampling</u>:
Sampling Strategy: see Chapter 14
Collection Media: Whatman Filter (No. 41 or 42), moistened with distilled water
Special Instructions: Seal wipe sample in plastic bag, vial, or jar.

Grab Sampling:
Sampling Strategy: see Chapters 11 & 13
Collection Media:
1. Detector Tube [*mercury vapor*]: Dräger detector tube, #CH23101, range 0.05-2 mg/m^3 (EF = 1.30)
2. Direct Reading Instrument [*mercury vapor*]: Jerome (Model 411) Gold Film Mercury Vapor Analyzer, range 0.003 - 1.999 mg/m^3 (EF = 1.09); Jerome (Model 431X) Gold Film Mercury Vapor Analyzer, range 0.003 - 0.999 mg/m^3 (EF = 1.09).

Mercury, Solids
(Bulk)

CONTAMINANT INFORMATION
See "Mercury - Hg" above

LABORATORY INFORMATION
Analytical Technique: EPA 7471A: cold vapor - atomic absorption spectrophotometer (CV-AAS)
Analytical Reference Method: EPA 7471A [for measuring total (organic and inorganic) mercury in soils, sediments, bottom deposits, and sludge-type materials]

SAMPLING INFORMATION
Sampling Strategy: see Chapter 14
Collection: Bulk Material - 10 grams (soils, sediments, bottom deposits, and sludge-type materials)

Special Instructions: Coordinate with MSHA Laboratory. Refrigerate samples. Submit samples via overnight carrier to MSHA Laboratory (for contract laboratory analysis).

Metal Screen, Wipes
(Semiquantitative)

Metals Analyzed: Beryllium, Cadmium, Cobalt, Chromium, Copper, Iron, Lead, Manganese, Molybdenum, Nickel, Vanadium, and Zinc

CONTAMINANT INFORMATION

See individual contaminants

LABORATORY INFORMATION

Analytical Technique: Inductively coupled argon plasma, atomic emission spectroscopy
Analytical Reference Method: MSHA P-3

SAMPLING INFORMATION

Sampling Strategy: see Chapter 14
Collection Media: Whatman Filter (No. 41 or 42), moistened with distilled water
Special Instructions: Seal wipe sample in plastic bag, vial, or jar.

Metals, Solids*
(Bulk)

Metals Analyzed: Arsenic, Barium, Cadmium, Chromium, Lead, Nickel, Silver**,** Zinc

***Special Note:** **Other metals may be analyzed. Call to determine if other metals may be added.**

CONTAMINANT INFORMATION
See individual contaminants

LABORATORY INFORMATION
Analytical Technique: EPA 200.7: Inductively Coupled Plasma - Atomic Emission Spectrometry (ICP-AES)
Analytical Reference Method: EPA 200.7 (determination of metals and trace elements in water and wastes)

SAMPLING INFORMATION
Sampling Strategy: see Chapter 14
Collection: Bulk Material - 20 grams (in water and wastes)

Special Instructions: Coordinate with MSHA laboratory.

Methyl Alcohol (Methanol) - CH_3OH
6,000 ppm IDLH (NIOSH, 1995)

Contaminant Codes:	1973 ACGIH TLV:	ANSI Z37.14-1971 STEL/Ceiling (C):
231	200 ppm	600 ppm (C)

CONTAMINANT INFORMATION

Synonyms: Carbinol, Columbian spirits, pyroligneous spirit, wood alcohol, wood naphtha, wood spirit
Sources: Paints, varnishes, cements, antifreeze, octane booster for gasoline
Description: Colorless liquid with a characteristic pungent odor
Incompatibilities: Strong oxidizers
Exposure: Inhalation, skin absorption, ingestion, skin and/or eye contact
Health Effects: Irritation eyes, skin, upper respiratory system; headache, drowsiness, dizziness, vertigo (an illusion of movement), lightheadedness, nausea, vomiting; visual disturbance, optic nerve damage (blindness); dermatitis
PPE: Respirator: Recommendations - NIOSH/OSHA: Up to 2000 ppm: (APF = 10) any supplied-air respirator; up to 5000 ppm: (APF = 25) any supplied-air respirator operated in a continuous-flow mode; up to 6000 ppm: (APF = 50) any supplied-air respirator that has a tight-fitting facepiece and is operated in a continuous-flow mode; (APF = 50) any self-contained breathing apparatus with a full facepiece; (APF = 50) any supplied-air respirator with a full facepiece
Skin: Prevent skin contact; 8 hr: Butyl, Teflon, Viton, Saranex, PE/EVAL, Responder, Trellchem, Tychem
Eyes: Prevent eye contact
Special Precautions: Class IB Flammable Liquid

LABORATORY INFORMATION

CAS Number: 67-56-1
Analytical Technique: Gas Chromatography / Flame Ionization Detection (GC-FID)
Analytical Reference Method: NIOSH 2000

SAMPLING INFORMATION

Full Shift Sampling:

Sampling Strategy: see Chapter 9
Collection Media: 100/50 mg silica gel tube
Sample Flow Rate: Minimum - Maximum (Lpm): 0.02-0.2; Must use a pump adaptor or arrange for low flow pumps.
Air Collection Volume: Minimum - Maximum (L): 1-5

Short Term Sampling:

Sampling Strategy: see Chapter 9
Sampling Duration: 15 min.
Collection Media: 100/50 mg silica gel tube
Sample Flow Rate: Minimum - Maximum (Lpm): 0.02-0.2; Must use a pump adaptor or arrange for low flow pumps.
Air Collection Volume: Minimum - Maximum (L): 1-5

Special Instructions: Coordinate with MSHA laboratory. A sample will remain stable for 30 days if maintained at 5°C.

Methyl Chloroform - CH_3CCl_3
700 ppm IDLH (NIOSH, 1995)

Contaminant Codes:	**1973 ACGIH TLV:**	**1968 PA Rules STEL/Ceiling (C):**
205	350 ppm	1,500 ppm - 5 min.

CONTAMINANT INFORMATION

Synonyms:	Chlorothene, 1,1,1-trichloroethane
Sources:	Solvents, cleaning of cold metals
Description:	Colorless liquid with a mild, chloroform-like odor
Incompatibilities:	Strong caustics; strong oxidizers; chemically-active metals (e.g., zinc, aluminum, magnesium powders, sodium); water (note: reacts slowly with water to form hydrochloric acid.)
Exposure:	Inhalation, ingestion, skin and/or eye contact
Health Effects:	Irritation: eyes, skin; headache, lassitude (weakness, exhaustion), central nervous system depressant/depression, poor equilibrium, dermatitis, cardiac arrhythmias, liver damage
PPE: Respirator:	Recommendations - NIOSH/OSHA: Up to 700 ppm: (APF = 10) any supplied-air respirator (note: substance reported to cause eye irritation or damage; may require eye protection); (APF = 50) any self-contained breathing apparatus with a full facepiece
Skin:	Prevent skin contact; 8 hr: PVA, Viton, PE/EVAL, Barricade, CPF3, Responder, Tychem; 4 hr: Teflon
Eyes:	Prevent eye contact
Special Precautions:	Combustible liquid, but burns with difficulty

LABORATORY INFORMATION

CAS Number: 71-55-6

Analytical Technique: NIOSH 1003 (IV) / OSHA 14: gas chromatography (GC) / flame ionization detection (FID); 3M: passive monitor

Analytical Reference Method: NIOSH 1003 (IV); OSHA 14; 3M

SAMPLING INFORMATION

Full Shift Sampling:

Sampling Strategy: see Chapter 9

1. NIOSH 1003 (IV):

Collection Media: 100/50 mg: solid sorbent tube (coconut shell charcoal)

Sample Flow Rate: Minimum - Maximum (Lpm): 0.01-0.2; Must use a pump adaptor or arrange for low flow pumps.

Air Collection Volume: Minimum - Maximum (L): 0.1-8

2. OSHA 14:

Collection Media: 100/50 mg: solid sorbent tube (coconut shell charcoal)

Sample Flow Rate (Lpm): 0.2; Must use a pump adaptor or arrange for low flow pumps.

Air Collection Volume (L): 3

3. 3M:

Collection Media: Passive monitor, 3M, 3500 series

Note: maximum 8-hour sample per badge

Short Term Sampling:

Sampling Strategy: see Chapter 9

Sampling Duration: 5 min.

1. NIOSH 1003 (IV):

Collection Media: 100/50 mg: solid sorbent tube (coconut shell charcoal)

Sample Flow Rate: Minimum - Maximum (Lpm): 0.01-0.2; Must use a pump adaptor or arrange for low flow pumps.

Air Collection Volume: Minimum - Maximum (L): 0.1-8

2. OSHA 14:

Collection Media: 100/50 mg: solid sorbent tube (coconut shell charcoal)

Sample Flow Rate (Lpm): 0.2; Must use a pump adaptor or arrange for low flow pumps.

Air Collection Volume (L): 3

Methyl Ethyl Ketone (2-Butanone) - $CH_3COCH_2CH_3$

3,000 ppm IDLH (NIOSH, 1995)

Contaminant Codes:	1973 ACGIH TLV:	1968 PA Rules STEL/Ceiling (C):
251	200 ppm	300 ppm - 5 min.

CONTAMINANT INFORMATION

Synonyms:	MEK, ethyl methyl ketone, methyl acetone
Sources:	Solvent, synthetic colorless resins
Description:	Colorless liquid with a moderately sharp, fragrant, mint- or acetone-like odor
Incompatibilities:	Strong oxidizers, amines, ammonia, inorganic acids, caustics, isocyanates, pyridines
Exposure:	Inhalation, ingestion, skin and/or eye contact
Health Effects:	Irritation eyes, skin, nose; headache; dizziness; vomiting; dermatitis
PPE: Respirator:	Recommendations - NIOSH/OSHA: Up to 3000 ppm: (APF = 25) any supplied-air respirator operated in a continuous-flow mode (note: substance causes eye irritation or damage; eye protection needed); (APF = 25) any powered, air-purifying respirator with organic vapor cartridge(s) (note: substance causes eye irritation or damage; eye protection needed); (APF = 50) any chemical cartridge respirator with a full facepiece and organic vapor cartridge(s); (APF = 50) any air-purifying, full-facepiece respirator (gas mask) with a chin-style, front- or back-mounted organic vapor canister; (APF = 50) any self-contained breathing apparatus with a full facepiece; (APF = 50) any supplied-air respirator with a full facepiece
Skin:	Prevent skin contact; 8 hr: Butyl, Teflon, PE/EVAL, Barricade, CPF3, Tychem; 4 hr: Responder
Eyes:	Prevent eye contact
Special Precautions:	Class IB Flammable Liquid

LABORATORY INFORMATION

CAS Number: 78-93-3

Analytical Technique: Gas chromatography / flame ionization detector (GC-FID); 3M: passive monitor

Reference Method: NIOSH 2500 (IV); 3M

SAMPLING INFORMATION

Full Shift Sampling:

Sampling Strategy: see Chapter 9

1. NIOSH 2500 (IV):

Collection Media: 160/80 mg: solid sorbent tube (carbon molecular sieve)

Sample Flow Rate: Minimum - Maximum (Lpm): 0.01-0.2; Must use a pump adaptor or arrange for low flow pumps.

Air Collection Volume: Minimum - Maximum (L): 0.25-12

2. 3M:

Collection Media: Passive monitor, 3M, 3500 series

Note: maximum 8-hour sample per badge

Special Instructions: Coordinate with MSHA Laboratory when sampling with 3M passive monitor. When sampled in high relative humidity this contaminant may show a decreased recovery during the laboratory analysis. Refrigerate the sample and expedite the analysis to ensure accurate results.

Short Term Sampling:

Sampling Strategy: see Chapter 9

Sampling Duration: 5 min.

NIOSH 2500 (IV):

Collection Media: 160/80 mg: solid sorbent tube (carbon molecular sieve)

Sample Flow Rate: Minimum - Maximum (Lpm): 0.01-0.2; Must use a pump adaptor or arrange for low flow pumps.

Air Collection Volume: Minimum - Maximum (L): 0.25-12

Methyl Isoamyl Ketone - $CH_3COCH_2CH_2CH(CH_3)_2$

Contaminant Codes:	1973 ACGIH TLV:	1973 ACGIH Excursion STEL/Ceiling (C):
995	100 ppm	150 ppm - 15 min.

CONTAMINANT INFORMATION

Synonyms:	MIAK, isoamyl methyl ketone, isopentyl methyl ketone, 2-methyl-5-hexanone, 5-methyl-2-hexanone
Sources:	Solvents, cellulose acetate, butyrate
Description:	Colorless, clear liquid with a pleasant, fruity odor
Incompatibilities:	Oxidizers
Exposure:	Inhalation, ingestion, skin and/or eye contact
Health Effects:	Irritation eyes, skin, mucous membrane; headache, narcosis, coma; dermatitis
PPE: Respirator:	Recommendations - NIOSH: Up to 500 ppm: (APF = 10) any chemical cartridge respirator with organic vapor cartridge(s) (note: substance reported to cause eye irritation or damage; may require eye protection); (APF = 10) any supplied-air respirator (note: substance reported to cause eye irritation or damage; may require eye protection); up to 1250 ppm: (APF = 25) any supplied-air respirator operated in a continuous-flow mode (note: substance reported to cause eye irritation or damage; may require eye protection); (APF = 25) any powered, air-purifying respirator with organic vapor cartridge(s) (note: substance reported to cause eye irritation or damage; may require eye protection); up to 2500 ppm: (APF = 50) any chemical cartridge respirator with a full facepiece and organic vapor cartridge(s); (APF = 50) any air-purifying, full-facepiece respirator (gas mask) with a chin-style, front- or back-mounted organic vapor canister; (APF = 50) any powered, air-purifying respirator with a tight-fitting facepiece and organic vapor cartridge(s) (note: substance reported to cause eye irritation or damage; may require eye protection); (APF = 50) any supplied-air respirator that has a tight-fitting facepiece and is operated in a continuous-flow mode (note: substance reported to cause eye irritation or damage; may require eye protection); (APF = 50) any self-contained breathing apparatus with a full facepiece; (APF = 50) any supplied-air respirator with a full facepiece; up to 5000 ppm: (APF = 2000) any supplied-air respirator that has a full facepiece and is operated in a pressure-demand or other positive-pressure mode

Skin: Prevent skin contact; contact the manufacturer for recommendations
Eyes: Prevent eye contact
Special Precautions: Class IC Flammable Liquid

LABORATORY INFORMATION

CAS Number: 110-12-3
Analytical Technique: None available
Analytical Reference Method: None available

SAMPLING INFORMATION

Full Shift Sampling:
Sampling Strategy: N/A
Collection Media: N/A
Sample Flow Rate: Minimum - Maximum (Lpm): N/A
Air Collection Volume: Minimum - Maximum (L): N/A

Short Term Sampling:
Sampling Strategy: N/A
Sampling Duration: 15 min.
Collection Media: N/A
Sample Flow Rate: Minimum - Maximum (Lpm): N/A
Air Collection Volume: Minimum - Maximum (L): N/A

Special Instructions: N/A

Methyl Isobutyl Carbinol - $(CH_3)_2CHCH_2CH(OH)CH_3$
400 ppm IDLH (NIOSH, 1995)

Contaminant Codes:	1973 ACGIH TLV:	1973 ACGIH Excursion STEL/Ceiling (C):
233	25 ppm - (Skin)	37.5 ppm - 15 min.

CONTAMINANT INFORMATION

Synonyms:	MIBC, isobutylmethylcarbinol, methyl amyl alcohol, 4-methyl-2-pentanol
Sources:	Solvent, brake fluid
Description:	Colorless liquid with a mild odor
Incompatibilities:	Strong oxidizers
Exposure:	Inhalation, skin absorption, ingestion, skin and/or eye contact
Health Effects:	Irritation: eyes, skin; headache, drowsiness, dermatitis
PPE: Respirator:	Recommendations - NIOSH/OSHA: Up to 250 ppm: (APF = 10) any supplied-air respirator (note: substance reported to cause eye irritation or damage; may require eye protection); up to 400 ppm: (APF = 25) any supplied-air respirator operated in a continuous-flow mode (note: substance reported to cause eye irritation or damage; may require eye protection); (APF = 50) any self-contained breathing apparatus with a full facepiece; (APF = 50) any supplied-air respirator with a full facepiece
Skin:	Prevent skin contact; contact the manufacturer for recommendations
Eyes:	Prevent eye contact
Special Precautions:	Class II combustible liquid

LABORATORY INFORMATION

CAS Number: 108-11-2

Analytical Technique: NIOSH 1402 (IV) / OSHA 7: gas chromatography / flame ionization detection (GC-FID)

Reference Method: NIOSH 1402 (IV); OSHA 7

SAMPLING INFORMATION

Full Shift Sampling:

Sampling Strategy: see Chapter 9

1. NIOSH 1402 (IV):

Collection Media: 100/50 mg: solid sorbent tube (coconut shell charcoal)

Sample Flow Rate: Minimum - Maximum (Lpm): 0.01-0.2; Must use a pump adaptor or arrange for low flow pumps.

Air Collection Volume: Minimum - Maximum (L): 1-10

2. OSHA 7:

Collection Media: 100/50 mg: solid sorbent tube (coconut shell charcoal)

Sample Flow Rate: Minimum - Maximum (Lpm): 0.2; Must use a pump adaptor or arrange for low flow pumps.

Air Collection Volume (L): 10

Short Term Sampling:

Sampling Strategy: see Chapter 9

Sampling Duration: 15 min.

1. NIOSH 1402 (IV):

Collection Media: 100/50 mg: solid sorbent tube (coconut shell charcoal)

Sample Flow Rate: Minimum - Maximum (Lpm): 0.01-0.2; Must use a pump adaptor or arrange for low flow pumps.

Air Collection Volume: Minimum - Maximum (L): 1-10

2. OSHA 7:

Collection Media: 100/50 mg: solid sorbent tube (coconut shell charcoal)

Sample Flow Rate: Minimum - Maximum (Lpm): 0.2; Must use a pump adaptor or arrange for low flow pumps.

Air Collection Volume (L): 10

Special Instructions: NIOSH 1402 (IV): Coordinate with MSHA Laboratory. Stability of sample is unknown. Store samples in freezer and ship on ice.

Mica (< 1% quartz)

1,500 mg/m^3 IDLH (NIOSH, 1995)

Contaminant Codes:	1973 ACGIH TLV:	1973 ACGIH Excursion STEL/Ceiling (C):
513	20 mppcf (3.0 mg/m^3)	40 mppcf (6.0 mg/m^3) - 15 min.
	(PEDS "screening" units of measure in parentheses)	

CONTAMINANT INFORMATION

Synonyms:	Biotite, lepidolite, margarite, muscovite, phlogopite, roscoelite, zimmwaldite
Sources:	Silicate ores with same names as above
Description:	Colorless, odorless flakes or sheets of hydrous silicates
Incompatibilities:	None reported
Exposure:	Inhalation, skin and/or eye contact
Health Effects:	Irritation: eyes; pneumoconiosis, cough, dyspnea (breathing difficulty), weakness, weight loss
PPE: Respirator:	Recommendations - NIOSH: Up to 15 mg/m^3: (APF = 5) any dust and mist respirator; up to 30 mg/m^3: (APF = 10) any dust and mist respirator except single-use and quarter-mask respirators; (APF = 10) any supplied-air respirator; up to 75 mg/m^3: (APF = 25) any supplied-air respirator operated in a continuous-flow mode; (APF = 25) any powered, air-purifying respirator with a dust and mist filter; up to 150 mg/m^3: (APF = 50) any air-purifying, full-facepiece respirator with a high-efficiency particulate filter; (APF = 50) any supplied-air respirator that has a tight-fitting facepiece and is operated in a continuous-flow mode; (APF = 50) any powered, air-purifying respirator with a tight-fitting facepiece and a high-efficiency particulate filter; (APF = 50) any self-contained breathing apparatus with a full facepiece; (APF = 50) any supplied-air respirator with a full facepiece; up to 1500 mg/m^3: (APF = 1000) any supplied-air respirator operated in a pressure-demand or other positive-pressure mode
Skin:	No specific recommendation can be made; determine based on working conditions
Eyes:	No recommendation is made specifying the need for eye protection
Special Precautions:	Noncombustible solid

LABORATORY INFORMATION
CAS number: 12001-26-2
Analytical Technique:
1. X-ray diffraction
2. Mineral Dust: impinger method
Analytical Reference Method: NIOSH 0600 (IV); impinger method, MSHA P-2

SAMPLING INFORMATION
Full Shift Sampling: Screening - **Note: cannot be used for enforcement**
Sampling Strategy: see Chapter 6
Collection Media: cyclone and filter [10-mm nylon cyclone and 37-mm diameter, 5-µm pore size polyvinyl chloride (PVC) filter]
Sample Flow Rate (Lpm): 1.7

Full Shift - Partial Period Sampling: Enforcement - **Note: for compliance with TLV**
Sampling Strategy: see Chapter 6
Collection Media: impinger
Sample Flow Rate (Lpm): 2.8
Air Collection Volume (L): 168

Special Instructions: Coordinate with MSHA Technical Support. Dust Division personnel will conduct impinger sampling with inspector escort.

Mine Gas (Profile)

Gases Analyzed: Acetylene, Argon, Carbon Monoxide*, Carbon Dioxide**,** Ethane, Ethylene, Hydrogen, Oxygen, Methane, Nitrogen

LABORATORY INFORMATION

Analytical Technique: Gas Chromatograph (GC)/DRI
Analytical Reference Method: Gas Chromatography

SAMPLING INFORMATION

Grab Sampling:
Sampling Strategy: see Chapter 12
Collection Media: 50 mL vacuum bottle or 10 mL vacutainer (EF = 1.11).
***Note:** For inclusion of carbon monoxide (CO) use 50 mL vacuum bottle
Sample Flow Rate: Minimum - Maximum (Lpm): NA
Air Collection Volume: Minimum - Maximum (L): 10 mL - 50 mL

Grab Sampling:
Sampling Strategy: see Chapter 13
Collection Media: Direct Reading Instrument TMX 410 or TMX412 (EF = 1.25): for carbon monoxide (CO), oxygen (O_2), methane (CH_4/combustibles - LEL%).
Various other electronic direct-reading instruments are available. Consult the manufacturer's instructions and specifications to determine suitability for particular contaminants.

Special Instructions: Gases normally sampled and tested for are methane, oxygen, carbon monoxide and carbon dioxide. Contact the MSHA laboratory for information if other gases are to be analyzed. There is a 14-day hold time for vacuum samples and a 7-day hold time for vacutainers. Submit the sample as soon as possible to MSHA laboratory.

Molybdenum - Mo

5,000 mg/m^3 (insoluble compounds, as Mo) IDLH (NIOSH, 1995)
1,000 mg/m^3 (soluble compounds, as Mo) IDLH (NIOSH, 1995)

Contaminant Codes:	1973 ACGIH TLV:	1973 ACGIH Excursion STEL/Ceiling (C):
163 (insoluble dust)	10 mg/m^3	20 mg/m^3 - 15 min.
731 (fume)	10 mg/m^3	20 mg/m^3 - 15 min.
645 (soluble compounds)	5 mg/m^3	10 mg/m^3 - 15 min.

CONTAMINANT INFORMATION

Synonyms:	Molybdenum metal
Sources:	Lubricants, detection of inorganics, corrosion inhibitor
Description:	*Metal*: dark gray or black powder with metallic luster *soluble compounds*: appearance and odor varies by compound
Incompatibilities:	*Metal*: strong oxidizers *soluble compounds*: vary depending upon the specific soluble molybdenum compound
Exposure:	*Metal*: inhalation, ingestion, skin and/or eye contact
Health Effects:	*Metal*: respiratory system and central nervous system effects *Soluble compounds*: irritation of respiratory system. Confirmed animal carcinogen with unknown relevance to humans.
PPE: Respirator:	*Metal*: –OSHA Recommendation: Up to 75 mg/m^3: (APF = 5) any dust and mist respirator (if not present as a fume); up to 150 mg/m^3: (APF = 10) any dust and mist respirator except single-use and quarter-mask respirators (note: if substance not present as a fume); (APF = 10) any supplied-air respirator; up to 375 mg/m^3: (APF = 25) any supplied-air respirator operated in a continuous-flow mode; (APF = 25) any powered, air-purifying respirator with a dust and mist filter (note: if substance not present as a fume); up to 750 mg/m^3: (APF = 50) any air-purifying, full-facepiece respirator with a high-efficiency particulate filter; (APF = 50) any supplied-air respirator that has a tight-fitting facepiece and is operated in a continuous-flow mode; (APF = 50) any powered, air-purifying respirator with a tight-fitting facepiece and a high-efficiency particulate filter; (APF = 50) any self-contained breathing apparatus with a full facepiece; (APF = 50) any supplied-air respirator with a full facepiece; up to 5000 mg/m^3: (APF = 1000) any supplied-air respirator operated in a pressure-demand or other positive-pressure mode

*soluble compounds***:** Recommendations - OSHA: Up to 25 mg/m^3: (APF = 5) any dust and mist respirator (note: substance reported to cause eye irritation or damage; may require eye protection); up to 50 mg/m^3: (APF = 10) any dust and mist respirator except single-use and quarter-mask respirators (note: substance reported to cause eye irritation or damage; may require eye protection); (APF = 10) any supplied-air respirator (note: substance reported to cause eye irritation or damage; may require eye protection); up to 125 mg/m^3: (APF = 25) any supplied-air respirator operated in a continuous-flow mode (note: substance reported to cause eye irritation or damage; may require eye protection); (APF = 25) any powered, air-purifying respirator with a dust and mist filter (note: substance reported to cause eye irritation or damage; may require eye protection); up to 250 mg/m^3: (APF = 50) any air-purifying, full-facepiece respirator with a high-efficiency particulate filter; (APF = 50) any supplied-air respirator that has a tight-fitting facepiece and is operated in a continuous-flow mode (note: substance reported to cause eye irritation or damage; may require eye protection); (APF = 50) any powered, air-purifying respirator with a tight-fitting facepiece and a high-efficiency particulate filter (note: substance reported to cause eye irritation or damage; may require eye protection); (APF = 50) any self-contained breathing apparatus with a full facepiece; (APF = 50) any supplied-air respirator with a full facepiece; up to 1000 mg/m^3: (APF = 2000) any supplied-air respirator that has a full facepiece and is operated in a pressure-demand or other positive-pressure mode

Skin: *Metal*: No specific recommendation can be made; actual working conditions will determine the need and type of personal protective equipment;
soluble compounds: Prevent skin contact; contact the manufacturer for recommendations for specific compounds

Eyes: *Metal*: Determine based on working conditions;
soluble compounds: Prevent eye contact

Special Precautions: *Metal*: combustible solid in form of dust or powder
soluble compounds: vary depending upon the specific soluble molybdenum compound

LABORATORY INFORMATION

CAS Number: 7439-98-7 *(metal)*

Analytical Technique: Inductively coupled argon plasma, atomic emission spectroscopy (ICAP-AES); NIOSH 7300 (IV): inductively coupled argon plasma, atomic emission spectroscopy

Analytical Reference Method: MSHA P-3

SAMPLING INFORMATION

Full Shift Sampling:

Sampling Strategy: see Chapter 7

Collection Media: 37-mm diameter, 0.8-µm pore size mixed cellulose ester (MCE) filter

Sample Flow Rate (Lpm): 1.7

Short Term Sampling:

Sampling Strategy: see Chapter 7

Sampling Duration: 15 min.

Collection Media: 37-mm diameter, 0.8-µm pore size mixed cellulose ester (MCE) filter

Sample Flow Rate (Lpm): 1.7

Special Instructions: N/A

Wipe Sampling:

Sampling Strategy: see Chapter 14

Collection Media: Whatman Filter (No. 41 or 42), moistened with distilled water

Special Instructions: Seal wipe sample in plastic bag, vial, or jar.

Naphtha (Coal Tar)

1,000 ppm IDLH (NIOSH, 1995),
based strictly on safety considerations (i.e., being 10% of the lower explosive limits of the various constituents of coal tar naphtha which range from 1.0 to 1.3%)

Contaminant Codes:	1973 ACGIH TLV:	1973 ACGIH Excursion STEL/Ceiling (C):
253	100 ppm	125 ppm - 15 min.

CONTAMINANT INFORMATION

Synonyms:	Crude solvent coal tar naphtha, high solvent naphtha, naphtha
Sources:	Diluent for paints, coatings, and cements; solvents
Description:	Reddish-brown, mobile liquid with an aromatic odor
Incompatibilities:	Strong oxidizers
Exposure:	Inhalation, ingestion, skin and/or eye contact
Health Effects:	Irritation eyes, skin, nose; lightheadedness, drowsiness; dermatitis
PPE: Respirator:	Recommendations - NIOSH/OSHA: Up to 1000 ppm: (APF = 25) any supplied-air respirator operated in a continuous-flow mode (note: substance causes eye irritation or damage; eye protection needed); (APF = 50) any chemical cartridge respirator with a full facepiece and organic vapor cartridge(s); (APF = 50) any air-purifying, full-facepiece respirator (gas mask) with a chin-style, front- or back-mounted organic vapor canister; (APF = 25) any powered, air-purifying respirator with organic vapor cartridge(s) (note: substance causes eye irritation or damage; eye protection needed); (APF = 50) any self-contained breathing apparatus with a full facepiece; (APF = 50) any supplied-air respirator with a full facepiece
Skin:	Prevent skin contact; 8 hr: Viton; 4 hr: Nitrile, PVA
Eyes:	Prevent eye contact
Special Precautions:	Class II combustible liquid

LABORATORY INFORMATION

CAS Number: 8030-30-6

Analytical Technique: NIOSH 1550 (IV): gas chromatography / flame ionization detection (GC-FID)

Analytical Reference Method: NIOSH 1550 (IV)

SAMPLING INFORMATION

Full Shift Sampling:

Sampling Strategy: see Chapter 9

Collection Media: 100/50 mg: solid sorbent tube (coconut shell charcoal)

Sample Flow Rate: Minimum - Maximum (Lpm): 0.01-0.2 Lpm; Must use a pump adaptor or arrange for low flow pumps.

Air Collection Volume: Minimum - Maximum (L): 1.3-20

Short Term Sampling:

Sampling Strategy: see Chapter 9

Sampling Duration: 15 min.

Collection Media: 100/50 mg: solid sorbent tube (coconut shell charcoal)

Sample Flow Rate: Minimum - Maximum (Lpm): 0.01-0.2 Lpm; must use a pump adaptor or arrange for low flow pumps.

Air Collection Volume: Minimum - Maximum (L): 1.3-20

Special Instructions: Samples of this contaminant will remain stable at least one week at room temperature. Submit samples via overnight carrier to MSHA laboratory. Submit a 5-10 mL bulk sample separately.

Nickel - Ni

10 mg/m^3 (as Ni) IDLH (NIOSH, 1995)

Contaminant Codes:	1973 ACGIH TLV:	1973 ACGIH Excursion STEL/Ceiling (C):
621 (metal & soluble compounds)	1.0 mg/m^3	3.0 mg/m^3 - 15 min.
733 (fume)	1.0 mg/m^3	3.0 mg/m^3 - 15 min.

CONTAMINANT INFORMATION

Synonyms: Elemental nickel metal, nickel catalyst
[**Note:** The IDLH, TLV, & STEL do not apply to nickel carbonyl.]

Sources: Corrosion-resistant alloys, electroplating, nickel sulfide (Ni_3S_2) in smelting and refining of some nickel ores

Description: Lustrous, silvery, odorless solid

Incompatibilities: Strong acids, sulfur, selenium, wood & other combustibles, nickel nitrate

Exposure: Inhalation, ingestion, skin and/or eye contact

Health Effects: Sensitization; dermatitis, allergic asthma, pneumonitis; [potential occupational carcinogen - NIOSH]

PPE: Respirator: Recommendations - NIOSH: At concentrations above the NIOSH REL (i.e., 0.015 mg/m^3): (APF = 10,000) any self-contained breathing apparatus that has a full facepiece and is operated in a pressure-demand or other positive-pressure mode; (APF = 10,000) any supplied-air respirator that has a full facepiece and is operated in a pressure-demand or other positive-pressure mode in combination with an auxiliary self-contained positive-pressure breathing apparatus

Skin: Prevent skin contact; contact the manufacturer for recommendations for specific compounds

Eyes: No recommendation is made specifying the need for eye protection

Special Precautions: Combustible solid; nickel sponge catalyst may ignite spontaneously in air

LABORATORY INFORMATION

CAS Number: 7440-02-0
Analytical Technique: Inductively coupled argon plasma, atomic emission spectroscopy
Analytical Reference Method: MSHA P-3

SAMPLING INFORMATION

Full Shift Sampling:
Sampling Strategy: see Chapter 7
Collection Media: 37-mm diameter, 0.8-μm pore size mixed cellulose ester (MCE) filter
Sample Flow Rate (Lpm): 1.7

Short Term Sampling:
Sampling Strategy: see Chapter 7
Sampling Duration: 15 min.
Collection Media: 37-mm diameter, 0.8-μm pore size mixed cellulose ester (MCE) filter
Sample Flow Rate (Lpm): 1.7

Special Instructions: N/A

Wipe Sampling:
Sampling Strategy: see Chapter 14
Collection Media: Whatman Filter (No. 41 or 42), moistened with distilled water
Special Instructions: Seal wipe sample in plastic bag, vial, or jar.

Nitric Acid - HNO_3
25 ppm IDLH (NIOSH, 1995)

Contaminant Codes:	1973 ACGIH TLV:	1968 PA Rules STEL/Ceiling (C):
491	2.0 ppm	15 ppm - 5 min.

CONTAMINANT INFORMATION

Synonyms:	Aqua fortis, engravers acid, hydrogen nitrate, red fuming nitric acid (RFNA), white fuming nitric acid (WFNA)
Sources:	Explosives
Description:	Colorless, yellow, or red, fuming liquid with an acrid, suffocating odor; [Note: Often used in an aqueous solution. Fuming nitric acid is concentrated nitric acid that contains dissolved nitrogen dioxide.]
Incompatibilities:	Combustible materials, metallic powders, hydrogen sulfide, carbides, alcohols; [Note: Reacts with water to produce heat. Corrosive to metals.]
Exposure:	Inhalation, ingestion, skin and/or eye contact
Health Effects:	Irritation eyes, skin, mucous membrane; delayed pulmonary edema, pneumonitis, bronchitis; dental erosion
PPE: Respirator:	Recommendations - NIOSH/OSHA: Up to 25 ppm: (APF = 25) any supplied-air respirator operated in a continuous-flow mode [note: substance reported to cause eye irritation or damage; may require eye protection]; (APF = 50) any chemical cartridge respirator with a full facepiece and cartridge(s) providing protection against the compound of concern [note: only nonoxidizable sorbents allowed (not charcoal)]; (APF = 50) any air-purifying, full-facepiece respirator (gas mask) with a chin-style, front- or back-mounted canister providing protection against the compound of concern [note: only nonoxidizable sorbents allowed (not charcoal)]; (APF = 50) any self-contained breathing apparatus with a full facepiece; (APF = 50) any supplied-air respirator with a full facepiece
Skin:	Prevent skin contact; (<70% only) --- 8 hr: Butyl, Viton, Saranex, Barricade, CPF3, Trellchem, Tychem; 4 hr: Neoprene, PE, PE/EVAL, Responder
Eyes:	Prevent eye contact
Special Precautions:	Noncombustible liquid, but increases the flammability of combustible materials

LABORATORY INFORMATION

CAS Number: 7697-37-2
Analytical Technique: NIOSH 7903 (IV): ion chromatography; Dräger: detector tube
Analytical Reference Method: NIOSH 7903 (IV); Dräger

SAMPLING INFORMATION

Full Shift Sampling:
Sampling Strategy: see Chapter 9
Collection Media: 400/200 mg: solid sorbent tube (washed silica gel, with glass fiber filter plug)
Sample Flow Rate: Minimum - Maximum (Lpm): 0.2-0.5
Air Collection Volume: Minimum - Maximum (L): 3-100

Short Term Sampling:
Sampling Strategy: see Chapter 9
Sampling Duration: 5 min.
Collection Media: 400/200 mg: solid sorbent tube (washed silica gel, with glass fiber filter plug)
Sample Flow Rate: Minimum - Maximum (Lpm): 0.2-0.5
Air Collection Volume: Minimum - Maximum (L): 3-100

Special Instructions: N/A

Grab Sampling:
Sampling Strategy: see Chapter 11
Collection Media: Dräger detector tube, #6728311, range 1-50 ppm (EF = 1.25).

Nitric Oxide - NO

100 ppm IDLH (NIOSH, 1995)

Contaminant Codes:	1973 ACGIH TLV:	1973 ACGIH Excursion STEL/Ceiling (C):
301	25 ppm	37.5 ppm - 15 min.

CONTAMINANT INFORMATION

Synonyms:	Mononitrogen monoxide, nitrogen monoxide
Sources:	Blasting, diesel exhaust
Description:	Colorless gas
Incompatibilities:	Fluorine, combustible materials, ozone, NH_3, chlorinated hydrocarbons, metals, carbon disulfide; [Note: reacts with water to form nitric acid; rapidly converts in air to nitrogen dioxide.]
Exposure:	Inhalation
Health Effects:	Irritation: eyes, wet skin, nose, throat; drowsiness; unconsciousness; methemoglobinemia
PPE: Respirator:	Recommendations - NIOSH/OSHA: Up to 100 ppm: (APF = 25) any supplied-air respirator operated in a continuous-flow mode [note: substance reported to cause eye irritation or damage; may require eye protection]; (APF = 50) any chemical cartridge respirator with a full facepiece and cartridge(s) providing protection against the compound of concern [note: only nonoxidizable sorbents allowed (not charcoal)]; (APF = 25) any powered, air-purifying respirator with cartridge(s) providing protection against the compound of concern [note: substance reported to cause eye irritation or damage; may require eye protection; only nonoxidizable sorbents allowed (not charcoal)]; (APF = 50) any air-purifying, full-facepiece respirator (gas mask) with a chin-style, front- or back-mounted canister providing protection against the compound of concern [note: only nonoxidizable sorbents allowed (not charcoal)]; (APF = 10) any supplied-air respirator [note: substance reported to cause eye irritation or damage; may require eye protection]; (APF = 50) any self-contained breathing apparatus with a full facepiece
Skin:	No recommendation is made specifying the need for personal protective equipment for the body; determine based on working conditions
Eyes:	No recommendation is made specifying the need for eye protection
Special Precautions:	Nonflammable gas, but will accelerate the burning of combustible materials

LABORATORY INFORMATION

CAS Number: 10102-43-9
Analytical Technique: NIOSH 6014 (IV): visible absorption spectrophotometry; OSHA ID-190: ion chromatography (IC)
Analytical Reference Method: NIOSH 6014 (IV); OSHA ID-190

SAMPLING INFORMATION

Full Shift Sampling:
Sampling Strategy: see Chapter 9
1. NIOSH 6014 (IV):
Collection Media: 3 sorbent tubes in series (i.e., 3-tube sampling device): Tube A = 400 mg triethanolamine-impregnated molecular sieve (TEA-IMS) [type 13x, 30-40 mesh]; Tube B = 800 mg oxidizer (chromate) to convert NO to nitrite ion (NO_2^-); and Tube C (positioned closest to the pump inlet): same as Tube A.
Sample Flow Rate (Lpm): 0.025; Must use a pump adaptor or arrange for low flow pumps.
Air Collection Volume: Minimum - Maximum (L): 1.5-6
2. OSHA ID-190:
Collection Media: 3 sorbent tubes in series (i.e., 3-tube sampling device): Tube A = 400 mg triethanolamine-impregnated molecular sieve (TEA-IMS); Tube B = 800 mg oxidizer (chromate) to convert NO to nitrite ion (NO_2^-); and Tube C (positioned closest to the pump inlet): same as Tube A. {Principle: The sampling device consists of three glass tubes connected in series. The front and back tubes contain TEA-IMS, the middle or oxidizer tube contains an inert carrier impregnated with a chromate salt. The first TEA-IMS tube does not capture NO; this tube is only used to capture and convert NO_2 to NO_2^-. The middle tube oxidizes the sampled NO to NO_2. The back TEA-IMS tube then captures and converts this NO_2 to NO_2^-. Both TEA-IMS samples are desorbed using an aqueous TEA solution and analyzed as NO_2^- by IC. The front tube analytical results are reported as NO_2 and the back tube as NO.}
Sample Flow Rate (Lpm): 0.025; Must use a pump adaptor or arrange for low flow pumps.
Air Collection Volume: Maximum (L): $\leq$ 6

Short Term Sampling:
Sampling Strategy: see Chapter 9
Sampling Duration: 15 min.
1. NIOSH 6014 (IV):
Collection Media: 3 sorbent tubes in series (i.e., 3-tube sampling device): Tube A = 400 mg triethanolamine-impregnated molecular sieve (TEA-IMS) [type 13x, 30-40 mesh]; Tube B = 800 mg oxidizer (chromate) to convert NO to nitrite ion (NO_2^-); and Tube C (positioned closest to the pump inlet): same as Tube A.
Sample Flow Rate (Lpm): 0.025; Must use a pump adaptor or arrange for low flow pumps.
Air Collection Volume: Minimum - Maximum (L): 1.5-6
2. OSHA ID-190:

Collection Media: 3 sorbent tubes in series (i.e., 3-tube sampling device): Tube A = 400 mg triethanolamine-impregnated molecular sieve (TEA-IMS); Tube B = 800 mg oxidizer (chromate) to convert NO to nitrite ion (NO_2^-); and Tube C (positioned closest to the pump inlet): same as Tube A. {Principle: The sampling device consists of three glass tubes connected in series. The front and back tubes contain TEA-IMS, the middle or oxidizer tube contains an inert carrier impregnated with a chromate salt. The first TEA-IMS tube does not capture NO; this tube is only used to capture and convert NO_2 to NO_2^-. The middle tube oxidizes the sampled NO to NO_2. The back TEA-IMS tube then captures and converts this NO_2 to NO_2^-. Both TEA-IMS samples are desorbed using an aqueous TEA solution and analyzed as NO_2^- by IC. The front tube analytical results are reported as NO_2 and the back tube as NO.}
Sample Flow Rate (Lpm): 0.025; Must use a pump adaptor or arrange for low flow pumps.
Air Collection Volume: Maximum (L): ≤ 6

Grab Sampling:
Collection Media: Various electronic direct-reading instruments are available. Consult the manufacturer’s instructions and specifications to determine suitability for particular contaminants.

Special Instructions: NIOSH 6014 (IV): Coordinate with the MSHA Laboratory. Samples are stable at least 7 days at 25°C. Submit 3 to 6 field blanks and 10 media blanks per set.

Nitrogen Dioxide - NO_2
20 ppm IDLH (NIOSH, 1995)

Contaminant Codes:	1973 ACGIH TLV:	1973 ACGIH Excursion STEL/Ceiling (C):
493	5.0 ppm	5.0 ppm (C)

CONTAMINANT INFORMATION

Synonyms:	Dinitrogen tetroxide (N_2O_4)**,** nitrogen peroxide, nitrogen tetroxide
Sources:	Explosives, diesel-powered equipment exhaust
Description:	Yellowish-brown liquid or reddish-brown gas (above 70°F) with acrid, pungent odor; [Note: in solid form (below 15°F) it is found structurally as N_2O_4]
Incompatibilities:	Combustible material, water, chlorinated hydrocarbons, carbon disulfide, ammonia; [note: reacts with water to form nitric acid.]
Exposure:	Inhalation, ingestion, skin and/or eye contact
Health Effects:	Irritation: eyes, nose, throat; cough, mucoid frothy sputum, decreased pulmonary function, chronic bronchitis, dyspnea (breathing difficulty); chest pain; pulmonary edema, cyanosis, tachypnea, tachycardia
PPE: Respirator:	Recommendations - NIOSH: Up to 20 ppm: (APF = 25) any supplied-air respirator operated in a continuous-flow mode [note: substance causes eye irritation or damage; eye protection needed]; (APF = 50) any self-contained breathing apparatus with a full facepiece; (APF = 50) any supplied-air respirator with a full facepiece
Skin:	Prevent skin contact; 8 hr: Saranex
Eyes:	Prevent eye contact
Special Precautions:	Noncombustible liquid/gas, but will accelerate the burning of combustible materials

LABORATORY INFORMATION

CAS Number: 10102-44-0

Analytical Technique: Dräger: diffusion tube; NIOSH 6014 (IV): visible absorption spectrophotometry; OSHA ID-182: ion chromatography (IC); Dräger: detector tube; Industrial Scientific: electronic direct reading instrument (DRI) [with catalytic and electrochemical sensors]

Analytical Reference Method: Dräger; NIOSH 6014 (IV); OSHA ID-182; Dräger; Industrial Scientific

SAMPLING INFORMATION

Full Shift Sampling:

Sampling Strategy: see Chapters 9 and 11

1. Dräger

Collection Media: Dräger diffusion tube, #8101111; range 10-200 ppm (1 hour), 5-100 ppm (2 hours), 2.5-50 ppm (4 hours), 1.3-25 ppm (8 hours); **Note:** up to 8 hours per tube. (EF = 1.41).

2. NIOSH 6014 (IV):

Collection Media: 3 sorbent tubes in series (i.e., 3-tube sampling device): Tube A = 400 mg triethanolamine-impregnated molecular sieve (TEA-IMS) [type 13x, 30-40 mesh]; Tube B = 800 mg oxidizer (chromate) to convert NO to nitrite ion (NO_2^-); and Tube C (positioned closest to the pump inlet): same as Tube A.

Sample Flow Rate (Lpm): 0.025; Must use a pump adaptor or arrange for low flow pumps.

Air Collection Volume: Minimum - Maximum (L): 1.5-6

3. OSHA ID-182:

Collection Media: **(A):** solid sorbent tube, 400/200 mg triethanolamine-impregnated molecular sieve (TEA-IMS); or

(B): 3 sorbent tubes in series (i.e., 3-tube sampling device): Tube A = 400 mg triethanolamine-impregnated molecular sieve (TEA-IMS); Tube B = 800 mg oxidizer (chromate) to convert NO to nitrite ion (NO_2^-); and Tube C (positioned closest to the pump inlet): same as Tube A.

Sample Flow Rate (Lpm): 0.2; Must use a pump adaptor or arrange for low flow pumps.

Air Collection Volume (L): 3

Short Term Sampling:

Sampling Strategy: see Chapter 9

Sampling Duration: 15 min.

2. NIOSH 6014 (IV):

Collection Media: 3 sorbent tubes in series (i.e., 3-tube sampling device): Tube A = 400 mg triethanolamine-impregnated molecular sieve (TEA-IMS) [type 13x, 30-40 mesh]; Tube B = 800 mg oxidizer (chromate) to convert NO to nitrite ion (NO_2^-); and Tube C (positioned closest to the pump inlet): same as Tube A.

Sample Flow Rate (Lpm): 0.025; Must use a pump adaptor or arrange for low flow pumps.

Air Collection Volume: Minimum - Maximum (L): 1.5-6

3. OSHA ID-182:

Collection Media: **(A):** solid sorbent tube, 400/200 mg triethanolamine-impregnated molecular sieve (TEA-IMS); or

(B): 3 sorbent tubes in series (i.e., 3-tube sampling device): Tube A = 400 mg triethanolamine-impregnated molecular sieve (TEA-IMS); Tube B = 800 mg oxidizer (chromate) to convert NO to nitrite ion (NO_2^-); and Tube C (positioned closest to the pump inlet): same as Tube A.

Sample Flow Rate (Lpm): 0.2; Must use a pump adaptor or arrange for low flow pumps.

Air Collection Volume (L): 3

Special Instructions: NIOSH 6014 (IV): Coordinate with the MSHA Laboratory. Samples are stable at least 7 days at 25°C. Submit 3 to 6 field blanks and 10 media blanks per set.

Grab Sampling:
Sampling Strategy: see Chapters 11 and 13
1. Collection Media: Dräger detector tube, #CH30001, range 0.5-25 ppm (EF = 1.25).
2. Collection Media: Industrial Scientific electronic direct reading instrument, TMX410 or TMX412 (EF = 1.25).
Various other electronic direct-reading instruments are available. Consult the manufacturer's instructions and specifications to determine suitability for particular contaminants.

Octane - $CH_3(CH_2)_6CH_3$

1,000 ppm IDLH (NIOSH, 1995),
based strictly on safety considerations (i.e., being 10% of the lower explosive limit of 1.0%)

Contaminant Codes:	1973 ACGIH TLV:	1973 ACGIH Excursion STEL/Ceiling (C):
271	400 ppm	500 ppm - 15 min.

CONTAMINANT INFORMATION

Synonyms:	N-octane, normal-octane
Sources:	Motor fuels, industrial solvent
Description:	Colorless liquid with gasoline-like odor
Incompatibilities:	Strong oxidizers
Exposure:	Inhalation, ingestion, skin and/or eye contact
Health Effects:	Irritation: eyes, nose; drowsiness; dermatitis; chemical pneumonia (aspiration liquid)
PPE: Respirator:	Recommendations - NIOSH: Up to 750 ppm: (APF = 10) any supplied-air respirator [note: substance reported to cause eye irritation or damage; may require eye protection]; up to 1000 ppm: (APF = 25) any supplied-air respirator operated in a continuous-flow mode [note: substance reported to cause eye irritation or damage; may require eye protection]; (APF = 50) any self-contained breathing apparatus with a full facepiece; (APF = 50) any supplied-air respirator with a full facepiece
Skin:	Prevent skin contact; 8 hr: Responder, Tychem; 4 hr: Nitrile, Viton
Eyes:	Prevent eye contact
Special Precautions:	Class IB flammable liquid

LABORATORY INFORMATION

CAS Number: 111-65-9

Analytical Technique: NIOSH 1500 (IV): gas chromatography (GC) / flame ionization detector (FID); OSHA 7: gas chromatography (GC) / flame ionization detector (FID); 3M: passive monitor

Analytical Reference Method: NIOSH 1500 (IV); OSHA 7; 3M

SAMPLING INFORMATION

Full Shift Sampling:
Sampling Strategy: see Chapter 9
1. NIOSH 1500 (IV):
Collection Media: 100/50 mg: solid sorbent tube (coconut shell charcoal)
Sample Flow Rate: Minimum - Maximum (Lpm): 0.01-0.2; Must use a pump adaptor or arrange for low flow pumps.
Air Collection Volume (L): 4
2. OSHA 7:
Collection Media: 100/50 mg: solid sorbent tube (coconut shell charcoal)
Sample Flow Rate: Minimum - Maximum (Lpm): 0.01-0.2; Must use a pump adaptor or arrange for low flow pumps.
Air Collection Volume (L): 4
3. 3M:
Collection Media: Passive monitor, 3M, 3500 series
Note: maximum 8-hour sample per badge

Short Term Sampling:
Sampling Strategy: see Chapter 9
Sampling Duration: 15 min.
1. NIOSH 1500 (IV):
Collection Media: 100/50 mg: solid sorbent tube (coconut shell charcoal)
Sample Flow Rate: Minimum - Maximum (Lpm): 0.01-0.2; Must use a pump adaptor or arrange for low flow pumps.
Air Collection Volume (L): 3
2. OSHA 7:
Collection Media: 100/50 mg: solid sorbent tube (coconut shell charcoal)
Sample Flow Rate: Minimum - Maximum (Lpm): 0.01-0.2; Must use a pump adaptor or arrange for low flow pumps.
Air Collection Volume (L): 3

Special Instructions: N/A

Oil Mist (Mineral Oil)

2,500 mg/m^3 IDLH (NIOSH, 1995)

Contaminant Codes:	1973 ACGIH TLV:	1973 ACGIH Excursion STEL/Ceiling (C):
535 (total particulate)	5.0 mg/m^3	10 mg/m^3 - 15 min.

CONTAMINANT INFORMATION

Synonyms:	Heavy mineral oil mist, paraffin oil mist, white mineral oil mist; airborne mist of the following water-insoluble petroleum-based cutting oils: cable oil, cutting oil, drawing oil, engine oil, heat-treating oils, hydraulic oils, machine oil, transformer oil
Sources:	Lubricating machinery
Description:	Colorless, oily liquid aerosol dispersed in air; [note: has an odor like burned lubricating oil]
Incompatibilities:	None reported
Exposure:	Inhalation, skin and/or eye contact
Health Effects:	Irritation eyes, skin, respiratory system
PPE: Respirator:	Recommendations - NIOSH/OSHA: Up to 50 mg/m^3: (APF = 10) any air-purifying respirator with a high-efficiency particulate filter; (APF = 10) any supplied-air respirator; up to 125 mg/m^3: (APF = 25) any supplied-air respirator operated in a continuous-flow mode; (APF = 25) any powered, air-purifying respirator with a high-efficiency particulate filter; up to 250 mg/m^3: (APF = 50) any air-purifying, full-facepiece respirator with a high-efficiency particulate filter; (APF = 50) any supplied-air respirator that has a tight-fitting facepiece and is operated in a continuous-flow mode; (APF = 50) any powered, air-purifying respirator with a tight-fitting facepiece and a high-efficiency particulate filter; (APF = 50) any self-contained breathing apparatus with a full facepiece; (APF = 50) any supplied-air respirator with a full facepiece; up to 2500 mg/m^3: (APF = 1000) any supplied-air respirator operated in a pressure-demand or other positive-pressure mode
Skin:	Prevent skin contact; contact the manufacturer for recommendations
Eyes:	No recommendation is made specifying the need for eye prevention
Special Precautions:	Class IIIB combustible liquid

LABORATORY INFORMATION

CAS Number: 8012-95-1

Analytical Technique: NIOSH 5026 (IV): infrared spectrophotometry, visible absorption

Analytical Reference Method: NIOSH 5026 (IV)

SAMPLING INFORMATION

Full Shift Sampling:

Sampling Strategy: see Chapter 9
Collection Media: 37-mm diameter, 0.8-µm or 5-µm pore size polyvinyl chloride (PVC) or mixed cellulose ester (MCE) filter
Sample Flow Rate: Minimum - Maximum (Lpm): 1-3
Air Collection Volume: Minimum - Maximum (L): 20-500

Short Term Sampling:
Sampling Strategy: see Chapter 9
Sampling Duration: 30 min.

Special Instructions: Coordinate with MSHA Laboratory. Collect a bulk sample of 5-10 mL unused, undiluted mineral oil for standard preparation. Submit air and bulk samples via overnight carrier to MSHA Laboratory.

Interferences: Any aerosol (*e.g.*, tobacco smoke) which absorbs infrared radiation near 2950 cm^{-1} interferes.

Organic Solvents (Screen)*

Note: "Screening" sample for field application when contaminants listed below are suspected. Analyses will quantify individual components. The results can be used for compliance with respective TLV's.

Organics Analyzed: Chloroform, n-Hexane, Octane, Perchloroethylene (Tetrachloroethylene), Trichloroethylene, 1,1,1-Trichloroethane, 1,2-Dichloroethane

*__Special Note__**: Other components may be determined. Call the Laboratory to determine if other solvents may be added to the screen.**

CONTAMINANT INFORMATION

See individual contaminants

LABORATORY INFORMATION

Analytical Technique: NIOSH 1500: gas chromatography flam ionization detector (FID)
Analytical Reference Method: NIOSH 1500: NIOSH 2549 (IV)

SAMPLING INFORMATION

Full Shift Sampling:
Sampling Strategy: see Chapter 9
Air Collection Volume (L): 1-6
1. OSHA 7: [n-Hexane, Octane]
Collection Media: 100/50 mg: solid sorbent tube (coconut shell charcoal)
Sample Flow Rate: Minimum - Maximum (Lpm): 0.01-0.2; Must use a pump adaptor or arrange for low flow pumps.
Air Collection Volume (L): 2-30
2. NIOSH 2549 (IV):
Collection Media: thermal desorption tube (i.e., multi-bed sorbent tubes containing graphitized carbons and carbon molecular sieve sorbents)
Sample Flow Rate: Minimum - Maximum (Lpm): 0.01-0.05; Must use a pump adaptor or arrange for low flow pumps.
Collection Media: Passive monitor, 3M, 3500 series
Note: maximum 8-hour sample per badge

Short Term Sampling: N/A

Special Instructions: NIOSH 2549 (IV): Coordinate with MSHA Laboratory. Replace caps immediately after sampling. Keep field blanks capped at all times. Tubes can act as diffusive samplers if left uncapped in a contaminated environment. Store samples at -10^{o}C. Ship in sample storage containers at ambient temperature. Submit samples via overnight carrier to MSHA Laboratory.

Ozone - O_3

5.0 ppm IDLH (NIOSH, 1995)

Contaminant Codes:	1973 ACGIH TLV:	1968 PA Rules STEL/Ceiling (C):
481	0.1 ppm (100 ppb)	1.0 ppm (1000 ppb) - 30 min.

(PEDS units of measure in parentheses)

CONTAMINANT INFORMATION

Synonyms: Triatomic oxygen

Sources: Welding, electrostatic precipitators, ionizing air filters, disinfectants

Description: Colorless to blue gas with a very pungent, bleach-like odor

Incompatibilities: All oxidizable materials (both organic & inorganic)

Exposure: Inhalation, skin and/or eye contact

Health Effects: Irritation: eyes, mucous membranes; pulmonary edema; chronic respiratory disease

PPE: Respirator: Recommendations - NIOSH/OSHA: Up to 1 ppm: (APF = 10) any chemical cartridge respirator with cartridge(s) providing protection against the compound of concern [note: only nonoxidizable sorbents allowed (not charcoal)]; (APF = 10) any supplied-air respirator; up to 2.5 ppm: (APF = 25) any supplied-air respirator operated in a continuous-flow mode; (APF = 25) any powered, air-purifying respirator with cartridge(s) providing protection against the compound of concern [note: only nonoxidizable sorbents allowed (not charcoal)]; up to 5 ppm: (APF = 50) any chemical cartridge respirator with a full facepiece and cartridge(s) providing protection against the compound of concern [note: only nonoxidizable sorbents allowed (not charcoal)]; (APF = 50) any air-purifying, full-facepiece respirator (gas mask) with a chin-style, front- or back-mounted canister providing protection against the compound of concern [note: only nonoxidizable sorbents allowed (not charcoal)]; (APF = 50) any supplied-air respirator that has a tight-fitting facepiece and is operated in a continuous-flow mode; (APF = 50) any self-contained breathing apparatus with a full facepiece; (APF = 50) any supplied-air respirator with a full facepiece

Skin: No specific recommendation can be made; actual working conditions will determine the need and type of personal protective equipment

Eyes: No recommendation is made specifying the need for eye protection

Special Precautions: Nonflammable gas, but a powerful oxidizer

LABORATORY INFORMATION

CAS Number: 10028-15-6

Analytical Technique: OSHA ID-214: ion chromatography as nitrate using ultraviolet-visible (UV-VIS) detector (at 200 nm wavelength) or conductivity detector; Dräger: detector tube

Analytical Reference Method: OSHA ID-214; Dräger

SAMPLING INFORMATION

Full Shift Sampling:

Sampling Strategy: see Chapter 9

Collection Media: 37-mm diameter, nitrite-impregnated glass fiber filters (IGFFs)

Sample Flow Rate: Minimum - Maximum (Lpm): 0.25-0.5

Air Collection Volume: Minimum - Maximum (L): 90-120

Short Term Sampling:

Sampling Strategy: see Chapter 9

Sampling Duration: 30 min.

Collection Media: 37-mm diameter, nitrite-impregnated glass fiber filters (IGFFs)

Sample Flow Rate (Lpm): 0.75

Air Collection Volume (L): 22.5

Special Instructions: Coordinate with MSHA Laboratory. Use a preconditioned oxidizer tube only if SO_2 is suspected of being present in the sampled air.

Grab Sampling:

Sampling Strategy: see Chapter 11

Collection Media: Dräger detector tube, #6733181, range 0.005-1.4 ppm (EF = 1.15);
Dräger detector tube, #CH21001, range 10-300 ppm (EF = 1.15).
Various electronic direct-reading instruments are available. Consult the manufacturer’s instructions and specifications to determine suitability for particular contaminants.

Perchloroethylene - $(CCl_2)_2$

150 ppm IDLH (NIOSH, 1995)

Contaminant Codes:	1973 ACGIH TLV:	1968 PA Rules STEL/Ceiling (C):
218	100 ppm	200 ppm - 30 min.

CONTAMINANT INFORMATION

Synonyms:	Perchlorethylene, perk, tetrachlorethylene, tetrachloroethylene; ethylene tetrachloride; Nema; Tetracap; Tetropil; Perclene; Ankilostin; Didakene
Sources:	Metal degreaser, solvent, insulating/cooling gas in electrical transformers
Description:	Colorless liquid with a mild, chloroform-like odor
Incompatibilities:	Strong oxidizers; chemically-active metals (e.g., lithium, beryllium, barium); caustic soda; sodium hydroxide; potash
Exposure:	Inhalation, skin absorption, ingestion, skin and/or eye contact
Health Effects:	Irritation: eyes, skin, nose, throat, respiratory system; nausea; flush face, neck; vertigo (an illusion of movement), dizziness, incoordination; headache, somnolence (sleepiness, unnatural drowsiness); skin erythema (skin redness); liver damage; [note: potential occupational carcinogen]
PPE: Respirator:	Recommendations - NIOSH: At any detectable concentration: (APF = 10,000) any self-contained breathing apparatus that has a full facepiece and is operated in a pressure-demand or other positive-pressure mode; (APF = 10,000) any supplied-air respirator that has a full facepiece and is operated in a pressure-demand or other positive-pressure mode in combination with an auxiliary self-contained positive-pressure breathing apparatus
Skin:	Prevent skin contact; 8 hr: PVA, Teflon, Viton, PE/EVAL, Barricade, CPF3, Responder, Trellchem, Tychem
Eyes:	Prevent eye contact
Special Precautions:	Noncombustible liquid, but decomposes in a fire to hydrogen chloride and phosgene

LABORATORY INFORMATION

CAS Number: 127-18-4

Analytical Technique: NIOSH 1003 (IV): gas chromatography (GC) / flame ionization detection (FID); OSHA 1001: gas chromatography (GC) / flame ionization detection (FID); 3M: passive monitor; Dräger: detector tube

Analytical Reference Method: NIOSH 1003 (IV); OSHA 1001; 3M; Dräger

SAMPLING INFORMATION

Full Shift Sampling:

Sampling Strategy: see Chapter 9

1. NIOSH 1003 (IV):

Collection Media: 100/50 mg: solid sorbent tube (coconut shell charcoal)

Sample Flow Rate: Minimum - Maximum (Lpm): 0.01-0.2; Must use a pump adaptor or arrange for low flow pumps.

Air Collection Volume: Minimum - Maximum (L): 0.2-40

2. OSHA 1001:

Collection Media: 100/50 mg: solid sorbent tube (coconut shell charcoal)

Sample Flow Rate (Lpm): 0.05; Must use a pump adaptor or arrange for low flow pumps.

Air Collection Volume: Maximum (L): 12

3. 3M:

Collection Media: Passive monitor, 3M, 3500 series

Note: maximum 8-hour sample per badge

Short Term Sampling:

Sampling Strategy: see Chapter 9

Sampling Duration: 30 min.

1. NIOSH 1003 (IV):

Collection Media: 100/50 mg: solid sorbent tube (coconut shell charcoal)

Sample Flow Rate: Minimum - Maximum (Lpm): 0.01-0.2; Must use a pump adaptor or arrange for low flow pumps.

Air Collection Volume: Minimum - Maximum (L): 0.2-40

2. OSHA 1001:

Collection Media: 100/50 mg: solid sorbent tube (coconut shell charcoal)

Sample Flow Rate (Lpm): 0.05; Must use a pump adaptor or arrange for low flow pumps.

Air Collection Volume: Minimum (L): 0.25

Special Instructions: N/A

Grab Sampling:

Sampling Strategy: See Chapter 11

Collection Media: Dräger detector tube, #8101551, range 0.1-4 ppm (EF = 1.25); Dräger detector tube, #8101501, range 2-300 ppm (EF = 1.20); Dräger detector tube, #CH30701, range 10-500 ppm (EF = 1.20); Dräger detector tube, #8101851, range 50-10,000 ppm (EF = 1.25).

Perlite

Contaminant Codes:	1973 ACGIH TLV:	1973 ACGIH Excursion STEL/Ceiling (C):
515	30 mppcf (8.6 mg/m^3)	60 mppcf (17.2 mg/m^3) - 15 min.

CONTAMINANT INFORMATION

Synonyms:	Expanded perlite [note: an amorphous material consisting of fused sodium potassium aluminum silicate]
Sources:	Perlite mining
Description:	Odorless, light-gray to glassy-black solid; [note: expanded perlite is a fluffy, white particulate]
Incompatibilities:	None reported
Exposure:	Inhalation, skin and/or eye contact
Health Effects:	Irritation: eyes, skin, throat, upper respiratory system
PPE: Respirator:	Recommendations: N/A
Skin:	No specific recommendation can be made; actual working conditions will determine the need and type of personal protective equipment
Eyes:	No recommendation is made specifying the need for eye protection
Special Precautions:	Noncombustible solid

LABORATORY INFORMATION

CAS number: 93763-70-3

Analytical Technique:

1. NIOSH 0500 (IV) [particulates not otherwise regulated, total]: gravimetric (filter weight)

2. NIOSH 0600 (IV) [particulates not otherwise regulated, respirable]: gravimetric (filter weight)

3. Mineral Dust: impinger method

Analytical Reference Method: NIOSH 0500 (IV); NIOSH 0600 (IV); impinger method

SAMPLING INFORMATION

Full Shift Sampling: Screening - **Note: cannot be used for enforcement**

Sampling Strategy: see Chapter 5

1. NIOSH 0500 (IV)**:**

Collection Media: Filter [37-mm diameter, 5-µm pore size polyvinyl chloride (PVC) filter]

Sample Flow Rate (Lpm): 1.7

Air Collection Volume: Minimum - Maximum (L): 7-133

2. NIOSH 0600 (IV):

Collection Media: Cyclone and filter [10-mm nylon cyclone and 37-mm diameter, 5-µm pore size polyvinyl chloride (PVC) filter]

Sample Flow Rate (Lpm): 1.7

Air Collection Volume: Minimum - Maximum (L): 20-400

Short Term Sampling:
Sampling Strategy: see Chapter 5
Sampling Duration: 15 min.
1. NIOSH 0500 (IV)**:**
Collection Media: Filter [37-mm diameter, 5-µm pore size polyvinyl chloride (PVC) filter]
Sample Flow Rate (Lpm): 1.7
Air Collection Volume: Minimum - Maximum (L): 7-133
2. NIOSH 0600 (IV):
Collection Media: Cyclone and filter [10-mm nylon cyclone and 37-mm diameter, 5-µm pore size polyvinyl chloride (PVC) filter]
Sample Flow Rate (Lpm): 1.7
Air Collection Volume: Minimum - Maximum (L): 20-400

Full Shift - Partial Period Sampling: Enforcement - **Note: for compliance with TLV**
Sampling Strategy: see Chapter 6
Collection Media: impinger
Sample Flow Rate (Lpm): 2.8
Air Collection Volume (L): 168

Special Instructions: Coordinate with MSHA Technical Support. Dust Division personnel will conduct impinger sampling with inspector escort.

Petroleum Distillates (Screen)*
(semiquantitative - as Napthas)

Note: "Screening" sample for field application when contaminants listed below are suspected. The results can be used for compliance with applicable TLV's.

Organics Analyzed: Gasoline, Kerosene, Mineral Spirits, Stoddard Solvent, Turpentine, VM&P Naphtha

***Special Note:** **Semiquantitative data requires each sample or set of samples be accompanied by a bulk sample or "reference material." This material is the raw material or product that contains the specific petroleum distillate.**

CONTAMINANT INFORMATION
See individual contaminants (organics analyzed)

LABORATORY INFORMATION
Analytical Technique: NIOSH 1550 (IV): gas chromatography / flame ionization detection (GC-FID)
Analytical Reference Method: NIOSH 1550 (IV)

SAMPLING INFORMATION
Full Shift Sampling:
Sampling Strategy: see Chapter 9
Collection Media: 100/50 mg: solid sorbent tube (coconut shell charcoal)
Sample Flow Rate: Minimum - Maximum (Lpm): 0.01-0.2 Lpm; Must use a pump adaptor or arrange for low flow pumps.
Air Collection Volume: Minimum - Maximum (L): 1.3-20

Short Term Sampling:
Sampling Strategy: see Chapter 9
Sampling Duration: 15 min.
Collection Media: 100/50 mg: solid sorbent tube (coconut shell charcoal)
Sample Flow Rate: Minimum - Maximum (Lpm): 0.01-0.2 Lpm; Must use a pump adaptor or arrange for low flow pumps.
Air Collection Volume: Minimum - Maximum (L): 1.3-20

Special Instructions: Stable at least one week at room temperature. Submit a 5-10 mL bulk sample separately. Submit samples via overnight carrier to MSHA Laboratory.

Phosgene - $COCl_2$

2.0 ppm IDLH (NIOSH, 1995)

Contaminant Codes:	1973 ACGIH TLV:	1968 PA Rules STEL/Ceiling (C):
495	0.1 ppm (100 ppb)	1.0 ppm (1000 ppb) - 5 min.
	(PEDS units of measure in parentheses)	

CONTAMINANT INFORMATION

Synonyms:	Carbon oxychloride, carbonyl chloride, carbonyl dichloride, chloroformyl chloride
Sources:	Gases from welding or torch cutting metals cleaned with chlorinated hydrocarbons; byproduct of some chemical processes
Description:	Colorless gas with a suffocating odor like musty hay; [note: a fuming liquid below 47°F; shipped as a liquefied compressed gas]
Incompatibilities:	Moisture, alkalis, ammonia, alcohols, copper; [note: reacts slowly in water to form hydrochloric acid and carbon dioxide]
Exposure:	Inhalation, skin and/or eye contact (liquid)
Health Effects:	Irritation eyes; dry burning throat; vomiting; cough, foamy sputum, dyspnea (breathing difficulty), pulmonary edema; chest pain, cyanosis; liquid: frostbite
PPE: Respirator:	Recommendations - NIOSH/OSHA: Up to 1 ppm: (APF = 10) any supplied-air respirator [note: substance reported to cause eye irritation or damage; may require eye protection]; up to 2 ppm: (APF = 50) any self-contained breathing apparatus with a full facepiece; (APF = 50) any supplied-air respirator with a full facepiece
Skin:	Prevent skin contact (liquid); 8 hr: Responder, Tychem; 4 hr: Teflon
Eyes:	Prevent eye contact (liquid)
Special Precautions:	Nonflammable gas

LABORATORY INFORMATION

CAS Number: 75-44-5

Analytical Technique: OSHA 61: gas chromatography (GC) / nitrogen selective detector; Dräger: detector tube

Analytical Reference Method: OSHA 61; Dräger

SAMPLING INFORMATION

Full Shift Sampling:
Sampling Strategy: see Chapter 9
Collection Media: Solid sorbent tube [i.e., silane-treated glass tubes packed with 150/75 mg pretreated XAD-2 adsorbent coated with 2-(hydroxymethyl) piperidine (2-HMP)]
Sample Flow Rate (Lpm): 1
Air Collection Volume (L): 240

Short Term Sampling:
Sampling Strategy: see Chapter 9
Sampling Duration: 15 min.
Collection Media: Solid sorbent tube [i.e., silane-treated glass tubes packed with 150/75 mg pretreated XAD-2 adsorbent coated with 2-(hydroxymethyl) piperidine (2-HMP)]
Sample Flow Rate (Lpm): 1
Air Collection Volume (L): 15

Special Instructions: N/A

Grab Sampling:
Sampling Strategy: see Chapter 11
Collection Media: Dräger detector tube, #8101521, range 0.02-1 ppm (EF=1.15); Dräger detector tube, #CH28301, range 0.25-25 ppm (EF=1.25).

Phosphine - PH_3

50 ppm IDLH (NIOSH, 1995)

Contaminant Codes:	1973 ACGIH TLV:	1968 PA Rules STEL/Ceiling (C):
315	0.3 ppm (300 ppb)	1.0 ppm (1000 ppb) - 30 min.

(PEDS units of measure in parentheses)

CONTAMINANT INFORMATION

Synonyms:	Hydrogen phosphide, phosphorated hydrogen, phosphorus hydride, phosphorus trihydride
Sources:	Gases from welding or torch cutting steel coated with phosphate-based rustproofing
Description:	Colorless gas with fish- or garlic-like odor; [pesticide]; [note: shipped as a liquefied compressed gas; pure compound is odorless]
Incompatibilities:	Air, oxidizers, chlorine, acids, moisture, halogenated hydrocarbons, copper; [note: may ignite spontaneously on contact with air]
Exposure:	Inhalation, skin and/or eye contact (liquid)
Health Effects:	Nausea, vomiting, abdominal pain, diarrhea; thirst; chest tightness, dyspnea (breathing difficulty); muscle pain, chills; stupor or syncope; pulmonary edema; liquid: frostbite
PPE: Respirator:	Recommendations - NIOSH/OSHA: Up to 3 ppm: (APF = 10) any supplied-air respirator; up to 7.5 ppm: (APF = 25) any supplied-air respirator operated in a continuous-flow mode; up to 15 ppm: (APF = 50) any air-purifying, full-facepiece respirator (gas mask) with a chin-style, front- or back-mounted canister providing protection against the compound of concern; (APF = 50) any self-contained breathing apparatus with a full facepiece; (APF = 50) any supplied-air respirator with a full facepiece; up to 50 ppm: (APF = 1000) any supplied-air respirator operated in a pressure-demand or other positive-pressure mode
Skin:	Prevent skin contact / frostbite; 8 hr: Responder; prevent possible skin freezing from direct liquid contact
Eyes:	Prevent eye contact / frostbite
Special Precautions:	Flammable gas

LABORATORY INFORMATION

CAS Number: 7803-51-2

Analytical Technique: OSHA ID-180: ion chromatography (IC) / conductivity detector; OSHA 1003: inductively coupled plasma - atomic emission spectrometry (ICP-AES); NIOSH 6002 (IV): ultraviolet-visible (UV-VIS) spectrometer (at 625 nm wavelength); Dräger: detector tube

Analytical Reference Method: OSHA ID-180; OSHA 1003; NIOSH 6002 (IV); Dräger

<u>SAMPLING INFORMATION</u>

<u>Full Shift Sampling</u>:

Sampling Strategy: see Chapter 9

1. OSHA ID-180:

Collection Media: Solid sorbent tube [i.e., 1.5 g beaded carbon impregnated with potassium hydroxide]

Sample Flow Rate: Minimum - Maximum (Lpm): 0.05 to 0.15 Lpm; Must use a pump adaptor or arrange for low flow pumps.

Air Collection Volume: Maximum (L): 36

2. OSHA 1003: 37-mm diameter, glass fiber filter (GFF) followed by a polyester filter coated with mercuric chloride

Sample Flow Rate (Lpm): 1.0

Air Collection Volume (L): 240

3. NIOSH 6002 (IV):

Collection Media: 300/150 mg mercuric cyanide-treated silica gel tube

Sample Flow Rate: Minimum - Maximum (Lpm): 0.01 to 0.2 Lpm; Must use a pump adaptor or arrange for low flow pumps.

Air Collection Volume: Minimum - Maximum (L): 1-16

<u>Short Term Sampling</u>:

Sampling Strategy: see Chapter 9

Sampling Duration: 15 min.

1. OSHA ID-180:

Collection Media: Solid sorbent tube [i.e., 1.5 g beaded carbon impregnated with potassium hydroxide]

Sample Flow Rate (Lpm): 0.3

Air Collection Volume (L): 4.5

2. OSHA 1003: 37-mm diameter, glass fiber filter (GFF) followed by a polyester filter coated with mercuric chloride

Sample Flow Rate (Lpm): 2.0

Air Collection Volume (L): 30

3. NIOSH 6002 (IV):

Collection Media: 300/150 mg mercuric cyanide-treated silica gel tube

Sample Flow Rate: Minimum - Maximum (Lpm): 0.01 to 0.2 Lpm; Must use a pump adaptor or arrange for low flow pumps.

Air Collection Volume: Minimum - Maximum (L): 1-3

Special Instructions:

1. OSHA ID-180: Analyze samples within 12 days after collection. Samples should be refrigerated to increase stability.
2. OSHA 1003: N/A
3. NIOSH 6002 (IV): Coordinate with MSHA Laboratory. Analyze samples within 7 days after collection.

Grab Sampling:

Sampling Strategy: see Chapter 11

Collection Media: Dräger detector tube, #8101611, range 0.01-3 ppm (EF=1.15); Dräger detector tube, #CH31101, range 0.01-40 ppm (EF=1.20); Dräger detector tube, #8101801, range 1-200 ppm (EF=1.20); Dräger detector tube, #8101621, range 25-10,000 ppm (EF=1.15); Dräger detector tube, #CH21201, range 50-3,000 ppm (EF=1.15)

n-Propyl Alcohol - $CH_3CH_2CH_2OH$
800 ppm IDLH (NIOSH, 1995)

Contaminant Codes:	1973 ACGIH TLV:	1973 ACGIH Excursion STEL/Ceiling (C):
255	200 ppm	250 ppm - 15 min.

CONTAMINANT INFORMATION

Synonyms:	Ethyl carbinol, 1-propanol, n-propanol, propyl alcohol
Sources:	Solvents
Description:	Colorless liquid with mild, alcohol-like odor
Incompatibilities:	Strong oxidizers
Exposure:	Inhalation, skin absorption, ingestion, skin and/or eye contact
Health Effects:	Irritation: eyes, nose, throat; dry cracking skin; drowsiness, headache; ataxia, gastrointestinal pain; abdominal cramps, nausea, vomiting, diarrhea
PPE: Respirator:	Recommendations - NIOSH/OSHA: Up to 800 ppm: (APF = 10) any chemical cartridge respirator with organic vapor cartridge(s) [note: substance reported to cause eye irritation or damage; may require eye protection]; (APF = 25) any powered, air-purifying respirator with organic vapor cartridge(s) [note: substance reported to cause eye irritation or damage; may require eye protection]; (APF = 50) any air-purifying, full-facepiece respirator (gas mask) with a chin-style, front- or back-mounted organic vapor canister; (APF = 10) any supplied-air respirator [note: substance reported to cause eye irritation or damage; may require eye protection]; (APF = 50) any self-contained breathing apparatus with a full facepiece
Skin:	Prevent skin contact; 8 hr: Butyl, Nitrile, Viton; 4 hr: Neoprene, PVA
Eyes:	Prevent eye contact
Special Precautions:	Class IB flammable liquid

LABORATORY INFORMATION

CAS Number: 71-23-8

Analytical Technique: NIOSH 1401 (IV): gas chromatography (GC) / flame ionization detector (FID); OSHA 7: gas chromatography (GC) / flame ionization detector (FID); 3M: passive monitor

Analytical Reference Method: NIOSH 1401 (IV); OSHA 7; 3M

SAMPLING INFORMATION

Full Shift Sampling:

Sampling Strategy: see Chapter 9

1. Collection Media: NIOSH 1401 (IV): 100/50 mg: solid sorbent tube (coconut shell charcoal)

Sample Flow Rate: Minimum - Maximum (Lpm): 0.01-0.2 Lpm; Must use a pump adaptor or arrange for low flow pumps.

Air Collection Volume: Minimum - Maximum (L): 1-10

2. Collection Media: OSHA 7: 100/50 mg: solid sorbent tube (coconut shell charcoal)

Sample Flow Rate: Minimum - Maximum (Lpm): 0.01-0.2 Lpm; Must use a pump adaptor or arrange for low flow pumps.

Air Collection Volume (L): 10

3. Collection Media: 3M: Passive monitor, 3M, 3500 series

Note: Maximum 6-hour sample per badge

Short Term Sampling:

Sampling Strategy: see Chapter 9

Sampling Duration: 15 min.

1. Collection Media: NIOSH 1401 (IV): 100/50 mg: solid sorbent tube (coconut shell charcoal)

Sample Flow Rate: Minimum - Maximum (Lpm): 0.01-0.2 Lpm; Must use a pump adaptor or arrange for low flow pumps.

Air Collection Volume: Minimum - Maximum (L): 1-3

2. Collection Media: OSHA 7: 100/50 mg: solid sorbent tube (coconut shell charcoal)

Sample Flow Rate: Minimum - Maximum (Lpm): 0.01-0.2 Lpm; Must use a pump adaptor or arrange for low flow pumps.

Air Collection Volume (L): 3

Special Instructions: NIOSH 1401 (IV): Coordinate with MSHA Laboratory. Store samples in freezer. Ship on ice. Overnight samples to MSHA Laboratory.

Quartz (Crystalline Silica) - SiO_2
(Respirable)
50 mg/m^3 IDLH (NIOSH, 1995)

Contaminant Codes:	1973 ACGIH TLV:	1973 ACGIH Excursion STEL/Ceiling (C):
523 (dust, respirable fraction, > 1% quartz)	$\frac{10}{\% \text{ resp } SiO_2 + 2}$ mg/m^3	N/A

CONTAMINANT INFORMATION

Synonyms: Silicon dioxide

Sources: Sandblasting, metal casting, granite cutting; mining and milling of sandstone, crushed stone, sand and gravel, tripoli, diatomaceous earth

Description: Colorless, odorless solid; [note: a component of many mineral dusts]

Incompatibilities: Powerful oxidizers (e.g., fluorine, chlorine trifluoride, manganese trioxide, oxygen difluoride, hydrogen peroxide); acetylene; ammonia

Exposure: Inhalation, skin and/or eye contact

Health Effects: Cough, dyspnea (breathing difficulty), wheezing; decreased pulmonary function, progressive respiratory symptoms (silicosis); irritation eyes; [note: potential occupational carcinogen]

PPE: Respirator: Recommendations - NIOSH: Up to 0.5 mg/m^3: (APF = 10) any air-purifying respirator with a high-efficiency particulate filter; up to 1.25 mg/m^3: (APF = 25) any powered, air-purifying respirator with a high-efficiency particulate filter; (APF = 25) any supplied-air respirator operated in a continuous-flow mode; up to 2.5 mg/m^3: (APF = 50) any air-purifying, full-facepiece respirator with a high-efficiency particulate filter; (APF = 50) any powered, air-purifying respirator with a tight-fitting facepiece and a high-efficiency particulate filter; up to 25 mg/m^3: (APF = 1000) any supplied-air respirator operated in a pressure-demand or other positive-pressure mode; unknown concentrations or IDLH conditions: (APF = 10,000) any self-contained breathing apparatus that has a full facepiece and is operated in a pressure-demand or other positive-pressure mode; (APF = 10,000) any supplied-air respirator that has a full facepiece and is operated in a pressure-demand or other positive-pressure mode in combination with an auxiliary self-contained positive-pressure breathing apparatus

Skin: No specific recommendation can be made; actual working conditions will determine the need and type of personal protective equipment

Eyes: No recommendation is made specifying the need for eye protection

Special Precautions: Noncombustible solid

LABORATORY INFORMATION

CAS Number: 14808-60-7

Analytical Technique: NIOSH 7500 (IV): x-ray diffraction spectrometry; OSHA ID-142: x-ray diffraction spectrometry

Analytical Reference Method: NIOSH 7500 (IV); OSHA ID-142

SAMPLING INFORMATION

Full Shift Sampling:

Sampling Strategy: see Chapter 5

1. NIOSH 7500 (IV):

Collection Media: Cyclone and filter [10-mm nylon cyclone and 37-mm diameter, 5-µm pore size polyvinyl chloride (PVC) filter]

Sample Flow Rate (Lpm): 1.7

Air Collection Volume: Minimum - Maximum (L): 400-1000

2. OSHA ID-142:

Collection Media: Cyclone and filter [10-mm nylon cyclone and 37-mm diameter, 5-µm pore size polyvinyl chloride (PVC) filter]

Sample Flow Rate (Lpm): 1.7

Air Collection Volume: Minimum - Maximum (L): 408-816

Note: Do not invert cyclone. Anything other than a horizontal orientation may deposit oversized particles on the filter from the cyclone body.

Selenium Compounds (as Se)
(except Selenium Hexafluoride)

1 mg/m^3 (as Se) IDLH **(NIOSH**, 1995)

Contaminant Codes:	1973 ACGIH TLV:	1968 PA Rules STEL/Ceiling (C):
627	0.2 mg/m^3 (200 µg/m^3)	0.3 mg/m^3 (300 µg/m^3) - 30 min.

(PEDS units of measure in parentheses)

CONTAMINANT INFORMATION

Synonyms: Elemental selenium, selenium alloy

Sources: Copper and heavy metal ore dust and refining (including silver and gold), ores of pyrite, clausthalite, naumannite, tiemannite and selenosulfur.

Description: *Elemental:* amorphous or crystalline, red to gray solid; [note: occurs as an impurity in most sulfide ores]
compounds: vary

Incompatibilities: Acids, strong oxidizers, chromium trioxide, potassium bromate, cadmium

Exposure: Inhalation, ingestion, skin and/or eye contact

Health Effects: Irritation: eyes, skin, nose, throat; visual disturbance; headache; chills, fever; dyspnea (breathing difficulty), bronchitis; metallic taste, garlic breathing, gastrointestinal disturbance; dermatitis; eye, skin burns

PPE: Respirator: Recommendations - NIOSH/OSHA: Up to 1 mg/m^3: (APF = 5) any dust and mist respirator [note: if not present as a fume; substance reported to cause eye irritation or damage; may require eye protection]; (APF = 10) any dust, mist, and fume respirator [note: substance reported to cause eye irritation or damage; may require eye protection]; (APF = 50) any air-purifying, full-facepiece respirator with a high-efficiency particulate filter; (APF = 25) any powered, air-purifying respirator with a dust and mist filter [note: if not present as a fume; substance reported to cause eye irritation or damage; may require eye protection]; (APF = 25) any powered, air-purifying respirator with a dust, mist, and fume filter [note: substance reported to cause eye irritation or damage ; may require eye protection]; (APF = 10) any supplied-air respirator [note: substance reported to cause eye irritation or damage; may require eye protection]; (APF = 50) any self-contained breathing apparatus with a full facepiece

Skin: Prevent skin contact; contact the manufacturer for recommendations

Eyes: No recommendation is made for specific eye protection

Special Precautions: Combustible solid

LABORATORY INFORMATION

CAS Number: 7782-49-2 (*elemental*)
Analytical Technique: OSHA ID-121: atomic absorption spectroscopy (AAS) or atomic emission spectroscopy (AES); NIOSH 7300 (IV): inductively coupled argon plasma, atomic emission spectroscopy (ICAP-AES)
Analytical Reference Method: OSHA ID-121; NIOSH 7300 (IV)

SAMPLING INFORMATION

Full Shift Sampling:
Sampling Strategy: See Chapter 7
1. OSHA ID-121:
Collection Media: 37-mm (or 25-mm) diameter, 0.8-µm pore size mixed cellulose ester (MCE) filter
Sample Flow Rate (Lpm): 2
Air Collection Volume: Minimum - Maximum (L): 480-960
2. NIOSH 7300 (IV):
Collection Media: 37-mm diameter, 0.8-µm pore size mixed cellulose ester (MCE) filter
Sample Flow Rate (Lpm): 1.7
Air Collection Volume: Minimum - Maximum (L): 13-2000

Short Term Sampling:
Sampling Strategy: See Chapter 7
Sampling Duration: 15 min.
1. OSHA ID-121:
Collection Media: 37-mm (or 25-mm) diameter, 0.8-µm pore size mixed cellulose ester (MCE) filter
Sample Flow Rate (Lpm): 2
Air Collection Volume (L): 30
2. NIOSH 7300 (IV):
Collection Media: 37-mm diameter, 0.8-µm pore size mixed cellulose ester (MCE) filter
Sample Flow Rate (Lpm): 1.7
Air Collection Volume: Minimum - Maximum (L): 13-2000

Special Instructions: N/A

Wipe Sampling:
Sampling Strategy: see Chapter 14
Collection Media: Whatman Filter (No. 41 or 42), moistened with distilled water
Special Instructions: Seal wipe sample in plastic bag, vial, or jar.

Silica, Crystalline (Quartz) - SiO_2 (Respirable)

50 mg/m^3 IDLH (NIOSH, 1995)

Contaminant Codes:	1973 ACGIH TLV:	1973 ACGIH Excursion STEL/Ceiling (C):
523 (dust, respirable fraction, > 1% quartz)	$\frac{10}{\% \text{ resp } SiO_2 + 2}$ mg/m^3	N/A

CONTAMINANT INFORMATION

Synonyms:	Silicon dioxide
Sources:	Sandblasting, metal casting, granite cutting; mining and milling of sandstone, crushed stone, sand and gravel, tripoli, diatomaceous earth
Description:	Colorless, odorless solid; [note: a component of many mineral dusts]
Incompatibilities:	Powerful oxidizers (e.g., fluorine, chlorine trifluoride, manganese trioxide, oxygen difluoride, hydrogen peroxide); acetylene; ammonia
Exposure:	Inhalation, skin and/or eye contact
Health Effects:	Cough, dyspnea (breathing difficulty), wheezing; decreased pulmonary function, progressive respiratory symptoms (silicosis); irritation eyes; [note: potential occupational carcinogen]
PPE: Respirator:	Recommendations - NIOSH: Up to 0.5 mg/m^3: (APF = 10) any air-purifying respirator with a high-efficiency particulate filter; up to 1.25 mg/m^3: (APF = 25) any powered, air-purifying respirator with a high-efficiency particulate filter; (APF = 25) any supplied-air respirator operated in a continuous-flow mode; up to 2.5 mg/m^3: (APF = 50) any air-purifying, full-facepiece respirator with a high-efficiency particulate filter; (APF = 50) any powered, air-purifying respirator with a tight-fitting facepiece and a high-efficiency particulate filter; up to 25 mg/m^3: (APF = 1000) any supplied-air respirator operated in a pressure-demand or other positive-pressure mode; unknown concentrations or IDLH conditions: (APF = 10,000) any self-contained breathing apparatus that has a full facepiece and is operated in a pressure-demand or other positive-pressure mode; (APF = 10,000) any supplied-air respirator that has a full facepiece and is operated in a pressure-demand or other positive-pressure mode in combination with an auxiliary self-contained positive-pressure breathing apparatus
Skin:	No specific recommendation can be made; actual working conditions will determine the need and type of personal protective equipment
Eyes:	No recommendation is made specifying the need for eye protection
Special Precautions:	Noncombustible solid

LABORATORY INFORMATION

CAS Number: 14808-60-7
Analytical Technique: NIOSH 7500 (IV): x-ray diffraction spectrometry; OSHA ID-142: x-ray diffraction spectrometry
Analytical Reference Method: NIOSH 7500 (IV); OSHA ID-142

SAMPLING INFORMATION

Full Shift Sampling:

Sampling Strategy: See Chapter 5
1. NIOSH 7500 (IV):
Collection Media: Cyclone and filter [10-mm nylon cyclone and 37-mm diameter, 5-µm pore size polyvinyl chloride (PVC) filter]
Sample Flow Rate (Lpm): 1.7
Air Collection Volume: Minimum - Maximum (L): 400-1000
2. OSHA ID-142:
Collection Media: Cyclone and filter [10-mm nylon cyclone and 37-mm diameter, 5-µm pore size polyvinyl chloride (PVC) filter]
Sample Flow Rate (Lpm): 1.7
Air Collection Volume: Minimum - Maximum (L): 408-816

Bulk Sampling:

Sampling Strategy: See Chapters 5 & 14
1. NIOSH 7500 (IV): [high-volume air]
Collection Media: 37-mm diameter, 5-µm pore size polyvinyl chloride (PVC) filter
Sample Flow Rate (Lpm): 3
Air Collection Volume: Minimum - Maximum (L): 400-1000
2a. OSHA ID-142: [high-volume filter sample - respirable]
Quantity: > 1.0 grams
2b. OSHA ID-142: [high-volume filter sample - nonrespirable]
Quantity: > 1.0 grams
2c. OSHA ID-142: [representative settled dust (*i.e.*, rafter sample)]
Quantity: > 1.0 grams
2d. OSHA ID-142: [representative workplace material]
Quantity: 10-20 grams

Special Instructions: Coordinate with MSHA laboratory. Collect a bulk sample (*e.g.*, high-volume air; settled dust; workplace material) to identify interferences. Submit air and bulk samples via overnight carrier to MSHA laboratory.

Silver - Ag
(Metal and Soluble Compounds)
10 mg/m^3 (as Ag) IDLH (NIOSH, 1995)

Contaminant Codes:	1973 ACGIH TLV:	1973 ACGIH Excursion STEL/Ceiling (C):
653 (dust)	0.01 mg/m^3 (10 µg/m^3)	0.03 mg/m^3 (30 µg/m^3) - 15 min.
735 (fume)	0.01 mg/m^3 (10 µg/m^3)	0.03 mg/m^3 (30 µg/m^3) - 15 min.
	(PEDS units of measure in parentheses)	

CONTAMINANT INFORMATION

Synonyms:	*Metal*: argentum *compounds*: vary depending upon the specific compound
Sources:	Silver plating, explosives; ores of gold, lead, copper, argentite, horn silver, cerargyrite, proustite, pyrargyrite
Description:	*Metal*: white, lustrous solid *compounds*: varies depending upon the specific compound
Incompatibilities:	Acetylene, ammonia, hydrogen peroxide, bromoazide, chlorine trifluoride, ethyleneimine, oxalic acid, tartaric acid
Exposure:	Inhalation, skin and/or eye contact, or ingestion
Health Effects:	Argyrosis (a slate-gray or bluish discoloration of the skin, cornea of the eye, nasal septum, or throat,; irritation or ulceration of the skin; gastrointestinal disturbance
PPE: Respirator:	Recommendations - NIOSH/OSHA: Up to 0.25 mg/m^3: (APF = 25) any supplied-air respirator operated in a continuous-flow mode [note: substance causes eye irritation or damage; eye protection needed]; (APF = 25) any powered, air-purifying respirator with a high-efficiency particulate filter [note: substance causes eye irritation or damage; eye protection needed]; up to 0.5 mg/m^3: (APF = 50) any air-purifying, full-facepiece respirator with a high-efficiency particulate filter; (APF = 50) any self-contained breathing apparatus with a full facepiece; (APF = 50) any supplied-air respirator with a full facepiece; up to 10 mg/m^3: (APF = 2000) any supplied-air respirator that has a full facepiece and is operated in a pressure-demand or other positive-pressure mode
Skin:	Prevent skin contact; contact the manufacturer for recommendations for specific compound
Eyes:	Prevent eye contact
Special Precautions:	*Metal:* noncombustible solid, but flammable in form of dust or powder

__LABORATORY INFORMATION__
CAS Number: 7440-22-4 (silver metal)
Analytical Technique: OSHA ID-121: atomic absorption spectroscopy (AAS) or atomic emission spectroscopy (AES); NIOSH 7300 (IV): inductively coupled argon plasma, atomic emission spectroscopy (ICAP-AES)
Analytical Reference Method: OSHA ID-121; NIOSH 7300 (IV)

__SAMPLING INFORMATION__
__Full Shift Sampling__:
Sampling Strategy: See Chapter 7
1. OSHA ID-121:
Collection Media: 37-mm (or 25-mm) diameter, 0.8-µm pore size mixed cellulose ester (MCE) filter
Sample Flow Rate (Lpm): 2
Air Collection Volume: Minimum - Maximum (L): 480-960
2. NIOSH 7300 (IV):
Collection Media: 37-mm diameter, 0.8-µm pore size mixed cellulose ester (MCE) filter
Sample Flow Rate (Lpm): 1.7
Air Collection Volume: Minimum - Maximum (L): 250-2000

__Short Term Sampling__:
Sampling Strategy: See Chapter 7
Sampling Duration: 15 min.
1. OSHA ID-121:
Collection Media: 37-mm (or 25-mm) diameter, 0.8-µm pore size mixed cellulose ester (MCE) filter
Sample Flow Rate (Lpm): 2
Air Collection Volume (L): 30
2. NIOSH 7300 (IV):
Collection Media: 37-mm diameter, 0.8-µm pore size mixed cellulose ester (MCE) filter
Sample Flow Rate (Lpm): 1.7
Air Collection Volume: Minimum - Maximum (L): 250-2000

__Special Instructions__: Studies demonstrate that some forms of silver are more toxic than others. Contact the lab or District IH for addtional information to distinguish soluble from insoluble silver in workplace air samples.

__Wipe Sampling__:
Sampling Strategy: see Chapter 14
Collection Media: Whatman Filter (No. 41 or 42), moistened with distilled water
Special Instructions: Seal wipe sample in plastic bag, vial, or jar.

Soapstone (< 1% quartz) - $3MgO\text{-}4SiO_2\text{-}H_2O$

3,000 mg/m^3 IDLH (NIOSH, 1995)

Contaminant Codes:	1973 ACGIH TLV:	1973 ACGIH Excursion STEL/Ceiling (C):
511 (talc, nonfibrous, < 1% quartz)	20 mppcf (3.3 mg/m^3)	40 mppcf (6.6 mg/m^3) - 15 min.

(PEDS “screening” units of measure in parentheses)

CONTAMINANT INFORMATION

Synonyms:	Massive talc, soapstone silicate, steatite
Sources:	Talc mines, clarifying liquids by filtration
Description:	Odorless, white-gray powder
Incompatibilities:	None reported
Exposure:	Inhalation, skin and/or eye contact
Health Effects:	Pneumoconiosis: cough, dyspnea (breathing difficulty); digital clubbing; cyanosis; basal crackles, corpulmonale
PPE: Respirator:	Recommendations - NIOSH: Up to 30 mg/m^3: (APF = 5) any dust and mist respirator; up to 60 mg/m^3: (APF = 10) any dust and mist respirator except single-use and quarter-mask respirators; (APF = 10) any supplied-air respirator; up to 150 mg/m^3: (APF = 25) any powered, air-purifying respirator with a dust and mist filter; up to 300 mg/m^3: (APF = 50) any air-purifying, full-facepiece respirator with a high-efficiency particulate filter; (APF = 50) any supplied-air respirator that has a tight-fitting facepiece and is operated in a continuous-flow mode [note: substance reported to cause eye irritation or damage; may require eye protection]; (APF = 50) any powered, air-purifying respirator with a tight-fitting facepiece and a high-efficiency particulate filter [note: substance reported to cause eye irritation or damage; may require eye protection]; (APF = 50) any self-contained breathing apparatus with a full facepiece; (APF = 50) any supplied-air respirator with a full facepiece; up to 3000 mg/m^3: (APF = 2000) any supplied-air respirator that has a full facepiece and is operated in a pressure-demand or other positive-pressure mode
Skin:	No specific recommendation can be made; actual working conditions will determine the need and type of personal protective equipment
Eyes:	No recommendation is made specifying the need for eye protection
Special Precautions:	Noncombustible solid

LABORATORY INFORMATION

CAS number: 14807-96-6 [talc (containing no asbestos and less than 1% quartz)]
Analytical Technique:
1. NIOSH 0500 (IV) [particulates not otherwise regulated, total]: gravimetric (filter weight)
2. NIOSH 0600 (IV) [particulates not otherwise regulated, respirable]: gravimetric (filter weight)
3. Mineral Dust: Impinger method
Analytical Reference Method: NIOSH 0500 (IV); NIOSH 0600 (IV); impinger method

SAMPLING INFORMATION

Full Shift Sampling: Screening - **Note: cannot be used for enforcement**
Sampling Strategy: see Chapter 5
1. NIOSH 0500 (IV)**:**
Collection Media: filter [37-mm diameter, 5-µm pore size polyvinyl chloride (PVC) filter]
Sample Flow Rate (Lpm): 1.7
Air Collection Volume: Minimum - Maximum (L): 7-133
2. NIOSH 0600 (IV):
Collection Media: cyclone and filter [10-mm nylon cyclone and 37-mm diameter, 5-µm pore size polyvinyl chloride (PVC) filter]
Sample Flow Rate (Lpm): 1.7
Air Collection Volume: Minimum - Maximum (L): 20-400

Short Term Sampling:
Sampling Strategy: see Chapter 5
Sampling Duration: 15 min.
1. NIOSH 0500 (IV)**:**
Collection Media: filter [37-mm diameter, 5-µm pore size polyvinyl chloride (PVC) filter]
Sample Flow Rate (Lpm): 1.7
Air Collection Volume: Minimum - Maximum (L): 7-133
2. NIOSH 0600 (IV):
Collection Media: cyclone and filter [10-mm nylon cyclone and 37-mm diameter, 5-µm pore size polyvinyl chloride (PVC) filter]
Sample Flow Rate (Lpm): 1.7
Air Collection Volume: Minimum - Maximum (L): 20-400

Full Shift - Partial Period Sampling: Enforcement - **Note: for compliance with TLV**
Sampling Strategy: See Chapter 6
Collection Media: impinger
Sample Flow Rate (Lpm): 2.8
Air Collection Volume (L): 168

Special Instructions: Coordinate with MSHA Technical Support. Dust Division personnel will conduct impinger sampling with inspector escort.

Sodium Hydroxide - NaOH

10 mg/m^3 IDLH (NIOSH, 1995)

Contaminant Codes:	1973 ACGIH TLV:	1973 ACGIH Excursion STEL/Ceiling (C):
455	2.0 mg/m^3	2.0 mg/m^3 (C)

CONTAMINANT INFORMATION

Synonyms: Caustic soda, lye, soda lye, sodium hydrate

Sources: Metal cleaning, electrolytic extraction of zinc, neutralizing acids

Description: Colorless to white, odorless solid (flakes, beads, granular form)

Incompatibilities: Water; acids; flammable liquids; organic halogens; metals (e.g., aluminum, tin & zinc; nitromethane; [note: corrosive to metals]

Exposure: Inhalation, ingestion, skin and/or eye contact

Health Effects: Irritation: eyes, skin, mucous membrane; pneumonitis; burns: eye, skin; temporary loss of hair

PPE: Respirator: Recommendations - NIOSH/OSHA: Up to 10 mg/m^3: (APF = 25) any supplied-air respirator operated in a continuous-flow mode [note: substance causes eye irritation or damage; eye protection needed]; (APF = 50) any air-purifying, full-facepiece respirator with a high-efficiency particulate filter; (APF = 25) any powered, air-purifying respirator with a dust and mist filter [note: substance causes eye irritation or damage; eye protection needed]; (APF = 50) any self-contained breathing apparatus with a full facepiece; (APF = 50) any supplied-air respirator with a full facepiece

Skin: Prevent skin contact; (solution >70% only): 8 hr: Neoprene, PVC, Barricade

Eyes: Prevent eye contact

Special Precautions: Noncombustible solid, but when in contact with water may generate sufficient heat to ignite combustible materials

LABORATORY INFORMATION

CAS Number: 1310-73-2

Analytical Technique: NIOSH 7401 (IV): acid-base titration

Analytical Reference Method: NIOSH 7401 (IV)

SAMPLING INFORMATION

Full Shift Sampling:

Sampling Strategy: See Chapter 9
Collection Media: 37-mm diameter, 1.0-µm pore size polytetrafluoroethylene (PTFE) membrane filter
Sample Flow Rate: Minimum - Maximum (Lpm): 1-4
Air Collection Volume: Minimum - Maximum (L): 70-1000

Short Term Sampling:

Sampling Strategy: See Chapter 9
Sampling Duration: 15 min.
Collection Media: 37-mm diameter, 1.0-µm pore size polytetrafluoroethylene (PTFE) membrane filter
Sample Flow Rate: Minimum - Maximum (Lpm): 1-4
Air Collection Volume: Minimum - Maximum (L): 70-1000

Special Instructions: N/A

Stoddard Solvent

20,000 mg/m^3 (3,390 ppm) IDLH (NIOSH, 1995)

Contaminant Codes:	1973 ACGIH TLV:	1973 ACGIH Excursion STEL/Ceiling (C):
241	200 ppm	250 ppm - 15 min.

CONTAMINANT INFORMATION

Synonyms: Dry cleaning safety solvent, mineral spirits, petroleum solvent, spotting naphtha

***Note: Stoddard Solvent is a subgroup of the Naphtha family of solvents. There may be several synonyms in this list that also refer to naphtha (coal tar). The CAS number should be used to distinguish between the two contaminants.**

Sources: Parts cleaning solvents, paint thinner, degreasing agents
Description: Colorless liquid with a kerosene-like odor
Incompatibilities: Strong oxidizers
Exposure: Inhalation, ingestion, skin and/or eye contact
Health Effects: Irritation: eyes, nose, throat; dizziness; dermatitis; chemical pneumonia (aspiration liquid)
PPE: Respirator: Recommendations - NIOSH: Up to 3500 mg/m^3 [or 593 ppm]: (APF = 10) any chemical cartridge respirator with organic vapor cartridge(s) [note: substance reported to cause eye irritation or damage; may require eye protection]; (APF = 10) any supplied-air respirator [note: substance reported to cause eye irritation or damage; may require eye protection]; up to 8750 mg/m^3 [or 1483 ppm]: (APF = 25) any supplied-air respirator operated in a continuous-flow mode [note: substance reported to cause eye irritation or damage; may require eye protection]; (APF = 25) any powered, air-purifying respirator with organic vapor cartridge(s) [note: substance reported to cause eye irritation or damage; may require eye protection]; up to 17,500 mg/m^3 [or 2966 ppm]: (APF = 50) any chemical cartridge respirator with a full facepiece and organic vapor cartridge(s); (APF = 50) any air-purifying, full-facepiece respirator (gas mask) with a chin-style, front- or back-mounted organic vapor canister; (APF = 50) any powered, air-purifying respirator with a tight-fitting facepiece and organic vapor cartridge(s) [note: substance reported to cause eye irritation or damage; may require eye protection]; (APF = 50) any self-contained breathing apparatus with a full facepiece; (APF = 50) any supplied-air respirator with a full facepiece; up to 20,000 mg/m^3 [or 3390 ppm]: (APF = 2000) any supplied-air respirator that has a full facepiece and is operated in a pressure-demand or other positive-pressure mode

Skin: Prevent skin contact; 8 hr: Nitrile, Viton, Saranex, PE/EVAL, Barricade, Responder; 4 hr: PVA

Eye: Prevent eye contact

Special Precautions: Class II combustible liquid

LABORATORY INFORMATION

CAS Number: 8052-41-3 (Stoddard Solvent)

Analytical Technique: NIOSH 1550 (IV): gas chromatography / flame ionization detection (GC-FID)

Analytical Reference Method: NIOSH 1550 (IV)

SAMPLING INFORMATION

Full Shift Sampling:

Sampling Strategy: See Chapter 9

Collection Media: 100/50 mg: solid sorbent tube (coconut shell charcoal)

Sample Flow Rate: Minimum - Maximum (Lpm): 0.01-0.2 Lpm; Must use a pump adaptor or arrange for low flow pumps.

Air Collection Volume: Minimum - Maximum (L): 1.3-20

Short Term Sampling:

Sampling Strategy: See Chapter 9

Sampling Duration: 15 min.

Collection Media: 100/50 mg: solid sorbent tube (coconut shell charcoal)

Sample Flow Rate: Minimum - Maximum (Lpm): 0.01-0.2 Lpm; Must use a pump adaptor or arrange for low flow pumps.

Air Collection Volume: Minimum - Maximum (L): 1.3-20

Special Instructions: Stable at least one week at room temperature. Submit a 5-10 mL bulk sample separately. Submit samples via overnight carrier to MSHA Laboratory.

Sulfur Dioxide - SO_2

100 ppm IDLH (NIOSH, 1995)

Contaminant Codes:	1973 ACGIH TLV:	1968 PA Rules STEL/Ceiling (C):
421	5.0 ppm	20 ppm - 5 min.

CONTAMINANT INFORMATION

Synonyms:	Sulfurous acid anhydride, sulfurous oxide, sulfur oxide
Sources:	Blasting, processing and casting of nonferrous metal (zinc, brass, aluminum, copper), exhaust from combustion of materials containing sulfur (high sulfur diesel fuels)
Description:	Colorless gas with a characteristic, irritating, pungent odor; [note: shipped as a liquefied compressed gas]
Incompatibilities:	Powdered alkali metals (e.g., sodium, potassium); water; ammonia; zinc; aluminum; brass; copper; [note: reacts with water to form sulfurous acid (H_2SO_3)]
Exposure:	Inhalation, skin and/or eye contact
Health Effects:	Irritation: eyes, nose, throat; rhinorrhea (discharge of thin nasal mucous); choking, cough; reflex broncho-constriction; pulmonary edema; liquid: frostbite
PPE: Respirator:	Recommendations - NIOSH: Up to 20 ppm: (APF = 10) any chemical cartridge respirator with cartridge(s) providing protection against the compound of concern [note: substance reported to cause eye irritation or damage; may require eye protection]; (APF = 10) any supplied-air respirator [note: substance reported to cause eye irritation or damage; may require eye protection]; up to 50 ppm: (APF = 25) any supplied-air respirator operated in a continuous-flow mode [note: substance reported to cause eye irritation or damage; may require eye protection]; (APF = 25) any powered, air-purifying respirator with cartridge(s) providing protection against the compound of concern [note: substance reported to cause eye irritation or damage; may require eye protection]; up to 100 ppm: (APF = 50) any chemical cartridge respirator with a full facepiece and cartridge(s) providing protection against the compound of concern; (APF = 50) any air-purifying, full-facepiece respirator (gas mask) with a chin-style, front- or back-mounted canister providing protection against the compound of concern; (APF = 50) any powered, air-purifying respirator with a tight-fitting facepiece and cartridge(s) providing protection against the compound of concern [note: substance reported to cause eye irritation or damage; may require eye protection]; (APF = 50) any supplied-air respirator that has a tight-fitting facepiece and is operated in a continuous-flow mode [note: substance reported to

cause eye irritation or damage; may require eye protection]; (APF = 50)
any self-contained breathing apparatus with a full facepiece; (APF = 50)
any supplied-air respirator with a full facepiece

Skin: Prevent skin contact / frostbite; 8 hr: Saranex, Barricade, Responder
4 hr: Teflon; prevent possible skin freezing from direct liquid contact

Eyes: Prevent eye contact / frostbite

Special Precautions: Nonflammable gas

LABORATORY INFORMATION

CAS Number: 7446-09-5

Analytical Technique: Dräger: diffusion tube; NIOSH 6004 (IV): ion chromatography (IC); OSHA ID-200: ion chromatography (IC); Dräger: detector tube; Industrial Scientific: electronic direct reading instrument (DRI) [with catalytic and electrochemical sensors]

Analytical Reference Method: Dräger; NIOSH 6004 (IV); OSHA ID-200; Dräger; Industrial Scientific

SAMPLING INFORMATION

Full Shift Sampling:

Sampling Strategy: See Chapters 9 and 11

1. Dräger

Collection Media: Dräger diffusion tube, #8101091; range 5-150 ppm (1 hour), 2.5-75 ppm (2 hours), 1.3-38 ppm (4 hours), 0.7-19 ppm (8 hours); **Note:** up to 8 hours per tube. (EF = 1.25).

2. NIOSH 6004 (IV):

Collection Media: 2 filter cassettes in series (i.e., 2-cassette sampling device): Front cassette = 37-mm diameter, 0.8-µm pore size cellulose ester (CE) membrane filter; Back cassette = 37-mm diameter, cellulose filter (Whatman 40 or equivalent) saturated with Na_2CO_3 fixative solution.

Sample Flow Rate: Minimum - Maximum (Lpm): 0.5-1.5

Air Collection Volume: Minimum - Maximum (L): 4-200

3. OSHA ID-200:

Collection Media: **(A):** Type I: solid sorbent tube, 100/50 mg impregnated activated beaded carbon (IABC); or
(B): Type II: combination sampling device; front part = Teflon filter (to remove particulate and collect H_2SO_4 mist); second part = 100/50 mg IABC (to collect SO_2).

Sample Flow Rate (Lpm): 0.1; Must use a pump adaptor or arrange for low flow pumps.

Air Collection Volume (L): 12

Short Term Sampling:
Sampling Strategy: See Chapter 9
Sampling Duration: 15 min.
1. NIOSH 6004 (IV):
Collection Media: 2 filter cassettes in series (i.e., 2-cassette sampling device): Front cassette = 37-mm diameter, 0.8-µm pore size cellulose ester (CE) membrane filter; Back cassette = 37-mm diameter, cellulose filter (Whatman 40 or equivalent) saturated with Na_2CO_3 fixative solution.
Sample Flow Rate: Minimum - Maximum (Lpm): 0.5-1.5
Air Collection Volume: Minimum - Maximum (L): 4-200
2. OSHA ID-200:
Collection Media: **(A):** Type I: solid sorbent tube, 100/50 mg impregnated activated beaded carbon (IABC); or
(B): Type II: combination sampling device; front part = Teflon filter (to remove particulate and collect H_2SO_4 mist); second part = 100/50 mg IABC (to collect SO_2).
Sample Flow Rate (Lpm): 0.1; Must use a pump adaptor or arrange for low flow pumps.
Air Collection Volume (L): 1.5

Special Instructions: N/A

Grab Sampling:
Sampling Strategy: See Chapters 11 and 13
1. Collection Media: Dräger detector tube, #6727101, range 0.1-3 ppm (EF = 1.15); Dräger detector tube, #6728491, range 0.5-25 ppm (EF = 1.15); Dräger detector tube, #CH31701, range 1-25 ppm (EF = 1.15); Dräger detector tube, #CH24201, range 10-2,000 ppm (EF = 1.20); Dräger detector tube, #8101531, range 50-8,000 ppm (EF = 1.15).
2. Collection Media: Industrial Scientific electronic direct reading instrument, TMX410 or TMX412 (EF = 1.25).
Various other electronic direct-reading instruments are available. Consult the manufacturer's instructions and specifications to determine suitability for particular contaminants.

Sulfuric Acid - H_2SO_4

15 mg/m^3 IDLH (NIOSH, 1995)

Contaminant Codes:	1973 ACGIH TLV:	1968 PA Rules STEL/Ceiling (C):
423	1.0 mg/m^3	3.0 mg/m^3 - 5 min.

CONTAMINANT INFORMATION

Synonyms:	Battery acid, hydrogen sulfate, oil of vitriol, sulfuric acid (aqueous)
Sources:	Metal cleaning, explosives, processing bauxite, metallurgy, electrowinning **(Note: For copper electrowinning operations contact lab for special sampling procedures).**
Description:	Colorless to dark-brown, oily, odorless liquid
Incompatibilities:	Organic materials, chlorates, carbides, fulminates, water, powdered metals; [note: reacts violently with water with evolution of heat; corrosive to metals]
Exposure:	Inhalation, ingestion, skin and/or eye contact
Health Effects:	Irritation: eyes, skin, nose, throat; pulmonary edema, bronchitis; emphysema; conjunctivitis; stomatis; dental erosion; tracheobronchitis; burns: eye, skin; dermatitis
PPE: Respirator:	Recommendations - NIOSH/OSHA: Up to 15 mg/m^3: (APF = 25) any supplied-air respirator operated in a continuous-flow mode [note: substance causes eye irritation or damage; eye protection needed]; (APF = 25) any powered, air-purifying respirator with acid gas cartridge(s) in combination with a high-efficiency particulate filter [note: substance causes eye irritation or damage; eye protection needed]; (APF = 50) any chemical cartridge respirator with a full facepiece and acid gas cartridge(s) in combination with a high-efficiency particulate filter; (APF = 50) any air-purifying, full-facepiece respirator (gas mask) with a chin-style, front- or back-mounted acid gas canister having a high-efficiency particulate filter; (APF = 50) any self-contained breathing apparatus with a full facepiece; (APF = 50) any supplied-air respirator with a full facepiece
Skin:	Prevent skin contact; (solution >70% only): 8 hr: Butyl, PE, Teflon, Saranex, PE/EVAL, Barricade, CPF3, Responder, Trellchem, Tychem; 4 hr: Viton
Eye:	Prevent eye contact
Special Precautions:	Noncombustible liquid, but capable of igniting finely divided combustible materials

LABORATORY INFORMATION

CAS Number: 7664-93-9
Analytical Technique: NIOSH 7903 (IV): ion chromatography (IC); Dräger: detector tube
Analytical Reference Method: NIOSH 7903 (IV); Dräger

SAMPLING INFORMATION

Full Shift Sampling:
Sampling Strategy: See Chapter 9
Collection Media: 400/200 mg: solid sorbent tube (washed silica gel, with glass fiber filter plug)
Sample Flow Rate: Minimum - Maximum (Lpm): 0.2-0.5
Air Collection Volume: Minimum - Maximum (L): 3-100

Short Term Sampling:
Sampling Strategy: See Chapter 9
Sampling Duration: 5 min.
Collection Media: 400/200 mg: solid sorbent tube (washed silica gel, with glass fiber filter plug)
Sample Flow Rate: Minimum - Maximum (Lpm): 0.2-0.5
Air Collection Volume: Minimum - Maximum (L): 3-100

Special Instructions: N/A

Talc - $Mg_3Si_4O_{10}(OH)_2$

1,000 mg/m^3 IDLH (NIOSH, 1995)

Contaminant Codes:	30 CFR §§56/57.5001(b) MSHA TLV:	30 CFR §§56/57.5001(b) MSHA STEL/Ceiling (C):
503 (talc, fibrous, <1% quartz)	2.0 fibers/mL	10.0 fibers/mL - 15 min.

Contaminant Codes:	1973 ACGIH TLV:	1973 ACGIH Excursion STEL/Ceiling (C):
511 (talc, nonfibrous, <1% quartz)	20 mppcf (3.3 mg/m^3)	40 mppcf (6.6 mg/m^3) - 15 min.

CONTAMINANT INFORMATION

Synonyms:	Hydrous magnesium silicate, steatite talc
Sources:	Talc mines
Description:	Odorless, white powder
Incompatibilities:	None reported
Exposure:	Inhalation, skin and/or eye contact
Health Effects:	Fibrotic pneumoconiosis, irritation eyes
PPE: Respirator:	Recommendations - NIOSH: Up to 10 mg/m^3: (APF = 5) any dust and mist respirator; up to 20 mg/m^3: (APF = 10) any dust and mist respirator except single-use and quarter-mask respirators; (APF = 10) any supplied-air respirator; up to 50 mg/m^3: (APF = 25) any powered, air-purifying respirator with a dust and mist filter; (APF = 25) any supplied-air respirator operated in a continuous-flow mode; up to 100 mg/m^3: (APF = 50) any air-purifying, full-facepiece respirator with a high-efficiency particulate filter; (APF = 50) any supplied-air respirator that has a tight-fitting facepiece and is operated in a continuous-flow mode; (APF = 50) any powered, air-purifying respirator with a tight-fitting facepiece and a high-efficiency particulate filter; (APF = 50) any self-contained breathing apparatus with a full facepiece; (APF = 50) any supplied-air respirator with a full facepiece; up to 1,000 mg/m^3: (APF = 1000) any supplied-air respirator operated in a pressure-demand or other positive-pressure mode
Skin:	No specific recommendation can be made; actual working conditions will determine the need and type of personal protective equipment
Eyes:	No recommendation is made specifying the need for eye protection
Special Precautions:	Noncombustible solid

LABORATORY INFORMATION - for nonfibrous (i.e., non-asbestiform) Talc

CAS number: 14807-96-6
Analytical Technique:
1. NIOSH 0500 (IV) [particulates not otherwise regulated, total]: gravimetric (filter weight)
2. NIOSH 0600 (IV) [particulates not otherwise regulated, respirable]: gravimetric (filter weight)
3. Mineral Dust: impinger method
Analytical Reference Method: NIOSH 0500 (IV); NIOSH 0600 (IV); impinger method

SAMPLING INFORMATION

Full Shift Sampling: Screening - **Note: cannot be used for enforcement**
Sampling Strategy: See Chapter 5
1. NIOSH 0500 (IV)**:**
Collection Media: filter [37-mm diameter, 5-µm pore size polyvinyl chloride (PVC) filter]
Sample Flow Rate (Lpm): 1.7
Air Collection Volume: Minimum - Maximum (L): 7-133
2. NIOSH 0600 (IV):
Collection Media: cyclone and filter [10-mm nylon cyclone and 37-mm diameter, 5-µm pore size polyvinyl chloride (PVC) filter]
Sample Flow Rate (Lpm): 1.7
Air Collection Volume: Minimum - Maximum (L): 20-400

Short Term Sampling:
Sampling Strategy: See Chapter 5
Sampling Duration: 15 min.
1. NIOSH 0500 (IV)**:**
Collection Media: filter [37-mm diameter, 5-µm pore size polyvinyl chloride (PVC) filter]
Sample Flow Rate (Lpm): 1.7
Air Collection Volume: Minimum - Maximum (L): 7-133
2. NIOSH 0600 (IV):
Collection Media: cyclone and filter [10-mm nylon cyclone and 37-mm diameter, 5-µm pore size polyvinyl chloride (PVC) filter]
Sample Flow Rate (Lpm): 1.7
Air Collection Volume: Minimum - Maximum (L): 20-400

Full Shift - Partial Period Sampling: Enforcement - **Note: for compliance with TLV**
Sampling Strategy: see Chapter 6
Collection Media: impinger
Sample Flow Rate (Lpm): 2.8
Air Collection Volume (L): 168

<u>Special Instructions</u>: Coordinate with MSHA Technical Support. Dust Division personnel will conduct <u>impinger</u> sampling with inspector escort.

<u>LABORATORY INFORMATION for fibrous (i.e. asbestiform)Talc</u>

CAS Number: 14807-96-6

Analytical Technique:

1. Personal: **(A):** NIOSH 7400 (IV): phase contrast microscopy (PCM)
(B): OSHA ID-160: PCM [at 400x]
(C): NIOSH 7402 (IV): transmission electron microscopy (TEM)

2. Bulk: **(A):** OSHA ID-191: polarized light microscopy (PLM)
(B): EPA 600/R93/116: qualitative identification by polarized light microscopy (PLM) and analytical transmission electron microscopy (TEM)
(D): NIOSH 9002 (IV): stereo (10-45x) and polarized light microscopy (PLM)

Analytical Reference Method:

1. Personal: **(A):** NIOSH 7400 (IV)
(B): OSHA ID-160
(C): NIOSH 7402 (IV)

2. Bulk: **(A):** OSHA ID-191
(B): EPA 600/R93/116
(C): NIOSH 9002 (IV)

<u>SAMPLING INFORMATION</u>

<u>Full Shift Sampling</u>:

Sampling Strategy: See Chapter 8 – Asbestos Fibers [note: for optimal filter loading without overloading, sampling times or flow rate may need to be adjusted;
see Chapter 8, V. Section F. 4.]

1. Personal:

Collection Media: 25-mm diameter, 0.8-µm pore size cellulose ester (CE) membrane filter; 50-mm electrically conductive extension cowl

Sample Flow Rate: Minimum - Maximum (Lpm): 0.5-5.0; [note 1: commonly, 1.7 Lpm] [note 2: always choose a flow rate that will not produce overloaded filters]

Air Collection Volume: Minimum - Maximum (L): 25-2,400

<u>Short Term Sampling</u>:

Sampling Strategy: see Chapter 8 – Asbestos Fibers

Sample Duration: 15-30 minutes

Collection Media: 25-mm diameter, 0.8-µm pore size cellulose ester (CE) membrane filter; 50-mm electrically conductive extension cowl;

Sample Flow Rate: Minimum - Maximum (Lpm): 1.7 – maximum stable pump capacity

Air Collection Volume: Minimum - Maximum (L): use larger sample volumes to acieve quantitfiable loadings, however, do not overload the filter with background dust.

Bulk Sampling:
Sampling Strategy: see Chapter 8 – Asbestos Fibers
Collection Media: Bulk material or cork-borer type sampler
Collect approximately 1 to 10 grams of material and place into screw-cap plastic vials of 10- to 50-mL capacity

Special Instructions:

1. Send the samples to the laboratory with paperwork requesting asbestos analysis. List any known fibrous interferences present during sampling on the paperwork. Also, note the workplace operation(s) sampled.
2. Secure and handle the samples so that they will not rattle during shipment nor be exposed to static electricity. Do not ship samples in expanded polystyrene peanuts, vermiculite, paper shreds, or excelsior. Tape sample cassettes to sheet bubbles and place in a container that will cushion the samples without rattling.
3. To avoid the possibility of sample contamination, always ship bulk samples in separate mailing containers.
4. Ship samples in a rigid container (with sufficient packing material to prevent damage) to MSHA Laboratory (for contract laboratory analysis).

Titanium Dioxide - TiO_2

5,000 mg/m^3 IDLH (NIOSH, 1995)

Contaminant Codes:	1973 ACGIH TLV:	1973 ACGIH Excursion STEL/Ceiling (C):
153 (dust)	10 mg/m^3	20 mg/m^3 - 15 min.
739 (fume)	10 mg/m^3	20 mg/m^3 - 15 min.

CONTAMINANT INFORMATION

Synonyms:	Rutile, ilmenite, leucoxene, titanium oxide, titanium peroxide
Sources:	Welding rod coatings, some enamels; titanium ores and sands: rutile, ilmenite, leucoxene, perovskite, anatase, octahedrite, brookite, sphene, titanite, benitoite
Description:	White, odorless sand or powder
Incompatibilities:	None reported
Exposure:	Inhalation
Health Effects:	Lung fibrosis; [potential occupational carcinogen]
PPE: Respirator:	Recommendations - NIOSH: Up to 5,000 mg/m^3: (APF = 10,000) any self-contained breathing apparatus that has a full facepiece and is operated in a pressure-demand or other positive-pressure mode; (APF = 10,000) any supplied-air respirator that has a full facepiece and is operated in a pressure-demand or other positive-pressure mode in combination with an auxiliary self-contained positive-pressure breathing apparatus
Skin:	No specific recommendation can be made; actual working conditions will determine the need and type of personal protective equipment
Eyes:	No recommendation is made specifying the need for eye protection
Special Precautions:	Noncombustible solid

LABORATORY INFORMATION

CAS Number: 13463-67-7

Analytical Technique: Atomic absorption spectroscopy (AAS) or atomic emission spectroscopy (AES); inductively coupled argon plasma, atomic emission spectroscopy (ICAP-AES)

Analytical Reference Method: MSHA P-14

<u>SAMPLING INFORMATION</u>

<u>Full Shift Sampling</u>:

Sampling Strategy: See Chapter 7

1. OSHA ID-121:

Collection Media: 37-mm (or 25-mm) diameter, 0.8-µm pore size mixed cellulose ester (MCE) filter

Sample Flow Rate (Lpm): 2

Air Collection Volume: Minimum - Maximum (L): 480-960

2. NIOSH 7300 (IV):

Collection Media: 37-mm diameter, 0.8-µm pore size mixed cellulose ester (MCE) filter

Sample Flow Rate (Lpm): 1.7

Air Collection Volume: Minimum - Maximum (L): 5-100

<u>Short Term Sampling</u>:

Sampling Strategy: See Chapter 7

Sampling Duration: 15 min.

1. OSHA ID-121:

Collection Media: 37-mm (or 25-mm) diameter, 0.8-µm pore size mixed cellulose ester (MCE) filter

Sample Flow Rate (Lpm): 2

Air Collection Volume (L): 30

2. NIOSH 7300 (IV):

Collection Media: 37-mm diameter, 0.8-µm pore size mixed cellulose ester (MCE) filter

Sample Flow Rate (Lpm): 1.7

Air Collection Volume: Minimum - Maximum (L): 5-100

<u>Special Instructions</u>: N/A

<u>Wipe Sampling</u>:

Sampling Strategy: See Chapter 14

Collection Media: Whatman Filter (No. 41 or 42), moistened with distilled water

Special Instructions: Seal wipe sample in plastic bag, vial, or jar.

Toluene - $C_6 H_5CH_3$
500 ppm IDLH (NIOSH, 1995)

Contaminant Codes:	1973 ACGIH TLV:	ANSI Z37.12-1974 STEL/Ceiling (C):
221	100 ppm	200 ppm (C)

CONTAMINANT INFORMATION

Synonyms: Methyl benzene, methyl benzol, phenyl methane, toluol

Sources: Solvents, gasoline, off-gassing of new building materials

Description: Colorless liquid with a sweet, pungent, benzene-like odor

Incompatibilities: Strong oxidizers

Exposure: Inhalation, skin absorption, ingestion, skin and/or eye contact

Health Effects: Irritation: eyes, nose; fatigue, weakness, confusion, euphoria, dizziness, headache; dilated pupils, lacrimation (discharge of tears); nervousness, muscle fatigue, insomnia; paresthesia; dermatitis; liver, kidney damage

PPE: Respirator: Recommendations - NIOSH: Up to 500 ppm: (APF = 10) any chemical cartridge respirator with organic vapor cartridge(s) [note: substance reported to cause eye irritation or damage; may require eye protection]; (APF = 25) any powered, air-purifying respirator with organic vapor cartridge(s) [note: substance reported to cause eye irritation or damage; may require eye protection]; (APF = 50) any air-purifying, full-facepiece respirator (gas mask) with a chin-style, front- or back-mounted organic vapor canister; (APF = 10) any supplied-air respirator [note: substance reported to cause eye irritation or damage; may require eye protection]; (APF = 50) any self-contained breathing apparatus with a full facepiece

Skin: Prevent skin contact; 8 hr: PVA, Teflon, Viton, PE/EVAL, Barricade, CPF3, Responder, Trellchem, Tychem

Eyes: Prevent eye contact

Special Precautions: Class IB flammable liquid

LABORATORY INFORMATION

CAS Number: 108-88-3

Analytical Technique: NIOSH 1500 (IV): gas chromatography (GC) / flame ionization detector (FID); NIOSH 1501 (IV): gas chromatography (GC) / flame ionization detector (FID); OSHA 111: gas chromatography (GC) / flame ionization detector (FID); 3M: passive monitor; Dräger: diffusion tube; Dräger: detector tube

Analytical Reference Method: NIOSH 1500 (IV); NIOSH 1501 (IV); OSHA 111; 3M; Dräger

SAMPLING INFORMATION

Full Shift Sampling:

Sampling Strategy: See Chapter 9

1. NIOSH 1500 (IV):

Collection Media: solid sorbent tube (100/50 mg coconut shell charcoal)

Sample Flow Rate: Minimum - Maximum (Lpm): 0.01-0.2; Must use a pump adaptor or arrange for low flow pumps.

Air Collection Volume: Minimum – Maximum (L): 2-8

2. NIOSH 1501 (IV):

Collection Media: solid sorbent tube (100/50 mg coconut shell charcoal)

Sample Flow Rate: Minimum - Maximum (Lpm): 0.01-0.2; Must use a pump adaptor or arrange for low flow pumps.

Air Collection Volume: Minimum – Maximum (L): 1-8

3. OSHA 111:

Collection Media: Solid sorbent tube [100/50 mg coconut shell charcoal; or 140/70 mg Anasorb® 747 (beaded activated carbon)]

Sample Flow Rate (Lpm): 0.05; Must use a pump adaptor or arrange for low flow pumps.

Air Collection Volume (L): $\leq$12

4. 3M:

Collection Media: Passive monitor, 3M, 3500 series

Note: maximum 8-hour sample per badge

5. Dräger:

Collection Media: Dräger diffusion tube, #8101421; range 100-3,000 ppm (1 hour), 50-1,500 ppm (2 hours), 25-750 ppm (4 hours), 13-380 ppm (8 hours); **Note:** up to 8 hours per tube. (EF = 1.25).

Short Term Sampling:

Sampling Strategy: See Chapter 9

Sampling Duration: 10 min.

1. NIOSH 1500 (IV):

Collection Media: Solid sorbent tube (100/50 mg coconut shell charcoal)

Sample Flow Rate: Minimum - Maximum (Lpm): 0.01-0.2; Must use a pump adaptor or arrange for low flow pumps.

Air Collection Volume (L): 2

2. NIOSH 1501 (IV):

Collection Media: Solid sorbent tube (100/50 mg coconut shell charcoal)

Sample Flow Rate: Minimum - Maximum (Lpm): 0.01-0.2; Must use a pump adaptor or arrange for low flow pumps.

Air Collection Volume: Minimum – Maximum (L): 1-8

3. OSHA 111:
Collection Media: Solid sorbent tube [100/50 mg coconut shell charcoal; or 140/70 mg Anasorb® 747 (beaded activated carbon)]
Sample Flow Rate (Lpm): 0.05; Must use a pump adaptor or arrange for low flow pumps.
Air Collection Volume (L): >0.5

Special Instructions: N/A

Grab Sampling:
Sampling Strategy: See Chapter 11
Collection Media: Dräger detector tube, #8101661, range 5-600 ppm (EF = 1.15); Dräger detector tube, #8101701, range 50-400 ppm (EF = 1.20); Dräger detector tube, #CH23001, range 50-400 ppm (EF = 1.15); Dräger detector tube, #8101731, range 100-1,800 ppm (EF = 1.20).

Trichloroethylene - $ClCH=CCl_2$

1,000 ppm IDLH (NIOSH, 1995)

Contaminant Codes:	1973 ACGIH TLV:	1968 PA Rules STEL/Ceiling (C):
211	100 ppm	200 ppm - 30 min.

CONTAMINANT INFORMATION

Synonyms:	Ethylene trichloride, TCE, trichloroethene, trilene
Sources:	Degreasing and paint solvents
Description:	Colorless liquid (unless dyed blue) with a chloroform-like odor
Incompatibilities:	Strong caustics & alkalis; chemically-active metals (e.g., barium, lithium, sodium, magnesium, titanium, beryllium)
Exposure:	Inhalation, skin absorption, ingestion, skin and/or eye contact
Health Effects:	Irritation: eyes, skin; headache, vertigo (an illusion of movement); visual disturbance, fatigue, giddiness, tremor, somnolence (sleepiness, unnatural drowsiness), nausea, vomiting; dermatitis; cardiac arrhythmias, paresthesia; liver injury; [potential occupational carcinogen]
PPE: Respirator:	Recommendations - NIOSH: Up to 1,000 ppm: (APF = 10,000) any self-contained breathing apparatus that has a full facepiece and is operated in a pressure-demand or other positive-pressure mode; (APF = 10,000) any supplied-air respirator that has a full facepiece and is operated in a pressure-demand or other positive-pressure mode in combination with an auxiliary self-contained positive-pressure breathing apparatus
Skin:	Prevent skin contact; 8 hr: PVA, Viton, PE/EVAL, Barricade, Trellchem, Tychem; 4 hr: Teflon, Responder
Eyes:	Prevent eye contact
Special Precautions:	Combustible liquid (but burns with difficulty)

LABORATORY INFORMATION

CAS Number: 79-01-6

Analytical Technique: NIOSH 1022 (IV): gas chromatography (GC) / flame ionization detector (FID); OSHA 1001: gas chromatography (GC) / flame ionization detector (FID); 3M: passive monitor; Dräger: diffusion tube; Dräger: detector tube

Analytical Reference Method: NIOSH 1022 (IV); OSHA 1001; 3M; Dräger

SAMPLING INFORMATION

Full Shift Sampling:
Sampling Strategy: See Chapter 9
1. NIOSH 1022 (IV):
Collection Media: Solid sorbent tube (100/50 mg coconut shell charcoal)
Sample Flow Rate: Minimum - Maximum (Lpm): 0.01-0.2; Must use a pump adaptor or arrange for low flow pumps.
Air Collection Volume: Minimum – Maximum (L): 1-30
2. OSHA 1001:
Collection Media: Solid sorbent tube (100/50 mg coconut shell charcoal)
Sample Flow Rate (Lpm): 0.05; Must use a pump adaptor or arrange for low flow pumps.
Air Collection Volume (L): ≤12
3. 3M:
Collection Media: Passive monitor, 3M, 3500 series
Note: Maximum 8-hour sample per badge
4. Dräger:
Collection Media: Dräger diffusion tube, #8101441; range 200-1,000 ppm (1 hour), 100-500 ppm (2 hours), 50-250 ppm (4 hours), 25-125 ppm (8 hours); Note: up to 8 hours per tube. (EF = 1.25).

Short Term Sampling:
Sampling Strategy: See Chapter 9
Sampling Duration: 5-10 min.
1. NIOSH 1022 (IV):
Collection Media: Solid sorbent tube (100/50 mg coconut shell charcoal)
Sample Flow Rate: Minimum - Maximum (Lpm): 0.01-0.2; Must use a pump adaptor or arrange for low flow pumps.
Air Collection Volume: Minimum – Maximum (L): 1-30
2. OSHA 1001:
Collection Media: Solid sorbent tube (100/50 mg coconut shell charcoal)
Sample Flow Rate (Lpm): 0.05; Must use a pump adaptor or arrange for low flow pumps.
Air Collection Volume (L): >0.25

Special Instructions: N/A

Grab Sampling:
Sampling Strategy: See Chapter 11
Collection Media: Dräger detector tube, #6728541, range 2-250 ppm (EF = 1.15); Dräger detector tube, #8101881, range 50-2,000 ppm (EF = 1.40).Dräger detector tube, #CH24401, range 50-2,000 ppm (EF = 1.40).

Tridymite - SiO_2 (Respirable)

25 mg/m^3 IDLH (NIOSH, 1995)

Contaminant Codes:	1973 ACGIH TLV:	1973 ACGIH Excursion STEL/Ceiling (C):
527	$\frac{5}{\% SiO_2 + 2}$ mg/m^3	N/A

CONTAMINANT INFORMATION

Synonyms:	Crystalline silica
Sources:	Volcanic silica-bearing rock
Description:	Colorless, odorless solid; [note: silica is a component of many mineral dusts]
Incompatibilities:	Powerful oxidizers (*e.g.*, fluorine, chlorine trifluoride, manganese trioxide, oxygen difluoride, hydrogen peroxide); acetylene; ammonia
Exposure:	Inhalation, skin and/or eye contact
Health Effects:	Cough, dyspnea (breathing difficulty), wheezing; decreased pulmonary function, progressive respiratory symptoms (silicosis); irritation: eyes; [potential occupational carcinogen]
PPE: Respirator:	Recommendations - NIOSH: Up to 0.5 mg/m^3: (APF = 10) any air-purifying respirator with a high-efficiency particulate filter; up to 1.25 mg/m^3: (APF = 25) any powered, air-purifying respirator with a high-efficiency particulate filter; (APF = 25) any supplied-air respirator operated in a continuous-flow mode; up to 2.5 mg/m^3: (APF = 50) any air-purifying, full-facepiece respirator with a high-efficiency particulate filter; (APF = 50) any powered, air-purifying respirator with a tight-fitting facepiece and a high-efficiency particulate filter; up to 25 mg/m^3: (APF = 1000) any supplied-air respirator operated in a pressure-demand or other positive-pressure mode
Skin:	No specific recommendation can be made; actual working conditions will determine the need and type of personal protective equipment
Eyes:	No recommendation is made specifying the need for eye protection
Special Precautions:	Noncombustible solid

LABORATORY INFORMATION

CAS Number: 14808-60-7

Analytical Technique: NIOSH 7500 (IV): x-ray diffraction spectrometry; OSHA ID-142: x-ray diffraction spectrometry

Analytical Reference Method: NIOSH 7500 (IV); OSHA ID-142

__SAMPLING INFORMATION__

__**Full Shift Sampling**__**:**

Sampling Strategy: See Chapter 5

1. NIOSH 7500 (IV):

Collection Media: Cyclone and filter [10-mm nylon cyclone and 37-mm diameter, 5-µm pore size polyvinyl chloride (PVC) filter]

Sample Flow Rate (Lpm): 1.7

Air Collection Volume: Minimum - Maximum (L): 400-1000

2. OSHA ID-142:

Collection Media: Cyclone and filter [10-mm nylon cyclone and 37-mm diameter, 5-µm pore size polyvinyl chloride (PVC) filter]

Sample Flow Rate (Lpm): 1.7

Air Collection Volume: Minimum - Maximum (L): 408-816

__**Bulk Sampling:**__

Sampling Strategy: See Chapters 5 & 14

1. NIOSH 7500 (IV): [high-volume air]

Collection Media: 37-mm diameter, 5-µm pore size polyvinyl chloride (PVC) filter

Sample Flow Rate (Lpm): 3

Air Collection Volume: Minimum - Maximum (L): 400-1000

2a. OSHA ID-142: [high-volume filter sample - respirable]

Quantity: > 1.0 grams

2b. OSHA ID-142: [high-volume filter sample - nonrespirable]

Quantity: > 1.0 grams

2c. OSHA ID-142: [representative settled dust (*i.e.*, rafter sample)]

Quantity: > 1.0 grams

2d. OSHA ID-142: [representative workplace material]

Quantity: 10-20 grams

__**Special Instructions**__**:** Coordinate with MSHA Laboratory. Collect a bulk sample (e.g., high-volume air; settled dust; workplace material) to identify interferences. Submit air and bulk samples via overnight carrier to MSHA Laboratory.

Trimethylbenzene - $C_6H_3(CH_3)_3$

Contaminant Codes:	1973 ACGIH TLV:	1973 ACGIH Excursion STEL/Ceiling (C):
269	25 ppm	37.5 ppm - 15 min.

CONTAMINANT INFORMATION

Synonyms: *1,2,3-trimethylbenzene:* hemellitol; [note: hemimellite is a mixture of the 1,2,3-isomer with up to 10% of related aromatics such as the 1,2,4-isomer]
1,2,4-trimethylbenzene: asymmetrical trimethylbenzene, psi-cumene, pseudocumene; [note: hemimellite is a mixture of the 1,2,3-isomer with up to 10% of related aromatics such as the 1,2,4-isomer]
1,3,5-trimethylbenzene: mesitylene, symmetrical trimethylbenzene, sym-trimethylbenzene

Sources: Raw material in chemical syntheses, solvents, constituent of gasoline, coal tar

Description: *All isomers:* clear, colorless liquid with a distinctive, aromatic odor

Incompatibilities: *All isomers:* oxidizers, nitric acid

Exposure: *All isomers:* inhalation, ingestion, skin and/or eye contact

Health Effects: *All isomers:* irritation: eyes, skin, nose, throat, respiratory system; bronchitis; hypochromic anemia; headache, drowsiness, fatigue, dizziness, nausea, incoordination; vomiting, confusion; chemical pneumonia (aspiration of liquid)

PPE: Respirator: Recommendations - NIOSH: Note: NIOSH has not published respirator recommendations for this substance. If sampling is required, seek guidance before exposing oneself. *all isomers:* N/A

Skin: *all isomers:* prevent skin contact
1,2,3-trimethylbenzene: contact the manufacturer for recommendations
1,2,4-trimethylbenzene: 8 hr: PVA, Viton, PE/EVAL, Barricade, CPF3, Tychem; 4 hr: Teflon, Responder
1,3,5-trimethylbenzene: contact the manufacturer for recommendations

Eyes: *all isomers:* prevent eye contact

Special Precautions: *1,2,3-trimethylbenzene:* Flammable liquid
1,2,4-trimethylbenzene: Class II flammable liquid
1,3,5-trimethylbenzene: Class II flammable liquid

LABORATORY INFORMATION

CAS Number: *1,2,3-trimethylbenzene:* 526-73-8
1,2,4-trimethylbenzene: 95-63-6
1,3,5-trimethylbenzene: 108-67-8

Analytical Technique: Dräger: detector tube
Analytical Reference Method: Dräger

SAMPLING INFORMATION

Full Shift Sampling:
Sampling Strategy: N/A
Collection Media: N/A

Short Term Sampling:
Sampling Strategy: N/A
Sampling Duration: N/A

Special Instructions: N/A

Grab Sampling:
Sampling Strategy: See Chapter 11
Collection Media: *all isomers:* Dräger detector tube, #8101661, range 10-100 ppm (EF = 1.20).

Tungsten and Compounds (as W)

Contaminant Codes:	1973 ACGIH TLV:	1973 ACGIH Excursion STEL/Ceiling (C):
741 (fumes)	5.0 mg/m^3	10 mg/m^3 - 15 min.
155 (insoluble dusts, as W)	5.0 mg/m^3	10 mg/m^3 - 15 min.
323 (soluble compounds, as W)	1.0 mg/m^3	3.0 mg/m^3 - 15 min.

CONTAMINANT INFORMATION

Synonyms: *Insoluble dusts & fumes:* tungsten metal, wolfram
soluble compounds: (note: synonyms vary depending upon the specific soluble tungsten compound)

Sources: Ores of wolframite and scheelite, welding or torch cutting of tungsten steel and tungsten alloys

Description: *Insoluble dusts & fumes:* hard, brittle, steel-gray to tin-white solid
soluble compounds: (note: appearance and odor vary depending upon the specific soluble tungsten compound)

Incompatibilities: *Insoluble dusts & fumes:* bromine trifluoride, chlorine trifluoride, fluorine, iodine pentafluoride
soluble compounds: (note: varies)

Exposure: *Insoluble dusts & fumes:* inhalation, ingestion, skin and/or eye contact
soluble compounds: inhalation, ingestion, skin and/or eye contact

Health Effects: *Insoluble dusts & fumes:* irritation: eyes, skin, respiratory system; diffuse pulmonary fibrosis; loss of appetite, nausea, cough; blood changes
soluble compounds: irritation: eyes, skin, respiratory system

PPE: Respirator: Recommendations - NIOSH:
insoluble dusts & fumes: Up to 50 mg/m^3: (APF = 10) any air-purifying respirator with a high-efficiency particulate filter; (APF = 10) any supplied-air respirator; (APF = 50) any self-contained breathing apparatus with a full facepiece
soluble compounds: Up to 10 mg/m^3: (APF = 10) any air-purifying respirator with a high-efficiency particulate filter; (APF = 10) any supplied-air respirator; up to 25 mg/m^3: (APF = 25) any supplied-air respirator operated in a continuous-flow mode; up to 50 mg/m^3: (APF = 50) any air-purifying, full-facepiece respirator with a high-efficiency particulate filter; (APF = 50) any self-contained breathing apparatus with a full facepiece; (APF = 50) any supplied-air respirator with a full facepiece

Skin: *Insoluble dusts & fumes:* no specific recommendation can be made; actual working conditions will determine the need and type of personal protective equipment *soluble compounds:* recommendations regarding personal protective clothing vary depending upon the specific compound; contact the manufacturer for recommendations for the specific compound

Eyes: *Insoluble dusts & fumes:* prevent eye contact
soluble compounds: recommendations regarding eye protection vary depending upon the specific compound

Special Precautions: *Insoluble dusts & fumes:* combustible in the form of finely divided powder; may ignite spontaneously
soluble compounds: (note: varies depending on the compound)

LABORATORY INFORMATION

CAS Number: 7440-33-7 *(insoluble dusts & fumes)*; varies *(soluble compounds)*
Analytical Technique: NIOSH 7074 (IV): flame atomic absorption spectrometry (FAAS); OSHA ID-213: inductively coupled plasma - atomic emission spectrometer (ICP-AES)
Analytical Reference Method: NIOSH 7074 (IV); OSHA ID-213

SAMPLING INFORMATION

Full Shift Sampling:
Sampling Strategy: See Chapter 7
1. NIOSH 7074 (IV):
Collection Media: 37-mm diameter, 0.8-µm pore size cellulose ester (CE) filter
Sample Flow Rate: Minimum - Maximum (Lpm): 1-4
Air Collection Volume: Minimum - Maximum (L): 200-1000
2. OSHA ID-213:
Collection Media: 37-mm diameter, 0.8-µm pore size mixed cellulose ester (MCE) filter
Sample Flow Rate (Lpm): 2
Air Collection Volume (L): 480

Short Term Sampling:
Sampling Strategy: See Chapter 7
Sampling Duration: 15 min.
1. NIOSH 7074 (IV):
Collection Media: 37-mm diameter, 0.8-µm pore size cellulose ester (CE) filter
Sample Flow Rate: Minimum - Maximum (Lpm): 1-4
Air Collection Volume: Minimum - Maximum (L): 200-1000
2. OSHA ID-213:
Collection Media: 37-mm diameter, 0.8-µm pore size mixed cellulose ester (MCE) filter
Sample Flow Rate (Lpm): 2
Air Collection Volume (L): 30

Special Instructions: N/A

Bulk Sampling:
Sampling Strategy: See Chapter 8
OSHA ID-213:
Special Instructions: Place bulk samples in 20-mL scintillation vials. Fill 20-mL scintillation vials at least half full of material sampled. Large pieces that do not fit inside 20-mL scintillation vials may be shipped in larger containers.

Wipe Sampling:
Sampling Strategy: See Chapter 14
OSHA ID-213:
Collection Media: Whatman Filter (No. 41 or 42) or smear tabs, moistened with distilled water
Special Instructions: Seal wipe sample in vial.

Turpentine - $C_{10}H_{16}$ (approx)
800 ppm IDLH (NIOSH, 1995)

Contaminant Codes:	1973 ACGIH TLV:	1973 ACGIH Excursion STEL/Ceiling (C):
995	100 ppm	150 ppm - 15 min.

CONTAMINANT INFORMATION

Synonyms: Gumspirits, gum turpentine, spirits of turpentine, steam distilled turpentine, sulfate wood turpentine, turps, wood turpentine

Sources: Solvents, insecticides

Description: Colorless liquid with a characteristic odor

Incompatibilities: Strong oxidizers, chlorine, chromic anhydride, stannic chloride, chromyl chloride

Exposure: Inhalation, skin absorption, ingestion, skin and/or eye contact

Health Effects: Irritation: eyes, skin, nose, throat; headache, vertigo (an illusion of movement), convulsions; skin sensitization; hematuria (blood in the urine), albuminuria; kidney damage; abdominal pain, nausea, vomiting, diarrhea; chemical pneumonia (aspiration of liquid)

PPE: Respirator: Recommendations - NIOSH/OSHA: Up to 800 ppm: (APF = 25) any supplied-air respirator operated in a continuous-flow mode [note: substance causes eye irritation or damage; eye protection needed]; (APF = 25) any powered, air-purifying respirator with organic vapor cartridge(s) [note: substance causes eye irritation or damage; eye protection needed]; (APF = 50) any chemical cartridge respirator with a full facepiece and organic vapor cartridge(s); (APF = 50) any air-purifying, full-facepiece respirator (gas mask) with a chin-style, front- or back-mounted organic vapor canister; (APF = 50) any self-contained breathing apparatus with a full facepiece; (APF = 50) any supplied-air respirator with a full facepiece

Skin: Prevent skin contact; 8 hr: Viton, PE/EVAL, Responder;
4 hr: Nitrile, PVA, Teflon

Eyes: Prevent eye contact

Special Precautions: Class IC flammable liquid

LABORATORY INFORMATION

CAS Number: 8006-64-2

Analytical Technique: NIOSH 1551 (IV): gas chromatography (GC) / flame ionization detector (FID)

Analytical Reference Method: NIOSH 1551 (IV)

SAMPLING INFORMATION

Full Shift Sampling:
Sampling Strategy: See Chapter 9
Collection Media: Solid sorbent tube (100/50 mg coconut shell charcoal)
Sample Flow Rate: Minimum - Maximum (Lpm): 0.01-0.2; Must use a pump adaptor or arrange for low flow pumps.
Air Collection Volume: Minimum – Maximum (L): 1-10

Short Term Sampling:
Sampling Strategy: See Chapter 9
Sampling Duration: 15 min.
Collection Media: Solid sorbent tube (100/50 mg coconut shell charcoal)
Sample Flow Rate: Minimum - Maximum (Lpm): 0.01-0.2; Must use a pump adaptor or arrange for low flow pumps.
Air Collection Volume: Minimum – Maximum (L): 1-10

Special Instructions: Stable for only one week at room temperature; bulk sample (1 to 10 mL) required, to be shipped in separate container. Submit samples overnight to MSHA Laboratory.

Vanadium - V
Vanadium Oxide - V_2O_5
35 mg/m^3 (as V) IDLH (NIOSH, 1995)

Contaminant Codes:	1973 ACGIH TLV:	1968 PA Rules STEL/Ceiling (C):
471 (vanadium dust)	0.5 mg/m^3 (500 $\mu g/m^3$)	0.5 mg/m^3 (500$\mu g/m^3$) - 30 min.

Contaminant Codes:	1973 ACGIH TLV:	1973 ACGIH Excursion STEL/Ceiling (C):
743 (V_2O_5 fume, as V)	0.05 mg/m^3 (50 $\mu g/m^3$)	0.05 mg/m^3 (50 $\mu g/m^3$) - (C)

(PEDS unit of measure in parentheses)

CONTAMINANT INFORMATION

Synonyms: Divanadium pentoxide, vanadic anhydride, vanadium pentoxide

Sources: *Dust*: ores of patronite (polysulfide - VS_4), vanadinite, volborthite, aegirite
fume: welding, additive to specialty steels, oxidation of sulfur dioxide, some fuel oils

Description: *Dust*: yellow-orange powder or dark gray, odorless flakes dispersed in air
fume: bright white, soft metal, corrosion resistant

Incompatibilities: *Dust and fume*: lithium, chlorine trifluoride

Exposure: *Dust*: inhalation, ingestion, skin and/or eye contact
fume: inhalation, skin and/or eye contact

Health Effects: *Dust*: irritation: eyes, skin, throat; green tongue, metallic taste, eczema; cough; fine rales, wheezing, bronchitis, dyspnea (breathing difficulty)
fume: irritation: eyes, throat; green tongue, metallic taste; cough, fine rales, wheezing, bronchitis, dyspnea (breathing difficulty); eczema

PPE: Respirator: Recommendations - NIOSH: (as V)
dust and fume: Up to 0.5 mg/m^3: (APF = 10) any air-purifying respirator with a high-efficiency particulate filter [note: substance reported to cause eye irritation or damage; may require eye protection]; (APF = 10) any supplied-air respirator [note: substance reported to cause eye irritation or damage; may require eye protection]; up to 1.25 mg/m^3: (APF = 25) any supplied-air respirator operated in a continuous-flow mode [note: substance reported to cause eye irritation or damage; may require eye protection]; (APF = 25) any powered, air-purifying respirator with a high-efficiency particulate filter [note: substance reported to cause eye irritation or damage; may require eye protection]; up to 2.5 mg/m^3:

(APF = 50) any air-purifying, full-facepiece respirator with a high-efficiency particulate filter; (APF = 50) any powered, air-purifying respirator with a tight-fitting facepiece and a high-efficiency particulate filter [note: substance reported to cause eye irritation or damage; may require eye protection]; (APF = 50) any self-contained breathing apparatus with a full facepiece; (APF = 50) any supplied-air respirator with a full facepiece; up to 35 mg/m^3: (APF = 2000) any supplied-air respirator that has a full facepiece and is operated in a pressure-demand or other positive-pressure mode

Skin: *Dust*: prevent skin contact; any barrier that will prevent contamination from the dust
fume: no specific recommendation can be made; actual working onditions will determine the need and type of personal protective equipment

Eyes: *Dust*: prevent eye contact
fume: no recommendation is made for specific eye protection

Special Precautions: *Dust*: noncombustible solid, but may increase intensity of fire when in contact with combustible materials
fume: noncombustible solid

LABORATORY INFORMATION

CAS Number: 1314-62-1
Analytical Technique: NIOSH 7300 (IV): inductively coupled argon plasma, atomic emission spectroscopy (ICAP-AES)
Analytical Reference Method: NIOSH 7300 (IV)

SAMPLING INFORMATION

Full Shift Sampling:
Sampling Strategy: See Chapter 7
Collection Media: 37-mm diameter, 0.8-µm pore size mixed cellulose ester (MCE) filter
Sample Flow Rate (Lpm): 1.7
Air Collection Volume: Minimum - Maximum (L): 5-2000

Short Term Sampling:
Sampling Strategy: See Chapter 7
Sampling Duration: 15 min.
Collection Media: 37-mm diameter, 0.8-µm pore size mixed cellulose ester (MCE) filter
Sample Flow Rate (Lpm): 1.7
Air Collection Volume: Minimum - Maximum (L): 5-2000

Special Instructions: N/A

Wipe Sampling:
Sampling Strategy: See Chapter 14
Collection Media: Whatman Filter (No. 41 or 42), moistened with distilled water
Special Instructions: Seal wipe sample in plastic bag, vial, or jar.

Vinyl Chloride - CH_2=CHCl

Contaminant Codes:	1973 ACGIH TLV:	1968 PA Rules STEL/Ceiling (C):
995	200 ppm	500 ppm - 5 min.

CONTAMINANT INFORMATION

Synonyms: Chloroethene, chloroethylene, ethylene monochloride, monochlorethene, monochlorethylene, VC, vinyl chloride monomer (VCM)

Sources: Refrigerant

Description: Colorless gas or liquid (below 7°F) with a pleasant odor at high concentrations; [note: shipped as a liquefied compressed gas]

Incompatibilities: Copper, oxidizers, aluminum, peroxides, iron, steel; [note: polymerizes in air, sunlight, or heat unless stabilized by inhibitors such as phenol; attacks iron and steel in presence of moisture]

Exposure: Inhalation, skin, and/or eye contact (liquid)

Health Effects: Weakness; abdominal pain, gastrointestinal bleeding; enlarged liver; pallor or cyanosis of extremities; liquid: frostbite; [note: potential occupational carcinogen]

PPE: Respirator: Recommendations - NIOSH: At any detectable concentration: (APF = 10,000) any self-contained breathing apparatus that has a full facepiece and is operated in a pressure-demand or other positive-pressure mode; (APF = 10,000) any supplied-air respirator that has a full facepiece and is operated in a pressure-demand or other positive-pressure mode in combination with an auxiliary self-contained positive-pressure breathing apparatus

Skin: Prevent skin contact; frostbite; 8 hr: Tychem; 4 hr: PVA, Teflon; prevent possible skin freezing from direct liquid contact

Eyes: Wear appropriate eye protection to prevent eye contact with the liquid that could result in burns or tissue damage from frostbite

Special Precautions: Flammable gas

LABORATORY INFORMATION

CAS Number: 75-01-4

Analytical Technique: NIOSH 1007 (IV): gas chromatography (GC) / flame ionization detector (FID); OSHA 75: gas chromatography (GC) / flame ionization detector (FID); Dräger: detector tube

Analytical Reference Method: NIOSH 1007 (IV); OSHA 1001; Dräger

SAMPLING INFORMATION

Full Shift Sampling:

Sampling Strategy: See Chapter 9

1. NIOSH 1007 (IV):

Collection Media: solid sorbent tubes [i.e., two tandem tubes, each with 150 mg of 20/40 mesh activated (600°F) coconut shell charcoal; (note: a pair of two-section 100/50 mg tubes may be used)]

Sample Flow Rate: Minimum - Maximum (Lpm): 0.05; Must use a pump adaptor or arrange for low flow pumps.

Air Collection Volume: Minimum – Maximum (L): 0.7-5

2. OSHA 75:

Collection Media: solid sorbent tube [130/65 mg of 60/80 mesh Carbosieve S-III (carbon based molecular sieve) adsorbent tube]

Sample Flow Rate (Lpm): 0.05; Must use a pump adaptor or arrange for low flow pumps.

Air Collection Volume (L): 3

Short Term Sampling:

Sampling Strategy: See Chapter 9

Sampling Duration: 15 min.

1. NIOSH 1007 (IV):

Collection Media: solid sorbent tubes [i.e., two tandem tubes, each with 150 mg of 20/40 mesh activated (600°F) coconut shell charcoal; (note: a pair of two-section 100/50 mg tubes may be used)]

Sample Flow Rate: Minimum - Maximum (Lpm): 0.05; Must use a pump adaptor or arrange for low flow pumps.

Air Collection Volume: Minimum – Maximum (L): 0.75

2. OSHA 75:

Collection Media: solid sorbent tube [130/65 mg of 60/80 mesh Carbosieve S-III (carbon based molecular sieve) adsorbent tube]

Sample Flow Rate (Lpm): 0.05; Must use a pump adaptor or arrange for low flow pumps.

Air Collection Volume (L): 0.75

Special Instructions:

1. NIOSH 1007 (IV): Separate primary and backup tubes, and cap each. Sample remains stable for 10 days at room temperature.

2. OSHA 75: Samples are to be stored at reduced temperature after they have been received at the analytical laboratory.

Grab Sampling:
Sampling Strategy: See Chapter 11
Collection Media: Dräger detector tube, #8101721, range 0.125-30 ppm (EF = 1.35); Dräger detector tube, #6728031, range 1-50 ppm (EF = 1.15); Dräger detector tube, #CH19601, range 100-3,000 ppm (EF = 1.30).

Welding Fume Profile
(Metals)

Metal Analyzed: Arsenic, Beryllium, Cadmium, Chromium, Cobalt, Copper, Iron, Lead, Manganese, Magnesium, Molybdenum, Nickel, Vanadium, Zinc

CONTAMINANT INFORMATION

Synonyms: Vary depending upon the specific component of the welding fumes

Sources: Welding and cutting of metals and alloys; electroplating; nickel sulfide (Ni_3S_2) in smelting and refining of some nickel ores

Description: Properties vary depending upon the specific component of the welding fumes

Incompatibilities: Vary depending upon the specific component of the welding fumes

Exposure: Inhalation, skin and/or eye contact

Health Effects: Symptoms vary depending upon the specific component of the welding fumes; metal fume fever: flu-like symptoms, dyspnea (breathing difficulty), cough, muscle pain, fever, chills; interstitial pneumonia; [note: some welding fumes are potential occupational carcinogens]

PPE: Respirator: Recommendations - NIOSH: At any detectable concentration: (APF = 10,000) any self-contained breathing apparatus that has a full facepiece and is operated in a pressure-demand or other positive-pressure mode; (APF = 10,000) any supplied-air respirator that has a full facepiece and is operated in a pressure-demand or other positive-pressure mode in combination with an auxiliary self-contained positive-pressure breathing apparatus

Skin: No recommendation is made specifying the need for personal protective equipment for the body

Eyes: No specific recommendation is made for type of eye protection

Special Precautions: Vary depending upon the specific component of the welding fumes

LABORATORY INFORMATION

CAS Number: Varies depending upon the specific component of the welding fumes

Analytical Technique: OSHA ID-125G: inductively coupled argon plasma, atomic emission spectroscopy (ICAP-AES); NIOSH 7300 (IV): inductively coupled argon plasma, atomic emission spectroscopy (ICAP-AES)

Analytical Reference Method: OSHA ID-125G; NIOSH 7300 (IV)

SAMPLING INFORMATION

Full Shift Sampling:

Sampling Strategy: See Chapter 7
1. OSHA ID-125G:
Collection Media: 37-mm (or 25-mm) diameter, 0.8-µm pore size mixed cellulose ester (MCE) filter
Sample Flow Rate (Lpm): 2
Air Collection Volume (L): 480
2. NIOSH 7300 (IV):
Collection Media: 37-mm diameter, 0.8-µm pore size mixed cellulose ester (MCE) filter
Sample Flow Rate (Lpm): 1.7
Air Collection Volume: Minimum - Maximum (L): 5-1000

Short Term Sampling:

Sampling Strategy: See Chapter 7
Sampling Duration: 15 min.
1. OSHA ID-125G:
Collection Media: 37-mm (or 25-mm) diameter, 0.8-µm pore size mixed cellulose ester (MCE) filter
Sample Flow Rate (Lpm): 2
Air Collection Volume (L): 30
2. NIOSH 7300 (IV):
Collection Media: 37-mm diameter, 0.8-µm pore size mixed cellulose ester (MCE) filter
Sample Flow Rate (Lpm): 1.7
Air Collection Volume: Minimum - Maximum (L): 5-1000

Special Instructions: N/A

Wipe Sampling:

Sampling Strategy: See Chapter 14
Collection Media: Whatman Filter (No. 41 or 42), moistened with distilled water
Special Instructions: Seal wipe sample in plastic bag, vial, or jar.

Xylene (Xylol) - $C_6H_4(CH_3)_2$
900 ppm IDLH (NIOSH, 1995)

Contaminant Codes:	1973 ACGIH TLV:	ANSI Z37.10-1971 STEL/Ceiling (C):
223	100 ppm	200 ppm (C)
225 (m-xylene)	100 ppm	200 ppm (C)
227 (o-xylene)	100 ppm	200 ppm (C)
229 (p-xylene)	100 ppm	200 ppm (C)

CONTAMINANT INFORMATION

Synonyms: *o-xylene:* 1,2-dimethylbenzene, ortho-xylene, o-xylol
m-xylene: 1,3-dimethylbenzene, meta-xylene, m-xylol
p-xylene: 1,4-dimethylbenzene, para-xylene, p-xylol

Sources: Solvents, cleaning agents, fuels

Description: Colorless liquid with an aromatic odor

Incompatibilities: Strong oxidizers, strong acids

Exposure: Inhalation, skin absorption, ingestion, skin and/or eye contact

Health Effects: Irritation eyes, skin, nose, throat; dizziness, excitement, drowsiness, Loss of coordination, staggering gait; corneal vacuolization; anorexia, nausea, vomiting, abdominal pain; dermatitis

PPE: Respirator: Recommendations - NIOSH/OSHA: up to 900 ppm: (APF = 10) any chemical cartridge respirator with organic vapor cartridge(s) [note: substance reported to cause eye irritation or damage; may require eye protection]; (APF = 25) any powered, air-purifying respirator with organic vapor cartridge(s) [note: substance reported to cause eye irritation or damage; may require eye protection]; (APF = 10) any supplied-air respirator [note: substance reported to cause eye irritation or damage; may require eye protection]; (APF = 50) any self-contained breathing apparatus with a full facepiece

Skin: Prevent skin contact; contact the manufacturer for recommendations

Eyes: Prevent eye contact

Special Precautions: Class IC flammable liquid

LABORATORY INFORMATION

CAS Numbers: 1330-20-7 (all isomers), 95-47-6 (o-xylene), 108-38-3 (m-xylene), 106-42-3 (p-xylene)

Analytical Technique: NIOSH 1501 (IV): gas chromatography (GC) / flame ionization detector (FID); OSHA 1002: gas chromatography (GC) / flame ionization detector (FID); 3M: passive monitor; Dräger: detector tube

Analytical Reference Method: NIOSH 1501 (IV); OSHA 1002; 3M; Dräger

SAMPLING INFORMATION

Full Shift Sampling:

Sampling Strategy: See Chapter 9

1. NIOSH 1501 (IV):

Collection Media: solid sorbent tube (100/50 mg coconut shell charcoal)

Sample Flow Rate: Minimum - Maximum (Lpm): 0.01-0.2; Must use a pump adaptor or arrange for low flow pumps.

Air Collection Volume: Minimum – Maximum (L): 2-23

2. OSHA 1002:

(A) **Collection Media:** Solid sorbent tube (100/50 mg coconut shell charcoal)
Sample Flow Rate (Lpm): 0.05; Must use a pump adaptor or arrange for low flow pumps.
Air Collection Volume (L): 12

(B) **Collection Media:** Passive monitor, SKC, 575-002 (500 mg of Anasorb 747)
Note: maximum 4-hour sample per badge

3. 3M:

Collection Media: Passive monitor, 3M, 3500 series

Note: maximum 8-hour sample per badge

Short Term Sampling:

Sampling Strategy: See Chapter 9

Sampling Duration: 5-15 min.

1. NIOSH 1501 (IV):

Collection Media: solid sorbent tube (100/50 mg coconut shell charcoal)

Sample Flow Rate: Minimum - Maximum (Lpm): 0.01-0.2; Must use a pump adaptor or arrange for low flow pumps.

Air Collection Volume: Minimum – Maximum (L): 2-23

2. OSHA 1002:

(A) **Collection Media:** solid sorbent tube (100/50 mg coconut shell charcoal)
Sample Flow Rate (Lpm): 0.05; Must use a pump adaptor or arrange for low flow pumps.
Air Collection Volume (L): ≥0.25

(B) **Collection Media:** Passive monitor, SKC, 575-002 (500 mg of Anasorb 747)
Note: minimum 5-minute sample per badge

Special Instructions:

1. NIOSH 1501 (IV): Sample stability not determined; a bulk sample (1 to 10 mL) is desirable, to be shipped in a separate container.

2. OSHA 1002:

(A) List any chemicals that could be considered potential interferences, especially solvents that are in use in the sampling area. Submit the samples to the MSHA laboratory for analysis as soon as possible. Store the samples in a refrigerator if delay is unavoidable. Ship any bulk samples separate from air samples.

(B) Record sampling site temperature and atmospheric pressure. List any chemicals that could be considered potential interferences, especially solvents that are in use in the sampling area. Submit the samples to the MSHA laboratory for analysis as soon as possible. Store the samples in a refrigerator if delay is unavoidable. Include the port plugs and PTFE tubes which will be used in the laboratory analysis. Ship any bulk samples separate from air samples.

3. 3M: N/A

Grab Sampling:

Sampling Strategy: See Chapter 11

Collection Media: Dräger detector tube, #6733161, range 10-1,000 ppm (EF = 1.30).

Zinc Oxide - ZnO
500 mg/m^3 IDLH (NIOSH, 1995)

Contaminant Codes:	1973 ACGIH TLV:	1968 PA Rules STEL/Ceiling (C):
745 (fume)	5.0 mg/m^3	10 mg/m^3 - 30 min.

CONTAMINANT INFORMATION

Synonyms:	Zinc peroxide; china white; zinc white; zincite
Sources:	*Oxide*: metallic zinc in galvanizing, electroplating, alloying: zinc oxide in pigments; smelting ores of zincite, smithsonite, willemite, hemimorphite, franlinite, lead, copper. *chloride*: soldering flux, iron/copper processing
Description:	White, odorless solid
Incompatibilities:	Chlorinated rubber (at 419°F); water; [note: slowly decomposed by water]
Exposure:	Inhalation
Health Effects:	Metal fume fever: chills, muscle ache, nausea, fever, dry throat, cough; weakness, lassitude (weakness, exhaustion); metallic taste; headache; blurred vision; low back pain; vomiting; fatigue; malaise (vague feeling of discomfort); tightness chest; dyspnea (breathing difficulty), rales, decreased pulmonary function
PPE: Respirator:	Recommendations - NIOSH/OSHA: Up to 50 mg/m^3: (APF = 10) any dust, mist, and fume respirator; (APF = 10) any supplied-air respirator; up to 125 mg/m^3: (APF = 25) any supplied-air respirator operated in a continuous-flow mode; (APF = 25) any powered, air-purifying respirator with a dust, mist, and fume filter; up to 250 mg/m^3: (APF = 50) any air-purifying, full-facepiece respirator with a high-efficiency particulate filter; (APF = 50) any supplied-air respirator that has a tight-fitting facepiece and is operated in a continuous-flow mode; (APF = 50) any powered, air-purifying respirator with a tight-fitting facepiece and a high-efficiency particulate filter; (APF = 50) any self-contained breathing apparatus with a full facepiece; (APF = 50) any supplied-air respirator with a full facepiece; up to 500 mg/m^3: (APF = 1000) any supplied-air respirator operated in a pressure-demand or other positive-pressure mode
Skin:	No recommendation is made specifying the need for personal protective equipment for the body
Eyes:	No recommendation is made specifying a need for eye protection
Special Precautions:	Noncombustible solid

LABORATORY INFORMATION

CAS Number: 1314-13-2
Analytical Technique: NIOSH 7502 (IV): x-ray powder diffraction; OSHA ID-143: x-ray diffraction
Analytical Reference Method: NIOSH 7502 (IV); OSHA ID-143

SAMPLING INFORMATION

Full Shift Sampling:
Sampling Strategy: See Chapter 7
1. NIOSH 7502 (IV):
Collection Media: 25-mm diameter, 0.8-µm pore size polyvinyl chloride (PVC) filter in open-face cassette (note: an extension cowl on the filter cassette is desirable to produce a more uniform deposit and to prevent contamination of the open-face filter during sampling)
Sample Flow Rate: Minimum - Maximum (Lpm): 1-3
Air Collection Volume: Minimum - Maximum (L): 10-400
2. OSHA ID-143:
Collection Media: 37-mm diameter, 5-µm pore size polyvinyl chloride (PVC) filter
Sample Flow Rate (Lpm): 2
Air Collection Volume (L): 960

Short Term Sampling:
Sampling Strategy: See Chapter 7
Sampling Duration: 30 min.
1. NIOSH 7502 (IV):
Collection Media: 25-mm diameter, 0.8-µm pore size polyvinyl chloride (PVC) filter in open-face cassette; (note: an extension cowl on the filter cassette is desirable to produce a more uniform deposit and to prevent contamination of the open-face filter during sampling)
Sample Flow Rate: Minimum - Maximum (Lpm): 1-3
Air Collection Volume: Minimum - Maximum (L): 10-400
2. OSHA ID-143:
Collection Media: 37-mm diameter, 5-µm pore size polyvinyl chloride (PVC) filter
Sample Flow Rate (Lpm): 2
Air Collection Volume (L): 30

Special Instructions:
1. NIOSH 7502 (IV): Take a required bulk, high-volume (4,000 L) air sample using a clean sampler and high-volume sampling pump in the same area as the personal sample(s) for qualitative identification.
2. OSHA ID-143: N/A

Zirconium Compounds (as Zr)

25 mg/m^3 (as Zr) IDLH (NIOSH, 1995)

Contaminant Codes:	1973 ACGIH TLV:	1973 ACGIH Excursion STEL/Ceiling (C):
643	5.0 mg/m^3	10 mg/m^3 - 15 min.

CONTAMINANT INFORMATION

Synonyms:	*Metal:* zirconium metal *compounds*: vary depending upon the specific compound
Sources:	Zircon ore, monazite, all crystalline rocks (especially granite, sanity, schist, and gneiss), reducing agent in metallurgy
Description:	*Metal:* soft, malleable, ductile, solid or gray to gold, amorphous powder *compounds*: varies; zircon ore is a sand, sometimes pink in color
Incompatibilities:	*Metal:* potassium nitrate, oxidizers; [note: fine powder may be stored completely immersed in water] *compounds*: vary
Exposure:	Inhalation, skin and/or eye contact
Health Effects:	Skin, lung granulomas
PPE: Respirator:	Recommendations - NIOSH/OSHA: Up to 25 mg/m^3: (APF = 5) any dust and mist respirator; up to 50 mg/m^3: (APF = 10) any dust and mist respirator except single-use and quarter-mask respirators; (APF = 25) any powered, air-purifying respirator with a dust and mist filter; (APF = 50) any air-purifying, full-facepiece respirator with a high-efficiency particulate filter; (APF = 10) any supplied-air respirator; (APF = 50) any self-contained breathing apparatus with a full facepiece
Skin:	Recommendations regarding personal protective clothing vary depending upon the specific compound; contact the manufacturer for recommendations for the specific compound
Eyes:	Recommendations regarding eye protection vary depending upon the specific compound
Special Precautions:	*Metal:* combustible, but solid form is difficult to ignite; however, powder form may ignite SPONTANEOUSLY and can continue burning under water

LABORATORY INFORMATION

CAS Number: 7440-67-7 (*metal*)

Analytical Technique: OSHA ID-121: atomic absorption spectroscopy (AAS) or atomic emission spectroscopy (AES); NIOSH 7300 (IV): inductively coupled argon plasma, atomic emission spectroscopy (ICAP-AES)

Analytical Reference Method: OSHA ID-121; NIOSH 7300 (IV)

SAMPLING INFORMATION

Full Shift Sampling:
Sampling Strategy: See Chapter 7
1. OSHA ID-121:
Collection Media: 37-mm (or 25-mm) diameter, 0.8-µm pore size mixed cellulose ester (MCE) filter
Sample Flow Rate (Lpm): 2
Air Collection Volume: Minimum - Maximum (L): 480-960
2. NIOSH 7300 (IV):
Collection Media: 37-mm diameter, 0.8-µm pore size mixed cellulose ester (MCE) filter
Sample Flow Rate (Lpm): 1.7
Air Collection Volume: Minimum - Maximum (L): 5-200

Short Term Sampling:
Sampling Strategy: See Chapter 7
Sampling Duration: 15 min.
1. OSHA ID-121:
Collection Media: 37-mm (or 25-mm) diameter, 0.8-µm pore size mixed cellulose ester (MCE) filter
Sample Flow Rate (Lpm): 2
Air Collection Volume (L): 30
2. NIOSH 7300 (IV):
Collection Media: 37-mm diameter, 0.8-µm pore size mixed cellulose ester (MCE) filter
Sample Flow Rate (Lpm): 1.7
Air Collection Volume: Minimum - Maximum (L): 5-200

Special Instructions: N/A

Wipe Sampling:
Sampling Strategy: See Chapter 14
Collection Media: Whatman Filter (No. 41 or 42), moistened with distilled water
Special Instructions: Seal wipe sample in plastic bag, vial, or jar.

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Chapter 3

APPENDIX A
Abbreviations

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Chapter 3
Appendix A
ABBREVIATIONS

ANSI	American National Standards Institute
C	Ceiling Limit
DRI	Direct Reading Instrument
EPA	Environmental Protection Agency
L	Liter
Lpm	Liter per minute
mL	milliLiters (or cubic centimeters)
N/A	Not Applicable
NIOSH	National Institute for Occupational Safety and Health
OSHA	Occupational Safety and Health Administration
PA Rule	Pennsylvania Rule STELs
STEL	Short-Term Exposure Limit
TLV	Threshold Limit Value

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Chapter 3

APPENDIX B
Synonyms

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Chapter 3
Appendix B
Synonyms

Chemical	**Cross Reference**
1,1,1-trichloroethane	methyl chloroform
1,2,5,6-dibenzonaphthalene	coal tar pitch volatiles
1,4-dimethyl benzene	xylene
1,2-dimethyl benzene	xylene
1,3-dimethyl benzene	xylene
1,1,3-trichloroethylene	trichloroethylene
1,1-dichloro-2-chloroethylene	trichloroethylene
1-butanol	n-butyl alcohol
1-chlor-2,2-dichloroethylene	trichloroethylene
1-hydroxybutane	n-butyl alcohol
1-hydroxy-2-methylbenzene	cresol
1-hydroxy-3-methylbenzene	cresol
1-hydroxy-4-methylbenzene	cresol
1-propanol	n-propyl alcohol
2-butanol	sec-butyl alcohol
2-butanone	methyl ethyl ketone
2-hydroxybutane	sec-butyl alcohol
2-methyl-2-propanol	tert-butyl alcohol
2-methyl-4-pentanone	hexone (methyl isobutyl ketone)
2-methyl-5-hexanone	methyl isoamyl ketone
2-oxobutane	methyl ethyl ketone
2-propanol	isopropyl alcohol
2-propanone	acetone
4-methyl-2-pentanol	methyl isobutyl carbinol
4-methyl-2-pentanone	hexone (methyl isobutyl ketone)
5-methyl-2-hexanone	methyl isoamyl ketone
A-Fil cream	titanium dioxide
aboline	oil mist (mineral oil)
absolute alcohol	ethyl alcohol
acetic acid (aqueous)	acetic acid
acetic ester	ethyl acetate
acetic ether	ethyl acetate
acetidin	ethyl acetate
acetoxuethane	ethyl acetate
acetylene trichloride	trichloroethylene
actinolite	asbestos
actinolite asbestos	asbestos
adepsine oil	oil mist (mineral oil)
aero liquid HCN	hydrogen cyanide

aerothene	methyl chloroform
agate	quartz, crystalline silica
alcohol	ethyl alcohol
algrain	ethyl alcohol
algylen	trichloroethylene
alumina	aluminum
aluminum trioxide	aluminum
alundum	aluminum
alundum	dust, total
amethyst	quartz, crystalline silica
ammonia gas	ammonia
amorphous carbon	graphite (natural)
amosite	asbestos
anhydrol	ethyl alcohol
anhydrous alcohol	ethyl alcohol
anhydrous ammonia	ammonia
anhydrous hydrochloric acid	hydrogen chloride
anhydrous hydrofluoric acid	hydrogen fluoride
ankilostin	perchloroethylene
anone	cyclohexanone
anthophyllite	asbestos
anthophyllite asbestos	asbestos
anthracin	coal tar pitch volatiles
antimonate	antimony
antimonic	antimony
antimonial	antimony
antimonious	antimony
antimony hydride	antimony (stibine)
antimony trihydride	antimony (stibine)
antimonyl	antimony
aqua ammonia	ammonia
aqua fortis	nitric acid
aqueous ammonia	ammonia
aqueous hydrogen chloride	hydrogen chloride
aqueous hydrogen fluoride	hydrogen fluoride
aqueous hydrogen peroxide	hydrogen peroxide
argentic fluoride	silver (soluble compounds)
argentium crede	silver
argentum	silver
arsenia	arsenic
arsenic acid	arsenic
arsenic chloride	arsenic
arsenic disulfide	arsenic
arsenic hydride	arsine
arsenic pentoxide	arsenic
arsenic salt	arsenic

arsenic sesquioxide	arsenic
arsenic trichloride	arsenic
arsenic (III) trichloride	arsenic
arsenic trihydride	arsine
arsenic trioxide	arsenic
arsenic trisulfide	arsenic
arsenic yellow	arsenic
arseniuretted hydrogen	arsine
arsenous acid	arsenic
arsenous acid anhydride	arsenic
arsenous chloride	arsenic
arsenous hydride	arsine
arsenous oxide	arsenic
austiox	titanium dioxide
azotic acid	nitric acid
B(a)P	coal tar pitch volatiles
barium carbonate	barium
barium chlorate	barium
barium chromate	barium
barium cyanide	barium
barium hydroxide	barium
barium nitrate	barium
barium oxide	barium
barium perchlorate	barium
barium permanganate	barium
barium peroxide	barium
barium sulfate	barium
barium sulfide	barium
barium sulfite	barium
battery acid	sulfuric acid
bayeritian	titanium dioxide
benz(a)phenanthrene	coal tar pitch volatiles
benz(a)pyrene	coal tar pitch volatiles
benzin	naphtha (coal tar)
benzine	naphtha (coal tar)
benzinoform	carbon tetrachloride
benzinol	trichloroethylene
benzo(a)phenanthrene	coal tar pitch volatiles
benzo(b)quinoline	coal tar pitch volatiles
benzo(d,e,f)chrysene	coal tar pitch volatiles
benzo(d,e,f)phenanthrene	coal tar pitch volatiles
benzol	benzene
benzole	benzene
benzoline	naphtha (coal tar)
benzophenanthrene	coal tar pitch volatiles
benzopyrene	coal tar pitch volatiles

benzypyrene	coal tar pitch volatiles
beryllium chloride	beryllium
beryllium fluoride	beryllium
beryllium nitrate	beryllium
beryllium oxide	beryllium
beryllium salts	beryllium
beryllium sulfide	beryllium
biotite	mica
bisulfite	sulfur dioxide
bituminous coal	coal dust
black lead	graphite (natural)
boracic acid anhydride	boron oxide
boric anhydride	boron oxide
boric oxide	boron oxide
boron sesquioxide	boron oxide
boron trioxide	boron oxide
BOV	sulfuric acid
brocide	1,2-dichloroethane
BTEX	benzene, toluene, ethylbenzene, xylene
burnt lime	calcium oxide
buttercup yellow	chromic acid
butanol	n-butyl alcohol
butyl acetate	n-butyl acetate
butyl alcohol	n-butyl alcohol
butyl ethanoate	n-butyl acetate
butyl hydroxide	n-butyl alcohol
butylene hydrate	sec-butyl alcohol
butyric alcohol	n-butyl alcohol
cable oil	oil mist (mineral oil)
cadmium acetate	cadmium
cadmium bromide	cadmium
cadmium chloride	cadmium
cadmium cyanide	cadmium
cadmium fluoroborate	cadmium
cadmium nitrate	cadmium
cadmium oxide	cadmium
cadmium sulfate	cadmium
calcichew	calcium oxide (calcium compounds)
calcidia	calcium oxide (calcium compounds)
calcined diatomite	cristobalite
calcined diatomite	tridymite
calcined silica	tridymite
calcit	calcium oxide (calcium compounds)
calcium carbonate	dust, total
calcium hydrate	calcium oxide

calcium hydroxide	calcium oxide
calcium salt	calcium oxide (calcium compounds)
calx	calcium oxide
canadol	naphtha (coal tar)
cannel coal	coal dust
carbinol	methyl alcohol
carbon bichloride	perchloroethylene
carbon bisulfide	carbon disulfide
carbon chloride	carbon tetrachloride
carbon dichloride	perchloroethylene
carbon disulphide	carbon disulfide
carbon nitride	cyanide
carbon oxide	carbon monoxide
carbon oxychloride	phosgene
carbon Tet	carbon tetrachloride
carbonic acid	calcium oxide (calcium compounds)
carbonic acid gas	carbon dioxide
carbonic anhydride	carbon dioxide
carbonic gas	carbon dioxide
carbonyl chloride	phosgene
carbonyl dichloride	phosgene
caustic	sodium hydroxide
caustic arsenic chloride	arsenic
caustic flake	sodium hydroxide
caustic soda	sodium hydroxide
cellulose (paper fiber)	dust, total
cement	dust, total
cement clinker	dust, total
cement kiln dust	calcium oxide
cement kiln feed	dust, total
cement raw meal	dust, total
chalcedony	quartz, crystalline silica
chalk	calcium oxide (calcium compounds)
China white	zinc oxide
chlorine oxide	chlorine dioxide
chlorine peroxide	chlorine dioxide
chloroetene	methyl chloroform
chloroethene	vinyl chloride
chloroethylene	vinyl chloride
chloroformyl chloride	phosgene
chlorothene	methyl chloroform
chlorten	methyl chloroform
chlorylene	trichloroethylene
chromic acetate hexahydrate	chromous salts
chromic acid salts	chromic acid
chromic anhydride	chromic acid

chromic anhydride	chromous salts
chromic nitrate	chromous salts
chromic oxide	chromous salts
chromic sulfate	chromous salts
chromium trioxide	chromic acid
chromium trioxide	chromous salts
chrysotile	asbestos
citrical	calcium oxide (calcium compounds)
clinker	dust, total
CKD	calcium oxide
coal oil	kerosene
coal tar creosote, vapors	coal tar pitch volatiles
cobalt metal dust	cobalt
cobalt metal fumes	cobalt
coking coal	coal dust
collargol	silver
colloidal manganese	manganese
colloidial silver	silver
cologne spirit	ethyl alcohol
colonial spirit	methyl alcohol
Columbian spirits	methyl alcohol
copperas	iron oxide (iron salts)
copper metal dust	copper
copper metal fumes	copper
copper oxide	copper
corundum	aluminum
corundum	dust, total
creosote volatiles	coal tar pitch volatiles
-cresol	cresol
cresyl alcohol	cresol
-cresylic acid	cresol
cresylol	cresol
crocidolite	asbestos
crude solvent	naphtha (coal tar)
crystalline carbon	graphite (natural)
crystalline silica	quartz
crystosol	oil mist (mineral oil)
cummingtonite	asbestos
cutting oil	oil mist (mineral oil)
cyclohexatriene	benzene
cyclohexyl ketone	cyclohexanone
dehydrated alcohol	ethyl alcohol
denatured alcohol	ethyl alcohol
deobase	kerosene
diatomaceous earth	amorphous silica
diatomaceous silica	amorphous silica

diatomite	amorphous silica
dibenzo(b,e)pyridine	coal tar pitch volatiles
dichloroethane	1,2-dichloroethane
dichromates	chromic acid
didakene	perchloroethylene
diiron trisulfate	iron oxide (iron salts)
dimethyl benzine	xylene
dimethylcarbinol	isopropyl alcohol
dimethyl ketone	acetone
dinitrogen tetroxide	nitrogen dioxide
dipping acid	sulfuric acid
dipropyl methane	n-heptane
distillates	naphtha (coal tar)
divanadium pentoxide	vanadium oxide
drakeol	oil mist (mineral oil)
dried ferrous sulfate	iron oxide (iron salts)
drierite	calcium oxide (calcium compounds)
dry ice	carbon dioxide
dry-cleaners’ naphtha	stoddard solvent
dusting powder	talc
Dutch liquid	1,2-dichloroethane
EB	ethylbenzene
EDC	1,2-dichloroethane
elemental mercury	mercury
elemental nickel metal	nickel
emery	dust, total
engravers’ acid	nitric acid
ethanoic acid	acetic acid
ethanol	ethyl alcohol
ethinyl	trichloroethylene
ethyl carbinol	n-propyl alcohol
ethyl ester of acetic acid	ethyl acetate
ethyl ethanoate	ethyl acetate
ethyl hydrate	ethyl alcohol
ethyl hydroxide	ethyl alcohol
ethyl methyl ketone	methyl ethyl ketone
ethylbenzol	ethylbenzene
ethylene chloride	1,2-dichloroethane
ethylene dichloride	1,2-dichloroethane
ethylene monochloride	vinyl chloride
ethylene tetrachloride	perchloroethylene
ethylene trichloride	trichloroethylene
ethylmethyl carbinol	sec-butyl alcohol
ETOH	ethyl alcohol
exhaust gas	carbon monoxide
expanded perlite	perlite

fat coal	coal dust
feosfor	iron oxide (iron salts)
feosol	iron oxide (iron salts)
feospan	iron oxide (iron salts)
fermenicide liquid	sulfur dioxide
fermenicide powder	sulfur dioxide
feromax	iron oxide (iron salts)
feroritard	iron oxide (iron salts)
ferric chloride	iron oxide (iron salts)
ferric nitrate	iron oxide (iron salts)
ferric oxide	iron oxide
ferric persulfate	iron oxide (iron salts)
ferric sesquioxide	iron oxide
ferric susquisulfate	iron oxide (iron salts)
ferric sulfate	iron oxide (iron salts)
ferric tersulfate	iron oxide (iron salts)
ferrous chloride	iron oxide (iron salts)
ferrous sulfate	iron oxide (iron salts)
fertilizer acid	sulfuric acid
fespan	iron oxide (iron salts)
fiber glass	dust, total
fibrous glass dust	dust, total
flamenco	titanium dioxide
flaming coal	coal dust
Fleet-X	trimethyl benzene
flint	quartz, crystalline silica
Flores Martis	iron oxide (iron salts)
florspar	fluorine
flowers of zinc	zinc oxide
flue gas	carbon monoxide
fluoride	fluorine
fluorine-19	fluorine
fluorite	fluorine
fluorohydric acid	hydrogen fluoride
fluorspar	fluorine
formalin	formaldehyde
formalith	formaldehyde
formic aldehyde	formaldehyde
formol	formaldehyde
formonitrile	hydrogen cyanide
French chalk	talc
Freon® 10	carbon tetrachloride
fuel oil No. 1	kerosene
fuming liquid arsenic	arsenic
fused boric acid	boron oxide
fused silica	amorphous silica

fused sodium potassium aluminum silicate	perlite
fyde	formaldehyde
gas coal	coal dust
gemalgene	trichloroethylene
glacial acetic acid	acetic acid
glass dust	dust, total
glass - fibrous	dust, total
glass wool	dust, total
glucinium	beryllium
glycerin mist	dust, total
glycol dichloride	1,2-dichloroethane
glynol	oil mist (mineral oil)
grain alcohol	ethyl alcohol
graphite (synthetic)	dust, total
gray arsenic	arsenic
green oil	coal tar pitch volatiles
green vitriol	iron oxide (iron salts)
grunerite	asbestos
gum turpentine	turpentine
gum spirits	turpentine
gypsum	calcium oxide (calcium compounds)
gypsum	dust, total
Halon® 104	carbon tetrachloride
heavy lubricating oil	oil mist (mineral oil)
hemimellitene	trimethyl benzene
hepatic gas	hydrogen sulfide
heptane	n-heptane
heptyl hydride	n-heptane
hexane	n-hexane
hexanon	cyclohexanone
hexyl hydride	n-hexane
hi-flash naphtha	naphtha (coal tar)
high solvent naphtha	naphtha (coal tar)
high-strength hydrogen peroxide	hydrogen peroxide
hombitan	titanium dioxide
hot liquor	sodium hydroxide
hyacinth	zirconium
hydrated calcium oxide	calcium oxide
hydrated mineral silicates	asbestos
hydrocyanic acid	hydrogen cyanide
hydrofluoric acid	hydrogen fluoride
hydrofluoric acid gas	hydrogen fluoride
hydrofluoride	hydrogen fluoride
hydrogen antimonide	antimony
hydrogen arsenide	arsine
hydrogen dioxide	hydrogen peroxide

hydrogen nitrate	nitric acid
hydrogen sulfate	sulfuric acid
hydroperoxide	hydrogen peroxide
hydrosulfuric acid	hydrogen sulfide
hydrotreated naphtha	naphtha (coal tar)
hydrous magnesium silicate	talc
-hydroxy toluene	cresol
hytrol-o	cyclohexanone
illuminating oil	kerosene
ilmenite	titanium dioxide
infusorial earth	amorphous silica
infusorial silica	amorphous silica
inhibisol	methyl chloroform
IPA	isopropyl alcohol
iron dihydrate	iron oxide (iron salts)
iron persulfate	iron oxide (iron salts)
iron sesquisulfate	iron oxide (iron salts)
iron tersulfate	iron oxide (iron salts)
iron tetrahydrate	iron oxide (iron salts)
iron trichloride	iron oxide (iron salts)
iron trinitrite	iron oxide (iron salts)
iron vitriol	iron oxide (iron salts)
ironate	iron oxide (iron salts)
isoamyl methyl ketone	methyl isoamyl ketone
isobutyl methyl carbinol	methyl isobutyl carbinol
isobutyl methyl ketone	hexone (methyl isobutyl ketone)
isopentyl methyl ketone	methyl isoamyl ketone
isopropanol	isopropyl alcohol
isopropyl acetone	hexone (methyl isobutyl ketone)
jet fuel (JT-1)	kerosene
jeweler’s rouge	iron oxide
kaolin	dust, total
kaydol	oil mist (mineral oil)
kerosine	kerosene
ketone propane	acetone
ketohexamethylene	cyclohexanone
kieselguhr	amorphous silica
King’s gold	arsenic
King’s yellow	arsenic
kremol	oil mist (mineral oil)
lead oxide	lead
lepidolite	mica
leucoxene	titanium dioxide
light naphtha	naphtha (coal tar)
ligroin	naphtha (coal tar)
lime	calcium oxide

limestone	dust, total
liquid ammonia	ammonia
liquid caustic	sodium hydroxide
liquid paraffin	oil mist (mineral oil)
liquid petrolatum	oil mist (mineral oil)
lunar caustic	silver (soluble compounds)
lutosol	isopropyl alcohol
lye	sodium hydroxide
m-xylene	xylene
m-xylol	xylene
magnesia fume	magnesium oxide fume
magnesite	dust, total
manganese oxide	manganese
marble	calcium oxide (calcium compounds)
marble	dust, total
margarite	mica
masonry cement	dust, total
massive talc	soapstone
MEK	methyl ethyl ketone
mercurious vitae	antimony
mercury acetate	mercury (alkyl compounds)
mercury liquid	mercury
mercury metal	mercury
mercury oleate	mercury (alkyl compounds)
mercury salts	mercury
mercury vapor	mercury
mesitylene	trimethyl benzene
meta-xylene	xylene
metallic arsenic	arsenic
metallic lead	lead
methacide	toluene
methanal	formaldehyde
methane carboxylic acid	acetic acid
methane tetrachloride	carbon tetrachloride
methane trichloride	chloroform
methanol	methyl alcohol
methenyl tribromide	bromoform
methyl aldehyde	formaldehyde
methylamyl alcohol	methyl isobutyl carbinol
methylbenzene	toluene
methylbenzol	toluene
methylethylcarbinol	sec-butyl alcohol
methyl hydroxide	methyl alcohol
methyl mercury	mercury (alkyl compounds)
methyl phenol	cresol
-methyl phenol	cresol

methyl toluene	xylene
methyl tribromide	bromoform
methyl trichloromethane	methyl chloroform
methylene oxide	formaldehyde
methylol	methyl alcohol
MIAK	methyl isoamyl ketone
MIBC	methyl isobutyl carbinol
MIBK	hexone (methyl isobutyl ketone)
MIK	hexone (methyl isobutyl ketone)
mineral carbon	graphite (natural)
mineral spirits	naphtha (coal tar)
mineral spirits	stoddard solvent
mineral oil mist	oil mist (mineral oil)
molecular chlorine	chlorine
molol	oil mist (mineral oil)
molybdenum metal	molybdenum
monochlorethene	vinyl chloride
monochlorethylene	vinyl chloride
monohydroxy methane	methyl alcohol
mononitrogen monoxide	nitric oxide
monoxide	carbon monoxide
morbicid	formaldehyde
motor fuel	gasoline
motor fuel	n-heptane
motor spirits	gasoline
motor spirits	n-heptane
muriatic acid	hydrogen chloride
muscovite	mica
n-butanol	n-butyl alcohol
n-butyl ester of acetic acid	n-butyl acetate
n-octane	octane
n-propanol	n-propyl alcohol
n-propylcarbinol	n-butyl alcohol
nadone	cyclohexanone
naphtha	naphtha (coal tar)
naphtha safety solvent	stoddard solvent
natural gasoline	Gasoline
NBA	n-butyl alcohol
necatorina	carbon tetrachloride
nema	perchloroethylene
nickel catalyst	nickel
nitric acid iron + 3 salt	iron oxide (iron salts)
nitrogen monoxide	nitric oxide
nitrogen peroxide	nitrogen dioxide
nitrogen tetroxide	nitrogen dioxide
normal-hexane	n-hexane

normal-octane	octane
nuisance dust	dust, total
o-xylene	xylene
o-xylol	xylene
oil of turpentine	turpentine
oil of vitriol	sulfuric acid
oil rectifier	turpentine
opaline silica	amorphous silica
optal 1-hydroxy propane	n-propyl alcohol
organic mercury	mercury (alkyl compounds)
orpiment	arsenic
orthoarsenic acid	arsenic
orthoboric acid anhydride	boron oxide
ortho-xylene	xylene
oxomethane	formaldehyde
oxymethylene	formaldehyde
p-xylene	xylene
p-xylol	xylene
painters’ naphtha	naphtha (coal tar)
pantaerythritol	dust, total
paraffin oil mist	oil mist (mineral oil)
para-xylene	xylene
Paris white	calcium oxide (calcium compounds)
parol	oil mist (mineral oil)
paroleine	oil mist (mineral oil)
parrot coal	coal dust
perchlor	perchloroethylene
perchloromethane	carbon tetrachloride
perclene	perchloroethylene
percosolve	perchloroethylene
perk	perchloroethylene
perklone	perchloroethylene
permachlor	trichloroethylene
peroxide	hydrogen peroxide
persec	perchloroethylene
petrohol	isopropyl alcohol
petrol	n-heptane
petrol	gasoline
petroleum	naphtha (coal tar)
petroleum benzin	naphtha (coal tar)
petroleum distillates	naphtha (coal tar)
petroleum ether	naphtha (coal tar)
petroleum naphtha	naphtha (coal tar)
petroleum solvent	stoddard solvent
petroleum spirits	naphtha (coal tar)
petroleum spirits	stoddard solvent

phenantrin	coal tar pitch volatiles
phenylethane	ethylbenzene
phenyl hydride	benzene
phenyl methane	toluene
phlogopite	mica
phosphorated hydrogen	phosphine
phosphorus hydride	phosphine
phosphorus trihydride	phosphine
pigment white	titanium dioxide
pimelic ketone	cyclohexanone
plaster of Paris	calcium oxide (calcium compounds)
plaster of Paris	dust, total
plumbago	graphite (natural)
plumbum	lead
plumbous salts	lead
polychromates	chromic acid
portland cement	dust, total
potassium cyanide	cyanide
powder of Algaroth	antimony
precipitated amorphous silica	amorphous silica
propan-2-ol	isopropyl alcohol
propyl alcohol	n-propyl alcohol
propylcarbinol	n-butyl alcohol
propyl methane	n-heptane
propylic alcohol	n-propyl alcohol
prussic acid	hydrogen cyanide
pseudocumene	trimethyl benzene
pseudocumol	trimethyl benzene
psi-cumene	trimethyl benzene
β-pyrine	coal tar pitch volatiles
pyroacetic ether	acetone
pyroligneous spirit	methyl alcohol
pyroxylic spirit	methyl alcohol
quick lime	calcium oxide
quicksilver	mercury
range oil	kerosene
rayox	titanium dioxide
realgar	arsenic
red arsenic glass	arsenic
red arsenic sulfide	arsenic
red fuming nitric acid	nitric acid
red orpiment	arsenic
refined solvent naphtha	naphtha (coal tar)
RFNA	nitric acid
riebeckite	asbestos
roscoelite	mica

rouge	dust, total
rubbing alcohol	isopropyl alcohol
rubigine	hydrogen fluoride
ruby arsenic	arsenic
rutile	titanium dioxide
Safety-Kleen	stoddard solvent
salt of Saturn	lead
sand	quartz, crystalline silica
sassolite	boron oxide
sec-propyl alcohol	isopropyl alcohol
selenide	selenium
selenious	selenium
selenyl	selenium
selsun	selenium
sewer gas	hydrogen sulfide
sextone	cyclohexanone
silica	tridymite
silica	cristobalite
silica	quartz, crystalline silica
silica gel	amorphous silica
silicic anhydride	quartz, crystalline silica
silicon carbide	dust, total
silicon dioxide	quartz, crystalline silica
silicon dioxide (amorphous)	amorphous silica
silver (II) fluoride	silver (soluble compounds)
silver graphite	graphite (natural)
Skelly Solve - B	n-hexane
Skelly Solve - C	n-heptane
soapstone silicate	soapstone
soda lye	sodium hydroxide
sodium cyanide	cyanide
sodium hydrate	sodium hydroxide
soft coal	coal dust
solvent naphtha	naphtha (coal tar)
spectrar	isopropyl alcohol
spirits of turpentine	turpentine
spotting naphtha	stoddard solvent
spotting naphtha	stoddard solvent
starch	dust, total
steam distilled turpentine	turpentine
steatite	soapstone
steatite talc	talc
stibic	antimony
stibo-	antimony
stove black	graphite (natural)
strobane	methyl chloroform

sucrose	dust, total
sulfate wood turpentine	turpentine
sulferrous	iron oxide (iron salts)
sulfur oxide	sulfur dioxide
sulfuretted hydrogen	hydrogen sulfide
sulfuric acid (aqueous)	sulfuric acid
sulfurous acid anhydride	sulfur dioxide
sulfurous anhydride	sulfur dioxide
sulfurous oxide	sulfur dioxide
sulphuric acid	sulfuric acid
t-butinol	tert-butyl alcohol
talcum	talc
TBA	tert-butyl alcohol
TCE	trichloroethylene
terebenthine	turpentine
tetlen	perchloroethylene
tetracap	perchloroethylene
tetrachloroethene	perchloroethylene
tetrachloroethylene	perchloroethylene
tetrachloromethane	carbon tetrachloride
tetraleno	perchloroethylene
tetralex	perchloroethylene
tetrapil	perchloroethylene
tetravec	perchloroethylene
tetucur	iron oxide (iron salts)
tin oxide	dust, total
tiofine	titanium dioxide
tioxide	titanium dioxide
titanium dioxide	dust, total
TM8	trimethyl benzene
toluol	toluene
tremolite	asbestos
tremolite asbestos	asbestos
trethylene	trichloroethylene
triclene	trichloroethylene
tri-ethane	methyl chloroform
triatomic oxygen	ozone
tribromomethane	bromoform
trichloran	trichloroethylene
trichloren	trichloroethylene
trichloride	trichloroethylene
trichloroethene	trichloroethylene
trichloromethane	chloroform
tridimite	tridymite
trilene	trichloroethylene
trimar	trichloroethylene

trimethyl benzene	trimethyl benzene
trimethyl benzole	trimethyl benzene
trimethylcarbinol	tert-butyl alcohol
trioxide	titanium dioxide
tripolite	amorphous silica
tronox	titanium dioxide
tungsten carbide	tungsten
tungsten trioxide	tungsten
tungstate	tungsten
tungstic	tungsten
tungstic (VI) acid	tungsten
turpentine substitutes	stoddard solvent
turps	turpentine
unitane	titanium dioxide
vanadic anhydride	vanadium oxide
vanadium pentoxide	vanadium oxide
varnish makers’ and painters’ naphtha	naphtha (coal tar)
varnoline	stoddard solvent
VC	vinyl chloride
vegetable oil mists (except castor, cashew nut, or similar irritant oils)	dust, total
veracur	formaldehyde
vinegar	acetic acid
vinegar naphtha	ethyl acetate
vinyl chloride monomer	vinyl chloride
vitriol broom oil	sulfuric acid
VM&P Naptha	naphtha (coal tar)
volcanic sand	cristobalite
volcanic sand	tridymite
westrosol	trichloroethylene
WFNA	nitric acid
white arsenic	arsenic
white caustic	sodium hydroxide
white fuming nitric acid	nitric acid
white mineral oil mist	oil mist (mineral oil)
white spirits	naphtha (coal tar)
white spirits	stoddard solvent
wolfram	tungsten
wolframite	tungsten
wood alcohol	methyl alcohol
wood naphtha	methyl alcohol
wood spirit	methyl alcohol
wood turpentine	turpentine
xylol	xylene
yellow arsenic sulfide	arsenic
yellow ultramarine	chromic acid

zimmwaldite	mica
zinc butter	zinc oxide
zinc muriate	zinc oxide
zinc peroxide	zinc oxide
zinc white	zinc oxide
zinc yellow	chromic acid
zincite	zinc oxide
zircat	zirconium
zircon	zirconium
zirconic	zirconium
zirconocene	zirconium
zirconyl	zirconium
zirconium silicate	zirconium
zopaque baytitan	titanium dioxide

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SAMPLING PUMPS

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Appendix A Personal Sampling Pumps 4A-1

Table 4-1 Specifications and Operating Parameters of the Personal Sampling Pumps Used by Metal and Nonmetal 4A-1

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Chapter 4
SAMPLING PUMPS

I. Introduction

Metal and Nonmetal uses constant-flow personal sampling pumps to collect several different types of exposure samples in conjunction with filter cassettes, sorbent tubes (coconut shell charcoal and high purity washed silica gel), or midget impingers. These collection media are used when sampling for respirable and total dust, mineral dusts from silicates, welding fumes and elemental metal dust, asbestos fibers, organic vapors, and ionizing radiation. To preserve the integrity of each sample, the sampling pump must be operating properly. That is, the sampling pump must be sufficiently charged, properly maintained, and calibrated with appropriate instrumentation.

II. Definitions

Bubble Generator: a tube assembly that is an integral part of an air sampling pump calibration instrument. When a sampling pump is connected to the bubble generator, the vacuum created draws a soap bubble through the device. The device automatically computes the air flow rate of the sampling pump by calculating the speed of the bubble as it travels through the known volume of the calibration tube.

Burette: a cylindrical glass or plastic tube, usually 1.0 liter in volume, that can be used to calibrate air sampling pumps. With a sampling pump connected to the upper end of the burette, the vacuum created draws a soap bubble through the burette. A stopwatch is used to time the period for the soap bubble to travel a specific distance through the known volume of the burette. The air flow rate of the sampling pump can be calculated from the data collected during the timing of several bubbles. It is considered a primary calibration method.

Calibration: direct measurement of an instrument output using a calibration standard. The levels of calibration standards should bracket the levels for which actual measurements are to be made.

Calibration Standard: a reference used to quantify the relationship between the output of an instrument and the property to be measured. Calibration standards should be traceable to a primary standard.

Dry Calibrator: a calibration instrument which uses a dry piston to measure the output of a sampling pump. The device automatically computes the air flow rate of the sampling pump by calculating the change in volume and movement of the piston over a given time period.

Flow meter: an indicator on an air sampling pump that is used to monitor air flow rate through the pump.

Primary Standard: a measurement device that is directly traceable to the National Institute of Standards and Technology (NIST) or another recognized organization. Examples of a primary standard for volume are soap bubble flow meters and dry-piston type flow meters.

Rotameter: a flow meter device consisting of a transparent tube with a small float inside. The air flowing through the device causes the float to rise inside the tube to indicate the approximate air flow rate. The sampling pumps currently used by Metal and Nonmetal are provided with rotameter-type flow meters.

Sampling Pump: a mechanical, battery-operated device that is used to draw air through specific collection media (filter or sorbent tube) in order to collect a representative sample of airborne contaminant(s) in the mine environment.

III. General Characteristics

Metal and Nonmetal primarily uses two different personal sampling pumps. They are the SKC Model 224-44XR (see Figure 4-1) and the Gilian Model HFS 513A-U

Figure 4-1. SKC Model 224-44XR Sampling Pump

(see Figure 4-2). As shown in Appendix A to this Chapter, the specifications and operating parameters are very similar. The internal components of each sampling pump work on the same basic principles. Sections A. and B. below outline these components and their respective functions.

Note: Use MSHA permissible sampling pumps in gassy mines where required.

Figure 4-2. Gilian Model HFS 513A-U Sampling Pump

A. **Pneumatic System** - consists of five basic assemblies: pump/valve; pulsation dampener; pressure regulator; flow meter; and inlet filter.

1. **Pump/Valve Assembly** - the pump consists of dual silicone diaphragm pistons driven by a high-efficiency DC motor. The diaphragm pump is combined with low pressure, positive acting valves to direct air flow. The unit is sealed in a housing to prevent dirt from entering. The DC motor operates from a rechargeable nickel-cadmium (NiCad) battery pack.

2. **Pulsation Dampener or Damper Assembly** - consists of silicone diaphragms within a housing which stack directly above the pump motor to provide pulsation-free flow. During the intake stroke, the diaphragms are stretched inward by vacuum. During the exhaust stroke, the

diaphragm elasticity forces the diaphragms apart, maintaining a continuous vacuum on the intake to the pump.

3. **Pressure Regulator Assembly** - used for low flow sampling from 1 to 750 milliliters per minute (mL/min). The purpose of the regulator is to maintain suction or discharge at a nominal pressure drop (20.0 to 25.0 inches of water) across the control restrictor. The regulator is <u>not</u> used at flows above 750 mL/min. A manual valve is provided on the sampling pump to connect the regulator in and out of the system for low and high flow applications, respectively.

4. **Flow Meter or Flow Indicator** - a rotameter style flow meter is mounted vertically inside the case and is visible from outside the case through a clear viewing window. It is used to monitor sampling pump flow rates over the operating range of 0.5 to 5.0 liters per minute (Lpm). The rotameters are <u>not</u> precision flow meters (± 20 %) and should be backed up and set by using a more accurate calibration instrument. However, they are repeatable; and once the correct volumes have been established, they are very useful in setting an approximate pump flow on a routine basis.

5. **Inlet Filter Assembly** - consists of a transparent plastic housing and filter membrane held in place with an O-ring. All air drawn into the sampling pump passes through the pump inlet filter. As dust collects on the sampling pump inlet filter over time, the transparent housing permits the operator to view the filter to determine when changing is necessary.

B. **Electrical or Control System** - consists of battery pack; control panel; and motor control circuitry.

1. **Battery Pack** - five rechargeable NiCad cells arranged in series within a plastic housing or “pack” to provide 6.0 volts at 1.8 to 2.0 Ah (ampere-hours) to the sampler. The battery pack is rechargeable without removal from the sampling pump via the exterior plug-in port.

2. **Control Panel** - consists of an on/off switch and recessed flow adjustment control. The flow adjustment control is used to adjust flow rates from 0.75 Lpm to 5.0 Lpm (750 mL/min. to 5000 mL/min). Adjustments turned clockwise increase the flow rate, and counterclockwise turns decrease the flow rate. When sampling a security cover protects the control panel from inadvertent adjustments.

3. **Motor Control Circuitry** - comprises the Constant Flow System which provides for constant air flow even though the back pressure of the collecting device may have increased. For example, pressure increase caused by dust accumulation on a filter. As the back pressure increases, the motor voltage is automatically corrected to maintain constant flow over the operating range.

IV. Care and Maintenance

Replacement parts are available from the sampling pump manufacturer. Notify your field office supervisors of the items needed. To maintain the personal sampling pumps in peak operating condition, adhere to the following procedures:

A. Battery Maintenance

"Memory Effect" is a characteristic of all NiCad cells and prevents the batteries from fully recharging even though a full charge is indicated. This can prevent the sampling pump from running a full-shift sampling period in some instances. By using cycling chargers (as furnished by SKC) or battery maintenance stations (as furnished by Gilian), the sampling pump can be discharged and re-charged without turning the pump on or off. This has the same effect as running the sampling pump down and recharging. If cycling chargers or battery maintenance stations are not available, the rechargeable NiCad battery pack should be completely discharged from time to time to minimize the potential for "memory effect". If discharging is necessary, perform the following steps approximately every 10 recharges:

1. Attach a filter cassette to the intake port to prevent the inlet filter from becoming clogged.

2. Turn the sampling pump on using the on/off switch.

3. Set flow rate to 3.0 Lpm.

4. Allow sampling pump to run until the battery discharges completely and the pump stops.

5. Turn the sampling pump off and charge the battery for a full 14 to 16 hours.

Note: Do <u>not</u> check the battery with a volt-ohm-meter to determine voltage since this can result in damage to the battery's resistor.

B. Changing Battery

1. Removal - Remove the two screws which secure the battery to the front case cover and loosen the four case screws above and below the belt clip. Carefully slide the battery pack out to the right from under the belt clip, being careful not to cock it at an angle. Edge rails should guide the pack out.

2. Replacement - Stand the sampling pump up vertically on a flat surface. Slip the front edge of the new battery pack under the belt clip and rotate the battery pack so that the rails engage the slots in the case front. Push the battery to the left until it is properly located, reinstall the battery screws and tighten the case screws.

C. Storage

1. If the sampling pump is stored for long periods, occasionally run the pump down with a filter in line or discharge the battery using a cycling charger/ battery maintenance station (as described in A. above).

2. Recharge battery and return sampling pump to storage.

D. Sampling Pump Inlet Filter

The sampling pump inlet filter, located inside the clear plastic intake port housing, prevents particulates and liquids from being drawn into the pump mechanism. As the filter becomes dirty or clogged, it can create an excessive load on the sampling pump, decreasing pump performance. Occasionally replace the inlet sampling pump filter and O-ring as follows:

1. Wipe or blow all dust and debris from around the filter housing.

2. Remove the four screws and the front filter housing.

3. Remove and discard the filter membrane and O-ring.

4. Clean the removed filter housing.

5. Insert a new filter membrane and O-ring.

6. Reattach the front filter housing and tighten the four screws.

E. Other

1. Carry sampling pumps in a closed, padded case to avoid damage from impact or dropping.

2. When sampling, position the sampling pump in the safest location available on the person being sampled. Instruct the person not to adjust, turn off, bump, drop, or otherwise abuse the sampling pump.

3. Clean the sampling pump after each use and visually inspect it for defects and damage.

4. If the sampling pump fails to function properly during a survey, discontinue the survey and void the sample. Report the incident without delay to your supervisor. Do not use the sampling pump again until it is repaired.

V. Calibration Procedures

A. General Instructions

Calibration procedures, equipment, and location should be in accordance with the following procedures:

1. **Equipment** - Metal and Nonmetal uses two types of sampling pump calibrators: manual, using a glass burette, and electronic, using various instruments.

2. **Set-up - The calibration instrument used must be assembled with representative media and sampling train in line**. This procedure is necessary to simulate the resistance of the media and sampling train to be used during sampling. Do not use the calibration media for sampling purposes. To include the cyclone (for respirable dust) in-line, it is necessary to enclose the media in an air-tight container (e.g., a Mason jar or flask) as shown in Figures 4-3, 4-4, 4-5, and 4-6.

3. **Location** - Calibrate the sampling pump as near to the sampling site elevation as practical.

4. **Frequency** - Calibrate a fully charged sampling pump before each full-shift usage. Pre-calibration should be conducted within one day of the sampling survey. It is permissible to use a post-calibration check from a

previous sampling survey that has been performed no more than one week prior to the current sampling shift.

5. **Post-Sampling Calibration Acceptability** - Post-sampling calibration checks are acceptable when they agree within ± 5 % of the pre-sampling target flow rate. If the post-sampling check does not agree, the sample is invalid. Post-sampling should be conducted as soon as possible after the sampling shift, preferably <u>within</u> <u>one</u> <u>day</u> of the sampling survey. Do not charge the pump before post-sampling calibration.

6. **Record of Calibration** - A written record of sampling pump calibrations and post-sampling calibration checks must be kept with, or made part of, the inspection Health Field Notes.

B. Manual Calibration Using 1.0 Liter Burette and Stopwatch

This method involves the simplest and least expensive equipment. It has the advantage of requiring no calibration, but the equipment is cumbersome to transport in the field and the glass burette is fragile.

1. Pre-inspection Calibration

   a. Assemble using the diagram in Figure 4-3:

      - Assemble the tripod stand by screwing the legs into the sockets in the tripod base. Attach the support rod and clamp to the base. Place the tripod/support rod assembly upright on a level surface.

      - Wet the entire inside surface of a 1.0 liter glass burette by pouring water through it or holding under a faucet. Insert the burette into the tripod base right side up, until it is several inches above the level surface.

   b. Connect the apparatus to the sampling pump with an assembled sampling train in line.

   c. Check the seals on all hose connections. The entire system must be leak-free.

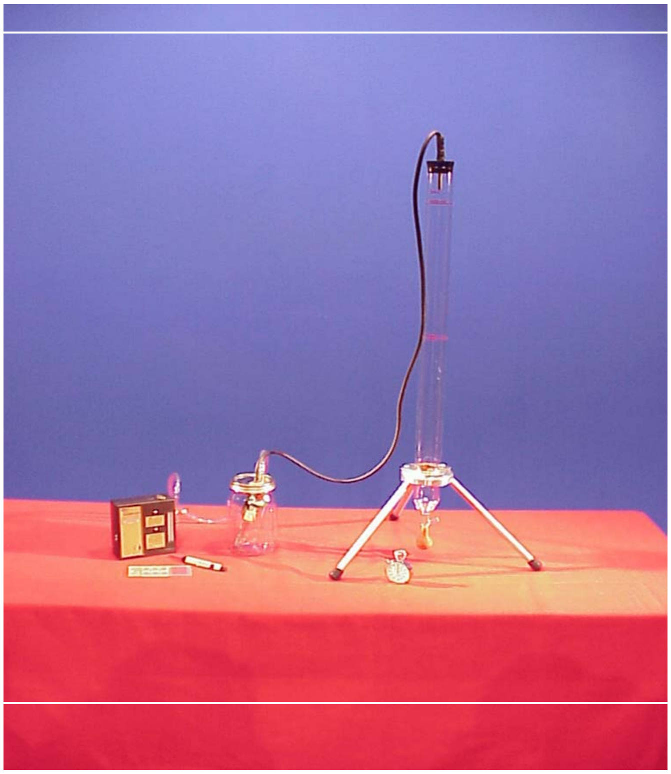

Figure 4-3. Standard 1.0 Liter Burette Set-up for Calibration

d. Turn the sampling pump on; let it run for 5 minutes to dissipate any surface charge and stabilize voltage.

e. Raise the beaker containing the soap solution and momentarily submerge the opening of the burette.

- Raise the beaker to form <u>one</u> bubble at a time after the burette is thoroughly prepared
- Repeat several times until a bubble travels the entire distance up the burette without breaking

f. Using a stopwatch, time the travel of the bubble from the 'zero' line (0.0 liter) to the 1.0 liter mark.

- Travel times for common flow rates are:

Flow Rate	Time
1.4 Lpm	42.8 sec.
1.7 Lpm	35.3 sec.
2.0 Lpm	30.0 sec.

- For other flow rates, use the formula below to calculate the time required for the bubble to travel the length of the burette:

$$\frac{\text{1.0 liter}}{\text{Desired flow rate (Lpm)}} = \text{time (min.)}$$

[time in min. X 60 sec./min. = time in sec.]

g. For calculating low-flow rates using a 100 mL burette:

$$\frac{\text{100 mL}}{\text{Desired flow rate (mL/min.)}} = \text{time (min.)}$$

[time in min. X 60 sec./min. = time in sec.]

h. The sampling pump must be within 5 % of the target flow rate. For example, the acceptable range of 1.7 liters per minute (± 5 %) is 1.615 to 1.785 Lpm. This is the same as the bubble passing the 1.0 liter length of the burette between 33.7 and 37.0 seconds. Adjust the sampling pump flow rate as described in the operating instructions for the individual pump by turning the flow adjustment set screw with a screwdriver. When the measured flow rate is within the acceptable ± 5 % range, take two more readings for each sampling pump and average the three.

i. Record the following in the Health Field Notes:
  - Sampling pump ID number;
  - Calibrated flow rate (average of three readings);
  - Date and location of calibration; and
  - Name of person performing calibration.

2. Post-inspection Calibration

- Repeat steps 1.a. through 1.i. above.

- If more than a few days will elapse before doing further calibrations, remove the burette from the tripod stand and rinse the inner surface of the burette thoroughly with tap water to avoid buildup of soap residue.

C. Gilian Gilibrator (Electronic Bubble Generator)

Like the burette, this method generates a series of soap bubbles through a tube connected to the air sampling pump. However, the time for the bubble to rise the length of the tube is measured automatically and the flow rate is subsequently calculated by a computer chip in the calibrator base. While the equipment is more expensive than that used in the previous method, it is more portable than the burette and less time consuming in setup. Each field Gilian Gilibrator requires an annual check against a factory-calibrated instrument. Each field office must submit at least one instrument to the factory on an annual basis to be used as the calibration standard for checking the other office Gilibrator functions against it. The annual check of each field office Gilibrator must fall within a 1% tolerance of the volume measured with the calibration standard.

1. Pre-Inspection Calibration. Refer to Figure 4-4 and follow these steps:

Figure 4-4. Gilian Gilibrator Set-Up for Calibration (Respirable Dust Cassette and Cyclone In-line)

a. It takes 14 hours to fully charge a calibrator; the device can be used while charging.

b. Attach the bubble generator (the plastic cylinder) to the base by placing it upright in the socket on top of the base and turning the bubble generator until it "clicks" into place, with the electrical socket on the side facing toward the rear of the base.

c. Insert the control unit's cable assembly into the sensor block connecting jack located on the back of the sensor block.

d. Add the soap bubble solution through the lower filler boss (or nipple) of the bubble generator to a depth of about 1/8 inch or until the bubble generating ring is immersed in soap solution. Do <u>not</u> overfill!

Figure 4-4a. Total Dust Cassette in-line

Figure 4-4b. MCE Cassette in-line

Figure 4-4c. Asbestos Cassette in-line

Figure 4-4d. Sorbent tube in-line

e. Connect the sampling pump (with the sampling train in line) to the upper outlet boss.

f. Turn on the sampling pump; let it run 5 min. to dissipate any surface charge and stabilize voltage.

g. Prime (wet) the inner walls of the flow tube by depressing the bubble initiator button several times.

h. Turn on the calibrator power switch and wait approximately 10 seconds while the system runs through its check sequence. The calibrator is not ready until the Run LED signal and a series of five (5) dashes displayed on the LCD go off. ‘Ready’ operation is indicated by a series of <u>four</u> dashes (- - - -).

i. Generate a bubble, and read the flow rate that appears on the LCD display. Actual flow for each bubble will be displayed. The flows will accumulate and be averaged with each successive timing.

Note: Each time the button is pushed, the display will show the flow rate in milliliters per minute (mL/min.). Convert these values to liters per minute (Lpm) by dividing the number by 1000 (or moving the decimal point <u>three</u> places to the left).

<u>Averaging readings</u>

- Depress and hold the AVG button to display average and number of samples.
- Release the button to display the last flow reading.
- Repress the button to display the number of samples accumulated for that averaging sequence and release again to display the last flow reading.
- Additional pressing and holding will repeat this sequence.

Note: If a bubble breaks before the time sequence is completed, timing will continue until another bubble is generated. The subsequent bubble will cause an erroneous reading. To subtract the erroneous reading from the average, push the DEL (delete) button.

Deleting readings

- To delete obvious false readings, push the DEL button. This will automatically delete the false information from the average and reset the average and sample number back to the previous reading.

Reset

- To reinitiate the sequence for additional sampling pump calibrations, push the RESET button. This zeroes out all samples and average registers within the unit and starts a new sequence.

- The RESET button is also used if a malformed bubble is generated and has not been subtracted from the average by use of the DEL button.

j. The sampling pump must be within 5 % of the target flow rate. For example, the acceptable range of 1.7 liters per minute (± 5 %) is 1.615 to 1.785 Lpm. Adjust the sampling pump flow rate by turning the flow adjustment set screw with a screwdriver. When the measured flow rate is within the acceptable ± 5 % range, press and hold the reset button on the base until all readings are "0." Then take 3 more readings.

k. Record the following in the Health Field Notes:

- Sampling pump ID number;
- Calibrated flow rate (average of three readings);
- Date and location of calibration; and
- Name of person performing calibration.

2. Post-Inspection Calibration

- Repeat steps 1.a. through 1.k. above.

- Sampling is valid when the post- and pre-sampling flow rates agree within ± 5 % of the target flow rate for two (2) consecutive timings. Otherwise, the sample is invalid.

- This post-sampling calibration check may be used as the pre-sampling calibration flow-rate for the next full-shift sample if the sampling pump is used within a week.

3. Care and Maintenance

a. Cleaning

- If the calibrator is not to be used for a period of time, reinstall the rubber storage tubing between the inlet and outlet bosses. This will prevent evaporation which may alter the soap solution's concentration.

- If more than a few days will elapse before doing further calibrations, remove the bubble generator from the base. Rinse the inside of the bubble generator thoroughly with tap water to avoid buildup of soap residue. The easiest way to rinse the bubble generator is to fasten a short piece of rubber hose to the bottom nipple of the bubble generator, place the open end of the hose under the tap, and let the tap water run freely through the hose, into the generator, and out the top nipple. Remove excess water by turning the bubble generator alternately upside down and right side up and gently shaking it. Allow the cylinder to dry thoroughly before using or placing it in the storage case. **Do <u>not</u> disassemble and clean the inside of the bubble generator.**

b. Charging Battery

- "Low Battery" will appear on the display if the battery voltage is too low to operate the unit properly on battery power alone.

- The battery charges automatically when the charger unit is plugged into an electrical outlet and the charger unit cord is plugged into the Gilibrator base. The charger also serves as an AC adapter. An indicator light glows red when charging is taking place.

c. Transporting

Do not transport the unit with soap solution or storage tubing in place. When transporting or shipping the electronic calibrator, especially by air freight, it is important to remove one side of the seal tube that connects the inlet and outlet bosses. This allows for equalizing internal pressure within the generator.

Caution: Do not pressurize the flow cell! Excessive pressure may cause the cell to rupture, possibly resulting in personal injury.

d. Other Maintenance

There is no other maintenance required by the user. If the unit requires repair (including replacement of the rechargeable NiCad battery), coordinate repairs through the district health specialist or industrial hygienist.

D. Mini-Buck Wet Bubble Calibrator

Like the Gilibrator, this device generates a series of soap bubbles through a tube connected to the air sampling pump. The bubble rise rate is measured automatically and the flow rate is automatically calculated by a computer chip in the calibrator. Each field Mini-Buck Wet Bubble Calibrator requires an annual check against a factory-calibrated instrument in the field office. This requires each field office to submit one instrument to the manufacturer on an annual basis to be used as the calibration standard. The annual check of the Mini-Buck Calibrator against the factory calibrated instrument must fall within a 1% tolerance of the volume measured.

1. Pre-inspection Calibration Procedure. Refer to Figure 4-5.

   a. Using the squeeze bottle included, pour enough soap solution through the bottom nipple (at the rear of the transparent tube assembly) to cover the bottom of the flow cell (bubble generator). The level of the solution should not be higher than the etched line.

   b. Fasten a piece of rubber or Tygon hose (several inches in length) to the upper (not the filler) nipple. Fasten a filter cassette (of the same type to be used in sampling) onto the loose end of the rubber or Tygon hose. The inlet side should face toward the nipple.

   c. Fasten a second piece of hose between the air sampling pump and the filter. Do not connect the filter to the Mini-Buck's filler nipple.

   d. Turn on the air sampling pump and run it for approximately 5 minutes to ensure the voltage (and flow rate) has stabilized. Wet the inside of the flow cell by rapidly pressing and releasing the spring-loaded button (front of the transparent tube assembly) until complete bubbles rise all the way to the top of the tube. At the same time, push the Mini-Buck "on" switch. The calibrator will display "0000." If the calibrator does not turn on, it may be operated on AC current by plugging it into its charger unit and plugging the charger unit into an electrical outlet.

   e. Firmly press and release the button on the base of the transparent flow cell. A number will flash in the Mini-Buck display.

Figure 4-5. Mini-Buck Wet Bubble Calibrator Set-up for Calibration

Wait until the number stops flashing, then repeat twice until one or more bubbles rise all the way to the top of the bubble generator and the reading is stable. Each time the button is pushed, the display will show the flow rate in **milliliters per minute** (mL/min.). Convert these values to **liters per minute** (Lpm) by dividing the number by 1000 (or moving the decimal point <u>three</u> places to the left).

f. The sampling pump must be within 5 % of the target flow rate. For example, the acceptable range of 1.7 Lpm (± 5 %) is 1.615 to 1.785 Lpm. Adjust the sampling pump flow rate as described in the operating instructions for the individual pump by turning a set screw with a screwdriver. When the measured flow rate is within the acceptable ± 5% range, press and hold the “on” button of the Mini-Buck until “0000" is displayed; then take <u>three</u> more readings for that sampling pump (waiting for the flashing to stop between each press of the button).

g. Record the following in the Health Field Notes:

- Sampling pump ID number;
- Calibrated flow rate (average of three readings);
- Date and location of calibration; and
- Name of person performing calibration.

2. Post-Inspection Calibration

a. Repeat steps 1.a. through 1.g. above.

b. Sampling is valid when the post- and pre-sampling flow rates agree within ± 5 % of the target flow rate for two (2) consecutive timings. Otherwise, the sample is invalid.

c. This post-sampling calibration check may be used as the pre-sampling calibration flow-rate for the next full-shift sample if the sampling pump is used within a week.

d. After calibrating all sampling pumps, press the “off” button, disconnect the rubber hoses and plug both nipples (usually with a short piece of rubber tubing that connects the two nipples) to keep the flow cell from drying out. If more than a few days will elapse before doing further calibrations, remove the flow cell from the base by unscrewing the three screws on the underside of the base. Rinse the inside of the flow cell thoroughly with tap water to avoid buildup of soap residue. Fasten a short piece of rubber hose to the bottom nipple, place the open end of the hose under the tap, and let the tap water run gently but freely through the hose, into the flow cell, and out the top nipple. Remove excess water by turning the flow cell alternately upside down and right side up and gently shaking it. Dry the outside of the flow cell with a soft paper or cloth towel and reinstall in the Mini-Buck base by replacing the three screws. Allow the inside to air dry; do not attempt to disassemble and clean the inside of the flow cell.

Note: The Mini-Buck automatically shuts-off after seven minutes of non-use.

3. Battery Charging and Replacement

   a. The battery charges automatically when the charger unit is plugged into an electrical outlet and the charger unit cord is plugged into the Mini-Buck base. The charger also serves as an AC adapter. Do <u>not</u> leave the AC adapter plugged in when not in use, as this could damage the battery supply.

   b. The fully charged battery will operate the unit for up to 8 hours. Low Battery light will appear on the faceplate of the Mini-Buck if the battery voltage is too low to operate the unit properly. The Mini-Buck requires 16 hours to charge the battery fully.

4. Maintenance

There is no maintenance required by the user. If the unit requires repair (including replacement of the rechargeable NiCad battery), coordinate repairs through the District health specialist or industrial hygienist. Always leave the filler nipples <u>open</u> and <u>disconnected</u> from any tubing when instrument is being mailed or shipped.

CHAPTER 4
APPENDIX
Personal Sampling Pumps

Chapter 4
Appendix A
Personal Sampling Pumps

Table 4-1. Specifications and Operating Parameters of the Personal Sampling Pumps Used by Metal and Nonmetal

Specification	Sampling Pumps	
	SKC Model 224-44XR	Gilian Model HFS 513A-U
Operating Range	0.005 - 5.0 Lpm (5 - 5000 mL/min.)	0.001 - 5.0 Lpm (1 - 5000 mL/min.)
Weight	34 oz. (963 g)	36 oz. (1020 g)
Dimensions	4.9 x 11.9 x 13 cm, 758 cu. cm (1-15/16" x 4-11/16" x 5-1/8", 46.5 cu. in.)	4.8 x 11.7 x 13 cm, 732 cu. cm (1-7/8" x 4-5/8" x 5-1/8", 44.7 cu. in.)
Compensation Range	750 - 2500 mL/min. to 40 in. water back pressure 2500 - 4000 mL/min. to 20 in. water back pressure	750 mL/min. to 35 in. water back pressure 1000 mL/min. to 40 in. water back pressure 2000 mL/min. to 40 in. water back pressure 3000 mL/min. to 35 in. water back pressure 4000 mL/min. to 20 in. water back pressure 5000 mL/min. to 15 in. water back pressure
Flow Control	± 5 % of set point	± 5 % of set point
Run Time	At least 8 hours at 4000 mL/min. and 20 inches of water back pressure on full charge.	At least 8 hours across range of operation on full charge.
Flow Indicator	Built-in flow meter from 0.0 - 5.0 Lpm with 250 mL/min. divisions	Built-in flow meter from 0.0 - 5.0 Lpm with 500 mL/min. divisions.
Battery Assembly	Plug-in rechargeable NiCad battery pack delivers 6.0 volts at 2.0 Ah (ampere-hours)	Plug-in rechargeable NiCad battery pack delivers 6.0 volts at 1.8 Ah (ampere-hours)
Intrinsically Safe	UL approved intrinsically safe for use in hazardous locations: Class I, Groups A, B, C, D; Class II, Groups E, F, G; Class III; and Temperature Code T3C.	UL approved intrinsically safe for use in hazardous locations: Class I, Groups A, B, C, D; Class II, Groups E, F, G; Class III; and Temperature Code T3C.
Operating Temperature	- 20° to 45° C (- 4° to 113° F)	- 20° to 45° C (- 4° to 113° F)
Storage Temperature	- 40° to 45° C (- 40° to 113° F)	- 40° to 45° C (- 40° to 113° F)
Charging	5° to 45° C (41° to 113° F)	5° to 45° C (41° to 113° F)

Table 4-1. Specifications and Operating Parameters of the Personal Sampling Pumps Used by Metal and Nonmetal

Specification	Sampling Pumps	
	SKC Model 224-44XR	**Gilian Model HFS 513A-U**
Temperature		
Operating Humidity	0 to 95 % Relative	0 to 95 % Relative
RFI/EMI Shielding Performance	RFI/EMI Shielded Case with added circuit protection. • Complies with requirements of EN 55022, FCC Part 15 Class B, EN 50082-1 • Frequency range of the radiated susceptibility test was 27 MHZ to 1000 MHZ.	RFI/EMI Shielded Case.
Battery Charger(s)	1. Single Unit Charger. Must not charge more than 16 continuous hours. 2. Deluxe Charger. Five unit charger with various battery maintenance functions.	1. Single Unit Charger. Must not charge more than 16 continuous hours. 2. Battery Maintenance Station. Five unit charger with various battery maintenance functions.
Additions	None	1. Battery Charge Indicator - Activated by press-to-test button confirms a sufficient battery capacity to operate a minimum of 8 hours under any conditions within the instrument's range of operation. 2. Flow Fault Indication - LED is activated by either an under voltage, over current, or over pressure condition which occurs when the sampling pump is operated beyond its performance envelope. A suitable time delay (15 – 30 sec) is built into the system to avoid unnecessary shutdowns.

CHAPTER 5
MINERAL DUSTS - GRAVIMETRIC METHOD

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Chapter 5
MINERAL DUSTS - GRAVIMETRIC METHOD

I. Introduction

In most cases, exposure to mineral dust is determined by the gravimetric method, using a sampling pump and filter cassette (pre-weighed) to determine dust concentrations in the mine atmosphere. Gravimetric sampling is used to determine personal exposure (breathing zone) and can also be used to screen for other mineral dusts that may require particle counting to determine compliance, such as the six silicates specified in Chapter 6 (non-asbestiform talc, perlite, natural graphite, mica, soapstone, and amorphous silica or diatomaceous earth).

II. Definitions

Cyclone - also called “cyclone separator” or “particle sizer” – is a dust collecting device which separates particles by size and is used as part of the respirable dust sampling train. As air enters the intake hole, or “vortex,” respirable dust swirls in a conical device toward a filter cassette where it is trapped. The larger dust particles fall to the bottom and are collected in the “grit pot.”

Filter Lot - all of the filter cassettes with the same pre-weight date**.** A list of the filter lots is provided by MSHA Technical Support and is periodically updated. The list contains a range of filter numbers, by date, for each filter lot. Unused filters may be used for another sampling shift if they have not been individually opened and are in the same filter lot. Double-check the filter list to confirm the lot.

Gravimetric Method - a sampling procedure that measures the weight of the dust collected on the filter media to determine the concentration of the contaminant in the miner’s breathing zone. Most mineral dusts are sampled gravimetrically.

Respirable Dust - particles suspended in the air with a size of less than or equal to 10 microns in diameter. Although these dusts are invisible, they can be highly toxic because their small size allows them to penetrate to the deepest areas of the lungs and cause pneumoconiosis. Some examples of respirable dusts are silica, coal, and metal ore dusts.

Respirable dust is identified as that fraction of dust that passes a size selector (MSHA uses a 10mm nylon cyclone) and has the following characteristics:

Aerodynamic Diameter microns (unit density sphere)	% Passing Selector
≦ 2.0	90
2.5	75
3.5	50
5.0	25
10.0	0

Total Dust - airborne particles that are <u>not</u> selectively collected with regard to their size. Larger particles tend to be deposited within the nose and upper airways of the respiratory tract, whereas smaller particles may be drawn deeper into the respiratory tract and may be deposited in the airways and airspaces of the lung. These dusts may cause toxic effects when inhaled in large quantities.

III. Threshold Limit Values (TLVs®)

A. Respirable Dust

In metal and nonmetal mines, *crystalline silica* (which is sometimes called *free silica*) is one of two substances for which MSHA has a respirable dust standard. The other substance is coal dust and is typically encountered at MNM operations utilizing coal-fired kilns. There are three forms of crystalline silica: *quartz, cristobalite, and tridymite*.

- *Quartz* is the most common form of crystalline silica and it is found in almost every type of metal and nonmetal ore. It is important to sample for the miners' respirable silica-bearing dust exposures.

- *Cristobalite and tridymite* are forms of silica derived from superheating quartz. They have a different crystalline structure than quartz and are generally accepted as the most hazardous forms of crystalline silica. They are found naturally in volcanic rock formations or in some refractories and fire brick used to insulate some cement kilns, lime kilns or dryers. Cristobalite is also found in bentonite and calcined diatomaceous earth. Note that routine respirable samples are not analyzed for cristobalite and tridymite unless specifically requested.

The TLVs® for respirable silica-bearing dust is dependent upon the amount (%) of quartz (Q), cristobalite (C), and/or tridymite (T) present in the dust.

$$\frac{\text{wt. of silica (Q, C, or T) in milligrams (mg)}}{\text{total wt. of dust on filter in milligrams (mg)}} \times 100 = \text{\% silica (Q, C, or T)}$$

Note: The percentage of each form of silica must be calculated separately and rounded to one decimal place.

For example, if the weight of quartz is 0.90 milligrams:

$$\frac{\text{0.90 mg quartz}}{\text{5.0 mg total wt. on filter}} \times 100 = \text{18.0 \% quartz}$$

1. The TLV® formula for respirable quartz is:

$$\frac{10\ \text{mg/m}^3}{\text{\%quartz} + 2} = \text{TLV}^{®}\ \text{in mg/m}^3$$

For example, if the quartz content of the sample is 18.0 percent (%):

$$\frac{10\ \text{mg/m}^3}{18.0\ \text{quartz} + 2} = \frac{10\ \text{mg/m}^3}{20.0} = 0.50\ \text{mg/m}^3\ \text{TLV}^{®}\ \text{for quartz}$$

2. The TLV® formula for respirable cristobalite is:

$$\frac{5\ \text{mg/m}^3}{(\text{\%C}) + 2} = \text{TLV}^{®}\ \text{in mg/m}^3$$

For example, if the cristobalite content of the sample is 18.0 percent (%):

$$\frac{5\ \text{mg/m}^3}{18.0 + 2} = \frac{5\ \text{mg/m}^3}{20.0} = 0.25\ \text{mg/m}^3\ \text{TLV}^{®}\ \text{for cristobalite}$$

3. The TLV® formula for respirable tridymite is:

$$\frac{5 \text{ mg/m}^3}{(\%T) + 2} = \text{TLV}^{®} \text{ in mg/m}^3$$

For example, if the tridymite content of the sample is 8.0 percent (%):

$$\frac{5 \text{ mg/m}^3}{8.0 + 2} = \frac{5 \text{ mg/m}^3}{10.0} = 0.50 \text{ mg/m}^3 \text{ TLV}^{®} \text{ for tridymite}$$

B. Additive Respirable Exposure Formula

Since the three forms of silica -- quartz, cristobalite, and tridymite -- affect the respiratory system similarly, combined exposures to these contaminants are *additive*. The formula for the mixture of quartz, cristobalite, and tridymite is:

$$\frac{10 \text{ mg/m}^3}{(\%Q) + 2(\%C) + 2(\%T) + 2} = \text{TLV}^{®} \text{ in mg/m}^3 \text{ for mixture}$$

where: Q = Quartz, C = Cristobalite, and T =Tridymite.

For example, if the sample contained 3.0 percent (%) quartz, 4.0 % cristobalite, and no (0%) tridymite:

$$\frac{10 \text{ mg/m}^3}{3.0 + 2(4.0) + 2(0) + 2} = \frac{10 \text{ mg/m}^3}{13} = 0.77 \text{ mg/m}^3 \text{ TLV}^{®} \text{ for the mixture.}$$

C. Nuisance Dusts

Total dust sampling should be considered at mines where the sampling history indicates that the dust contains less than one percent quartz and no asbestos. The dust must have a specific enforceable TLV® or be considered a “nuisance dust.” A TLV® of 10 mg/m^3 is applicable for the Nuisance Particulates listed in Appendix E of the ***Threshold Limit Values for Chemical Substances in Workroom Air Adopted by the ACGIH for 1973***. These “nuisance” or “listed” dusts are also named on the request for laboratory analysis form (MSHA Form 4000-29) under the heading **Appendix E, 1973 ACGIH TLV Material List.

Note: Silica analysis is not performed on total dust samples.

The classification of a dust as a “nuisance” or “listed” dust is dependent on the commodity generating the dust exposure, and not by the analysis requested or whether the sample is of a total or respirable particle size. For example, if a respirable dust sample is collected at a limestone handling facility and a quartz analysis is requested, the sample should be identified as a listed dust on Form 4000-29 (“Yes” on Line 18 of the respective sample data column).

IV. Respirable and Total Dust Sampling Equipment

A. Filter Cassette

Use only the pre-weighed filter cassettes purchased from the contract manufacturer. These cassettes consist of a 37-mm diameter polyvinyl chloride membrane filter with a 5-micron (µ) pore size. The cassettes are individually sealed in a small plastic bag by the manufacturer (refer to Figure 5-1).

The individually sealed filter cassettes are provided in *lots*. Each lot is pre-weighed on the same date. This sealed packaging method makes any tampering with the unused cassettes readily apparent. In order for a sample to be taken, the individually sealed plastic bag containing the sampling filter cassette must first be opened. This sealed plastic bag should only be opened when it is time to mount the cassette on the sampling train. Likewise, the sealed plastic bag containing the control sample cassette does not need to be opened. The control sample cassette must be from the same lot as the sample cassettes.

Dust filters are not shipped with an expiration date. The sample will be voided by the lab if the control is determined out of range at the time of analysis.

NOTE: Excess unused filters may be sent to the MSHA Laboratory, used for calibration purposes, or for demonstration purposes. Contact your District Office for guidance if needed.

Figure 5- 1. Filter Cassettes, Lots, and Storage Bags

B. Sampling Pump

1. **Respirable Dust** - The flow rate for the sampling pump must be 1.7 liters per minute (Lpm), plus or minus a field tolerance of 5 percent, which is a range of 1.615 Lpm to 1.785 Lpm. Sampling at this flow rate ensures that the 10-mm cyclone properly separates respirable from non-respirable particles.

2. **Total Dust** - The recommended flow rate is 1.7 Lpm. However, flow rates between 1.0 Lpm and 2.0 Lpm are acceptable.

C. Respirable Dust Sampling Train

The “sampling train” includes all parts of the sampling setup: steel lapel holder, filter cassette, 10-mm cyclone assembly, tubing, and sampling pump (refer to Figures 5-2 and 5-3).

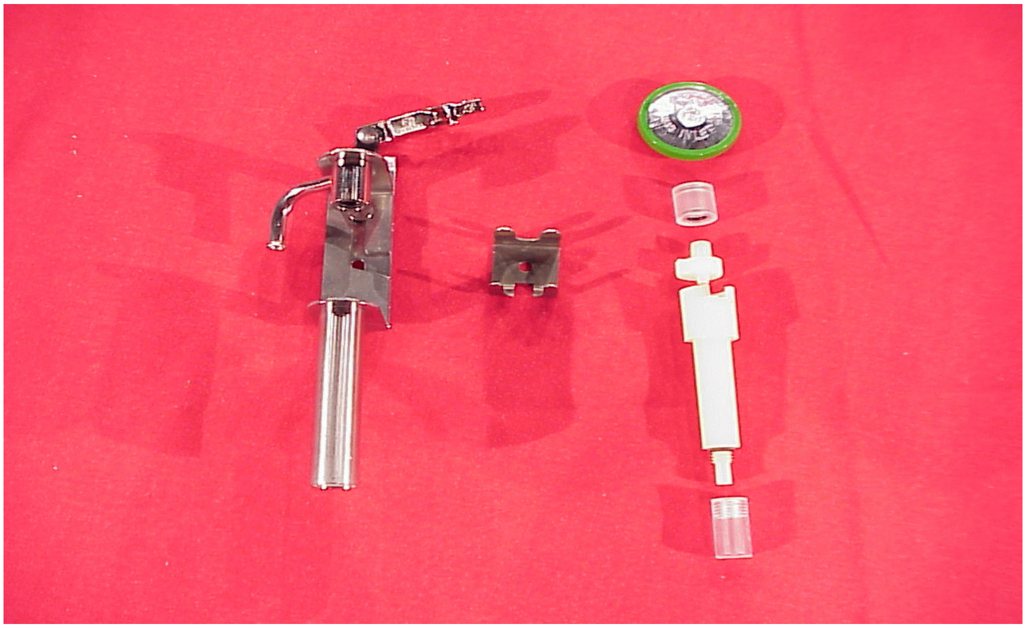

Figure 5- 2. Respirable Dust Cyclone and Holder Assembly

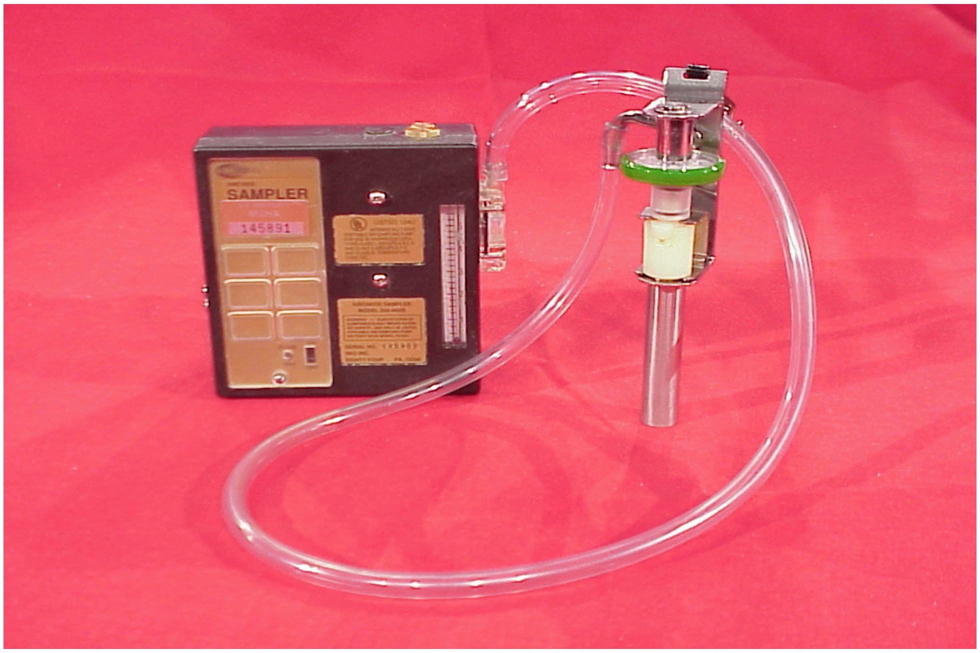

Figure 5-3. Respirable Dust Sampling Train

D. Total Dust Sampling Train

Total dust sampling uses the same type of filter cassette required for respirable dust sampling. Assemble the apparatus with O-rings placed on the top and bottom of the cassette to seat the cassette snugly in the cassette holder (refer to Figure 5-4), or use the top of the metal cyclone holder seated into the cassette holder, as shown in Figure 5-4a. **Note: A cyclone is <u>not</u> used**.

Figure 5- 4. Total Dust Sampling Train

Figure 5- 4a. Total Dust Cassette Holder Option

V. Respirable and Total Dust Sampling Procedures

Full-shift personal samples must be collected during the miner's entire workshift, regardless of the number of hours worked. [Short-term sampling is not acceptable for mineral dust contaminants.]

A. Pre-Survey Calibration of Sampling Pump

Prepare and calibrate the sampling pump using the procedures in Chapter 4.

B. Control Filter Cassette

A control filter cassette is used to adjust post-weights for variability associated with temperature and humidity variations. Prepare one *control* filter during the sampling period for each day of sampling. The control filter(s) must be from the same filter lot as the sample filter cassettes (*i.e.*, the same pre-weight date and stored under same environmental conditions). Do not remove the caps or end plugs from the control filter cassette. When sample filters from different lots are used, a control filter from each lot must be used.

1. Remove the control filter cassette from its storage bag. Do not remove the inlet or outlet plugs from the cassette.

2. Expose the control filter to the same time, temperature, and handling conditions as the ones that are used for sampling; *i.e.*, carry the control filter(s) in a shirt or coverall pocket while making rounds to check on the samples; keep the control filter(s) with the exposure samples after sampling; and treat the control filter(s) the same as the exposed filters when in the office or laboratory.

3. At the end of the shift, place a white sample seal label (MSHA Form 4000-30) on the filter cassette. Date, sign, and mark "CONTROL" on the sample seal. Record all control filter information in the Health Field Notes.

C. Assemble the Sampling Train

1. Respirable Dust

a. Remove the sample filter cassette from its individually-sealed plastic bag. If the bag has been opened or the cassette is damaged, do not use it.

b. Record the cassette number on the Health Field Notes form.

c. Remove the plugs from the cassette and place them in a clean, convenient location.

d. Make sure the number of the cassette is facing up, on the pump side of the assembly. When properly assembled, the cyclone will "lock" into the steel lapel holder and the cyclone inlet will face forward.

e. Tighten the set screw on the lapel holder so that all fittings are tight and the cassette is secured.

f. Connect the tubing to the metal outlet tube of the lapel holder holding the cyclone and filter cassette and attach the other end of the tubing to the sampling pump inlet.

2. Total Dust (Note: Quartz analysis is <u>no</u>t performed on total dust samples.**)** .

a. Remove the sample filter cassette from the plastic storage bag. If the bag has been opened or the cassette is damaged, do not use it.

b. Record the cassette number on the Health Field Notes form.

c. Remove the plugs from the cassette and place them in a clean, convenient location.

d. Attach the cassette outlet (the side where the cassette number is visible) to one end of the tubing with a nylon or plastic coupler. The other end of the tubing is connected to the sampling pump inlet. Note: A cyclone is <u>not</u> used.

D. Attach the Sampling Train to the Miner

1. Attach the sampling pump and sampling train to the miner. Clip, pin, or tape the tubing to the miner's clothing so that it does not interfere with the miner's job performance and does not present a safety hazard (such as, tubing catching on moving machine parts or railings). If the miner is not wearing a shirt or belt, the inspector should provide a belt or vest to facilitate sampling. These may be purchased as needed through the District Office.

2. Attach the sampler to the miner’s clothing within the breathing zone. For respirable dust sampling, attach the sampling train so that the cyclone's grit pot is on the bottom of the assembly and the numbered side of the cassette is facing up. Be certain that the cyclone inlet is facing away from the body of the miner.

E. Instructions to the Miner

1. Explain to the miner what you are doing, what the sampling device does, and the reason for the sampling (i.e., the hazard). If available, issue a Miner Health Hazard Information Sheet or Card.

2. Instruct the miner not to remove the sampling pump or sampling train at any time or cover the sampler or cyclone inlet with a coat or anything else. If the miner must leave the mine property or work area during the shift, the inspector should turn the sampling pump off and remove the sampling train. Sampling should resume once the miner returns.

3. Instruct the miner not to bump, drop, abuse, or tamper with the sampling pump or sampling train.

4. Emphasize the need for the miner to continue to work in a routine manner and report to you any unusual occurrences or problems encountered during the sampling period.

5. Inform the miner when and where the sampler will be removed and that you will be checking the equipment throughout the shift.

6. When conducting respirable sampling, instruct the miner not to invert the cyclone holder. If this occurs, it should be reported immediately to the inspector.

F. Collect the Sample

1. Start the sampling pump and replace the security cover.

2. Record the following information in the Health Field Notes (refer to Chapter 21, Section V):

- Time the sampling pump was started;
- Pump and filter cassette identification numbers;
- Miner's name, job title, and work location(s);
- Shift hours per day and days per week worked;
- Any respirator worn or expected to be worn (brand, model, type of filters); and
- Whether an acceptable respiratory protection program exists (see Chapter 16 for criteria for evaluating respiratory protection program).

3. During each full-shift sample, the inspector must observe the miner being sampled as frequently as is necessary to determine that a representative sample is being conducted of the normal activities. Check the sampling pump and sampling train to make sure that the sampling pump is operating properly, and to make sure the tubing and connections are not leaking. Do not adjust the flow rate at any time while sampling. Record what tasks the miner has performed in the time between subsequent checks so that the completed Health Field Notes will describe the miner's full work shift. This requirement does not necessarily preclude the inspector from doing other inspection work while conducting the sampling.

4. Evaluate dust conditions. Dusty work environments may require changing filter cassettes to keep them from becoming overloaded. If dust conditions are excessive during respirable and total dust sampling, the filter should be changed. Consecutive samples, using shorter sampling periods, should be collected for the full shift. See Chapter 2 Section IV, for discussion of collecting consecutive samples.

5. Throughout the shift, record all other pertinent information in the Health Field Notes:

- Times that the sampling train was checked and condition of sampling equipment. If the sampling pump needs to be changed out, stopped, or restarted for any reason, record the times involved;
- If consecutive samples were taken, record the number of any additional cassettes used during the sampling period;
- Activity of miner, equipment operating in the area, and approximate time spent at each activity;
- General description of the controls in use and whether or not they seem adequate;
- Potential sources of exposure, a general description of these sources, number of persons affected, and possible additional control measures;
- Any other samples taken and the results, if available (e.g. noise, detector tubes, organic vapor badges); and
- Environmental conditions (such as wind conditions, temperature, humidity, etc.).

6. Collect the sampling train from the miner.

a. <u>Turn</u> <u>off</u> the sampling pump. Turn off the pump **before** removing the sampling train or pump. Record the time the pump was turned off.

b. <u>Carefully</u> remove the sampling train:

- Respirable dust sampling - keep the cyclone <u>upright</u> to prevent the non-respirable dust in the grit pot from falling back through the cyclone onto the filter. Remove the sample filter cassette from the lapel holder and replace the cassette plugs. Place a white sample seal (MSHA Form 4000-30) on the sample filter cassette. Date and sign the sample filter cassette seal.

- Total dust sampling - uncouple the sample filter cassette from the sampling train and replace the cassette plugs. Place a seal on the sample filter cassette. Date and sign the sample filter cassette seal.

VI. Post-Inspection Procedures

A. Review Health Field Notes

Check that all the necessary information is included in the Health Field Notes.

B. Post-Survey Calibration of Sampling Pump

Check the sampling pump calibration using the procedures in Chapter 4.

C. Cyclone Cleaning and Assembly (respirable dust sampling only)

1. Unscrew the *grit pot* from the cyclone. Empty the grit pot by turning it upside down and tapping it gently on a solid surface.

2. Gently wash cyclone, grit pot, *coupler* (or collar) and the *vortex finder* (cyclone cap) by agitating in warm soapy water or, preferably, wash in an ultrasonic bath. Do not insert anything which can score or scratch the inner lining walls of the cyclone (e.g., pipe cleaner).

3. Rinse thoroughly in clean water, shake off excess water, and set aside to dry before reassembly.

4. Inspect the cyclone and filter holder parts for damage or excessive wear, for a loose coupler or vortex finder, and for scoring or rifling (which can trap respirable particles, preventing them from reaching the filter). Pay special attention to the top internal circumference of the cyclone when inspecting for scoring and rifling. Replace damaged or defective parts.

5. Reassemble the cyclone, vortex finder (cyclone cap), and grit pot.

D. Transport the Samples for Analysis

1. Complete the Request for Laboratory Analysis (MSHA Form 4000-29) for the samples taken (refer to Chapter 21, Section VII). In Item No. 15 on the form, designate “R” for respirable samples, “T” for total dust samples or “CB” for blank cassette / control filter cassette. In Item No. 16, fill in the analysis desired, for example, “quartz,” or “total weight.” Samples and controls from different lots, used on the same day, should be listed on separate Request for Laboratory Analysis (RLA) forms. If consecutive filters were used for an individual, list the individual’s filters on a separate RLA form. Be sure to provide all the information the laboratory will need to fill out the Personal Exposure Data Summary (PEDS) or Area Sample Data Summary (ASDS).

2. Ship the Request for Laboratory Analysis form(s) with the samples to the MSHA Laboratory. Filter cassettes and controls can be shipped together in the same container if space allows. Never split cassettes from the same inspection and mail them separately.

E. Compliance Determination

The laboratory will complete the analysis and return an Analytical Report that will include the information that was formerly calculated using the Lotus Health Calculation spreadsheet application. The Analytical Report will include the sample weight, concentration, TLV® or STEL, error factor, and calculated enforcement TLV® (TLV® times error factor). A PEDS or ASDS will also be generated as appropriate.

F. Report Writing

1. Inspection reports should include a copy of the Request for Laboratory Analysis, Health Field Notes, the Laboratory-provided Analytical Report, completed Personal Exposure Data Summary (PEDS), or ASDS calculation worksheets, citation/orders, and any other supplemental information collected during the inspection.

2. The laboratory submits electronic PEDs and analytical reports for samples analyzed to the inspector, supervisor, and district health specialist via Email. These must be copied by the inspector and completed with the Action Code and Citation number when applicable.

3. When manually completing the PEDS or the ASDS (refer to Chapter 21, Sections VIII & IX), be sure that the concentration and exposure limit units of measurement are the same as those listed for the contaminant code (refer to Chapter 3), and that the Action Code and Citation number have been included when applicable.

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MINERAL DUST - IMPINGER METHOD

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Chapter 6
MINERAL DUST - IMPINGER METHOD

I. Introduction

In the past, inspectors collected midget impinger samples and the analysis was performed by laboratory technicians located in each Metal and Nonmetal District. These functions have now been transferred to MSHA Technical Support. When impinger sampling is necessary (see discussion below), contact Technical Support to arrange for equipment and personnel. Because the sampling will be used for enforcement, an inspector must accompany Technical Support personnel and participate in the on-site sampling activities.

A. Contaminants Sampled Using Impingers

There are six silicates[1] sampled by the impinger method for determining personal exposures and subsequent compliance. Their TLVs® are expressed only in **mppcf units (million particles per cubic foot)**.

Silicates (<1% quartz)	TLV® (mppcf)
Mica	20
Perlite	30
Soapstone	20
Talc (non-asbestiform)	20
Graphite (natural)	15
Amorphous Silica and Natural Diatomaceous Earth	20

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[1] As listed on page 33 in the ***TLVs® Threshold Limit Values for Chemical Substances in Workroom Air Adopted by the ACGIH for 1973***.

B. Gravimetric Screening and Exposure Sampling

Before considering the impinger sampling method, conduct full-shift screening sampling (personal respirable dust sampling) for the silicates listed above. Follow the guidelines in Chapter 5 of this Handbook for respirable dust sampling. If a respirable sample exceeds the equivalent TLV® listed in Figure 6-1 and contains less than one percent (1%) free silica, it cannot be used for compliance. Follow-up sampling is required using the impinger method to determine compliance. If a respirable sample exceeds the equivalent TLV® and contains more than one percent (1%) silica, cite for non-compliance with the silica TLV®. **Use contaminant code 523 for all samples with > 1% silica**. When compliance with the silica TLV® has been achieved, re-screen for the listed substance. If the exposure is still over the equivalent TLV®, conduct impinger sampling for compliance determination.

Substance	Impinger Limit (mppcf)	Equivalent TLV® (mg/m^3)	Contaminant Code
Mica	20	3.0	513
Perlite	30	8.6	515
Talc (non-asbestiform) and Soapstone	20	3.3	511
Graphite (natural)	15	1.9	517
Amorphous Silica and Natural Diatomaceous Earth	20	1.5	519

Figure 6-1. Gravimetric/Impinger Equivalent TLVs®

II. Impinger Sampling Equipment

A. Description of Impinger

Air is drawn through the impinger (refer to Figure 6-2) using a sampling pump at a recommended rate of 2.8 Lpm. The air sample is drawn through a one

Figure 6 -2. Impinger Assembly

millimeter (1mm) bore nozzle located five millimeters (5mm) from the bottom of the flask. The dust particles in the air are collected in the flask and retained in the liquid. Note: The impinger may be glass, so appropriate precautions should be taken when handling or shipping to the MSHA Laboratory.

B. Number and Duration of Samples

For an 8-hour shift, a minimum of nine impingers (eight exposure samples and one blank) are generally used for each miner sampled. Shifts longer than 8 hours require more impingers. Use an average of one impinger sample per hour. Impingers should be replaced in the impinger case immediately after sampling.

C. Collection Liquids

Depending on the contaminant sampled, the impinger collection liquids may be alcohol, distilled water, a combination of the two, or a special liquid for a particular problem. The most common collection liquid for mineral dust is reagent grade isopropyl alcohol.

D. Sampling Pump

Any pump can be used that can maintain a flow rate of 2.8 Lpm. The pump should be used with a trap to prevent the liquid from being drawn into the pump.

E. Nozzle Calibration Check

The calibration of all impinger nozzles must be checked using the configuration diagrams in Figure 6-3. The impinger nozzle calibration is checked using a sampling pump calibrated to a flow rate of 2.8 Lpm with a vacuum gauge or water manometer in line. If a differential pressure of 12.0 inches of water cannot be maintained, discard the nozzle.

F. Damaged or Defective Nozzle

If it is suspected that a nozzle is defective or damaged, discard it. If a damaged nozzle is found during or after sampling, void the sample.

G. Sampling Pump Calibration

When using a midget impinger (with a nozzle whose calibration has been checked), calibrate the sampling pump to 2.8 Lpm, in accordance with Chapter 4 of this Handbook.

III. Impinger Sampling Procedures

A. Assignment of Unique Identification Number

Record the number(s) in the Health Field Notes. If the impinger does not have a number, assign one and record it.

B. Prepare Blank Impinger

Prepare a blank impinger for each group of impinger samples representing a miner’s full-shift exposure.

1. Prepare the blank impinger in the work area being sampled by first removing the side arm cap and then the nozzle cap. The “Z” guard and sampling tubing should be installed and removed before replacing the caps. This will represent all possible contamination sources from sample handling without pulling air through the impinger.

2. Do not connect the blank impinger to the sampling pump hose.

3. Mark the blank to identify whose exposure it affects and to identify it as a blank sample. Record the blank sample information in the Health Field Notes.

C. Prepare the Sampling Pump and Impinger

Approximately one meter (or three feet) of tubing is needed to connect the sampling pump and impinger. The tubing must reach from the belt of the collector (who wears the pump) to the end of the collector's arm, so the impinger can be held in the breathing zone of the miner with minimal interference from the collector. Tygon tubing is recommended because it is clear, making any potential sample loss more evident, but rubber tubing may also be used.

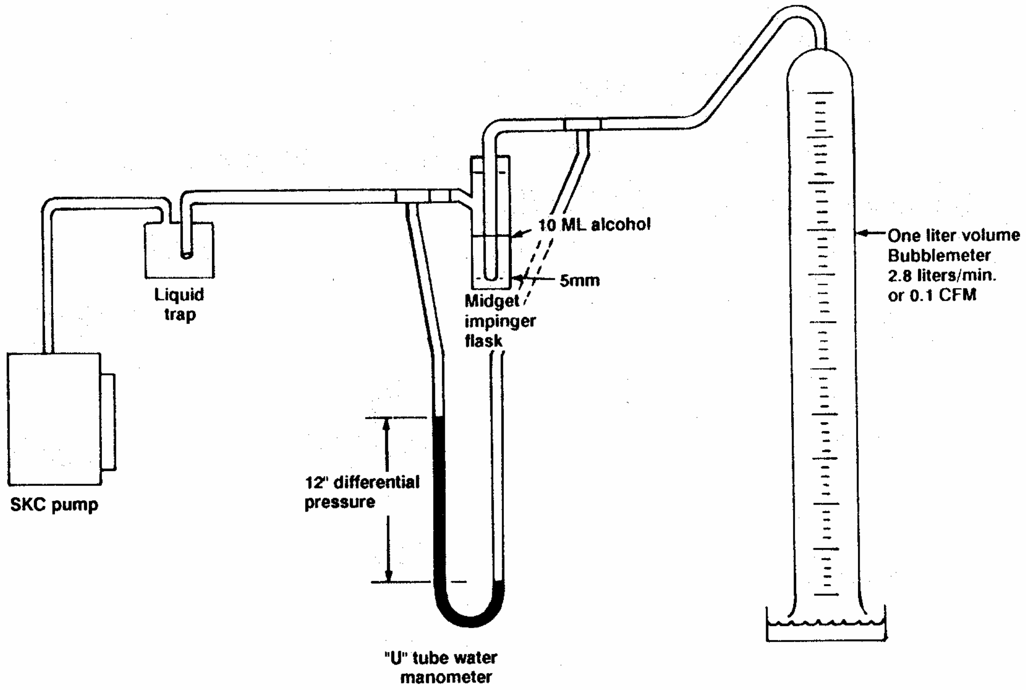

Figure 6-3. Impinger Nozzle Calibration Check Setup

D. Instructions to Miner

Inform the miner about the following:

1. Emphasize the need for the miner to continue to work in a routine manner and to indicate to you any unusual occurrence during the sample period.

2. Explain to the miner what you are doing, what the sampling device does, and the reason for sampling.

E. Collect the Sample

1. Check the impinger to verify:

- The number of the impinger used;
- That the level of collection liquid is at the expected level (slightly above the 10 mL mark and not below 5 mL during sampling); and
- The nozzle is set at the 5 mm line.

2. Remove the side arm cap first, then the nozzle cap. Place the caps in a plastic bag or a dust-free envelope.

3. Connect the side arm of the impinger to the tubing connected to the pump.

4. Start the sampling pump and begin timing (record time).

5. Wear the pump on your own belt for impinger sampling.

6. Hold the impinger near the miner’s breathing zone for the duration of the sample. Do not require the miner to wear the impinger.

7. Sample for about 10 minutes. Sampling periods may range between 5 and 15 minutes. The exact sampling period must be recorded in the Health Field Notes.

8. At the end of the sampling time, stop the pump and record the time.

9. Remove the tubing from the impinger (keep the open end of the tubing in your pocket to avoid dust exposure). Replace the nozzle cap first, then replace the side arm cap.

10. Write the time period of the sample on the impinger label and place the impinger in the carrying block. Record the miner's activities and sources of exposure in the Health Field Notes.

11. Repeat steps 1 through 10 for each impinger until sufficient samples are collected to determine representative exposures for the miner.

F. Record Information

Throughout the shift record the following pertinent information in the Health Field Notes (refer to Chapter 21, Section V):

- The number of each impinger used and the corresponding sampling times;
- Miner's name, job title, and work location(s);
- Shift hours per day and days per week worked;
- Activity of miner, equipment operating in the area, and approximate time spent at each activity;
- Controls in use, a general description of the controls, and whether or not they seem adequate;
- Potential sources of exposure, a general description of these sources, whether they are routine sources or occasional sources, and suggested possible additional controls;
- Any other samples taken and results, if available (*e.g.*, noise, detector tubes, etc.);
- Any respirator worn (brand, model, type of filters);
- Whether an acceptable respiratory protection program exists (see Chapter 16 for criteria for evaluating respiratory protection program); and
- Environmental conditions (such as wind, temperature, and humidity).

. G. Transport

After collecting the samples and one blank, securely place impingers in a container to prevent leakage, breakage, and jostling. The samples must be analyzed within 24 hours of collection. To achieve this, Technical Support may need to analyze the results at field locations.

IV. Post-Inspection Procedures

A. Review Health Field Notes

Check that you have recorded all the necessary information in the Health Field Notes.

B. Post-Calibration of Sampling Pump

Check sampling pump calibration in accordance with Chapter 4 of this Handbook.

C. Submit Samples for Analysis

Coordinate with Technical Support to ensure that the analysis is conducted within the 24-hour period.

D. Compliance Determination

1. **Calculations.** Particle counting is performed by Technical Support and is referenced to each impinger. All impingers used to sample the full-shift exposure of a miner are counted and each count is time weighted for that segment of the shift that it represents. The sum of these counts becomes the shift-weighted average (SWA) count for that miner. See Chapter 2 of this Handbook for calculations and procedures.

2. **Error Factor.** The error factor for impinger sampling will be supplied by Technical Support.

E. Report Writing

1. Report **gravimetric screening** on the Personal Exposure Data Summary (PEDS - refer to Chapter 21, Section VIII). When the **impinger sampling** results are received from Technical Support, complete another PEDS.

2. Submit a copy of the Health Field Notes, the sampling results, citations or orders (if applicable), and the PEDS with the inspection report.

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CHAPTER 7
METAL DUSTS, FUMES AND MISTS

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Chapter 7
METAL DUSTS, FUMES AND MISTS

I. Introduction

Metals, alloys, and compounds are found in a wide variety of mining operations. Milling, welding, and plating are examples of mechanical, thermal or electrochemical processes that can alter the size, state or chemistry of a metal or its compounds. Welding produces fumes; grinding and milling produce dusts and electrolytic refining processes create mists containing soluble metallic compounds. Inhalation is the most common route of entry for metal dusts, fumes, and mists. Exposures to metals are evaluated as the mass of a metal or its compound in a known volume of air. The analytic methods used allow multiple metals to be identified from one sample.

Acute or chronic exposure to hazardous metals and their compounds can cause injury or illness. For example:

1. <u>Metal fume fever and pneumonitis</u> are caused by acute exposure to high concentrations of metal fumes (such as zinc, magnesium, and their oxides). Symptoms, usually fever and chills, appear from 4 to 12 hours after exposure. Persons usually recover within one to two days, but symptoms can recur with repeated exposure. Over-exposure to cadmium or cadmium oxide fume can result in fatal pulmonary edema a day after exposure.

2. <u>Pneumoconiosis</u> is a “dust disease of the lungs” caused by the accumulation of mineral or metallic dust particles in the lungs due to chronic exposure. This can result in decreased lung function, an increase in the demand placed on the cardiovascular system, and eventual heart failure. The accumulations are identified as “shadows” on the lungs that can be seen in chest radiographs. Some of the pneumoconioses are benign, while others may lead to fibrosis (scarring) of the lung and continue to spread after exposure to the hazard ends. Some metal exposures can cause cancer (arsenic, beryllium, cadmium, chromates, nickel, and lead). Exposure to beryllium and its alloys may lead to a progressive lung disease know as berylliosis.

3. <u>Systemic poisoning</u> is the damage to organs (such as kidneys or liver) or organ systems (such as the reproductive, urinary, circulatory, respiratory, or central nervous systems) when a toxic agent enters the body. Inhalation

is the most common route of entry for metal fumes and dusts. Bone cancer, blood cancer (leukemia), kidney failure, or heart failure can result. Because the early symptoms of metal poisoning (e.g., blurred vision, headache, fatigue, delirium, diarrhea, and chest pains) are often attributed to other causes, misdiagnosis can occur.

II. Definitions

Dust - fine, dry, solid particles of earth or metal. Dust particles can be produced and suspended in the air by cutting, drilling, crushing, grinding, screening, loading, etc. Dusts can be inhaled and ingested. Sources of metal dusts are primarily associated with metal ore mines and mills. Equipment operators and cleanup personnel may experience a higher risk of dust overexposure near "concentrate piles" or in processing plants where minerals are processed, transported, handled or loaded.

Elemental Analysis - typically, a profile performed by the MSHA Laboratory to determine the amount of 14 elemental metals and metalloids in fumes and 8 metals in dust samples. Refer to Section V.B.2.d. for soluble salt analysis. An elemental analysis can be requested for one or any combination of the 14 basic elements. The results are used to determine compliance with the respective limits for oxides or compounds listed or referenced in the ***TLVs® Threshold Limit Values for Chemical Substances in Workroom Air Adopted by the ACGIH for 1973***.

Elemental Metal - the basic form of a metal, uncombined (as a compound) with any other chemical element. For example, elemental lead is pure lead, as opposed to lead oxide (in welding fumes) or lead sulfide (lead ore dust). Of the 92 basic natural elements, 53 are metals. Thirty-six of these metals have enforceable TLVs®.

Fumes - airborne particles formed when a metal, which is solid at room temperature, is melted, vaporizes into the atmosphere, and then condenses to a solid. Fumes usually assume rounded or smooth, irregular shapes, generally less than one micron in size, but sometimes they join together to form larger particles. Fumes are produced by welding and oxy-fuel torch cutting operations, in furnaces producing molten metal and in small assay lab furnaces.

Metalloid - chemical elements with both metallic and non-metallic properties that may have toxic systemic effects on the human body. Metalloids can be found in dusts and fumes. Some metalloids found in the mining industry are boron, tellurium (telluride), arsenic, and antimony.

Mists – suspended liquid droplets generated from the mechanical disruption of a liquid via agitation or atomization. These droplets can be formed from liquids containing soluble forms of metals.

Stoichiometric Multiplier or Gravimetric Factor - a number used in an exposure calculation when the standard in the ***TLVs® Threshold Limit Values for Chemical Substances in Workroom Air Adopted by the ACGIH for 1973*** is listed as a metal oxide and when the analytical method is not specific for the compound. The stoichiometric multiplier is used to compensate for the additional weight of oxygen which is not included in the metal analysis (see Section VIII). The MSHA laboratory will include the appropriate adjustments in the exposure report.

Hazards Associated with Welding and Cutting - the following factors can affect the type and toxicity of hazards:

1. Type of material - iron or steel can produce iron oxide, nickel compounds, and chromium trioxide fumes. Stainless steel can produce manganese and other toxic fumes. Alloys may produce copper, zinc, and tin oxide fumes.

2. Coatings - on base metals will be vaporized during welding or torch cutting. Plated or galvanized metal may release cadmium or zinc oxide fumes. Metals painted with lead-based or older latex paints may release lead or mercury fumes. Metals with residues of chlorinated-chemicals like solvents or metals with plastic coverings can release hydrogen chloride into the air, an acid gas which becomes hydrochloric acid if it contacts the moist linings of one’s respiratory system.

3. Welding rods and electrodes, fluxes, and fillers - release metal fumes into the atmosphere. Welding and hard-facing rods and electrodes typically contain chromium, copper, iron, manganese, molybdenum, nickel and titanium. Take titanium samples on a separate filter. Many welding rods and electrodes contain fluoride flux which can be released in toxic forms. Most filler compounds contain silica or calcium which may become free silica or calcium oxide.

4. Gases - commonly produced during welding include carbon monoxide, carbon dioxide, ozone, nitrogen oxides, phosgene (from the decomposition of chlorinated hydrocarbons), and hydrogen chloride. Inert shielding gases can, without proper ventilation, displace breathing air.

III. Exposure Limits

The full-shift threshold limit values (TLV®) and short-term exposure limits (STEL) for metals and metalloids are listed or referenced in the ***TLVs® Threshold Limit Values for Chemical Substances in Workroom Air Adopted by the ACGIH for 1973*** and are incorporated by reference in MSHA standards for Metal and Nonmetal mines. Refer to chapter 3, Contaminant Index. The MSHA Laboratory will provide the appropriate TLV® or STEL for the form of the metal that was sampled and analyzed.

IV. Sampling Equipment

A. Filter Cassette

Use mixed cellulose ester (MCE), 37 mm in diameter, 0.8 micron pore size filter cassettes for all metal fumes and dusts, including welding fumes. See V.B.1. below. Aluminum and titanium require different sample preparation from the other 14 metals sampled this way and should be submitted with a separate MCE filter for each analysis required. Chromic acid and chromates require a separate sample because the analytical method requires a different filter material. See V.B.2., “Other-Special,” for a description of PVC filters for chromates and chromic acid.

B. Personal Sampling Pump

Any sampling pump may be used that can maintain the specified flow rate (see Section VI.A).

V. Sampling Strategy

A. Duration of Samples

1. Full-Shift Samples

Full-shift sampling should be used when miners will be exposed to metal dusts or fumes during all or most of their workshift. In order to determine if the TLVs® have been exceeded, sample the miner’s entire workshift, regardless of the number of hours worked. [Refer to Chapter 2. III. A. 1.]

2. Short-Term Samples

Short-term samples can be taken independently or in conjunction with full-shift samples to determine if the short-term exposure limits (STEL) or ceiling limits have been exceeded during suspected periods of peak exposure. When monitoring for short-term exposure limits, refer to the sampling times listed in Chapter 3. In general, when sampling welding fumes, the sample duration should be 30 minutes to encompass all of the specified time periods for the 14-element profile. When sampling a mixture of similar metallic contaminant dusts or fumes, the sampling duration should correspond to the contaminant with the longest STEL time period. However, if sampling for one specific contaminant, the duration should correspond to the listed time for the respective STEL. This can be accomplished by:

a. Taking a sample in the miner’s breathing zone using the sampling procedure described in section VI;

b. Taking an additional short term sample during a full shift sample to determine if short term exposure limits or ceiling limits for a specific contaminant are exceeded;

c. Interrupting the full-shift sample to conduct short term sampling. This method requires taking consecutive samples. Each sampling period requires a separate cassette, and the contaminant amounts on each cassette must be added to obtain the full-shift exposure for each contaminant. (For example, if two short-term samples were taken in addition to the full shift sample, the shift weight of the contaminant equals the weight on the full-shift filter plus the weight on the first short-term filter plus the weight on the second short-term filter.) [Refer to Chapter 2. III. A. 2.]

B. Laboratory Analysis

1. Elemental

An elemental analysis can be requested for one, or any combination of the following metals (unless specified, the analysis will include all 14):

Arsenic (As)
Beryllium (Be)
Cadmium (Cd)
*Chromium (Cr)
Cobalt (Co)
Copper (Cu)
Iron (Fe)
Lead (Pb)
Magnesium (Mg)
Manganese (Mn)
Molybdenum (Mo)
Nickel (Ni)
Vanadium (V)
Zinc (Zn)

* Note: Chromium results from elemental analysis with ICP can only be applied to the TLVs® for contaminant codes 545 and 547:

- Chromium metal;
- Soluble chromic and chromous salts - chrome, chromium phosphate, chromium carbonate, and chromium acetate; and
- Insoluble chromium salts.

When the lab performs an elemental analysis on a welding or metal fume sample, chromium is reported as the metal only (i.e., contaminant code 547), not the oxide form. There is another more specific method available for determining the oxidized form of chromium. If exposure to hexavalent chromium is suspected, arrangements for expedited sample analyses must be made prior to sampling. Sample flow rate: usually 1.7 Lpm for up to 9 hours. Reference Chapter 3 and NIOSH Method 7600.

2. Other-Special

a. During certain welding operations (*e.g.*, on stainless steel), and in some ore dusts, chromium may occur in the especially hazardous “hexavalent” form (CrVI). When chromium VI, chromic acid, or chromates are present or suspected, take a separate sample using a pre-weighed mineral-dust filter cassette (37 mm diameter, polyvinyl chloride (PVC), 5 micron (µm) pore size). **Note: Remove the filter from cassette and place filter into a glass vial after sampling. Discard the plastic cassette. Since the sample will be stable for only two weeks, it must be shipped without delay (overnight) to the MSHA Laboratory (see Chapter 3).** Notify the MSHA Laboratory in advance of your need to sample for hexavalent chromium.

b. The MSHA Laboratory routinely processes samples for other metals, such as silver, barium, calcium, mercury, and sodium. These must be sampled individually using a separate MCE filter and blank. Contact the MSHA Laboratory for handling and shipping requirements for these samples.

c. If it is necessary to sample for additional metals or metalloids, contact the MSHA Laboratory for sampling and handling guidance.

d. Analyzing for soluble metal salts including Cd, Cr, Fe and Mo requires a different sample preparation procedure than that routinely performed for welding fumes. Please specify on the RLA form if an analysis for soluble metal salts is needed. If insoluble metals are also required, take two side-by-side samples.

VI. Sampling Procedure

A. Pre-survey Calibration of the Sampling Pump

Calibrate the personal sampling pumps for fume and elemental dust sampling in accordance with the policy and procedures contained in Chapter 4. The recommended flow rate for full-shift and short-term sampling is 1.7 Lpm. Acceptable sampling flow rate ranges are listed in Chapter 3.

B. Prepare Blank Filter

A blank filter cassette(s) is submitted to determine contamination of the cassette from sample handling, storage, and shipping. Prepare one blank filter for each type of analysis desired. For example, “elemental” (all 14 metals listed in Section V.B.1) analysis requires one blank and “silver” would require another. In addition, separate blanks must be submitted for each set or shift sampled. Blanks must come from the same (lot) box of cassettes used for the exposure sampling period.

1. Remove the inlet and outlet plugs and quickly replace them. This should be done at the mine site, preferably at the sampling area.

2. Number or uniquely identify the cassette. Treat the blank filter the same as the exposed filters.

3. At the end of the shift, place a Sample Seal label (MSHA Form 4000-30) on the filter cassette. Date, sign, and mark "BLANK" on the sample seal. Record all blank filter information in the Health Field Notes.

C. Assemble the Sampling Train

1. Number or uniquely identify the cassette. This will be the sample number noted on the Request for Laboratory Analysis form.

2. Attach the cassette to the sampling pump.

  a. Remove the inlet and the outlet plugs of the cassette (to take a "closed-face" sample). Place the plugs in a clean, convenient location (*e.g.*, in a plastic bag) for future re-use.

  b. Insert the coupler in the end of the sampling hose into the outlet side of the cassette. Then attach the other end of this hose to the sampling pump inlet.

  c. Make sure that all fittings are tight and that the cassette is secured in the lapel holder (if used).

D. Attach the Sampling Train to Miner

1. Attach the sampling pump and sampling train to the miner so that it will not create a safety hazard to him or her or anyone else while performing normal activities. If the miner is not wearing a shirt or belt, the inspector should provide a belt or vest to facilitate sampling.

2. Attach the closed-faced filter cassette assembly, filter facing downward, and in the miner's breathing zone (see Figure 7-1). For welding fume samples, the breathing zone of a welder wearing a welding hood is considered to be under the hood when the face shield is in the down position (see Figure 7-2). Note: Helmet sampling adaptors (pre-formed tubing with Velcro attachments) for welding fume sampling are available from several manufacturers. Contact your District Office to coordinate this purchase.

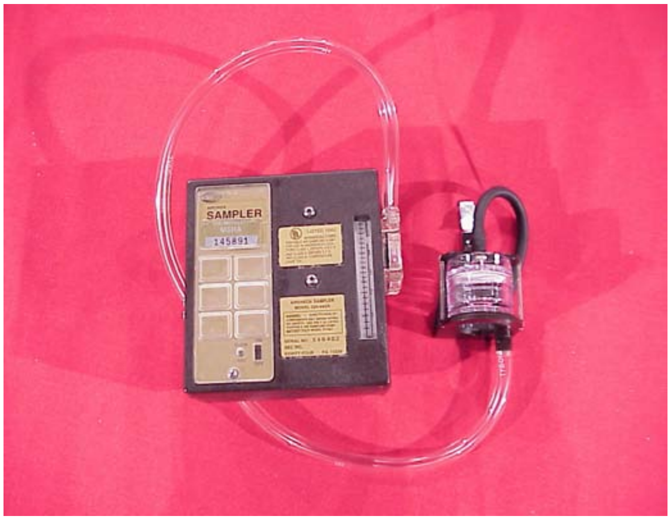

Figure 7-1. Elemental Dust Sampling Train

Figure 7-2. Welding Fume Sampling Train

E. Instructions to the Miner

1. Explain to the miner what you are doing, what the sampling device does, and the reason for the sampling (i.e., the hazard). If available, issue a Miner Health Hazard Information Sheet or Card.

2. Instruct the miner not to remove the sampling pump or sampling train at any time or cover the cassette inlet with a coat or anything else. If the miner must leave the mine property during the shift, the inspector should remove the sampling train and turn the sampling pump off. Sampling should continue once the miner returns.

3. Instruct the miner not to bump, drop, abuse, or tamper with the sampling pump or sampling train.

4. Emphasize the need for the miner to continue to work in a routine manner and report to you any unusual occurrences during the sampling period.

5. Inform the miner when and where the sampler will be removed and that you will be checking the equipment throughout the shift.

F. Collect the Sample

1. Turn on the sampling pump and replace the cover plate.

2. When the sampling train has been attached, record in the Health Field Notes (refer to Chapter 21, Section V):

  a. Time the sampling pump was started;

  b. Pump and filter cassette identification numbers;

  c. Miner's name, job title, and work location(s);

  d. Shift hours per day and days per week worked;

  e. Any respirator worn or expected to be worn (brand, model, type of filters); and

  f. Whether an acceptable respiratory protection program exists (see Chapter 16 for criteria for evaluating respiratory protection program).

3. During each full-shift sample, the inspector must observe the miner being sampled as frequently as is necessary to determine that a representative sample is being conducted of the normal activities. Check the sampling pump and sampling train to make sure that the sampling pump is operating properly, and to make sure the tubing and connections are not leaking. Do not adjust the flow rate at any time while sampling. Record what tasks the miner has performed in the time between subsequent checks, so that the completed Health Field Notes will describe the miner's full work shift. This requirement does not necessarily preclude the inspector from doing other inspection work while sampling.

4. Evaluate dust and fume conditions. Significant amounts of dust and fume in the work environment may require the changing of filter cassettes to keep them from becoming overloaded.

Filter overloading may occur when collecting personal samples for metals during certain processes (e.g., charging furnaces, pouring ingots, sanding, grinding, etc.) because of the short-term generation of large volumes of particulate matter. To prevent overloading (as evidenced by any loose particulate on the filter), use consecutive sampling with shorter sampling periods.

5. Throughout the shift, record all other pertinent information in the Health Field Notes:

- **a.** Times that the sampling train was checked and condition of sampling equipment. If the sampling pump needs to be changed out, stopped, or restarted for any reason, record the times involved;
- **b.** If consecutive samples were taken, record the number of any additional cassettes used during sampling period;
- **c.** Activity of miner, equipment operating in the area, and approximate time spent at each activity;
- **d.** General description of controls in use and whether or not they seem adequate;
- **e.** Potential sources of exposure, a general description of these sources, number of persons affected, and possible additional control measures;
- **f.** Any other samples taken and the results, if available (*e.g.*, noise, detector tubes, organic vapor badges); and
- **g.** Environmental conditions (such as wind conditions, temperature, humidity, etc.).

6. Collect the sampling train from the miner.

- **a.** Turn off the sampling pump. Record the time the pump was turned off.
- **b.** Carefully remove the sampling train.
- **c.** Uncouple the filter cassette from the sampling train and replace the cassette plugs. Place a sample seal on the filter cassette. Date and sign the sample seal.

VII. Post-Inspection Procedures

A. Review Health Field Notes

Check that you have recorded all necessary information in the Health Field Notes (MSHA 4000-31).

B. Post-Survey Calibration of Sampling Pump

Check the sampling pump calibration using the procedures in Chapter 4.

C. Transport Samples for Analysis

1. Complete the Request for Laboratory Analysis (MSHA Form 4000-29) for air samples and blanks (refer to Chapter 21, Section VII).

- Item No. 15 (sample type) - designate “MD” for metal dust sample, “W” for welding fume sample, “MF” for other metal fume sample, or “CB” for blank cassettes.
- Item No. 16 (analysis desired) - identify analysis desired. For example; “elemental 14,” “chromates,” “silver,” or “calcium oxide.”

2. Ship the Request for Laboratory Analysis Form(s) and samples to the MSHA Laboratory. (Keep a copy for yourself.) Filter cassettes and blanks can be shipped together in the same container if space allows.

VIII. Documentation and Recordkeeping

A. Compliance Determination

Results will be received from the Laboratory with exposure concentrations calculated using the appropriate stoichiometric factor and applicable TLV®/STEL on an “Analytical Report.” A value greater than 1.0 in the C/TLV®*EF column indicates a citable violation. Complete the Action Code and Citation number on the accompanying PEDS.

1. Stoichiometric Multiplier (S.M.) (Gravimetric Factor)

The analytical method is specific for the element to be determined and does not distinguish different compounds. To calculate a compound value, a gravimetric factor is applied. When the standard in the ***TLVs® Threshold Limit Values for Chemical Substances in Workroom Air Adopted by the ACGIH for 1973*** is listed as a metal oxide, a stoichiometric multiplier (S.M.) is used in the exposure calculation for fume samples. The stoichiometric multiplier is used to compensate for the additional weight of the oxygen which is not included in the metal analysis. The metal weight is multiplied by the stoichiometric multiplier to obtain the mass of the oxide. The stoichiometric multipliers used by the MSHA Laboratory for metal oxides with an applicable TLV® are listed below.

Contaminant as Listed in 1973 TLV® Booklet	Compound for Which the TLV® is Calculated	Stoichiometric Multiplier
Alundum (Aluminum Oxide)	Al_2O_3	1.889
Iron Oxide Fume	Fe_2O_3	1.430
Magnesium Oxide Fume	MgO	1.658
Titanium Dioxide	TiO_2	1.668
Zinc Oxide Fume	ZnO	1.245
Calcium Oxide	CaO	1.399

Note: When a metal compound does not have a specific TLV®, a stoichiometric multiplier is not used in the exposure calculation; for example, lead sulfide does not have a specific TLV®, but is regulated as "lead, inorganic, fumes and dusts." If it is present in a sample, a stoichiometric multiplier would not be applied. In this case, the Laboratory would report the concentration as elemental lead, not the compound. Therefore, if the concentration of elemental lead exceeded the TLV® or STEL, an overexposure occurred.

2. Calculations

Exposure concentrations are calculated using the following formulae. Determine compliance by comparing calculated exposure concentrations with respective exposure limits. The MSHA Laboratory will calculate personal exposure sample result concentrations in an "Analytical Report" mailed back to the sample collector.

a. Full-Shift Sample - Shift-Weighted Average (SWA)

Calculate full-shift exposure using the following formula:

$$\frac{\text{wt. of contaminant (mg)} \times \text{S.M. (when applicable)}}{\text{Flow rate (Lpm)} \times 480 \text{ (min)} \times 0.001 \text{ (m}^3\text{/L)}} = \text{SWA in mg/m}^3$$

where: S.M. = Stoichiometric Multiplier.

(If the full-shift sample was started and then interrupted to take consecutive short-term samples, the weight of contaminant is the sum of the contaminant on each filter.)

b. Short-Term Sample - Time-Weighted Average (TWA)

Calculate the concentration for each contaminant from the following:

$$\frac{\text{wt. of contaminant (mg)} \times \text{S.M. (when applicable)}}{\text{Flow rate (Lpm)} \times \text{actual sampling time (min)} \times 0.001 \text{ (m}^3\text{/L)}} = \text{TWA in mg/m}^3$$

where: S.M. = Stoichiometric Multiplier.

c. Additive Effects

See Chapter 2 for a discussion of additive effects and calculation examples.

d. Error Factors

The error factors for metal fume and dust sampling and analysis will be supplied by the MSHA Laboratory.

B. Report Writing

1. Inspection reports should include a copy of the Health Field Notes, the Request for Laboratory Analysis forms, Laboratory Analytical Reports, the completed Personal Exposure Data Summary (PEDS), calculation worksheets, citation/orders, and any other supplemental information collected during the inspection.

2. When completing the PEDS for mists by hand (refer to Chapter 21, Section VIII), be sure that the concentration and exposure limit units of measurement are the same as those listed for the contaminant code (refer to Chapter 3).

CHAPTER 8
ASBESTOS FIBERS

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Chapter 8
ASBESTOS FIBERS

I. Introduction

Asbestos is an inhalation and ingestion hazard which causes chronic lung disease (asbestosis) and certain cancers of the lung (mesothelioma) and digestive tract, as well as other asbestos related diseases. Asbestos occurs naturally in a variety of mineral deposits and is used for thermal and electrical insulation, fire-proofing, and cement products. The physical form of asbestos includes fibers of various sizes, colors, and textures.

A. Definitions

Asbestos - a generic term for several hydrated silicates. When these silicates are crushed or processed, they separate into flexible fibers. The term asbestos, as stated in 30 CFR §§ 56/57.5001(b), is limited to the following mineral fibers: *chrysotile, amosite, crocidolite, anthophyllite asbestos, tremolite asbestos, and actinolite asbestos*.

Asbestos is classified as either serpentine or amphibole. About 95% of all commercial asbestos is serpentine. The following table outlines the groups of asbestos and their respective types:

Group	Mineral Name	Type of Asbestos	CAS* No.
Serpentine	Serpentine	Chrysotile	12001-29-5
Amphibole	Grunerite (cummingtonite-grunerite)	Amosite (grunerite asbestos or brown asbestos)	12172-73-5
	Riebeckite	Crocidolite (blue asbestos)	12001-28-4
	Anthophyllite	Anthophyllite asbestos	77536-67-5
	Tremolite	Tremolite asbestos	77536-68-6
	Tremolite-actinolite	Actinolite asbestos	77536-66-4

* CAS - Chemical Abstract Service

Fibers - fibrils with a length greater than five microns.

B. Sources of Asbestos Fibers

Natural Occurrence - Asbestos occurs in asbestos-producing mines (of which there are presently none active in the U.S.), and in association with certain other mineral ores. Therefore, asbestos sampling should be considered at mine properties where the following rock and minerals are found: talc, vermiculite, taconite, serpentinized limestone, and banded ironstone.

Asbestos fibers may be released into the ambient air by the breaking, crushing, grinding, drilling, or general abrasive handling of a solid material having asbestos components.

Introduced Commercial Asbestos - Asbestos exposure can occur from products brought onto the mine property, such as brake linings and pads, asbestos cement boards, asbestos welding blankets, asbestos jointing and packing compounds and asbestos coated wiring. Inspectors should encourage operators to replace these items with asbestos-free materials where miners could be exposed. Removal of asbestos containing materials, such as building insulation, requires the use of special precautions. See section III below.

If asbestos-containing items are used, collect samples in their areas of use. For example, collect fiber samples when a mechanic is fabricating and/or changing brake linings, or in large dragline housings where asbestos brakes are used. Inspectors must use appropriate Personal Protective Equipment when collecting samples.

II. Applicable MSHA Standards for Metal and Nonmetal:

A. Threshold Limit Values (TLVs®) per 30 CFR 56/57.5001(b):

The exposure limits for airborne asbestos fiber concentrations are:

1. **Full-shift** - an exposure limit of 2.0 fibers/mL (same as 2.0 fibers/cc).
2. **Short-term** - a 15-minute exposure limit of 10.0 fibers/mL (same as 10.0 fibers/cc).

B. Other Standards in 30 CFR That Should Be Evaluated if Asbestos Presence is Known or Suspected:

47.41	Labeling of toxic materials, HazCom
56/57.5002	Exposure monitoring
56/57.5005	Control of exposure to airborne contaminants
56/57.15004	Eye protection
56/57.15006	Protective equipment and clothing for hazards and irritants
56/57.16003	Storage of hazardous materials
56/57.16004	Containers for hazardous materials
56/57.18002	Examination of working places
56/57.18006	New employees
56/57.20011	Barricades and warning signs
56/57.20014	Prohibited areas for food and beverages

III. Handling Materials Containing Asbestos

When asbestos exposure is possible (known or suspected), inspectors should wear appropriate personal protective equipment (PPE). To determine what PPE to use, refer to the *Recommendations for Chemical Protective Clothing, NIOSH Pocket Guide to Chemical Hazards,* or consult with the district health specialist/industrial hygienist. PPE and appropriate sampling equipment can be obtained from the District.

Adhere to the following guidelines when miners are observed mining, installing, stabilizing, or removing materials containing asbestos, or demolishing structures containing asbestos.

A. Asbestos Known

When an extraction, insulation, or demolition operation is in progress on mining property, the inspector should inquire whether there is asbestos in the ore, insulation, or structure. If asbestos is known to be present, take personal fiber samples (refer to sections IV, V, and VII below). Be sure the mine operator or contractor understands the hazards of asbestos and how to control or eliminate miner exposure. This includes ensuring that the workplace is examined once each shift, a record is kept, and safety and health hazards are corrected. Ensure that asbestos is properly identified and segregated by barricades. Anyone coming into contact with asbestos must have adequate personal protective equipment. Additionally, when the material is removed, it must be appropriately bagged, labeled, and disposed in accordance with applicable state or Federal asbestos regulations. Individuals must be trained in the proper use of PPE and safe procedures for working with asbestos.

B. Asbestos Suspected

If the mine operator has not sampled the material and the inspector believes the material could contain asbestos, the inspector should take a bulk sample (refer to sections VI and VII below) and submit it to the MSHA laboratory for analysis. If the inspector strongly suspects the presence of asbestos, personal sampling should be immediately conducted. If the bulk sample results show asbestos is present, the inspector should conduct personal sampling. Alert the mine operator or contractor to the hazards and control of asbestos.

C. Environmental Protection Agency (EPA) Notification

The EPA requires notification when asbestos is present in a building that is to be demolished or renovated and when the asbestos is being removed. However, if all of the asbestos is only being encapsulated and left in place, EPA does not have to be notified. If asbestos is found at a mine site during demolition, renovations, or removal activities, determine if the mine operator or contractor has notified the EPA. If the operator or contractor will not notify EPA, the inspector should notify the nearest EPA Regional Office. EPA will need an estimate of the amount of asbestos-containing material present, in linear feet on pipes or square feet on other facility components. If the phone number of an EPA Regional Office cannot be obtained, contact the District Office.

IV. Personal Exposure Sampling Equipment

A. Filter-Cassette Assembly

Fiber sampling filter-cassette assemblies are factory pre-packaged. Use a 25-millimeter (mm) mixed cellulose ester (MCE) membrane 0.8 micron cassette (SKC or Millipore) mounted inside a black 50-mm electrically conductive plastic extension cowl that has passed quality assurance testing by the manufacturer (refer to Figure 8-1).

Figure 8-1. Filter-Cassette Assembly

B. Personal Sampling Pump

Any personal sampling pump that can maintain the specified flow rate for the sampling period (see discussion below) can be used.

V. Personal Exposure Sampling Procedure

A. Calibrate the Sampling Pump

Calibrate the sampling pumps for fiber sampling in accordance with the procedures contained in Chapter 4. The recommended flow rate for full-shift personal sampling is 1.7 Lpm. Use consecutive samples if necessary to avoid overloading the filter. Do not adjust pump flow rate once sampling has begun.

When sampling for a short term exposure, such as from a task requiring a short amount of time, sample for 15 to 30 minutes at a flow rate of 2.5 Lpm or greater.

B. Prepare Blank Filters

To determine any contamination of the filter in manufacturing or handling, submit at least two field blanks from the same lot (or 10% of the total samples, whichever is greater) for each set of samples.

1. Prepare field blanks at the same time as other cassettes prior to sampling. Remove the inlet cover and outlet plugs, then quickly replace them. Place a new sample seal (MSHA Form 4000-30) over the cassette.

2. Number or uniquely identify the cassette if it is not already marked. This will be the blank sample noted on the Request for Laboratory Analysis form.

3. Treat the blank filter-cassette assemblies the same as the exposed filters. *i.e.*, blank filters are sent along with the air samples to the MSHA laboratory for analysis.

C. Assemble Sampling Train

1. Number or uniquely identify the cassette if it is not already marked. This will be the sample number noted on the Request for Laboratory Analysis (RLA) form.

2. Attach the cassette to the sampling pump.

    a. Remove the inlet cover and the outlet plug of the cassette. Place them in a clean, convenient location (*e.g.*, in a plastic bag).

    b. Attach the sampling tube onto the outlet of the cassette. Attach the other end of the tubing to the sampling pump inlet (refer to Figure 8-2). The cassette can be placed in an optional holder (Refer to figure 8-2a).

    c. Make sure that all fittings are tight and that the cassette is secured to the lapel holder.

Figure 8-2. Asbestos Fiber Sampling Train

Figure 8-2a. Alternate Asbestos Fiber Sampler

D. Attach Sampling Train to Miner

1. Attach the sampling pump and sampling train to the miner so that it will not create a safety hazard to him or her or anyone else while performing normal activities. If the miner is not wearing a shirt or belt, the inspector should provide a belt or vest to facilitate sampling. These are available in various sizes from the District.

2. Attach the open-faced filter-cassette assembly; facing downward, in the miner's breathing zone.

E. Instructions to the Miner

1. Explain to the miner what you are doing, what the sampling device does, and the reason for the sampling (i.e., the hazard). If available, issue a Miner Health Hazard Information Sheet or Card.

2. Instruct the miner not to remove the sampling pump or sampling train at any time or cover the filter-cassette assembly with a coat or other garment. If the miner must leave the mine property during the shift, the inspector should remove the sampling train and turn the sampling pump off. Sampling should continue once the miner returns.

3. Instruct the miner not to bump, drop, abuse, or tamper with the sampling pump or sampling train.

4. Emphasize the need for the miner to continue to work in a routine manner and report to you any unusual occurrences during the sampling period.

5. Inform the miner when and where you will remove the sampler and that you will be checking the equipment throughout the shift.

F. Collect Sample

1. Start the sampling pump and replace the security cover.

2. Record the following information in the Health Field Notes (refer to Chapter 21, Section V):

- Time the sampling pump was started;
- Pump and cassette identification numbers;
- Miner’s name, job title, and work location(s);
- Shift hours per day and days per week worked;
- Any respirator worn or expected to be worn (brand, model, type of filters); and
- Whether an acceptable respiratory protection program exists (see Chapter 16 for criteria for evaluating respiratory protection program).

3. During each full-shift sample, the inspector must observe the miner being sampled as frequently as is necessary to determine that a representative sample is being conducted of the normal activities. Check the sampling pump and sampling train to make sure that the sampling pump is operating properly, and to make sure the tubing and connections are not leaking. Do not adjust the flow rate at any time while sampling. Record what tasks the miner has performed in the time between subsequent checks so that the completed Health Field Notes (Form 4000-31) will describe the miner’s full work shift. This requirement does not necessarily preclude the inspector from doing other inspection work while sampling.

4. Accurate fiber counting depends on optimal fiber loading on the sampling filter. That is, the sampling duration must be sufficient to accumulate at least a density of 100 fibers per square millimeter on the filter. However, dusty atmospheres may cause excessive background dust on the filter and the sample may not be able to be analyzed due to overloading. Observe the dust conditions in the workplace and check the collecting filter surface for excessive accumulation. The filter may need to be changed out periodically during the shift. Any visible dust accumulation on the filter necessitates a complete filter-cassette assembly replacement.

5. Throughout the shift, include the following pertinent information in the Health Field Notes:

- Times that the sampling train was checked and condition of sampling equipment; record the times involved if the sampling pump needs to be changed out, stopped, or restarted for any reason;
- If consecutive samples were taken, record the number of additional cassettes used during sampling period; group consecutive samples taken on a miner onto one RLA; do not mix individuals on the same form;
- Activity of miner, equipment operating in the area, and approximate time spent at each activity;
- General description of controls in use and whether or not they seem adequate;
- Potential sources of exposure, a general description of these sources, number of persons affected, and possible additional control measures;
- Any other samples taken and the results, if available (such as noise, detector tubes, organic vapor badges); and
- Environmental conditions (such as wind conditions, temperature, humidity, etc.).

G. Remove Sampler

Collect the sampling train from the miner.

1. Turn off the sampling pump and immediately record the time.

2. Carefully remove the sampling apparatus, replace the inlet cover and the outlet plug, and apply a sample seal end over end to seal to the cassette.

3. Send the samples to the MSHA laboratory in a rigid container with packing material to prevent jostling or damage. (Do not use polystyrene foam for packing.)

VI. Bulk Sampling Procedures

Use caution when taking a bulk sample of a material that is suspected or known to contain asbestos because it can damage the material and cause significant release of fibers. The following guidelines are designed to minimize fiber release and potential exposures to asbestos fiber:

- As a minimum, wear a NIOSH-approved half-face respirator with high efficiency filters (N, P, or R-100), disposable gloves, and safety glasses or goggles (unvented or indirectly vented).
- Wet the surface of the material to be sampled with water (to which a few drops of liquid dish detergent have been added) from a spray bottle, or place a plastic bag around the sampler.
- Label each rigid container with a unique identifier and apply the sample seal.
- For pipe and boiler insulation, use a non-asbestos mastic (binding material). For other material, use latex paint, tape, or a sealant to cover the sample area.
- Do not submit bulk samples in plastic bags; see Sections A. - C. below for proper containers.
- Submit all bulk samples separate from the air sampling cassettes.

A. Settled Dust

Collect settled dust bulk samples (several grams or a sample about the size and thickness of a quarter) in areas where asbestos is suspected or where personal samples (for asbestos) are being collected. Collection areas can be on top surfaces of equipment and tops of beams and supports. Collect the samples in a clean vial (plastic or glass), jar, or other rigid container. (Note: Do not “vacuum” a sample of the surface contamination using a sampling pump and cassette. This collection method could separate fibers from bundles and skew the results.) Label the sample appropriately and submit it to the MSHA laboratory to determine the percentage and type of asbestos.

B. Bulk Pieces

Bulk samples can also be simply taken from raw ore, final products, and other materials (e.g., broken floor tiles) where asbestos may be suspected. If the material is being removed, take a piece of the removed material. Submit samples in a rigid container (jar, vial, etc.) to the MSHA laboratory to determine the type and percentage of asbestos.

C. Bulk Samples Using Sampler/Container

Bulk/core samples can also be taken from wallboard, boiler wrap, gaskets, pipe insulation, or other friable (flaky, crumbly, etc.) materials suspected to contain asbestos. These materials can be sampled with a sampler/container (see Figure 8-3) which is available from the District. Note: Do not take a sample if there is potential for significant substrate damage or a fiber release, especially if the substrate material is in otherwise good condition. Contact the District Health Specialist or Industrial Hygienist for assistance.

To use these samplers, hold the “T” handle provided and slowly push and twist the sampler into the material. Be sure to penetrate any paint or protective coating and all the layers of the material. Each sampler comes with a clear, plastic, shatter-proof container and protective cap. After sampling, insert the sampler in the plastic container and cap it as a unit. Then seal it in a larger container for shipment. **Note**: For your safety, never remove the sample from the sampler. The MSHA laboratory will eject the sample under controlled conditions (hood) prior to analysis. Mail the samplers in a strong container (cardboard box, etc.) to the MSHA laboratory to determine the percentage and type of asbestos.

Figure 8-3. Bulk/Core Asbestos Sampler/Container

VII. Post-Inspection Procedures

A. **Review Health Field Notes (MSHA Form 4000-31)**. Check that all necessary information has been recorded on the form.

B. **Post-Calibration**. Check sampling pump calibration in accordance with Chapter 4.

C. Submit Samples for Analyses

Complete Request for Laboratory Analysis (RLA) forms for air samples and bulk samples (refer to Chapter 21, Section VII). Send RLA forms in container with sample cassettes to the MSHA laboratory for counting and analysis. To prevent possible cross contamination, do not ship mixtures of air cassettes and bulk samples in the same package.

- <u>Item No. 5 (sample type)</u> - designate "F" for asbestos fiber sample, "B" for bulk sample (for asbestos determination), and "CB" for blank cassettes.

- <u>Item No. 16 (analysis desired)</u> - designate Asbestos Fiber.

D. Compliance Determination

1. The MSHA laboratory will calculate personal exposure results in an "Analytical Report" mailed back to the sample collector. The "Report" will present fiber concentrations as determined by the Phase Contrast Microscopy (PCM) analytical method. The PCM method is non-specific and reports unidentified total fiber concentrations. Any PCM fiber concentrations greater than 0.1 fibers/cc will be re-analyzed by the Transmission Electron Microscopy (TEM) method to confirm the identity and concentration of the asbestos fiber proportion of the sample. In these cases two concentration values will be reported, *i.e.*, the PCM value <u>and</u> the TEM value. Determine compliance by comparing the TEM asbestos fiber exposure concentrations with the respective exposure limit:

a. **Full-shift** - an 8 hour time-weighted average exposure limit of 2.0 asbestos fibers/mL (cc is same as mL).

b. **Short-term** - a 15-minute exposure limit of 10.0 asbestos fibers/mL (cc is same as mL).

2. If consecutive samples were taken over the length of the shift, and the results are reported as the TWA for each sample, the calculation of the 8-hour equivalent shift-weighted average (SWA) is determined by the following formula:

$$\mathbf{SWA = (TWA_1 \times t_1 + TWA_2 \times t_2 + \ . \ . \ . \ + TWA_n \times t_n) / 480 \ min.}$$

where: TWA = Contaminant concentration measured by actual sampling time;
t = Time period of each sample in minutes; and
$t_1 + t_2 + \ . \ . \ . \ t_n$ is the total time of the full workshift.

Note: Both the SWA for unidentified fiber concentrations determined by PCM, and asbestos fiber concentrations determined by TEM, are calculated the same way.

3. The error factor for asbestos sampling and analysis will be supplied by the MSHA laboratory.

E. Report Writing

1. Complete the Personal Exposure Data Summary (refer to Chapter 21, Section VIII). Record full-shift SWA and short-term STEL personal exposure results for samples collected and analyzed for: unidentified fiber concentration by PCM as code 505, and asbestos fiber concentration by TEM as code 501; even if the results are zero. Note: Code 505 has no TLV.

2. Submit a copy of the Field Notes and Health Field Notes, the Request for Laboratory Analysis, citations/orders, and the Personal Exposure Data Summary with the inspection report.

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CHAPTER 9
SORBENT MEDIA SAMPLING

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Chapter 9
SORBENT MEDIA SAMPLING

I. Introduction

Sorbent tubes and passive monitors (badges) may be used to determine the airborne concentration of certain vapors and gases. These samplers contain media such as charcoal, silica gel, florisil, and hopcalite. Collection on sorbent media can be done by active sampling, where a sampling pump is used to draw contaminated air slowly through the media, or by passive sampling, where a monitor collects a contaminant by natural diffusion of air.

II. Definitions

Active Sampling - a method of sampling which requires the use of a sampling pump and sorbent tubes to assess short-term and full-shift exposures.

Adsorbent Media - substances inside sorbent tubes or passive badges that collect specific contaminants. The contaminants condense or attach to the surface of the collecting substance, rather than being absorbed into a filter, liquid, or other absorbent media.

Adsorption - the attachment of gases and vapors to the surface of a solid.

Breakthrough - also called “overload.” When contaminated air is not captured in the primary section of a sorbent media sampler and passes through to the secondary “backup” section. This condition can occur because: the primary section is saturated and cannot adsorb additional contaminant; or the flow rate is too high and the primary section does not have sufficient time to adsorb the contaminant.

Charcoal tube - most common type of sorbent tube. It is used extensively for sampling organic contaminants (e.g., solvents). The glass tube contains two sections of activated charcoal: the larger section is the sampling section and the smaller section is the back-up section. Charcoal tubes come in various sizes.

Diffusion - the natural passage of gas or vapor from an area of high concentration to an area of lower concentration. When gases or vapor pass through a membrane, the rate of diffusion depends on the concentration of contaminants on each side of the membrane. In a passive monitor, the gases or vapors will diffuse across the barrier membrane into the monitor and be collected on a sorbent media.

Diffusion tube - a detector tube that is a special type of passive monitor in which the gas being sampled (carbon monoxide, carbon dioxide, sulfur dioxide, hydrogen sulfide, nitrogen dioxide, cyanide, etc.) enters the tube by natural diffusion of air. As gases or vapors diffuse through the tube, the chemicals within react and produce a color change or stain which varies in length according to the concentration (for description and use, see Chapter 11).

Passive monitor - a sampling device which collects a contaminant (organic vapors, mercury, various mine gases) by the principle of diffusion, without the use of a sampling pump ("passive sampling").

Passive Sampling - a method of sampling that uses passive monitors and does not require the use of a sampling pump.

Sorbent tube - glass tube with both ends flame sealed, containing two sections of adsorbent material (e.g., charcoal, silica gel, florisil, hopcalite, etc.). The larger section is the sampling section and the smaller section is the back-up section. Sorbent tubes come in various sizes. A sampling pump is used to draw air through the sorbent tube ("active sampling").

III. Exposure Limits

The full-shift threshold limit values (TLV®) and short-term exposure limits (STEL) for contaminants sampled with sorbent media are listed or referenced in the ***TLVs® Threshold Limit Values for Chemical Substances in Workroom Air Adopted by the ACGIH for 1973*** and incorporated by reference in MSHA standards. For the exposure limits of specific contaminants, refer to Chapter 3.

IV. Sampling Equipment

Shelf Life: Sorbent media samplers have a shelf life that is normally found on the box or on the sampler itself. Do not use samplers for enforcement that cannot be analyzed before their shelf life expires.

Temperature and Humidity: The collection efficiency of the media may be dependent on the temperature and the relative humidity. Refer to the manufacturer's instructions or contact the District Health Specialist or Industrial Hygienist for the applicable ambient operating conditions before using sorbent media.

Interferences: Sorbent media samplers may be adversely affected by other contaminants present. Depending on the type of sampler used, other contaminants may interfere with the measurement or the analysis. Refer to the manufacturer's instructions or contact the

District Health Specialist or Industrial Hygienist for possible interferences before using sorbent media.

A. Active Sampling

1. Personal Sampling Pump

Sorbent tube sampling requires a sampling pump capable of maintaining the specified flow rate for the respective sampling period found in Chapter 3. The flow rate is dependent on the contaminant being collected. Some contaminants are sampled using extremely low flow rates which require the use of special “low flow” adaptors. The adaptors are normally supplied with the sampling pump as part of the tube holder assembly. Contact the District Office to coordinate specific sampling needs.

2. Sorbent Tube

Sorbent tubes come in various sizes. The type of tube used for exposure sampling depends on the contaminant (see Chapter 3.)

3. Tube Holder

Tube holders vary depending on the manufacturer. They are available in various sizes to accommodate the different sizes of sampling tubes, and have a clothing clip to use when conducting personal sampling and are designed to protect the wearer should the ends of the sampling tubes break.

B. Passive Sampling

1. Organic Vapor Monitor (activated charcoal adsorbent badges)

Organic Vapor Monitors are used to assess exposure to a wide variety of organic chemicals. Some contain a single charcoal filter, while others contain two: one for collection and a second as a back-up. Refer to Chapter 3 for the preferred monitor for a specific organic vapor, or contact your District Office for assistance.

2. **Mercury Vapor Monitor (adsorbent badge)** - A mercury vapor monitor unit is used only to assess exposure to mercury vapors.

3. **Diffusion tube** - A diffusion tube is a direct-read detector tube used to assess personal exposures to common mine gases (nitrogen dioxide, sulfur dioxide, hydrogen sulfide, carbon monoxide, carbon dioxide, cyanide, ammonia, etc.). Refer to Chapter 11 for further discussion and the field application of diffusion tubes.

V. Sampling Strategy

A. Full-Shift Samples

Full-shift sampling should be conducted to determine if the respective TLVs® have been exceeded when miners will be exposed to vapors or gases during their scheduled workshift. Refer to Chapter 3 for TLVs® and specific sampling guidelines for individual contaminants.

1. **Active Sampling** - The number of sorbent tubes used during the sampling shift is dependent on the concentration of the contaminant in the mine environment. That is, in higher concentrations the sorbent tube may become overloaded and it may be necessary to perform consecutive sampling by changing the sorbent sampler at short time intervals. Refer to Chapter 3 for guidance on required pump flow rates and the maximum allowable volume for the sorbent tube specified for each contaminant.

2. **Passive Sampling** - one organic vapor badge is sufficient for sampling up to 8 hours. The mercury vapor badge is also sufficient for up to 8 hours. For shifts exceeding 8 hours, use two monitors consecutively to assess a full-shift exposure.

B. Short-term Samples (Sorbent tubes only)

Short-term samples can be taken independently or in conjunction with full-shift samples to determine if short-term (STEL) or ceiling limits have been exceeded during suspected periods of peak exposure. When monitoring for short-term exposure limits, refer to the minimum sampling times listed in Chapter 3. When sampling for more than one of these contaminants, the sample duration should be for the longest listed time to encompass all of the specified time periods. However, if sampling for one specific contaminant, the duration should correspond to the listed time for the respective STEL. This can be accomplished by:

1. Taking an additional sample in the miner’s breathing zone using the sampling setup described below, or

2. Interrupting the full-shift sample to take a short-term sample. This method requires taking consecutive samples. Each sampling period requires a separate sorbent tube; and the contaminant amounts (determined by analysis) on each tube must be added to obtain the full-shift exposure for each contaminant.

VI. Sampling Procedures

A. Sorbent Tubes (Active Sampling)

1. Pre-Survey Calibration of Sampling Pump

Prepare and calibrate the sampling pump using the procedures in Chapter 4.

2. Prepare a Blank (Control) Tube

Blanks are submitted to determine contamination of the tube from sample handling, storage, and shipping. Prepare one blank tube for each type of analysis desired. For example, “benzene” analysis requires one blank and “sulfuric acid” would require another. In addition, separate blanks must be submitted for each shift sampled. Blanks must come from the same lot or envelope used for the exposure sampling period.

- Carefully break each end of the tube and immediately attach a cap on both ends. **Note:** Use a tube scorer/breaker device to avoid the risk of injury. Place a sample seal on the blank tube(s). Date, sign, and mark “BLANK” on the sample seal. Record all blank tube information in the Health Field Notes.

- Treat the blank tube(s) the same as the exposed tubes. That is, the blank tube should be subjected to the same temperature and handling conditions as the ones that are used for sampling. Carry the blank control tube in a shirt or coverall pocket while making rounds to check on the samples, and submit the blank tube(s) to the MSHA Laboratory with the exposure samples.

3. Assemble the Sampling Train (see Figures 9-1 and 9-2)

a. Number or uniquely identify the sorbent tubes, using a unique number for that event. This will be the sample number recorded on the Request for Laboratory Analysis, MSHA Form 4000-29.

b. Immediately before sampling, use a tube scorer/breaker device to carefully break off each end of the tube to provide openings approximately one-half the internal diameter of the tube.

c. Place the sampling tube in the tube holder with the back-up (smaller) section positioned nearest the sampling pump. Usually there is an arrow on the tube to show the direction of the air flow.

- The air being sampled must enter directly into the open end of the sorbent sample tube.
- Tubing or other materials must not be placed on the open end of the tube.
- Tube holders are designed to protect the wearer from the broken glass tip.

Figure 9-1. Sorbent Tube Sampling Train (SKC Pump)

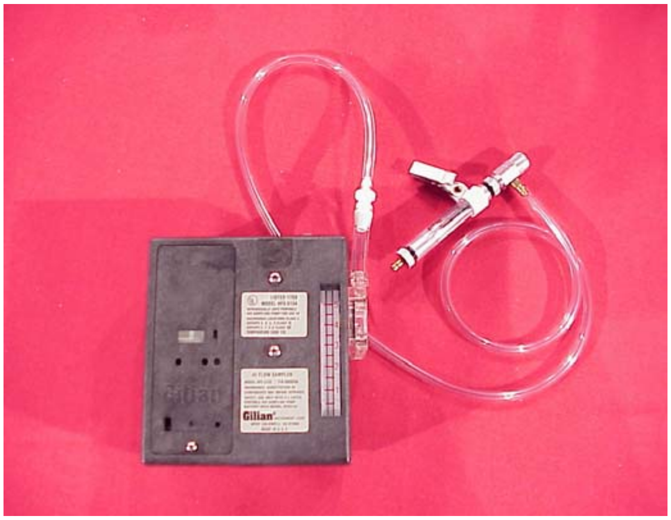

Figure 9-2. Sorbent Tube Sampling Train (Gilian Pump)

Figure 9-2a. Charcoal Tube

4. Attach the Sampling Train to the Miner

a. Attach the sampling pump and sampling train to the miner so that it will not create a safety hazard to him or her or anyone else while performing normal activities. If the miner is not wearing a shirt or belt, the inspector should provide a belt or vest to facilitate sampling. Coordinate this purchase with your District Office if needed.

b. Attach the tube holder to the miner's clothing within the breathing zone.

c. Clip, pin, or tape the tubing to the miner's clothing so that it does not interfere with the miner's job performance and does not present a safety hazard (such as tubing catching on a moving machine part or railing).

5. Instructions to the Miner

a. Explain to the miner what you are doing, what the sampling device does, and the reason for the sampling (i.e., the hazard). If available, issue a Miner Health Hazard Information Sheet or Card.

b. Instruct the miner not to remove the sampling pump or sampling train at any time or cover the tube holder inlet with a coat or other garment. If the miner must leave the mine property or work area during the shift, the inspector should remove the sampling train and turn the sampling pump off. Sampling should resume once the miner returns.

c. Instruct the miner not to bump, drop, abuse, or tamper with the sampling pump or sampling train.

d. Emphasize the need for the miner to continue to work in a routine manner and report to you any unusual occurrences during the sampling period.

e. Inform the miner when and where you will remove the sampler and that you will be checking the equipment throughout the shift.

6. Collect the Sample

a. Turn on the sampling pump and replace the cover plate.

b. When the sampling train has been attached, record the following in the Health Field Notes:

- Time the sampling pump was started;

- Pump and sorbent tube identification numbers;
- Miner's name, job title, and work location(s);
- Shift hours per day and days per week worked;
- Record the flow rate for the sampling pump;
- Any respirator worn or expected to be worn (brand, model, type of filters); and
- Whether an acceptable respiratory protection program exists (see Chapter 16 for criteria for evaluating a respiratory protection program).

c. Observe the sampling pump operation for a short time to check the flow rate.

d. During each full-shift sample, the inspector must observe the miner being sampled as frequently as is necessary to determine that a representative sample is being conducted of the normal activities.
Check the sampling pump and sampling train to make sure the sampling pump is operating properly and the tubing and connections are not leaking. Do not adjust the flow rate at any time while sampling. Record what tasks the miner has performed in the time between subsequent checks, so that the completed Health Field Notes describe the miner's full work shift. This requirement does not necessarily preclude the inspector from doing other inspection work while sampling.

e. Throughout the shift, record all other pertinent information in the Health Field Notes, including:

- Times that the sampling train was checked and condition of sampling equipment; if the sampling pump needs to be changed out, stopped, or restarted for any reason, record the times involved;
- If consecutive samples were taken, record the number of any additional cassettes used during sampling period;
- Activity of miner, equipment operating in the area, and approximate time spent at each activity;
- General description of controls in use and whether or not they seem adequate;
- Potential sources of exposure, a general description of these sources, number of persons affected, and possible additional control measures;

- Any other samples taken and the results if available (e.g., noise, detector tubes, organic vapor badges); and
- Environmental conditions (such as wind conditions, temperature, and humidity).

f. Collect the sampling train from the miner.

- Turn off the sampling pump. Record the time that the pump was turned off.
- Carefully remove the sampling train.
- Remove the sorbent tube from the holder and place a cap on each end of the tube. Place a sample seal on the tube. Date and sign the sample seal.

B. Organic Vapor and Mercury Badges (Passive Sampling)

Each type of badge (see Figures 9-3 and 9-4) comes with a unique number and an instruction booklet or insert in the original container. For proper field sampling, follow the manufacturer's recommended procedures. Submit mercury badges directly to Assay Technology for analysis.

Figure 9-3. Passive Monitor Badge (Organic Vapors)

Figure 9-4. Passive Monitor Badge (Mercury Vapor)

1. **Prepare a blank Badge** - Controls are submitted to determine if there has been any contamination of the badge from sample handling, storage, and shipping. Prepare one blank badge for each type of badge submitted for analysis. In addition, separate blanks <u>must</u> be submitted for each shift sampled. Blanks <u>must</u> come from the same lot or box used for the exposure sampling period.

    a. Open the badge in the area where personal exposure samples will be collected and quickly cap it. Place a sample seal on the blank badge. Date, sign, and mark "BLANK" on the sample seal. Record all blank badge information in the Health Field Notes.

    b. Treat the blank badge the same as the exposed badges. That is, the blank badge should be subjected to the same temperature and handling conditions as the ones that are used for sampling. Carry the blank(s) in a shirt or coverall pocket while making rounds to check on the samples and submit the blank badge(s) to the MSHA Laboratory with the exposure samples.

2. **Position the Badge** - Clip the badge(s) to the miner's clothing within the breathing zone. The sorbent media side should face away from the miner (see Figure 9-5).

Figure 9- 5. Position of Passive Monitor Badge

3. Instructions to the Miner

a. Explain to the miner what you are doing, what the sampling device does, and the reason for the sampling (i.e., the hazard). If available, issue a Miner Health Hazard Information Sheet or Card.

b. Instruct the miner not to remove the badge at any time or cover it with a coat or anything else. If the miner must leave the mine property or work area during the shift, the inspector should remove the sampling badge and cap it. Sampling should resume once the miner returns.

c. Instruct the miner not to abuse or tamper with the badge.

d. Emphasize the need for the miner to continue to work in a routine manner and report to you any unusual occurrences during the sampling period.

e. Inform the miner when and where you will remove the badge and that you will be checking the badge throughout the shift.

4. Collect the Sample

a. When the badge has been attached, record the following in the Health Field Notes:

- Time the badge was opened and attached;
- Badge identification number;
- Miner's name, job title, and work location(s);
- Shift hours per day and days per week worked;
- Any respirator worn or expected to be worn (brand, model, type of filters); and
- Whether an acceptable respiratory protection program exists (see Chapter 16 for criteria for evaluating a respiratory protection program).

b. Check the condition and positioning of the badge as frequently as practical to determine that a representative sample is being conducted of the normal activities. Record what tasks the miner has performed in the time between subsequent checks, so that the completed Health Field Notes describe the miner's full work shift. This requirement does not necessarily preclude the inspector from doing other inspection work while sampling.

c. Throughout the shift, record all other pertinent information in the Health Field Notes:

- Times the badge was checked; if the badge needs to be removed or replaced for any reason, record the times involved;
- Activity of miner, equipment operating in the area, and approximate time spent at each activity;
- General description of controls in use and whether or not they seem adequate;
- Potential sources of exposure, a general description of these sources, number of persons affected, and possible additional control measures;
- Any other samples taken and the results, if available (e.g., noise, detector tubes, sorbent tubes); and
- Environmental conditions (such as wind conditions, temperature, and humidity).

d. Collect the badge from the miner. Cap the badge and record the time. If the badge has a sample container, place a sample seal on the container. Date and sign the seal (see Figure 9-6). Otherwise, place a sample seal on the badge. Date and sign the sample seal.

Figure 9- 6. Sealed Passive Monitor Badge Container

C. Bulk Samples

It is not necessary to collect bulk samples during sorbent media sampling, unless stated in Chapter 3 for the specific contaminant. However, when unknown substances are encountered during an inspection and analysis would help to identify specific contaminants for future exposure sampling, collect a bulk sample.

When a bulk is required:

1. Collect a minimum of one bulk sample of the suspected source of the contaminant. **Do not collect bulk samples of highly flammable or extremely toxic materials**.

2. Wear appropriate personal protection when collecting the bulk sample.

3. Label the container as the "bulk sample." Containers for liquid samples must be glass with Teflon®-lined caps to prevent leaching of components from a plastic container by solvents.

4. Place a sample seal on the bulk sample.

5. Place the bulk sample in a separate container from the sample tubes or badges to prevent contamination. Ship the bulk sample(s) to the MSHA Laboratory for analysis.

VII. Post-Inspection Procedures

A. Review Health Field Notes

Check that you have recorded all necessary information in the Health Field Notes (MSHA Form 4000-31); refer to Chapter 21, Section V.

B. Post-Survey Calibration of Sampling Pump (when necessary)

Check the sampling pump calibration using the procedures in Chapter 4.

C. Transport Samples for Analysis

1. Complete the Request for Laboratory Analysis Form (MSHA Form 4000-29) for air samples and blanks (refer to Chapter 21, Section VII).

- Item No. 15 (sample type) - designate “OV” for organic vapor sample passive badge, “HG” for mercury vapor sample (hopcalite tube), “CT” for charcoal tube, “ST” for silica gel tube, “MISC” for florisil tubes, or “CB” for blank sorbent tubes or badges.

- Item No. 16 (analysis desired) - identify analysis desired. For example, “mercury,” “BTEX” (benzene/toluene/xylene group), “alcohols” (e.g., ethanol, isopropyl, methanol), “petroleum distillates” (e.g., gasoline, kerosene, mineral spirits), or the name of the individual contaminant(s). Refer to Chapter 3.

2. Ship the Request for Laboratory Analysis Form(s) and samples to the MSHA Laboratory. Blank sorbent tubes and badges should be shipped together with the exposure samples if space allows.

VIII. Compliance Determination

A. Sorbent Tubes

The laboratory will return an analytical report that will include the sample weight, concentration, TLV® or STEL, error factor, and calculated enforcement TLV® (TLV® times error factor). A PEDS or ASDS will also be generated as appropriate. Determine compliance by comparing calculated exposure concentrations with respective exposure limits. Exposure concentrations are calculated using the following formulae (round concentrations to two decimal places). The error factors for sorbent media sampling will be supplied by the MSHA Laboratory.

1. Full-Shift Sample - Shift-Weighted Average (SWA)

Calculate full-shift exposure using the following formula with 480 minutes regardless of the actual duration of the sample:

$$\frac{\text{weight of contaminant (mg)*}}{\text{Flow rate (Lpm) x 480 (min) x 0.001 (m}^3\text{/L)}} = \text{SWA in mg/m}^3$$

***Note: weight of contaminant is the weight of the full-shift tube or the sum of the weights of consecutive tubes.**

2. Short-Term Sample - Time-Weighted Average (TWA)

Calculate the concentration for each contaminant from the following:

$$\frac{\text{weight of contaminant (mg)}}{\text{Flow rate (Lpm) x sampling time (min)* x 0.001 (m}^3\text{/L)}} = \text{TWA in mg/m}^3$$

***Note: sampling time should not exceed 30 minutes.**

For organic solvents with TLVs® expressed in units of ppm, the MSHA laboratory reports the concentrations as ppm. The following formula is used to convert mg/m^3 to ppm concentrations:

$$\frac{mg/m^3 \times 24.45}{MW} = ppm$$

where: MW = molecular weight of the compound.

B. Badges

For each badge, the results received from the MSHA laboratory will indicate the concentration (ppm, mg/m^3, etc.) for each contaminant requested and the appropriate error factor and associated TLV®. Refer to Chapter 3. Assay Technology will provide results of mercury badge analyses to both the inspector and the MSHA laboratory.

C. Additive Effects

See Chapter 2 for a discussion of additive effects and calculation examples.

IX. Report Writing

A. Inspection reports should include a copy of the Health Field Notes, the request for laboratory analysis form, laboratory reports, the completed Personal Exposure Data Summary (PEDS), calculation worksheets, citation/orders, and any other supplemental information collected during the inspection.

B. When completing the PEDS (refer to Chapter 21, Section VIII), be sure that the concentration and exposure limit units of measurement are the same as those listed for the contaminant code (refer to Chapter 3).

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CHAPTER 10
IONIZING RADIATION

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Chapter 10
IONIZING RADIATION

I. Introduction

This chapter includes sampling procedures for evaluating four types of ionizing radiation hazards**:** ***alpha, beta, gamma, and x-ray*****.** Ionizing radiation can cause cancer. At high doses, ionizing radiation causes radiation sickness. Ionizing radiation can be emitted by the mined ore, the surrounding rock, or nuclear gauges such as those that monitor the flow of materials. Miners can be exposed to hazardous levels of ionizing radiation at mines other than those producing radioactive minerals.

II. Definitions

Alpha Counter/Scaler - an instrument that counts alpha decay events when used with a scintillation detector.

Alpha Radiation - a **particle** that has a positive (+2) charge and is emitted from the nucleus of an atom. An alpha particle consists of two protons and two neutrons. When inhaled, dust containing alpha producing particles can cause lung cancer. While alpha particles travel at a high energy rate, they are so large that a sheet of paper or a few centimeters of air can block their path. Alpha particles are emitted by radon, uranium, and thoron. Examples of alpha emitters are uranium-238, radium-226, and radon-222.

Beta Radiation - a **particle** that has a negative (-1) charge and is emitted from the electron shell of an atom. A beta particle consists of one electron. Beta radiation has more penetrating capability than alpha radiation because the particle is much smaller. Even so, a light-weight barrier material, such as cardboard or sheet metal, can block beta radiation.

Gamma Radiation - short wavelength electromagnetic radiation emitted from radioactive elements such as uranium. Lead or concrete can block this type of radiation.

Geiger-Mueller counter - small hand-held meter designed to measure x-ray and gamma radiation.

Half-life - the time required for a radioactive substance to lose 50 % of its activity by decay. Each radionuclide has a characteristic half-life.

Ionizing Radiation - a form of energy capable of changing a stable, electrically-neutral atom into an unstable electrically-charged particle (ion). Radiation from uranium, radon, and other radioactive sources is ionizing.

Isotope - a form of an element that differs from other forms of the same element in the number of neutrons in each atom's nucleus. Isotopes of the same element may have different levels of stability and potential radioactivity.

Kusnetz method - a method for determining exposure to alpha radiation emitted from radon and thoron daughters/progeny. It was developed in the 1950's by H. L. Kusnetz.

Radioactive decay - the natural process of a radioactive material shedding mass from its nucleus. After each decay event, another element or isotope of lesser mass is formed. The decay process trends toward more stable elements with elemental lead (Pb 207) the most stable.

Radon - the radioactive gas produced by the radioactive decay of the element radium.

Radon Daughters/Radon Progeny - unstable, short-lived decay products of radon gas which emit alpha particles during the decay process. (Terms are used interchangeably.)

REM - abbreviation of **Roentgen Equivalent Man** - a unit for measuring the absorbed dose by humans (and biological effects) of ionizing radiation. Personal exposure limits for gamma and X-Ray radiation are expressed in REMs.

Roentgen (R) - a unit for measuring X-rays or gamma rays. For radiation protection, one R equals the dose measurement of one REM.

Scintillation detector - type of detector used to determine alpha emissions from filter samples. Operates as photons are released from a zinc sulfide phosphor and amplified with a photo-multiplier tube. Works in train with an alpha scaler/counter.

Thoron - a gas formed from the radioactive decay of thorium (Th), an element. Thoron is similar to radon as a health hazard in that respirable thoron daughters/progeny emit alpha radiation. It is an isotope of radon gas.

Working level (WL) - the unit of measurement of airborne radon or thoron alpha particles in an area. Working levels are used to express the concentrations of radon daughters in underground mines for compliance sampling. It is calculated by the general formula:

$$\text{WL} = \text{Radiation Level X Time (hours)}$$

Working level months (WLM) - the unit of measurement for determining compliance with the annual exposure limit for miners. A lung dose of 10 REM is equal to 1.0 WLM. For compliance determination, 30 CFR § 57.5040 requires WLM be calculated by the following formula:

$$\text{WLM} = \frac{\text{Number of hours exposed in a month X average WL}}{\text{173 hours per month}}$$

X-ray radiation - is similar to gamma radiation in that it is a ray and not a particle but different in that it is man-made versus naturally-occurring radiation. X-rays are produced when a focused electron beam is aimed at a Tungsten surface resulting in an emanation of high energy, highly penetrating radiation. Lead or thick concrete can block this type of radiation.

III. Standards Applicable to Ionizing Radiation

A. Exposure Limits

Title 30 CFR §§ 57.5037 through 57.5047 contain the ionizing radiation exposure limits for miners:

1. Miners shall not be exposed to air having a radon daughter concentration exceeding 1.0 working level (WL) in active workings.

2. Ventilation is the primary means for controlling radon daughters to below the allowable exposure limits. However, respirators approved by NIOSH for radon daughters shall be used in atmospheres whose radon daughter concentrations exceed 1.0 WL.

3. If the WL concentration exceeds 10 WL, protection against radon gas shall be provided by supplied air devices or by face masks containing absorbent material capable of removing both radon and its daughters.

4. No miner shall be exposed to more than 4.0 WLM in any calendar year.

5. Annual individual gamma radiation exposure shall not exceed 5 REMs.

B. Sampling requirements

1. Underground Non-Uranium Mines

a. **Screening Frequency** - Annually sample all metal and nonmetal mines where radon daughters have exceeded 0.1 WL in the past, per 30 CFR § 57.5037(a). Sample remaining nonmetal and stone mines every three years. Sample new or reopened mines as soon as possible. Sample exhausts (return airways) and poorly ventilated areas for radon daughters. Where any screening sample exceeds 0.1 WL, follow the additional procedures below.

b. **Concentration 0.1 WL** - Sample all active work areas four times annually (Full-Time Permanent - FTP) or whenever conducting a regular inspection (Intermittent - INT). Also evaluate the mine operator's (quarterly) sampling procedures for possible inadequacies.

Monitor mine operator compliance with 30 CFR §§ 57.5037(a)(2), 57.5038, 57.5039, 57.5040(a)(2), 57.5041, 57.5044, 57.5045, and 57.5046 where radon/thoron daughters concentrations exceed 0.3 WL.

Check the mine operator's sampling records and thoroughly sample any work area exceeding 0.3 WL. A mine operator may invoke the five consecutive week provisions of 30 CFR §§ 57.5037 and 57.5040. If MSHA sampling verifies the mine operator's claims that alpha emissions have remained under 0.3 WL, the operator can suspend weekly sampling in favor of quarterly sampling.

However, the mine operator must continue weekly sampling and worker exposure record keeping if MSHA results exceed 0.3 WL.

2. Underground Uranium Mines

a. **Sampling Frequency** - Sample all active work areas for both radon and thoron daughters four times annually or whenever a regular inspection is conducted. Also, monitor compliance with 30 CFR §§ 57.5037 and 57.5040. Where any sample exceeds 0.1 WL, follow the additional procedures below:

b. **Concentration 0.1 WL** - Evaluate the mine operator's sampling procedures and employee exposure records to verify conformity to the standard.

Monitor mine operator compliance with 30 CFR §§ 57.5037, 57.5038, 57.5039, 57.5041, 57.5044, 57.5045 and 57.5046 where radon daughters concentrations exceed 0.3 WL.

Check the mine operator's sampling records and thoroughly sample the area in question if an operator invokes the five consecutive week provisions of 30 CFR §§ 57.5037 and 57.5040. If MSHA sampling verifies the operator's findings, the mine operator can revert to biweekly sampling. If MSHA sampling results exceed 0.3 WL, however, the operator must continue weekly sampling.

c. **Screening for Gamma Radiation** - Perform annual gamma radiation screening in all underground mines where radioactive ores are mined. Monitor compliance with 30 CFR § 57.5047.

- Average readings in excess of 2 milliroentgens per hour (mR/hr) require implementation of personal dosimeters for all persons affected. Note: 2 milliroentgens per hour is equivalent to 2 millirems per hour.

- Perform calculation presented in Appendix to obtain projected shift exposure. Multiply projected shift exposure by the number of shifts per week if doing a one day screening and divide by 1000 to obtain estimated REM value for a work week. Compare this calculation with records to check the consistency of recorded exposures with calculated exposures. Any significant discrepancy should be investigated.

- Records of cumulative individual exposures should be checked to ensure compliance with 5 REM annual exposure limit.

- Failure to provide personal dosimeters and keep records of cumulative individual exposures are citable offenses when circumstances require, (see item 1 above.)

C. Nuclear Gauges

For those operations that have radiation sources or nuclear gauges, the inspector should:

1. Review the Nuclear Regulatory Commission (NRC) license;

2. Check the provisions of the NRC license during inspections; and

3. If violations are found, inform the office issuing the license.

D. Other Related Standards

56/57.15006 - Protective equipment and clothing for hazards and irritants.
Application: this would apply to high concentrations of alpha radiation (1 WL and above) where respirators are required, and when working around x-ray and gamma radiation where lead vests may be required.

56/57.16003 - Storage of hazardous materials.
Application: gamma sources such as cobalt isotopes must be kept in lead-shielded containers.

56/57.16004 - Containers for hazardous material.
Application: same as 56/57.16003.

56/57.18002 - Examination of workplace.
Application: may apply where nuclear gauges and laboratory assay equipment are in use.

56/57.18006 - New employees.
Application: new employees should be taught best practices for working around nuclear gauges and other radioactive equipment and environments.

56/57.20011 - Barricades and warning signs.
Application: should be placed wherever radioactive sources are used and where background levels of radiation in mine exceed the standard; i.e., 0.3 WL for alpha and 2 mR/hr for gamma.

56/57.20012 - Labeling of toxic materials.
Application: radioactive sources should be clearly labeled as such at all times.

IV. General Sampling Guidelines

The time spent in an area and the radiation concentration in that area are used to calculate a miner's personal exposure. The following table outlines the ionizing radiation sampling instruments available to inspectors:

Table 10-1. Radiation Detection Instruments Used by MSHA

Model Number	Common Name	Company	Radiation Type	Method	Appendix Section
L-2000	Scaler	Ludlum	Alpha*	Kusnetz	I & II
L-2200	Scaler	Ludlum	Alpha*	Kusnetz	I & II
L-1000	Scaler	Ludlum	Alpha*	Kusnetz	I & II
PS-1, PS-2***	Scaler	Eberline	Alpha*	Kusnetz	I & II
PRS-2	Rascal	Eberline	Gamma	DRI**	V
L-2	Geiger-Mueller	Ludlum	Gamma Beta	DRI**	V

*radon
**DRI – Direct Reading Instrument
***being replaced by Ludlums

A. Sampling Non-Uranium Mines

1. Only a few radon samples are necessary for a preliminary evaluation. Sample the main return airways (exhausts) and any poorly ventilated travelways or work areas. If the counts from these samples indicate less than 0.1 WL, it can be assumed that the health hazard does not exist. No further sampling for radon daughters is required for the remaining active working areas. Several samples may be taken before the filters need to be counted.

2. If the radon daughter level in the return exceeds any of the levels in 30 CFR §§ 57.5037 through 57.5047, samples in the active work areas must be collected.

B. Sampling Uranium Mines

1. For radon samples, select locations that are most representative of the miner's average exposure.

2. When in doubt, sample all prominent work stations, giving priority to the face and out of the way work areas**.** Take representative samples in all active stoping areas, travelways, shops, lunch rooms, and other occupied mine areas.

C. Guidelines for Enforcement Sampling For Alpha Radiation

1. Follow the sampling strategies outlined in paragraphs A. and B. above.

2. Check air currents at the sampling locations for unusual conditions, using a smoke-cloud producing apparatus and/or anemometer.

3. Measure and record the ventilation quantity at the time and place of sampling.

4. Take ample notes regarding all conditions which might affect radon daughter concentrations in the areas sampled.

5. Follow good sampling procedures.

6. Take all possible precautions to maintain the integrity of the calibration sampling equipment.

7. Take as many samples as necessary to determine compliance with the applicable standard and to establish an appropriate time limit for the abatement of any citations which are issued.

D. Collecting the Sample

1. Pump and Filter Sampling Combination Kusnetz Method

a. Calibrate sampling pump at 2.0 Lpm or more (up to the stable limit of your personal sampling pump), using the procedures in Chapter 4, and calibrate the readout instrument.

b. Use a 25 mm fiberglass filter (Gelman Type AE). Identify the filter with a unique number gently using a gel type pen, a felt tip pen or soft lead pencil. **Caution**: Handle and write with care; the fiberglass filters are very delicate and easily cracked or broken. The fiberglass filter has a semi-smooth "waffled" pattern side and a rough side. The filter should be placed in the cassette holder with the semi-smooth waffled side facing the sampling pump and the rough side exposed to the mine atmosphere. The sampling set-up is shown in Figure 10-2.

Figure 10-2. Sampling Set-up

c. Turn on sampling pump for 5 minutes.

d. Record in the Health Field Notes (refer to Chapter 21, Section V):

- Time the sampling pump started;
- Pump identification number;
- Miner's name and job title (if personal sample), and work location;
- Shift hours per day and days per week;
- Any respirator worn or expected to be worn (brand, model, type of filters); and
- Whether an acceptable respiratory protection program exists (see Chapter 16 for criteria for evaluating a respiratory protection program).

e. Throughout the shift, record all other pertinent information in the Health Field Notes:

- Controls in use with general description and whether or not they seem adequate;
- Potential sources of exposure, a general description of these sources, number of persons affected, and possible additional control measures;
- Activity of miner, equipment operating in the area, and approximate time spent at each activity; and
- Any other samples taken (e.g., detector tubes, badges, noise, etc.) and results, if available.

f. After the sampling period has ended, turn off the sampling pump, record the time, and place the cassette containing the filter in a safe place for counting. It may be possible to sample several areas before counting.

g. Analyze the sample filters between 40 and 90 minutes after sample has been taken, and record all results.

2. Hand-Held Direct Reading Instruments, i.e., Geiger-Mueller counters.

a. Check battery level.

b. Calibrate sampling instrument.

c. Turn on the instrument and Record in the Health Field Notes:

- Time the instrument turned on and off;
- Instrument identification number;
- Miner’s name and job title (if personal sample), and work location;
- Shift hours per day and days per week;
- Any respirator worn or expected to be worn (brand, model, type of filters); and
- Whether an acceptable respiratory protection program exists (see Chapter 16 for criteria for evaluating a respiratory protection program).

d. Throughout the shift, record all other pertinent information in the Health Field Notes:

- Controls in use with general description and whether or not they seem adequate;
- Potential sources of exposure, a general description of these sources, number of persons affected, and possible additional control measures;
- Activity of miner, equipment operating in the area, and approximate time spent at each activity; and
- Any other samples taken (e.g., detector tubes, badges, noise, etc.) and results, if available.

E. Instructions to the Miner

1. Tell the miner what you are doing, what the sampling device does, and the reason for the sampling (i.e., the hazard). If available, issue a Miner Health Hazard Information Sheet or Card.

2. Emphasize the need for the miner to continue to work in a routine manner and report to you any unusual occurrences during the sampling period.

F. Conditions for Repeat Sampling

The standards do <u>not</u> require more than one sample for the purposes of enforcing safe environmental standards. However, multiple samples are often beneficial, (refer to statements in III.B.1.).

V. Post-Inspection Procedures

A. Review Health Field Notes

Check that you have recorded all necessary information in the Health Field Notes (MSHA Form 4000-31).

B. Post-Inspection Calibration of Sampling Pump

Check the sampling pump, using the procedures in Chapter 4.

C. Post-Inspection Calibration Check of Alpha Detector and Scaler

Check the instrument for proper operation with the alpha assigned source.

D. Post-Inspection Calibration Check of Geiger-Mueller Counter

Check the instrument for proper operation, using the gamma radiation source attached to the side of the detector box.

E. Data Summary Forms (ASDS and PEDS)

When completing the Area Sample Data Summary (ASDS) - refer to Chapter 21, Section IX) or Personal Exposure Data Summary (PEDS) - refer to Chapter 21, Section VIII), be sure that the contaminant code and concentration and exposure limit units of measurements are as follows:

Contaminant Code	Contaminant	Units
801	Alpha Radiation	WL
803	Gamma Radiation	mR/hr

F. Error Factor

The error factor for determining compliance, using radiation instrumentation outlined in the Appendix to this Chapter, is 1.3 (or 30 %).

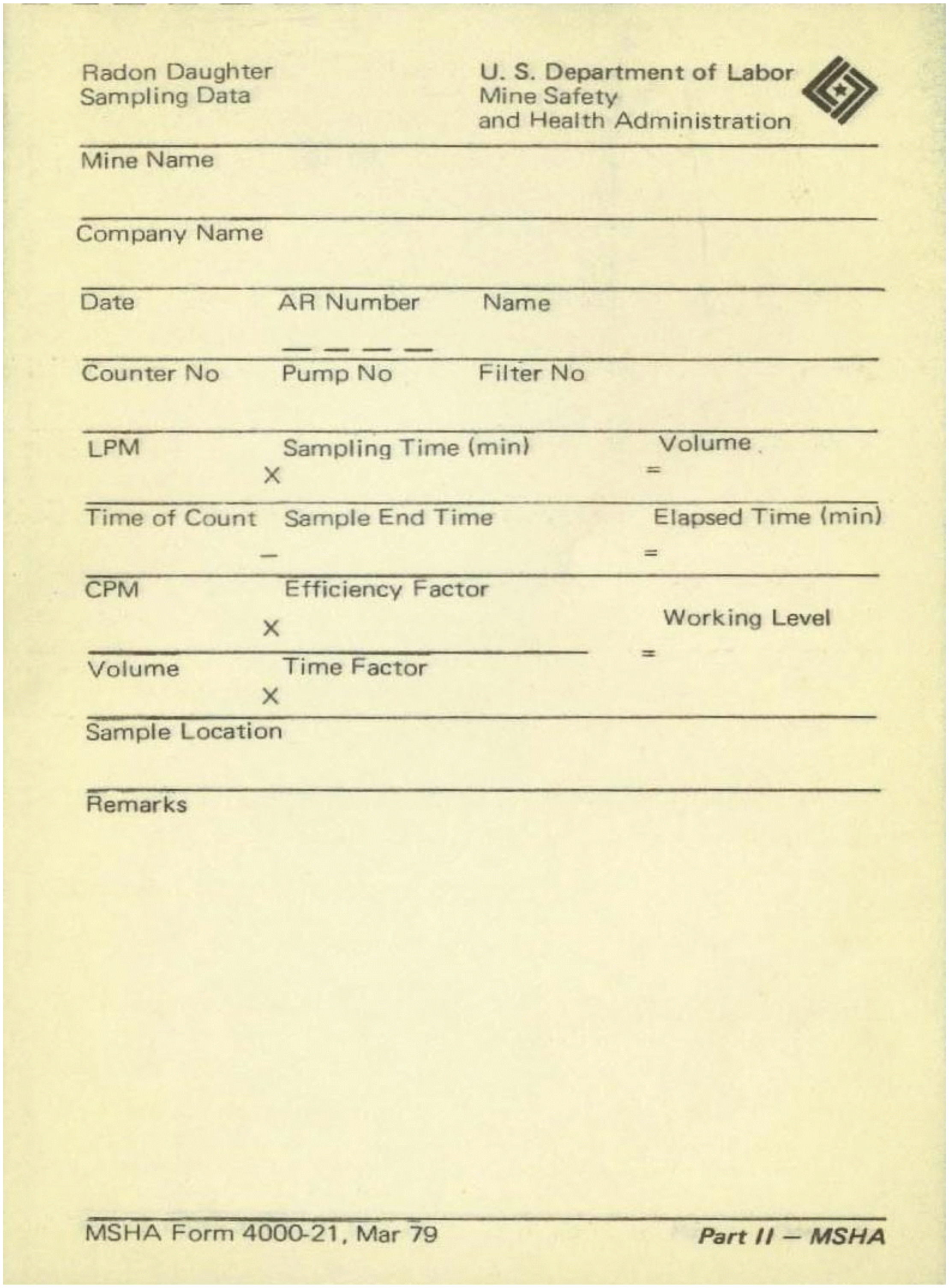
G. Radon Daughter Sampling Data Form (MSHA Form 4000-21)

Complete this form when sampling is conducted at underground mines for radon daughters using the Filter and Sampling Method (see Figure 10-3).

VI. Recordkeeping

Inspection reports should include a copy of the Health Field Notes, the completed Area Sample Data Summary (ASDS), Personal Exposure Data Summary (PEDS), Radon Daughter Sampling Data Form, citation/orders, and any other supplemental information collected during the inspection.

Figure 10-3. Radon Daughter Sampling Data Form



Radon Daughter
Sampling Data

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

Mine Name

Company Name

Date | AR Number — — — — | Name

Counter No | Pump No | Filter No

LPM × Sampling Time (min) = Volume

Time of Count − Sample End Time = Elapsed Time (min)

CPM × Efficiency Factor
Volume × Time Factor
= Working Level

Sample Location

Remarks

MSHA Form 4000-21, Mar 79 *Part II — MSHA*

CHAPTER 10 – APPENDIX
RADIATION SAMPLING INSTRUMENTATION

Chapter 10 - Appendix
Radiation Sampling Instrumentation

I. Kusnetz Equipment and Accessories

A. Filter and Cassette

1. Filter - MSHA uses the 25 mm diameter Gelman, Type AE, glass fiber filters for the Kusnetz method of radon and thoron daughters sampling. Keep the filters dry, free of dirt, and intact.

2. Sampling Cassette - Ludlum and Eberline instruments use a two-piece plastic filter holder or cassette which attaches to the pump, usually with surgical rubber or Tygon tubing (refer to Figure 10-2).

B. Sampling Pump

Operation and Calibration - For all methods of radon daughters sampling, MSHA uses personal monitoring pumps that draw at least 2.0 Liters of air per minute (Lpm) through a filter and filter holder. For sampling, all pump by-passes must be closed. Operate and calibrate the pumps in accordance with Chapter 4.

C. Scalers and Detectors

The most common scaler that MSHA uses for counting alpha radiation in the field is the Ludlum Model 2000 (see Figure 10A-1). This model is used when following the Kusnetz method to determine radiation exposure in working levels. The scaler is connected to a detector with a high voltage cable. The most common detectors are the Ludlum 43-9 and the Eberline SPA-1.

Note: After a scaler and a detector are calibrated <u>as a unit</u>, they must <u>not</u> be interchanged with similar pieces from another instrument.

Figure 10A-1. Ludlum 2000 with accessories

D. Accessories

1. Thorium Standard (Th-230)

2. Batteries

   a. Check the battery condition on all instruments before use because low batteries can cause misleading results. For those instruments for which the battery condition cannot be checked before operation, count the Th-230 standard to confirm proper operation.

   b. Alkaline batteries may be used in the instruments, but they cannot be re-charged. Recharging may cause them to explode and corrode the inside of the instrument.

   c. <u>Remove the batteries</u> when an instrument is to be stored more than two weeks, or is sent in for recalibration.

3. Rechargeable Batteries

   a. Ludlum instrument rechargeable batteries have a trickle charger and should be left on charge whenever possible. Eberline instrument batteries require 100 hours for an initial full charge, and should not be overcharged. Nickel-Cadmium (NiCad) batteries have an almost indefinite life, if they are fully discharged and then fully recharged occasionally.

b. Operate all instruments on battery power only.

4. High Voltage Connections

a. Keep all connections between the high voltage cord and the scaler and detector clean.

b. Do not adjust high voltage screws and discriminator screws. These are for calibration adjustments only.

E. Calibration Policy

1. Periodic Calibration

Field alpha counters are calibrated by the Physical and Toxic Agents Division, Pittsburgh Safety and Health Technology Center. Instruments need to be recalibrated whenever the following occurs:

a. The instrument has been repaired;

b. The Th-230 source count rate consistently deviates by more than 10% of the count obtained at the time of calibration; or

c. Six months have elapsed since the last calibration.

For calibration send instruments to:
MSHA Laboratory
PSHTC Alpha Detector Calibration
Cochrans Mill Rd, Bldg 38
P.O. Box 18233
Pittsburgh, PA 15236
Ph. 412-386-6984

2. Calibration Check

a. Before and after counting a batch of field samples, check instrument reliability by counting the Th-230 standard in the detector for one minute. Do not move the instruments during counting. If the instrument is operating properly, the count rate obtained with the standard should be within ± 10 % of the average count rate obtained at the time of calibration.

b. To ensure that an instrument is operating properly, first count the Th-230 standard and then get a count with nothing in the detector slide (background count). The background count rate should be less than 5 counts per minute (cpm). If the background level is too high, contact the District Office for guidance.

c. Keep the Th-230 standard clean and touch only the edges or back side of the disk. Dirt or oil deposited on the front side of the disk may affect the performance of the check standard.

d. The back side of the standard has a serial number on it. Store the standard with the back side up (shiny side down).

F. Warnings - Electrical Noise

1. Do not use the instruments near power supplies such as electric generators. Electrical noise may be picked up by the instruments.

2. Obtain a background count at the sampled location to check for electrical noise.

II. Kusnetz Sampling Method

A. Radon Daughters/Progeny Working Levels

1. Calibrate the pump to draw 2.0 Lpm or more with a representative filter and filter holder in line. <u>Higher flow rates improve the counting statistics and should be used whenever possible</u>. Pump calibration procedures are provided in Chapter 4 of this Handbook.

2. Number each filter with a gel type pen, a felt tip pen or a soft lead pencil and each filter cover cap and holder before sampling. With a filter in place, assemble the filter holder snugly to ensure that air will not leak around the filter during sampling. The woven pattern side of the filter is the back side (downstream) and should be placed against the screen half of the cassette.

3. Carry several pre-loaded and numbered filter holders to the mine.

4. Choose the location(s) to be sampled before beginning the survey.

5. Assemble the sampling train. Connect the filter holder with the open face away from the pump (upstream).

6. Start both the pump and the stopwatch at the same time.

7. Time each sample for exactly 5 minutes.

8. Place the contaminated filter in a safe location until it is counted 40 to 90 minutes later. Leaving the filter in the cassette until counting is acceptable.

9. More samples may be taken before counting, if time allows.

10. Before and after counting a batch of filters, check the counter reliability by counting the Th-230 source supplied with the counter.

11. For radon daughters, each sample must be counted 40 to 90 minutes after the end time of the sample. To improve accuracy, the count time can be two or more minutes. For long count times, use the midpoint of the counting time when determining the time factor used in the formula noted in 12 below. The count rate used in the calculation is the total of the counts indicated divided by the number of minutes of counting.

12. The radon daughters working level is calculated by completing MSHA Form 4000-21. The formula used on the form is shown below:

$$WL = \frac{CPM \times EF}{Vol \times TF}$$

Where:

WL = radon daughters concentration in working levels
CPM = count rate of sample in counts per minute
EF = efficiency factor of counter indicated on probe
Vol = total sample volume in liters
TF = time factor from Table 10A-2

13. Complete **Radon Daughter Sampling Data Form** (MSHA Form 4000-21). Be sure to include the following under Remarks on MSHA Form 4000-21:

- Number of workers at location sampled;
- Description of work being performed or equipment operating;
- Respirator usage and approval number; and
- Ventilation conditions (estimated air volume).

14. Report sampling on Area Sampling Data Summary Sheet, MSHA Form 4000-42

Table 10A-2. Time Factor for Calculating Radon Daughters/Progeny Working Levels

Elapsed time after sampling, minutes	Time Factor	Elapsed time after sampling, minutes	Time Factor	Elapsed time after sampling, minutes	Time Factor
40	150	57	116	74	84
41	148	58	114	75	83
42	146	59	112	76	81
43	144	60	110	77	80
44	142	61	108	78	78
45	140	62	106	79	77
46	138	63	104	80	75
47	136	64	102	81	74
48	134	65	100	82	72
49	132	66	98	83	71
50	130	67	96	84	69
51	128	68	94	85	68
52	126	69	92	86	66
53	124	70	90	87	65
54	122	71	89	88	63
55	120	72	87	89	62
56	118	73	86	90	60

B. Thoron Daughters/Progeny Working Levels

1. Repeat steps 1 through 10 in Section I.A above. The time for collecting the sample may be more than 5 minutes and the same volume over 50 L of air when sampling for only thoron daughters. A simple thoron screening may be done with as little as 10 L of air which permits using the filters counted earlier for radon.

2. For thoron daughters, each sample count must be performed between 5 and 17 hours after the end of the sample collection period. Saving the radon daughters filters after counting them is therefore necessary. To improve accuracy, the counting period time should be 5 or more minutes.

3. The thoron daughters working level is now calculated by completing MSHA Form 4000-21; however, a <u>different time factor</u> table is used for thoron daughters than is used for radon daughters. The formula used on MSHA Form 4000-21 is:

$$WL = \frac{CPM \times EF}{Vol \times TF}$$

Where: WL = thoron daughters concentration in working levels
CPM = count rate of sample in counts per minute
EF = efficiency factor of counter
Vol = total sample volume in liters
TF = time factor from Table 10A-3

4. When mixtures of thoron and radon daughters are found, the radon daughters concentrations obtained by the Kusnetz method must be corrected. The values that must be subtracted from the radon daughters concentrations are listed in Table 10A-4. Once it has been determined that thoron is not a factor in a given mine, it is not necessary to screen for thoron each time radon samples are taken; every two to three years should be adequate.

Table 10A-3. Time Factors for Calculating Thoron Daughter Working Levels

Elapsed time after sampling, hours	Time factor	Elapsed time after sampling, hours	Time factor	Elapsed time after sampling, hours	Time factor
5.0	13.00	9.0	9.95	13.0	7.75
5.2	12.84	9.2	9.83	13.2	7.65
5.4	12.67	9.4	9.71	13.4	7.55
5.6	12.52	9.6	9.59	13.6	7.45
5.8	12.36	9.8	9.47	13.8	7.35
6.0	12.20	10.0	9.35	14.0	7.25
6.2	12.03	10.2	9.24	14.2	7.16
6.4	11.86	10.4	9.13	14.4	7.07
6.6	11.69	10.6	9.02	14.6	6.98
6.8	11.52	10.8	8.91	14.8	6.89
7.0	11.35	11.0	8.80	15.0	6.80
7.2	11.21	11.2	8.69	15.2	6.71
7.4	11.07	11.4	8.58	15.4	6.62
7.6	10.93	11.6	8.47	15.6	6.53
7.8	10.79	11.8	8.36	15.8	6.44
8.0	10.65	12.0	8.25	16.0	6.35
8.2	10.51	12.2	8.15	16.2	6.25
8.4	10.37	12.4	8.05	16.4	6.15
8.6	10.23	12.6	7.95	16.6	6.05
8.8	10.09	12.8	7.85	16.8	5.95
----	----	----	----	17.0	5.85

C. Example of Calculations

1. Computing Radon Daughters/Progeny Working Levels (WL, Kusnetz)

   a. Sample volume (Vol) = 2.1 Lpm x 5 min. = 10.5 liters.

   b. Efficiency factor of the counter (EF) = 3.3 (factor, labeled on each scaler or detector).

   c. Time at beginning of sample = 10:10.

   d. Time at end of sample = 10:15.

   e. Time of counting = 11:05.

   f. Count rate (CPM) = 260 CPM.

   Note: For count time of over 1 minute, CPM = total count/count time (min)

   g. Elapsed time between end of sample and time of counting = 50 minutes (10:15 to 11:05).

   h. Time factor (TF) = 130 (from Figure 10A-2).

   i. Radon Daughters WL =

$$\frac{\text{CPM x EF}}{\text{Vol x TF}} = \frac{260 \text{ x } 3.3}{10.5 \text{ x } 130} = 0.63 \text{ WL}$$

2. Computing Thoron Daughters Working Levels (WL, Kusnetz)

   a. Sample volume (Vol) = 2.1 Lpm x 5 min. = 10.5 liters

   Note: Take a longer sample if <u>only</u> thoron daughters are to be measured (sample up to 1 hour).

   b. Counter efficiency factor (EF) = 3.3.

   Note: This is the same EF as used for radon daughters.

   c. Time at beginning of sample = 10:10.

d. Time at end of sample = 10:15.

e. Time of counting = 16:15 (16:11 to 16:18).

Note: Use midpoint of the counting time of count if count is longer than 1 minute.

f. Count rate (CPM) = 23 counts/7 min = 3.3 CPM.

Note: For count time of over 1 minute, CPM = total count/count time (min).

g. Elapsed time between end of sample and time of counting = 6.0 hours (10:15 to 16:15).

h. Time factor (TF) = 12.20 (from Figure 10A-3).

i. Thoron Daughters WL =

$$\frac{\text{CPM x EF}}{\text{Vol x TF}} = \frac{3.3 \text{ x } 3.3}{10.5 \text{ x } 12.20} = 0.08 \text{ WL}$$

3. Computing Mixtures of Radon and Thoron Daughters (WL, Kusnetz)

a. Compute radon daughters concentrations as in C.1.a through h. above.

b. Compute thoron daughters concentrations as in C.2.a through i. above.

c. Correct radon daughters concentration for thoron daughters present during radon daughters count by reducing radon daughters WL by factor in Figure 10A-4. For example:

Radon daughters concentration = 0.63 WL at 50 minutes

Thoron daughters concentration = 0.08 WL at 6.0 hours

Correction from Figure 10A-4 = 0.02 WL

Corrected radon daughters WL = 0.63 - 0.02 = 0.61 WL

d. Total exposure rate =
radon daughters WL + thoron daughters WL = 0.61 + 0.08 =
= 0.69 WL

Table 10A-4. Reduction of Radon Daughter Concentrations (WL) for Thoron Daughters Present

Measured thoron daughter concentration, WL	Radon daughter count time, minutes					
	40	50	60	70	80	90
0.1	0.01	0.02	0.02	0.02	0.03	0.03
0.2	0.02	0.02	0.03	0.03	0.04	0.05
0.3	0.03	0.04	0.05	0.06	0.07	0.08
0.4	0.04	0.05	0.06	0.08	0.08	0.10
0.5	0.05	0.06	0.07	0.09	0.11	0.13
0.6	0.07	0.08	0.09	0.11	0.13	0.17
0.7	0.08	0.09	0.11	0.12	0.15	0.18
0.8	0.09	0.11	0.12	0.14	0.17	0.22
0.9	0.10	0.12	0.14	0.17	0.20	0.23
1.0	0.11	0.13	0.15	0.19	0.23	0.28
1.2	0.13	0.15	0.18	0.22	0.25	0.32
1.4	0.15	0.18	0.21	0.26	0.31	0.37
1.6	0.18	0.21	0.24	0.29	0.35	0.43
1.8	0.20	0.23	0.27	0.32	0.39	0.48
2.0	0.23	0.25	0.30	0.37	0.43	0.53

III. Gamma and X-Ray Radiation Sampling

For those operations that have radiation sources and nuclear gauges, the inspector should review the Nuclear Regulatory Commission (NRC) license. These sources and gauges typically emit gamma radiation or X-rays. The inspector should check the provisions of the NRC license during inspections. If violations of the license agreement are found, the inspector should inform the office issuing the license and the company radiation safety officer (RSO), if one is designated in the license. If the inspector has questions about a particular license, the NRC lists the following toll-free numbers:

Region 1 (Northeastern states) - 800-432-1156
Region 2 (Southeastern states) - 800-577-8510
Region 3 (North Central states) - 800-522-3025
Region 4 (All other states) - 800-952-9677
24-hour emergency hotline - 301-816-5100

To sample for gamma and X-Ray radiation, MSHA inspectors presently use the Ludlum Model L-2 Geiger-Mueller scaler:

A. Operation Check

1. Slide the battery box button to the rear and open the lid. Do <u>not</u> twist the lid button; it slides to the rear. Install two size “D” alkaline batteries. Note (+) and (-) marks on the inside of the lid. Match the battery polarity to these marks.

   Note: Center post of size “D” battery is positive.

2. Close the battery box lid.

3. Move the range switch to BAT. The meter should deflect to the battery check portion of the meter scale. If the meter does not respond, recheck that batteries have proper polarity.

4. Connect the cable to the instrument and detector.

5. Turn the instrument range switch to X10. Expose the detector to the check source. The speaker should click with AUDIO ON-OFF switch to ON.

6. Move range to lower scales until the meter reading is indicated. The toggle switch labeled “F - S” should have fast response in “F,” slow response in “S.”

7. Depress the RES switch. The meter should zero.

8. Proceed to use the instrument.

Note: Never store the instrument more than 30 days without removing batteries. Although this instrument will operate at very high ambient temperatures, battery seal failure can occur at 100° F.

B. Procedure

Using the Geiger-Mueller Ludlum, walk slowly around the work area at a steady pace and obtain an average of the meter readings. Record this average and the high and low readings for the work area.

C. Gamma Radiation Exposure Calculations

- To calculate gamma radiation exposure, multiply the number of hours of exposure (the amount of time the worker is expected to remain in the area) by the exposure rate (mR/hr) of the area.

- If taking samples over a period of days such as a working week, add the daily exposures together to obtain the miner's cumulative exposure for the given time period.

- Divide mR by 1000 to convert to REMs.

- This calculated exposure level provides an estimate of a typical exposure in that working area for a given period of time. The inspector can then compare the calculated value with the company's individual exposure records. Differences greater than 10% should be investigated.

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CHAPTER 11
DETECTOR/DIFFUSION TUBE SAMPLING

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Chapter 11
DETECTOR/DIFFUSION TUBE SAMPLING

I. Introduction

Ambient air contains about 78% nitrogen, 21% oxygen, 0.04% (400 ppm) carbon dioxide, and small amounts of argon, helium, and other gases. If the concentrations of these gases change due to the addition of another gas, the potential for adverse health effects exists.

The list of other gases that might be present is extremely broad and the associated hazard of each varies considerably. The contaminant, its concentration, duration of exposure, and additive effects with other gases must all be considered. Although some gases have odors, the odors may not be detectable at concentrations below the exposure limits.

If there is a suspected hazard, the air should be tested to determine the substance that caused the change. To determine the hazard potential of a gas, it is necessary to measure its concentration. Detector tubes can be used for instantaneous measurements of approximately 350 different gases and vapors. Diffusion tubes can be used for full-shift sampling of approximately 20 of these contaminants.

II. Definitions

Detector tubes - small glass tubes with both ends flame-sealed which contain reagent chemicals. When the ends are broken and contaminated air is drawn through the tube, the reagent chemicals react with the gas or vapor to produce a color change (stain). The color change varies in length in proportion to the concentration of the contaminant.

Diffusion - the natural passage of gas or vapor from an area of high concentration to an area of lower concentration. When gases or vapor pass through a membrane, the rate of diffusion depends on the concentration of contaminants on each side of the membrane. In a diffusion tube, the gases or vapors will diffuse through the reagent chemical contained in the tube and cause a color change which corresponds to a time-dependent concentration.

Diffusion tube - a specialized detector tube that can be used as a passive monitor for long-term sampling of mine gases and vapors. The contaminants sampled enter the tube by natural diffusion of air. As gases or vapors diffuse through the tube, the chemicals within will react and produce a color change or stain which varies in length according to the concentration. Diffusion tubes are typically used during a work shift of up to eight hours, but can be used to determine average concentrations over periods of several hours. Follow the manufacturer's instructions provided with each box of tubes.

Grab sample - a term used to describe a sample taken in a short period of time to assess the concentration of a given contaminant (e.g., detector tube sample).

III. Exposure Limits

The full-shift threshold limit values (TLVs®), Ceiling and Excursion limits, and the short-term exposure limits (STELs) for contaminants sampled with detector tubes and diffusion tubes are listed or referenced in the ***TLVs® Threshold Limit Values for Chemical Substances in Workroom Air Adopted by the ACGIH for 1973***. They are incorporated by reference in MSHA standards (30 CFR §§ 56/57.5001). For the appropriate selection of different tubes and the respective exposure limits for specific contaminants, refer to Chapter 3.

IV. Equipment Factors and Environmental Corrections

Many variables can affect the measurement accuracy of detector and diffusion tubes and must be carefully controlled.

A. **Shelf Life** - All detector (short-term) and diffusion (long-term) tubes have a shelf life that is normally noted on the box or on the sampler itself. Do not use tubes for enforcement sampling after their shelf life expires. Do not re-use tubes.

B. **Storage** - Specific instructions for tube storage are printed on the tube box or in the instructions. Refrigeration is recommended, but is not necessary. Some tubes must be protected from freezing temperatures, and others from extended periods of time at temperatures above 85° F (30° C). Always check for the manufacturer's storage instructions and recommended ambient operating conditions.

C. **Temperature and Humidity** - Use a sling psychrometer or a digital thermometer / hygrometer to determine temperature and humidity conditions. Record these readings in the Health Field Notes. Corrections for temperature or humidity are a function of each particular tube. Read the instructions which come with each set of tubes to determine the appropriate correction factors for that tube. Do not use tubes outside the recommended temperature or humidity range without using correction factors. Normally, if sampling is done between 50° F and 85° F (10° C to 30° C), and below 65% humidity, no correction factors are necessary. If sampling conditions are outside the manufacturer's specified limits, contact your District Office for guidance.

Moisture (steam, rain, snow, mist, or fog) can reduce collection efficiency by saturating the tube and interfering with the collection of the contaminant. Check the manufacturer's instructions for use and plan your sampling accordingly.

D. **Interferences** - Sampling may be adversely affected when other gases or vapors are present because these gases or vapors can react with the reagent chemicals inside the detector or diffusion tube. Refer to the instructions inside each box of tubes to ensure that your sampling result shows only the contaminant you intend to measure.

For example: a certain tube measuring carbon monoxide becomes inaccurate when hydrogen sulfide is present. If hydrogen sulfide may be present, use a tube that isn't affected by hydrogen sulfide or use another means of sampling. Contact your District Office for guidance.

E. **Tube reading** - Watch the length of color change in the tube's indicating layer. Any departure from a sharp demarcation between the reacted chemical and the un-reacted chemical in the tube is the "indicating layer." Read the stain length from the zero point to the best estimate of the end point of this layer. Take special care to note the units for tubes marked with concentration gradations. Some are marked in percent and some in ppm, depending on the concentration range to be measured.

Note: Some detector tubes are marked with two scales, dependent on the number of strokes taken. Use the appropriate scale when reading the tube.

If multiple stains occur in the tube, it is an indication of the presence of interfering contaminants, and the tube cannot be used for compliance. Caution: do not mistake normal color gradations with multiple stains. Multiple stains vary appreciably in both color and end point and may be separated by uncolored areas between the multiple end points.

F. **Error Factor** - The sampling factors needed to determine compliance when using detector or diffusion tubes vary and can be found in Chapter 3.

G. **Correction Factors for Elevation** - Elevation changes relative to sea level affect tube accuracy because they affect the density of the air being drawn or diffused through the tube. Make appropriate corrections for elevation to detector and diffusion tube readings by multiplying the concentration indicated on the tube by the correction factors given in Figure 11-1.

Figure 11-1. Elevation Correction Table for Detector and Diffusion Tubes

Elevation in feet (meters)	Correction Factor	Elevation in feet (meters)	Correction Factor	Elevation in feet (meters)	Correction Factor
-5000 (-1524)	0.83	500 (152)	1.02	7000 (2134)	1.31
-4500 (-1372)	0.85	1000 (305)	1.04	8000 (2438)	1.36
-4000 (-1219)	0.86	1500 (457)	1.06	9000 (2743)	1.41
-3500 (-1067)	0.88	2000 (610)	1.08	10000 (3048)	1.46
-3000 (-914)	0.90	2500 (762)	1.10	11000 (3353)	1.52
-2500 (-762)	0.91	3000 (914)	1.12	12000 (3658)	1.58
-2000 (-610)	0.93	3500 (1067)	1.14	13000 (3962)	1.64
-1500 (-457)	0.95	4000 (1219)	1.16	14000 (4267)	1.71
-1000 (-305)	0.96	4500 (1372)	1.18	15000 (4572)	1.77
-500 (-152)	0.98	5000 (1524)	1.21	---	---
0 (sea level)	1.00	6000 (1829)	1.26	---	---

V. Sampling Strategy

A. Full-Shift Samples

Full-shift sampling using detector or diffusion tubes should be used when miners may be exposed to gases or vapors during their scheduled workshift and to determine if TLV®'s have been exceeded. Always follow the manufacturer's guidelines for sampling times and concentration ranges. If the shift extends beyond 8 hours, the tube may need to be changed. Refer to Chapter 3 for TLV®s and specific sampling guidelines for individual contaminants. The full-shift samples should be supplemented with grab samples (detector tube, TMX-412 readings, or other electronic direct-reading instruments) for persons of the same occupation taken throughout the shift to corroborate the full-shift data. The grab samples also serve as "stand-alone" short-term samples for compliance with the associated short-term exposure limits (STELs). If, in the midst of full-shift sampling, an individual grab sample exceeds the STEL for an individual gas, that sample can stand alone for citing an overexposure based on exceeding a short-term limit.

Since diffusion tubes are not available for many contaminants found in the mine environment, full-shift compliance determinations must be made using other means. For contaminants which can be assessed by using detector tubes, full-shift sampling can be accomplished using partial-period sampling by taking a series of grab samples spaced periodically throughout the shift. Each such grab sample serves the dual purpose of being part of the full-shift sampling process as well as being a stand-alone short-term sample. See Chapter 2 for calculating full-shift exposure from partial-period data.

B. Short-Term Grab Samples

Short-term samples can be taken independently with calibrated detector tube pumps or electronic direct-reading instruments (e.g., TMX-412) to determine if short-term exposure limits (STEL), excursion limits, or ceiling limits have been exceeded during suspected periods of peak exposure. When monitoring for short-term exposure limits, refer to the sampling times in Chapter 3.

Note: Short-term samples should be taken in conjunction with full-shift samples to corroborate the full-shift data.

VI. Diffusion Tube Sampling Procedures

Diffusion tubes are specialized detector tubes that are used as long-term monitors for 8 - 12 hours. For workshifts longer than 8 – 12 hours use consecutive tubes. The gas being sampled enters the tube by natural diffusion of air (no pump is required). The gas reacts with the chemical reagents within the tube to produce a color change. These tubes can be used as full-shift personal samples, with the full-shift exposure being calculated (the direct reading divided by the time in hours) at the end of the shift. Diffusion tubes are available for several contaminants commonly found in the mining environment, such as ammonia (NH_3), carbon monoxide (CO), carbon dioxide (CO_2), nitrogen dioxide (NO_2), sulfur dioxide (SO_2), hydrogen sulfide (H_2S), and hydrocyanic acid (HCN).

A. Preparing the Tube

The diffusion tube has a breaking bead designated by a “red” dot. Wait until you are ready to sample before breaking the tube, then, following the manufacturer’s instructions, break the tube and place it in the associated holder. Push the half of the tube that has the indicating layer as far as it will go in the direction of the arrow into the top part of the holder. Fold the bottom part of the holder around the tube and click it in place. Push the tube down until the glass rim of the open end rests against the bottom part of the tube holder (see Figure 11-2).

B. Positioning the Holder

Figure 11-2. Diffusion Tube and Holder

Clip the tube holder(s) to the miner’s clothing within the breathing zone. When properly assembled and attached, the open side of the tube should point downward. If the miner is not wearing a shirt, the inspector should provide a vest to facilitate sampling. Vests can be obtained through the District Office.

C. Instructions to the Miner

1. Explain to the miner what you are doing, what the sampling device does, and the reason for the sampling (*i.e.*, the hazard). If available, issue a Miner Health Hazard Information Sheet or Card.

2. Instruct the miner not to remove the diffusion tube at any time or cover it with a coat or anything else. If the miner must leave the mine property or work area during the shift, the inspector should remove the diffusion tube and immediately record the direct-reading ("detector tube indication") and sampling time. When the miner returns, resume sampling with a new diffusion tube.

3. Instruct the miner not to abuse or tamper with the diffusion tube.

4. Emphasize the need for the miner to continue to work in a routine manner and report to you any unusual occurrences during the sampling period.

5. Inform the miner when and where you will remove the diffusion tube and that you will be checking the tube throughout the shift.

D. Collect the Sample

1. When the diffusion tube holder has been attached, record in the Health Field Notes the following:

- The contaminant being sampled;
- Time the tube was opened and attached;
- Miner's name, job title, and work location(s);
- Shift hours per day and days per week worked;
- Expiration date of the tube and ID number; and
- Elevation of the sampling site.

2. During each full-shift sample, the inspector must observe the miner being sampled as frequently as is necessary to determine that a representative sample is being conducted of the normal activities. Check the condition and positioning of the diffusion tube. Record what tasks the miner has performed in the time between subsequent checks, so that the completed Health Field Notes will describe the miner's full work shift. This requirement does not necessarily preclude the inspector from doing other inspection work while sampling.

3. Throughout the shift, record any other pertinent information in the Health Field Notes, such as:

- Times that the diffusion tube was checked. If the tube needs to be removed or replaced for any reason, record the times involved.
- Controls in use with general description and whether or not they seem adequate.
- Potential sources of exposure, a general description of these sources, number of persons affected, and possible additional control measures.
- Activity of miner, equipment operating in the area, and approximate time spent at each activity.
- Any other samples taken (e.g., detector tubes, badges, noise, etc.) and results, if available.
- For any consecutive samples taken, the direct-readings and sampling times for any additional tubes used during sampling period.
- Environmental conditions (such as wind conditions, temperature, humidity, ventilation, etc.).

4. Collect the diffusion tube and holder from the miner. Immediately record the ending time. Read the tube, determine the test result and record it.

VII. Detector Tube Sampling Procedure

Detector tubes are small glass tubes which contain reagent chemicals. Both ends are flame-sealed. When the ends are broken and contaminated air is drawn through the tube, the reagent chemicals react with the gas or vapor to produce a color change (stain). These color changes vary in length according to the contaminant concentration.

A. Detector Tube Pump System

A detector tube and bellows-type sampling pump are used together to form a direct-reading sampling system (see Figure 11-3). This system is used to determine the short-term concentration of gases or vapors in the air. Several manufacturers are marketing pump-tube systems for measuring a wide variety of contaminants. Each manufacturer has specific instructions which apply only to that particular pump-tube system. <u>Read, understand, and follow the manufacturer's instructions</u> for the pump-tube system you are using. Never interchange units or components from one pump-tube system to another.

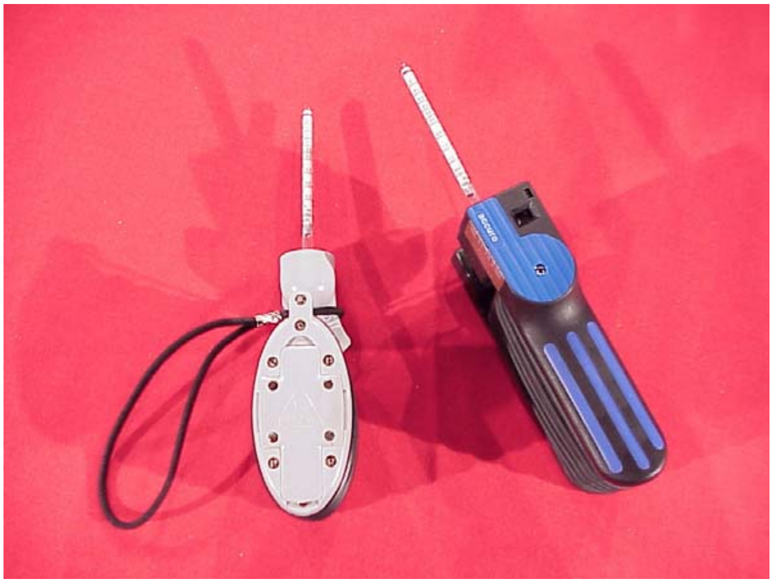

Figure 11-3. Detector Tube and Bellows-Type Pump Systems

1. **Bellows Pump Testing** - The length of color change on a detector tube is directly related to sample size. The hand-operated bellows pump supplies 100 mL of sample with each full stroke. Any malfunction will result in less volume being pulled through the detector tube. Therefore, it is essential to check the volume drawn through the pump <u>at least once a year</u>. In addition, the bellows pump must be re-tested any time it has been repaired or disassembled for cleaning.

   <u>Volume Test</u> - A 100 mL glass burette or a digital sample pump calibrator can be used to check the volume pulled by the pump per stroke.

   - Using a 100 mL glass burette or sample pump calibrator, connect the apparatus as shown in Figure 11-4.

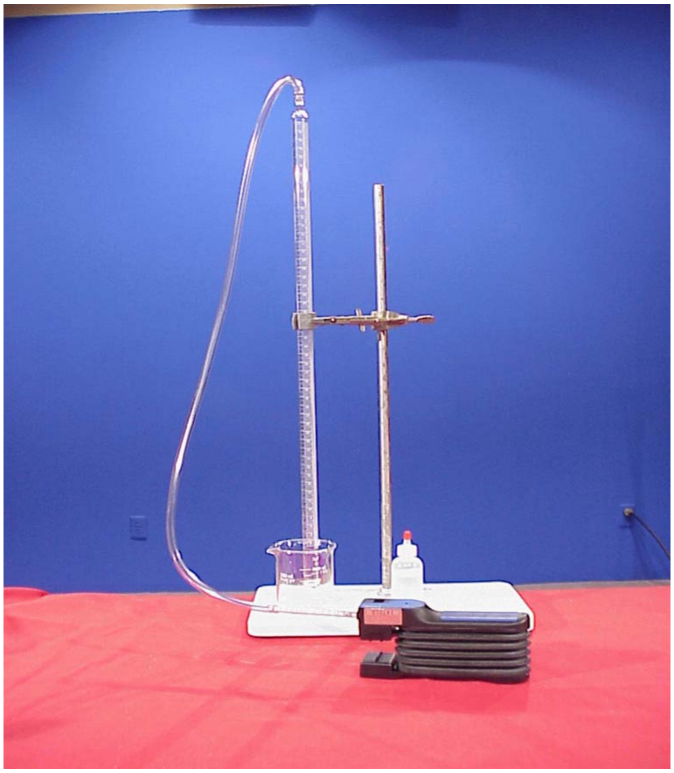

Figure 11-4. Assembly for Volumetric Testing of Bellows Pump

- Thoroughly wet the inside of the calibration burette or calibrator cylinder. Position a soap bubble at the zero mark of the burette or cylinder, using the pump to ease the bubble into position.
- Depress the bellows completely and release.
- Measure the volume of air pulled through the burette. Take several measurements to ensure that the reading is consistent.
- The pump must pull between 95 and 105 mL (±5 percent) for an acceptable test. If the pump pulls less than 95 mL or more than 105 mL, the pump must not be used before it is repaired.
- Record the pump ID number, volume (mL) pulled, date of testing, and initials of person performing calibration. Record this information on a gummed label and apply the label to the inside of the pump carrying case. An alternative is to record this information in a pump calibration log.

Leak Test - When a detector tube sample is taken with a bellows-type pump, the pump must be checked before and after each survey shift to ensure that the sample volume is drawn first through the tube and then through the bellows pump. Any leakage through the pump causes erroneous concentration values. To perform a leak test, follow this procedure:

- Insert an unbroken detector tube into the tube holder and completely compress the bellows.
- Wait 10 minutes. If the bellows pump remains compressed for the duration of the test period, assume no air leak.
- If there is leakage, the pump needs cleaning or repair. Do not use it for compliance determination.

Suction Test - To ensure that the bellows pump can draw air through the sample tube, perform the following before and after each survey shift:

- Compress the bellows pump completely.
- Release the pump - the bellows should instantly return to the starting position.
- If not, the pump needs cleaning or repair. Do not use it for compliance determination.

2. **Sampling Time** - A definite period of time must elapse from the start of sampling to the time when the tube is read. This ensures that enough time has passed for the chemical reaction to take place between the tube ingredients and the contaminant.

   The amount of air required (number of strokes), the waiting period between strokes, and the chemical reaction time vary with the individual type of tube, the tube manufacturer, and the concentration of the contaminant. Each box of tubes contains this information, which must be followed exactly.

B. Assess Sampling Conditions

If required by the manufacturer's directions, use a sling psychrometer or a digital thermometer / hygrometer to take temperature and humidity measurements at the sampling site. Also, note the elevation of the site. Record all necessary information in the Health Field Notes.

C. Prepare Tube for Sampling

1. Select the appropriate tube for the measurement required, and note the number of strokes required, as specified in the instructions packed with the tubes.

2. Open each end of the tube by using a tube breaker or by inserting the tip gently into the tube opener hole in the bellows pump. The openings should be approximately one-half the internal diameter of the tube.

3. Insert the proper end of the detector tube into the tube holder of the pump. An arrow on the tube indicates the direction of air flow. Air to be sampled must not pass through any hose or tubing before entering the detector tube. Note: If the bellows pump is provided with a stroke counter, reset the counter before taking a sample.

D. Collecting a Grab Sample

1. **Instructions to the miner** - Explain to the miner what you are doing, what the sampling device does, and the reason for the sampling (*i.e.*, the hazard). If available, issue a Miner Health Hazard Information Sheet or Card. Emphasize the need for the miner to continue to work in a routine manner and report to you any unusual occurrences during the sampling period.

2. **Procedure** - Position the detector tube in the breathing zone of the miner, taking care not to endanger the miner with the broken end of the tube. Take the required number of strokes to properly assess the gas concentration:

- Squeeze the pump completely, release it, and wait until the bellows pump fully expands. Note: when using a pump with a stroke counter, wait until the end-of-stroke indicator appears. If more than one stroke is needed, squeeze the pump completely again. Repeat until the number of strokes corresponds to that given in the tube instructions.
- In between samples, remove the tube from the socket, and flush bellows pump with a few pump strokes of clean air.

<u>Ceiling limit</u> - take the required number of strokes on the detector tube and compare the reading with the ceiling limit concentration.

Short-term exposure limit (STEL) and excursion limit - determine the minimum time (refer to Chapter 3) allowed for the exposure limit of the gas or vapor you intend to measure. Use partial-period sampling by taking detector tube readings over this entire time period and calculate the average concentration.

Example: the short-term limit is for a 30-minute exposure:

- Take one tube reading during the first 5-minute period.
- Take the second tube reading midway through the 30-minute period.
- Take the third tube reading in the final 5-minute period.
- Add all three readings and average (divide by 3) to obtain the concentration of the short-term exposure.

Record the tube readings, calculations, and concentration in the Health Field Notes.

VIII. Post-Inspection Procedures

A. Review Health Field Notes

Check that you have recorded all necessary information in the Health Field Notes (MSHA Form 4000-31). Refer to Chapter 21, Section V.

B. Post-Survey Leak Test of Bellows Pump (when using detector tubes)

After the survey, perform a leak test as described in Section IV.B.1 of this chapter. If the bellows pump fails the leak test, void the results of any grab samples taken.

IX. Compliance Determination

A. Diffusion Tubes

Determine compliance by comparing calculated exposure concentrations with respective enforcement exposure limits.

1. **Full-Shift Sample**: calculate the full-shift exposure using the following formula:

$$\textbf{SWA in ppm} = \frac{\textbf{Diffusion Tube reading in ppm}\cdot\textbf{h}}{\textbf{8 hours}}$$

where: h represents hours.

Example: The TLV® for sulfur dioxide (SO_2) is 5 ppm. An SO_2 sample is taken for 7 hours 30 minutes at sea level, and tube stain reaches
the 50 ppm·h demarcation line.
At sea level, the correction factor is 1.00 (from Figure 11-1):
(50 ppm·h) X (1.00) = 50 ppm·h

$$\text{SWA} = \frac{50 \text{ ppm}\cdot\text{h}}{8 \text{ hours}} = 6.25 \text{ ppm}$$

The error factor for Dräger SO_2 5/a-D diffusion tube # 8101091 is 1.41.
The full-shift enforcement TLV® = 1.41 x 5 ppm = 7.05 ppm.
The sample with the error factor applied indicates compliance.

2. **Consecutive Tube Sampling (Full-Shift longer than 8 hours)**: If the workshift is longer than 8 hours, use an additional diffusion tube. Each of the additional sampling periods must be 1 to 8 hours in duration. It may also be necessary to change tubes during a shift if the limit of the tube's capacity is approached. In either case, calculate the full-shift exposure using the following formula:

$$\textbf{SWA in ppm} = \frac{D_1 + D_2 + D_3 + \ldots + D_n}{\textbf{8 hours}}$$

where: D = Diffusion Tube reading in ppm·h

Example: The TLV for carbon monoxide (CO) is 50 ppm. At 7:00 a.m., a CO diffusion tube_1 was placed on a miner working at a depth equal to 1500 feet below sea level. A spot check of the tube at approximately 11:00 a.m. indicated a reading of 200 ppm·h. At 12:00 p.m. the tube_1 read 300 ppm·h. This reading was recorded and a new CO tube_2 was placed in the holder. It was noted that a very smoky diesel-powered piece of equipment had begun operation in the area. At 1:00 p.m. the reading on the new tube_2 was 400 ppm·h. The reading was recorded and a new tube_3

was placed in the holder. By 7:00 p.m., the end of the shift, tube_3 read 300 ppm·h.

The three recorded tube readings require adjustment for elevation.

At -1500 feet, the correction factor is 0.95 (from Figure 11-1):

(300 ppm·h) X (0.95) = 285 ppm·h
(400 ppm·h) X (0.95) = 380 ppm·h
(300 ppm·h) X (0.95) = 285 ppm·h

Apply compliance determination formula:

$$\text{SWA} = \frac{(285\ \text{ppm}\cdot\text{h})_1 + (380\ \text{ppm}\cdot\text{h})_2 + (285\ \text{ppm}\cdot\text{h})_3}{8\ \text{hours}} = \frac{950\ \text{ppm}\cdot\text{h}}{8\ \text{hours}} = 119\ \text{ppm}$$

The error factor for Dräger CO 50/a-D diffusion tube # 6733191 is 1.41.
The full shift enforcement TLV® is: 1.41 X 50 ppm = 70.5 ppm.
The sample indicates a citable overexposure has occurred.

B. Detector Tubes

Determine compliance by comparing direct-read exposure concentrations with respective enforcement exposure limits. Detector tube samples or electronic direct-reading instrument measurements should be taken in conjunction with diffusion tube samples to corroborate the full-shift data.

<u>Example</u> - the ceiling limit for nitrogen dioxide is 5 ppm. A detector tube grab sample taken in a miner’s breathing zone read 10 ppm.

The error factor for Dräger NO_2 2/c detector tube # 6719101 is 1.25.
The enforcement ceiling limit = 1.25 x 5 ppm = 6.25 ppm.
The sample indicates a citable overexposure has occurred.

<u>Example</u> - the short-term exposure limit (STEL) for carbon monoxide (CO) is 400 ppm for a 15-minute exposure. Take partial-period sampling to determine compliance:

- Detector tube reading during the first 5-minute period was 250 ppm.
- Detector tube reading during the second 5-minute period was

600 ppm.

- Detector tube reading during the final 5-minute period was 150 ppm.
- Add the three readings and average (divide by 3) to obtain the concentration of the short-term exposure:

$$\text{Exposure Concentration} = \frac{250 \text{ ppm} + 600 \text{ ppm} + 150 \text{ ppm}}{3} = 333 \text{ ppm}$$

The error factor for Dräger CO 5/c detector tube # CH25601 is 1.25.
The enforcement STEL = 1.25 x 400 ppm = 500 ppm.
The sample indicates compliance.

C. Additive Effects

See Chapter 2 for a discussion of additive effects and calculation examples.

X. Report Writing

A. Inspection reports should include a copy of the Health Field Notes; the Area Sample Data Summary (ASDS) or Personal Exposure Data Summary (PEDS); appropriate citation/orders; and any other supplemental information collected during the inspection.

B. Complete the Area Sample Data Summary (refer to Chapter 21, Section IX) or the Personal Exposure Data Summary (refer to Chapter 21, Section VIII), as applicable. List full-shift exposure samples as a single sample result. Do not list individual samples used as part of the full-shift exposure calculation. Any short-term or individual sampling results which exceed the short-term exposure limit (or the excursion or ceiling limit) or are not used in calculating a full-shift exposure may be listed separately. Be sure that the concentration and exposure limit units of measurement are the same as those listed for the contaminant code (refer to Chapter 3).

CHAPTER 12
VACUUM SAMPLERS

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Chapter 12
VACUUM SAMPLERS

I. Introduction

Vacuum samplers are used primarily to determine the concentration of methane (CH_4) generated underground in a 24-hour period. This data is used to determine the frequency of required inspections according to Section 103 of the Act and 30 CFR Part 57 Subpart T. Vacuum samplers are not to be routinely used to test for air quality. Direct-reading instruments (electronic direct-read instruments or detector tubes) should be used to determine methane (CH_4), oxygen (O_2), carbon monoxide (CO), and carbon dioxide (CO_2) concentrations to enable rapid response to identified hazards. However, if direct-reading instruments are not available, or if unusual circumstances warrant their use, vacuum samplers may be used for air quality samples. The MSHA Laboratory should be contacted for expedited sample analysis. There are three types of vacuum samplers: vacuum bottles (50 mL), vacutainers (10 mL), and bistables (or “crickets”). Vacuum bottles and vacutainers are single-use, small glass containers, which are vacuum-sealed by the manufacturer, while the bistable is a reusable metal container. Vacuum bottles, vacutainers, or bistables can be used to sample either ambient air or air from inaccessible areas such as behind seals and in drilled holes. A pump assembly is required if sampling air from inaccessible areas.

II. Sampling Equipment

Vacuum samplers and mailing containers are available from the MSHA National Air & Dust Laboratory (Mount Hope, WV). Bistables are available from the MSHA Denver Laboratory.

A. Vacuum Bottle

The 50 mL vacuum bottle is a cylindrical glass bottle with a long narrow tip used to sample for methane (CH_4), oxygen (O_2), carbon dioxide (CO_2), and carbon monoxide (CO). The bottle is sealed while under vacuum, and the tip is scored for easy breaking (refer to Figure 12-1). Air is drawn into the bottle when the tip is broken off. Vacuum bottles are labeled with a pre-printed sample identification number and come with a wax filled cap and a mailing container. The cap has an indefinite shelf life as long as the wax plug remains present and pliable. The bottle itself has an indefinite shelf life as long as it remains intact. Vacuum bottle samples need to be shipped within 14 days of sampling and should be submitted as soon as possible.

Figure 12-1. 50 mL Vacuum Bottle

B. Vacutainer

A vacutainer is a small 10 mL glass evacuated tube sealed with a rubber stopper, similar in shape to a test tube, and used for CH_4, O_2, and CO_2. Vacutainers are **not** intended for CO sampling. Vacutainers are prepared in-house exclusively for MSHA use (refer to Figure 12-2), and come pre-labeled with a sample identification number, a plunger, and a Styrofoam packing mailer. Samples collected in vacutainers should be shipped overnight to the MSHA Laboratory (Pittsburgh), so that the time from collection to analysis does not exceed 7 days. Alert the Laboratory that samples are being sent.

Figure 12-2. 10 mL Vacutainer, Plunger, and Sealed Sample

Note: Do not use commercially available over-the-counter vacutainers from medical supply sources.

C. Bistable

A bistable or “cricket” is a specialized vacuum sampler consisting of two thin circular metal plates welded together, with a threaded sample port soldered to the edge. (Refer to Figure 12-3). It is used to sample for CO, CH_4, O_2, CO_2 and other gases. A threaded metal cap and a small lead ball are provided to seal the port opening once the sample has been collected. To use this sampling method, the inspector must carry an adequate supply of bistables, extra caps, extra lead balls, and extra sample labels. Send bistables to the Denver Technical Support Laboratory for analysis.

Caution: Bistables come with two different size stems and caps, which are not to be interchanged. The long stems require long caps and the short stems require short caps. In either case, the use of lead balls is essential to ensure an airtight seal.

SAMPLING PROCEDURE

1. UNSCREW CAP ONE TURN (DO NOT REMOVE CAP.)
2. APPLY THUMB PRESSURE TO CENTER TO COLLAPSE SAMPLER.
3. APPLY FINGER AND THUMB PRESSURE ALONG EDGES TO EXPAND SAMPLER.
4. REPEAT STEPS 2 AND 3 THREE TIMES.
5. SAMPLER SHOULD BE IN THE EXPANDED POSITION.
6. TIGHTEN CAP AS FAR AS POSSIBLE USING ONLY FINGER PRESSURE.
7. SECURE CAP WITH MASKING TAPE.

SAMPLE NO.

A02293

DATE REC'D ____________ LAB NO ____________

MINE ____________

OPERATOR ____________

STATE ____________ TOWN ____________

COLLECTOR FIELD OFC. ____________

LOCATION ____________

DATE-HOUR SAMPLED ____________

ANALYSIS DESIRED ____________

EST METHANE ____________

Figure 12-3. Bistable

III. Sampling Procedures - Ambient Air

A. Vacuum bottle

1. Keep the wax caps in an inside pocket of your clothing or hold them in your hands so that the wax remains pliable.

2. Select the location to be sampled.

3. Collect the sample.

- **a.** Break the glass tip off the bottle neck at the scored location. Wear safety glasses for protection against flying glass particles, hold the bottle at waist level and use a glove or handkerchief while breaking to protect fingers. Be careful to dispose of any waste or broken glass particles.

- **b.** Hold the bottle away from your body for a minimum of one minute. Be sure to hold the bottle away from your breathing zone to avoid contaminating the sample.

- **c.** Seal the bottle using a wax-filled cap which has been adequately warmed. Apply firm, steady pressure to the cap until the bottle neck is filled along its length with wax. When the wax has been warmed sufficiently, the wax will flow smoothly and quickly into the bottle neck, forming a good seal and preserving the sample long enough to complete the analysis.

- **d.** Apply a sample seal to ensure the sample against tampering, as illustrated in Figure 12-4.

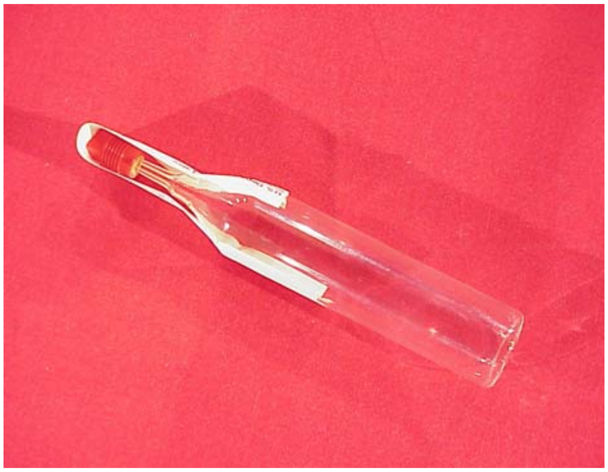

Figure 12-4. 50 mL Vacuum Bottle with Sample Seal

e. Record the bottle number, time, and location sampled on the back side of the Health Field Notes (refer to Chapter 21, Section V). In addition, record:

- Location of sample;
- Miners present and equipment operating in the area;
- General description of controls (e.g., ventilation) in use and whether or not they seem adequate;
- Potential sources of exposure, a general description of these sources, number of persons affected, and possible additional control measures;
- Any other samples taken and the results, if available (e.g., noise, detector tubes, organic vapor badges); and
- Environmental conditions (such as temperature and humidity).

f. Avoid storing the sample where elevated temperatures may occur. If the wax plug were to melt, the sample would become contaminated.

g. Send the bottle and Request for Laboratory Analysis form (refer to Chapter 21, Section VII) together in a packing container to the MSHA Laboratory for analysis.

B. Vacutainer

Vacutainers are easier to use, store, and transport than vacuum bottles. In addition, they are less expensive to purchase than vacuum bottles.

1. Select the location to be sampled.

2. Collect the sample.

a. Push the vacutainer, stopper first, into the plunger until the needle in the plunger punctures the stopper, allowing the vacuum to be replaced with mine air. Refer to Figure 12-5. Note: Always handle this apparatus with care since it contains a sharp medical-grade needle. Hold the bottle away from your body and away from your breathing zone to avoid contaminating the sample.

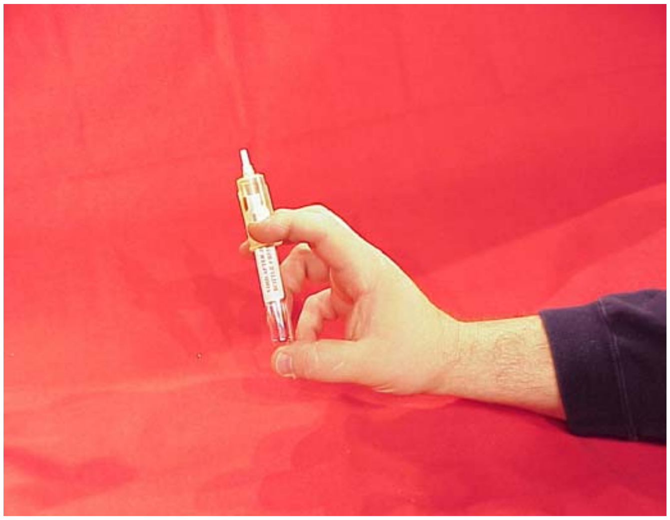

Figure 12-5. Taking a 10 mL Vacutainer Sample

b. Withdraw the vacutainer from the plunger. The hole in the stopper made by the needle will automatically seal itself.

c. Place a sample seal on the vacutainer as shown in Figure 12-2.

d. Record the sample number, time, and location sampled on the back side of the Health Field Notes (refer to Chapter 21, Section V). In addition, record:

- Location;
- Miners present and equipment operating in the area;
- General description of controls in use (e.g., ventilation) and whether or not they seem adequate;
- Potential sources of exposure, a general description of these sources, number of persons affected, and possible additional control measures;
- Any other samples taken and the results, if available (e.g. noise, detector tubes, organic vapor badges); and
- Environmental conditions (such as temperature, humidity, etc.).

e. Ship the vacutainer and Request for Laboratory Analysis Form (refer to Chapter 21, Section VII) together in a packing container overnight to the MSHA Laboratory for analysis. Ship the vacutainer overnight.

C. Bistable

1. Select the location to be sampled.

2. Collect the sample.

a. Unscrew the bistable cap one turn. Do <u>not</u> remove the cap.

b. Holding the bistable in both hands as illustrated in Figure 12-6, apply thumb pressure to the two opposing edges of the bowed side so the two metal plates separate from one another. This will draw air through the sample port into the newly created space between the plates. Then, apply pressure to the center of the bistable disc with your thumbs to collapse the bistable and expel its contents. Repeat this process two or three times.

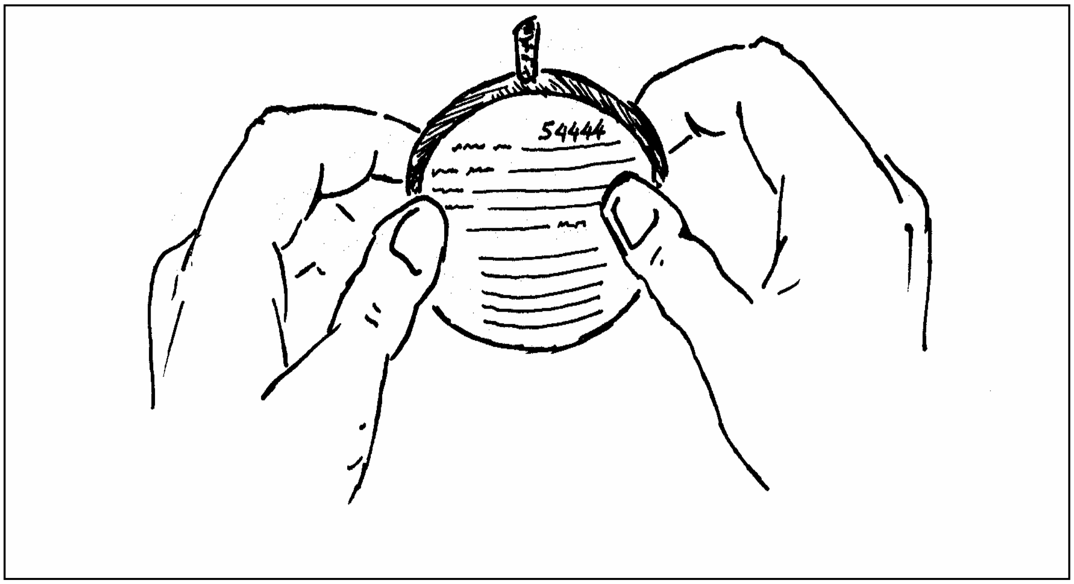

Figure 12-6. Taking a Bistable Sample

c. Tighten the cap using only finger pressure. Excessive tightening may not provide a gas-tight seal.

d. Check that the bistable is sealed by applying finger pressure to the center of the disc. If the unit collapses, the lead ball is missing or faulty or the cap is loose. Take off the cap and replace the lead ball. Repeat steps “a” through “c.” If the bistable still does not properly seal, use another bistable for the sample.

e. A cap guard may be used to prevent accidental loosening of the cap in transit. The cap guard consists of a short length of flexible hose which has been split halfway up each side. Push the cap guard down over the cap so that the split ends grip the bistable (refer to Figure 12-7).

f. Complete the label on the bistable, noting the mine name, operator's name, state and nearest town, collector's name and field office, sample location, date and time collected, analysis desired, and the estimated percent methane in the sample.

g. Place a sample seal over the tightened cap as illustrated in Figure 12-7.

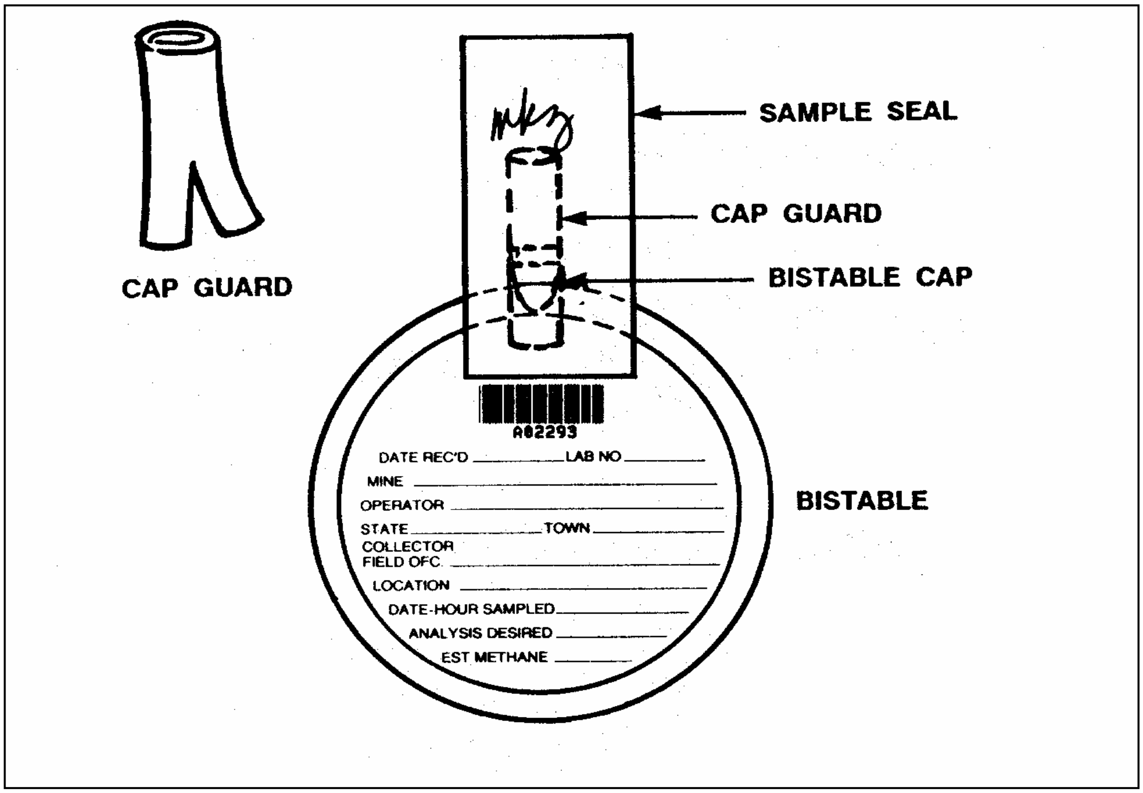

Figure 12-7. Bistable with Sample Seal

h. Record the bistable number, time, and location sampled on the back side of the Health Field Notes (refer to Chapter 21, Section V). In addition, record:

- Location;
- Miners present and equipment operating in the area;
- General description of controls in use (e.g., ventilation) and whether or not they seem adequate;
- Potential sources of exposure, a general description of these sources, number of persons affected, and possible additional control measures;
- Any other samples taken and the results, if available (e.g., noise, detector tubes, organic vapor badges); and
- Environmental conditions (such as temperature, humidity, etc.).

i. Send the bistable and Request for Laboratory Analysis form (refer to Chapter 21, Section VII) together in a packing container to the MSHA Laboratory for analysis.

IV. Sampling Procedures - Inaccessible Areas

In the unlikely event that samples must be taken remotely with a vacuum sampler, contact the district office for guidance. MSHA Technical Support has specialized equipment and trained personnel for sampling in remote areas.

V. Post-Inspection Procedures

A. Health Field Notes

Review Health Field Notes to see that all necessary information has been recorded.

B. Submit Samples for Analysis

Complete Request for Laboratory Analysis (RLA) forms (refer to Chapter 21, Section VII).

- Item 14. Field Sample No: Record the number printed on the sampler label (vacutainer and bistable) or sample card (vacuum bottle).
- Item 16. Analysis Requested: State that you want a complete analysis, unless specific circumstances dictate otherwise. Use Sample Type “G” in Item 15.
- Item 24. Sample Location: Identify if the sample is a “face” sample, a “return air” sample, a “sealed area” sample, etc., in addition to the specific physical location within the mine and Location Code.

1. Submit all vacuum samples for analysis as soon as possible after collecting. **Send them in the packing mailers that have been provided.**

  - Vacutainer samples must be shipped overnight.
  - Vacuum bottle and bistable samples must be sent no more than 14 days after sampling.

2. Submit vacuum bottle and vacutainer samples to the Pittsburgh Technical Support Laboratory or the MSHA Denver Laboratory (addresses are listed below).

3. Submit bistables to the MSHA Denver Laboratory (address is listed below.)

Technical Support Laboratory Addresses and Telephone Numbers

The addresses and telephone numbers of the Technical Support Laboratories are:

Pittsburgh, PA Laboratory

USDOL/MSHA
Pittsburgh Safety and Health Technology Center
PTAD Labs
Cochrans Mill Road, Bldg. 38
P.O. Box 18233
Pittsburgh, PA 15236

Telephone numbers: (412) 386-6984, FAX (412) 386-6154

Denver, CO Laboratory

USDOL/MSHA
Denver Federal Center
6th & Kipling
2nd Street, Building 25, Room 1828
Denver, Colorado 80225
or
P. O. Box 25367, Denver, CO 80225

Telephone numbers: (303) 231-5547 or 5548

Mount Hope, WV Laboratory

MSHA National Air & Dust Laboratory
100 Bluestone Road
Mount Hope, West Virginia 25880

Telephone number: (304) 877-3900

C. Documentation and Recordkeeping

1. Complete the Area Sample Data Summary (refer to Chapter 21, Section IX) if not provided by the Laboratory. Be sure that the concentration and exposure limit units of measurement are the same as those listed for the contaminant code (refer to Chapter 3).

2. Inspection reports should include: a copy of the Health Field Notes; the completed Area Sample Data Summary (ASDS); citation/orders; and any other supplemental information collected during the inspection.

CHAPTER 13
ELECTRONIC DIRECT-READ INSTRUMENTS

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CHAPTER 13
ELECTRONIC DIRECT-READ INSTRUMENTS

I. Introduction

Electronic direct-read instruments (DRI) are battery operated devices that take real-time measurements of contaminant gases and vapors. Some electronic direct-read instruments can be operated from an electrical outlet. They are important tools available to inspectors for detecting and quantifying health hazards because they eliminate the lag time between collecting the sample and receiving the results from the laboratory.

DRIs are used to sample for a variety of contaminants such as the common mine gases: oxygen (O_2), carbon monoxide (CO), nitrogen dioxide (NO_2), sulfur dioxide (SO_2), methane (CH_4), and mercury (Hg) vapor. They may be used to obtain short term or continuous environmental measurements. These instruments may also be used to sample for combustible gas mixtures. Combustible gases are displayed as the percent of the Lower Explosive Limit (LEL).

Ambient air contains about 78% nitrogen, 21% oxygen, 0.04% (400 ppm) carbon dioxide, and small amounts of argon, helium, and other gases. If the concentrations of these gases change due to the displacement of oxygen by other gases, aerobic bacterial activity, combustion, or oxidation of metal, there may be adverse health effects. Human beings can tolerate moderate variations in the amount of oxygen in the air. Breathing becomes labored when the air contains less than 19.0 % oxygen. Oxygen concentrations below 16.0 % present a life-threatening condition.

II. Definitions

Accuracy - how close to the “true” concentration measured by the instrument.

Calibration - determining the variation of an instrument’s response from a standard, and adjusting the instrument to indicate the true value.

Grab sample - a sample taken over a very short period of time by a DRI or other instrument (e.g., detector tube) to assess the concentration of a given contaminant.

Lower Explosive Limit (LEL) - the minimum concentration in air of a flammable vapor or gas-air mixture at which ignition can occur. Concentrations below the LEL are too lean to burn. Note: Although hydrogen sulfide (H_2S) is combustible and explosive, its Threshold Limit Value® (TLV®) is considerably lower than its LEL.

Over-Range - concentrations of a particular contaminant that exceed the range of accurate measurement of a particular instrument. For example: concentrations of carbon monoxide (CO) greater than 1000 ppm would be over-range for an instrument which can accurately measure concentrations of CO between 0 and 999 ppm.

Precision - repeatability, that is, how close several readings taken in the same atmosphere are to each other.

Real Time - characteristic of a DRI that enables it to measure concentration levels of a contaminant instantaneously, or almost instantaneously, and display them as they occur.

Sensitivity (lower detectable limit) - the minimum concentration detectable by the instrument.

Span Calibration (spanning) - using a gas of known concentration to check the accuracy of the response of an instrument to the same type of gas.

III. Exposure Limits

DRIs are normally used to assess compliance with the following standards. They may also be used to determine whether an imminent danger exists.

- 30 CFR §§ 56/57.5001(a) - Threshold Limit Values® (TLVs®), short-term exposure limits (STELs), Ceiling limits, and Excursion Limits for contaminants are listed or referenced in the ***TLVs® Threshold Limit Values for Chemical Substances in Workroom Air Adopted by the ACGIH for 1973*** and incorporated by reference in this MSHA standard.

- 30 CFR § 57.5015 requires minimum oxygen levels of 19.5% by volume in all active working areas.

- 30 CFR Part 57 Subpart T and Section 103(i) of the Mine Act specify criteria for maintenance of methane gas levels at or below certain concentrations depending on the classification of the underground mine.

IV. Sampling Equipment

There are various types of electronic direct-read instruments used by MSHA, including:

1. Industrial Scientific Corporation; models TMX-410 & TMX-412; and the MSA; “Solaris”, multi-gas monitors.
2. Jerome; Models 411 and 431X, mercury analyzers.

Check, calibrate, and maintain these instruments according to the manufacturer’s recommendations (see the Appendix to this Chapter for operating instructions for DRIs). Perform a field calibration check or function test (“bump” test for TMXs) and periodic calibration as specified in the Appendix.

Note: The internal gas sensors of the TMXs have limited shelf and service lives (as little as 6 months).

Each electronic direct-reading instrument has an operating manual that lists operating parameters, accuracy of the instrument reading, and instrument sensitivity. For example, if the instrument sensitivity is 2 ppm, the instrument will not accurately measure concentrations of less than 2 ppm.

Usually the accuracy of the reading is reported as a percentage. Some manufacturers may list a different accuracy for different concentration ranges. In all cases, however, increasing the number of samples taken in a given area increases confidence in the measurements. Error factors for the DRIs are given in the Appendix of this chapter.

V. Equipment Factors and Environmental Considerations.

Where safety procedures require, as in gassy mines, all electronic battery-operated instruments must be intrinsically safe (permissible) according to MSHA Part 18, and must be labeled accordingly. Many variables can affect the measurement accuracy of DRIs and must be controlled.

1. **Temperature and Humidity** - Use a sling psychrometer or a digital thermometer/hygrometer to determine temperature and humidity conditions. Record these readings in the Health Field Notes. Do not use DRIs outside the recommended temperature or humidity range. If sampling conditions are outside the manufacturer’s specified limits, contact your District Office for guidance. Heavy moisture (steam, rain, snow, mist, or fog) can reduce collection efficiency by interfering with the measurement of the contaminant.

2. **Interferences** - Sampling may be adversely affected when there is an interfering influence caused by the presence of other gases or vapors. These gases or vapors can react with the same sensor in the DRI. Refer to the instructions for each DRI and applicable sensor to ensure that your sampling result shows only the contaminant you intend to measure. For example:

   a. The TMX-412 gives erroneously low readings for combustible gas in oxygen deficient atmospheres. (Conversely, oxygen enriched atmospheres cause erroneously high readings for combustible gas.)

   b. Silicone compound vapors may cause desensitization of the combustible gas sensor and cause the reading to be lower than actual.

   c. Combustible gases affect the methane concentration measured by an instrument. When other combustible gases are present, the measured methane concentration may not be accurate.

   d. The Jerome mercury analyzer reads erroneously if high concentrations of ammonia are present.

   In these cases, contact your District Office for guidance.

VI. Sampling Procedures for Electronic Direct-Read Instruments (DRIs)

Grab samples taken with electronic direct-read instruments (e.g., TMX-412) may be used to corroborate full-shift data or to determine if short-term exposure limits (STEL), excursion limits, or ceiling limits have been exceeded during suspected periods of peak exposure. When monitoring for short-term exposure limits, refer to the minimum sampling times listed in Chapter 3.

Full-shift sampling can also be accomplished using partial-period sampling by taking a series of grab samples (with DRIs) spaced periodically throughout the shift. Each grab sample serves the dual purpose of being part of the full-shift sampling process as well as being a stand-alone, short-term sample. See Chapter 2 for calculating full-shift exposure from partial-period data.

1. **Instructions to the miner -** Tell the miner what you are doing, what the sampling device does, and the reason for the sampling (i.e., the hazard). If available, issue a Miner Health Hazard Information Sheet or Card. Emphasize the need for the

miner to continue to work in a routine manner and report to you any unusual occurrences during the sampling period.

2. **Procedure** - Position the DRI in the breathing zone of the miner, taking care not to endanger the miner.

3. **Ceiling limit** - compare the reading with the ceiling limit concentration. A single reading may be used to determine an imminent danger situation.

4. **Low Oxygen**- as with Ceiling Limits, a single reading may be used to determine if an imminent danger situation exists. (See 30 CFR 57.5015.)

5. **Short-term exposure limit (STEL) and excursion limit** - determine the time (refer to Chapter 3) allowed for the exposure limit of the gas or vapor you intend to measure (typical range is from 5 to 30 minutes). Use partial-period sampling by taking DRI readings over this entire time period and calculate the average concentration.

   Example (for a 15 minute STEL):

   a. Take one DRI reading during the first 5-minute period;

   b. Take the second DRI reading during the second 5-minute period;

   c. Take the third DRI reading in the final 5-minute period; and

   d. Add all three readings and average (divide by 3) to obtain the concentration of the short-term exposure.

6. **Record** - the DRI readings and calculations in the Health Field Notes. In addition, record the following:

   a. Miners present and equipment operating in the area;

   b. General description of controls in use (e.g., ventilation) and whether or not they seem adequate;

   c. Potential sources of exposure, a general description of these sources, number of persons affected, and possible additional control measures;

d. Any other samples taken and the results, if available (e.g., noise, detector tubes, and organic vapor badges); and

e. Environmental conditions such as temperature and humidity.

VII. Post-Inspection Procedures

A. Review Health Field Notes

Check that you have recorded all necessary information in the Health Field Notes (MSHA Form 4000-31); refer to Chapter 21, Section V.

B. Post-Survey Calibration Test

Perform a post-survey test as described in the Appendix of this chapter. If the DRI fails the test, void the results of any grab samples taken.

C. Compliance Determination

Electronic direct-read instruments may be used to measure compliance with oxygen and methane standards as well as exposure limits for specific contaminants. They can also be used to corroborate data collected with other sampling media (e.g., diffusion or detector tubes). When using the DRI for enforcement purposes, use the error factor (EF) for the instrument and multiply it times the TLV®. When determining compliance with exposure limits, the sampling strategy must be in accordance with Chapter 3 of this Handbook.

Determine compliance by comparing direct-read exposure concentrations with respective enforcement exposure limits.

Example:
The ceiling limit for nitrogen dioxide is 5 ppm. A DRI grab sample taken near a miner's breathing zone reads 7 ppm.

- The error factor for this DRI is 1.25 (25 percent).
- The enforcement ceiling limit is TLV® X EF = 5 ppm X 1.25
  = 6.25 ppm.
- The sample indicates a citable overexposure has occurred.

<u>Example</u>:
The short-term exposure limit (STEL) for carbon monoxide (CO) is 400 ppm for a 15-minute exposure. Take partial-period sampling to determine compliance:

1. DRI reading during the first 5-minute period was 250 ppm.
2. DRI reading during the second 5-minute period was 600 ppm.
3. DRI reading during the final 5-minute period was 150 ppm.
4. Add all three readings and average (divide by 3) to obtain the concentration of the short-term exposure.

$$\text{Exposure Concentration} = \frac{250\text{ ppm} + 600\text{ ppm} + 150\text{ ppm}}{3} = 333\text{ ppm}$$

- The error factor for this DRI is 1.25
- The enforcement STEL is STEL X EF = 400 ppm X 1.25
  = 500 ppm
- The sample indicates compliance.

D. Additive Effects

See Chapter 2 for a discussion of additive effects and calculation examples.

E. Recordkeeping

1. Complete the Area Sample Data Summary (refer to Chapter 21, Section IX) or Personal Exposure Data Summary (refer to Chapter 21, Section VIII) as applicable. Be sure that the concentration and exposure limit units of measurement are the same as those listed for the contaminant code (refer to Chapter 3).

2. Inspection reports should include a copy of the Health Field Notes, the completed Area Sample Data Summary (ASDS), Personal Exposure Data Summary (PEDS), citation/orders, and any other supplemental information collected during the inspection.

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CHAPTER 13
APPENDIX:
Electronic Direct-Read Instruments

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Chapter 13
Appendix
Electronic Direct-Read Instruments

I. Industrial Scientific Model TMX-410 Multi-Gas Monitor (Figure 13A-1)

Note: This instrument has interchangeable sensors for various gases. If the instrument fails to indicate a particular contaminant or fails calibration for a particular sensor, contact your field office supervisor for sensor replacement or instrument repair procedures.

Figure 13A-1. Industrial Scientific Corporation Models TMX – 410 and TMX – 412

A. Characteristics

Error Factor: 1.25

Sensors: Combustible Gases and Methane - Catalytic
Oxygen and Toxic Gases – Electrochemical

Measuring Range:

LEL (combustible gases)	0 - 100% in 1% increments
CH_4 (methane)	0 - 5% Volume in 0.1% increments
O_2 (oxygen)	0 - 30% Volume in 0.1% increments
CO (carbon monoxide)	0 - 999 ppm in 1 ppm increments
H_2S (hydrogen sulfide)	0 - 999 ppm in 1 ppm increments
SO_2 (sulfur dioxide)	0 - 99.9 ppm in 0.1 ppm increments
NO_2 (nitrogen dioxide)	0 - 99.9 ppm in 0.1 ppm increments
$C1_2$ (chlorine)	0 - 99.9 ppm in 0.1 ppm increments

Temperature Range:
Continuous Operation is 5° to 104° F (-15° to 40° C)
Continuous Operation in CO mode is 23° to 104° F (-5° to 40° C)

Humidity Range: 15 - 90 % relative humidity non-condensing

B. Summarized Operating Instructions

The TMX-410 is powered by a rechargeable 7.5 volt nickel-cadmium battery that can be replaced in the field. The instrument is certified as intrinsically safe.

1. Turning ON the TMX-410

a. Loosen the finger nut at the base of the instrument and rotate the calibration cover to expose five switches.

b. Slide the ON/OFF switch to the left. The four LEDs will flash once and the instrument will emit a short beep.

c. The following screens are displayed during start-up sequence:

Display test - All display segments are activated briefly to verify that they are operating properly.

Battery - If the battery is not fully charged, the voltage reading will blink.

Sensor configuration - Displays installed sensors.

Code - Normal startup continues without any operator response. The calibration procedure can be accessed by entering the correct code.

Hygiene - Startup continues without any operator response. A new data logging session is started if (E) is pressed while the HYGIENE screen is displayed (if instrument is equipped with hygiene option).

d. The TMX-410 begins operating in the INSTANT (default) mode. This mode displays the current levels of each installed gas sensor. At this point, the calibration cover can be repositioned and the finger nut tightened.

2. Changing Viewing Modes

To view the sensor configuration, press and hold the MODE switch. The sensor configuration is displayed for 5 seconds. If the MODE switch is released while the sensor configuration is displayed, the instrument will return to the INSTANT mode. To access the remaining viewing modes, continue holding the MODE switch until ZERO appears.

3. Instrument Check

A functional (“bump”) test should be performed on each instrument prior to each day’s use. The test is a brief exposure, until the instrument goes into visual or audible alarms, of the instrument to a known concentration of gas for the purpose of verifying sensor and alarm operation. Each sensor on the instrument should be tested.

If an instrument fails to operate properly following any functional (“bump”) test, a full instrument calibration should be performed prior to its use.

4. Accessing the Calibration Procedure

In order to calibrate the instrument you must enter the correct code or use the factory code of zero (0). The following are the steps preceding calibration.

a. Ensure that the battery is fully charged.

b. Turn on the instrument and follow the start-up sequence from the operating manual.

c. Enter the code and press (E), and the calibration cycle is accessed.

d. The calibration procedure consists of four functions identified by the following:

- ZERO
- SPAN
- ALARMS
- CODE

The scrolled prompt “PRESS (+) TO STEP (E) to SELECT (M) TO EXIT” appears on each screen.

5. Zeroing the Instrument

a. To select Zero, press (E) when the word appears on the display. At this point the scrolled prompt reads, PRESS (E) TO START (M) TO EXIT.

b. Press (E) to start zeroing in fresh air. If air purity is a concern, move to an uncontaminated location. The zero process will continue for two minutes. At the end of the two minute period, the sensors should display 20.9% oxygen and zero for all other combustible and toxic sensors. The instrument will emit a short beep and return to the zero screen.

6. Span Calibration (see Figure 13A-2)

Figure 13A-2. Calibration of TMX-410 and TMX-412 Instruments

The instrument should be zeroed before calibrating low oxygen span and the combustible or toxic gas spans.

a. Press (+) to advance from the ZERO screen to the SPAN sequence. Press (+) to step through the list of available gas sensors. The name of the gas and the current reading are displayed as each gas is accessed. Only installed sensors are displayed.

b. Press (E) when the desired gas is displayed. The last span concentration used is displayed and the gas identifier blinks, indicating that the displayed gas has been selected for calibration. The scrolled prompt reads: PRESS (+) OR (-) TO SET (E) TO ENTER (M) TO EXIT.

c. Press (+) or (-) to adjust the displayed number so that it reads as closely as possible to the concentration printed on the calibration gas cylinder. Press (E) to enter the set concentration. When the instrument accepts the number, the gas identifier stops blinking and the scrolled prompt reads: APPLY GAS PRESS (E) TO START (M) TO EXIT.

d. Connect the calibration cup to the appropriate calibration gas cylinder. Place the calibration cap on the instrument and turn on the gas supply. Press (E) to start the automatic span cycle. The gas reading is displayed to full sensitivity. A displayed value greater than the span gas indicates reserve sensitivity of the gas sensor.

e. Upon completion of the automatic span cycle, the instrument will respond to one of the following conditions:

- The sensor sensitivity is at least 70 % of a new sensor. A short beep is heard, verifying calibration. The instrument returns to the gas identifier screen and displays the current measured value.
- The sensor activity is less than 70% but greater than 50% of a new sensor. A short beep is heard and the instrument returns to the identifier screen. However, the current displayed value flashes until the screen is changed, indicating the sensor should be changed soon.
- The sensor sensitivity is below 50% of a new sensor. The calibration FAIL screen appears and a fault alarm sounds until a key switch is pressed. If a new sensor is installed without a follow up calibration, a sensor fail will be indicated during normal operation.

7. Changing Alarm Settings

a. Press (+) to advance from SPAN screen to ALARMS screen.

b. Press (E) to select ALARMS. The INSTANT screen then appears and the scrolled prompt reads, PRESS (+) TO SELECT (M) TO EXIT.

c. To access the INSTANT alarms, press (E). The current low-level alarm setting of the first available gas then appears on the display. Pressing (+) allows you to step through the current low and high alarm settings for the available gases.

d. To change any alarm setting, press (E) when the desired alarm is displayed. The gas identifier then blinks, indicating that you may change the existing alarm. The scrolled prompt reads, PRESS (+) OR (-) TO SET (E) TO ENTER (M) TO EXIT.

e. Press (+) or (-) to change the concentration (numerical value) of the alarm. Press (E) to enter the new setting. The display then stops flashing.

- As a guide, low and high alarm values may be set at:

  LOW ALARM SETTING - 50 % of a TLV® or PEL
  HIGH ALARM SETTING - 80-100 % of the TLV® or PEL

- To provide an additional measure of warning protection for the miner and MSHA field personnel, it is recommended that the factory Default Alarm Setting for CO High Alarm be reduced from 70 ppm to 50 ppm; the factory Default Alarm Setting for NO_2 Low Alarm be reduced from 3 ppm to 2 ppm; and the NO_2 factory Default Alarm Setting for NO_2 High Alarm be reduced from 6 ppm to 4 ppm.

II. Industrial Scientific Model TMX-412 Multi-gas Monitor (Figure 13A-1)

Note: This instrument has interchangeable sensors for various gases. If the instrument fails to indicate a particular contaminant or fails calibration for a particular sensor, contact your field office supervisor for sensor replacement or instrument repair procedures.

A. Characteristics

Error Factor: 1.25

Sensors: Combustible Gases and Methane - Catalytic
Oxygen and Toxic Gases - Electrochemical

Measuring Range:

LEL (combustible gases)	0 - 100% in 1% increments
CH_4 (methane)	0 - 5% Volume in 0.1% increments
O_2 (oxygen)	0 - 30% Volume in 0.1% increments
CO (carbon monoxide)	0 - 999 ppm in 1 ppm increments
H_2S (hydrogen sulfide)	0 - 999 ppm in 1 ppm increments
SO_2 (sulfur dioxide)	0 - 99.9 ppm in 0.1 ppm increments
NO_2 (nitrogen dioxide)	0 - 99.9 ppm in 0.1 ppm increments
$C1_2$ (chlorine)	0 - 99.9 ppm in 0.1 ppm increments

Temperature Range:
Continuous Operation is -4° to 122° F (-20° to 50° C)

Humidity Range:
15 - 90 % relative humidity (continuous operation)
0 % to 99 % relative humidity (intermittent operation)

See Figures 13A-3 through 5 for the original version, Figure 13A-6 through 9 for the new version. The TMX-412 is powered by a rechargeable 7.5 volt nickel cadmium battery that can be replaced in the field. The instrument is certified as intrinsically safe.

B. Summarized Operating Instructions

1. Turning ON the TMX-412

Start with Figure 13A-3 for the original version or Figure 13A-6 for the new version.

Press and hold the MODE key. All segments of the display are activated for about a second to verify proper operation. The HOLD screen appears and the instrument sounds a beep once every second. Continue pressing the MODE key for five beeps until the RELEASE screen appears. The RELEASE screen will remain for a few seconds.

The following start-up screens are displayed during the start-up sequence:

a. <u>Sensor configuration</u> - Displays the type and position of installed sensors.

b. <u>Code</u> - Normal start-up continues without any operator response. The calibration system may be accessed while this screen is displayed by entering the correct code.

c. <u>Hygiene</u> (only on instruments with this option) - Normal start-up continues without any operator response.

The TMX-412 begins normal operation in the INSTANT readings mode, monitoring all installed and calibrated gases.

2. Changing Viewing Modes

The TMX-412 offers different display modes for accessing various features. To change viewing modes, press the MODE switch and release it when the next screen appears. The modes are accessed in the following sequence:

a. <u>Instant</u> - The instantaneous levels of all gases are continuously displayed. The battery charge level is shown graphically.

b. <u>Sensor configuration</u> - All installed sensor types are displayed ZERO. This mode allows the user to zero the instrument and span oxygen without accessing the calibration system.

c. PK (peak readings) - This mode displays the highest measured levels of installed combustible and toxic gas, as well as the lowest measured level of oxygen since the peaks were last cleared.

d. PK CLR - Allows the operator to clear the peak values.

After the PK CLR screen, the standard TMX-412 repeats the mode sequence beginning with the INSTANT readings. If the instrument is equipped with the HYGIENE option, the sequence continues with viewing modes for this application. (See Figure 13A-5 for original version.)

3. Daily Instrument Check

A functional ("bump") test should be performed on each instrument prior to each day's use. The test is a brief exposure, until the instrument goes into visual or audible alarms, of the instrument to a known concentration of gas for the purpose of verifying sensor and alarm operation. Each sensor on the instrument should be tested.

If an instrument fails to operate properly following any functional ("bump") test, a full instrument calibration should be performed prior to use.

4. To Zero the Instrument and Span Oxygen

The instrument may be zeroed and the oxygen sensor, if installed, may be spanned without accessing the calibration system. Note: The instrument can only be successfully zeroed in clean air with a normal oxygen level of 20.9 %.

a. Press MODE to access the zero screen.

b. Press (E) to start the ZEROING function. The instrument returns to the INSTANT mode after the ZEROING and OXYGEN SPAN sequence is completed.

5. To Clear Peak Readings

The TMX-412 continuously saves the highest measured values of toxic and combustible gases and the lowest measured value of oxygen. These readings are displayed in the PK (peak readings) mode. To clear the peak readings:

a. Press mode to access the PK CLR screen.

b. Press (E) to clear peaks. The PK screen (Peak Readings) verifies that peak values have been cleared.

6. To Clear Combustible Gas Over-Range

When the TMX-412 detects combustible gas in excess of 100 % of LEL, or 5.0 % of CH_4 by volume, a high alarm condition is engaged, and +OR (for over-range) is displayed for the combustible gas. This feature protects the combustible gas sensor from damage. If this occurs, exit the contaminated area, turn off the instrument temporarily, restart the TMX-412, and clear the instrument in clean air.

Note: The calibration procedure outlined in items 7 and 8 are illustrated in the manufacturer's instruction flowsheets at the end of this section (see Figures 13A-3 through 13A-9). The TMX-412 can be electronically calibrated with the use of test span gas by using the sequence of push-button steps as described in the manufacturer's instruction flowsheet. However, first you must determine which program version the instrument has. To determine if you have the original older version TMX-412 or the new version TMX-412, observe the following at start up. If the display reads "CODE 0" after displaying the sensor configuration, you have the older original version. If your instrument counts backwards after displaying the sensor configuration, you have the new version. The instructions that follow are summarized from the TMX-412 original version instruction manual.

7. Accessing the Calibration System

See Figure 13A-4 for the original version, or Figure 13A-7 for the new version. New version screen commands that are different are given in brackets [ ].

To access the calibration system, the correct code must be entered upon initial start-up. TMX-412 units have a factory code of zero (0). Be sure the unit is fully charged. In order to ensure user safety, a calibration check should be performed prior to each use.

a. Turn on the instrument and follow the start-up sequence.

b. When the CODE screen appears, the number 0 is displayed. The scrolled prompt reads: PRESS (+) OR (-) TO SET (E) TO ENTER (M) TO EXIT. If the access code has been changed from 0, you must enter the correct number on the display by pressing (+).

c. Press (E) to enter set code. The calibration system main menu is accessed. If the correct code is not entered in 40 seconds, the unit will begin normal operation. The calibration system can be exited by pressing the MODE key at any time. To access the Calibration system again, the instrument must be turned off and on again.

The calibration system menu consists of the following three functions:

- CAL [GO CAL]
- ALARMS
- CODE

The scrolled prompt PRESS (+) TO STEP (E) TO SELECT (M) TO EXIT appears on each screen.

8. Calibrating the Instrument (see Figure 13A-2)

a. To select CAL [GO CAL], press (E) when the word CAL [GO CAL] is displayed. The zeroing sequence is started. Zeroing in room air is preferred provided there is no contaminant present.

b. The instrument remains in the zeroing sequence for two minutes. During the sequence, the word zeroing is displayed and the scrolled prompt reads PRESS (M) TO EXIT. To zero the instrument on zero grade air, apply gas before pressing (E) to select CAL [GO CAL].

c. APPLY GAS means to connect the calibration cup to the appropriate calibration gas cylinder. Place the calibration cap on the instrument and turn on the gas supply.

d. When the zeroing sequence ends, the instrument emits a short beep and the first available gas appears.

e. Press (+) to step through the available gases. The name of the gas and the current reading are displayed as each gas is accessed. The scrolled prompt reads: PRESS (+) TO STEP (E) TO SELECT (M) TO EXIT.

f. Press (E) when the desired gas appears on the display. The most recent span concentration used is displayed and the gas identifier blinks, indicating that the gas was selected for calibration. The scrolled prompt reads: APPLY GAS [APPLY] PRESS (+) OR (-) TO SET (E) TO START (M) TO EXIT.

g. Apply the span gas and press (+) or (-) to adjust the displayed number to agree as closely as possible with the concentration printed on the gas cylinder.

h. Press (E) to enter the set concentration and start the calibration sequence. When the instrument accepts the number, the gas identifier stops blinking and the scrolled prompt reads: PRESS (M) TO EXIT. During the span cycle the gas reading is displayed to full sensitivity. A value greater than the span gas concentration indicates reserve sensitivity.

i. When the automatic span cycle ends, the instrument will respond to one of the following conditions.

1) The sensor sensitivity is at least 70 % of a new sensor. A short beep is heard, verifying calibration. The instrument returns to the gas identifier screen and displays the current measured value.

2) The sensor activity is less than 70 % but greater than 50 % of a new sensor. A short beep is heard and the instrument returns to the identifier screen. However, the current value displayed flashes until the screen is changed, indicating the sensor should be changed soon.

3) The sensor sensitivity is below 50 % of a new sensor. The calibration FAIL screen appears and a fault alarm sounds until a key switch is pressed. If new sensor installation followed by calibration is not conducted; a sensor fail will be indicated during normal operation.

If calibration fails, check whether the gas cylinder emptied during calibration gas application. If this occurred, recalibrate with a new calibration cylinder. If the instrument still fails calibration, the sensor may need to be replaced.

9. Changing Alarm Settings

See Figure 13A-4 for the original version or Figure 13A-8 for the new version.

a. Press (+) to advance from the CAL screen to the ALARMS screen.

b. Press (E) to select ALARMS. The INSTANT screen appears and the scrolled prompt reads: PRESS (+) TO STEP (E) TO SELECT (M) TO EXIT.

c. Press (E) to select INSTANT alarms. The current low-level alarm setting of the first available gas appears on the display.

d. Press (+) to step through the current alarm settings for all available gases. The display will identify the gas and the INSTANT alarm type as either high (H) or low (L).

e. To change any alarm setting, Press (E) when the desired alarm is displayed. The gas identifier then blinks, indicating that you may change the existing alarm. The scrolled prompt reads: PRESS (+) OR (-) TO SET (E) TO ENTER (M) TO EXIT.

f. Press (+) or (-) to change the alarm setting.

g. Press (E) to enter the new setting. The display then stops flashing.

Follow this procedure to change the alarm settings for any available gas. Once the changes are complete, press (M) to return to the instant screen.

As a guide, low and high alarm values may be set at:

LOW ALARM SETTING - 50 % of a TLV® or PEL.
HIGH ALARM SETTING - 80 - 100 % of the TLV® or PEL.

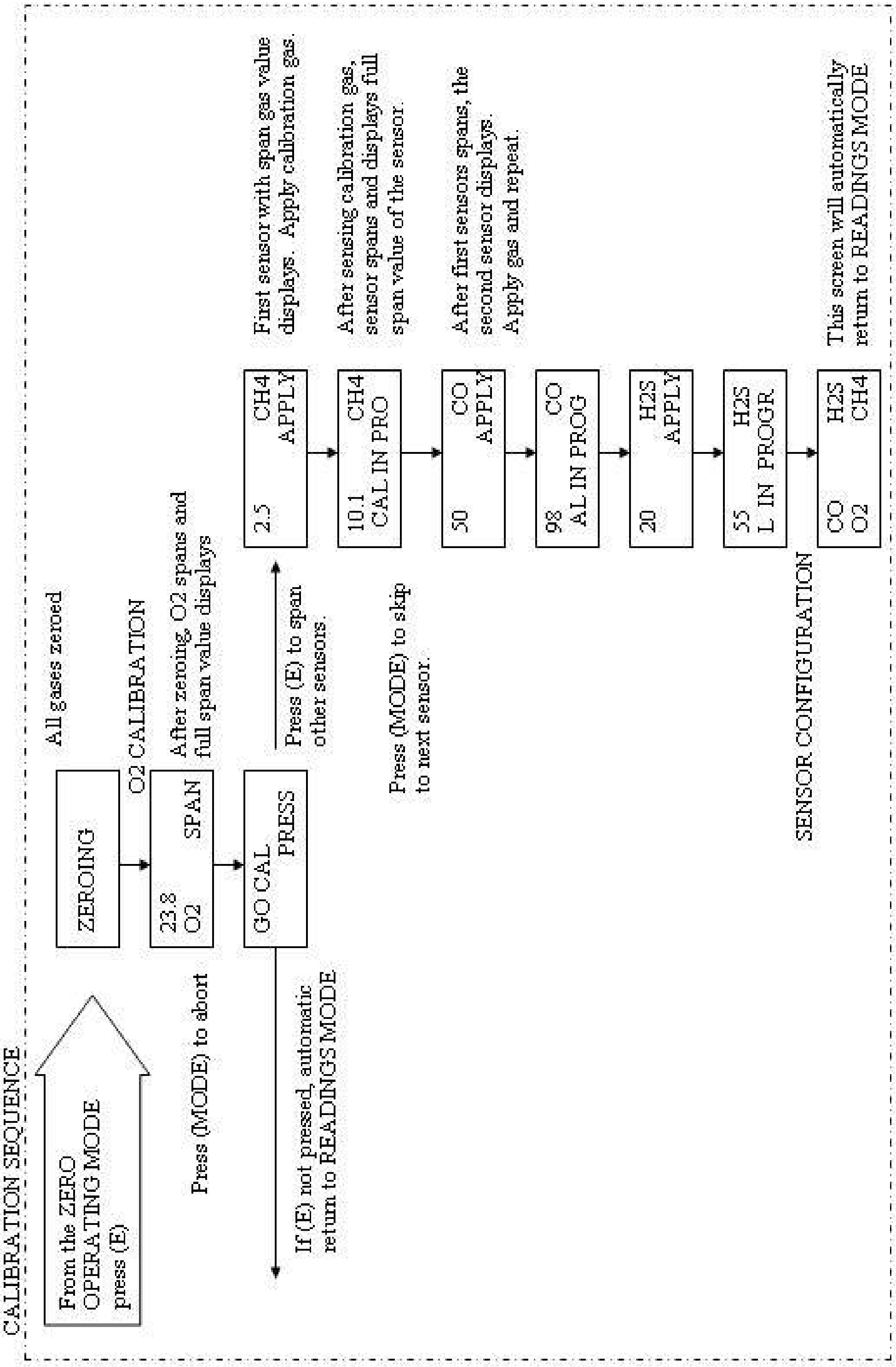

Figure 13A-3. Command Flowsheet for TMX-412 (Original Version), page 1

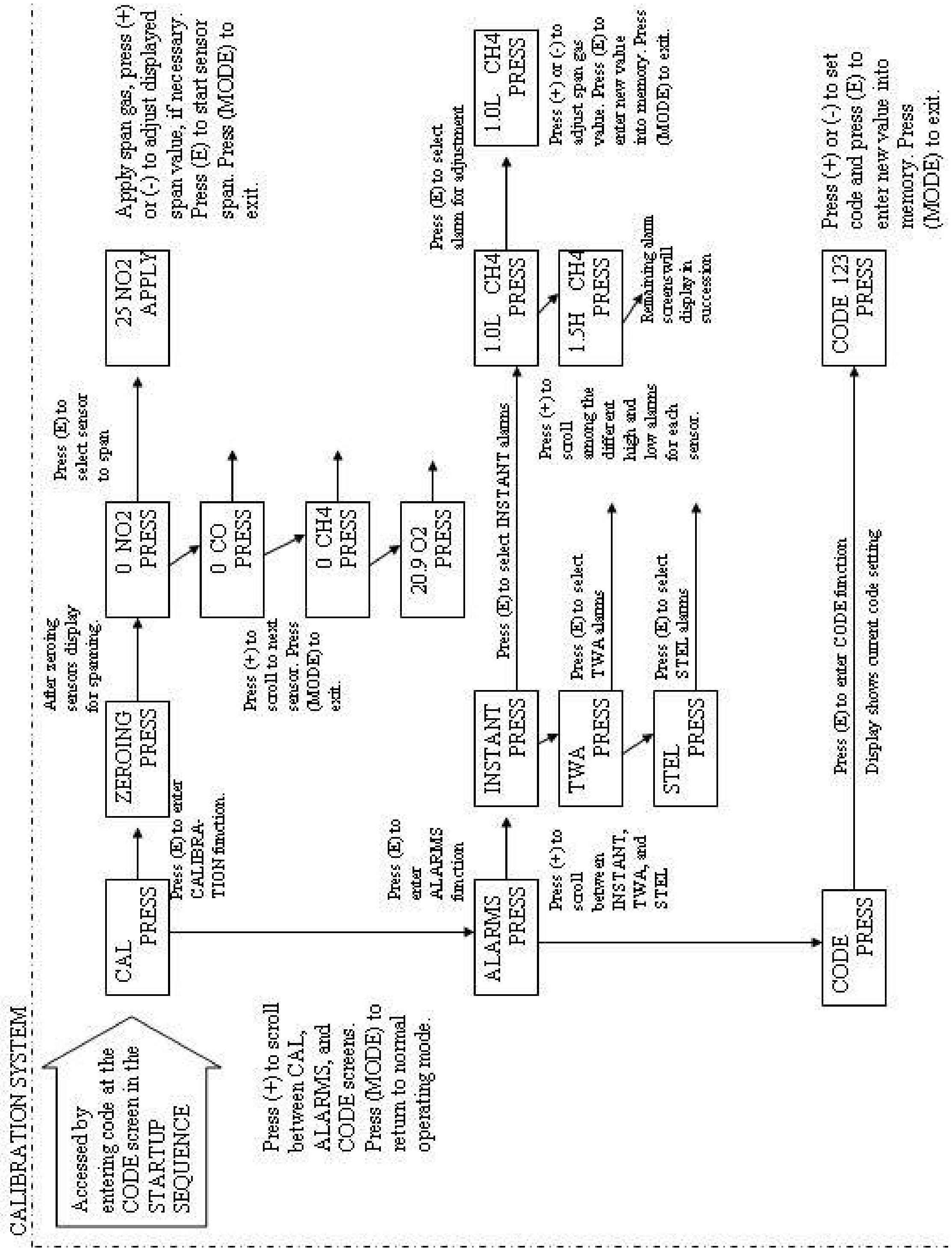

Figure 13A-4. Command Flowsheet for TMX-412 (Original Version), page 2

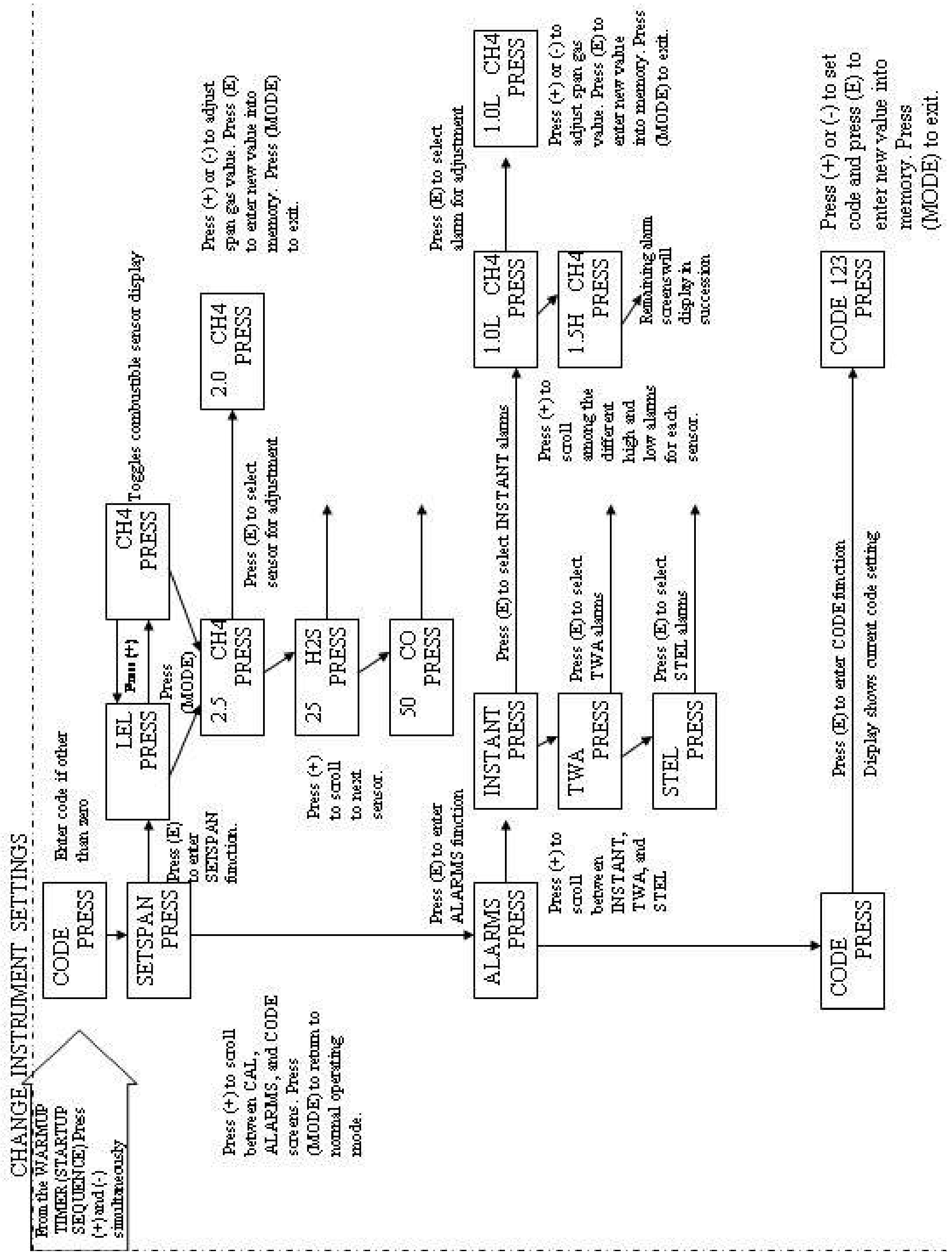

Figure 13A-5, Command Flowsheet for TMX-412 (Original Version), page 3

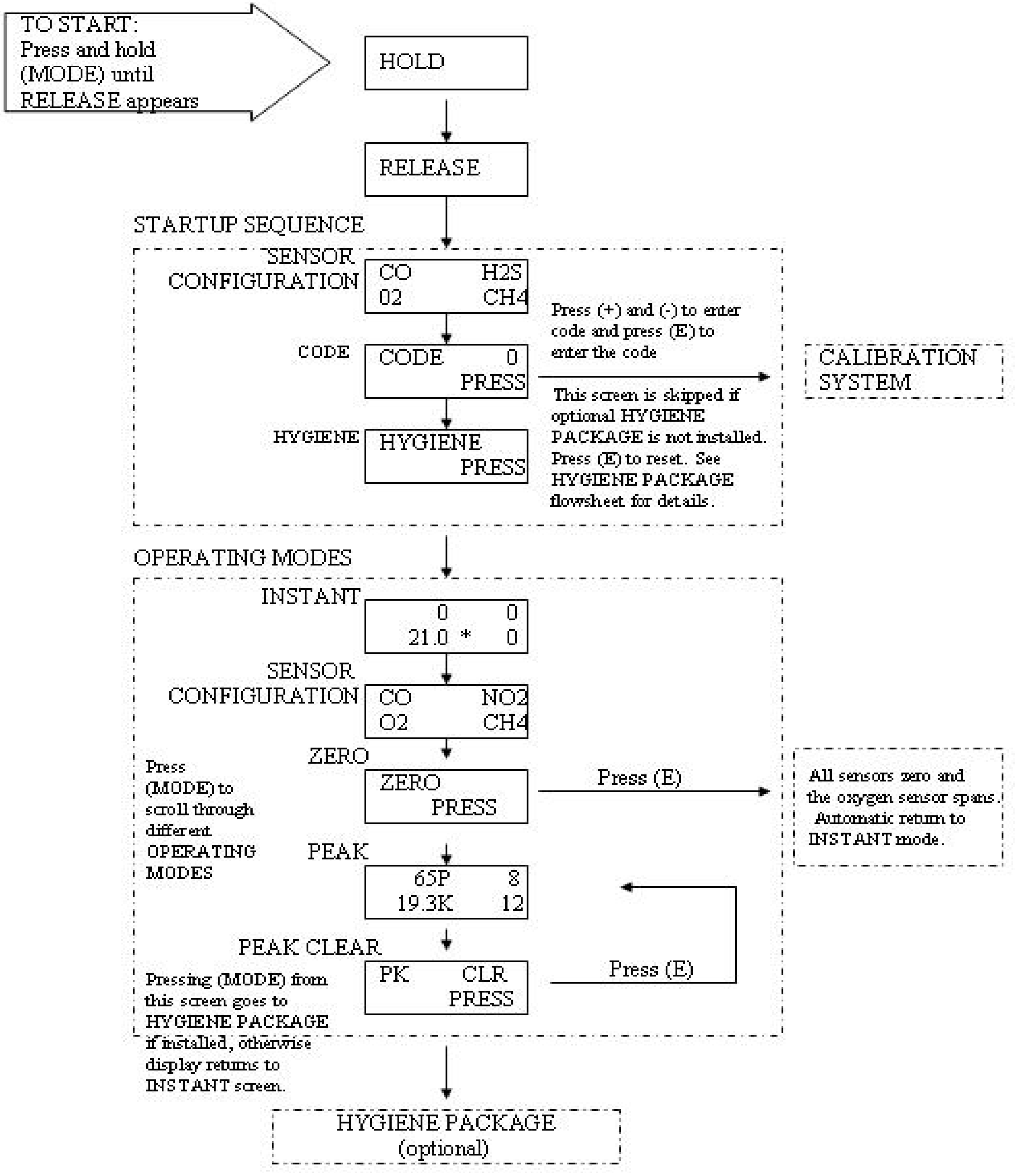

Figure 13A-6. Command Flowsheet for TMX-412 (New Version), page 1

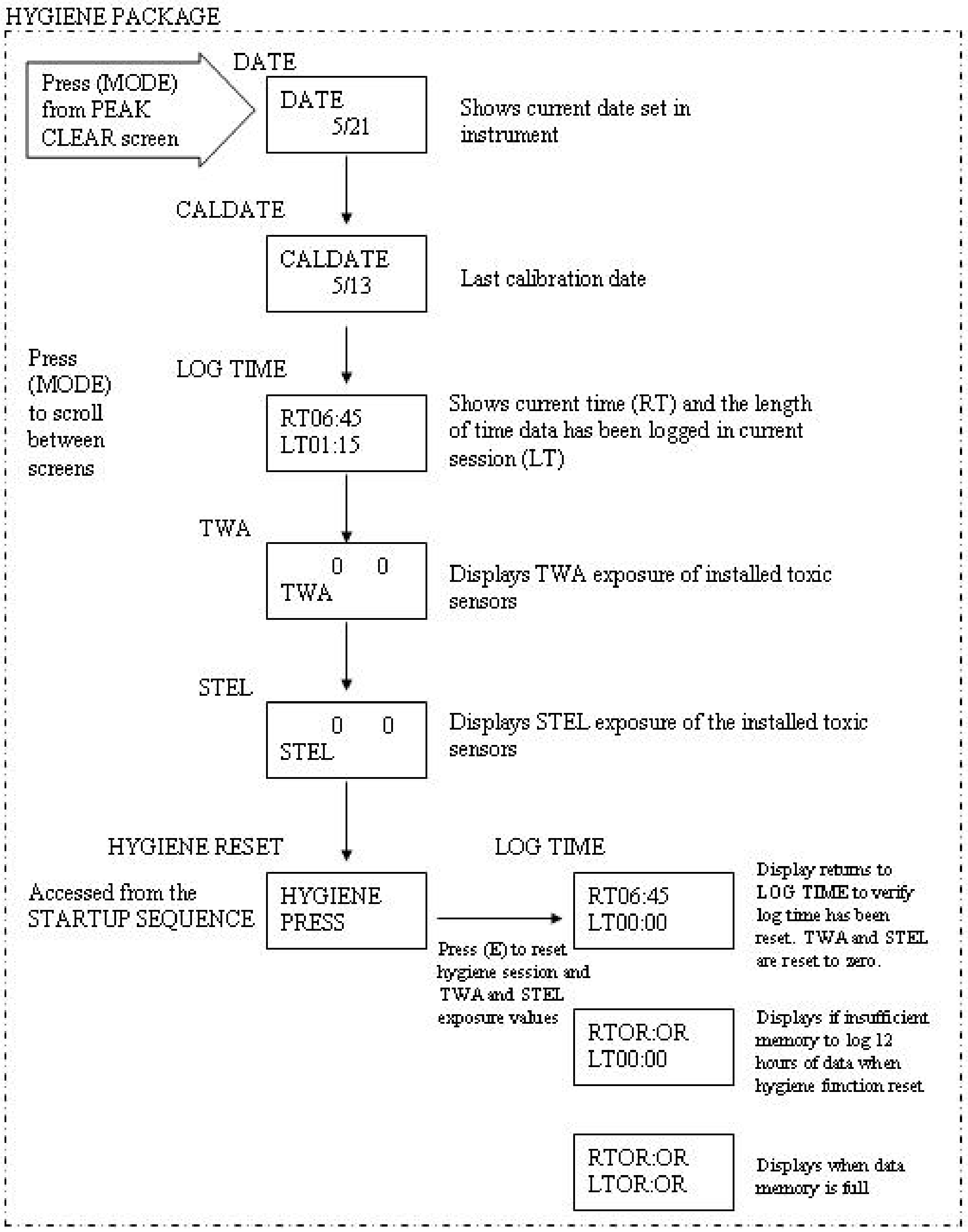

Figure 13A-7. Command Flowsheet for TMX-412 (New Version), page 2

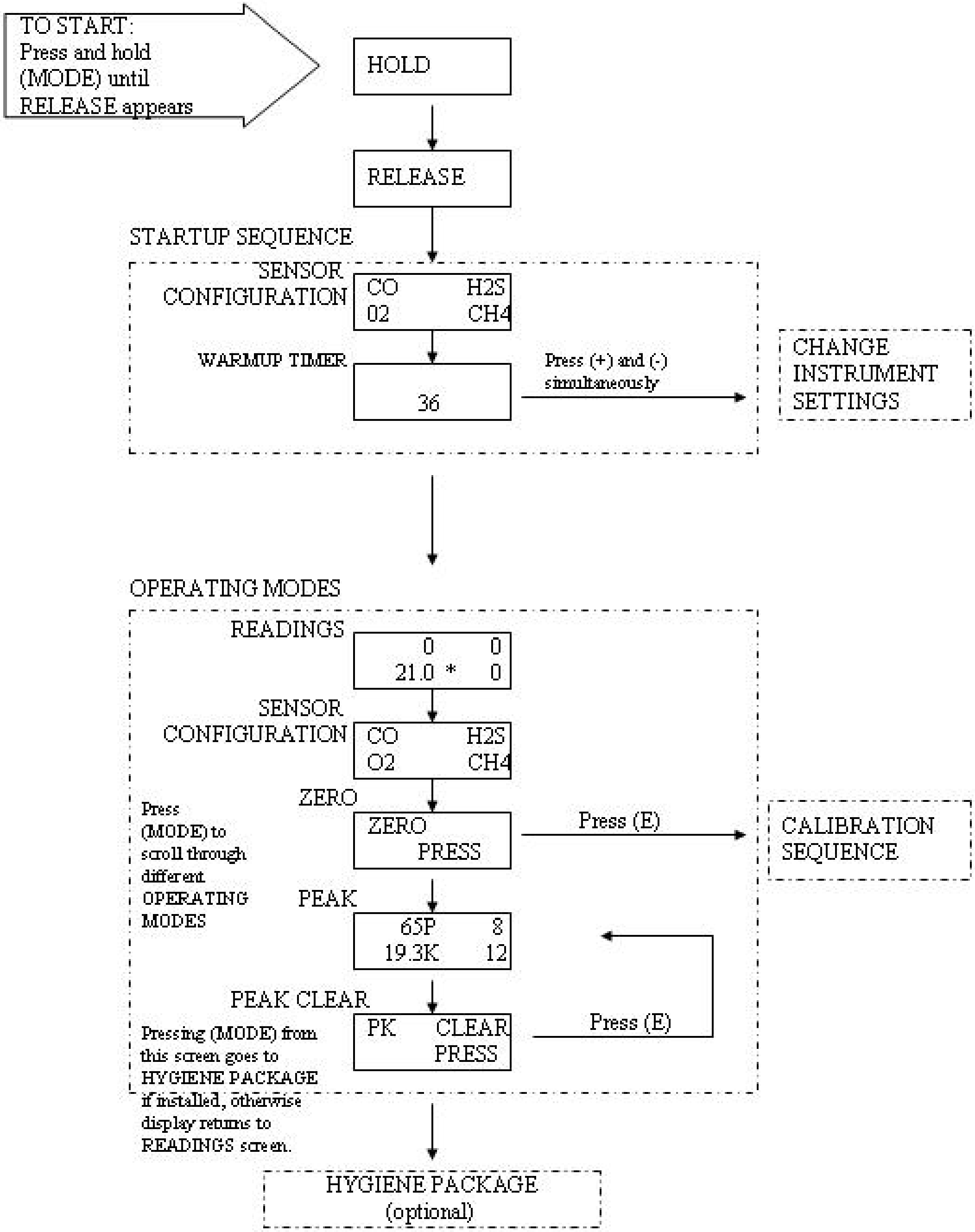

Figure 13A-8. Command Flowsheet for TMX-412 (New Version), page 3

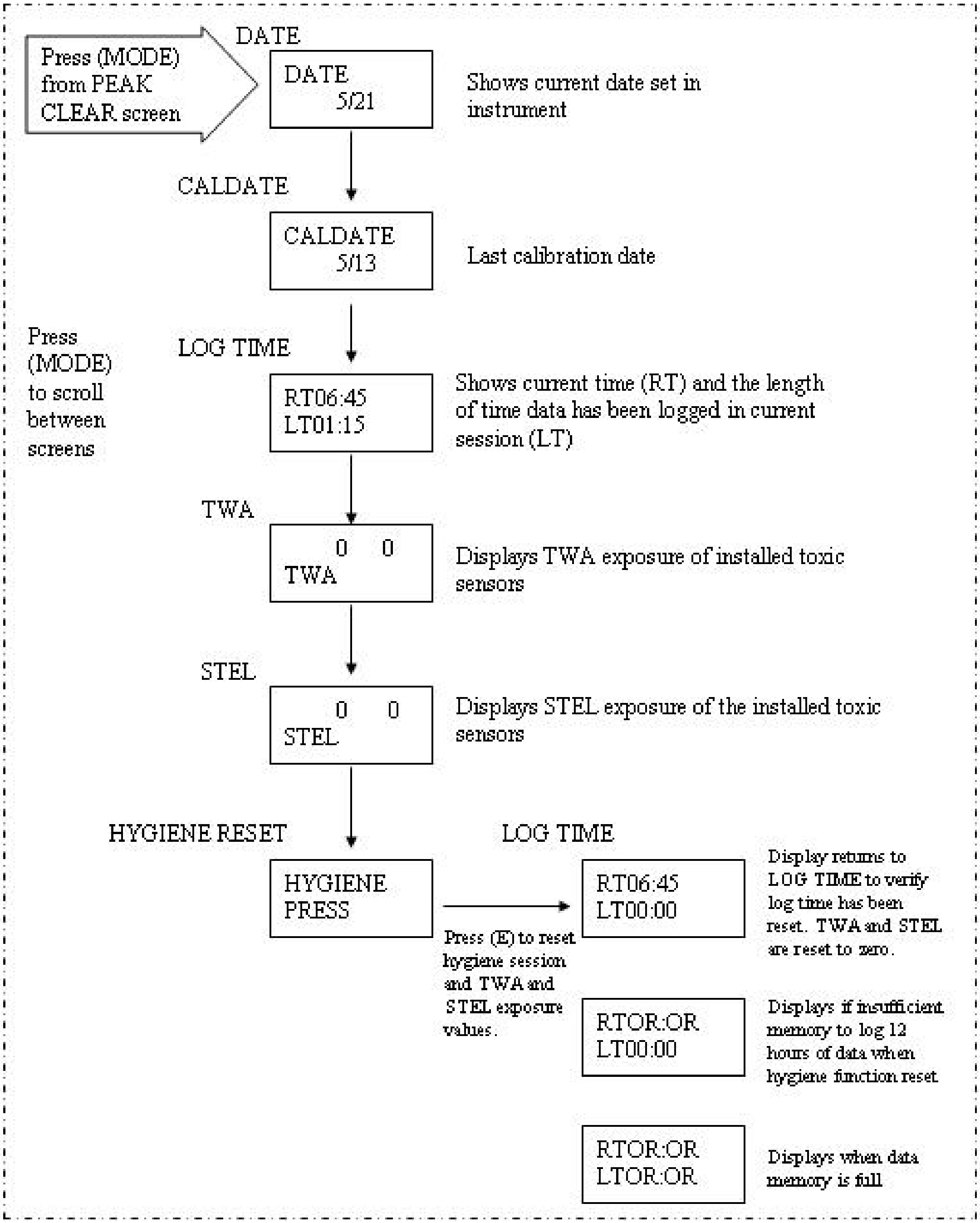

Figure 13A-9. Command Flowsheet for TMX-412 (New Version), page 4

III. Jerome Model 411 Gold Film Mercury Vapor Analyzer (Figure 13A-10)

A. Characteristics

Error Factor: 1.09

Flow rate: 0.75 Liters/min = 750 cc/min

Sensitivity: 0.003 mg/m^3

Range: 0.000 - 1.999 mg/m^3

Accuracy: ± 5 % at 0.107 mg/m^3 Hg

Temperature Range: 32° to 104° F (0° to 40° C)

B. Summarized Operating Instructions

1. Press power ON.

2. Check battery status. If LOW BAT (low battery) shows, recharge or replace.

3. Check Sensor Status %. The LCD display in % saturation must be between 01 and 99 for the instrument to operate.

4. If the meter reads .L.L.L, the bridge balance needs adjustment.

5. Press SAMPLE. If after 10 seconds the meter reads .8.8.8, the gold film sensor is 100% saturated and the films must be heated. The meter must go through a 15-minute film heat cycle at the following times:

- When the meter reads .8.8.8;
- At the end of each day of use; and
- After periods of storage longer than 3 months.

Film Heat Procedure:

a. Attach a clean air filter to the intake filter housing.

   - **b.** Attach the line cord to the 411 and plug into an AC electrical outlet.

   - **c.** Connect the battery charger to the 411 and plug the battery charger into an AC electrical outlet.

   - **d.** Press POWER ON.

   - **e.** Press FILM HEAT. The meter reads .H.H.H during the 15-minute cycle.

   - **f.** Press SENSOR STATUS and hold down. Disregard this reading.

   - **g.** Adjust BRIDGE BALANCE; use trimmer tool to read between 02 and 06.

   - **h.** Press POWER OFF.

   - **i.** Disconnect battery charger and line cord.

   - **j.** Remove clean air filter.

6. Press SURVEY (1 sec) or SAMPLE (10 sec).

7. Read the meter. The number displayed is the mercury concentration in mg/m^3.

8. For locating spills, keep the SURVEY button pressed down so that each reading will be a discrete one second sample.

9. Occasionally check SENSOR STATUS %.

10. Press POWER OFF when not in use.

C. Calibration

The manufacturer recommends calibration by the factory every 12 months, depending on use. The following field calibration check or “Functional Test” should be performed after 20 hours of use or every 3 months (whichever comes first).

1. Set up Test Vapor

- **a.** Unwrap the thermometer assembly.
- **b.** Remove the cap from the calibration vessel (thermos).
- **c.** In your calibration kit locate the vial labeled “Caution: Hg.”
- **d.** Wearing gloves and any other appropriate PPE, hold the vial over a lipped container. Remove the cap from the vial containing mercury and carefully pour the liquid mercury into the calibration vessel.
- **e.** Install the thermometer assembly securely in the mouth of the calibration vessel (i.e., thermos).
- **f.** Place the calibration vessel in a location with a stable ambient temperature, preferably between 64°F and 72° F (18°C and 22° C).

2. Procedure (see Figure 13A-10)

- **a.** Lightly shake the calibration vessel.
- **b.** Leave the calibration vessel at a stable room temperature for 2 hours.
- **c.** Unplug line cord and battery charger.
- **d.** Change the intake filter disc and septum. Plug the septum assembly into the intake filter housing.
- **e.** Attach the clean air filter to the septum assembly.

f. Press POWER ON.

g. Note the temperature of the calibration vessel.

h. Inject 1 cc of mercury vapor from the calibration vessel (Thermos) using the syringe, and record the meter reading.

i. Repeat step h. three times. The three readings must be ± 5 % of each other.

j. Refer to the Temperature Conversion Chart, Figure 13A-11, acceptable range, and compare to 411 meter display.

k. If the average of the three meter readings does not fall within the acceptable range, perform a film heat, adjust the bridge balance, and repeat the calibration procedure.

l. If the meter cannot be brought into calibration range, return to the manufacturer according to District procedures.

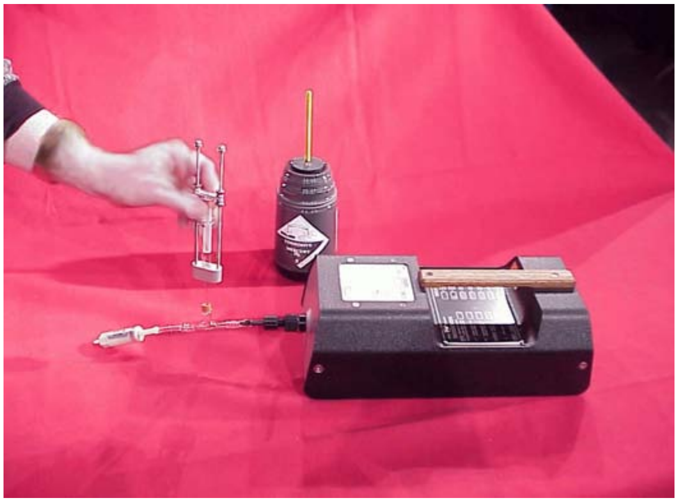

Figure 13A-10. Calibration of the Jerome Mercury Analyzer

Figure 13A-11. 411 Temperature Conversion Chart

Temperature °C	Acceptable Range of Digital Meter Response
16	0.064 to 0.086
17	0.070 to 0.094
18	0.076 to 0.102
19	0.082 to 0.112
20	0.090 to 0.122
21	0.097 to 0.131
22	0.105 to 0.143
23	0.115 to 0.155
24	0.124 to 0.168

D. Maintenance and Repair

1. Battery Charging

To obtain maximum battery life, wait until LOW BAT appears on the LCD meter, and then charge the battery with instrument power OFF for 16 hours. Battery life under normal use is 1 - 2 years. Replace batteries when they fail to hold a charge.

2. Replacing Battery Pack

a. Disconnect the battery charger and line cord from the 411 and turn power OFF.

  - **b.** Open the 411 by removing two side screws from the meter end of the case.
  - **c.** Disconnect battery jacks.
  - **d.** Remove the two screws holding the battery pack.
  - **e.** Install new battery pack.
  - **f.** Replace the battery pack bracket and tighten the screws.
  - **g.** Reconnect the battery jacks.
  - **h.** Close the case and replace the screws.

3. Replace the intake filter disc after 20 hours of use or every 3 months, as needed.

  - **a.** Unscrew the intake filter housing from the 411.
  - **b.** Remove the disc by pushing it out with the trimmer tool.
  - **c.** Replace with a new disc. Do not touch the disc with your fingers - use tweezers.
  - **d.** Screw the intake filter housing back on the 411.

4. Change the internal filter cartridge and tubing after 6 months of use, or as needed.

  - **a.** Remove the two side screws on the 411 meter end and open the case.
  - **b.** Disconnect Tygon Tubing and discard.
  - **c.** Remove the filter cartridge and discard.
  - **d.** Attach tubing “A” to intake filter housing. Gently expand the end of tubing with needle nose pliers and moisten end of filter cartridge. Attach new pre-cut Tygon tubing “B” to the arrow end of the new filter.

e. Install this assembly in the 411.

f. Push the filter into the mounting clip.
g. Remove kinks in the tubing and check that tubing connections are secure.

h. Close the case and replace the screws.

5. Exterior zero air filter and the interior Hg Exhaust Filter should be replaced at least annually.

IV. JEROME 431X GOLD FILM MERCURY VAPOR ANALYZER (Figure 13A-12)

Figure 13 A-12. Jerome Model 431X Mercury Vapor Analyzer

A. Characteristics

Error Factor: 1.09

Flow rate: 0.75 Liters/min = 750 cc/min

Sensitivity: 0.003 mg/m^3

Range: 0.003 - 0.999 mg/m^3

Accuracy: ± 5 % at 0.100 mg/m^3 Hg

Temperature Range: 32° to 104° F (0° to 40° C)

B. Summarized Operating Instructions

1. Press power ON. Allow a 1 minute warm-up period.

2. Perform a sensor regeneration according to the procedure in Section C below. Thirty minutes after completion of this cycle, re-zero the instrument.

3. Press the SAMPLE button once.

4. At the end of the 12 second cycle, read the digital meter. The number on the meter is the mercury concentration in mg/m^3.

5. At the end of each day's use, perform a sensor regeneration. Do not allow contamination to remain on film overnight.

C. Sensor Regeneration Procedure

A sensor regeneration is needed to clear the 431X sensor of any accumulated mercury under the following circumstances:

- When the meter displays .8.8.8, indicating saturation;
- At the beginning of the day on which it is to be used;
- During the mercury survey, if the sensor becomes saturated; and
- At the end of the day's survey before storage.

1. Attach power cord and plug into an AC electrical outlet.

2. Press the power ON button.

3. Press the REGEN (regeneration) button. The meter will flash .H.H.H for 10 minutes and display .0.0.0 when completed. Do not interrupt this cycle.

4. While pressing the ZERO button, turn the ZERO ADJUST, using the tool, until the meter reads 0. Note: Wait at least 30 minutes after the sensor regeneration cycle is completed to ensure maximum sample accuracy.

5. Press OFF button and disconnect power cord.

D. Survey Mode (to locate spills or access potentially high concentrations)

1. Press the power ON and allow a 1 minute warm-up.

2. Press and hold the SAMPLE button. The instrument has a 12 second cycle and in the survey mode, a sample is taken every 3 seconds. The display flashes the measured concentration at the end of each 3 second period.

3. When the survey has been completed, release the sample button. The final survey value remains displayed until the next sample is taken.

4. Press the power OFF button when not in use.

E. Calibration (see Figure 13A-12)

The manufacturer recommends calibration by the factory every 12 months, depending on use. The following field calibration check or "Functional Test" should be performed after 20 hours of use, or every 3 months (whichever comes first).

1. Carefully unpack and inspect the parts of the kit.

2. In a ventilated area, remove the mercury vial.

3. Wearing gloves and any other appropriate PPE, open the vial and carefully pour the mercury into the center of the functional test kit's vessel's opening.

4. Install the stopper assembly to prevent breakage of the thermometer.

5. Allow 2 hours for the kit to adjust to room temperature:
64°F - 72° F (18°C - 22° C).

6. Loosen, but do not remove, the base of the vessel. The base unscrews from the body.

7. Set on a firm surface. Hold the base stationary and unscrew the body from the base.

8. Hold the base and inner glass vessel with one hand while removing the body and gasket with the other.

9. After the mercury is transferred into the glass inner vessel, reassemble in the reverse order.

10. Replace the 0.25 mm fritware.

11. Replace the septum on the septum holder assembly.

12. Attach a zero air filter to the septum assembly.

13. Press power on.

14. Take 3 samples. If the average meter reading is less than 0.005, continue to next step. If not, the instrument may be contaminated. Stop here.

15. Note the temperature of the calibration vessel.

16. Press the SAMPLE button, and wait 2 seconds. When the display flashes, inject 1 cc of mercury vapor using the syringe technique.

17. Record reading.

18. Repeat last two steps. The average of the last 3 readings should fall within the range shown in Figure 13A-13. If within range, the meter is functioning properly.

Figure 13A-13. 431X Temperature Conversion Chart

Temperature °C	Acceptable Range of Digital Meter Response
16	0.091 to 0.123
17	0.100 to 0.135
18	0.108 to 0.146
19	0.118 to 0.159
20	0.129 to 0.174
21	0.138 to 0.187
22	0.151 to 0.204
23	0.164 to 0.222
24	0.177 to 0.240

19. If the calibration was successful, perform another “Sensor Regeneration” (see Section C. above). If the meter cannot be brought into calibration range after repeating the complete procedure, return to the manufacturer according to District procedures.

F. Maintenance

Refer to the manufacturer’s operations manual for a preventive maintenance calendar. Follow these general guidelines. Note: Maintenance frequency depends on the amount of use, rather than a set time interval.

1. Replace the 0.25 mm fritware once a week, or more often in a dusty environment.

   a. Unscrew and remove the intake.

   b. Push the old fritware disk out, using trimmer tool.

   c. Use tweezers to insert new fritware. Avoid using fingers.

   d. Use blunt end of trimmer tool to seat fritware disc firmly against inner ledge of intake.

   e. Screw the intake back on.

2. Change internal filters after 6 months or as needed. Change the external zero air filter annually.

   a. Turn instrument off and unplug power cord.

   b. Remove the two side screws from the intake end of instrument and open case.

   c. Carefully disconnect the Tygon tubing from both ends of the internal filters (C/M filter and scrubber filter) and discard.

   d. Connect new filters to Tygon tubing, ensuring all filter nipples point toward the intake. Push the Tygon tubing as far as it will go onto the filter fittings.

   e. Push the filters into the mounting clips.

f. Remove any crimps in the tubing and ensure connections are secure.

g. Close case and replace screws.

G. Operating on Battery Power

Battery power will allow use of the Jerome 431X as a portable instrument. Be aware of the following conditions.

1. A fully charged battery pack provides power for a minimum of 6 hours operation.

2. For use beyond 6 hours, a new fully charged battery pack is needed.

3. A complete battery recharging requires 14 hours.

The 431X contains a trickle charger so it may be continually plugged into an AC power source without damaging the battery pack. Replace batteries annually or as needed.

<u>Caution</u>**:** The Jerome 431X is intended for vapor use only. Do not allow the probe or the instrument's intake to come in contact with liquids.

V. MSA SOLARIS GAS MULTI-TESTER (FIGURE 13A-14)

Figure 13A-14. MSA SOLARIS GAS MULTI-TESTER

When activated, MSA Solaris detects and measures concentrations of carbon monoxide, methane, and oxygen in the ambient air continuously and simultaneously. It has also been configured, upon MSHA request, for nitrogen dioxide testing as the fourth sensor.

A. Characteristics

Error Factor: 1.25

Sensors: Combustible Gases and Methane - Catalytic
Oxygen and Toxic Gases - Electrochemical

Measuring Range:

LEL (combustible gases)	0 - 100% in 1% increments
CH_4 (methane)	0 - 5% Volume in 0.1% increments
O_2 (oxygen)	0 - 25% Volume in 0.1% increments
CO (carbon monoxide)	0 - 500 ppm in 1 ppm increments
NO_2 (nitrogen dioxide)	0 - 50 ppm in 0.1 ppm increments

(the manufacturer can configure the instrument for NO_2 upon request)

Temperature Range:

Normal:	0 to 40°C
Extended *****	-20 to 0°C, 40 to 50°C

(*Extended temperature range indicates gas readings may vary slightly if calibrated at room temperature. For optimal performance, calibrate instrument at temperature of use.)

Short Periods:	-40 to -20°C (15 minutes)

Humidity Range: If humidity changes to any significant degree (*e.g.*, going from a dry, air conditioned environment to outdoor, moisture-laden air), oxygen levels can change up to 0.5%. This is due to water vapor in the air displacing oxygen, thus reducing oxygen readings as humidity increases. The oxygen sensor has a special filter to reduce the affects of humidity changes on oxygen readings. This effect will not be noticed immediately, but will slowly impact oxygen readings over a several hour period.

Hazardous US Locations: (see instrument label to determine applicable approval):
(Non-Mining) UL913 for Class I, Div. 1, Groups A, B, C and D, T3C,
T_{amb} = -20°C to +50°C
US (Mining) 30 CFR Part 22, Methane Detector

Factory-Set Alarm Setpoints:
(Low Alarm, High Alarm, STEL, TWA)
CO: 35 ppm, 100 ppm, 400 ppm, 35 ppm
NO_2: 2.5 ppm, 5.0 ppm, 5 ppm, 2.5 ppm
H_2S: 10 ppm, 15 ppm, 15 ppm, 10 ppm
LEL: 10%, 20%, NA, NA

B. Summarized Operating Instructions

1. Turning ON the Solaris Multigas Detector

Press the Power ON button; turn the instrument on by pressing the power button on the control face panel for one beep. This is the second button from the left and is identified by the international symbol for power: a circle with a slash at the 12 o'clock position.

The instrument displays:

a. Self-test:

- Alarm setpoints: Low; High; STEL (if activated); TWA (if activated)
- Calibration gas (expected calibration gas values)
- Time and date (if data logging option installed)
- Last CAL date (if data logging option installed)
- CAL due date (if activated and if data logging option installed)
- Instrument warm-up period
- Fresh Air Setup option.

b. Last Cal Date

- The Solaris Multigas Detector is equipped with a "last successful calibration date" feature. The date shown is the last date on which all installed sensors were successfully calibrated. "**LAST CAL**" is displayed with this date in the following format: **MM:DD:YY.** If any of the sensors were not previously calibrated, "**LAST CAL, INVALID**" is displayed.

c. Cal Due Date

- The Solaris Multigas Detector (with data logging and software version 1.1 or higher) is equipped with a Calibration Due Date feature. To activate this feature, see Chapter 3 of the operating manual.
- If the calibration due date feature is activated, following Last Cal Date, the message "**CAL DUE, X DAYS**" appears on the instrument LCD, where x = the number of days until a calibration is due, user selectable for 1 to 180 days. If the number of days

until calibration is due reaches 0, an alert occurs and "**CAL DUE, --NOW--**" displays.

- Press the RESET button to clear the alert and continue with the instrument warm-up period. During Normal Measure mode, if the calibration due date feature is activated and calibration is due, the instrument beeps and displays "**CAL DUE**" every 30 seconds until the unit is calibrated.
- Perform a calibration check before each day's use to verify proper instrument operation (see Chapter 2 of the operating manual, "Calibration Check").

2. Instrument Alarm Bypass Options

The Solaris Multigas Detector (with software version 1.1 or higher) is equipped with a feature to disable or silence the visual, backlight, audible, and vibrator options. To activate this feature, see Chapter 3 of the operating manual, "Accessing the Instrument Setup Mode". If any of these options (visual, backlight, audible, or vibrator) are disabled during instrument startup, the Solaris Detector displays:

- "VISUAL OFF" if the red LEDs are disabled
- "BACKLITE OFF" if backlight is disabled
- "AUDIBLE OFF" if audible buzzer is disabled
- "VIBRATE OFF" if the vibrator is disabled.
- If the visual, audible, or vibrator options are disabled, "ALARM OFF" flashes on the LCD during Normal Measure mode.

3. Instrument Zeroing

a. **Fresh Air Set Up Option** (for automatic zero adjustment of the Solaris Multigas Detector sensors). **NOTE:** The Fresh Air Setup (FAS) has limits. If a hazardous level of gas is present, the Solaris Multigas Detector ignores the FAS command and goes into alarm. **Do not activate the Fresh Air Setup unless you are certain you are in fresh, uncontaminated air; otherwise, inaccurate readings can occur which can falsely indicate that a hazardous atmosphere is safe. If you have any doubts as to the quality of the surrounding air, do not use the Fresh Air Setup feature. Do not use the Fresh Air Setup as a substitute for daily calibration checks. The calibration check is required to verify**

span accuracy. Failure to follow this warning can result in serious personal injury or death.

b. Persons using the Solaris Multigas Detector must determine whether or not the Fresh Air Setup option should be used. The user's abilities, training and normal work practices must be considered when making this decision.

- Turn ON the Solaris Multigas Detector. Once the instrument self check is complete, **ZERO?** flashes for 10 seconds.
- To perform a Fresh Air Setup, push the ON/OFF button while **ZERO?** is flashing.
- To immediately skip the Fresh Air Setup, push the RESET button. If no buttons are pushed, the **ZERO?** automatically stops flashing after the 10 seconds have expired and the Fresh Air Setup is not performed.

4. Battery Life Indicator (FIGURE 2-1)

The battery condition icon continuously displays in the upper portion of the screen, regardless of the selected page. As the battery charge dissipates, segments of the battery icon go blank until only the outline of the battery icon remains.

a. Battery Warning

A Battery Warning indicates that a nominal 15 minutes of operation remain before instrument batteries are completely depleted. **NOTE:** Duration of remaining instrument operation during Battery Warning depends on ambient temperatures. When the Solaris Multigas Detector goes into Battery Warning:

- Battery Life indicator flashes
- “BATT WRN” flashes every 15 seconds
- Alarm sounds
- Lights flash every 15 seconds
- The Solaris Multigas Detector continues to operate until the instrument is turned OFF or battery shutdown occurs.

b. Battery Shutdown

When the batteries can no longer operate the instrument, the instrument goes into Battery Shutdown mode:

- **LOW** and **BATTERY** flash on the display
- Alarm sounds and lights flash
- Alarm can be silenced by pressing the RESET button
- No other pages can be viewed
- After approximately one minute, the instrument automatically turns OFF.

When Battery Shutdown condition sounds, stop using the instrument; it can no longer alert you of potential hazards because it does not have enough power to operate properly:

- **Warn others and leave the area immediately**
- **Turn OFF the instrument if it is ON**
- **Report the problem to the person responsible for maintenance**
- **Recharge the battery**

Failure to follow this procedure could result in serious personal injury or death. During "Battery Low" condition, prepare to exit the work area since the instrument could go into "Battery Shutdown" at any time, resulting in loss of sensor function. Depending on the age of the batteries, ambient temperature and other conditions, the instrument "Battery Low" and "Battery Shutdown" times could be shorter than anticipated. Recharge the instrument when the "Battery Low" or "Battery Shutdown" conditions occur.

5. Sensor Missing Alarm

The Solaris Multigas Detector will enter the Sensor Missing alarm if the instrument detects that an enabled sensor is not properly installed in the instrument. For O_2, CO, and H_2S sensors, the Sensor Missing feature is checked when the instrument is turned ON and when leaving the Setup mode. The combustible Sensor Missing feature is continually monitored. If a sensor is detected as missing, the following occurs:

- **SENSOR** and **MISSING** flash on the display
  The flag above the sensor detected as missing flashes on the display
- Alarm sounds and lights flash
- Alarm can be silenced by pressing the RESET button
- No other pages can be viewed
- After approximately one minute, the instrument automatically turns OFF

If a Sensor Missing condition occurs, stop using the instrument; it can no longer alert you of potential hazards.

- **Warn others and leave the area immediately.**
- **Turn OFF the instrument if it is ON.**
- **Report the problem to the person responsible for maintenance**
- **Failure to follow this procedure could result in serious personal injury or death.**

6. Calibration Check

The calibration check is simple and should only take about one minute. Perform this calibration check before each day's use.

- Turn ON the Solaris Multigas Detector in clean, fresh air.
- Verify that readings indicate no gas is present.
- Attach calibration cap to the Solaris Multigas Detector.
- Ensure that "TOP" and "↑" on the calibration cap are oriented so that “TOP” is positioned at the top of the instrument.
- Attach regulator (supplied with calibration kit) to the cylinder.
- Connect tubing (supplied with calibration kit) to the regulator.
- Attach other end of tubing to the calibration cap.
- Open the valve on the regulator.
- The regulator flow rate is 0.25 Lpm.
- The reading on the Solaris Multigas Detector display should be within the limits stated on the calibration cylinder.
- If necessary, change cylinder to introduce other calibration gases.
- If readings are not within these limits, the Solaris Multigas Detector requires recalibration. See Chapter 4 of the operating manual, "Calibration."

7. Measuring Gas Concentrations

a. Combustible Gases (% LEL) (FIGURE 2-2)

The Solaris Multigas Detector can be equipped to detect combustible gases in the atmosphere.

Alarms sound under three conditions: when concentrations reach the Alarm Setpoint, 100% of LEL (Lower Explosive Limit), or 5% CH_4.

When the combustible gas indication reaches the Alarm Setpoint:

- Alarm sounds
- Alarm lights flash
- % LEL or CH_4 flag above the concentration flashes.

To silence the alarm, press the RESET button.

NOTE: The alarm will stay silent if the alarm condition has cleared.

When the combustible gas indication reaches either 100% LEL or 5% CH_4, the LockAlarm^{TM} circuit locks the combustible gas reading and alarm and:

- Alarm sounds
- Alarm lights flash
- 100 or 5.00 appears on the display and flashes.
- This alarm cannot be reset with the RESET button.

If the 100% LEL or 5.00% CH_4 alarm condition is reached, you may be in a life-threatening situation; there is enough gas in the atmosphere for an explosion to occur. In addition, any rapid up-scale reading followed by a declining or erratic reading can also be an indication that there is enough gas for an explosion. If either of these indications occur, warn others and leave the contaminated area immediately. Failure to follow this warning can result in serious personal injury or death.

After moving to a safe, fresh-air environment, reset the alarm by turning OFF the instrument and turning it ON again.

b. Oxygen Measurements (% O_2)

The Solaris Multigas Detector can be equipped to detect the amount of oxygen in the atmosphere.

Two conditions trigger the alarm:

- Too little oxygen (deficient)
- Too much oxygen (enriched).

When the alarm setpoint is reached for either of the above:

- Alarm sounds
- Alarm lights flash
- % O_2 flag above the concentration flashes.

If the Oxygen alarm condition is reached while using the instrument as a personal or area monitor, warn others and leave the area immediately; the ambient condition has reached a preset alarm level. If using the instrument as an inspection device, do not enter the area without proper protection. Failure to follow this warning will cause exposure to a hazardous environment which can result in serious personal injury or death.

c. Toxic Gas Measurements

The Solaris Multigas Detector can be equipped to detect:

- Carbon Monoxide (CO) and/or
- Hydrogen Sulfide (H_2S), and/or
- Nitrogen Dioxide (NO_2) in the atmosphere.

When the alarm setpoint is reached for Carbon Monoxide (CO), and/or Hydrogen Sulfide (H_2S), and/or Nitrogen Dioxide (NO_2):

- Alarm Sounds
- Alarm Lights flash
- PPM CO or PPM H_2S flag above the concentration flashes.

If the Toxic Gas alarm condition is reached while using the instrument as a personal or area monitor, warn others and leave the area immediately; the ambient condition has reached a preset alarm level. If using the instrument as an inspection device, do not enter the area without proper protection.

Failure to follow this warning will cause over-exposure to toxic gases, which can result in serious personal injury or death.

8. Safe LED

The Solaris Multigas Detector is equipped with a green "SAFE LED". This green SAFE LED will flash every 15 seconds under the following conditions:

- The green SAFE LED is enabled
- Instrument is on the normal Measure Gases page
- Combustible reading is 0% LEL or 0% CH_4
- Oxygen (O_2) reading is 20.9%
- Carbon Monoxide (CO) reading is 0 ppm
- Hydrogen Sulfide (H_2S) reading is 0 ppm
- Nitrogen Dioxide (NO_2) reading is 0 ppm
- No gas alarms are present (low or high)
- Instrument is not in Low Battery warning or alarm
- STEL and TWA readings are 0 ppm

9. Operating Beep

The Solaris Multigas Detector is equipped with an operating beep. This operating beep activates every 30 seconds by momentarily sounding the horn and flashing the alarm LEDs under the following conditions:

- Operating beep is enabled
- Instrument is in the normal Measure Gases page
- Instrument is not in Battery Warning
- Instrument is not in Gas Alarm
- Audible and visible options enabled

10. Peak and Minimum Readings (PEAK and MIN)

a. PEAK appears in the upper portion of the display to show the highest levels of gas recorded by the Solaris Multigas Detector since:

  - Turn-ON, or
  - Peak readings were reset

To Reset the Peak Readings:
- Access the Peak page.
- Press the RESET button.

b. MIN appears in the upper portion of the display to show the lowest level of oxygen recorded by the Solaris Multigas Detector since:
- Turn-ON, or
- Minimum readings were reset

To Reset the Minimum Readings:
- Access the Min page.
- Press the RESET button.

11. Short Term Exposure Limits (STEL)

a. The STEL flag appear in the upper portion of the display to show the average exposure over a 15-minute period.

b. When the amount of gas detected by the Solaris Multigas Detector is greater than the STEL limit:
- Alarm sounds
- Alarm lights flash
- STEL flashes.

To Reset the STEL:
- Access the STEL page.
- Press the RESET button.

c. The STEL alarm is calculated over a 15-minute exposure.
Calculation examples are as follows:
Assume the Detector has been running for at least 15 minutes:

1) 15-minute exposure of 35 ppm:

$$\frac{(15 \text{ minutes x } 35 \text{ PPM})}{15 \text{ minutes}} = 35 \text{ ppm}$$

2) 10-minute exposure of 35 PPM + 5-minute exposure of 5 ppm:

$$\frac{(10 \text{ minutes x } 35 \text{ PPM}) + (5 \text{ minutes x } 5 \text{ PPM})}{15 \text{ minutes}} = \frac{350 + 25}{15} = 25 \text{ ppm}$$

d. If the STEL alarm condition is reached while using the instrument as a personal or area monitor, warn others and leave the contaminated area immediately; the ambient gas concentration has reached the preset STEL alarm level. Failure to follow this warning will cause over-exposure to toxic gases, which can result in serious personal injury or death.

12. Time Weighted Average (TWA)

a. The TWA flag will appear in the upper portion of the display to show the average exposure since the instrument was turned ON or the TWA reading was reset.
When the amount of gas detected by the Solaris Multigas Detector is greater than the eight-hour TWA limit:

- Alarm sounds
- Alarm lights flash
- TWA flashes.

To Reset the TWA:

- Access the TWA page.
- Press the RESET button.

b. The TWA alarm is calculated over an eight-hour exposure. Calculation examples are as follows:

1) 1-hour exposure of 50 PPM:

$$\frac{(1 \text{ hour x } 50 \text{ PPM}) + (7 \text{ hours x } 0 \text{ PPM})}{8 \text{ hours}} = 6.25 \text{ ppm}$$

2) 4-hour exposure of 50 PPM + 4-hour exposure of 100 PPM:

$$\frac{(4 \text{ hours x } 50 \text{ PPM}) + (4 \text{ hours x } 100 \text{ PPM})}{8 \text{ hours}} = 75 \text{ ppm}$$

3) 12-hour exposure of 100 PPM:

$$\frac{(12 \text{ hours x } 100 \text{ PPM})}{8 \text{ hours}} = 150 \text{ ppm}$$

NOTE: The accumulated reading is always divided by eight hours.

c. **If the TWA alarm condition is reached while using the instrument as a personal or area monitor, warn others and leave the contaminated area immediately; the ambient gas concentration has reached the preset TWA alarm level. Failure to follow this warning will cause over-exposure to toxic gases, which can result in serious personal injury or death.**

13. **Time Display**
TIME appears on the display to show the current time of day in a 24-hour format.

14. **Date Display**
DATE appears on the display with the current date displayed in the following format: MM:DD:YY

15. **Turning OFF the Solaris Multigas Detector**
Push and Hold the ON-OFF button for three seconds.
NOTE: Releasing the ON-OFF button before the three seconds elapse returns the instrument to the Measure page.

CHAPTER 14
MISCELLANEOUS SAMPLING METHODS

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Chapter 14
MISCELLANEOUS SAMPLING METHODS

I. Introduction

This chapter addresses sampling methods that are occasionally used to sample uncommon situations which require special expertise. The following sampling methods are included in this chapter: wipe sampling, bag sampling, and bulk sampling for "unknowns."

II. Wipe Sampling

A method of sampling used to determine the presence of solid or liquid contaminants on surfaces. Wipe sampling kits are available through the district office health specialist or industrial hygienist. Some situations where wipe sampling can be used are: after a chemical spill or to determine if toxic materials are present in working or eating areas. Wipe Sampling should be coordinated with the district office in consultation with the MSHA laboratory before collecting samples. Coordination is necessary because:

- Specific wipes (filter papers wetted with solvents) are needed for different contaminants; and
- Depending on the contaminant, the sample-collecting material may cause an interference during analysis if the proper type of wipe is not used.

A. Supplies Required

A wipe sampling kit (see Figure 14-1) includes the following items:

1. Whatman No. 41 or No. 42 filter paper
2. Disposable gloves
3. Distilled water bottle (primarily used for contaminants in Chapter 3)
4. Isopropanol (isopropyl alcohol) bottle
5. Ethylene glycol (antifreeze) bottle
6. Litmus paper
7. Masking tape
8. Plastic sampling template (10 cm x 10 cm grid)

Figure 14-1. Wipe Sampling Kit

B. Sampling Procedure

See Figure 14-2, Taking a Wipe Sample.

1. Wear clean, impervious, disposable gloves when taking each wipe sample. This will prevent sample contamination.

2. Moisten the wipe filters with distilled water or the appropriate solution prior to use.

3. Gently wipe a surface area covering at least 16 in^2 (4 in. x 4 in.) or 100 cm^2 (10 cm x 10 cm), if possible.

4. Fold the wipe sample with the exposed side in.

5. Transfer wipe samples for substances other than mercury or mercury compounds into a plastic bag, vial, or jar. Seal the vial or jar with a <u>nonmetallic</u> (e.g., teflon) cap or lid. In addition, seal the cap or lid with vinyl or electrical tape. Wipe samples for mercury and mercury compounds should be placed into a 20 ml borosilicate glass scintillation vial, with a Teflon- or polypropylene-lined cap. Plastic bags should not be used as the primary container for mercury wipes.

6. Mark the container with a sample number and place a sample seal on it so that the sample cannot be tampered with.

7. Record the pertinent information in the Health Field Notes.

8. Fill out a Request For Laboratory Analysis Form, and write “WS” in Item No. 15, Sample Type.

For more information regarding the appropriate use of wipe sampling, contact your District Office**.**

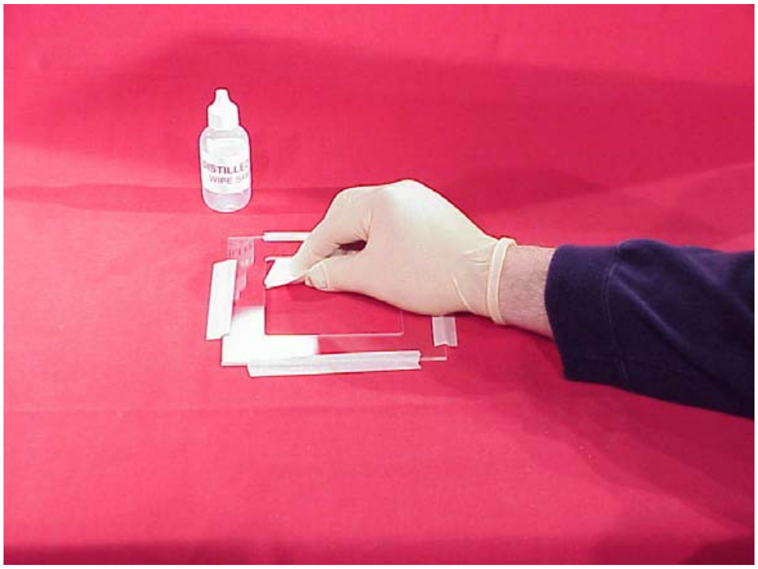

Figure 14-2. Taking a Wipe Sample

Precautions

Several contaminants may be collected and analyzed on the same wipe; however, interference or overload may affect the analyses. Alert the MSHA laboratory about the potential for interferences by submitting a note with the wipe sample container. This note should inform the laboratory of any contaminants suspected of being present in the sample(s) that are in addition to the specific contaminants requested for analysis. For example, when a sample is analyzed for metals, in particular arsenic, aluminum can cause interference if present in the sample. Before collecting a combination of metals on the same wipe, consult the laboratory to determine how many wipe samples are needed.

C. Prepare Blank

At least one blank (or unused) wipe must be submitted to the MSHA laboratory with each set of wipe samples. Blank wipes must be submitted in the same shipment, but placed in a separate vial. The blank wipe should be handled with clean disposable gloves.

III. Bag Sampling

Sampling bags are collection devices which use a sampling pump to draw contaminated air into the air sample bag. The entire sampling bag is sent to the MSHA laboratory for analysis. The most common contaminants sampled by this method are typical mine gases. Coordinate with your district office and the laboratory when considering bag sampling.

IV. Bulk Sampling for "Unknowns"

Bulk sampling is a screening method used to identify "unknown" contaminants which may be present at the mine site. The samples may be collected from accumulations of material (located anywhere at the mine site) when a hazard is suspected. Any information that the inspector can supply with the bulk sample relevant to the composition will help the MSHA Laboratory select an appropriate analysis. This should include location where sample was collected, processes involved, and, whenever possible, Material Safety Data Sheets (MSDS) and/or independent laboratory analysis reports. Coordinate with your district office and the MSHA laboratory for proper collection containers and shipping instructions (see Figure 14-3). Note: Do not submit bulk samples in the same container as exposure samples.

Figure 14-3. Bulk Sample Containers

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CHAPTER 15
NOISE

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Chapter 15 - NOISE

I. Purpose

The purpose of this chapter is to establish procedures and guidelines for conducting noise sampling, evaluating sample results and verifying that the operator is in compliance with the noise standard. The chapter also implements the P-code policy for Coal and Metal and Nonmetal Mines and discusses technologically achievable engineering and administrative controls. **This supersedes the previously issued noise health inspection procedures.**

II. Introduction

Many miners are exposed to loud and sustained noise levels. The Mine Safety and Health Administration (MSHA) has determined that approximately 13.4% of miners will suffer material hearing impairment during their working lifetime unless preventive measures are taken to reduce overexposures. Noise sampling is an essential component in identifying miners whose exposures must be reduced to protect them from the risk of occupational noise-induced hearing loss.

III. Inspections

A. Noise Sampling Equipment

Full-shift noise samples must be taken using a personal noise dosimeter placed on the miner.

The Quest Q-200, Q-300, and Noise Pro DL personal noise dosimeters have multiple internal dosimeters.

1. Dosimeter I must be set for evaluating noise related to the 85 dBA action level. It must operate with the A-weighted network, slow response, 80 dBA threshold, 90 dBA criterion level, and 5 dBA exchange rate.

2. Dosimeter II must be set for evaluating noise related to the 90 dBA permissible exposure level (PEL). It must be set to operate with the A-weighted network, slow response, 90 dBA threshold, 90 dBA criterion level, and 5 dBA exchange rate.

3. Dosimeter III, if applicable, must be set at the same parameters as Dosimeter II [not used for enforcement purposes].

All Quest personal dosimeters must be set to the parameters listed in Table 1. Technical Support personnel will confirm the settings for Quest dosimeters during the annual calibration and lock the parameters in place. This will prohibit the settings from inadvertently being changed in the field.

Table 1

Quest Parameter Settings

Measurement Parameter	**Value**		
			If Applicable
	Dosimeter I (Action Level)	**Dosimeter II** (PEL)	**Dosimeter III** (PEL)
Calibration (QC-10)	114	114	114
Range	HI	HI	HI
UL (Upper Limit Level)	117	117	117
CL (Criterion Level)	90	90	90
ER (Exchange Rate)	5	5	5
TL (Lower Threshold Level)	80	90	90
Fast/Slow (Response Time)	Slow	Slow	Slow
A/C (Frequency Weighting)	A	A	A

The **Ametek MK-2 and MK-3** personal noise dosimeters have multiple internal dosimeters. The low threshold dose reading must be set for evaluating noise related to the 85 dBA action level. It must be set to operate with the A-weighted network, slow response, 80 dBA threshold, 90 dBA criterion level, and 5 dBA exchange rate.

1. The low threshold dose reading shows on the display screen as a **solid** “DOSE %”. The high threshold dose reading must be set for evaluating noise related to the 90 dBA permissible exposure level (PEL). It must be set to operate with the A-weighted network, slow response, 90 dBA threshold, 90 dBA criterion level, and 5 dBA exchange rate.

2. The high threshold dose reading shows on the display screen as a **flashing** “DOSE %”. Enter these readings as they are shown on the dosimeter display; do not round them off.

All Ametek personal noise dosimeters must be set to the parameters listed in Table 2. After the initial setup, Technical Support personnel will set the option switch settings during the annual calibration and the settings must not be changed.

Table 2

Ametek MK-2 and MK-3
Option Switch Settings

The option switch settings on the Ametek MK-2 and MK-3 personal noise dosimeters must be set as follows:

SWITCH NO. 1	ON	SLOW RESPONSE
SWITCH NO. 2	OFF	80 dBA THRESHOLD
SWITCH NO. 3	OFF	80 dBA THRESHOLD
SWITCH NO. 4	OFF	90 dBA CRITERION LEVEL
SWITCH NO. 5	OFF	90 dBA CRITERION LEVEL
SWITCH NO. 6	OFF	5 dBA DOUBLING RATE
SWITCH NO. 7	OFF	5 dBA DOUBLING RATE
SWITCH NO. 8	OFF	2 SEC >115 dBA TIME DELAY
SWITCH NO. 9	OFF	A WEIGHTING

Note: Use MSHA-approved permissible personal noise dosimeters and sound level meters in metal and nonmetal gassy mines and in underground coal mines, where required.

B. Frequency of Noise Sampling Equipment Calibration

Personal noise dosimeters and acoustical calibrators are required to be calibrated annually. A calibration schedule for all dosimeters and calibrators has been established for each district. The schedule must be strictly adhered to by each district to assure that all dosimeters and calibrators are properly calibrated. The calibration schedule established for M/NM districts is provided in Appendix 7. Dosimeter calibration schedules for Coal are in the District offices. The address for shipping dosimeters and calibrators is as follows:

Mine Safety and Health Administration
Chief, Physical and Toxic Agents Division
Pittsburgh Safety and Health Technology Center
626 Cochrans Mill Road, Building 38
Pittsburgh, PA 15236
(412) 386-6565 (Acoustical Calibration Lab)

C. Noise Sampling Strategy

1. Identify Miners to be Sampled

Observations and/or measurements using a sound level meter (SLM) or a personal noise dosimeter may be used to identify miners exposed to sound levels equal to or greater than 80 dBA. Miners exposed to sound levels equal to or greater than 80 dBA should be considered as candidates for a full shift, personal noise sampling. If a miner needs to shout to be heard a few feet away, the miner may be overexposed to noise.

Determine miners exposed to sound levels equal to or greater than 80 dBA by considering:

- high risk occupations;
- exposure conditions at the time of inspection;
- prior sampling history at the mine;
- reading of sound level meter or personal noise dosimeters; and
- any other information such as the mine's sampling records.

Typical mining occupations exposed to high sound levels include, but are not limited to, roof bolters, shuttle car operators, mobile bridge conveyor operators, shear operators, continuous miner operators, drillers, stone cutters, mobile equipment operators (truck, bulldozer, front-end loader, scraper, etc.), mechanics, laborers, and operators of crushers, mills, and screens.

Samples should be collected on the normal work shift and on off-shifts and week-ends where noise activities are present. At a minimum, miners who have the greatest risk of overexposure to noise should be identified and sampled.

When sampling at Metal / Nonmetal mines, enforcement personnel should include a representative number of miners from each of the high risk occupations at each mine. However, when previous sampling has demonstrated that adequate engineering and administrative controls are in place to ensure compliance, and there is no history or little likelihood of overexposure for that occupation at that mine, then sampling may not be necessary as deemed by the District Office. If sampling is not performed, enforcement personnel must document in the inspection notes the controls being used and the reason they believe miners are not at risk of overexposure to noise.

When sampling at Coal mines, the sampling strategy requirements for Coal should be followed. These requirements are provided in Section C.3.

When a sample based on the 90 dBA PEL produces a dosimeter reading greater than 100 percent but less than 132 percent, a follow-up noise sample is recommended within the next 6 months. All previously sampled miners or occupations must be re-sampled, if available. If all or some are not available, other available miners must be substituted.

2. <u>Determine a Miner's Full-Shift Noise Exposure</u>

A personal noise dosimeter must be used to determine a miner's full work shift noise exposure. Only full-shift samples are used to determine compliance with MSHA's noise standard. Because compliance with the permissible exposure level (PEL) and action level (AL) is determined using different thresholds (90 dBA and 80 dBA, respectively), MSHA's personal noise dosimeters are capable of simultaneously recording data for both thresholds.

3. Sampling Strategy - Coal Only

Enforcement personnel must remain in the work area/section where sampling is being conducted to ensure the sample(s) are representative of the normal activities for the entire sampling shift. Normally, when sampling areas outside the production section, the enforcement personnel should not remain with the miners for the entire sampling shift because of their logistics. Instead, the inspector must spend sufficient time to observe and record the operating conditions and work activities in the area, the noise controls in use, a general description of the conditions of the controls, and potential sources of noise exposure.

a. Mechanized Mining Units (MMUs)

A full-shift sample must be conducted on at least five (5) miners performing different occupations, if available, on each MMU. These must include the miner operator(s), roof bolters, shuttle cars and any mobile bridge conveyor operators. All MMUs will be sampled on an annual basis. The minimum number of noise samples expected to be completed each year, on MMUs at underground mines, will be based on the number of producing MMUs as of the first of each month averaged over the fiscal year. A representative number of samples will be collected on off-shifts and weekends where such activities are present.

b. Outby Areas Underground (Areas outside of production)

A full-shift sample must be collected from a representative number of outby miners where high levels of noise may exist. These should include, but not be limited to, motormen and belt cleaners. A representative number of outby miners must be sampled on an annual basis at each underground mine.

c. Surface Areas of Underground Mines

A full-shift sample must be conducted on at least five (5) miners, if available, on the surface area of an underground mine where high levels of noise may exist. All surface areas of underground mines are to be sampled on an annual basis.

d. Surface Mines and Surface Facilities

A full-shift sample must be conducted on at least five (5) miners, if available, at each surface mine. These must include bulldozer operators and other heavy equipment operators. All surface mines and surface facilities are to be sampled on an annual basis. The number of noise samples expected to be completed will be based on the number of the above listed producing mine areas as of the first of each month averaged over the fiscal year. A representative number of samples will be collected on off-shifts and weekends where such activities are present.

e. Follow-up Samples

When a sample based on the 90 dBA PEL produces a dosimeter reading greater than 100 percent but less than 132 percent, a follow-up noise sample is recommended within the next 6 months. All previously sampled miners or occupations must be re-sampled, if available. If all or some are not available, other available miners must be substituted.

The inspector **must** conduct a follow-up full-shift noise exposure sample upon expiration of the abatement time as originally set or extended **if** feasible noise controls have been implemented which may achieve compliance. All previously sampled miners or occupations must be re-sampled, if available. If all or some are not available, other available miners must be substituted.

D. Pre-Inspection and Post-Inspection Procedures

MSHA records, such as previous inspection reports, previous Noise Technical Investigation results, listing of assigned P-codes (see Section J for description of P-codes) and the Uniform Mine File (Mine File), must be reviewed prior to beginning the inspection at the mine.

Before taking each sample, the calibration label on the dosimeter and calibrator must be checked to ensure that the instruments have been calibrated within the past 12 months. A field calibration check must be conducted before and after each sampling shift. If the check indicates that the dosimeter is more than **+/-** 1.0 dBA of the calibrator, with either calibration check, the instrument or sampling results must not be used. The pre-calibration and post-calibration checks must be conducted with the same calibrator and never interchange the microphone unless it has been recalibrated. Procedural instructions for checking the calibration of the instruments are contained in Appendix 1.

For Coal mines, the record documenting pre- and post-shift calibration checks must be on Form 2000-84 as required by Section F. Include the serial number or MSHA Property Number of the dosimeter and field calibrator. A sample Form 2000-84 is provided in Appendix 4.

For Metal/Nonmetal mines, the record documenting pre- and post-shift calibration checks must be included in the Health Field Notes as required by Section G. Include the serial number or MSHA Property Number of the dosimeter and field calibrator.

After arriving at the mine, the mine inspector must review all the posted administrative controls and during the inspection, determine if they are being followed. All engineering controls must also be checked to determine if they are being maintained. Document this information in the notes.

E. Sampling Inspection Procedures

1. Instructions to the Miner

a. Explain to the miner what you are doing, what the sampling device does, and the reason for the sampling (i.e., the hazard). Emphasize that the personal noise dosimeter or sound level meter is not a tape recording device.

b. Instruct the miner not to remove a personal noise dosimeter or microphone at any time and not to cover the microphone with a coat or other garment. If the miner must leave the mine property during the shift, the inspector should remove the personal noise dosimeter and place it in the “pause” or “standby” mode. Sampling should resume once the miner returns.

c. Instruct the miner not to bump, drop, damage, or tamper with the personal noise dosimeter or microphone. Discourage whistling into, shouting into, or tapping on the microphone.

d. Emphasize the need for the miner to continue to work in a routine manner and report to you any unusual occurrences during the sampling period.

e. Inform the miner when and where the personal noise dosimeter will be removed, and that you will check the equipment and may take sound level meter readings periodically.

f. If a miner objects to wearing the personal noise dosimeter, determine the reasons for the objection. Explain the need for the sampling. If you cannot obtain the cooperation of the miner and another miner performing the same job at the same location is available and cooperative, sample the cooperative miner. If the refusal is an attempt to impede or prevent an inspection, the inspector should attempt to complete any parts of the inspection that do not involve sampling. Afterwards, the inspector’s supervisor should be contacted. In such cases, the supervisor is responsible for collecting all the facts, reducing them to writing, and contacting the District or Assistant District Manager. Consult the Program Policy Manual, Volume I, I.103-1, Assaulting, Intimidating or Impeding Inspectors, for current policy on actions to be taken in such circumstances.

2. Dosimeters

Noise exposure measurements must be made in accordance with the instrument manufacturer’s recommendations. This requires the dosimeter microphone to be located at the top of the shoulder midway between the neck and end of the shoulder, with the microphone diaphragm pointing in a vertical upward direction. The microphone must be located on the shoulder that is normally between the principal noise source and the miner's ear (see Figure 1). To the extent practical, the dosimeter instrument and microphone cable must be positioned underneath exterior clothing to minimize potential safety problems and damage to the instrument. The microphone must not be covered by clothing**.** At the start of each sample a wind screen must be attached to the dosimeter microphone in accordance with the instrument's manufacturer's instruction. If the wind screen is lost during sampling, samples requiring enforcement action must be VOIDED. Re-sampling must be conducted as soon as possible.

Figure 1. Placement of the dosimeter microphone.

The personal noise dosimeter must be worn by the miner whose noise exposure is being measured for an entire normal work shift, even if the normal work shift is in excess of 8 hours. Conduct sampling, both initial and follow-up, only when conditions are judged to be normal and representative. If unusual conditions arise during the sampling period then the sample may have to be voided. Re-sampling must be conducted as soon as possible.

<u>Determination of a "Normal" Workshift</u>

a. The following are examples of the types of information that can be used to determine if activities are characteristic of a "normal" representative workshift: the number of truckloads of material processed by a crusher operator; the number of holes or vertical feet drilled by a drill operator; the number of trucks loaded by a shovel operator; the type of product and number of bags produced by a bagging operator; and any indication of operation modifications.

b. A "normal" workshift at many operations may exhibit wide variations in working conditions and activities. Ask the miner if these are "usual" or "unusual" work conditions. Sample results are valid when collected on shifts that lie within the range of normal variations. All corrective actions taken to abate a citation / order must be documented in the body of the termination notice and field notes.

During each full-shift sample, the inspector must observe the miner being sampled as frequently as is necessary to determine that a representative sample is being conducted of the normal activities.

The inspector must observe enough of the work activity to ensure that:

(1) Dosimeters remain in the environment being sampled;
(2) Dosimeters are properly positioned or placed on the miner for sampling;
(3) Dosimeters are not damaged;
(4) Normal mining activities are taking place;
(5) A determination of production is made; and
(6) Noise controls (including administrative controls) are documented, etc.

This requirement does not necessarily preclude the inspector from doing other inspection work while conducting the noise sample. Normally, the inspector will accompany the miners out of the mine.

During sampling it is essential that the sources of the noise exposure be determined. One way this can be accomplished is using a SLM or the dosimeter in the SLM mode. When the source(s) of the exposure cannot be readily identified, make a sketch of the work area including location of the miner(s), noise source(s) and mark on the sketch where the noise readings were taken.

3. **Sound Level Meters - Dosimeters in Sound Level Meter Mode**

MSHA noise dosimeters can be used in the sound level meter (SLM) mode to check sound levels a miner may be exposed to in their work area. The following method can be used to check work area sound levels using a dosimeter in the SLM mode:

a. Calibration checks required in Section D must be followed.

b. The dosimeter microphone must be held at arm’s length within one or two feet of the miner’s ear in a normal work area, with the microphone pointed upward.

c. Compliance determinations must be based on a full-shift personal noise dosimeter sample.

d. Inspectors should not take noise measurements with sound level meters on moving equipment, such as shuttle cars and bulldozers, unless safe seating arrangements are provided.

4. Sound Level Meters (Non-Enforcement – Metal / Nonmetal)

Sound level meters can be used to check the sound levels in a work area, evaluate sources of noise and determine which miners to select for sampling.

a. Set the sound level meter (SLM) on the “A-weighting” scale and “slow” meter response for all measurements.

b. Check the accuracy of the SLM by performing a pre-sample check with an acoustical calibrator. The instrument must be within +/-1.0 dBA of the calibrator’s stated output. Make sure the reading has stabilized and record it in the Health Field Notes. **Note: Do not use the instrument if it is outside the +/-1.0 dBA tolerance.**

c. In general, hold the SLM at arm's length, keeping your body out of the path of the noise. Hold the microphone within one foot (hearing zone) of the miner's most exposed ear whenever possible. As specified by the manufacturer, hold the microphone either perpendicular (90-degree angle) toward the noise source, pointed at a 70-degree angle toward the source, or pointed directly at the source.

d. Because the needle or digital display on the SLM may fluctuate, observe the readings for of at least 30 consecutive seconds. Ignore any momentary high or low levels.

e. Take several readings for each activity the miner performs during the work shift.

f. Record the sound level reading or range of sound levels on the back side of the Health Field Notes. Also, record the time, location, specific activity of the miner, ID number of any equipment the miner is operating, and any other pertinent information. A sketch may be helpful in showing where the various readings were taken.

g. After sampling, check the accuracy of the instrument with an acoustical calibrator. If the difference between the pre- and post-sampling readings is more than +/- 1.0 dBA from the value of the calibrator, void the data obtained with the instrument.

h. Do not report SLM results to the computer database system. Record them in field notes.

F. Inspection Documentation – Coal

1. The following is a list of observations that **MUST** be described in the field notes:

   a. Administrative noise controls posted on the mine bulletin board. Detail whether they were followed during the sampling shift and if a copy was provided to affected miner(s).

   b. A miner refusing to wear a dosimeter.

   c. Interruptions in the sampling requiring the dosimeter to be placed in the "PAUSE MODE" (i.e., miner leaving mine property).

   d. Factors requiring a sample to be voided. (Includes information from the miners being sampled.)

   e. The sources of noise for the miner(s) being sampled.

   f. Engineering noise controls being utilized that could affect the dose of the miners being sampled; their condition and state of maintenance.

   g. If a citation is being issued, list feasible noise controls not being used to reduce the affected miner(s) dose or any other action or inaction causing the citation to be issued. (Refer to PIB 04-18.)

   h. Follow-up on an existing citation is required, detail the noise controls implemented during the abatement period.

2. An MSHA Form 7000-10P, June 93 (Revised), Noise note page must be completed during an inspection when sampling.

3. Complete the latest MSHA Form 2000-84 for each inspection where noise samples are conducted and review the information for clarity, legibility, and accuracy.

   a. **<u>Mine ID/Contractor ID Number</u>** - Enter the seven digit mine identification number assigned by MSHA and if appropriate, the three- or four-digit contractor ID.

   b. **<u>Event Number</u>** - Enter the event number for the inspection or investigation during which the noise samples were taken.

   c. **<u>AR/RE Number</u>** - Enter the five-digit identification number from the AR/RE card of authorization.

d. **Field Office No**. - Enter the five-digit number assigned to the MSHA CMS&H office under which the coal mine is inspected.

e. **Sampling Date** - Enter date of sample(s) in two-digit month-day-year format. This date must be the same for all noise samples documented on the same Form 2000-84. (Please note that when entering this data in the noise sample database, a four-digit year must be used.)

f. **Activity Code** - Enter the activity code for the type of event during which the noise samples were conducted.

g. **Mine Name** - Enter the mine name as it appears on the Legal ID.

h. **Company Name** - Enter the company name as it appears on the Legal ID.

i**.** **Sample Number** - The sample number is designated on the form for up to six samples per form.

j**.** **Sample Type** - Check the box that applies, indicating whether the noise sample is an initial sample or a follow-up sample.

k. **P-code** **–** Note whether there is a current P-code.

l. **MMU/Pit/Area Sampled** - Enter the MMU/DA/DWP identification number assigned to the section, entity or surface area(s) where the sample was conducted.

m. **Instrument Property Number** - Enter the number from the MSHA property ticket affixed to the instrument or the instrument's serial number.

n. **Calibrator Property Number** - Enter the number from the MSHA property ticket affixed to the calibrator or the instrument's serial number.

o. **Miner’s Last Name & First Initial** - Enter the last name and first initial for each miner for which a noise sample was conducted.

p. **Occupation Code** - Enter the MSHA three-digit code that best describes the duties performed during the sample period.

q. **Machine Code** - Enter the appropriate two-digit machine code from the list on the reverse side of MSHA Form 2000-84.

r. **Manufacturer's Code** - Enter the appropriate three-digit manufacturer's code from the list on the reverse side of MSHA Form 2000-84.

s. **Time Start** - Enter the 24-hour clock time when each sample was begun.

t. **Total Sampling Time** - Enter the total sample time in **minutes** for each sample conducted.

u. **Production This Shift** - Enter raw production in tons for the sample period (underground MMUs only).

v. **85 Action Level Dose (Dosimeter I)** - Enter the dose percent value as a truncated whole number (no decimals) for the noise exposure at the 85 dBA action level from Dosimeter I.

w. **90 PEL Dose (Dosimeter II)** - Enter the dose percent value as a truncated whole number (no decimals) for the noise exposure at the 90 dBA permissible exposure level from Dosimeter II.

x. **90 PEL Max** - Enter the maximum dBA level as a truncated whole number (no decimals) indicated for the noise exposure at the 90 dBA permissible exposure level from Dosimeter II.

y. **Upper Control Limit Time** - Enter the duration of exposure in **whole minutes** for noise above 117 dBA.

z. **Calibration Check** - Note the appropriate calibration checks made before and after each noise sample. Check the boxes that apply.

aa. **Type of Hearing Protective Device(s)** - Check the box(es) for all type(s) of HPDs worn by each miner sampled.

ab. **Enrolled in HCP** - Check this box if the miner sampled is enrolled in a Hearing Conservation Program regardless of his or her noise exposure.

ac. **Citation Number** - Enter the citation number **only** if a citation is written for overexposure to noise under 30 CFR Part 62.

ad. **Citation Abatement** – Enter the abatement code from the list on the reverse side of MSHA Form 2000-84 **only** if abatement actions were taken.

ae. **Comments** - Self-explanatory. The date(s) of the annual calibration checks of the dosimeters and/or calibrator may be entered here. Narrative information on the personal protective equipment used and abatement information should be provided here.

NOTE: **VOID** must be entered over the sample column which is not valid due to sampling equipment failure or activities or workshifts which are documented as abnormal. (See page 3-8, Determination of a “Normal” workshift.)

4. A completed **copy** of the most recent MSHA Form 2000-84 must be sent to the appropriate office within each District so the information can be entered into the noise database.

G. Inspection Documentation - Metal/Nonmetal

1. Document the following in the Health Field Notes (refer to Chapter 21, Section V):

    a. Clock time the personal noise dosimeter was started.

    b. Identification numbers of sampling equipment.

    c. Miner's name, job title code, and work location(s).

    d. Shift hours per day and days per week worked.

    e. Any hearing protection worn including brand, model, type, and noise reduction rating (NRR).

    f. Whether a hearing conservation program exists and whether the miner sampled has received audiometric tests and how often.

    g. Record what tasks the miner has performed in the time between checks, so that the completed Health Field Notes will describe the miner's full work shift, activity/exposure.

    h. Clock times that the personal noise dosimeter and microphone were checked and condition of sampling equipment (if the sample was paused or restarted for any reason, record the times involved) and explain.

    i. The activity of the miner, equipment operating in the area, and approximate time spent at each activity/task.

    j. General description of noise controls in use.

    k. Potential sources of exposure, a concise description of these sources, number of miners affected, and possible additional control measures.

    l. Environmental conditions (such as wind conditions, temperature, and humidity).

    m. At the end of the sample, record the clock time.

    n. Record the run time (displayed in hours and minutes).

    o. Record the dose percentage for the 85 dBA action level (80 dBA threshold) and associated time-weighted average (TWA_8) in dBA.

p. Record the dose percentage for the 90 dBA Permissible Exposure Level (90 dBA threshold) and associated time-weighted average (TWA_8) in dBA.

q. Record the pre - and post - calibration data.

r. Any SLM readings collected.

Whenever possible, perform tasks o, p, and q above in the presence of the miner, a representative of the mine operator, and the miner's representative (if applicable).

H. Decision Table

Provision	**Condition**	**Action required by the mine operator**
§ 62.120 ….	Miner's noise exposure is less than the action level.	None.
§ 62.120 ….	Miner's exposure equals or exceeds the action level, but does not exceed the permissible exposure level (PEL).	Operator enrolls the miner in hearing conservation program (HCP) which includes (1) a system of monitoring, (2) voluntary, with two exceptions, use of operator-provided hearing protectors, (3) voluntary audiometric testing, (4) training, and (5) record keeping.
§ 62.130 ….	Miner's exposure exceeds the PEL	Operator uses/continues to use all feasible engineering and administrative controls to reduce exposure to PEL; enrolls the miner in a HCP including ensured use of operator-provided hearing protectors; posts administrative controls and provides copy to affected miner; must never permit a miner to be exposed to sound levels exceeding 115 dBA.
§ 62.140 ….	Miner's exposure exceeds the dual hearing protection level.	Operator enrolls the miner in a HCP, continues to meet all the requirements of § 62.130, ensures concurrent use of earplug and earmuff.

I. Reporting of Sampling Results - Coal

Within 30 calendar days from completion of the sample, the data on the Form 2000-84 must be entered into the Coal Noise Sampling Database at either the field office or the district office.

J. Reporting of Sampling Results - Metal/Nonmetal

1. Inspection reports must include a copy of the Health Field Notes, the completed Personal Exposure Data Summary (PEDS), citations/orders, photos, and any other supplemental information collected during the inspection.

2. When completing the PEDS (refer to Chapter 21, Section VIII), be sure that the percent dose and exposure level units of measurement match the contaminant code (refer to Chapter 21). Sound level meter readings used for screening purposes **are not** reported

on the PEDS, Area Sample Data Summary (ASDS), or the Inspection and Investigation (I&I) Data Summary. Record the SLM screen readings in the health field notes.

K. Determination of the Feasibility of Noise Controls

For a noise overexposure greater than or equal to 132% of the permissible dose a feasibility determination must be made ***prior*** to issuing a citation for lack of controls.

Feasibility = Technological and/or Administrative Achievability + Economic Achievability

Using PIB 04-18 (see Appendix 5), determine whether there are technologically or administratively achievable engineering and/or administrative noise controls, which when used either singly or in combination with other controls would lower the noise exposure by at least 3 dBA[1]; and, whether the cost of the controls would be wholly out of proportion to the reduction in noise exposure expected by their implementation. This 3 dBA equivalent reduction is in a miner's noise exposure, not in noise levels. Exposure (% dose) and sound level (Sound Pressure Level, dBA) are not synonymous terms because an exposure includes a time factor. In addition to providing at least a significant noise exposure reduction (3 dBA), the specific application of the noise control(s) must be technologically (or administratively) achievable and economically achievable for the unique conditions at the mine.

In most instances, this determination process is transparent and quite straightforward, i.e., technologically or administratively achievable controls exist, are at a reasonable cost in light of the expected noise exposure reduction, and therefore must be implemented. For example, the PIB 04-18 states that mufflers are technologically achievable controls for hand-held percussive tools. A reasonable estimate of the cost of the muffler is less than $500, a sum that is economically achievable for most, if not all, situations. In 1991, the Federal Mine Safety and Health Review Commission determined that it was feasible to retrofit a bulldozer worth approximately $20,000 with an air-conditioned cab estimated to cost $10,000 at a small sand and gravel operation with 3 employees. It was feasible since it was technologically and economically achievable.

In some cases, it will be necessary to seek supervisory guidance when making the decision whether to require a control. Consultation is strongly encouraged. Follow the district procedures for consulting with the field office supervisor, district staff, Division of Health or Technical Support staff for advice.

Part 62 considers administrative controls to be equivalent to engineering controls, however, both must be found feasible before they can be required to be implemented.

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[1] A 3 dBA equivalent reduction in terms of an initial and final dose is equivalent to a 34% reduction in the initial dose. (If the final dose is 0.66% of the initial dose, or less, then a 3 dBA equivalent reduction has been achieved, i.e., Dfinal = Dinitial *0.66.)

The Process

1. Determine a miner's noise exposure using full-shift dosimetry. If the dose equals or exceeds 132%, an overexposure condition exists. ***Note: Do not issue a citation for lack of controls until a determination of feasibility is made.***

2. Record source(s) of noise overexposure in the notes and briefly describe the noise controls that have been installed or implemented and whether the controls are properly maintained.

3. Refer to PIB04-18 (see Appendix 5) for a list of controls. Determine which, if any, of the controls are technologically achievable or administratively achievable in this particular situation. Technologically achievable controls denoted as "conditional" should be reviewed and take into consideration the conditions that exist at the mine that could affect their effectiveness or create additional health or safety hazards.

4. If all technologically achievable engineering and administratively achievable administrative controls are determined to be properly selected, installed, used, and maintained, or there are none, do not issue a citation for lack of controls, rather, initiate the P-Code process. (See Appendix 6, PIB 04-5, "Basis for Assigning a P-Code for Noise Overexposure.")

5. When there are technologically or administratively achievable controls which have not been implemented, determine whether the controls are economically achievable in this particular situation.

   a. A reasoned estimate of the cost of the control under consideration.
   b. The nature and extent of the noise exposure.
   c. A comparison of cost estimates for original equipment, replacement, retrofit, and/or repairs.
   d. Estimated costs of abatement would be reasonable to achieve benefits (i.e., reduction in a miner's noise exposure).

NOTE: Assistance in estimating costs will be available on MSHA's website.

6. If a technologically achievable or administratively achievable control is extremely costly for the operator but the expected reduction in noise exposure is minimal, it may be determined that it is not economically achievable for the operator to install the control.

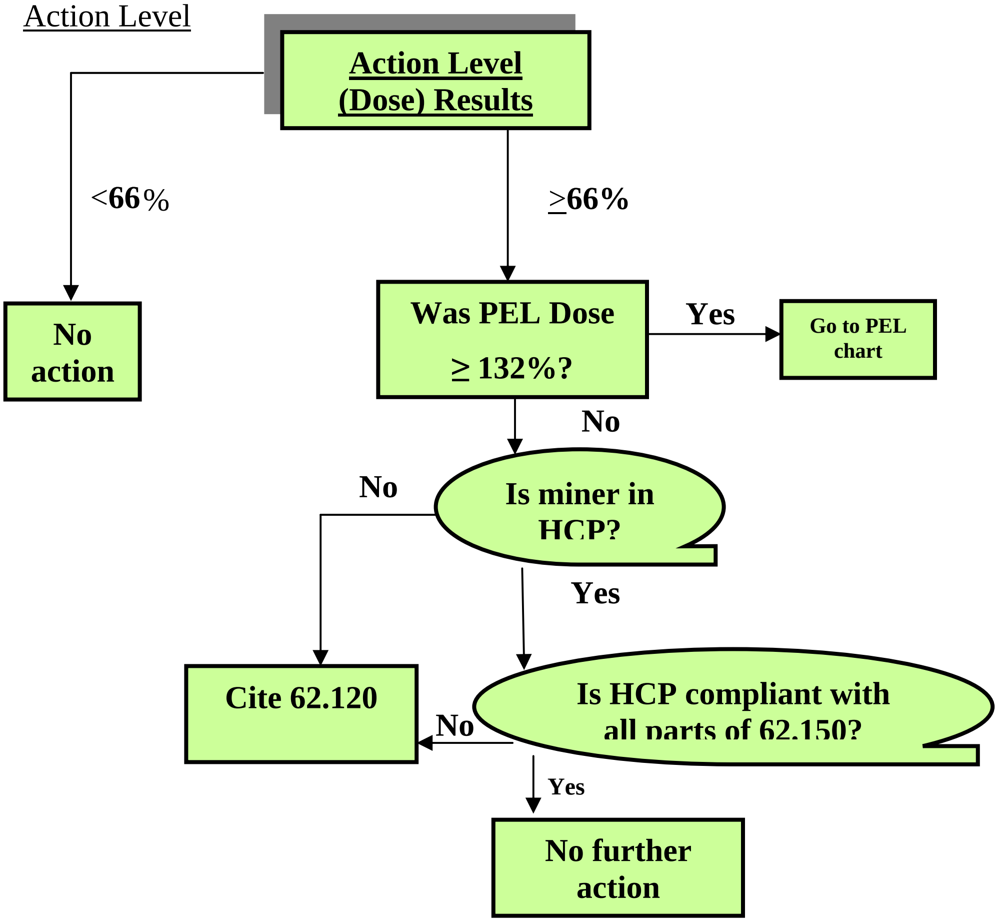
7. If a control is both technologically achievable or administratively achievable and economically achievable then it is feasible for implementation by the mine operator.

8. Once feasibility (economic and technological or administrative achievable) is established for controls not in place, then issue the citation for the overexposure and set an abatement period.

9. Once all feasible controls are implemented and sampling indicates continued overexposure, proceed to a P-Code. (See Appendix 6, PIB 04-5, "Basis for Assigning a P-Code for Noise Overexposure.")

L. Compliance Determination

1. Action Level



When a miner's exposure equals or exceeds the Action Level as defined in 30 CFR 62.101, but the miner's exposure does not exceed the PEL, a citation under 30 CFR 62.120 must be issued to the operator/contractor **IF** the results of a noise sample show that:

a. The full shift noise exposure of any miner is 66 percent or greater; **AND**

b. The affected miner(s) is/are not enrolled in a Hearing Conservation Program that complies with all elements of 30 CFR 62.150.

For an exposure equal to or exceeding the Action Level (TWA_8 of 85 dBA) up to the Permissible Exposure Level (TWA_8 of 90 dBA), hearing protection must be provided to the affected miner. However, for such exposures, the noise rule does not require miners to wear hearing protectors unless one of the following conditions exists:

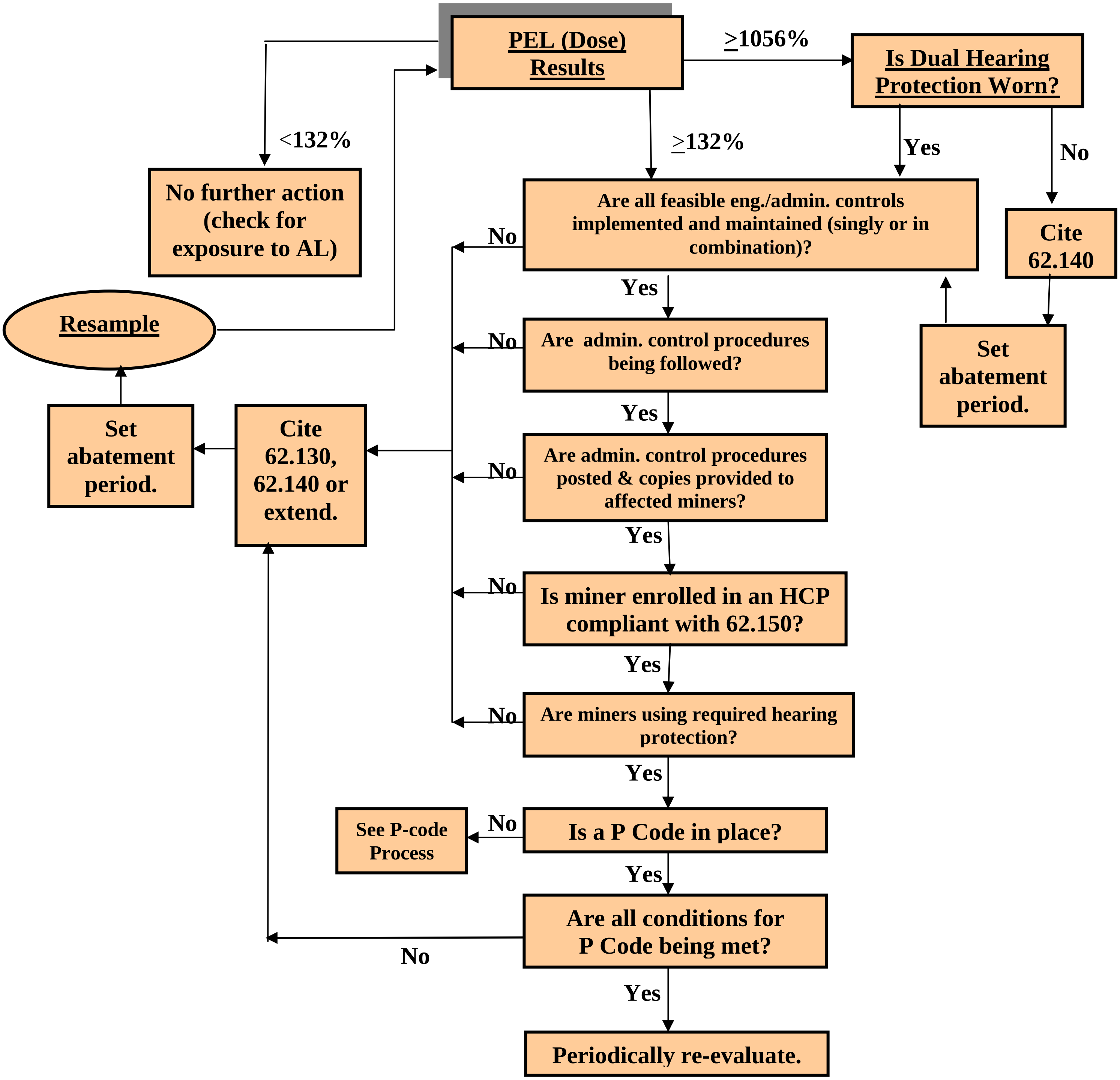
30 CFR 62.160(c) (1) – the miner has incurred a Standard Threshold Shift (STS); or

30 CFR 62.160(c) (2) – more than 6 months will elapse before a baseline audiogram is conducted.

Note: The citable level of 66 percent is based on the action level of 50 percent dose (TWA_8 of 85 dBA) plus an error factor of 2.0 dBA.

Note: 30 CFR 62.170 (2) – The mine operator MAY substitute the use of hearing protectors for the 14 hour quiet period before conducting audiometric testing. MSHA recommends that you strive to keep miner's noise exposures to below the Action Level of 85 dBA during the quiet period.

2. Permissible Exposure Level and Dual Hearing Protection Level, and Maximum Level (Refer to PEL chart shown below)



Determining whether a citation is warranted under 62.130 for exceeding the PEL, or whether a citation is warranted under 62.140 for exceeding the Dual Hearing Protection Level (DHPL), is a two-step process. The two steps are:

1. finding that a miner's full-shift noise exposure is 132% (or 1056% for DHPL) or greater. A dosimeter must be used for this finding; **AND**

2. finding that any one of the provisions of 62.130 or 62.140 have not been complied with (e.g., feasible engineering and administrative controls have not been installed or maintained; miners are not enrolled in a HCP; operator provided hearing protectors are not being worn; administrative controls are not posted on the mine bulletin board, copies have not been provided to affected miners or are not being followed; or any other element of the HCP is not followed).

When the permissible exposure level (PEL), dual hearing protection level, (DHPL) or maximum level as defined in 30 CFR 62.101 has been exceeded, do not issue a citation under 30 CFR 62.130 or 62.140 unless the full-shift noise exposure of any miner is 132 percent or greater: (1056% or greater for DHPL) **AND**

any one of the following conditions exists:

1. MSHA determines that all feasible engineering and administrative controls have **not** been implemented or maintained; or

2. administrative control procedures are **not** being followed; or

3. administrative control procedures have **not** been posted on the mine bulletin board and a copy provided to affected miners; or

4. the miner has **not** been enrolled in a hearing conservation program that complies with all elements of 62.150; or

5. miners are **not** wearing operator-provided personal protective equipment.

Miners **MUST WEAR** hearing protectors when their exposure exceeds the PEL **despite** the use of all feasible engineering and administrative controls. A citation issued for any of the criteria listed above must not identify the miner by Social Security number or the last 4 identifying digits of the miner's Social Security number. Identification should be made by section identification number, occupation code, or other data such as "right side roof bolter." A statement must also be included that personal hearing protection must be worn until the exposures are reduced to or below the PEL and/or dual personal hearing protection must be worn until the miner's exposure is reduced to or below the dual hearing protection level (DHPL). Where the action level has been met or exceeded, a statement indicating the elements of the Hearing Conservation Program that have not been implemented must be included in the body of the citation.

3. Citations and Orders

The operator will be cited separately for each overexposed miner. For example, at mills and preparation plants, where there are multiple noise sources, such as chutes, crushers, and screens, separate citations will be issued for each miner found to be overexposed. Likewise, at surface and underground mines where there are multiple noise sources such as bulldozers, loaders, haul trucks, etc., separate citations will be issued for each miner found to be overexposed.

However, if there is a single noise source causing an overexposure to numerous miners and its control would bring all exposed miners into compliance, then only one citation will be issued, provided all of the other requirements of the standard are met. The total number of miners overexposed will be indicated on a single citation. For example, one citation will be issued if an air track drill exposes both the driller and the drill helper to similar noise exposures above the PEL with the number of affected miners indicated on the citation.

For each miner found overexposed, a single citation of either 62.120, 62.130, or 62.140 will be issued with all other Part 62 provisions violated grouped as part of the citation. For example, if a miner's exposure exceeds the PEL and the operator failed to provide training and offer audiometric testing, a single citation of 62.130 will be issued and provisions of 30 CFR 62.150 that were violated will be stated in the body of the citation. Where a citation is pending abatement by either retiring or replacing a piece of equipment that is the source of noise, failure to maintain any controls implemented or to comply with requirements of 30 CFR 62.150 will result in a 104(b) order or a 104(a) citation. Where a mine has been assigned a "P"-code, failure to comply with any of the conditions of the "P"-code, including provisions of 30 CFR 62.150, will result in a separate citation for each miner affected. For example, if three miners exposed to the noise generated from a single piece of equipment that is covered by a "P"-code are observed not wearing hearing protection, three separate citations will be issued.

4. Noise Citation Examples

The following are examples that should be used as guidance when issuing citations:

a. Based on the results of an MSHA full shift noise sample taken on September 13, 2001, the continuous mining machine operator (036 occupation) working on the 2 South Section received a permissible exposure level dose of 170%. This exceeds the permissible exposure level of 100% plus error factor (or 132%).

The machine was a Joy 12CM-1 model, S/N 563852.

The operator was not wearing a hearing protector. A hearing protector must be provided and worn by the miner operating the continuous mining machine until the exposure is reduced to or below the permissible exposure level.

Section:	62.130(a)
Gravity:	Reasonably Likely Permanently Disabling S&S

If the miner was wearing a hearing protector, cite:

Section:	62.130(a)
Gravity:	Unlikely Permanently Disabling Non-S&S

b. Based on the results of an MSHA full shift noise sample taken on September 13, 2002, the laborer (XXX occupation) working in the XYZ Plant received a permissible exposure level dose of 1263%. This exceeds the dual hearing protection level of 800% plus error factor (or 1056%).

The miner was not wearing dual hearing protectors. Dual hearing protectors must be provided by the mine operator and its concurrent use ensured until the noise exposure is reduced to or below the dual hearing protection level. The initial abatement period is to allow time for the mine operator to provide and ensure the concurrent use of dual hearing protectors. After the dual hearing protection requirement is met, actions specified in 62.130 apply, for exposures that exceed the permissible exposure level.

Section:	62.140
Gravity:	Highly Likely Permanently Disabling S&S

If the miner was wearing dual hearing protectors, cite:

Section:	62.140
Gravity:	Unlikely Permanently Disabling Non-S&S

c. Based on the results of an MSHA full shift noise sample taken on September 13, 2003, the bulldozer operator (XXX occupation) working in the 001 pit received a noise dose of 84%. This exceeds the Action Level dose of 50% plus error factor (or 66%).

The bulldozer is a Caterpillar D-9 model, S/N 85Q65P2. The miner was enrolled into a hearing conservation program which does not comply with all provisions of 30 CFR 62.150. The provisions not complied include: (1) 62.170 Audiometric Testing and (2) 62.180 Training

The miner was not wearing a hearing protector.

Section: 62.120
Gravity: Unlikely
Permanently Disabling
Non S&S

Adequate justification needs to be documented before any subsequent action is issued.

The latest version of the MSHA Citation and Order Writing Handbook contains additional examples of citations, extensions, and terminations for violations of the noise rule.

M. Violation Abatement Procedures

1. Upon issuance of a citation for a violation of 62.120, Action Level, the following abatement procedures must be followed:

a. The citation can be terminated when it is determined that the mine operator has enrolled the affected miner(s) in a Hearing Conservation Program that fully complies with all elements of section 62.150.

However, with respect to the audiometric testing provision, the citation can be terminated if the operator has conducted or **scheduled** a reasonable date for implementing audiometric testing, and all other elements of 62.150 are being complied with. This information must be included in the justification for action, when the citation is terminated.

If the operator then fails to **provide** the audiometric testing as scheduled, a full-shift noise sample must be conducted to ensure that the miner(s) is still exposed at or above the action level. If the miner(s) is still exposed at or above the action level, issue a citation under 62.120, stating in the body of the citation that audiometric testing was not provided. If circumstances warrant, this citation should reflect a higher degree of negligence and/or gravity and allow a reasonable abatement period.

If the mine operator fails to abate the citation within the abatement period, re-sample and if a citable action level exposure is found, issue a 104(b) order.

If a 104(b) order is issued, the affected miner(s) must be withdrawn from the "affected area" and the "affected area" portion of the order must list the miner's location and occupation. The order cannot be lifted until compliance with all five elements of 62.150 has been achieved. Documentation outlining what actions were taken to terminate the citation is required.

b. A miner may be removed from the HCP when the miner's noise exposure has been reduced below the action level. If an operator is in the process of establishing an HCP but reduces miners' exposures below the action level prior to fully establishing and implementing the HCP, the operator is not required to complete the establishment and implementation of the HCP. However, if miners' exposures equal or exceed the action level at any time, the operator must establish an HCP and enroll affected miners.

Seasonal Operations Section

a. This paragraph applies to terminating citations for violations of the **action level (AL) at seasonal operations only**. When a citation is outstanding at a seasonal operation for equaling or exceeding the action level and it is infeasible for the operator to obtain an audiogram or complete training for affected miners before the mine shuts down, citations will be terminated when the mine operator has implemented all other aspects of the HCP and the operator provides a reasonable date for implementing the remaining elements of the HCP. The information must be included in the justification for action, when the citation is terminated. When the mine reopens, the operator must implement the remaining elements of the HCP, unless the operator has reduced the affected miners' exposures to below the AL.

b. If the operator has not implemented the remaining elements of the HCP, re-sample the affected miner. If the exposure still equals or exceeds the AL, issue appropriate citation (under 62.120), allowing a reasonable abatement period. If the mine operator fails to abate the citation within the abatement period and a full shift dosimeter sample indicates continuing non-compliance with the action level issue a 104(b) order.

Portable Operations Section

NOTE: When the operation or occupation under citation moves to a new location away from the initial mine site, follow procedure in the Citation and Order Writing Handbook [Ch.7, XI (B) (2)].

2. Upon issuance of a citation for a violation of 62.130, Permissible Exposure Level, the following abatement procedures must be followed:

a. The inspector **must** conduct a follow-up full-shift noise exposure sample upon expiration of the abatement time as originally set or extended if feasible noise controls have been implemented which may achieve compliance.

b. If the sample shows compliance:

(1) The citation must be terminated; and

(2) Documentation outlining what actions were taken to terminate the citation is required.

c. If compliance is not achieved and MSHA determines that additional feasible controls exist:

(1) Additional engineering and/or administrative controls are required to be installed or implemented to lower the miner's noise exposures further.

d. If compliance is not achieved and MSHA determines that all feasible engineering and administrative controls have been installed or implemented, and all other requirements of 62.130 have been met (e.g., feasible engineering controls are being maintained, miners are enrolled in an HCP that complies with all parts of 62.150, operator-provided hearing protection is being worn, and administrative control procedures are being followed, have been posted on the mine bulletin board and copies provided to affected miners):

(1). A P-code will be assigned for MSHA recordkeeping purposes;

(2) The citation will be terminated; and

(3) The termination language will reference the P-code minimum acceptable engineering and administrative controls and conditions in detail.

For violations of the permissible exposure level, a citation will not be terminated until the operator has complied with each of the following requirements:

(1). All feasible engineering and administrative controls have been implemented and maintained; and

(2). Administrative control procedures have been posted on the mine bulletin board, copies have been provided to affected miners, and the procedures are being followed; and

(3). Affected miners have been enrolled in an HCP that complies with **ALL** of section 62.150; and

e. If the mine operator fails to abate the citation within the abatement period, and an extension of the abatement period is not warranted:

(1) You must re-sample;

(2) If the overexposure is on-going, issue a 104(b) order; and

(3) If a 104(b) order is issued, the affected miner(s) must be withdrawn from the "affected area" and the "affected area" portion of the order must list the miner's location and occupation. Documentation outlining what actions were taken to terminate the citation is required.

3. Upon issuance of a citation for a violation of 62.140, Dual Hearing Protection Level, the following abatement procedures must be followed:

a. If the operator does not provide the miner with dual hearing protection within the **short** abatement period, and an extension is not warranted, issue a 104(b) order. If a 104(b) order is issued, the affected miner(s) must be withdrawn from the "affected area" and the "affected area" portion of the order must list the miner's location and occupation. Upon the abatement of the conditions or practices cited in the original citation the order can be terminated. Documentation outlining what actions were taken to terminate the citation is required.

b. After the miner is provided with dual hearing protection, the mine operator must continue actions to lower miners' exposures to the PEL, using the 90 dBA PEL dose. The citation should be extended to allow the mine operator time to comply with the requirements of 62.130.

c. The inspector **must** conduct a follow-up full-shift noise exposure sample upon expiration of the abatement time as originally set or extended if feasible noise controls have been implemented which may achieve compliance.

d. If it is found that the noise exposure has been reduced to or below the DHPL, but still exceeds the PEL, compliance with 62.130 must still be achieved before the citation can be terminated. (See PEL abatement procedure Section M.2.)

N. P-codes

1. Definition and Use

MSHA uses the letter "P" as an action code in its database to designate that an overexposure condition remains even though all feasible engineering and administrative controls are in place. Thus, a "P-code" is an administrative device that allows MSHA to track these special overexposure situations. There are two scenarios involving a miner's overexposure to noise where the use of a P-code would be appropriate:

a. No Citation Issued

MSHA determines that a miner's exposure exceeds the PEL.

1. All feasible engineering and administrative controls have already been put in place and are maintained **and**,

2. All affected miners are enrolled in a Hearing Conservation Program that complies with all elements of 62.150 **and**,

3. Hearing protection is being provided and worn **and**,

4. The mine operator has posted and provided affected miners with copies of any procedures for administrative controls being used.

No citation will be issued and the P-code review process will be initiated. (Appendices 2, 3 and 6).

b. Citation Issued

MSHA determines that a miner's exposure exceeds the PEL, and

1. All feasible engineering and administrative controls have not been implemented, or are implemented but not maintained; or

2. All affected miners are not enrolled in a Hearing Conservation Program that complies with all elements of 62.150; or

3. Hearing protection has not been provided or is not being worn; or

4. The mine operator has not posted or provided affected miners with copies of administrative controls being used.

A citation will be issued if the miner's exposure still exceeds the PEL. After the mine operator has complied with Part 62, the P-code review process will be initiated (Appendices 2, 3, and 6).

If either scenario exists, P-code documentation must be developed in accordance with the P-code Documentation Checklist (See Appendix 3). Documentation will be coordinated with the field office, district office, technical support and headquarters. Information will be obtained from the operator if it is needed.

This information will then be referred to the District Manager (DM) for a recommendation. If the DM believes a P-code is warranted, the DM reviews the situation in consultation with field enforcement staff, headquarters' officials, and MSHA technical experts. This review includes an evaluation of the circumstances surrounding the overexposure, with particular emphasis on assessing the feasibility and effectiveness of control options. (See Appendix 5.)

2. Assignment of a P-code

If MSHA determines that a P-code is warranted, it will be assigned to the miner's occupation. **P-codes ARE NOT ASSIGNED TO SPECIFIC PIECES OF MINING EQUIPMENT OR AREAS OF THE MINE.** The assigned P-code will be transmitted to the mine operator through the District Manager. All P-codes will be identified by a tracking number.

If a P-code is assigned, the mine operator must continue to abide by the requirements in 62.130 and the minimum acceptable engineering and administrative controls and conditions specified in the P-code assignment or citation termination documentation.

District offices will assure that periodic review of the P-code determines that the minimum acceptable engineering and administrative controls and conditions specified are being followed. P-codes can be rescinded if a full shift sample has been taken and,

a. the operator fails to comply with the specified minimum acceptable engineering and administrative controls and conditions; or

b. the sample demonstrates that the operator has reduced miners' exposures to or below the PEL; or

c. new feasible technology becomes available and the mine operator refuses to implement the technology; or

d. any of the requirements of 62.130 are not complied with.

APPENDIX 1

QUEST Q-200/300 OPERATING PROCEDURES

A. BATTERY CHECK

1. Turn the dosimeter on by pressing the **MENU/ON/OFF** key. After counting down, the display will read **"ON"** and **"PAUSE".**

2. Assure that the **"LOBAT"** indicator is not visible in the display. If it appears, you have less than 8 hours of battery life and it should be replaced. **MAXIMUM** – Two Samples per Battery.

****NOTE**RESET INSTRUMENT TWICE AFTER INSTALLING NEW BATTERY. (Failure to do this may result in lost samples.)**

a. The instrument will turn on automatically when a new battery is inserted.
b. Reset the instrument following Section B1-B3 below.
c. Turn the dosimeter off by pressing and holding the **MENU/ON/OFF** key until the screen clears.
d. Turn the dosimeter back on and follow Section B1-B3 below.

B. RESETTING THE INSTRUMENT – CLEARING STORED DATA

****NOTE**THIS MUST BE DONE PRIOR TO EVERY SAMPLE AND WILL ERASE ALL PREVIOUSLY STORED DATA IN THE UNIT**

1. With the unit on, press and release the **MENU ON/OFF** key until **"rES5"** is displayed.
2. Press and hold the **ENTER** key for 5 seconds as **"rES5"** counts down to **"rES1".** Release the button when the display shows "----"and the display will show **"ON"** and **"PAUSE".**
3. The data in memory will be cleared.
4. The unit is ready for calibration or to be turned off for later use.

C. PRE-SAMPLING CALIBRATION

1. Turn the dosimeter on, if not already on, by pressing the **MENU ON/OFF** key.
2. To calibrate, with the unit in **"ON"** and **"PAUSE"** mode, press and release the **ARROW UP** ▲key. The display will show **"114.0 CAL".**
3. Turn on the calibrator and carefully place the microphone into the adapter ring.
4. Press **RUN/PAUSE** key. The display will show **"CAL"** then **"PASS"** then **"114.0 CAL"** when complete. If calibration fails, **"FAIL"** will appear in the display. The unit must be turned in for repair.
5. Press the **MENU ON/OFF** key to exit calibration mode. The unit is now ready for a noise sample or to be turned off for later use. Record the **"PASS"** in your notes.

****NOTE** The windscreen should be used to conduct a VALID noise sample.**

D. CONDUCTING A NOISE SAMPLE

1. Turn dosimeter on, if not already on, by pressing the **MENU ON/OFF** key. The display will read **“ON”** and **“PAUSE**”.
2. Press the **RUN/PAUSE** key to begin the sample. The display reads **“ON”** and **“RUN”.**
3. Replace the cover and put the dosimeter on the miner.
4. Press the **RUN/PAUSE** key to end the sample. The display reads **“ON”** and **“PAUSE”.**
5. Data Retrieval.
    (a) If results will be retrieved when you return to the office, the instrument may be turned off. The data will be stored in memory until cleared using **Section B**. **GO TO Section E1.**
    (b) It is preferable for results to be retrieved at mine site, **GO TO Section E2**.

E. OBTAINING THE SAMPLE RESULTS

“I” = DOSIMETER I = 85dBA ACTION LEVEL
“II” = DOSIMETER II = 90dBA PERMISSIBLE EXPOSURE LEVEL (PEL) AND 90 PEL MAX

1. Turn on the instrument, if not already on, by pressing the **MENU ON/OFF** key. The display will read **“ON”** and **“PAUSE”.**
2. The **Total Sample Time** is obtained by pressing the **TIMES** key.
3. Press **ARROW UP ▲or ARROW DOWN ▼**key until **“RT” (Run Time)** is displayed.

Ensure the readings obtained in the following step are <u>NOT</u> “PT”**(Pause Time)** or “UL**” (Upper Limit Time). Use either Dosimeter I or II. The time will be the same.**

4. The number of hours is displayed as **“XX:hr”.** Press **ARROW UP ▲or ARROW DOWN▼** key until the number of minutes and seconds is displayed as **“XX:XX”.** Record Total Sample Time in notes/form.
5. Press the **DOSE** key until **Dosimeter “I”** is displayed. Record the **85 Action Level Dose** in notes/form.
6. Press the **DOSE** key until **Dosimeter “II”** is displayed. Record the **90 PEL Dose** in notes/form.

Note: Dosimeter I Dose will always be greater than Dosimeter II Dose.

7. <u>**For Coal**</u>, Press the **“LEVELS”** key then press the **ARROW UP ▲or ARROW DOWN ▼**until **“MAX”** is displayed. Record the **90 PEL Max** under item **“X”** on 2000-84. (use no decimals ex 123.9 = 123 dBA).
8. <u>**For Coal**</u>, Press the **“TIMES”** key then press the **ARROW UP ▲or ARROW DOWN ▼**key until **“UL”** is displayed. Follow STEP 4 above and record the **UCL (Upper Control Limit)** Time in minutes under item “Y” on Form 2000-84.
9. Press the **AVG** key until Roman numeral **“I”** is displayed. Press **ARROW UP ▲** key until **“TWA”** is displayed on the left. Write the number in the Health Field Notes. Press **AVG** key once and record **TWA** reading for Roman Numeral **“II”** in Health Field Notes. (The TWA dBA value is the same as Table 62-2 and must be included in the body of the citation if there is an overexposure.)

F. POST SAMPLING CALIBRATION CHECK

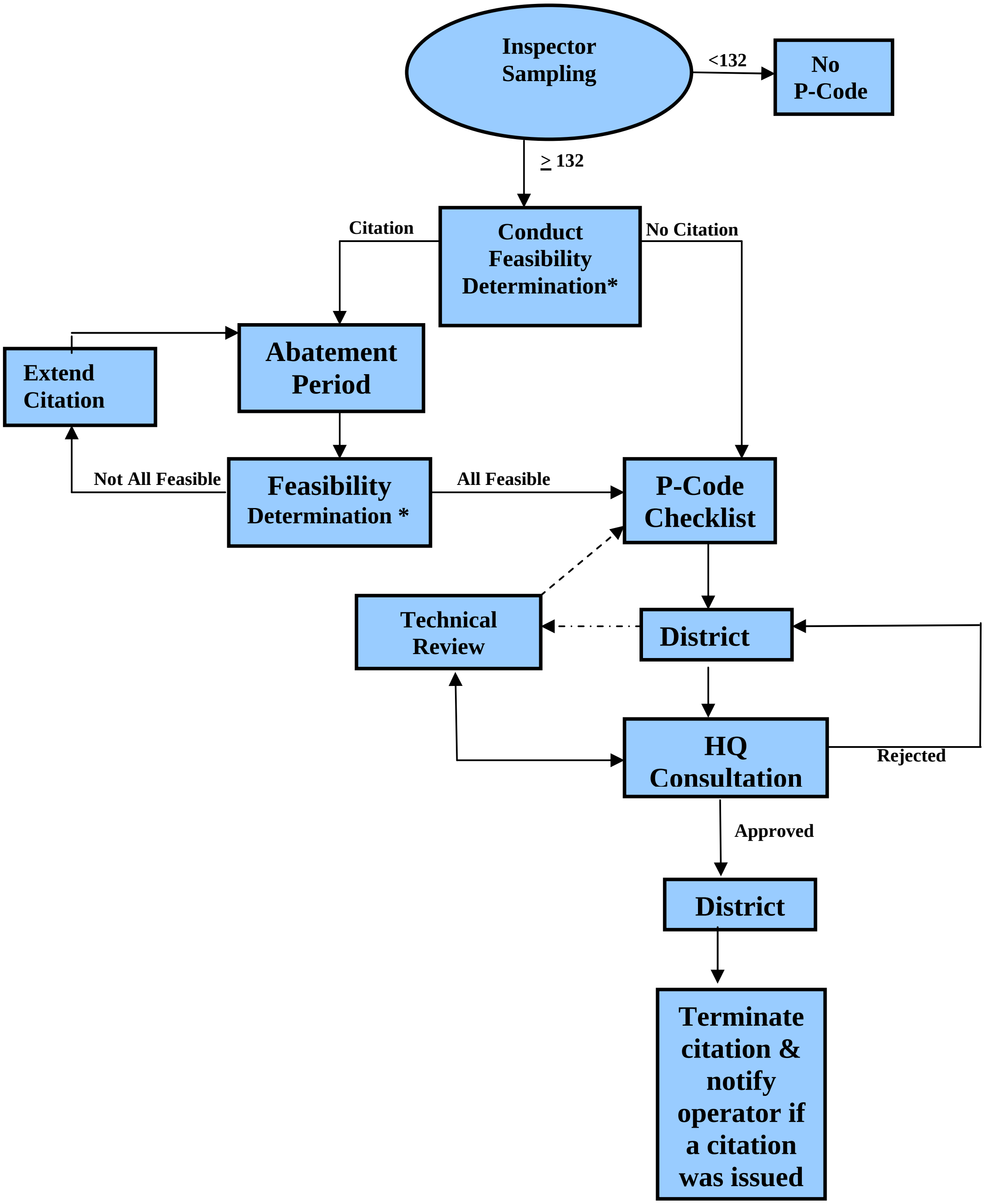
Use same calibrator for pre and post checks

1. Press the **MENU ON/OFF** key to exit Section E instructions or to turn unit on, if not already on.
2. Turn on the calibrator and carefully place the microphone in the adapter ring.
3. Press the **LEVELS** key until **Dosimeter "I" or "II"** Is displayed.
4. Press the **ARROW UP ▲** or **ARROW DOWN ▼** key until **"SPL" (Sound Pressure Level)** is displayed.
5. The display should read **"114.0"** within +/- 1.0 dBA. If not, the sample results are not valid. Document the validated 114 dBA SPL value.

Remove battery between sampling.

APPENDIX 2

P-Code Process



* Determine that all other parts of 62.130 have been met.

APPENDIX 3

P-Code Documentation Checklist

P-code Number ______________________
Date ______________________
District & Field Office ____
District Contact ____
Operator/Contractor Name and I.D. No. ____

ITEM	a	b	DOCUMENTATION
A.			**What is the origin of the P-code request?** a) Mine inspector request based on a citation b) Mine inspector request without a citation
ITEM	**YES**	**NO**	**Information for Items B – I to be provided**
B.			**Is a brief narrative describing the operation and working conditions that resulted in an overexposure included?** If so, please attach.
C.			**Are there occupational / tasks details such as:** What is the occupation(s)? What is the job / occupation code(s)? What is the occupation description? Please provide a full description of tasks involved with the miner's work.
D.			**Is the noise overexposure linked to a discrete piece or pieces of equipment?** If yes, is the following information listed for each piece of equipment? a) Manufacturer's name b) Manufacturer's address c) Manufacturer's telephone number d) Type and model of machine e) Year Manufactured f) Serial Number Is the noise overexposure linked to a specific area(s) of the mine? If so, list the area(s) and note why there is a concern.

E.			**Is a description and effectiveness of the engineering controls currently being used included?**
F.			**Is a description of engineering controls considered, but not used, included?** Are reasons included why the engineering controls were not used and /or considered infeasible?
G.			**Is a description and effectiveness of the administrative controls currently being used included?**
H.			**Is a description of administrative controls considered, but not used, included?** Are reasons included why the administrative controls were not used and /or considered infeasible?
I.			**Are any consultant's reports included with operator documentation?** If yes, are the following included? a) Test data and results b) Recommendations and conclusions
			Information for Items J – O to be provided by MSHA District
J.			**Has a citation been issued?** If yes, has the following information been provided and/ or conditions met? a) Citation b) Citation Extensions c) Inspectors field notes d) Compliance has not been achieved Is the citation based on: a) All feasible engineering and administrative are not in place b) Operator-provided hearing protection is not being worn by miners c) Affected miners are not enrolled in a HCP d) Administrative control procedures are not posted on the mine bulletin board or affected miners have not been provided a copy of administrative control procedures **If no citation has been issued, then have the following conditions been met?** a) Noise sampling indicating exposure > PEL b) All feasible engineering and administrative controls in place/maintained c) Copy of administrative control procedures posted and provided to all affected miners d) All affected miners enrolled in a compliant Hearing Conservation Program that meets all the aspects of 62.150 e) Operator-provided hearing protection has been provided and is being worn by miners.

K.			**Has Technical Support been involved?** If yes, is the report/recommendations attached? If no, are there Technical Support reports available on this class of equipment? Has Technical Support provided consultants' reports obtained from other sources?
L.			**Has the MSHA Noise Source Identification Team been involved?** If yes, are the report / recommendations attached?
M.			**If engineering/ administrative control options were provided by the inspector or specialist and not implemented, were reasons provided why not and what were they?**
N.			**Noise Data** Has a Q-300 noise dosimeter sampling **and time motion study** been conducted and attached? Have sound level readings been taken and included? If yes, what format? Table ___ Sketch ___ Other ___ What was the overexposure reading determined by MSHA sampling?
O.			**District Approval** Has a cover memo been included from the District Manager requesting a P-code?
			Item P for Headquarters use
P.			**Does the report provide the needed information to evaluate the P-Code request?** If no, list the deficiencies. If yes, what is the final determination and conditions for the P-code?
Q.			**Administrator's Action** Has the Administrator sent a memo to the District advising of the P-code determination, conditions and number? If no, why not?

Appendix 4

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CMS&H Noise Report

U.S. Department of Labor

Mine Safety and Health Administration

A. Mine ID/Contractor ID Number – –	**B. Event Number**	**C. AR Number**	**D. Office Code**	**E. Survey Date** Mo Day Year	**F. Activity Code**
G. Mine Name			**H. Company Name**		

I. Survey Sample Number	1	2	3	4	5	6
J. Survey Type	Initial Follow-up	Initial Follow-up	Initial Follow-up	Initial Follow-up	Initial Follow-up	Initial Follow-up
K. P-Code						
L. MMU/Pit/Area Surveyed						
M. Instrument Property Number						
N. Calibrator Property Number						
O. Miner's Last Name/First Initial						
P. Occupation Code						
Q1. Machine Code/Q2. Scrubber (Y or N)						
R. Manufacturer's Code						
S. Time Start (24 Hr. Clock)						
T. Total Survey Time (Minutes)						
U. Production this Shift						
V. 85 Action Level Dose (Dosimeter I) (no decimals)						
W. 90 PEL Dose (Dosimeter II) (no decimals)						
X. 90 PEL Max (no decimals)						
Y. UCL (117 dBA) Time (Minutes)						
Z. Calibration Check (Y or N)	Before After	Before After	Before After	Before After	Before After	Before After
AA. Type of PHP	Muff Plug Cap	Muff Plug Cap	Muff Plug Cap	Muff Plug Cap	Muff Plug Cap	Muff Plug Cap
AB. Enrolled in HCP (Y or N)						
AC. Citation Number						
AD. Citation Abatement Code						

AE. Comments/Abatement Action

Front, MSHA Form 2000-84, October 2004 (Revised)

Manufacturer Codes	
001	Abex
002	Acker
003	Acme
004	Advance Mining
005	Aerodyne
006	Allen-Sherman-Hoff
007	Allis-Chalmers Bulldozer & Fiat
008	Alpine
009	American Hoist
010	Atlas-Copco
011	Baldwin-Lime-Hamilton
012	Barber-Greene
013	Betti
014	Black & Decker
015	Bucyrus-Erie (BE)
016	Buffalo-American
017	Case
018	Caterpillar (cat)
019	Cedar Rapids
020	Chevrolet
021	Chicago Pneumatic
022	Clark
023	Cline
024	Coeur d'Alenes
025	Cushman
026	Dart
027	Demag
028	Deutz
029	Dorr-Oliver
030	Dravo
031	Eaton
032	Eickhoff
033	Eimco
034	Elkhorn
035	Emaco
036	Epling
037	Euclid (uke)
038	Fairchild
039	Fletcher
040	FMC & Link Belt
041	Ford
042	Fuller
043	Galis FM Calso
044	Gardner-Denver
045	General Electric
046	GMC (Jimmy)
047	Goodman
048	Gorman-Rupp
049	Gradeall
050	Grundlach
051	Harnischfeger & P&H
052	Hewitt-Robins
053	Ingersol-Rand
054	Insley
055	International Harvester (IH)
056	Jeffrey-Dresser
057	Jold
058	Joy
059	Kenworth
060	Kersey
061	Kobota
062	Koehring
063	Komatsu
064	Kress
065	Krupp
066	Lee-Norse
067	Long-Airdox
068	Mack (bulldog)
069	Manitowoc
070	Marion
071	Marathon Le Tourneau
072	Massey-Ferguson
073	McLanahan
074	Mescher
075	Michigan
076	Mine Equipment Co.
077	Mining Progress Inc.
078	Myers-Whaley
079	Nagle
080	National Mine Service
081	Nolan
082	Nordberg & Rexnord
083	Northwest
084	Orenstein & Kopper
085	Oshkosh
086	Owens
087	Page
088	Penndrill
089	Pioneer
090	Plymouth
091	Raygo
092	Richmond
093	Ripco
094	Robbins
095	Rosco
096	Royal
097	Salem
098	S & S
099	Schramm
100	Schroder
101	Stacy
102	Stamler
103	Symons
104	Telsmith
105	Terex
106	Unit Rig Equipment Co.
107	Universal
108	Wabco
109	Wagner
110	Warner Swessey
111	Westfalia
112	Westinghouse
113	White
114	Wilcox
115	Wilfley
116	Winter-weiss
117	Wirth
118	Yale
119	Not on this list
120	Unknown

Abatement Codes	
01	Engineering
02	Administrative
03	Combination
04	Removal of Equipment/Mine
05	Other

Equipment Codes	
01	Air Compressor
02	Auger Miner (UG or S)
03	Bulldozer
04	Classifer, Cyclone
05	Coal, Face Drill
06	Continuous Miner (ripper)
07	Continuous Miner (borer)
08	Conveyor (all types)
09	Crane (all types)
10	Crusher, Breaker
11	Cutting Machine
12	Dragline
13	Dredge
14	Elevator, Hoist
15	Fan (fixed or auxiliary)
16	Floatation & Filters
17	Forklift
18	Front End Loader, Highlift
19	Gunite Machine
20	Hand Tolls
21	Highwall Drill
22	Hydraulic Jets
23	L - H - D (surface)
24	Loading Machine
25	Locomotive (UG or S)
26	Longwall Plow
27	Longwall Shear
28	Roadgrader
29	Rockdusting Machine
30	Roof Bolting Machine
31	Rotary Bucket Excavator
32	Rotary Dump
33	Scraper, Pan
34	Screen
35	Shovel (not dragline)
36	Shuttle Car (diesel)
37	Shuttle Car (electric)
38	Tractor, Scoop
39	Truck
40	Not on this list

DA Codes	
001-0 to 099-0	UG MMU Identification Number
100-0 to 199-0	UG Track Haulage
200-0 to 299-0	UG Belt Area
300-0 to 399-0	UG Trackless Haulage
400-0 to 499-0	UG Shops
500-0 to 599-0	UG Section Dumping Point
600-0 to 699-0	UG Rotary Dumps and Crushers
700-0 to 799-0	UG Miscellaneous
800-0 to 899-0	UG Intake Air
900-0 to 999-0	UG Roof Bolters

DWP Codes	
001-0 to 099-0	Surface Mine
900-0 to 999-0	Surface Area of UG Mine

Other Location Codes	
U01	UG Travelways and Haulageways
U02	UG Shafts and Slopes
U03	UG Offices, Lunchrooms, Storerooms
U04	UG General (non-DA outby of areas)
U05	UG Construction
S01	Surface Roads (haulage, access, other travelways)
S02	Dredges or Barges
S03	Impoundments, Ponds, or Refuse Piles
S04	Surface Load-in/out, stockpiles, transfer points)
S05	Surface Shops
S06	Surface Offices, Lunchrooms, Storerooms
S07	Surface General (works in a number of areas)
S08	Surface Construction
F01	Plant or Facility; Crushing or Grinding
F02	Plant or Facility; Washing and Screening
F03	Plant or Facility; Drying and Roasting
F04	Plant or Facility; Load-in/out, stockpiles, transfer points)
F05	Plant or Facility; Shops
F06	Plant or Facility; Offices, Lunchrooms, Storerooms
F07	Plant or Facility; General (works in a number of areas)
F08	Plant or Facility; Flotation and Reagent Areas
F09	Plant or Facility; Pelletizing
F10	Plant or Facility; Bagging or Packaging
F11	Plant or Facility; Construction
L01	Laboratories

Appendix 5

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U.S. Department of Labor

Mine Safety and Health Administration
1100 Wilson Boulevard
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PROGRAM INFORMATION BULLETIN NO. P04-18

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SUBJECT: Technologically Achievable, Administratively Achievable, and Promising Noise Controls (30 CFR Part 62)

Scope

This Program Information Bulletin (PIB) applies to all Mine Safety and Health Administration (MSHA) enforcement personnel, equipment manufacturers, coal, metal, and nonmetal mine operators, independent contractors, miners, miners' representatives, and other interested parties.

Purpose

The purpose of this PIB is to provide guidance to operators, miners, miners' representatives, contractors, and equipment manufacturers on technologically and administratively achievable engineering and administrative noise controls. This document also identifies those engineering and administrative noise controls which offer *promise* for further investigation.

Information

The performance-oriented noise standards in 30 CFR Part 62 equate administrative and engineering controls and require that, when a miner's noise exposure exceeds the permissible exposure level (PEL), all feasible engineering and administrative controls be utilized to reduce the miner's exposure to the PEL. A feasible control is one that is both technologically (or administratively) and economically achievable. If such controls fail to reduce exposure to the PEL, personal protection equipment must be provided and used. These standards do not permit the use of personal protection equipment in lieu of feasible engineering or administrative controls. A technologically or administratively achievable control or a combination of controls which achieves at least a 3 dBA reduction in a miner's noise exposure is considered significant, even if it fails to reduce the miner's exposure to the PEL. "If a miner's noise exposure continues to exceed the PEL despite the use of all feasible engineering and administrative controls, the mine operator must continue to use the engineering and administrative controls to reduce the miner's noise exposure to as low a level as is feasible." (30 CFR Part 62.130(b)).

This PIB describes technologically achievable and promising controls for several types of machinery used in mines. Many of the controls listed in Section One are in use throughout the mining industry and have been referenced by MSHA in prior noise control documents. This PIB also provides guidance on taking a practical approach to reducing miners' exposure to noise. Section Two of this PIB is a checklist of simple, straightforward ways to control noise exposure. Examples of administrative controls are provided in Section Three of this PIB. MSHA's Noise Enforcement Policy states that labor/management agreements will not be affected by the noise standard. MSHA will not require an operator to hire additional miners in order to "exhaust" all feasible administrative controls.

For purposes of this PIB, MSHA limits use of the term "technologically achievable" to engineering controls. MSHA is mindful that this term is conventionally used to describe controls or devices that are mechanical in nature, rather than controls that reduce a miner's noise exposure by actions such as adjusting work practices, rotating miners, rescheduling tasks, or modifying work activities. For this reason, this PIB refers to certain administrative controls as "administratively achievable," rather than "technologically achievable." As with those controls denoted as "technologically achievable," use of the term "administratively achievable" to describe these administrative controls is solely intended to clarify that MSHA generally considers them to be capable of being done, executed, or effected, and not that it is necessarily economically achievable to do so.

Administratively and Technologically Achievable Noise Controls

Administratively and technologically achievable noise controls have demonstrated effectiveness either singly or as part of a suite of noise controls under actual mining conditions and are known to reduce sound levels and miner noise exposure in most cases. These controls:

1. Reduce sound levels or exposure time, as demonstrated in widespread application on similar types of equipment operating as part of similar mining methods, or alternatively demonstrated as part of a scientifically designed study in which the results can be generalized;
2. Reduce the noise exposure (3 dBA when used either singly or in combination) of miners performing the usual duties associated with the mining method and equipment, and based on measured miner doses; and

3. An engineering control does not necessarily have to be pre-fabricated or off-the-shelf, but it must have a realistic basis in present technology.

It is possible that unusual characteristics of the equipment, the mine, or the application could result in the inability of a technologically achievable control to reduce miner noise exposure, but it is unlikely. As with all technological achievability determinations, when these situations are encountered they will be evaluated on a case-specific basis. Some controls are technologically achievable, but only when used in more limited circumstances. These controls are considered conditional because they may work in some situations, and may not work in other settings; i.e., the case-by-case rationale. Some reasons for denoting a technologically achievable control as "conditional" would be:

1. Its effectiveness is dependent on the conditions that exist at the minesite; or
2. The installation and use of the control may create a collateral health or safety hazard, which must be addressed.

Case-by-Case Feasibility Determinations

Recognizing that "one-size does not fit all," MSHA will evaluate circumstances on a case-by-case basis to determine the achievability (technological or administrative and economic) of a listed control. Due to the large variety of mining equipment, mining methods and environmental conditions in mines, there may well be circumstances in which a described control is not technologically achievable for a specific application.

Promising Controls

Technologically and administratively promising (*promising*) noise controls offer potential for noise reduction by having demonstrated effectiveness but may lack evaluation and/or documentation in terms of significant reduction of a miner's noise exposure either singly or as part of a suite of noise controls. Technologically promising controls are being developed or studied by manufacturers, industry, and government. Some controls in this class have real potential and mine operators or equipment manufacturers may want to consider participating in cooperative research studies to further evaluate these controls. In general, promising controls:

1. Have potential for reducing sound levels or exposure time based on laboratory or limited field studies;
2. Have potential to reduce miner noise exposure based on time studies of miners performing the usual duties associated with the mining method and equipment; and
3. May require further development, refinement, study or research.

MSHA and others will further evaluate their demonstrated effectiveness during in-mine production usage and MSHA will make updated information available.

Other Considerations

While MSHA believes the listed controls are currently the most effective in reducing miner noise exposure, mine operators are not restricted in their selection of controls to those technologically and administratively achievable controls described in this document. They may use other administrative and engineering controls to comply with MSHA's noise standard. We encourage the mining industry to share information regarding controls that have been implemented and found to be successful in reducing a miner's exposure to noise. Please contact MSHA's Directorate of Technical Support to provide information about noise control advances in the mining industry. This PIB will be updated as additional technologies and controls become available.

Section One
Descriptions of Technologically Achievable, Administratively Achievable, and Promising Noise Controls

Introduction

MSHA considers the engineering and administrative controls contained in this Program Information Bulletin (PIB) to be **technologically or administratively achievable** or to offer *promise* as noise controls which, when used either singly or in combination, have a demonstrated effectiveness or potential for achieving compliance with the PEL or for reducing a miner's noise exposure by at least 3 dBA. MSHA and others are further evaluating the demonstrated effectiveness of promising controls during in-mine production usage and updated information will be made available.

While the noise controls compiled in this PIB are on a machine/equipment basis, MSHA's noise standards are occupational exposure standards, not equipment-based standards. Compliance with the noise standard is determined by the miner's personal exposure and not the sound levels generated by the piece of equipment. Therefore, the miner's total noise exposure should be examined from an occupational viewpoint and not solely on a machine or equipment basis. All sources/tasks that generate noise must be identified and considered when determining appropriate noise controls and their effects. Engineering and administrative noise controls should be applied to those occupational noise sources and tasks that will yield a significant reduction in the miner's total noise exposure. For example, noise sources of 85 dBA or less should not require attention, especially when a competing noise source is at a much higher level.

The implementation of retrofit noise controls involves the use of individual devices, systems and/or materials designed for the specific purpose of reducing noise. Acoustical devices include, but are not limited to, cabs, enclosures, barriers, mufflers, and silencers which decrease sound levels to which the miner is exposed, or other electro-mechanical or video systems which reduce the amount of time miners are exposed to excessive noise.

Acoustical materials can reduce noise either by absorbing or blocking sound waves, or damping vibrations. These materials are generally referred to as absorption, barrier, damping, and composite materials, and they can substantially increase the effectiveness of other noise control devices. Selection of appropriate acoustical materials must be made based on a firm noise control engineering basis and commensurate to the task, properly installed, used, and maintained. Also, mine operators should be aware of the flammability properties of acoustical materials and, prior to application, should consider MSHA's flammability guidelines. These guidelines can be obtained by contacting MSHA's Directorate of Technical Support, Approval and Certification Center.

In general, a noise control device specified by the original equipment manufacturer (OEM) and available for a specific piece of equipment will yield better results than one subsequently constructed by the mine operator, a third party or rebuild shop. However, much success in the mining industry in reducing sound levels has been realized through the design, production, installation, and use of noise controls developed by third party after market sources or individual mine operators. In the case of non-OEM noise controls, a detailed investigation and evaluation should be conducted on the machine or the environment to identify noise sources. This should be followed by the development of detailed instructions and specifications for the selection of appropriate acoustical materials and for the construction, fabrication, and installation of equipment-based noise controls.

Engineering noise controls are effective when they are properly selected, installed, used, and maintained. Care should be taken in their selection such that they are appropriate to the equipment design, and do not have a harmful effect on the operation or performance of the machinery on which they are installed. Hazards caused by the application of engineering noise controls should be addressed to minimize the effects on a miner's health and safety.

For the purposes of this PIB, an "environmental cab" or "environmental booth" includes the structure plus the application and installation of appropriate acoustical materials to the inside areas of the cab or booth (e.g., absorption materials, composite materials or acoustical floor mat), and an appropriate air filtration/air conditioning system. A "skin kit" is a sectionalized cab (e.g., a 4-section metal cab without acoustical materials) that is attached to the roll-over protection system (ROPS)/falling object protection system (FOPS) on a piece of mobile surface equipment. Prior to implementing and attaching such a device, guidance from the ROPS and FOPS manufacturers should be obtained so as not to void any structural certification.

This PIB contains a list of controls for the following equipment:

1. Air Arcing
2. Air-Actuated or Air-Operated Cylinders
3. Augers - Surface
4. Auxiliary Ventilation Fans
5. Car Shakers and Rotary Dumps
6. Channel Burners
7. Continuous-Mining Machines / Augers / Loaders (Underground)
8. Diesel - Locomotives
9. Diesel - Underground Diesel-Powered Equipment
10. Draglines, Shovels and Cranes Not Equipped with Operator Cabs
11. Draglines, Shovels and Cranes Equipped with Operator Cabs
12. Dredges and Associated Equipment
13. Drills – Jumbo Drills

14. Drills – Truck Mounted/Blast Hole/Air Track
15. Hand-Held Percussive Tools
16. Longwalls
17. Mantrips
18. Mills / Processing Plants / Coal Preparation Plants (including Breakers at Anthracite Mines)
19. Mobile Equipment - Surface
20. Portable Crushers / Screening Plants and Associated Equipment
21. Roof Bolting Machines
22. Scalers
23. Stone Saws

1. Air Arcing

Air arcing is a major tool used in bucket maintenance on draglines and other similar equipment. A welder's noise exposure depends on the amount of time spent using the air arcing equipment during the work shift. MSHA considers the following administrative noise controls, or a combination of these controls, to be **administratively achievable** in reducing the noise exposure of miners engaged in air arc welding:

- **Limit the duration of air arc welding per shift;**
- **Rotate welding personnel; and**
- **Avoid side-by-side air arc welding.**

Other noise controls that offer *promise* when there would be a need for the use of air arcing include:

- *Reduction of air pressure to the minimum;*
- *Use of constant current air arc welding/gouging techniques at the lowest effective current and air pressure;*
- *Use of constant voltage air arc welding/gouging techniques at the lowest effective voltage and air pressure; and*
- *Use of alternate rods (certanium and cronatron gouging rods) or a plasma torch with a gouging tip (these methods may be appropriate only in specific applications).*

2. Air-Actuated or Air-Operated Cylinders

MSHA considers the following engineering noise controls, or a combination of these controls, to be **technologically achievable** and effective in reducing the noise exposure of miners working around air-actuated or air-operated cylinders:

- ❖ **Mufflers on exhaust outlets/ports;**
- ❖ **Hose extension on exhaust ports; and**
- ❖ **Enclosures.**

MSHA considers the following engineering noise control to be conditional:

- **Barriers.**

3. Augers - Surface

MSHA considers the following engineering noise controls, or a combination of these controls, to be **technologically achievable** in reducing the noise exposure of miners operating or working around surface augers:

- ❖ **Environmental cabs that include appropriately selected, correctly installed, and properly maintained acoustical materials (see Section One Introduction) applied to internal surfaces; and**
- ❖ **Exhaust mufflers and redirection of exhaust.**

MSHA considers the following engineering noise control to be conditional:

- **Appropriately selected, correctly installed, and properly maintained acoustical materials (see Section One Introduction) in the operator's compartment and the engine compartment.**

The following engineering noise control offers *promise*:

- *Barrier between the engine and the operator.*

4. Auxiliary Ventilation Fans

MSHA considers the following engineering and administrative noise controls, or a combination of these controls, to be **technologically and administratively achievable** in reducing the noise exposure of miners working around auxiliary ventilation fans:

- **Silencers matched to the fan;**
- **Barriers or enclosures for work areas to minimize occupational exposures;**
- **Locate fans away from areas where miners spend a significant amount of time;**
  and
- **Clean and maintain fan silencers on a regular basis.**

MSHA considers the following engineering noise control to be conditional:

- **Good maintenance practices, such as sealing air leaks and wrapping of ventilation tubing joints.**

The following controls offer *promise* in reducing the exposure of miners who may be in the vicinity of auxiliary ventilation fans:

- *Flexible connections between the fan and ventilation tubing;*
- *Install damping materials on tubing and fan blades; and*
- *Line several tube sections with appropriately selected, correctly installed, and properly maintained acoustical materials at the inlet side of the fan on an exhausting face ventilation system.*

5. Car Shakers and Rotary Dumps

Car shakers and rotary dumps are used to empty railroad cars containing coal or other materials. On a car shaker, electromagnets attach to the top of the car and vibrate the car so that the material falls out the bottom. A rotary dump grasps the car and rotates it, emptying it from the top.

MSHA considers the following engineering noise controls, or a combination of these controls, to be **technologically achievable** in reducing the noise exposure of miners working around car shakers or rotary dumps:

The following **technologically achievable** control is available for car shakers:

- **Operator environmental control booth that includes "appropriate acoustical materials" (see Section One Introduction) applied to internal surfaces.**

The following **technologically achievable** controls are available for rotary dumps:

- **Operator environmental control booth that includes "appropriate acoustical materials" (see Section One Introduction) applied to internal surfaces; and**
- **Radio remote controls installed to position the operator away from the dump.**

The following controls may hold *promise* in reducing the noise exposure of car shaker operators:

- *Top pad attenuator;*
- *Foot pads; and*
- *Air-actuated cushions.*

6. Channel Burners

MSHA considers the following engineering noise controls, or a combination of these controls, to be **technologically achievable** in reducing the noise exposure of miners operating channel burners:

- **Automated channel burner to replace manual channel burners for the majority of cuts. A handheld channel burner may be needed to initiate the main cut or to perform specialty cuts;**
- **Automated channel burner with a control booth and video monitoring system to observe the cut;**
- **Remote controls; and**
- **Appropriate pressures for the fuel/air mixture as per manufacturer's specifications. Use oxygen instead of air.**

While MSHA considers the following engineering noise controls to be **technologically achievable** in reducing the noise exposure of a miner operating a channel burner, the feasibility of their use must be evaluated on a case-by-case basis:

- **Slot drill in combination with a 3-sided or portable enclosure for the operator;**
- **Wire saw or diamond wire saw;**
- **Use of hydraulic or pneumatic drill; and**
- **Water jet cutter.**

The following control offers *promise* in reducing a miner's noise exposure:

- *Quiet tips on the burner.*

7. Continuous-Mining Machines / Augers / Loaders (Underground)

MSHA considers the following engineering and administrative noise controls, or a combination of these controls, to be **technologically and administratively achievable** in reducing the noise exposure of miners operating on or working around this equipment:

- **Remote control with proper positioning of the operator;**
- **Treated cutting heads on auger miners (e.g., the application of stiffening gussets to the helix and filling of voids with sand);**
- **Proper maintenance, such as replacing bent or misaligned conveyor flights or sides and use of a chain with proper tension or one having an automatic chain tension device;**
- **Locate the shuttle car change-out point away from major noise sources (e.g., auxiliary fan);**
- **Avoid idle parking in high noise areas;**
- **Keep miners away from auxiliary fans;**
- **Have mechanics and electricians avoid working near high-noise sources during maintenance;**
- **Reduce utility personnel working time near face and auxiliary fan;**
- **Limit operation of empty chain conveyors on all equipment (i.e., shuttle car, loading machine, continuous miner, miner-bolter, and feeder-breaker);**
- **Eliminate a high-pitched screech by instructing roof bolters to drill straight holes and to avoid metal strap contact with the drill steel;**
- **Follow a cutting cycle (e.g., reduce cutting into roof and floor rock, cutting directly into in-seam rock, and over sumping) to minimize noise generation from both the continuous mining machine and the cutting process;**

- **Regulate engine RPM on diesel-powered shuttle cars during loading and dumping;**
- **Follow shuttle car loading and tramming procedures that minimize noise (e.g., time that the conveyor chain is turning, increase distance from continuous miner and its boom, etc.);**
- **Follow loading and tramming procedures for loading machines that minimize noise;**
- **Turn off any mobile equipment when not in operation;**
- **Maintain proper fan blade clearance on dust scrubbers associated with continuous-mining machines; and**
- **Constrained layer damping on the conveyor pan on an auger miner (e.g., the application of visco-elastic materials covered with wear steel to isolate the chain and flights from the conveyor pan line).**

The following engineering controls offer *promise* in reducing the noise exposure of miners working on continuous miner sections:

- *Transparent barrier between the operator and conveyor pan line;*
- *Constrained layer damping on the conveyor pan on a continuous ripper miner (e.g., the application of visco-elastic materials covered with wear steel to isolate the chain and flights from the conveyor pan line);*
- *Sand-filled conveyor decks;*
- *Enclosure and isolation of motors and pump housings where they have been demonstrated to be a significant noise source;*
- *Vibration isolation mounts on motors/pumps where they have been demonstrated to be a significant noise source;*
- *Chain conveyor with coated flights;*
- *Isolated cutting bits (e.g., the application of vibration isolation materials between the bits/block and the drum); and*
- *Sand-filled cutting heads.*

The following administrative control offers *promise* for reducing an operator's noise exposure:

- *Rotate center bolter operator with center bolter helper, roof bolter operators with utility personnel or shuttle car operators, miner-bolter operator with loading machine operator, or continuous miner operator with shuttle car operator.*

The following noise controls offer *promise* for dust scrubbers associated with continuous-mining machines:

- *Silenced fan housing;*
- *Sleeve-style attenuators;*
- *Alternative face air flow distribution systems (e.g., spray fan systems);*
- *Bolt-on attenuators; and*
- *Appropriately selected, correctly installed, and properly maintained acoustical materials (see Section One Introduction) applied to the dust scrubber.*

8. Diesel - Locomotives

MSHA considers the following engineering noise controls, or a combination of these controls, to be **technologically achievable** in reducing the noise exposure of miners working around this equipment:

- **Environmental cabs that include appropriately selected, correctly installed, and properly maintained acoustical materials (See Section One Introduction) applied to internal surfaces;**
- **Mufflers;**
- **Video cameras with monitors to view the rail and loading process;**
- **Smooth rail joints; and**
- **Good machine and track maintenance.**

MSHA considers the following engineering noise control to be conditional:

- **Appropriately selected, correctly installed, and properly maintained acoustical materials (see Section One Introduction) to the inside of the operator's compartment.**

The following engineering noise controls offer *promise*:

- *Composite wheels to prevent wheel-track squeal;*
- *Transmission enclosure; and*
- *Application of sound damping materials to the floorboards at the transmission.*

9. Diesel - Underground Diesel-Powered Equipment

MSHA considers the following engineering noise controls, or a combination of these controls, to be **technologically achievable** in reducing the noise exposure of miners operating underground diesel-powered equipment (e.g., LHDs, shuttle cars, haul trucks, tractors, generators, graders, scoops):

- **OEM Environmental cabs that include appropriately selected, correctly installed, and properly maintained acoustical materials (see Section One Introduction) applied to internal surfaces; and**
- **Exhaust mufflers.**

MSHA considers the following engineering noise controls to be conditional:

- **Non-OEM cabs; and**
- **Appropriately selected, correctly installed, and properly maintained acoustical materials (see Section One Introduction) to reduce noise from the engine and transmission compartments.**

The following controls offer *promise* in reducing a miner's noise exposure:

- *Redirection of the exhaust away from the operator; and*
- *Remote controls.*

10. Draglines, Shovels, and Cranes Not Equipped with Operator Cabs

MSHA considers the following engineering noise controls, or a combination of these controls, to be **technologically achievable** in reducing the operator's noise exposure:

- **Seal all openings (e.g., holes, cracks, openings around controls) to prevent outside noise from entering the operator compartment; and**
- **Exhaust mufflers.**

MSHA considers the following engineering noise controls to be conditional:

- **A barrier behind the operator to block the noise path of the diesel engine from reaching the operator compartment. The barrier may be flexible, constructed of acoustical vinyl curtain, or rigid;**
- **Appropriately selected, correctly installed, and properly maintained acoustical materials (see Section One Introduction) installed on the surfaces of the operator compartment, to the roof, sliding door, partition (if rigid) and any other available surface; and**
- **Silencers on air discharge valves.**

The following administrative controls offer *promise* for reducing the mechanic/ greaser/oiler noise exposure:

- *Limit time spent in engine compartment when the machine is running; and*
- *Perform cleanup duties when the dragline is not operating.*

11. Draglines, Shovels, and Cranes Equipped with Operator Environmental Cabs

MSHA considers the following engineering noise control to be **technologically achievable** in reducing the operator's noise exposure:

- **Existing OEM environmental cab including appropriately selected, correctly installed, and properly maintained acoustical materials (see Section One Introduction) applied to the interior surfaces.**

MSHA considers the following engineering noise control to be conditional:

- **Appropriately selected, correctly installed, and properly maintained acoustical materials (see Section One Introduction) to an existing OEM cab.**

Normally, the existing OEM environmental cab will be sufficient for assuring the operator's compliance.

MSHA considers the following engineering and administrative controls to be **technologically and administratively achievable** in reducing the oiler's noise exposure:

- **Performance of cleanup duties during downtimes for repairs/maintenance;**
- **Limited exposure near the MG set;**
- **Limited oiler time in the revolving frame; and**
- **Rotation of the oiler and machine operator, oiler and dozer operator/groundsmen.**

The following engineering controls offer *promise* for reducing oiler and mechanic noise exposure:

- *Barrier installed in front of MG sets, or where practical, enclosing the MG sets (may require additional ventilation or air conditioning); and*
- *Silencers on cooling fan motors.*

The following engineering and administrative controls offer *promise* for reducing the oiler noise exposure:

- *Silencers on compressed air discharge lines;*
- *Reduction in the time spent in engine house and revolving frame by utilizing the following:*
  - *Automatic lubrication system;*
  - *Remotely monitored temperature sensors;*
  - *Remotely monitored oil level gauges; and*
  - *Remotely monitored video coverage of strategic areas.*

The oiler and mechanic, due to their work demands, must spend time in the environment of the engine house. The isolation of the MG sets by either constructing a partial barrier in front of the sets or by totally enclosing them would reduce the sound levels. The implementation of this promising control would most likely require additional ventilation or air-conditioning for the MG sets.

12. Dredges and Associated Equipment

MSHA considers the following engineering noise controls, or a combination of these controls, to be **technologically achievable** in reducing the noise exposure of the dredge operator:

- Environmental cab/booth that includes appropriately selected, correctly installed, and properly maintained acoustical materials (see Section One Introduction) applied to internal surfaces;
- Pump enclosures;
- Engine barriers;
- Engine mufflers;
- Resilient screen decking;
- Barriers around pneumatic equipment;
- Redirection of the exhaust; and
- Enclosures / barriers at transfer points.

The following engineering noise control offers *promise*:

- *Video technology to position miners away from noise sources.*

13. Drills - Jumbo Drills

MSHA considers the following engineering noise controls, or a combination of these controls, to be **technologically achievable** in reducing the noise exposure of miners operating jumbo drills:

- **Environmental cabs that include appropriately selected, correctly installed, and properly maintained acoustical materials (see Section One Introduction) applied to internal surfaces;**
- **Barrier such as a windshield; and**
- **Exhaust mufflers.**

MSHA considers the following engineering noise controls to be conditional:

- **Barrier between the engine/compressor and the operator;**
- **Flexible curtain material around the perimeter of the canopy; and**
- **Appropriate acoustical materials (see Section One Introduction) at the operator's position on a cab equipped jumbo drill.**

While MSHA considers the following control to be **technologically achievable** in reducing the noise exposure of a miner operating a jumbo drill, the feasibility of its use must be evaluated on a case-by-case basis:

- ❖ **Hydraulic drill.**

The following controls offer *promise* in reducing miner noise exposures:

- *Remote controls;*
- *Ceramic or other non-metallic centralizers on the drill assembly;*
- *Programmable jumbo drills (computer automated); and*
- *Wet drilling (i.e., injection of water under pressure into the air stream of the drill hole clearance system) where it can be implemented due to the jumbo drill's design and when compatible with the geology and the mining method.*

14. Drills – Truck Mounted / Blast Hole / Air Track

MSHA considers the following engineering noise controls, or a combination of these controls, to be **technologically achievable** in reducing the noise exposure of miners operating drills:

- ❖ **Environmental cabs that include appropriate acoustical materials (see Section One Introduction) applied to internal surfaces;**
- ❖ **Exhaust mufflers and redirection of the exhaust away from the operator;**
- ❖ **Portable enclosures / barriers for the operator; and**
- ❖ **Appropriately selected, correctly installed, and properly maintained acoustical materials (see Section One Introduction) to treat the operator's compartment.**

MSHA considers the following engineering noise controls to be conditional:

- **Barrier between the engine /compressor and the operator;**
- **Silencers on air release nozzles; and**
- **Relocation of the air compressor away from the air track drill.**

The following control offers *promise* in reducing miner noise exposures:

- *Wet drilling (i.e., injection of water under pressure into the air stream of the drill hole clearance system) where it can be implemented due to the drill's design and is compatible with the geology and the mining method.*

15. Hand-Held Percussive Tools

MSHA considers the following engineering noise controls, or a combination of these controls, to be **technologically achievable** in reducing the noise exposure of miners operating many types of percussive tools:

- **Exhaust muffler; and**
- **Body muffler.**

MSHA considers the following engineering noise control to be conditional:

- **Piping exhaust away from the operator.**

16. Longwalls

MSHA considers the following engineering noise controls, or a combination of these controls, to be **technologically achievable** in reducing the noise exposure of miners working around the longwall mining system:

- **Automated shear;**
- **Automated jacks;**
- **Automated stage loader;**
- **Memory cut;**
- **Proper maintenance such as use of proper chain tensioning and flight spacing;**
- **Positioning of the miner to minimize exposure to noise such as keeping stageloader operator away from crusher, motors and gears, head drive, belt tail; head drum shear operator staying a minimum or 3 m (10 ft) outby the drum head; and**
- **Reduced run-time for face and stageloader conveyors when empty.**

MSHA considers the following engineering noise controls to be conditional:

- **Remote operation.**

MSHA also considers the following noise controls to offer *promise* in reducing the noise exposure of the shear operators and other miners working around the longwall mining system:

- *Barriers where appropriate;*
- *Appropriately selected, correctly installed, and properly maintained acoustical materials (see Section One Introduction);*
- *Rotation of head and tail shear operators with each other, shear operators with shieldman, stageloader operator with shieldman;*
- *Video cameras to monitor the cutting and other functions to limit miner exposure;*
- *Enclosure of motors, gears, pumps where demonstrated to be a significant noise source and can be done without damage to the equipment;*
- *Damping of enclosures and panels where demonstrated to be a significant noise source;*
- *Water-cooled motors instead of air-cooled motors where practical and when the motors are a significant source of noise exposure;*
- *Enclosure for the other miners (e.g., headgate operators) where practical;*
- *Isolated cutting bits on the longwall drum (e.g., the application of vibration isolation materials between the bits/block and the drum); and*
- *Sand-filled cutting heads.*

17. Mantrips

Mantrips and other similar modes of transportation may be a significant contributor to a miner's overall noise exposure and should be examined on a case-by-case basis. When attempting to reduce a miner's noise exposure, there are instances where engineering controls should be applied to mantrips to achieve a significant reduction.

MSHA considers the following engineering noise controls, or a combination of these controls, to be **technologically achievable** in reducing the noise exposure of miners working around and riding in mantrips:

- **Muffler(s);**
- **A fully enclosed passenger compartment**
- **Smooth rail joints; and**
- **Good machine and track maintenance.**

MSHA considers the following engineering noise controls to be conditional:

- **Motor enclosure for those machines where the motor is a significant noise source; and**
- **A passenger compartment treated with appropriate acoustical materials (see Section One Introduction).**

The following control offers *promise* in reducing miner noise exposures:

- *Composite wheels to reduce wheel-rail squeal.*

18. Mills / Processing Plants / Coal Preparation Plants (including Breakers at Anthracite Mines)

Miners working in mills, processing plants, coal preparation plants and breakers at anthracite mines, typically encounter high sound levels and are engaged in mobile occupations. Consequently, it is usually necessary to identify where and which tasks contribute the most to the miner's overall noise exposure, i.e., time-motion study. The successful reduction of a miner's noise exposure depends on the application of engineering and administrative controls to the locations and tasks which contribute the most to the miner's overall noise exposure. Therefore, the application of these controls must be evaluated on a case-by-case basis.

MSHA considers the following engineering and administrative noise controls, or a combination of these controls, to be **technologically and administratively achievable** in reducing the noise exposure of miners working in coal preparation plants and metal/nonmetal processing plants and mills:

- ❖ **Acoustically treated control booths; and**
- ❖ **Full enclosures without a top around equipment or miner work locations;**
- ❖ **Electro-mechanical sensing devices to limit exposure times;**
- ❖ **Video technology to limit exposure time;**
- ❖ **Bin-level indicators;**
- ❖ **Rotation of plant operator with control room operator; inside mechanics with outside mechanics; high-noise floor workers with low-noise floor workers; and in-plant workers with outside-plant workers;**
- ❖ **Limit plant worker time on noisy floors, working in or next to noisy equipment such as screens, crushers, centrifuges, and dryers;**
- ❖ **Relocate work stations / controls to quieter locations;**
- ❖ **Relocate tool boxes, cabinets, and supplies to quiet area;**
- ❖ **Operate noisy equipment / processes (welding, grinding, etc.) when fewer miners will be exposed; and**
- ❖ **Perform maintenance during downtimes, if possible.**

MSHA considers the following engineering noise controls to be conditional:

- **Partial enclosures without a top around equipment or miner work locations;**
- **Barriers, including curtains, especially on traveled walkways;**
- **Acoustic baffles suspended above enclosures;**
- **Resiliently backed mill liners;**
- **Chute liners;**
- **Covered chute enclosures;**
- **Dead boxes and impact pads; and**
- **Resilient screen decking.**

Other noise controls that offer *promise* for reducing the noise emitted from screens and other sizing devices include:

- *Replacement of spring mounts with vibration isolation mounts made of rubber, ROSTA mounts, and air bags (due to the engineering parameters involved in this type of equipment and the forces generated being transferred to the structure, their use should be considered on a case-by-case basis in conjunction with the equipment manufacturer);*
- *"Double isolation" mounting methods; and*
- *Banana screens (due to height requirements, banana screens may be applicable only in certain situations.)*

The following administrative control offers *promise* for reducing an operator's noise exposure in coal preparation plants:

- *Move density measuring to quiet location.*

19. Mobile Equipment -- Surface

MSHA considers the following engineering noise controls, or a combination of these controls, to be **technologically achievable** in reducing the noise exposure of miners operating surface mobile equipment (e.g., bulldozers, front-end loaders, trucks, graders, scrapers):

- **Environmental cabs (primarily on equipment manufactured since the mid-1970s) that include appropriately selected, correctly installed, and properly maintained acoustical materials (see Section One Introduction);**
- **Exhaust mufflers; and**
- **Redirection of the exhaust away from the operator.**

MSHA considers the following engineering noise controls to be conditional:

- **Installation of a full or partial skin kit to the ROPS/FOPS.**
- **Appropriate acoustical materials (see Section One Introduction) to treat the operator's compartment.**

The following control offers *promise* in reducing miner noise exposures:

- *Remote controls.*

20. Portable Crushers / Screening Plants and Associated Equipment

MSHA considers the following engineering noise controls, or a combination of these controls, to be **technologically achievable** in reducing the noise exposure of crusher operators:

- **Acoustically treated environmental control booths isolated from the main structure through the use of vibration-isolation techniques or through physical isolation (permanent or portable);**
- **Remotely controlled picks;**
- **Video monitoring of plant operations;**
- **Mufflers; and**
- **OEM controls on diesel engine/generator sets.**

MSHA considers the following engineering noise controls to be conditional:

- **Sound damping material at transfer points;**
- **Chute liners;**
- **Resilient screen decking; and**
- **Barriers, especially on traveled walkways.**

21. Roof Bolting Machines

MSHA considers the following engineering control and work practices to be **technologically and administratively achievable** in reducing a miner's noise exposure when working on or around a roof bolting machine:

- **Wet drilling (where it can be implemented due to the roof bolter design and when compatible with the geology and mining method);**
- **Sharp drill bits;**
- **Starter drill steel to begin the hole;**
- **Straight drill steel (one piece and with thick wall, if conditions and dust collection allow);**
- **Replacement of worn or defective drilling components (e.g., drill pot bushings or bearings, worn steel, bent steel); and**
- **Maintenance of manufacturer-recommended drilling parameters for thrust, torque, and rotational speed.**

The following engineering controls and work practices offer *promise* in reducing a miner's noise exposure:

- *Automated dust collection system or actuation of the dust collection system motors only during drilling, or use of administrative controls to accomplish the same task;*

- *Exhaust conditioner (water box) and/or manufacturer-recommended exhaust muffler;*
- *Controls for optimizing the drilling parameters (drill feedback system);*
- *Water misting system (i.e., injection of a small volume of water in a mist form into the drill hole clearance system);*
- *Grommet to isolate the drill steel and chuck;*
- *Acoustical liner in the tool tray; and*
- *Damped drill steels.*

22. Scalers

MSHA considers the following engineering noise controls, or a combination of these controls, to be **technologically achievable** in reducing the noise exposure of miners working around scalers:

- **Environmental cabs that include appropriately selected, correctly installed, and properly maintained acoustical materials (see Section One Introduction) applied to internal surfaces;**
- **Sealing of openings (e.g., around the gear controls, doors); and**
- **Muffler.**

MSHA considers the following engineering noise controls to be conditional:

- **Appropriately selected, correctly installed, and properly maintained acoustical materials (see Section One Introduction) on the inside surfaces of existing cabs; and**
- **Barrier between the engine and the operator.**

23. Stone Saws

MSHA considers the following engineering noise controls, or a combination of these controls, to be **technologically achievable** in reducing the noise exposure of the stone saw operator:

- **Operator booth with appropriately selected, correctly installed, and properly maintained acoustical materials (see Section One Introduction) applied to internal surfaces; and**
- **Barrier between the saw and the operator.**

There are two types of cutting blades. One is a silent core blade that is laminated. The other is a composite blade with filled expansion slots. These are available for all existing saws. Blade maintenance and the type of saw blade also are important factors.

Methods that offer *promise* in reducing the noise exposure of miners using stone saws include:

- *Quiet or composite blades; and*
- *Wet sawing systems.*

Section Two
Practical Approach to Reducing A Miner's Noise Exposure

MSHA believes that there is a practical approach that can be taken to reduce a miner's exposure to noise. Consideration of the responses to the following questions can be a valuable part of the noise control evaluation process. Besides the reduction of noise exposure, proper maintenance, work practices, and procedures, if applicable, may result in increased efficiency and less downtime.

Maintenance

- Are all existing noise controls maintained?
- Are mechanical components / systems adequately maintained including maintaining and greasing rollers, bearings, hubs, etc.?
- Are bolts tight, covers and compartments secure to prevent noise exposures?
- Do smooth transitions exist between track rails?
- Are openings around doors and between compartments sealed? Are air conditioners installed? Are broken windows repaired?
- Is all equipment properly maintained to reduce excessive noise resulting from lack of oil, grease, worn parts, etc.?
- Are miners instructed on proper use, operation and maintenance of equipment with noise controls?
- Is the air conditioning in booths and enclosures maintained?
- Are filters replaced on a scheduled basis for all air conditioners?

Work Practices

- Are sharp cutting tools used?
- Do dust collection systems operate only when needed?
- Are proper thrust, rotational speed, torque and chain tensioning being used?
- Are good work practices being employed?
- Are there work practices that result in unnecessary exposure to noise?
- Are conveyors operated either wet or with materials?

- Are doors and windows to cabs and booths kept closed?
- Are radios turned off or the volume reduced as low as possible?
- Is the exposed miner maintaining the greatest distance from the noise source while still being able to perform his/her job?
- What kind of cleanup or maintenance is used, e.g., hand shovels vs. small loaders?
- Do miners spend their breaks near high noise areas?
- Do miners park or idle equipment in high noise areas for waiting, loading or dispatching?
- Do miners stand next to high noise areas?
- Are manufacturer's air pressure recommendations followed for air-operated equipment?
- Are manufacturer's recommendations / maintenance schedules, etc. followed?
- Are air hoses used for cleanup rather than manual tools, vacuuming, or washing down with water?
- Is equipment located in such a manner to minimize miner exposures?

Engineering / Administrative Controls

- Are all feasible engineering and administrative controls installed and maintained?
- Are environmental cabs used on surface mobile equipment?
- Can a video camera/monitor be used to observe critical operations, thus limiting a miner's exposure?
- Can a remote control system be used to remove an operator or miner from a noisy environment?
- Are sound-treated booths provided for miner use, even on a periodic basis, where applicable?
- Are exhausts directed away from miners?
- Can miners be rotated to reduce exposure?
- Has the proper type of acoustical material been selected to suit the job? Has consideration been given to the material's flammability properties?
- Do impact points employ vibration damping materials?
- Do barriers separate miners and noise sources?

- If multiple noise sources are present, can barriers be installed to prevent the combined effects of sources?
- Is cleanup performed when the plant is running?
- Are normal travelways located away from noise sources?
- Are high noise areas identified with warning signs?
- Are miners instructed to avoid these high noise areas?
- Can noisy machines be replaced by quieter ones?
- When new or used equipment is purchased, are noise controls included? Is sound level or exposure data included?
- Is a "Buy Quiet" program in effect at the mine for the purchase of the quietest new and used equipment available?
- Has noise been considered in operational design?

Section Three
Some Examples of Administrative Controls

MSHA considers the following administrative controls to be applicable in many mining situations but administrative achievability must be assessed on a case-by-case basis. The following controls should be discussed with miners, miners' representatives and mine operators during the inspection process, as appropriate.

1. Adjust work schedules.
   - Share work tasks and/or rotate miners.
   - Schedule work tasks during quiet periods.
   - Limit duration of work shifts.

2. Utilize work practices to lower noise exposures.
   - Position miners in quieter locations without increasing safety risks;
   - Keep miners from congregating at high-noise areas;
   - Provide quiet areas while taking breaks;
   - Limit the duration of noisy tasks;
   - Switch / rotate miners from high- to low-noise exposure jobs/occupations;
   - Modify work activities to shorten time or decrease noise level;
   - Provide job-task-analysis training for the specific occupation to complete tasks more efficiently, safely, and in a manner to reduce the occupational noise exposure;
   - Eliminate tasks that are unnecessarily noisy;
   - Operate noisy equipment or complete noisy tasks during periods when fewer miners will be exposed; and
   - Restrict or limit miner access to high noise areas.

3. Use real-time noise dosimetry / instrumentation to measure exposures, trigger an administrative control, and prevent overexposures.

4. Use remote sensing technology and video monitoring.

5. Designate low-noise walkways /areas (e.g., dinner holes) or locate walkways /areas away from noise sources.

6. Assure maintenance practices critical to reducing noise generation are identified and followed:
   - Keep chain tension adjusted to specifications;
   - Keep panels tightly bolted;
   - Keep seals around compartments secure; and
   - Keep drive trains aligned and lubricated.

<u>Background</u>

Overexposure to occupational noise continues to be a pervasive health problem. As such, MSHA would like to offer its assistance to mine operators in the implementation of the noise standard.

Authority
30 CFR Part 62

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This information bulletin may be viewed on the Internet by accessing MSHA's home page at http://www.msha.gov by choosing Rules & Regs, and "Compliance Assistance Information."

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Appendix 6

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U.S. Department of Labor

Mine Safety and Health Administration
1100 Wilson Boulevard
Arlington, Virginia 22209-3939

ISSUE DATE: JANUARY 27, 2004

PROGRAM INFORMATION BULLETIN NO. P04-05

FROM: RAY McKINNEY Ray McKinney
Administrator for
Coal Mine Safety and Health

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Administrator for
Metal and Nonmetal Mine Safety and Health

SUBJECT: Basis for Assigning a P-Code for Noise Overexposure

Scope

This Program Information Bulletin (PIB) affects surface and underground coal and metal/nonmetal mines.

Purpose

Recently the Mine Safety and Health Administration (MSHA) has become aware that there are some misconceptions concerning the noise rule. This PIB clarifies several misunderstandings concerning P-codes. In the paragraphs below, you will find an explanation of what a P-code is, and the circumstances under which P-codes are assigned.

Information

MSHA has acknowledged that there are instances where all feasible engineering and administrative controls are being used and a miner's noise exposure cannot be reduced to the permissible exposure level. MSHA uses the letter "P" as an action code in its database to designate that an overexposure condition remains even though all feasible engineering and administrative controls are in place. Thus, a "P-code" is an administrative device that allows MSHA to track these situations. The term P-code derives from the requirement to wear protective equipment, i.e. the mine operator must provide the appropriate hearing protection to the affected miner and the miner must wear the hearing protection.

A P-code is not a petition for modification, because § 101(c) of the Mine Act only allows a petition for modification for mandatory safety standards. A P-code simply provides

MSHA with a means of tracking special overexposure situations. A P-code does not establish an alternative method of compliance with the noise standard. Therefore, mine operators may not apply for P-codes. In addition, P-codes are not assigned to pieces of equipment or to areas of a mine. MSHA will determine the suitability of a P-code on a case-by-case basis. The agency will identify the principal noise source(s) that contributed to the miner's overexposure and will include them in the documentation of the conditions that constitute grounds for a P-code. If the District Manager (DM) believes a P-code is warranted, the DM reviews the situation in consultation with field enforcement staff, headquarters' officials, and MSHA technical experts.

There are two scenarios involving a miner's overexposure to noise where the use of a P-code would be appropriate. In the first scenario, an MSHA inspector would determine that a miner's full-shift exposure exceeds the PEL. If MSHA also determines that: (1) all feasible engineering and administrative controls have already been implemented and are maintained; (2) all affected miners are enrolled in a Hearing Conservation Program that complies with each element of 30 CFR § 62.150; (3) hearing protection has been provided by the mine operator and is being worn by the affected miners; and, (4) the mine operator has posted (on the mine bulletin board) and provided affected miners with copies of any procedures for administrative controls being used, then a P-code will be assigned for the circumstances leading to the affected miner's overexposure. These circumstances include the job or occupation the miner is performing, the area where the miner works, and the equipment the miner is using or that is a source of the overexposure. A P-code will be assigned only if the mine operator has fully complied with each of the above requirements. Under this scenario, an operator would not receive a citation prior to the P-code being assigned.

In the second scenario, an MSHA inspector would determine that a miner's full-shift exposure exceeds the PEL. However, unlike the first scenario, MSHA would also have determined that the mine operator has failed to fully comply with some aspect of 30 CFR § 62.130. A citation would be issued because the mine operator has failed to: (1) implement or maintain all feasible engineering and administrative controls; or (2) enroll all affected miners in a Hearing Conservation Program that complies with each element of 30 CFR § 62.150; or (3) ensure that hearing protection has been provided to the affected miners and is being worn by the affected miners; or (4) post (on the mine bulletin board) and provide affected miners with copies of any procedures for administrative controls. In this scenario, a citation would be issued and an abatement period would be set. If compliance with the PEL still cannot be achieved through the implementation of (1) through (4) above, a P-code will be assigned and the citation will be terminated.

Once a P-code has been assigned, a mine operator must continue to abide by all of the noise requirements of Part 62. MSHA will review and re-evaluate all P-codes periodically to determine whether conditions have changed. A P-code can be withdrawn if the original justification for the P-code is no longer valid, i.e. if: (1) a mine operator fails to comply with the minimum specified engineering and administrative controls; or (2) a full-shift dosimeter sample demonstrates that the operator has reduced the affected miner's exposure to the PEL; or (3) new feasible technology becomes available and the mine operator refuses to implement the technology; or (4) the mine operator fails to comply with any of the requirements of 30 CFR § 62.130.

Background

Overexposure to occupational noise continues to be a pervasive health problem. As such, MSHA would like to offer its assistance to mine operators in the implementation of the noise standard.

Authority

30 CFR Part 62

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Appendix 7

In order to have a sufficient number of instruments available to continue conducting health surveys , and to ensure that the calibration lab is not overloaded , submit only ¼ of the total number of calibrators and dosimeters on hand during each of the four months specified.

DISTRICT	***Months***	***To***	***Send***	***Instruments***
Northeast	January	April	July	October
Southeast	January	April	July	October
North Central	February	May	August	November
South Central	February	May	August	November
Rocky Mountain	March	June	September	December
Western	March	June	September	December

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CHAPTER 16
PERSONAL PROTECTIVE EQUIPMENT

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Chapter 16
PERSONAL PROTECTIVE EQUIPMENT

I. Introduction

Personal protective equipment (PPE) consists of respiratory protection, hearing protection, protective clothing, and other items worn by miners to protect against hazards. (See CHAPTER 15, NOISE, for discussion of hearing protection.) MSHA does not consider PPE to be an engineering or administrative control for enforcement purposes.

During an inspection or investigation, document the use of PPE to ensure that miners are positively and reliably protected. Whenever personal protective equipment is required by an MSHA standard, the inspector should thoroughly evaluate all aspects of the mine operator's program. Common problems observed in the field include:

- Failure to enforce the use of PPE when overexposures or hazards exist;
- Wearing a respirator when facial hair interferes with the facepiece seal;
- Wearing a respirator with expired or incorrect cartridges or filters:
- Wearing the wrong PPE for the contaminant in question; and
- Using PPE that is damaged, contaminated or beyond its service life.

II. Definitions

Breakthrough - A term applicable to protective equipment (respirator cartridge, clothing, gloves, etc.) when contaminant contact overwhelms the ability of the device to filter or resist the contaminant and provide protection. This can be a function of contaminant concentration and/or the duration of exposure.

Breakthrough time - the time elapsed from the initial contact of the chemical on the outside surface of the barrier material until detection on the inside surface; the longer the breakthrough time, the greater the protection.

Escape-Only Respirator - a respirator designed for use only during escape from hazardous atmospheres. The capacity of the unit must be sufficient to allow escape.

Immediately Dangerous to Life or Health (IDLH) – Conditions that pose an immediate threat to life or health, and conditions that pose an immediate threat of severe exposure to contaminants likely to have adverse delayed effects on health (such as radioactive materials).

Personal Protective Equipment (PPE) – includes all items or materials worn by a miner to prevent injury or illness from exposure to a chemical or physical agent, or from physical trauma. Examples include (but are not limited to): hard hats, protective footwear, safety glasses, face shields, goggles, respirators, hearing protectors, safety belts, harnesses and lanyards, gloves, chemical resistant clothing, vibration resistant gloves, and clothing or aprons which reflect heat or protect against contact with hot materials.

Fit Check – A functional test of a respirator's integrity and the face-to-facepiece seal performed each time a respirator is donned. Fit check techniques can vary with respirator type. The manufacturer's guidance should be followed.

Qualitative Fit-Test - A pass/fail evaluation of the fit of a respirator using a challenge agent to test the integrity of the components and the face-to-facepiece seal. This test relies on the wearer's subjective response. If the wearer detects the presence of the challenge agent, then the respirator is inadequate and others must be tested until one respirator proves to be suitable for the wearer. The four most common types of qualitative fit-testing (based on the challenge agent used) are: irritant smoke; isoamyl acetate (banana oil); saccharin (sweet taste); and Bitrex® (bitter taste).

Quantitative Fit-Test – Evaluates the effectiveness of the face-to-facepiece seal by comparing conditions inside the facepiece with the atmosphere. This can be a calculated leakage rate or the relative concentrations of particles inside and outside the facepiece. The individual measure of effectiveness is called a fit factor. It does not rely on the wearer's senses and responses. The lowest expected average fit factor for a group of trained individuals using the same type of respirator is often used to determine the type of respirator need for a particular exposure. With some adjustments for safety, that measure is known as an assigned protection factor.

Respirator - A protective device worn on the face or head of the individual to prevent inhalation of harmful substances in the atmosphere. Respirators must be approved by NIOSH under 42 CFR Part 84 or, if manufactured before July 10, 1998, under 30 CFR Part 11 or 42 CFR Part 84.

III. Respiratory Protection

Respiratory protection is an interim measure used to protect miners from inhaling hazardous airborne contaminants while engineering and administrative controls are being established. Serious injury or illness can occur if a respirator, even though properly selected, is not fitted as required by the standard.

Inspectors should refer to the Program Policy Manual for instructions on how to combine standards §§56/57.5001 and §§56/57.5005 as one standard when issuing citations and for guidance on enforcement of these requirements. For respirators provided for protection from diesel particulates refer to the specific guidance provided in the compliance directive for that rule.

A. **Respirator Types**

Respirators are grouped by the way that they fit to the face, the type of treatment the breathing atmosphere receives, and relation of the pressure inside the facepiece to the atmosphere during inhalation. Components of a respirator include the facepiece, inhalation and exhalation valves, headband(s), and a connection for an air purifying filter or cartridge or a source of supplied air.

1. Facepieces are classed as either:

   a. **Loose-fitting**, such as hoods or helmets that cover the head completely, or

   b. **Tight fitting**, including half masks which cover the mouth and chin, and full facepieces which cover the face from the forehead to the chin.

   Filtering facepiece respirators or dust masks are considered “tight fitting”. As a general rule, tight fitting units provide more protection than loose fitting facepieces. Full facepieces provide greater protection than half masks.

2. Breathing air is either supplied or filtered:

   a. **Air purifying respirators** filter contaminants from the air.

   b. **Supplied air respirators** provide breathable air from an uncontaminated source.

   Supplied air is typically selected when the concentration of contaminant is high, unknown, or not appropriate for filters (e.g., oxygen deficiency).

3. Facial movements and the reduction in pressure inside the facepiece during inhalation may allow contaminants to infiltrate into the respirator.

   a. **Negative pressure r**espirators - the pressure inside the respirator during inhalation is less than the pressure outside the respirator.

   b. **Positive pressure r**espirators - the pressure inside the respirator always remains greater than the pressure outside the respirator.

Positive pressure facepieces are less likely to allow any infiltration of contaminant.

Air-Purifying Respirators (APR) include negative pressure, tight-fitting respirators and **powered air-purifying respirators (PAPRs).** These respirators remove contaminants from the outside air prior to inhalation, by passing it through a filter or cartridge containing a solid sorbent such as activated charcoal. Air-purifying respirators do not provide oxygen and must never be used in an oxygen-deficient atmosphere.

Supplied-Air Respirators (SAR) may be either positive or negative pressure. There are two types of SARs: the **Air-Line Respirator (ALR)** and the **Self-Contained Breathing Apparatus (SCBA).** Only SARs are safe for use in oxygen-deficient atmospheres. In IDLH atmospheres, Air-Line Respirators must have auxiliary self-contained breathing capability for escape purposes. Bottled air must be of Grade D (American National Standards Institute – Compressed Gas Association Commodity Specification for Air G-7.1.1989) quality and compressors must be protected from contaminating the air supply with engine exhaust or the thermal decomposition products of lubricating oils (e.g., carbon monoxide). Current NIOSH certifications also limit hose length as a function of approved assemblies.

Escape-Only Respirators are intended for use only during escape (emergency exit) from a hazardous atmosphere. No one should use an escape-only respirator to enter or re-enter a hazardous atmosphere for any purpose.

B. Respirator Approval

Respirators must be approved by NIOSH or have a joint MSHA/NIOSH approval*. Approved respirators bear a certification number on the filter, filter package, respirator box, or some part of the respirator assembly (usually the filtering element, if present).

Any modification to an approved respirator while in use, such as the substitution of another manufacturer's part, voids the approval. Approvals are given to the entire assembly submitted by a manufacturer. Therefore, all of the parts of the assembly must be from the same manufacturer. A respirator can be modified to allow quantitative fit-testing as long as the unit is returned to its original condition prior to use.

** Prior to June 1995, respirators were tested and approved under 30 CFR Part 11. These respirators were designated as having a joint MSHA/NIOSH* *approval. After June 1995, the testing and approval function was assumed by NIOSH under 42 CFR Part 84. However, filter self-rescuers (FSRs), self-contained self-rescuers (SCSRs) for mine escape purposes, and self-contained breathing apparatus (SCBAs) for mine rescue purposes, require a joint MSHA/NIOSH approval under 42 CFR Part 84. Operators can use up their inventory of particulate filters approved under 30 CFR Part 11 as long as the filters are appropriate for the contaminant. Respirators having electrical or electronic components are required to be intrinsically safe under 30 CFR Part 18 when used in gassy mines or where approved equipment is required under Part 57, Subpart T, and must be approved by MSHA.*

C. Respiratory Protection Programs

Whenever required under MSHA standards, such as 30 CFR §§ 56/57.5005, § 57.5060 or § 58.610, a respiratory protection program must be established for selection, maintenance, training, fitting, supervision, cleaning, and use. The program must meet the requirements of the “American National Standards Practices for Respiratory Protection ANSI Z88.2-1969.” The following elements of the ANSI standard are considered to constitute a minimally acceptable program; however, not all of the elements may be relevant to the situation at hand.

1. The operator must establish a standard operating procedure (SOP) governing the selection, use, and maintenance of respirators. If respirators are provided or required for protection against different types of contaminants, a written SOP should be developed. The SOP should be written so that anyone reading it will understand how all of the minimum requirements are addressed, including routine and emergency use.

2. The mine operator must select the respirator on the basis of the hazards to which the miner is exposed. The respirator must be approved for the specific hazards. Other factors such as atmospheric oxygen content, anticipated exposure levels, properties of the contaminant, work environment, and other physical factors must be considered. Each respirator has distinct limitations on its use. The manufacturer’s literature will list the limitations.

3. The miner (respirator user) shall be instructed and trained in the proper use of respirators and their limitations. ANSI Z88.2-1969 states:

   “Minimum training shall include the following:

   (a) Instruction in the nature of the hazard, whether acute, chronic, or both, and an honest appraisal of what may happen if the respirator is not used.

(b) Explanation of why more positive control is not immediately feasible. This shall include recognition that every reasonable effort is being made to reduce or eliminate the need for respirators.

(c) A discussion of why this is the proper type of respirator for the particular purpose.

(d) A discussion of the respirator's capabilities and limitations.

(e) Instruction and training in actual use of the respirator (especially a respirator for emergency use) and close and frequent supervision to ensure that it continues to be properly used.

(f) Classroom and field training to recognize and cope with emergency situations.

(g) Other special training as needed for special use.

4. “Training shall provide the miners opportunity to handle the respirator, have it fitted properly, test its face-to-facepiece seal, wear it in normal air for a long familiarity period, and, finally, to wear it in a test atmosphere.” The opportunity to wear the respirator in a test atmosphere is the fit test. All miners required to use respirators must be fit-tested prior to initial use of that particular make, model and size of respirator. Periodic re-testing is advisable but not required unless factors affecting the fit such as weight gain or loss, presence or absence of dentures or scarring is observed. Fit-testing may be either quantitative or qualitative.

5. The operator must be able to demonstrate that the proper respirator was issued to the respirator wearer. This is usually accomplished by recording the fit-test date and results for each wearer, and the respirator assigned or issued to each wearer.

6. Respirators must be inspected routinely before and after each use. Worn or deteriorated parts must be replaced to maintain proper approval. Self-contained breathing apparatus must be thoroughly inspected at least once per month and after each use. The mine operator must keep a record of the inspection dates and findings. A record of the inspection tag may be attached to the respirator or respirator storage container.

7. ANSI states that cleaning and disinfection shall be done “as frequently as necessary to ensure proper protection is provided to the wearer.” A visibly dirty respirator interior could indicate a bad seal, poor storage or that the user removes it while in the work environment. Skin irritation is possible due to contaminant and bacterial accumulation. Daily cleaning of respirators is recommended. Most filtering facepiece units are discarded after use (i.e., dust masks). If respirators are shared, the used respirator will be thoroughly cleaned and disinfected before being issued to another miner.

8. Respirators shall be stored in a convenient, clean, and sanitary location. The respirators must be stored in a manner that protects them against contamination, temperature extremes, and other potentially damaging conditions. This helps to maintain the respirator’s ability to function properly.

9. One individual shall administer the respiratory protection program. The administrator must have “sufficient knowledge of the subject to properly supervise the program.” The respirator program must include regular inspection and evaluation to determine the effectiveness of the program.

10. Additional sources of information for mine operators regarding respiratory protection program formats, methods for establishing SOPs, and appropriate respirator selection and use criteria include:

    a. Respirator manufacturers;

    b. NIOSH Publications (available through NIOSH Publication Dissemination Center at 1-800-356-4674): “Guide to Industrial Respiratory Protection” (Pub. No. 87-116); “NIOSH Respirator Selection Logic 2004”, 2005-100; “Respirator Decision Logic” (Pub. No. 87-108); and “NIOSH Guide to the Selection and Use of Particulate Respirators Certified Under 42 CFR 84” (Pub. No. 96-101);

    c. American Industrial Hygiene Association “Respiratory Protection - A Manual and Guidelines”; and

    d. Material Safety Data Sheets (MSDS).

D. Monitoring Respiratory Protection Programs

See **Appendix A** of this chapter for a list of review items which can be used to determine the adequacy of a mine operator's Respiratory Protection Program. **Appendix B** of this Chapter includes inspection procedures for half-mask respirators.

If any deficiencies are found in an operator's respiratory protection program, note them in the Health Field Notes and take appropriate action in accordance with the Program Policy Manual. Specific information on individuals who are evaluated should include the full-shift exposure limit to document the hazard to which they were exposed, respirator manufacturer and model, NIOSH or MSHA/NIOSH certification number, type of cartridge or filter, fit-testing information, job description, and duties.

E. Use in Atmospheres Immediately Dangerous to Life and Health (IDLH)

Under 30 CFR §§ 56/57.5005(c), when respirators are used in atmospheres that are immediately harmful to life, at least one person with back-up equipment and rescue capability must be present in case of failure of the respiratory equipment.

F. Abrasive Blasting

30 CFR § 58.610 requires that only respirators approved by NIOSH under 42 CFR Part 84 for abrasive blasting be used. These airline respirators (Type CE) are designed to protect the wearer from the impact of the abrasive material as well as toxic exposure. A special hood or shroud protects the wearer's head and neck, and shielding material protects the viewing windows of the head enclosure. When abrasive blasting is performed, all exposed miners must be protected.

IV. Self-Rescue Devices for Emergency Escape Only

According to 30 CFR § 57.15030, a 1-hour self-rescue device approved by MSHA and NIOSH under 42 CFR Part 84 must be made available to each miner working in an underground mine. The device is designed to permit safe egress from a contaminated atmosphere and must be maintained in good condition. Additionally, 30 CFR §57.15031 requires that the self-rescue device be worn or carried on the miner. However, it may be located on the mobile equipment the miner is operating in a readily accessible place, or if wearing or carrying the self-rescuer would create a hazard to the miner, it may be located a distance no greater than 25 feet from the miner.

Single-use filter self-rescuers (FSRs) are the most common type found in metal and nonmetal mining. The FSR will have 14G in its NIOSH certification number. It is designed to provide respiratory protection against carbon monoxide (resulting from mine fire and explosions) for approximately 60 minutes in atmospheres containing up to 1 percent (10,000 ppm) carbon monoxide. The FSR does not provide protection from an oxygen-deficient atmosphere or from other mine fire gases. Self-contained self-rescuers (SCSRs) that chemically generate oxygen or use compressed oxygen may also be found underground; those units will carry a 13F in the NIOSH certification.

- While the detection and reporting by miners of defective self-rescuers is a part of the training program required under 30 CFR §57.18028, the operator has the final responsibility to see that all self-rescue devices are fully operable and to replace them immediately if they are defective. This responsibility can be discharged successfully only through a regular inspection program conducted by the operator, supplemented by the training of each miner to recognize and report defective self-rescue devices. Items to consider when monitoring a mine operator's self-rescuer program include:

- Determining approval (NIOSH/MSHA certification should contain 13F or 14G);
- Availability to miners underground;
- Examination of devices for defects;
- Check of the "shelf life" and "service life" of devices;
- Records of periodic weighing (if applicable), maintenance, replacement;
- Training given to miners;
- Records of training; and
- Frequency of weighing and/or removal from service criteria.

Reference sources include "MSHA IG 2 - Filter Self-Rescue Devices" and NIOSH "Guide to Industrial Respiratory Protection" (Pub. No. 87-116).

V. Personal Body Protection

Personal body protection, as required under 30 CFR Parts 56/57 Subpart N - Personal Protection, includes items or materials worn by a miner to prevent a non-respiratory and non-auditory injury or illness resulting from exposure to a chemical/physical/biological agent or physical trauma. Examples of personal body protection include, but are not limited to, hard hats, protective footwear, safety glasses, face shields, goggles, safety belts and lanyards, harnesses, gloves, chemical-resistant clothing, vibration-resistant gloves, and heat-reflective clothing or aprons.

A. MSHA Standards

Safety standards requiring the use of personal protective equipment (PPE) include:

1. 30 CFR §§ 56/57.15002 Hard hats (protection against falling objects);
2. 30 CFR §§ 56/57.15003 Protective footwear;
3. 30 CFR §§ 56/57.15004 Eye protection;
4. 30 CFR §§ 56/57.15005 Safety belts and lines (fall protection);
5. 30 CFR §§ 56/57.15006 Protective equipment and clothing for hazards and irritants;
6. 30 CFR §§ 56/57.15007 Protective equipment or clothing for welding, cutting, or working with molten metal;
7. 30 CFR §§ 56/57.15014 Eye protection when operating grinding wheels; and
8. 30 CFR §§ 56/57.15020 Life jackets and belts.

Note - Where chemical hazards are present it is not necessary to demonstrate that an exposure could occur or has occurred. It is only necessary to clearly identify the potential hazard.

B. Chemical Protection for Skin and Eyes

Miners must have suitable body protection to prevent/minimize absorption of toxic substances through the skin and eyes as well as prevent damage to the skin and eyes.

1. **Identifying Chemical Hazards** - In order to determine if skin and eye protection is needed, a careful review of the chemicals and process must be conducted. Sources of information include:
   - **a.** ACGIH TLV® Booklet - ‘SKIN’ notation for material absorbed through the skin as well as characteristics of the hazards;
   - **b.** NIOSH Pocket Guide to Chemical Hazards;
   - **c.** Mine operator’s process flow sheets; and
   - **d.** Material Safety Data Sheets.

Note: It is important to consider pH in the mining process since both high (i.e., “caustic”) and low (i.e., “acidic”) pH materials can cause damage to the skin and eyes. Very high and very low pH materials can cause permanent, irreversible injury. Physiological reactions to acids and caustics may occur immediately, and/or may become more severe over time (i.e., hours post-exposure). Additionally, once the tissue is damaged, absorption of other chemicals and/or susceptibility to infection can occur more rapidly through the damaged skin.

2. **Analyses of Parts of the Body at Risk** - Identify the parts of the body that need to be protected as well as the extent of time the protection is needed. Since the purpose is to prevent injury, anticipate the accidents that could most likely occur. For example, if a miner's task is to repair chemical lines for two hours per day, it would be reasonable to assume that some protection to the hands would be needed during the entire two hours. It would also be reasonable to expect that a splash could occur which could affect the eyes, face, and front part of chest, legs and feet.

3. **Identification of Equipment Needed** - Once the hazards are analyzed, the necessary equipment can be identified. For example, in the case of the miner who repairs chemical lines for two hours per day, protective materials resistant for at least two hours would be selected, and would be used for long gloves, aprons, and footwear. A face shield would be necessary to protect the face and eyes. Glove selection must consider both chemical protection and the need for finger dexterity. It may be necessary to wear several different types of gloves at the same time to protect against multiple hazards.

4. **Selecting Suitable Chemical-Resistant Protective Equipment** - There is no such thing as totally impermeable clothing or materials. An item simply has a longer (or shorter) breakthrough time for a specific chemical. There is also no single material that is a barrier against all chemical exposures.

   Once the chemical hazard has been identified, selection of an adequate chemical-resistant material can be made. Guidance in making appropriate fabric selection may be found in the following:

   a. NIOSH “*Recommendations for Chemical Protective Clothing*” - available over the Internet links from the MSHA home page, the NIOSH *Pocket Guide to Chemical Hazards* CD-ROM, or Chapter 3 in this Health Manual;

b. Material Safety Data Sheets (MSDS) (Caution: In many cases MSDS are very general or only offer PPE recommendations for emergency use. Do not rely on them as a sole source of information.);

c. Equipment manufacturer selection tables; and

d. Other texts such as "*Guide to the Selection of Personal Protective Clothing*" by Arthur D. Little.

It is important to note that several materials may be suitable as a resistant material, depending on the length and type of exposure.

(ANSI Z87.1-1989(R1998) provides guidance for appropriate protection from specific hazards.

5. **Maintenance Programs** - Once items are selected to provide body protection, they must be maintained to ensure adequate protection. Items do not remain resistant forever. Chemicals gradually permeate and degrade the material, allowing possible chemical contact with the skin. Proper cleaning increases the useful life of equipment. Items that are worn and damaged will not provide adequate protection to the user. Equipment maintenance programs must be tailored to the particular equipment, its usage and mine conditions. Maintain the equipment according to the manufacturer's instructions.

C. Physical Agents Protection

Physical agents, such as ultraviolet radiation and high and low temperatures, can injure the skin and eyes, as well as cause other injuries and illness.

1. **Identifying the Hazard** - Review the process to identify any physical agent hazards which may be encountered. Information sources include:

a. ANSI Z87.1- 1989(R1998) Practice for Occupational and Educational Eye and Face Protection (especially for welding hazards to the eyes)

b. American Welding Society publications

c. Encyclopedia of Occupational Hazards

d. Equipment manufacturer

e. Any operator hazard assessments

2. **Evaluating Protective Equipment** - Review the equipment manufacturer's information to ensure that the equipment being used by the miner provides the necessary protection. Contact the equipment manufacturer if you have technical questions regarding their product and its use.

   If you need help in identifying suitable PPE or in evaluating the PPE in use, contact your district health specialist or industrial hygienist.

3. **Maintenance Programs** - As with other personal body protection, protective equipment for physical agents must be maintained to ensure adequate protection to the user. The maintenance program must be tailored to the equipment and use. Review the manufacturer's information on the product and interview the mine operator and miners as necessary to determine actual maintenance practices.

D. Inspection Procedures

Record all information concerning the need, selection, and use of personal body protection in the general field notes. Also note any deficiencies. Write any citations in accordance with the Program Policy Manual.

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CHAPTER 16
APPENDIX A:
(NON-MANDATORY)
Evaluating a Mine Operator’s Respiratory Protection Program

Chapter 16
Appendix A (NON-MANDATORY)
Evaluating a Mine Operator's Respiratory Protection Program

Whenever respirators are in use, whether on a voluntary basis, as part of a company policy, or required by an overexposure, the following items should be reviewed when evaluating a mine operator's respiratory protection program. **The following is a non-mandatory guideline**:

I. Program Administration

- ➢ Is the program in writing?
- ➢ Is there acknowledged employer responsibility?
- ➢ Does the program assign:
    - program responsibility?
    - accountability?
    - authority?
- ➢ Is program responsibility vested in one individual who is knowledgeable and who can coordinate all aspects of the program at the job site?
- ➢ Can feasible engineering controls or work practices eliminate the need for respirators?
- ➢ Are feasible engineering controls or work practices being established?
- ➢ Are these controls specified?
- ➢ Are there written procedures/statements covering the various aspects of the program, including:
    - designation of an administrator?
    - respirator selection?
    - respirators that are MSHA/NIOSH certified?
    - medical evaluations of respiratory users? (**Note**: NIOSH and more recent versipons of ANSI Z88.2 recommend medical evaluations of respirator users prior to issuance.)
    - issuance of equipment?
    - fit-testing?
    - training?
    - maintenance, storage, repair?
    - inspection?
    - use under special conditions?
    - work area surveillance?

II. Program Operation

General

- ➢ Are working conditions and miner exposures properly surveyed?
- ➢ Are selections made by individuals knowledgeable of proper selection criteria?

- Are selections based on the contaminants to which miners are exposed?
- Do the respirators provide adequate protection for the specified hazard and concentration of the contaminant?
- Is fit-testing being conducted?
- Are users fit-tested on an as-needed basis (for example, after loss of teeth)?

- Are required corrective lenses considered in fit-tests?
- Are approved fit-testing protocols being used?
- Is the fit-test appropriate for the required level of protection?
- Is the face piece-to-face seal tested in a test atmosphere?
- Are users prohibited from wearing respirators in designated work areas when they have facial hair or other characteristics which may cause leakage?
- Are respirators being worn correctly?
- Are respirators that are not individually assigned cleaned and disinfected regularly?
- Are respirators that are issued to individual users cleaned and disinfected as often as necessary?
- Are respirators stored in a manner so as to protect them from dust, sunlight, heat, excessive cold or moisture, or damaging chemicals?
- Are users inspecting respirators before and after wearing and during cleaning?

Emergency Use Respirators:

- Are devices designed as “emergency use” inspected at least monthly (in addition to after each use)?
- Are replacement/repair parts those of the manufacturer?
- Are repairs made by experienced individuals?

IDLH Atmospheres:

- Has a procedure been developed for usage in atmospheres that are immediately dangerous to life and health (IDLH)?
- Are users trained in the basis for selection of respirators?
- Are users trained in the proper routine and emergency use applications, cleaning, and inspection?

Recordkeeping:

- Are records kept (and up-to-date) on:
    - Individual issuance of respirators by model, name, and date?
    - Training (which includes names, dates, topics, etc.)?
    - Fit testing?

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CHAPTER 16
APPENDIX B:
Visual Inspection of Half-Mask Respirators

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Chapter 16
Appendix B
Visual Inspection of Half-Mask Respirators

This is a sample list of review items which applies only to half-mask, non-powered, tight-fitting, negative pressure air-purifying respirators provided to miners by mine operators and respirators supplied by MSHA to inspectors. It does not apply to full-face respirators, self-contained breathing apparatus (SCBA), supplied air respirators, powered air-purifying respirators, filter-type self-rescuers (FSRs), or self-contained self-rescuers (SCSRs). For other than half-mask respirators, follow the respirator manufacturer's instructions.

A. Facepiece

1. No excessive dirt or chemicals
2. No cracks, tears, holes or distortion
3. For rubber or plastic face pieces, face piece is soft, flexible and pliable
4. No broken or cracked holders for cartridges or canisters
5. No missing seals or gaskets
6. No broken or cracked valves

B. Head Straps

1. No breaks, tears or missing straps
2. No loss of strap elasticity
3. No broken or malfunctioning strap buckles
4. Straps are securely attached to face piece

C. Valves

1. No dust, dirt, or debris in or under seals
2. No cracked, torn, perforated, distorted, or missing valves, valve membranes, or valve covers
3. Valves inserted and seated properly in face piece

D. Air Purifying Elements (cartridges, canisters)

1. Cartridge, canister, or filter is appropriate for the hazard
2. Connections are tight, with no cross threading
3. Cartridge or canister not cracked, damaged, or missing
4. Cartridge or canister not expired; shelf life and service life conditions not exceeded, for example, cartridges that are to be used for only one shift are discarded at the end of the shift.
5. Proper cartridge, canister manufacturer, and model for respirator

E. Respirator Use

1. Persons in occupations required to wear respirators are wearing respirators while in their work place.

2. Respirators are inspected and fit-checked before use, and worn properly:

    a. Good face seal (subject is clean-shaven everywhere respirator touches face);
    b. Straps (the proper number of straps are being worn over the head and not over the hard hat, and that they are not too tight, or too loose); and
    c. Glasses don’t interfere with respirator fit or face seal.

CHAPTER 17
HEAT STRESS

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Chapter 17
HEAT STRESS

I. Introduction

Heat stress (also known as “thermal strain”) is a variety of health-related illnesses caused by excessive exposure to heat on the human body. Heat stress is a combination of heat generated by the human body and heat gained from the environment. In mining, environmental heat stress is caused by hot weather, working in the sun, near underground hot strata, furnaces, kilns or other heat sources. Heat stress also depends upon the type of clothing worn (especially protective clothing), humidity in the environment, and the miner’s work load. These factors affect miners’ deep body temperature, heart rate, sweating and sweat evaporation rate.

Heat stress increases the risk of accidents and heat-related illnesses or injuries. Miners who take medications that regulate blood pressure, thyroid, or kidney function are especially at risk. Drinking caffeinated beverages increases risk because they act as a diuretic. Heat-related illnesses include heat collapse (fainting), heat fatigue, heat rash, heat cramps, heat exhaustion, and heat stroke. Heat exhaustion can lead to heat stroke, a medical emergency that can rapidly lead to death. Each of these conditions can be prevented by appropriate engineering controls, as well as acclimatization (climatic conditioning), frequent rest breaks, adequate water intake (with electrolytes), and responsible supervision.

This chapter provides background information and a screening method for evaluating potential heat stress conditions at mines. Based on the results of an inspector’s screening survey, further evaluation may be required by the District Health Specialist or Industrial Hygienist, or by MSHA Technical Support.

II. Definitions

Acclimatization - The time period required for a person to adjust to environmental working conditions. When a miner has not worked under heat stress conditions in 2 weeks or more, heat acclimatization usually takes 5 to 7 days. Employees should work 50% of the workload the first day back and gradually work up to 100% on the last day. Miners who are not acclimated or are physically unfit are more at risk for heat stress than acclimatized, fit miners.

Deep Body Temperature - A measurement of the body core temperature, which is the temperature of the internal organs of the human body. Normal body core temperature is 37° C (98.6° F). Various organizations of health scientists (including NIOSH, WHO, and ACGIH)[1] recommend that the deep body temperature, when exposed to prolonged heat and work, should not exceed 38° C (100.4° F).

Dry Bulb Temperature - The ambient air temperature reading on a dry bulb thermometer. A dry bulb thermometer is an ordinary mercury thermometer and is not dependent on humidity.

Electrolyte - Any substance which changes into an ion when dissolved in a solution. Salts essential to the human body are electrolytes and are lost when sweating. Both water and electrolytes must be replaced to avoid or relieve heat stress.

Globe Temperature - The air temperature inside a hollow metal or thin copper globe that is painted black. The globe temperature is measured by a thermometer inside the center of the globe. The globe temperature measures the effect of direct exposure to radiant heat, such as the sun. In direct sunlight the globe temperature may be as much as 30° F higher than the Dry Bulb Temperature.

Heat Cramps - Painful muscle spasms that occur among those who sweat profusely in heat and drink large quantities of water, but do not adequately replace the body's salt loss. Drinking large quantities of water tends to dilute the body's fluids, while the body continues to lose salt. Shortly thereafter, the low salt level in the muscles causes painful cramps. The affected muscles may be part of the arms, legs, or abdomen, but tired muscles (those used in performing the work) are usually the ones most susceptible to cramps. It can occur despite drinking large quantities of liquids, since water, sodas and alcoholic beverages generally lack the needed salts (electrolytes). Lightly salted liquids or sports drinks can relieve or prevent these cramps.[2] Salt tablets irritate the stomach and should not be used.

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[1] National Institute for Occupational Safety and Health, World Health Organization (United Nations), and American Conference of Governmental Industrial Hygienists.

[2] CAUTION: Persons with heart problems or those on a low sodium diet who work in hot environments should consult a physician about what to do under these conditions.

Heat Exhaustion - A condition caused by the loss of large amounts of fluid by sweating, sometimes with excessive loss of salt. A miner suffering from heat exhaustion still sweats but experiences extreme weakness or fatigue, nausea, or headache. The victim may vomit or lose consciousness. Skin is clammy and moist, complexion is pale or flushed, and body temperature is normal or only slightly elevated. Resting in a cool place and drinking an ample supply of water or sports drinks will usually lead to recovery.[2]

Heat Rash (Prickly Heat) - Heat rash is likely to occur in hot, humid environments where sweat is not easily removed from the surface of the skin by evaporation and the skin remains wet most of the time. The sweat ducts become plugged, and a skin rash soon appears. Miners can help prevent this condition by resting in a cool place part of each day and by regularly bathing and drying the skin.

Heat Stroke - When the body's temperature regulatory system is overtaxed or fails and the body core temperature rises above 40° C (104° F). **This is a medical emergency and can result in death within minutes if not treated.** A heat stroke victim's skin is hot, usually dry, and red or spotted. The victim may be mentally confused, delirious, or possibly in convulsions or unconscious. First aid efforts include lowering the body temperature by loosening tight clothing, removing the victim to a cool area, and placing the victim in cool water or sponging the body with cool water.[3] **Seek medical attention immediately.**

Wet Bulb Temperature (Natural Wet Bulb Temperature) - The air temperature measured by a thermometer whose mercury bulb or other sensing element is covered with a sleeve or wick soaked in water. As the water evaporates, the wet bulb temperature drops below the dry bulb temperature and the wet bulb temperature approximates the evaporative cooling effect of perspiration on the human body. The wet bulb temperature helps assess heat stress under conditions where radiant heat and air velocity are not important factors. A temperature of 28°C (82.4°F) is the upper limit for moderate physical work; but when the wet bulb temperature increases, physical performance may decrease.

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[3] CAUTION: Persons with heart problems or those on a low sodium diet who work in hot environments should consult a physician about what to do under these conditions.

WBGT (Wet Bulb Globe Temperature) Index - A calculated number that indicates the combined effects of air temperature, direct radiant heat source, and the evaporative cooling effect of perspiration in contact with moving air. The WBGT is used for indoor and outdoor exposures with and without solar load. The two formulas for calculating the WBGT Index are in Section III below.

III. Exposure Limits

MSHA has no standards or regulations that specifically address heat stress and that can be cited for enforcement purposes. However, 30 CFR §§ 56/57.20002 requires mine operators to make sufficient potable (drinkable) water available to miners, and 30 CFR §§ 56/57.15006 requires operators to provide equipment to protect miners from hazards in the work environment. 30 CFR Parts 46 and 48 require appropriate hazard training for all miners. 30 CFR §§ 56/57.18010 requires that an individual capable of providing first aid be available on all shifts.

The American Conference of Governmental Industrial Hygienists (ACGIH) published Threshold Limit Values (TLVs®) for Heat Stress in 1999.[4] The TLVs® shown in Figure 17-1 are based on the **WBGT Index**. For MSHA, the WBGT Index is the simplest and most suitable method used to measure heat stress. MSHA personnel can use these TLVs® as a reference to evaluate the hazard and to make heat stress control recommendations to prevent heat-related illnesses. See Section VI.B of this Chapter. WBGT indices are based on the following formulae:

Formula 1 - Outdoors with solar load [i.e., in direct sunlight]:

$$\text{WBGT} = 0.7\ \text{NWB} + 0.2\ \text{GT} + 0.1\ \text{DB}$$

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[4] 1999 TLVs® and BEIs® - Threshold Limit Values for Chemical Substances and Physical Agents [and] Biological Exposure Indices, Heat Stress, Table 1, p.135.

Formula 2 - Indoors or Outdoors with no solar load:

WBGT = 0.7 NWB + 0.3 GT

where: WBGT = Wet Bulb Globe Temperature Index
NWB = Natural Wet-Bulb Temperature
DB = Dry-Bulb Temperature
GT = Globe Temperature

The following **work-rest cycles** apply to a 5-day work week and 8-hour work day, which includes a short morning and afternoon break and a longer lunch break. They also assume that cool drinking water is available for drinking about one cup every 15 - 20 minutes. These values are intended to be applied to the hottest one hour of exposure if the exposure is continuous. If the exposure is intermittent, these values are intended for the hottest two continuous hours.

Light work includes sitting or standing to write or control machines.
Moderate work includes walking with moderate lifting or working with hand tools.
Heavy work includes digging, shoveling, or heavy lifting.

Figure 17-1. Examples of Permissible Heat Exposure TLVs® (Values are given in WBGT°)

Work-Rest Regimen	Work Load		
	Light °C (°F)	Moderate °C (°F)	Heavy °C (°F)
Continuous Work	30.0 (86)	26.7 (80)	25.0 (77)
75% work - 25 % rest, each hour	30.6 (87)	28.0 (82)	25.9 (78)
50% work - 50 % rest, each hour	31.4 (89)	29.4 (85)	27.9 (82)
25% work - 75 % rest, each hour	32.2 (90)	31.1 (88)	30.0 (86)

Note: The TLVs® in Figure 17-1 assume that workers are acclimatized, fully clothed (e.g., lightweight pants and shirt) with adequate water and salt intake, and able to do the indicated level of work without exceeding a deep body temperature of 38° C (100.4° F). For unacclimitized workers performing a moderate level of work, TLVs® should be reduced by approximately 2.5° C (4.5° F).

Subtract the following from the TLVs® in Figure 17-1 to adjustments for clothing wear:

Figure 17-2. WBGT° Correction Factors for Clothing

Summer work uniform	0° C (0°F)
Cotton overalls	2° C (4°F)
Winter work uniform	4° C (7°F)
Waterproof suit	6° C (11°F)

IV. Screening and Surveying Equipment

A. Sling Psychrometer

This is a hand-held instrument consisting of two thermometers mounted side-by-side on a narrow support. The support is connected to a handle by a swivel. One thermometer measures the dry bulb temperature while the other measures the wet bulb temperature. By reading both thermometers, the sling psychrometer can determine relative humidity using the chart supplied with the instrument. However, for heat stress screening, only the wet bulb thermometer is used.

Figure 17-3. Sling Psychrometer

B. Metrosonics (Reuter-Stokes) Model 213 *Mini-Wibget®

This electronic heat stress monitor has the same dry bulb and wet bulb thermometers that comprise the sling psychrometer, as well as a globe thermometer. This instrument measures all three temperatures. It simultaneously calculates the WBGT heat index and displays the reading digitally. It is recommended, however, only for outdoor use. See paragraph V.B. for indoor WBGT Index estimates.

* No longer made replaced by IST, Model 214.

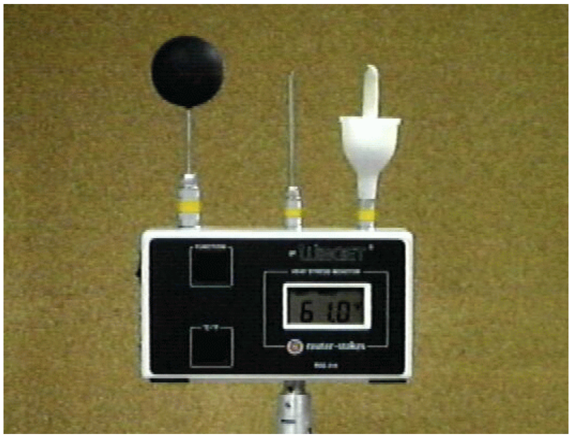

Figure 17-4. Mini-Wibget®

C. Personal Heat Stress Monitor

This instrument continuously measures the human body temperature using a sensor inside an ear plug inserted in the miner's ear canal. It has an alarm which warns the user that the body temperature has risen above a "safe" level. This is a more precise way to determine the heat hazard level to which a miner is exposed than using an environmental air temperature instrument. It is particularly useful for a miner who is enclosed in a protective suit which increases heat stress substantially. Although inspectors are not provided these instruments, Technical Support personnel may use them during an industrial hygiene survey.

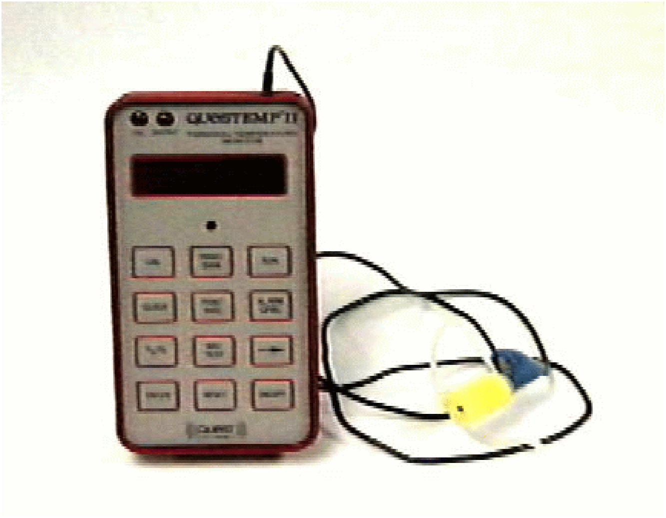

Figure 17-5. Personal Heat Stress Monitor

V. Screening and Surveying Procedures

When potential heat stress conditions are encountered, a screening survey should be conducted. Environmental heat stress should be checked at least every ½ hour during the hottest part of each work shift, particularly during the hottest months of the year.

A. Screening with the Sling Psychrometer

A sling psychrometer may be used to determine the Natural Wet Bulb Temperature (NWB).

1. Make sure the mercury column in the wet bulb thermometer does not contain any gaps (air bubbles). If it does, shake the thermometer vigorously to get the mercury back into a continuous column.

2. Thoroughly saturate the wick sleeve of the wet bulb thermometer, using clean (preferably distilled) water, at least one-half hour before reading the temperature. Make sure the wick is clean and completely covers the mercury reservoir at the bottom of the thermometer, plus about one additional bulb length.

3. Position the psychrometer at chest height in the area where the miner is working. If this is not possible, position it in an area representative of the miner's heat exposure.

4. Expose the thermometer only to natural air movement. Do not swing or whirl it.

5. Allow 5 minutes for the psychrometer's mercury level to stabilize. Then record both the dry bulb and wet bulb temperatures and the time of the reading.

B. Measuring the WBGT (Wet Bulb Globe Temperature) Index with the Mini-Wibget®

Note: The Mini-Wibget® must not be exposed to temperatures above 65° C (149° F).

1. Use a vane anemometer or other wind measurement instrument to determine air movement. The air flow must be at least 100 feet per minute for the Model 213 Mini-Wibget® to be accurate.

2. Push the wet bulb sensor and the globe sensor into the sockets indicated by the symbols on top of the instrument case. Looking at the display, the globe will be on the left and the wet bulb on the right.

3. Place a clean cotton wick over the element of the wet bulb sensor that has a sponge at the base of the water reservoir area. Fill the reservoir with distilled or demineralized water.

4. Turn the instrument on by pushing the on/off switch on the front of the instrument. Hold or place the instrument approximately 4 feet (1.2 meters) above the ground and at least 18 inches (60 cm) from any person for at least 3 minutes before taking readings.

5. Read the display when the number has stabilized. The reading is the WBGT Index.

6. When finished for the day, empty the Wet Bulb reservoir. See appendix A for maintenance and battery replacement instructions.

Note: The Mini-Wibget® is recommended only for outdoor use since it calculates the WBGT Index from the outdoor formula (Formula 1 in Section III above). However, it can be used indoors to roughly approximate the indoor WBGT Index.

C. Instructions to the Miner

1. Explain to the miner what you are doing, what the instrument does, and the reason for the survey (i.e., the heat stress hazard). If available, issue a Miner Health Hazard Information Sheet or Card.

2. Emphasize the need for the miner to continue to work in a routine manner and report to you any unusual occurrences during the survey period (such as unusual changes in temperature).

D. Determining the Level of Hazard

In general, the higher the speed of the wind or ventilation air flow, the faster that water (or perspiration) will evaporate, and the lower the wet bulb temperature (or skin temperature) will be as compared to the dry bulb temperature. The difference may be as much as 30° F. Similarly, perspiration evaporates faster as air speed increases. This lowers the body's skin temperature and, indirectly, deep body temperature. However, the human body may not be adequately cooled by the evaporation of perspiration when the environmental air temperature is above 35° C (95° F), regardless of wind speed.

1. Using a **Sling Psychrometer**:

   a. If the Natural Wet Bulb (NWB) Temperature exceeds 24.5° C (76° F), **contact the district health specialist or industrial hygienist as soon as possible.**

   b. Provide the dry bulb (DB) temperature reading as well as an estimate of the miner'(s') workload when exposed to the heat. When the NWB exceeds 24.5° C (76° F), the risk of heat injury to the miner increases as the difference decreases between the NWB and DB temperatures. When the air has nearly 100 % humidity and there is no air movement, the wet bulb temperature will be approximately the same as the dry bulb temperature.

2. Using the **Mini-Wibget®**:

   a. Read the WBGT Index from the digital display.

   b. Use Figure 17-1 to determine the TLV for the miner’s workload and work/rest cycle being followed. Subtract any clothing factor (use Figure 17-2) from that TLV.

   c. Compare the WBGT Index with the TLV. If the TLV is exceeded in any two consecutive measurements, inform the mine operator that work conditions should be modified through use of recommended engineering or administrative controls or personal heat-protective equipment.

EXAMPLE:

A miner is shoveling next to a crusher in the direct sun for 8-hour shifts, with only a 15-minute break in the morning and in the afternoon. A breeze is blowing much of the time on the mine property. A sling psychrometer indicates that between 12:00 noon and 4:00 pm, the average DB reading is 90° F and the NWB reading is 70° F. The crusher, however, allows little air movement to reach the shoveling miner, where the DB reading also averages 90° F, but the NWB reading averages 80° F. When the NWB is greater than 76° F, the risk of heat injury increases as the differences between the NWB and DB temperatures decrease. The inspector should contact the District health specialist for a follow-up survey with the WBGT the next day. Also, even though the miner was acclimatized, he complained of dizziness, rapid tiring, and extreme thirst.

Immediate Action: The miner is showing signs of heat exhaustion and should be treated immediately to avoid further complications such as heat stroke. Explain to the miner and to the mine operator the hazards of heat stress. The inspector should ensure that an adequate supply of potable drinking water has been provided as required by 30 CFR §§56/57.20002.

The following day the sling psychrometer indicates the same DB and NWB readings as the previous day. The Mini-Wibget® (which also measures globe temperature) shows a WBGT of 89° F for the shoveling miner.

Calculation: The miner is performing heavy work, and the work-rest regimen is continuous. From Figure 17-1, the TLV® is 77°. The miner is wearing bib overalls, and Figure 17-2 indicates that 2° should be subtracted from the TLV® to adjust for the additional heat load from clothing. The adjusted TLV® is therefore 75°F. The WBGT of 89° F exceeds the TLV® of 75°F.

Action: The operator must provide controls to lower the miner's heat load. This may be a change in the work-rest regimen, provision of shade or ventilation, or provision and use of a cooling vest. A citation for violation of 30 CFR §§56/57.15006 may be issued if the operator fails to provide adequate controls because a cooling vest could be used to reduce the heat load on the miner. Because the miner is in danger of heat exhaustion or heat stroke, an imminent danger order may also be considered. **Under these circumstances, it may be necessary to request a supporting survey from Technical Support.**

E. Health Field Notes

Record the following information in the health field notes:

1. The time the miner began and ended each task in each work area throughout the shift;
2. Temperature readings (from sling psychrometer) or WBGT readings during each task and the times of each reading;
3. Miner's name, job title, work location(s), shift hours per day, and days per week worked;
4. Type of clothing worn and any personal protective equipment (such as respirator, rain or slicker suit, chemical apron, or a cooling suit or vest);
5. Whether the miner was aware of the hazards of heat stress (indicating appropriate hazard training);
6. Availability of potable drinking water to the miner and approximate frequency and amount of liquids consumed during the shift;

7. Controls in use (such as air conditioning or work/rest cycles) with general description and whether or not they seem adequate;

8. Potential sources of heat stress (direct sun, kiln, etc.), a general description of these sources, number of persons affected, and possible additional control measures; and

9. Environmental conditions (such as wind conditions, temperature, humidity, or rain).

VI. Post-Inspection Procedures

A. Review Health Field Notes

Check that all the necessary information is included in the Health Field Notes. Refer to Chapter 21, Section V.

B. Report Writing

Inspection reports should include a copy of the Health Field Notes, calculation worksheets, citation/orders, and any other supplemental information collected during the inspection.

CHAPTER 17
APPENDIX A
Maintenance of the Mini-Wibget®

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Chapter 17
Appendix A
Maintenance of the Mini-Wibget®

A. Battery Replacement

1. When the battery is low, a LO BAT (low battery) or --> indicator will appear in the upper left corner of the display. The instrument can be operated for 4 hours after the indication first appears.

2. Remove the four slotted screws on back of case; then remove the back half of the case.

3. Replace battery and reinstall back half of case. The instrument can use either a 9-volt alkaline battery (100 hours of life) or carbon-zinc battery (30 hours).

B. Wick Replacement

1. Replace the wick when it shows signs of discoloration. Remove it by pulling both the wick and sponge straight up over the sensor.

2. Install a new wick in reverse order of its removal. Dampening the sponge first will make it easier to install.

3. Wick life may be prolonged by washing both the sponge and wick in detergent solution and rinsing them several times with distilled or demineralized water.

C. Calibration

The instrument should be checked for calibration at least once a year. This requires the use of the Calibration Check Sensor, which comes with complete instructions for its use.

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CHAPTER 18
VENTILATION

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Chapter 18
VENTILATION

I. Introduction

Adequate workplace ventilation is an important and one of the most easily provided engineering methods for controlling airborne contaminants. A properly designed ventilation system can remove contaminants from the atmosphere or dilute the contaminants in the mine atmosphere to safe levels.

II. Definitions

Air Course - a pathway through which air travels to an area.

Brattice - a partition placed in an underground mine to control the flow of ventilation; typically made of canvas or plywood.

Capture Velocity - the air velocity necessary to capture and convey airborne contaminants in a ventilation system.

General Ventilation - ventilation system in a room, area, or building designed to control contaminant levels within the structure by dilution or removal.

Local Exhaust Ventilation - ventilation system designed to capture airborne contaminants at the source (a specific operation or process) before the airborne contaminants can escape into the general work environment.

Make-Up Air - clean air brought into a building or area from outside to replace air that has been exhausted by ventilation systems.

Short-Circuit - the path that air may naturally travel to an exhaust outlet, bypassing worker-occupied areas and creating an unventilated area.

Traverse - a method of measuring air velocity in an air passage, in which the instrument is moved across the cross-section of the air course or a portion of it in a steady, sweeping motion, rather than measuring the velocity at a single fixed point.

III. Underground Ventilation

This section provides guidance to metal and nonmetal mine inspection personnel regarding enforcement of the health-related mine ventilation standards delineated in 30 CFR 57 Subpart G - Ventilation. This section is not intended to provide guidance on safety-related ventilation standards, although some of the concepts and techniques may be applicable. The safety-related ventilation standards address two issues: the spread of fire and toxic combustion byproducts, and the control of methane gas in gassy mines. The fire standards are contained in 30 CFR 57 Subpart C - Fire Prevention and Control, and the methane standards are contained in 30 CFR 57 Subpart T - Safety Standards for Methane in Metal and Nonmetal Mines.

A. Examining Mine Ventilation Plans and Maps

Under 30 CFR §57.8520, a plan of an underground mine's ventilation system must be provided by the mine operator in written form. Revisions must be noted and updated at least annually. When examining mine ventilation plans and maps:

1. Check to ensure that required elements are included as required by §57.8520.
2. Follow the air course from intake(s), through the working area(s), to the return(s). Look for discrepancies between where the map or schematic **shows** air flows, and where the air would **actually** flow based on the location of ventilation control structures such as brattices, stoppings, regulators, and doors. Also check for inconsistencies in the indicated airflow rates.

Unless proper ventilation control structures are provided, you cannot assume air will travel along the pathways shown on the ventilation map or schematic. **Airflow will follow the path of least resistance.** In mines where the air course cross sectional area is roughly uniform throughout the mine, air usually travels the shortest possible distance between two points. More precisely, more air travels the shorter paths, and less air travels the longer paths.

For example, consider the section of the ventilation map in Figure 18-1. The map shows air moving from 1 to 2 to 3 to 4, then turning to 8 to 12, and then turning to 11 to 10 to 9. However, without ventilation control structures to direct the airflow, much of the air would follow a shorter path. Instead, air would flow from 1 to 9. This path, called a **short-circuit**, is not indicated on the map; exists in reality and is the path of lesser resistance for air to travel.

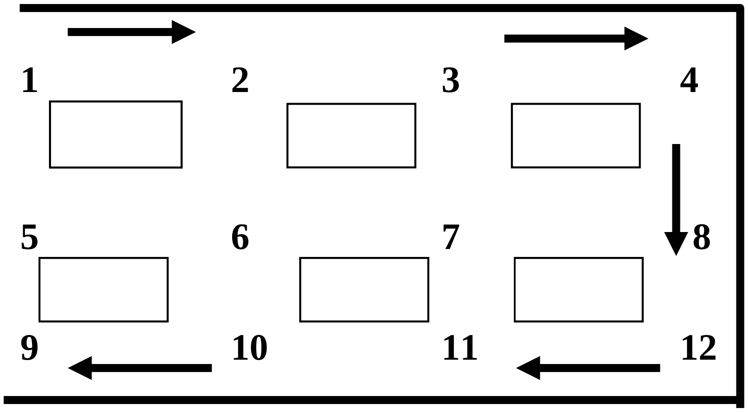

Figure 18-1. Mine airflow with no ventilation controls

The existence of a short-circuit is not a violation. However, a short-circuit could cause a violation of an air quality standard. For example, if the working face is at 4 or 8 or 12, and diesel equipment is being operated, overexposure to diesel exhaust gases might occur as a result of insufficient air reaching the face to dilute and carry away contaminants. Brattices or other suitable ventilation control structures between intersections 1 and 5, 2 and 6, 3 and 7, and 7 and 8 would force the fresh air into the face area, and prevent the short-circuit.

Recirculation is another problem caused by inadequate ventilation control structures. For example, consider the same section of the same ventilation map. This time, as shown in Figure 18-2, install brattices between 1 and 5, 2 and 6, 3 and 7, and 7 and 8, and insert a booster fan between 3 and 4 to increase air volume through the working areas at 4, 8, and 12.

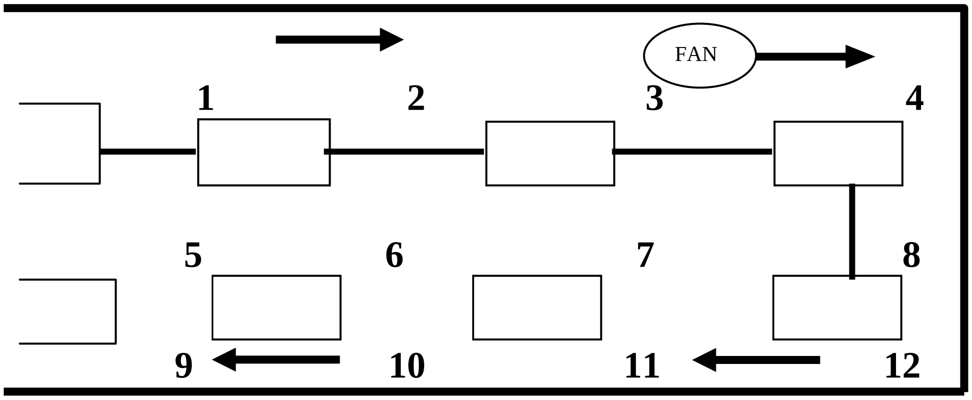

Figure 18-2. Mine airflow with ventilation controls

Although this fan will increase the airflow through the working areas as planned, it may have the unintended effect of creating a recirculation path through the brattices if there is leakage. This path would begin at the fan; travel through 4, 8, and 12, and back to the fan. Some fresh air will continue to enter this system and some contaminated air will be exhausted. But a portion of the air passing through the working areas is contaminated air that is being recirculated. Such a recirculation can cause air contaminant concentrations (dust, diesel exhaust, etc.) to become elevated, possibly resulting in overexposures of affected miners.

Another simple check when examining maps or schematics is to verify that indicated volumetric flows are consistent. For example, in this schematic, the flow rate (in cfm) on the left has to equal the sum of the flow rates on the right. Agreement between these numbers does not necessarily mean they are correct (they could all be wrong, but consistent with each other), but disagreement definitely indicates a problem.

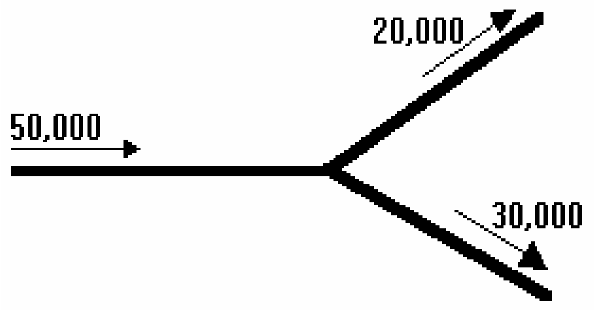

Figure 18-3. "Y" split with air quantities

The above examples are quite simple, and the ventilation system design flaws or map errors are obvious. Typically, however, airflow patterns are far more complex and the existence of short-circuits, recirculation paths, or other problems are very difficult to identify. In some cases, what appear to be errors may not be. For example, a recirculation path may actually be designed into a ventilation system as a cost saving strategy. Such systems may be acceptable according to 30 CFR 57.8529, as long as recirculation is minimal and provides fresh air that effectively sweeps the working places. If you find an air quality compliance problem (dust or contaminant gas overexposure) that you suspect could be caused or made worse by a complex ventilation problem (involving an auxiliary fan), contact your district office for assistance.

B. Inspecting Ventilation Systems

The surface and underground elements of the ventilation system must be thoroughly inspected to ensure compliance with applicable provisions of Subpart G - Ventilation. The elements of the system must also be consistent with the written ventilation plan or schematics, including items mentioned in Section I.A above. Note that ventilation plans need only be updated annually, so it is possible that recent changes in the ventilation system are not included in the plan.

C. Air Quantity Surveys

1. Airflow Direction and Quantity

Spot checks of airflow direction and quantity may be necessary to verify agreement between the ventilation system and the ventilation plan. Airflow direction can usually be determined without special tools or instrumentation. However, an aspirator bulb-type smoke generator (smoke tube) can be used to enable flow visualization when necessary, such as when airflow is very low, or where winzes or raises intersect a level. Trickling a small amount of dust out of your hand can provide adequate airflow visualization to determine the direction of airflow.

To determine quantity flow, the cross sectional area of the air course and the air velocity must be measured. Air quantity flow is then calculated using the following formula:

$$Q = VA$$

where: Q = air quantity flow in cubic feet per minute (cfm)
V = air velocity in feet per minute (fpm)
A = cross sectional area of air course in square feet

2. Calculating Cross Sectional Area of the Air Course

Use the following formulas for calculating cross sectional areas (A):

a. For a rectangle, A = H x W:

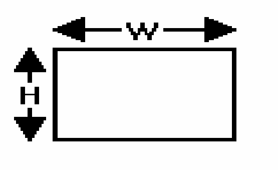

Figure 18-4. Rectangle

b. For a circle, $A = D^2 \times 0.785$:

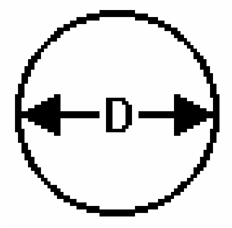

Figure 18-5. Circle

c. For a triangle, A = (½) x H x L:

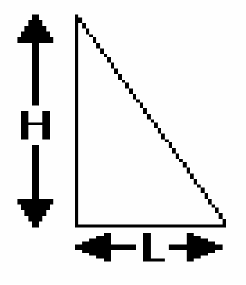

Figure 18-6. Triangle

d. For a parallelogram, A = H x W:

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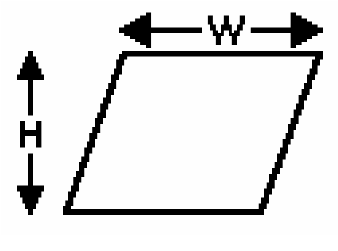

Figure 18-7. Parallelogram

For unusual shapes, divide the cross section into shapes for which area calculations can easily be made; then add the areas. For example:

e. For the half-circle on top, $A_1 = (½) \times [D^2 \times 0.785]$
For the rectangle, $A_2 = W \times H$
For the triangle, $A_3 = (½) \times L \times H$

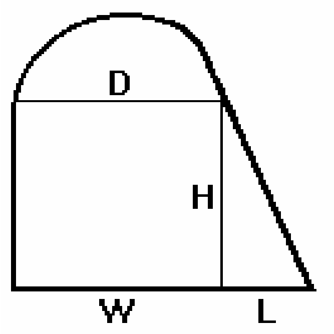

Figure 18-8. Circular Roof

f. Another common shape is a rectangle with a slanted top:
For the triangle on top, $A_1 = (½) \times W \times L$
For the rectangle on the bottom, $A_2 = W \times H$
Total Area = $A_1 + A_2$

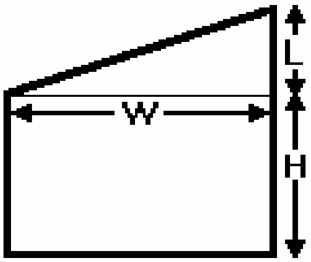

Figure 18-9. Slanted Roof

3. Determining Air Velocity

There are many techniques for measuring underground air velocity, but three are most common. These techniques utilize the rotating vane anemometer, swinging vane anemometer (velometer), and timed smoke clouds. The velometer is easiest to use, but the rotating vane anemometer provides much more accurate results. Therefore, a rotating vane anemometer should always be used when the air velocity is within its measurement range. Timed smoke clouds are used when an anemometer will not measure the velocity accurately.

a. **Rotating Vane Anemometer** (see Figure 18-10) - The measuring range of this anemometer is indicated on the calibration data provided with the instrument. The typical range is 200 to 3000 feet per minute (fpm), but other models are also available with ranges of 50 to 5000 fpm, 200 to 10,000 fpm, etc. Do not use a rotating vane anemometer to measure air velocities below or above its indicated range. At air velocities below the indicated range, measurements are highly inaccurate and unreliable. At velocities above the indicated range, instrument damage can occur.

Figure 18-10. Rotating Vane Anemometer

The standard method for performing a velocity measurement using a rotating vane anemometer involves a “traverse” of the cross section to be measured. In a traverse, the anemometer is swept across the cross section of the air course, or portion of the air course, in a controlled, steady motion. It is important to traverse the cross section because air travels faster in the center of the air course than along the roof, walls, or floor. A single measurement at a fixed position in the air course would not be representative of the average velocity across the entire cross section.

In small air courses, the entire air course can be traversed or the air course can be divided in half and each half traversed separately (split traverse). In larger air courses, it is preferable to divide the air course in half. When performing split traverses, the velocities determined for both halves are averaged to determine the average air velocity for the air course as a whole. If the air course has a very large cross sectional area and a high roof, divide the air course into four equal quarters with the upper edge of the lower quarters being at mid-wall height. Measure the two bottom quarters using the split traverse method. Figure 18-11 illustrates various traversing practices, depending on the dimensions of the air course cross section to be measured.

The anemometer can be attached to an extension handle when making a traverse. This allows the instrument to be held some distance away from the body to minimize air turbulence effects on the instrument reading. It is also helpful to use an extension handle when measurements must be made at locations with a high roof. If an extension handle is not available, the instrument should be held at arms length away from the body when traversing. When traversing, make sure the face of the anemometer is always perpendicular to the air flow and on the downstream side of the instrument.

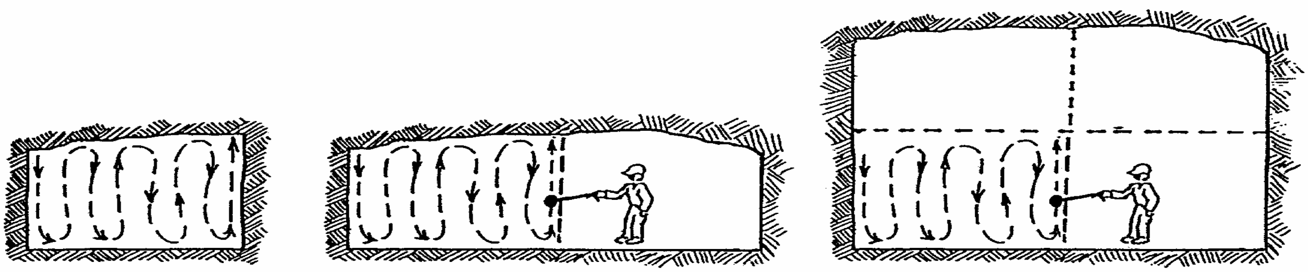

Figure 18-11. Anemometer Traverse

The traverse motion must be steady, and all parts of the area of the cross section must be covered equally, including corners, walls, roof, and floor (this may take some practice).

A suitable anemometer and a stopwatch are required to make a measurement. If a stopwatch is not available, a watch which measures in seconds is acceptable. It is easier to perform a measurement with two people - one to perform the traverse and one to operate the stopwatch - but it can be accomplished by one person. Normally, the timing period for a traverse is one minute (to make subsequent calculations easier), but any convenient time period is acceptable.

Measuring air velocity with a rotating vane anemometer involves the following:

(1) Stop the vanes and “zero” the anemometer dial with the appropriate levers.
(2) Position the instrument at a corner (wall/floor or wall/roof) where the velocity is slowest.
(3) Allow the anemometer to reach full speed (a few seconds), and simultaneously start the stopwatch, release the vanes, and begin the traverse.
(4) Simultaneously stop the stopwatch and the vanes at the end of the traverse.
(5) Record the anemometer dial reading and the elapsed time from the stopwatch.
(6) Repeat the above steps. If either traverse was not fully completed, do not use that measurement. Repeat the above steps until two good traverses are completed that agree to within 5 %. Again, this is easiest if the time period is constant at one minute. The resulting two readings would then be averaged.
(7) If split traverses were performed, repeat the above steps for the other half of the air course.

The dial reading on a rotating vane anemometer reads in feet. Air velocity is obtained by dividing the anemometer reading by the time measured on the stopwatch. If the traverse is completed in exactly 1 minute, the dial reading is equal to the air velocity in feet per minute (fpm).

For example, if the final anemometer value is 655 feet, and the traverse was completed in exactly 1 minute, the velocity would be:

$$\frac{655\text{ feet}}{1\text{ minute}} = 655\text{ feet/min} = 655\text{ fpm}$$

If the same traverse was completed in 1 minute, 10 seconds, the same calculation would be performed to determine air velocity, but the time would first need to be converted to minutes, as follows:

1 minute, 10 seconds = 70 seconds

$$\frac{70\text{ seconds}}{60\text{ seconds/minute}} = 1.17\text{ minutes}$$

$$\frac{655\text{ feet}}{1.17\text{ minutes}} = 560\text{ feet/min} = 560\text{ fpm}$$

The next step in determining velocity is the velocity correction. Initially, every anemometer is calibrated at the factory and provided with a velocity correction table. Subsequent calibrations provide a new correction table. Calculated velocities must be corrected using the correction factors provided on such tables. Listed correction factors are designated either "+" or "-." Factors that are designated "+" are added to the measured velocity. Factors that are designated "-" are subtracted from the measured velocity.

For example, using the following table of correction factors, a velocity reading of 200 would be corrected to 215.

Serial No. 123456 Cal. Date 01-15-99			
Est. Vel.	**Correction**	**Est. Vel.**	**Correction**
50	+65	500	-15
100	+42	600	-22
150	+29	750	-36
200	+15	1000	-68
250	+8	1250	-79
300	+2	1500	-90
350	-3	1750	-113
400	-8	2000	-131
When sign is : + Add - Subtract			

Figure 18-12. Correction Factors

Note: This table is only an example and is not to be used for correcting actual velocity measurements. Every anemometer is individually calibrated, and you must use the calibration table provided with the anemometer.

If the measured velocity is not on the table, the correction factor must be “interpolated,” or estimated. For example, if the measured velocity is 340 fpm, the correction would be about -2. If the measured velocity is 1655 fpm, the correction would be about -104, and so on.

If a split traverse were performed, the two corrected velocities would be averaged to determine the overall corrected average air velocity for the entire air course cross section.

To help avoid errors and omissions in this process, it is helpful to create a table into which the various measurements, readings, and calculated values are inserted, as shown in this example of a split traverse and using the velocity correction factors from Figure 18-12:

	Left Half		Right Half	
	Traverse 1	Traverse 2	Traverse 1	Traverse 2
Time (sec)	60	60	60	60
Feet	760	745	780	750
Within 5 %	OK		OK	
Average	753 feet		765 feet	
Correction	-36		-37	
Corrected Average	717 fpm		728 fpm	
Overall Corrected Average	723 fpm			

Figure 18-13. Split Traverse

b. Swinging Vane Anemometer -Velometer

The velometer is a small, convenient, and easy-to-use instrument, but it has limited applications (see Figure 18-14). It is a direct-reading instrument that provides a roughly instantaneous measure of the air velocity wherever it is positioned. It can be used for air course velocity measurement, but since it is somewhat cumbersome to traverse a cross section with a velometer, it is more commonly used to spot-check the velocity at a discrete location.

Figure 18-14. Velometer

Velometers are available with various scale ranges for velocity measurements and have accuracies of 5 % of full scale. For example, using a mid-range velometer set to the 0-1600 fpm scale, the accuracy would be 1600 x 0.05 = 80 fpm. Using this instrument, if the measured air velocity is 1350 fpm, the actual air velocity would be somewhere between 1270 fpm and 1430 fpm. However, as noted above, the overall accuracy of a velometer measurement in an air course is considerably lower than a rotating vane anemometer because of the errors inherent in sectional traversing.

To perform a traverse, the cross section of the air course needs to be divided into several sections having equal area. For example, the area might be divided into fourths, eighths, ninths, twelfths, sixteenths, etc. (See Figure 18-15).

The velometer is placed in the center of each section, and the velocity is read and recorded. The velocity through the cross section as a whole is the average of the velocities read for each section. The accuracy of the measurement improves as the number of sections increases, but the errors inherent in this method make it less accurate than a rotating vane anemometer.

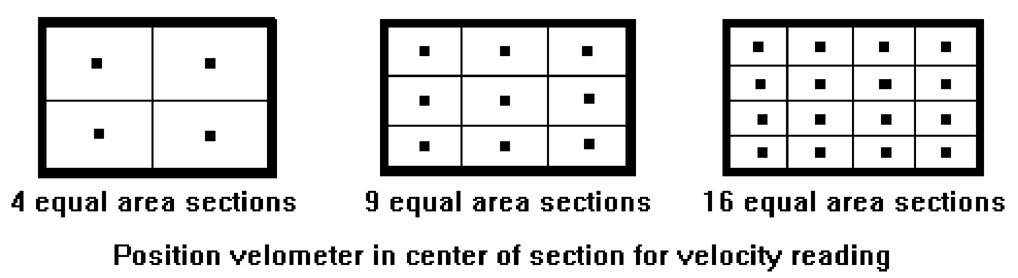

Figure 18-15. Velometer traverse

c. Timed Smoke Clouds

Use timed smoke clouds to measure velocities that are too low to measure accurately with an anemometer, usually below 100 fpm (see Figure 18-16).

Figure 18-16. Smoke Tube

(1) **Measure the Distance** - Determine the distance over which the smoke cloud measurements are taken by observing how well a smoke cloud holds together. Pick a location that is as straight, uniform, and free of obstructions as possible. Use an aspirator bulb-type smoke generator (smoke tube) to create a smoke cloud, and watch carefully how far the cloud travels before it breaks up. The smoke cloud begins to spread and dissipate as soon as it is released, but a discernible cloud should remain somewhat intact for a distance of at least 5 to 10 feet. Repeat this procedure enough times to produce reliable, repeatable results. Place upstream and downstream markers on the mine floor or wall corresponding to the smoke release point and the farthest point that the smoke clouds travel before breaking up. These markers are the reference points that are used for release of the smoke cloud and measurement of cloud travel time. The distance between them is critical and must equal the greatest distance the cloud holds together.

(2) **Use a Stopwatch -** If available, use a stopwatch graduated in tenths or hundredths of a minute to simplify subsequent calculations. If the stopwatch is graduated in seconds, a velocity unit conversion from feet per second (fps) to feet per minute (fpm) is necessary. This also applies to a standard watch graduated in seconds, which may be used if a stopwatch is not available. To convert from feet per second (fps) to feet per minute (fpm), multiply by 60.

For example: 2.5 fps x 60 sec./min. = 150 fpm

(3) **Measure the Smoke Travel Time**

(a) Two people are required, one at the upstream marker to release the smoke cloud and an observer/timer at the downstream marker who times the travel of the cloud.

(b) Divide the air course cross section into 4 quarters of roughly equal area.

(c) Simultaneously release the smoke cloud and start the stopwatch. Alternatively, release the smoke cloud upstream of the upstream marker and start the stopwatch when the cloud passes over the upstream marker. The smoke should be released roughly from the center point of one of the quarters.

(d) Stop the stopwatch when the leading edge of the cloud passes the downstream marker, and record the time.

(e) Repeat steps (c) and (d) two more times for each of the four quarters in the air course cross section. If a smoke cloud dissipates too quickly for an accurate timing, don't use that measurement. Repeat steps (c) and (d) until three good timings are recorded for each quarter.

(4) Determine Average Travel Time - Average all of the travel times recorded in step (c). It may be helpful to keep track of the measurements by preparing a table, as shown in Figure 18-17.

Quarter	Trial 1	Trial 2	Trial 3	Total Time (Seconds)
Upper Right	5	7	4	16
Lower Right	3	5	5	13
Upper Left	4	4	4	12
Lower Left	3	4	4	11
Total Time = 52 seconds Average Travel Time = 52 ÷ 12 = 4.3 seconds				

Figure 18-17. Smoke Travel Time

(5) Determine Air Course Cross Sectional Area - Determine the average cross sectional area of the air course by measuring the cross sections at the upstream and downstream markers and averaging the two.

If there are extreme variations in the dimensions of the air course over the measurement distance, an accurate determination of the cross sectional area requires measurements to be made at several locations. The cross sectional areas at each location are then averaged to obtain a reasonable approximation of the air course cross section.

In the following example (see Figure 18-18), the irregular areas shown encompass the distance (10 feet from end to end) for the smoke cloud measurement. The areas of the three rectangles would need to be determined. Add the three individual areas and divide by 3:

22 x 35 =	770
14 x 20 =	280
38 x 15 =	570
	1620

1620 ÷ 3 = 540 = average cross sectional area

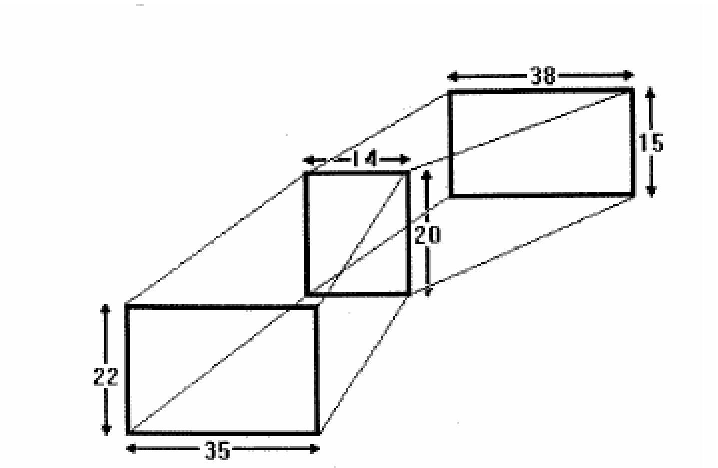

Figure 18-18. Three different areas in entry

(6) **Compute and Adjust Air Velocity** - The average air velocity in the air course is determined by dividing the distance the smoke cloud traveled by the average travel time. Remember that a velocity unit's conversion from feet per second to feet per minute is necessary if the stopwatch (or watch) used for time measurements is graduated in seconds. For example, using a measurement distance of 10 feet and the times shown in the above table:

Air velocity = 10 feet ÷ 4.3 seconds = 2.3 feet/second

2.3 feet/second x 60 seconds/minute = 138 feet/minute

When the leading edge of the smoke cloud is used to estimate cloud travel time, resulting determinations of air velocity are about 10 % too high. Thus, to improve accuracy, the velocity measurement must be adjusted by applying a method factor of 0.9. Using the above example, this factor would be applied as follows:

138 feet/minute x 0.9 = 124 feet/minute

(7) **Determine Airflow Rate** - Airflow rate in cubic feet per minute (cfm) is determined by multiplying the air velocity by the cross sectional area. For example, using the air velocity calculated in step (6) and the cross sectional area calculated in step (5):

Airflow rate = 124 feet/minute x 540 feet^2
= 67,000 feet^3/minute = 67,000 cfm

IV. Surface Ventilation

Proper ventilation at surface installations helps provide a healthful atmospheric environment for mill attendants, maintenance mechanics, clean-up personnel, laborers, etc. Ventilation may be natural or mechanical. Natural ventilation is air movement by wind, temperature difference or other nonmechanical factors. Mechanical ventilation is caused by a fan or other air-moving device. Building ventilation systems fall into two categories: general ventilation and local ventilation. General ventilation refers to systems that provide air to ventilate entire rooms, large work areas, bays, or whole buildings. Local ventilation systems provide ventilation to specific pieces of equipment or work processes. Both general and local ventilation systems incorporate supply and exhaust elements, which must be compatible for the overall system to function properly. Mills, shops, and other surface buildings are often equipped with ventilation systems that combine general and local ventilation. Note that ventilation of certain underground facilities and processes, such as equipment maintenance and repair operations, may incorporate both general ventilation and local exhaust ventilation. Therefore, portions of this section may be applicable to underground mines as well as surface installations.

MSHA does not have specific performance criteria standards that address ventilation system ratings in surface buildings, but 30 CFR 56/57.14213 require that all welding operations be well ventilated. Proper operation of such systems is necessary to ensure compliance with specific health standards. For example, lack of appropriate ventilation in a mill could lead to respirable silica-bearing dust overexposures as determined in accordance with 30 CFR 56/57.5001. Similarly, inadequate ventilation in a shop could result in overexposure to welding fumes, as per 30 CFR 56/57.5001. Therefore, an understanding of basic ventilation systems for buildings can help inspectors determine the likely cause of an overexposure condition. Further, as much as is feasible, control of airborne contaminants must be by prevention of contamination, removal by exhaust ventilation, or dilution with uncontaminated air (30 CFR 56/57.5005). The following sections describe ventilation systems for surface buildings and provide guidance to inspectors on identifying deficiencies.

A. General Ventilation

General industrial ventilation refers to the supply and exhaust of air to an area, room, or building. It is provided to dilute and carry away contaminants and to condition air for the comfort of occupants (usually heating and cooling). General ventilation systems may be large enough to accommodate an entire processing plant or small enough to service an operator's enclosed control room or booth.

There are numerous performance and design considerations that must be taken into account when planning and installing a general ventilation system, but these are usually beyond the scope of an inspector's enforcement activities. Inspectors should observe and document the general condition and operation of ventilation systems when conducting an inspection.

A major factor that influences whether mine management uses the general ventilation system is the outside temperature. Although these systems are usually designed for the dual purposes of controlling airborne contaminants and miner comfort, the miner comfort component sometimes prevails. In warm weather, the tendency would be to "crank up" the general ventilation system to draw in as much outside air as possible and to maintain a breeze across the work floor. Operating in this mode, the system would also be most effective in diluting and removing air contaminants.

In winter months, the tendency would be to "throttle down" the system to minimize heating expense and to reduce drafts of cold air on the work floor. In a large mill or shop, visible dust and haze in the air during a winter inspection might make it impossible to see from one end of the building to the other, whereas the air might be relatively free of visible contaminants during a summer inspection even though the work processes are roughly uniform throughout the year.

The presence of visible dust or haze does not necessarily indicate a hazardous condition. It should, however, alert the inspector to investigate further. When personal sampling is performed on employees working under these exposure conditions, the operating status of the general ventilation system should be noted in the Health Field Notes. If an overexposure is documented, the absence of general ventilation or the failure to operate an existing system in the affected area should be included in the body of the citation.

Inspectors should also note whether adequate provision is made for make-up air. A general ventilation system in a mill or shop often consists of ventilators and fans in the roof or walls that draw contaminated air from inside and exhaust it outside. In the summer, make-up air usually enters the building through open doors and windows. In the winter, however, these doors and windows are normally closed. If no provision is made for make-up air, the general ventilation system will operate at only a fraction of its rated capacity because the fans on the roof will be starved for air.

Make-up air is usually in the form of a blowing supply system that draws outside air into the building. The blowing supply system may or may not include an air heater. If no air heater is provided, the blowing supply system may be shut down or operated at a very low rate in an effort to maintain a warmer temperature on the work floor. Even if an air heater is provided, the blowing supply system may be operated only on a limited basis to save on heating expenses.

Another approach to providing make-up air is to install intake ventilation grates or louvers in the walls, doors, etc. However, in cold weather, these openings may be shuttered or covered to prevent drafts. Under any of these conditions, even if the exhaust fans in the roof are turned on, the general ventilation system will function poorly because of a lack of sufficient make-up air. When conducting an inspection, obvious indications of insufficient make-up air are doors that fly open or slam shut accompanied by an inrush of air into the building.

Note: The location of make-up air inlets or portals is important to air quality in a mill or a mine. **The source of the make-up air should be located away from contaminated airstreams such as idling equipment exhausts or ventilation exhaust ports.**

B. Local Exhaust Ventilation

Local exhaust ventilation systems are designed to capture air contaminants (dust, gases, mists, fumes) that are produced by a specific operation or process before they can escape into the general work environment. The air drawn into a local exhaust system can be transported away from the work area for removal of contaminants or exhausted to the outside.

A local exhaust system consists of an entry hood, a transport duct, a fan, and an exhaust. As noted above, it may or may not also include a provision for contaminant removal such as a dust collector, filter, bag house or electrostatic precipitator. Systems may be portable, such as a self-contained cart-mounted welding fume eliminator, or they may be fixed installations in buildings. Fixed systems may consist of a single hood at one work location, or scores of hoods attached to thousands of feet of interconnected duct.

A properly designed local exhaust system performs its intended function with maximum effectiveness at minimum cost. From a compliance standpoint, a system need not be performing at maximum efficiency to be acceptable; it only needs to function at a level necessary to achieve compliance. Many systems are not constructed from an engineered design. They are assembled from available parts to do a job, and they are successful if workers are not overexposed.

As is the case with general ventilation systems, there are numerous considerations that must be taken into account when planning and installing a local exhaust ventilation system. These design considerations are generally beyond the scope of an inspector's enforcement activities. However, inspectors should observe and document the general condition and operation of such systems when conducting an inspection. For example, if sampling for welding fumes, note whether a welding fume ventilator is present in the shop, if it is in use and its condition.

The most critical element in a local exhaust ventilation system is the entry hood. The other downstream elements of the system may be designed and functioning properly, but if the entry hood is missing, is the wrong size or shape, or is improperly positioned, the overall system may function so inefficiently as to be almost worthless in capturing and removing contaminants. Therefore, when inspecting a local exhaust ventilation system, start with the entry hood.

The most important feature of an entry hood is the velocity of the inflowing air at various distances and in various directions from the hood. Air velocity is critical because contaminant capture and conveyance does not occur if the velocity is too low. The minimum velocity necessary to capture and convey the contaminant into the hood is called the **capture velocity**. Capture velocity varies depending on the contaminant being captured and the nature of the operation producing the contaminant. The table in Figure 18-19 shows typical ranges for recommended capture velocity for various contaminants and processes (source: American Conference of Governmental Industrial Hygienists - ACGIH, Industrial Ventilation Manual).

Condition of Dispersion of Contaminant	**Example**	**Capture Velocity, fpm**
Released with practically no velocity into quiet air	Evaporation from tanks, degreasing, etc.	50-100
Released at low velocity into moderately still air	Spray booths, intermittent container filling, low speed conveyor transfers, welding	100-200
Active generation into zone of rapid air motion	Spray painting in shallow booths, barrel filling, conveyor loading, crushers	200-500
Released at high initial velocity into zone at very rapid air motion	Grinding, abrasive blasting, tumbling	500-2000

Figure 18-19. Range of Capture Velocities

The goal of the local exhaust system is to create an inwardly directed air flow field sufficient to maintain, at a minimum, the necessary capture velocity at the farthest point at which contaminants may be present. By capturing and drawing contaminants into the system, they are prevented from escaping into the general workplace environment where they can be inhaled by workers. When examining an entry hood, use a suitable air velocity meter (rotating vane anemometer or velometer) to measure the inflowing air velocity at the locations where the contaminants are being generated and where they are propelled by the process. If an anemometer is not available, the capture velocity can be qualitatively spot-checked with a smoke tube. Air velocity drops rapidly as the distance from the hood opening increases. This emphasizes the importance of proper positioning of the hood relative to the process creating the contaminants. If the hood is too far away from the process, the local exhaust ventilation system is ineffective. Observe the diagram of air velocity contours in Figure 18-20.

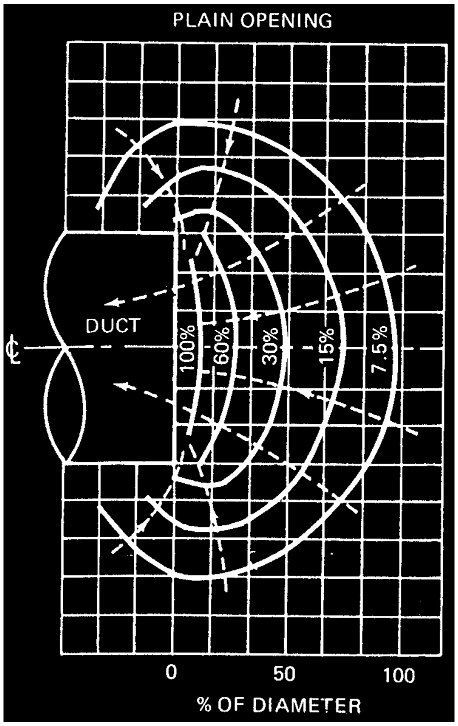

Figure 18-20. Velocity Contour around a Hood as a Percentage of the Velocity at the Opening

For example, using Figure 18-20, if the inflowing air velocity at the face of a 1-foot diameter circular hood is 500 fpm, the air velocity one foot directly in front of the hood opening is about 35 fpm.

> Calculation: A distance of 1 foot is equal to 100% of the diameter. The closest contour line is at 7.5%. Extrapolating down to 7%, the velocity is: 7% x 500 fpm= 35 fpm

Referring to the table of capture velocities in Figure 18-19, an air velocity of 35 fpm is not sufficient for even the least demanding application of local exhaust ventilation.

One way to improve contaminant capture is to fully or partially enclose the process control point with the hood. Enclosure hoods are often used on conveyor transfer points, feeders, and other similar applications.

If there is evidence of lack of capture efficiency despite adequate capture velocity, there may be random or intermittent interfering air currents that are adversely affecting the system. Sources of such air currents could include a portable fan, open door or window, machinery motion (grinding wheel, belt conveyor), material motion (dumping, bag filling), movements of the operator, or thermal or convective room air currents.

The other elements of the local exhaust ventilation system that should be checked during an inspection are the duct, fan, contaminant removal equipment (if any) and exhaust. The duct should be checked for discontinuity, leaks, restrictions and plugs, any of which will reduce system efficiency or cause it to cease functioning completely. Ducts may be designed with enlarged, sharp nearly vertical bends to reduce abrasion and plugging. Numerous sharp bends or flexible “accordion” style segments may cause an excessive pressure drop across the system, and reduce transport velocity and performance. The fan should be checked for vibration, temperature, and dust accumulation. The contaminant removal equipment should be checked for leaks, restrictions, plugs or excessive loading. Filtered exhaust air could be checked for contaminant loading if the air is directed back into the work area. If possible, exhaust air is best directed outside.

Remember that a poorly designed or ineffective local exhaust or ventilation system is not necessarily a violative condition. However, if personal sampling documents an overexposure to any contaminant that should have been controlled by the system, the performance characteristics of that system are relevant to any resulting citation, and they should be thoroughly documented.

CHAPTER 19
CHEMICAL STORAGE AND USE

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Chapter 19
CHEMICAL STORAGE AND USE

I. Introduction

All operators producing or using a hazardous chemical must comply with the Hazard Communication Standard 30 CFR Part 47.

One very important compliance function of an inspector is the determination of proper usage and storage of chemicals at a mine site. Certain chemicals and combinations of chemicals pose significant health and safety risks to miners working near them. For example, some chemicals, if accidentally spilled, can result in an explosion, a fire, or the release of toxic vapors. Even empty chemical storage tanks may have residual vapors or be oxygen deficient so that working in them may lead to injury or illness, unless appropriate precautions are taken.

In addition to process and laboratory chemicals, the use of alternative fuel sources is increasing in the mining industry, especially at operations with kilns, dryers, or other industrial furnaces (*e.g.*, cement plants). Alternative fuels range from the burning of whole or shredded vehicle tires, or shredded oil filters, to mixtures of liquid or solid hazardous waste. MSHA classifies operations using alternative fuels that contain hazardous waste as hazardous waste fuel (HWF) burning facilities. MSHA has jurisdiction for the health and safety of the miners at these facilities. The Environmental Protection Agency (EPA) has jurisdiction to regulate the burning of hazardous wastes as supplemental fuels. The EPA issues operating permits that specify system designs and operating procedures to ensure protection of the environment (i.e., air, soil, and water). The mine operator's operating permits should be available at the mine site and at the local EPA office.

II. Definitions

Alternative Fuel - any substitute or supplemental fuel other than fuel oil, pulverized coal, or natural gas used to fire a kiln, dryer, or other industrial furnace. Examples of alternative fuels include: used or off-specification oils, organic solvents, pesticides, herbicides, poly-chlorinated biphenyls (PCBs), paints, pigments, sludges, metals, resins, shredded or whole tires and agricultural products. Some alternative fuels may be classified by EPA as Hazardous Waste Fuels (HWF).

Department of Transportation (DOT) - the Federal agency that regulates transportation of materials to protect the public as well as fire, law enforcement, and other emergency response personnel. DOT classifications specify the use of appropriate warnings, such as "Oxidizing Agent" or "Flammable Liquid."

DOT Identification Number - four-digit number (e.g., 1203, gasoline) used on placards or labels to identify particular materials for regulation of their transportation (49 CFR §172.101). These numbers are called product identification numbers (PINs) in Canada. Those numbers used internationally may carry a UN prefix (e.g., UN 1170, ethyl alcohol), and those used only in North America may have an NA prefix (e.g., NA 9163, zirconium sulfate).

Environmental Protection Agency (**EPA) -** the Federal agency with environmental protection regulatory and enforcement authority. EPA administers the Clean Air Act (CAA), Clean Water Act (CWA), Resource Conservation and Recovery Act (RCRA), Toxic Substances Control Act (TSCA), and other Federal environmental laws.

Flash Point means the minimum temperature at which sufficient vapor is released by a liquid or solid to form a flammable vapor-air mixture at atmospheric pressure. (30 CFR §§56/57.2)

HazCom - Acronym for Hazard Communication Standard, an MSHA standard that requires mine operators to provide miners with information about the hazards of chemicals miners are exposed to in their work areas (30 CFR Part 47).

Hazardous Waste – chemicals regulated by EPA under the Solid Waste Disposal Act as amended by the Resource Conservation and Recovery Act. (30 CFR §§47.11, Table 47.11). EPA defines solid or liquid waste as materials exhibiting any of the following characteristics: ignitability, corrosiveness, reactivity, or toxicity. Resource Conservation and Recovery Act (RCRA), 40 CFR §261.

Hazardous Waste Number - a four-digit alpha numeric identification code (e.g., D003, F001, U169) assigned by the EPA per RCRA (40 CFR §261, 40 CFR §302) to identify and track wastes for recordkeeping and reporting purposes.

Hazardous Materials (HAZMAT) - any substance or mixture of substances capable of producing adverse affects on the health and safety of humans.

HAZWOPER - acronym for Hazardous Waste Operations and Emergency Response, an OSHA standard for protection of workers in hazardous waste operations.

Label - any written, printed, or graphic material displayed on or affixed to a container to identify its contents and convey other relevant information. (30 CFR §47.11, Table 47.11). MSHA's HazCom Standard requires a label to identify a hazardous material, give appropriate hazard warnings, and have a chemical identifier that permits cross-referencing between a list of hazardous materials, the chemical and its MSDS.

Laboratory - a facility that is equipped to perform scientific experiments, research, or qualitative and quantitative testing. Relatively small quantities of hazardous chemicals may be used on a non-production basis.

Material Safety Data Sheet (**MSDS) –** written or printed material concerning a hazardous chemical which – (1) An operator prepares in accordance with Table 47.52 – Contents of MSDS: or (2) An employer prepares in accordance with 29 CFR 1910.1200, 1915.1200, 1917.28, 1918.90, 1926.59, or 1928.21 (OSHA Hazard Communication regulations): or (3) An independent source prepares which contains equivalent information, such as International Chemical Safety Cards (ICSC) and Workplace Hazardous Materials Information Sheets (WHIMS). (30 CFR § 47.11, Table 47.11.) MSDSs provide information about material identification; hazardous ingredients; health, physical and fire hazards, first aid, chemical reactivities and incompatibilities; spill, leak and disposal procedures, and protective measures for safe handling and storage.

National Fire Protection Association (NFPA) - an international voluntary membership organization formed to promote and improve fire protection and prevention and develop consensus standards to safeguard against loss of life and property by fire. The National Fire Codes, a sixteen volume set of standards and recommended practices, were developed by NFPA committees and are periodically updated.

pH - a value that represents the acidity or alkalinity of a water solution. Pure water has a pH of 7. A pH below 7 indicates an acid solution (a pH of 1 is extremely acidic). A pH above 7 indicates an alkaline solution (a pH of 14 is extremely alkaline).

Polymerization - a chemical reaction in which one or more small molecules combine to form larger molecules. Some polymerization reactions take place at rates that release large amounts of energy that can cause fires or explosions or burst containers.

III. Applicable Metal/Nonmetal Standards

The Metal/Nonmetal standards commonly associated with chemical storage and use are as follows:

30 CFR Part 47	Hazard Communication
30 CFR §§56/57.5001	Exposure limits for airborne contaminants
30 CFR §§56/57.5002	Exposure monitoring
30 CFR §§56/57.5005	Control of exposure to airborne contaminants
30 CFR §§56/57.5006	Restricted use of chemicals
30 CFR §§56/57.15001	First-aid materials
30 CFR §§56/57.15004	Eye protection

30 CFR §§56/57.15006	Protective equipment and clothing for hazards and irritants
30 CFR §§56/57.16001	Stacking and storage of materials
30 CFR §§56/57.16002	Bins, hoppers, silos, tanks, and surge piles
30 CFR §§56/57.16003	Storage of hazardous materials
30 CFR §§56/57.16004	Containers for hazardous materials
30 CFR §§56/57.16005	Securing gas cylinders
30 CFR §§56/57.16006	Protection of gas cylinder valves
30 CFR §§56/57.16012	Storage of incompatible substances
30 CFR §§56/57.18002	Examination of working places
30 CFR §§56/57.18006	New employees
30 CFR §§56/57.18012	Emergency telephone numbers
30 CFR §§56/57.18013	Emergency communications system
30 CFR §§56/57.18014	Emergency medical assistance and transportation
30 CFR §56.18020	Working alone
30 CFR §57.18020	Working alone [Surface only]
30 CFR §57.18025	Working alone [Underground only]
30 CFR §§56/57.20011	Barricades and warning signs
30 CFR §§56/57.20014	Prohibited areas for food and beverages

For chemicals that are flammable or combustible, many of the standards in 30 CFR §§ 56/57, Subpart C - Fire Protection and Control are also applicable, especially those in the sections pertaining to firefighting procedures/alarms/drills, and flammable and combustible liquids and gases.

IV. Identifying the Hazard

Mine operators must identify chemical hazards under §47.21. Whenever chemicals are used or stored on mine property, the inspector should carefully review the Material Safety Data Sheets (MSDSs) and any other available reference information. Labels on containers may also provide important information. Chapter 3 of this Handbook and the ***NIOSH Pocket Guide to Chemical Hazards*** provide similar information. For more information or questions concerning identifying chemical hazards, contact your District Office.

It is a violation of HazCom if the mine has hazardous chemicals and has no MSDS available. At certain mine sites, the absence of MSDSs may be a violation of EPA regulations that require facilities to have MSDSs and to provide copies or lists of them to the Local Emergency Planning Committee (LEPC - see Section VII. below). If you suspect a violation of EPA regulations, inform the district manager so that the district can notify the appropriate EPA office.

Review the operator's HazCom Program, solid waste inventory and profile sheets (shipping manifests), process flow charts, and any other process information related to chemical storage and use. A complete inventory would include raw materials, additives, catalysts, products, wastes, and their final destination (*i.e.*, used in processing the ore; burned as fuel; liberated to water, air, or soil; or shipped from mine property as waste). Any of these may pose a risk to miners if not properly controlled. The inventory should also specify locations, use, and type of storage. Attempt to visualize a "worst case" scenario, such as the failure of valves, sensors, alarms, pressure vessels (bulk tanks, rail cars, or tank trucks), or backup systems. Do any of the chemicals, if released, have the potential to cause a catastrophic incident? Contact the district office if you need help in evaluating the hazard.

V. Evaluating the Work Environment

Once the hazard information is carefully reviewed, evaluate areas where the chemicals are stored and used. MSHA regulations require that the operator:

- Store hazardous materials in approved containers (§§ 56/57.16004)
- Store materials that can create a hazard if accidentally liberated in a manner that minimizes the danger (§§ 56/57.16003)
- Provide water or neutralizing agents wherever corrosive chemicals or other harmful substances are stored, handled, or used (this may also be used to require immediate access to automatic spray devices such as eyewash stations and deluge showers) (§§ 56/57.15001)
- Provide personal protective equipment (including appropriate respirators, gloves, eye protection, etc.) (§§ 56/57.5005, §§ 56/57.15004, and §§ 56/57.15006) and
- Provide container labels and other forms of warning for hazardous chemicals (§ 47 Subpart E).

MSDSs are a good source of information on the hazards the chemical may present, appropriate personal protective equipment, and the proper spill and emergency procedures.

A. Incompatibility

The accidental mixing of incompatible chemicals may result in explosions, fires, or toxic releases. For this reason, §§56/57.16012 prohibits mine operators from storing incompatible chemicals and materials together. If a chemical can be spilled and reach an incompatible chemical or material, they are both improperly stored. This includes the shelving material itself, as well as any berm material used. Chemicals are classified into compatibility groups according to the unique reactivity and corresponding storage criteria of each group. Consider the following chemical compatibility groups when inspecting work areas where chemicals are present:

1. **Corrosives** - chemicals that cause visible destruction of or irreversible alterations in living tissue by chemical action at the site of contact, or that destroy metallic materials.

   a. **Acid** - inorganic or organic compound that has a pH of less than 7.0. It also:

      - may be corrosive and must be handled with extra care (corrosive acids have a pH less than or equal to 2);
      - neutralizes bases (alkalis) to form salts;
      - dissociates in water yielding hydrogen or hydronium ions;
      - may react with metals to yield hydrogen; and
      - turns blue litmus paper to red.

      <u>Examples</u>

Inorganic:	boric acid, hydrobromic acid, hydrochloric acid, sulfuric acid, phosphoric acid
Organic:	acetic acid, citric acid

   b. **Base (also called alkali or caustic)** - inorganic or organic compound that has a pH of greater than 7.0. It also:

      - may be corrosive and must be handled with extra care (corrosive bases have a pH greater than or equal to 12);
      - neutralizes acids to form salts;
      - dissociates in water yielding hydroxide ions; and
      - turns red litmus paper to blue.

Examples

Common commercial alkalis are sodium carbonate (soda ash), caustic soda and caustic potash, lime, lye, aqueous ammonia, and ammonium hydroxide. Oxides and hydroxides of certain metals (lithium, sodium, potassium, rubidium, cesium, and francium) are also bases.

c. Additional Recommendations for Safe Storage and Use of Corrosive Chemicals:

- Segregate acids from alkalis.
- Isolate from toxic materials, organic materials, flammable substances, and substances that may release corrosive, toxic, or flammable vapors on reaction.
- Store in cool, dry, well-ventilated areas that are not subject to rapid temperature changes, and that are protected from direct sunlight.
- If storage cabinets are used, store liquid containers in trays with compatible absorbent material of sufficient volume to contain and prevent leakage onto materials stored below.
- Structural materials should be non-corroding or should be metal covered with acid-fume resistant paint.
- Have fire-fighting equipment readily available.

2. **Reactive Materials** - chemicals or mixtures that vigorously polymerize, decompose, condense, or become self-reactive due to shock, pressure, and/or temperature.

   a. **Oxidizers** - chemicals or chemical combinations (usually gases or liquids) that spontaneously release oxygen at room temperature or with slight heating, which accelerate combustion, and that on contact with combustible material may cause a fire or explosion.

Examples

Bromic acid, bromine, chlorine, chromic acid, fluorine, hypochlorite solutions (i.e., bleach), nitric acid, many perchlorates, perchloric acid, permanganates, and silver nitrate.

b. **Water Reactives** - a substance or mixture that reacts with water releasing heat, or flammable or toxic gas.

Examples
Aluminum chloride-anhydrous, calcium carbide, acetyl chloride, chlorosulfonic acid, phosphorous pentachloride, sodium, potassium, calcium, aluminum tribromide, calcium oxide, acid anhydrides, and metal hydrides.

c. **Pyrophoric Materials** - materials that ignite spontaneously in air below 54° C (130° F).

Examples
Boron, diborane, dichloroborane, diethyl aluminum chloride, 2-furaldehyde, lithium, white or yellow phosphorus, trimethyl aluminum.

d. **Additional Recommendations for Safe Storage and Use of Reactive Materials:**

Oxidizers -

- Isolate from organic materials, flammable solvents, corrosives, toxic materials.
- Store in cool, dry, well-ventilated areas out of direct sunlight.
- Protect from temperature extremes.
- Do not store containers directly on wooden shelves or on paper shelf liners (spills may react with the organic portion of the shelf or paper and ignite spontaneously).
- Storage building should be fireproof and provided with an automatic sprinkler system.

Water Reactive and Pyrophoric Materials -

- Isolate from water and water solutions, moist air, aqueous acids and alkalis, flammable storage areas, and other reactive chemicals.
- Store in cool, dry, well-ventilated areas.
- Store pyrophors under nonflammable, inert solvents.
- Locate storage building on high ground and remote from other storage areas. It should be fireproof, waterproof, and without an automatic sprinkler system.

- If materials are handled or soil clothing, do <u>not</u> use water to clean off. Consult the MSDS or NIOSH Pocket Guide for alternative to water (specific for each chemical).

3. Flammable and Combustible Materials

a. **Flammable** means capable of being easily ignited and of burning rapidly. (30 CFR §§56/57.2)

- **Flammable liquid**. A liquid that has a flash point below 100 °F (37.8 °C), a vapor pressure not exceeding 40 pounds per square inch (absolute) at 100 °F (37.8 °C), and is known as a Class I liquid. (30 CFR §§56/57.4000)

- **Flammable gas**. A gas that will burn in the normal concentrations of oxygen in the air. (30 CFR §§56/57.4000)

b. **Combustible liquids**. See definition under § 47.11, "physical hazard" heading.

Liquids having a flash point at or above 100 °F (37.8 °C). They are divided into the following classes:

Class II liquids--those having flash points at or above 100 °F (37.8 °C) and below 140 °F (60°C).

Class IIIA liquids--those having flash points at or above 140 °F (60 °C) and below 200 °F (93.4°C).

Class IIIB liquids--those having flash points at or above 200 °F (93.4 °C). (30 CFR §§56/57.4000)

c. **Combustible material**. A material that, in the form in which it is used and under the conditions anticipated, will ignite, burn, support combustion, or release flammable vapors when subjected to fire or heat. Wood, paper, rubber, and plastics are examples of combustible materials. (30 CFR §§56/57.4000)

d. **Safety can.** A container of not over five gallons capacity that is designed to safely relieve internal pressure when exposed to heat and has a spring-closing lid and spout cover.
(30 CFR §§56/57.4000)

e. **Storage tank**. A container exceeding 60 gallons in capacity used for the storage of flammable or combustible liquids.
(30 CFR §§56/57.4000)

Many of the storage and use criteria for flammable and combustible materials are contained in 30 CFR §§ 56/57, Subpart C - Fire Protection and Control (§§ 56.4000 - 56.4604 and §§ 57.4000 - 57.4761). In addition, see 30 CFR §§ 56/57.16005 Securing gas cylinders,
30 CFR §§ 56/57.16006 Protection of gas cylinder valves, and
30 CFR §§ 56/57.20011 Barricades and Warning Signs.

4. **Toxic Materials** - any chemical or material that can poison or otherwise injure the organs or tissues of the body. The **dose**, or the amount of the chemical exposure (usually a combination of exposure concentration and time), will elicit the degree of **response** of the miner. The dose-response relationship is an important variable in assessing a miner’s health risk.

Examples
Cyanide, mercury, isocyanates, beryllium and … are examples of toxic materials that may be encountered in a mining environment.

Additional Recommendations for Safe Storage and Use of Toxic Materials:

- Secure in locked area and minimize access.
- Minimize stored quantities.
- Store in cool areas with constant humidity.
- Operate independent and filtered ventilation system.
- Isolate from areas where workers gather.
- Post poison control, first aid, and other safety information.
- In addition to container labels, post warning signs where appropriate, for example, “Danger-Poison” or “Caution-Chemical Carcinogen.”

The National Fire Protection Association (NFPA) has many useful pamphlets on chemical storage including:

- NFPA 43A - Storage of Liquid and Solid Oxidizing Materials
- NFPA 43C - Storage of Gaseous Oxidizing Materials.

For more information, contact your district office.

B. Laboratory

All HazCom requirements apply to laboratories. Because most laboratories use hazardous chemicals, the facilities should be specifically designed and engineered for such work. Inspectors should check that fume hoods and other appropriate methods of containment are used properly, safe work practices are followed, and that laboratory and support personnel use the appropriate personal protective equipment. If deficiencies are observed during an inspection, health sampling should be conducted. Mine operators are required to conduct monitoring of air quality and noise exposures in laboratories the same as in other areas of the work environment. Inspectors should be aware that, in addition to chemical hazards, there may be electrical, fire, and other safety hazards due to the equipment used in the laboratory. For general information on best practices for laboratory safety, NIOSH provides a page of links to other websites on laboratory safety at http://www.cdc.gov/niosh/labsafe.html. One of the links, for example, is to the University of Virginia’s Office of Environmental Health and Safety website for their basic, user-friendly guide, “Laboratory Survival Manual,” at http://keats.admin.virginia.edu/lsm/home.html (accessed 3/19/2001, Internet).

C. Bulk Storage

The requirements previously discussed for the safe storage and use of chemicals apply to bulk (storage tanks) as well as to small quantities of chemicals. The risk of hazardous spills and vapor releases can be minimized by the proper design and construction of bulk storage tanks provided with suitable diking systems for containment of spills. Chemical filters may be needed to prevent escape of vapors from tank head spaces due to “tank breathing” during use, particularly during filling operations. These requirements are addressed in general by the application of §§56/57.16003--Storage of hazardous materials and §§56/57.16004--Containers for hazardous materials. For facilities storing flammable or combustible materials, additional requirements are included in 30 CFR Parts 56/57, Subpart C--Fire Prevention and Control. Consult the Program Policy Manual, Volume IV, for policy on enforcement of: §§56/57.16004--Containers for Hazardous Materials; §56.4531--Flammable or combustible liquid storage buildings or rooms; §57.4531--Surface flammable or combustible liquid storage buildings or rooms; §57.4533--Mine openings; and §§56/57.16003--Storage of Hazardous Materials.

VI. Non-hazardous Alternative Fuel Operations

Some mining operations with kilns or dryers may use non-hazardous alternative fuels as a substitute or supplement to standard fuels. Although the EPA may not classify such fuels as hazardous, they will likely still be regulated or permitted by federal or state environmental agencies. Alternative fuels are either combustible or flammable, and may be explosive, so there are safety issues with which MSHA is concerned. At operations where fuels are burned, inspectors should ask if alternative fuels are being used and, if so, what they are. If alternative fuels are burned, inspect the storage, handling, conveying, pulverizing, firing and dust collection systems in addition to those of the more traditional fuel systems. (Note: Fuels that are not pulverized may still generate explosive dust.) Determine what fire and explosion prevention and protection systems and equipment are provided, if they are properly maintained and what practices are used to prevent injury to miners.

VII. Hazardous Waste Fuel Operations

Hazardous waste fuels are, in general, various types of used fuels or combustible chemicals which may contain one or more hazardous waste as listed by the EPA. The EPA regulations pertaining to burning used fuel oils and hazardous wastes are found in 40 CFR Part 266, Subparts D and E.

HazCom covers hazardous waste. Three categories of waste fuels defined by EPA are as follows:

1. <u>Used Oil Fuel</u> - any oil that has been refined from crude oil, used, and thereby contaminated by physical or chemical impurities. Used oil fuel includes any fuel produced from oil by processing, blending, or other treatment which is burned for energy recovery.

   The supplier of used oil fuel is required to document analytical results demonstrating that the oil meets EPA specifications. The used oil fuel may also be tested at the mine site for other chemical and physical properties such as PCBs, pesticides, sulfur, heavy metals, BTU output, and specific gravity.

2. <u>Off-Specification Used Oil Fuel</u> - used oil fuel that exceeds EPA specifications. It can be burned for energy recovery only in EPA-

approved industrial furnaces and boilers and is handled in the same manner as hazardous waste fuel.

3. Hazardous Waste Fuel (HWF) - contains an assorted mixture of chemical compounds from industrial waste processes and exhibits any of the following characteristics: ignitability, corrosiveness, reactivity, or toxicity. Not all hazardous waste can be used as fuel. By EPA regulations, waste products can be burned as fuel if the incineration process is 99.99 % efficient.

A. Health and Safety Hazards

Mining personnel who work in and around HWF storage facilities and related operations are at risk from exposures associated with the handling, storage, processing, and burning of large amounts of flammable and combustible materials. The most prevalent hazards are fire, various forms of chemical reactivity, and toxicological effects from exposure to contaminants.

1. **Fire Hazard** - The threat of fire is a real and ever present hazard. Operating personnel must be constantly on guard against conditions which could result in a fire or explosion. Fire hazard conditions may occur during operations involving receiving and off-loading fuel shipments, maintaining and repairing storage tanks, fuel lines, pumps, and other equipment and transferring and burning of HWF. During burning operations, the hazard also exists for rupture of pressurized fuel lines located near sources of ignition.

   a. **HWF Fires** - HWF fires are NFPA Class B fires, or fires that occur in the vapor-air mixture formed above the surface of flammable or combustible liquids. These fires produce intense heat and noxious, debilitating smoke, fumes, and gases. Such fires are extremely difficult to control and may do extensive damage to the facility and the environment. As with any fire, sampling for air contaminants should be performed to ensure that potentially exposed miners are not overexposed to the vapors and gases generated by the fire.

b. **HWF Fire Response** - HWF fires may be controlled and extinguished by equipment, methods, and materials which deprive them of oxygen and additional fuel and/or inhibit the combustible effects of the fuel. Some general classes of fire extinguishing agents found to be effective in controlling this type of fire are dry chemicals foam, inert gases such as carbon dioxide, and halogenated hydrocarbons such as halon gas.

Water is not effective in fighting HWF fires because HWF will float on water and spread fire to other locations. However, water can be used for cooling supplies of stored fuels which are threatened. EPA permits and MSDSs specify the appropriate fire response for permitted-HWF.

2. **Chemical Reactivity** - The following types of chemical reactivity have been identified as being of greatest concern for mine operators and miners working at HWF sites. Fortunately, these hazards can be minimized through the implementation of safe handling and storage procedures (as discussed above in Section V.). Pre-screening of fuel streams prior to on-site acceptance could serve to aid in the selection of equipment and personal protective equipment that will not react excessively with the HWF.

a. **Reactivity with Strong Oxidizers** - HWF may react violently with oxidizing agents such as peroxides, nitric acid, and bottled oxygen, causing a fire or explosion. HWF facilities should be kept free and clear of oxidizing agents.

b. **Reactivity with Polymer Materials** - HWF may erode a variety of polymer materials such as seals, gaskets, linings, and personal protective equipment (PPE). Inspection of these items and prompt replacement when needed is required by §§56/57.18002 during the examination of working places.

c. **Reactivity with Metals, Water, and Alcohols** - HWF may contain organic compounds which can react with these materials. Organic acids such as acetic acid will erode metals. Some organic chlorides such as benzyl chloride and methyltrichlorosilane will decompose and form hydrochloric acid on contact with metals, water, or alcohols.

d. **Potential Polymerization of Hazardous Waste Fuels** - Depending on content and conditions, certain mixtures of HWF may polymerize in storage. That is, chemical reactions within the mixture may cause complex, heavier, and more viscous or solid substances to form within the storage vessel. Some examples of liquid organic compounds which can undergo polymerization are methyl acrylate, methyl methacrylate, methylene diisocyanate (MDI), and toluene-2,4-diisocyanate (TDI).

Under normal circumstances, most shipments of HWF materials received at storage facilities operating under EPA permits are not expected to chemically react with each other.

3. **Toxicological Hazards** - Potential health hazards due to HWF use depend on the chemistry of the fuel, how miners are exposed, the duration of the exposures, and the toxic mechanisms of the fuel components.

a. **Potential Hazard** - The potential hazard of HWF is based on the toxicities of the liquid organic constituents in the mixture. Combinations of different organic compounds in the fuel mixture will often enhance the hazard of the mixture as a whole.

b. **Routes of Entry –** There are three common type of exposure to HWF materials: skin absorption through direct contact, inhalation and ingestion.

The skin can be penetrated by certain chemicals, allowing the bloodstream to carry the chemical to other organs. Some areas of the skin are more susceptible to absorption than others, and moisture, heat, and damaged skin can enhance skin absorption. Some chemicals injure the skin directly, while others can sensitize the skin, causing an allergic-type response.

The eyes are particularly vulnerable to direct contact with chemicals. Irritation and absorption are much more pronounced on the surface of the eye than on most exposed skin surfaces.

Inhalation as a route of entry increases with importance as the temperature or pressure of the fuel increases and as the ventilation effectiveness diminishes. Inhaled vapors may affect the respiratory system directly or may be transferred to the bloodstream and carried to other organs. Some chemicals may be odorless and invisible to the miners or may not induce detectable health effects immediately.

Ingestion of HWF may occur due to mishandling, unsafe work practices or poor housekeeping. Ingestion can affect the gastrointestinal tract directly or, after absorption, can affect other organs throughout the body. Food should never be stored or consumed near HWF. Miners should be provided with facilities and supplies so they can practice good personal hygiene.

B. Assessing the Health Hazard

Exposure to HWF is usually limited to a few points in the waste fuel operation. Normally, a waste fuel circuit is a closed-circuit to the point of the flame. Miners may be at risk as a result of either routine or accidental exposure. Ensure that the PPE in use is appropriate for the chemicals being handled.

1. **Routine Exposures (fuel handlers)** - usually occur only when the circuit is open for quality control sampling, during transfer from a delivery vehicle, or during cleaning and disposal of normal spillage.

    a. **Quality Control Sampling** - Sampling exposures occur during the collection of core samples from delivery vehicles or collection of mixed samples through valves or storage tanks. Lab personnel also risk exposure during handling and storage of raw fuel samples.

    b. **Off-Loading From Tank Trucks** - Exposures may occur while opening the delivery vehicle, attaching or disconnecting hoses, cleaning and discharging in-line fuel filters or emptying the sump. Of particular concern is the truck driver who may not be regularly involved with the delivery and transfer of toxic or flammable materials and who may not be aware of the hazards. Delivery vehicle hatches should not be left open because vapors may evolve out of the liquids and adversely affect miners near or far.

    c. **Maintenance Activities** - Exposures may occur during the regular maintenance of waste fuel circuit equipment. These procedures include disassembling, cleaning, or other servicing of storage vessels, piping, valves, pumps, agitators, filters, and tanks.

Depending on burning conditions, especially temperature, HWF may deposit toxic chemical residue in the kiln and which could be encountered during the removal of an old refractory lining in preparation for re-bricking. Toxic elements such as heavy metals may be deposited in the storage and processing equipment, and they or hazardous vapors may be encountered during maintenance and/or cleaning activities. Cutting and welding operations on metals contaminated with HWF in confined spaces present a significant potential for exposure to hazardous contaminants.

2. **Accidental Spills (exposure to maintenance or production workers) –** A mine having significant quantities of hazardous substances is required by other agencies to have an Emergency Response Plan (ERP) and possibly a Spill Prevention, Containment and Countermeasures Plan (SPCC) too. Spillage, leakage or vapors vented from unloading operations, ruptured or improperly vented tanks, disconnected or ruptured lines, or defective seals or valves could result in large-scale exposures. Proper facility design and maintenance, and adherence to safe operating and repair procedures can minimize accidental exposures. Determine miners' knowledge of spill response procedures and proper PPE.

VIII. Personal Exposure Sampling

Even with substantial control measures in place and the wearing of personal protective equipment, when handling or using chemicals in the laboratory, maintenance shop, or other areas of the mine (including hazardous waste fuel sites), miners may be exposed to airborne concentrations of chemicals above the TLVs®. Mine operators are required to monitor employee exposures in accordance with §§56/57.5002. Inspectors should conduct sampling where there is a potential for overexposure. Refer to Chapter 3 of this manual for individual contaminants and the chapters pertaining to specific sampling equipment and methods for additional guidance. When in doubt, call the district office for advice concerning suspected exposures and sampling for chemical contaminants.

IX. Other Regulatory Agencies

Inspectors should be aware there are chemical environmental, health and safety laws enforced by other governmental agencies; however, inspectors are not expected to be well versed in each agency's regulations. If, during an inspection, it appears that there is an unsafe chemical-related situation, advise the field office supervisor or district office as soon as possible, in order to coordinate intervention by other agencies as appropriate. Table 19-1 lists the relevant regulations of the two Federal agencies which are most likely to become involved in activities on a mine site in an emergency situation because of overlapping jurisdiction. In most cases, there are also state and local entities, including state emergency response commissions. A mine having significant quantities of hazardous substances usually reports to the EPA-appointed Community Emergency Coordinator and Local Emergency Planning Committees (LEPC). LEPCs consist of representatives of government, police, fire department, hospitals, the media, community groups, and industry. They are also responsible for maintaining emergency plans covering hazardous substance facilities, and must be notified immediately in the event of release of certain amounts of hazardous chemicals. **In all situations, however, MSHA standards <u>must</u> be followed.**

Table 19-1. DOT and EPA Hazardous Material and Emergency Regulations That May Apply at Mine Sites

Agency	Recommended Regulations	Regulated Activity
Department of Transportation (DOT)	1. Hazardous Materials Transportation Act 2. Natural Gas Pipeline Safety Act 3. Hazard Liquid Pipeline Safety Act 4. Hazardous Materials Regulations and Procedures, Title 49 CFR Parts 100-185	Shipping of hazardous materials: packing, handling, labeling, marking, placarding, level of training, safety assurance during shipment, hazard classes, UN ID numbers, and quantity restrictions. 49 CFR 172 lists the hazardous materials subject to these laws.
Environmental Protection Agency (EPA)	1. Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) - (Superfund Act) (42 U.S.C. 9620) 2. Title III, Superfund Amendments and Reauthorization Act (SARA) - Community Right to Know (42 U.S.C. 11001) 3. Resource Conservation and Recovery Act (RCRA) (42 U.S.C. 6901) 4. Clean Water Act (40 CFR §§100 - 140, §§400 - 470) (33 U.S.C. 1251) 5. Clean Air Act, “National Emission Standard for Hazardous Air Pollutants” (40 CFR 61 Subpart M) 6. Risk Management Program, (40 CFR 68.130) 7. Toxic Substances Control Act (TSCA) (regulations 40 CFR 761 Subpart B) (15 U.S.C. 2601) 8. Solid Waste Disposal Act (42 U.S.C. 6901)	Chemical Entering the Environment: Reportable Quantities List [of Chemicals stored at a site]; Emergency planning, reporting & training requirements; Hazardous Waste treatment disposal and storage; Accidental Release Prevention Requirements (including a facility risk management plan & list of regulated substances); Accidental Release Reporting; and Permit Requirements (approval and issuance).

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CHAPTER 20
EATING AREAS AND SANITARY CONDITIONS

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Chapter 20
EATING AREAS AND SANITARY CONDITIONS

I. Introduction

A. Scope

Standards have been established to prevent adverse health effects in miners from exposure to toxic materials, physical agents, and biological hazards at sanitation facilities, to include toilets and shower facilities, in addition to the consumption and storage of food and beverages. The term "lunchroom" is used to describe traditional break rooms but may include food and beverage storage areas as well.

B. Applicable Standards

Consult the following standards for eating areas and sanitary conditions - 30 CFR:

§§ 56/57.20002	Potable water
§§ 56/57.20003	Housekeeping
§§ 56/57.20008	Toilet facilities
§§ 56/57.20011	Barricades and warning signs
§§ 56/57.20013	Waste receptacles
§§ 56/57.20014	Prohibited area for food and beverages

II. Eating Areas and the Prevention of Exposure to Toxic Materials during Food and Beverage Consumption

A **"toxic material"** is a chemical or other material determined to be a poison or otherwise potentially hazardous to the organs or tissues of the body. 30 CFR §§ 56/57.20014 addresses risks to miners posed by toxic materials in lunchrooms or found on food or beverage consumption and preparation areas. These regulations also prohibit improper storage of toxic materials near food and beverages and prohibit food and beverage consumption and storage in production areas where toxic materials are present.

A. Toxic Materials in the Lunchroom Environment

When the inspector confirms the airborne presence of a toxic material in a lunchroom, or presence of a toxic material in a lunchroom on food/beverage preparation and consumption surfaces, and documents a lack of reasonable steps for the control of exposure, the inspector may issue a citation for a violation of Sections §§56/57.20014.

Example - The inspector at a gold refinery finds a bead of liquid mercury on a lunchroom table. The inspector also notices that the miners are entering the lunchroom from the production area wearing their work clothes, gloves, and respirators, and are not provided any place to wash or remove their boots. Some of the miners remove and place their work gloves and respirators on the table from which they will eat. These facts would describe a violation of §§56/57.20014.

Example - The inspector at a silver mine finds that the mine washes its lunchroom tables with recycled water containing unusually high levels of arsenic. A wipe sample shows arsenic on the table tops. These facts would describe a violation of §§56/57.20014.

Example - The inspector at a gold mine carbon recycling facility finds trace low concentrations of mercury vapor by instantaneous reading, but there are otherwise effective controls in place preventing contamination (*i.e.*, rules such as requiring removal of work boots and coveralls worn in the production areas before entering the lunchroom). The company has observed a protocol of daily cleaning of the lunchroom with a mercury removal solution. These facts would not describe a violation of §§56/57.20014.

B. Improper Storage of Toxic Materials in Lunchrooms

Sections 56/57.20014 prohibit improper use, or improper storage of, toxic materials in lunchrooms. Storage of production samples or production chemicals containing toxic materials in a refrigerator which is also used to store food and beverage is also prohibited. Certain consumer products such as insecticides, rodenticides, drain cleaners, and other caustic cleaning products are not to be stored with food and beverages under §§56/57.20014.

C. Storage and Consumption of Food and Beverages in Production Areas

Areas where food or beverages are stored or consumed must be separate from work areas in which there is expected exposure to toxic materials. If miners are observed storing food or beverages or eating or drinking in production areas of the mine, including laboratories, the inspector must document whether toxic materials are also present. This hazard is addressed by §§56/57.20014.

III. Assessing Exposure to Toxic Materials in Lunchrooms

When the presence of a toxic material in a food and beverage storage or consumption area is suspected, the inspector must take multiple air samples and wipe samples of eating and drinking and food preparation surfaces, in order to determine the level of toxic material present in the air or on food or beverage-contact surfaces. Sampling will be most effective when done at various times such as before and after breaks. The inspector must request sampling data from company records and industrial hygiene protocols or posted rules (if any) in the area and determine what steps are being taken to keep toxic materials away from food and beverage consumption and storage areas. If no steps are being taken, or the steps are inadequate, the inspector must issue the citation under this regulation.

In making his or her compliance determination regarding whether the mine operator has taken reasonable steps to prevent exposure to toxic materials in a lunchroom, the inspector should examine the lunchrooms with respect to the surrounding production areas. Some questions that should be addressed are:

1. Is the mine operator providing physical separation of the lunchroom from the production areas? Some mine operators set up lunchrooms in separate buildings or trailers which are separate from production areas and others provide a lunchroom that is not physically separated. The physical separation is one step that can be taken to prevent exposure to toxic materials in a lunchroom.

2. Where a lunchroom is adjacent to production areas: Is the mine operator ventilating the lunchroom with fresh uncontaminated air or with potentially contaminated production area air? Where toxic materials are found in the production areas, the lunchroom should ideally be ventilated by an air supply coming from uncontaminated area of the mine or by an air supply effectively filtered to remove toxic materials. The inspector should consider air intake in relation to the lunchroom’s proximity to the production area air outlet locations. Where contamination potential exists, the lunch room ventilation should be designed to provide it with a positive pressure differential in relation to any adjacent contaminated work areas. Higher pressure in the lunchroom will prevent cross contamination when the doorway opens (Refer to Chapter 18 for a discussion of basic ventilation evaluation principles and techniques).

3. Is the operator preventing contamination of lunchrooms by persons using the lunchroom? The inspector should determine whether the operator is allowing potentially contaminated items from being brought into the lunchroom from the production areas. Obviously, the mine operator should prevent persons to enter an eating area with contaminated clothing, including PPE, shoes, boots, tools and gloves. There should also be a place where miners can wash their hands before entering a lunchroom. In circumstances of low potential for contamination, removal or washing of shoes and gloves and hands may be sufficient. In circumstances of high potential for contamination, accessibility to a change station is desirable, so that potentially contaminated work clothing may be temporarily stored during lunch or break periods. An inspector should determine the location and engineering controls that ensure segregation of the change station and observe the work practices to assure that the procedures are being followed.

4. Is the mine operator observing routine adequate cleaning protocols? To prevent contamination, the mine operator should require cleaning of tables, chairs, eating surfaces and food preparation surfaces and even refrigerator surfaces with a cleaning agent capable of eliminating the hazardous material.

Observations found during inspection of eating areas should be recorded in the Health Field Notes (MSHA Form 4000-31). It is also advisable to include schematics (e.g., sketches of eating areas, lunch table location, chemical storage locations, etc.) and to photograph the area in question. The exact time and location of any sampling should be noted.

IV. Sampling Methodology

If health hazards are observed or suspected during the inspection of lunchrooms, bathrooms and shower facilities, further action may be necessary to delineate scope and severity of the problem. Area sampling can be used to assess the environmental conditions under which the miners eat. Personal sampling can also be used when accessing a miner’s breathing zone air concentrations while in the lunchroom. Normally, the following area grab sampling methods are used to confirm the presence and quantify the real time concentrations of contaminants present in eating areas.

A. **Electronic Direct-Reading Instruments (DRI)** - As discussed in Chapter 13, the Jerome Mercury Analyzer (Models 411 or 431-X) and the Industrial Scientific Multi-Gas Monitor (Models TMX-410 and TMX-412) are battery operated direct-read instruments which take real-time measurements of mercury vapors and various gases. These are important tools available to inspectors for detecting and quantifying health hazards because they eliminate the lag time of analyzing samples in a laboratory.

B. **Detector tubes** - As discussed in Chapter 11, detector tubes and bellows-type sampling pumps are used together to form a direct-reading sampling system which is used to determine the short-term concentration of gases or vapors in the air.

C. **Wipe samples** - As discussed in Chapter 14, a wipe sample is used to determine the presence of contamination by toxic materials on surfaces. Some situations where wipe sampling can be used are after a chemical spill or to determine if toxic materials are present in working or eating areas. (It is important that gloves be changed between each wipe sample taken).

Example:
A lab technician is seen consuming his lunch while sitting at a laboratory counter next to production samples. The inspector suspects that the samples may contain lead and mercury. The inspector should take several wipe samples on the counter top where the miner is eating and request an elemental metal screen including analysis for lead and mercury in order to determine the presence of these contaminants. The inspector may also decide to take some of the production samples from the laboratory counter and request an analysis for lead and mercury levels in these bulk samples.

D. **Bulk samples** - as discussed in Chapter 14, bulk sampling, as a screening method, is used to identify the source of contaminants which may be present at the mine site. The samples may be collected from accumulations of material or a substrate (i.e., piece of table, floor, ceiling) when a hazard is suspected.

For interpretation of the analytical laboratory sampling results or additional guidance, consult the district or national office.

NOTE: Area or personal sampling is not necessary to warrant a violation of the 30 CFR §§56/57.20014 standard.

V. Unsanitary Conditions in Lunchrooms

In addition to risk of exposure to toxic materials, certain regulations address the risk of exposure to biological hazards in a lunchroom. Poor sanitary conditions can lead to rodent infestation, microbial contamination and infectious disease. Applicable standards include:

- 30 CFR §§ 56/57.20003 (Housekeeping). This standard requires that a mine operator maintain a clean and orderly workplace. This includes service rooms such as lunchrooms. An inspector must determine if an eating area has been maintained accordingly.

- 30 CFR §§ 56/57.20013 (Disposal). This standard requires that all foods, beverages, and associated waste materials should be disposed of in designated receptacles with appropriate covers. These receptacles must be emptied frequently and maintained in a clean and sanitary condition.

- 30 CFR §§ 56/57.20002 (Potable Water). This standard requires an adequate supply of potable drinking water must be available for the miners in active working areas. Potable drinking water dispensers must be designed, constructed, and serviced so that sanitary conditions are maintained as set forth in the standard. The inspector should take a sample of the water and have it analyzed for potability when complaints are received or when contamination is suspected. Contact the MSHA laboratory for sampling instructions. **Note**: Potable water means water which shall meet the applicable minimum health requirements for drinking water established by the State or community in which the mine is located or by the Environmental Protection Agency in 40 CFR part 141, pages 169-182 revised as of July 1, 1977. Where no such requirements are applicable, the drinking water provided shall conform with the Public Health Service Drinking Water Standards, 42 CFR part 72, subpart J, pages 527-533, revised as of October 1, 1976.

- 30 CFR §§ 56/57.20014 (Separation of lunchroom from toilet facilities). This standard specifically prohibits food and beverage storage and consumption in an area containing a toilet.

VI. Sanitary Measures in Toilet Facilities and Shower Rooms

30 CFR §§ 56/57.20008 requires that the mine operator provide miners ready access to a toilet facility. These standards require that the toilet facilities provided be clean and sanitary. Where shower rooms are provided, the housekeeping regulations (30 CFR §§ 56/57.20003) require that the mine operator maintain such facilities in a clean and orderly condition.

VII. Gravity Findings

The gravity and "Significant and Substantial" determination relating to health standards dealing with lunchrooms, toilet facilities and shower facilities, is very fact intensive and may be difficult to make on the spot and without specialized expertise. For these reasons the inspector should consult specialists in the district or national Office regarding these determinations before issuing a citation as "Significant and Substantial". When contamination of eating areas is suspected and sampling has been conducted, it is important to document the extent of the exposure to toxic materials or to biological hazards and number of potentially exposed individuals. An inspector should note the extent and duration of the contamination, and the number of miners in a lunchroom at the time of the inspection, as well as the number of miners who use an eating area on a daily basis. An inspector should note the number of breaks spent in an eating area and the duration of the breaks. If the specific times of day are known, they should be recorded. Also, the length of the lunch or dinner period and the time of the day when lunch or dinner is taken should be recorded. If necessary, this information can be used by MSHA to estimate the cumulative dose of a toxic material potentially absorbed by the affected miners, or potential risks caused by exposure to biological hazards.

VIII. Post-Inspection Procedures

A. Review Health Field Notes

Check that you have recorded all the necessary information in the Health Field Notes. Record calibration dates of any DRIs used.

B. Post-Calibration of Sampling Equipment

Check sampling pump calibration in accordance with Chapter 4 of this Handbook.

C. Submit Samples for Analysis

Submit any samples to the MSHA Laboratory on a Request for Laboratory Analysis form as soon as sampling is completed. **Note**: Some packaged chemical dosimeters (i.e., Mercury) include pre-paid analysis from a lab other than MSHA's. Send these dosimeters directly to the contract laboratory.

D. Compliance Determination

1. **Calculations.** The MSHA Laboratory will perform all necessary calculations and report results on an "Analytical Report" mailed to you.

2. **Error Factor.** The error factor applicable for the sampling type will be supplied by the MSHA Laboratory.

E. Report Writing

1. Report any real time or dosimetry personal sampling on the Personal Exposure Data Summary (PEDS), or area sampling on the Area Sample Data Summary (ASDS) form (refer to Chapter 21). When a PEDS or ASDS accompanies an MSHA Laboratory report, manual completion of a PEDS or ASDS is not necessary.

2. Submit a copy of the Health Field Notes, the MSHA Laboratory Analytical Reports, citations or orders (if applicable), and the PEDS, ASDS, with the inspection report.

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DOCUMENTATION AND RECORDKEEPING

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Chapter 21
DOCUMENTATION AND RECORDKEEPING

I. Introduction

Documenting observations and findings during an inspection is an essential part of an inspector's job. When health sampling is conducted, the inspector must document:

- Information about the occupation or area being sampled;
- Activity of the person being sampled;
- Information about sampling equipment being used;
- Personal protective equipment being worn or not being worn;
- Conditions at the time of sampling;
- Screening information and corroborative data collected during sampling;
- Potential sources of overexposure(s);
- Controls that are in place or that can be installed or implemented, and
- Information to determine S&S, gravity and negligence (this is especially critical for samples that need to be submitted for laboratory results).

Additionally, an inspector must complete the appropriate forms to provide information to the MSHA Laboratory and databases for samples collected.

II. Definitions

Area Sample Data Summary (ASDS) - MSHA Form 4000-42 - form used to report area sample results to the Management Standard Information Systems (MSIS).

Inspection/Investigation Data Summary (I&I) - MSHA Form 4000-40 - form used to document the inspection when it is initiated. This form provides the unique event number.

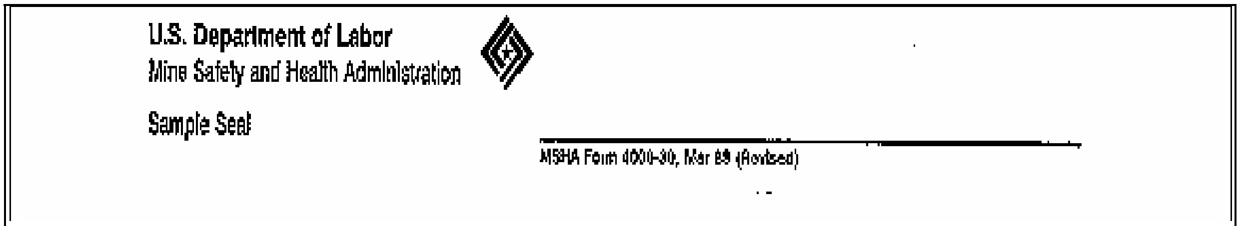
Management Standardized Information Systems (MSIS) – MSHA's Web-based database that allows for the integration of information systems into a common platform. The migrations of the system are in segments that allow for changes from the old to the new database. For example, health sample counts collected prior to 2005 were derived through the I&I entries.

Personal Exposure Data Summary (PEDS) - MSHA Form 4000-43 - form used to report personal sample results to the MSIS.

Request For Laboratory Analysis (RLA) - MSHA Form 4000-29 - form submitted with sampling media to provide information to the MSHA Laboratory for analytical purposes and to receive back an Analytical Report and applicable PEDS or ASDS.

III. Sample Seal - MSHA Form 4000-30

The sample seal is an integral part of the Metal/Nonmetal ‘Chain of Possession’ procedure. This procedure ensures that a sample has not been tampered with after it has been collected. The sample seal is placed on the sampling media (filter cassette, charcoal tube, etc.) after sampling. The inspector must sign or initial and date the seal prior to shipping it to the MSHA Laboratory.



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

Sample Seal

MSHA Form 4000-30, Mar 89 (Revised)

Figure 21-1 Sample Seal, MSHA Form 4000-30

IV. Diesel Particulate Matter Sampling Field Notes (MSHA Form 4000-128)

A. General Instructions

Diesel particulate matter sampling field notes must be completed when diesel particulate matter samples are taken. All diesel particulate matter sampling field notes, sketches, photographs, and additional notes applicable to a single inspection shall be kept together and maintained as part of the official mine file at the district office. A Diesel Particulate Matter Sampling Field Notes form must be completed for each sample taken. Up to three samples may be recorded on the same form. See Figures 21-2 and 21-3 for a sample MSHA Form 4000-128.

B. Completing Diesel Particulate Matter Sampling Field Notes

Complete the following items on the Diesel Particulate Matter Sampling Field Notes form:

1. **Mine name -** Record the name of the mine.
2. **Company name -** Record the name of the company.
3. **Mine ID** - Record the appropriate seven-digit identification number.
4. **Name of person conducting sampling** - Record the name of the person conducting the sampling.
5. **AR Number** - Record the Authorized Representative number of the person conducting the sampling.
6. **Date** - Record the date of sampling.
7. **Event # -** Record the event number from the Inspection/Investigation Data Summary form for this inspection or investigation.
8. **Commodity -** Record the commodity produced by the mine in the areas being sampled.
9. **Hours/Shift -** Record the number of hours of work during the shift sampled.
10. **Production Shifts/Day -** Record the number of production shifts a day.
11. **Maintenance Shifts/Day -** Record the number of maintenance shifts a day.
12. **Type of fuel in use at the mine -** Record the type of fuel being used in the

underground equipment.

13. **Fuel sulfur content (%) -** Record the percentage of sulfur in the diesel fuel being used in the equipment underground at the mine.

14. **Type of fuel additives used at the mine -** If fuel additives are used, record the type. If not, mark "none."

15. **Is there a person authorized to maintain diesel equipment? -** Mark yes (Y) or no (N). If the answer is "no," explain in item #41, Other Notes/ Observations.

16. **Is there a planned maintenance program in place? -** Mark yes (Y) or no (N). If the answer is "no," explain in item #41, Other Notes/ Observations.

17. **Has diesel equipment inventory been reviewed? -** Mark yes (Y) or no (N). If the answer is "no," explain in item #41, Other Notes/Observations.

18. **Has mine ventilation plan / map been reviewed? -** Mark yes (Y) or no (N). If the answer is "no," explain in item #41, Other Notes/Observations.

***Note**: Complete the following items 19 through 41 for each miner sampled. If more than one sample is taken on the individual miner being sampled, fill out items 19 through 41 for each sample taken.

19. **Sample Cassette No. -** Record the pre-printed sample cassette number.

20. **Name of miner sampled -** Record the name of the miner sampled, including first and last name.

21. **Number of miners affected -** Record the number of other miners working in the same work area as the miner sampled. This would include other miners who perform the same task on other shifts.

22. **Occupation sampled -** Record the job title or occupational classification of the miner being sampled.

23. **If a respirator is worn: brand, model, type of filters -** Record the name of the manufacturer of the respirator issued to the miner during sampling. If no respirator is worn during the sampling, note that none was worn. Record the model, name, filter/cartridge used, and NIOSH approval number of the respirator.

24. **If a respirator is worn: is there an acceptable respiratory protection program? -** Record whether a respirator program is in effect in

accordance with the respiratory requirements contained in ANSI Z88.2-1969 and if a medical evaluation and fit testing were done. Record any deficiencies in program in item #41, Other Notes/Observations.

25. **Equipment operated; Type or description; Identification #** - Record a description of the type of equipment the miner being sampled is operating, and the manufacturer and company identification number of that equipment.

26. **Location in mine -** Record a description of the location(s) where the miner is assigned to work during the sampling. If more than one location, enter the approximate amount of time (in hours) the miner spends in each.

27. **Is person sampled inside an environmental cab or booth with filtered breathing air? -** Mark yes (Y) or no (N). If the cab is not an *environmental* cab (positive pressure, air filtration system, etc.), then mark no (N).

28. **Temperature (°F) and humidity (%) -** Record the pertinent environmental conditions.

29. **Ventilation rate (CFM) in location sampled (measure if possible) -** Record the ventilation rate in the work area of the miner being sampled. If not measured or taken from mine map, mark "unknown" and explain in item #41, Other Notes/Observations.

30. **Sample pump make/model -** Record the manufacturer's name and model number of the pump used.

31. **Sample pump number -** Record the serial number and/or MSHA property number of the pump.

32. **Pre-calibration (average Lpm) -** Record the flow rate of the sampling pump during calibration before the survey.

33. **Post-calibration (average Lpm)** - Record the flow rate of the sampling pump during calibration after the survey.

34. **Sample pump time on -** Record the exact time sampling started. Document using 24-hour clock or indicating AM or PM for 12-hour clock.

35. **Sample pump time off -** Record the exact time sampling stopped. Document using 24-hour clock or indicating AM or PM for 12-hour clock.

(Reverse of Form 4000-128)

36. For each piece of diesel equipment used at the workplace sampled, list:

A. type or description - Record a description of the type of equipment operating.

B. Identification # - Record the manufacturer and company identification number of that equipment. If it can be safely obtained, you may also record the engine serial number here.

C. equipment condition - Describe the age and how well maintained the equipment is.

D. Does the engine emit black smoke during acceleration? Mark "yes," "no," or "did not check."

E. type of DPM control devices - Record whether any DPM filters or other on-board DPM control devices, catalytic converters, or fuel additives or catalysts have been implemented for this piece of equipment.

37. Piece # ___

38. Piece #___

39. Piece #___

40. Piece #___

(Use more sample blocks if needed) - Number sequentially.

41. Other Notes/Observations- Sampling equipment checks, environmental conditions, activities, DPM controls, ventilation control structures (stoppings, doors, brattices, etc.) Record any additional information or observations related to the inspection or the sampling. Record each time that notes and observations were made, using 24-hour clock or indicating AM or PM for 12-hour clock. Record the following, using additional pages if necessary:

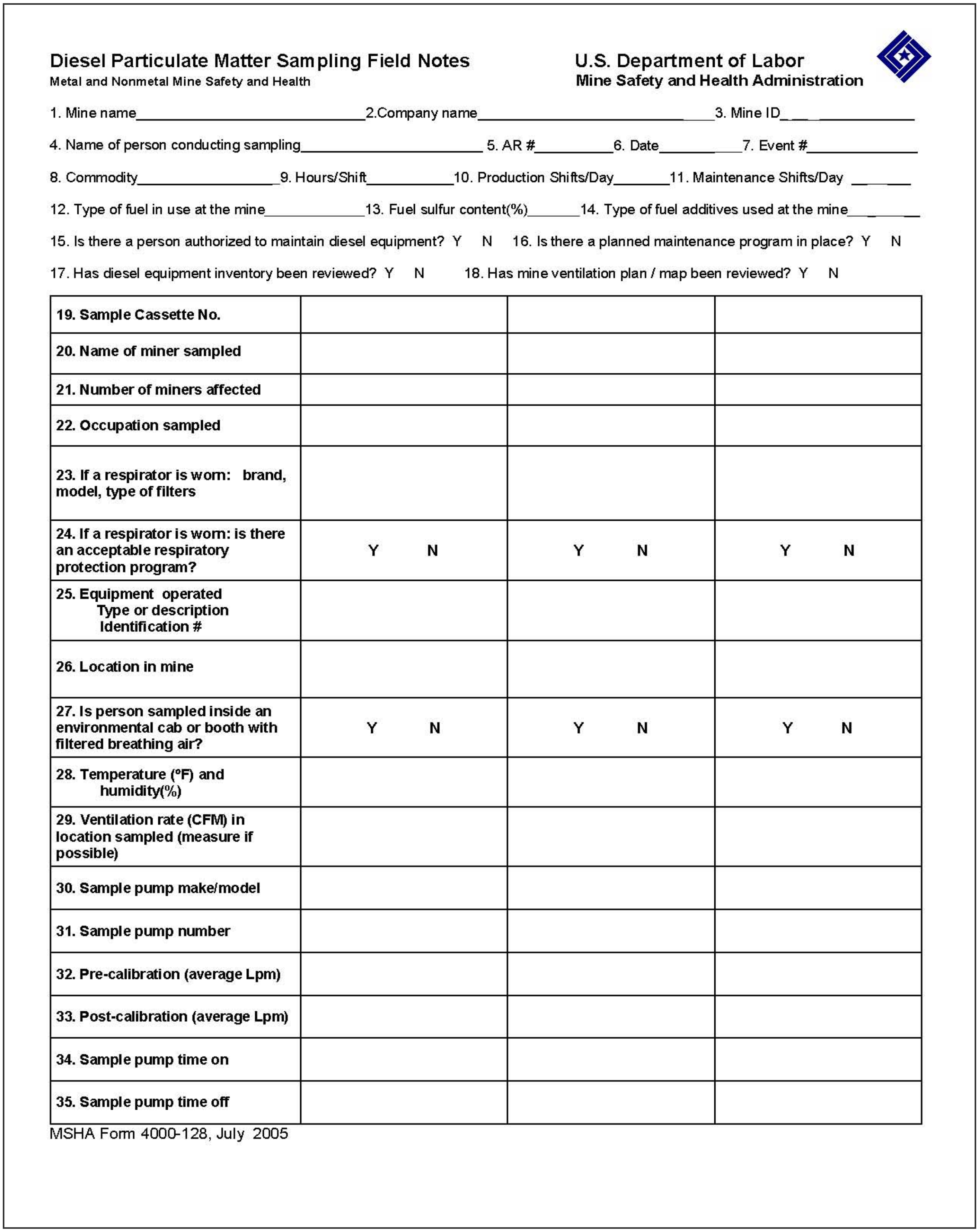
- Conditions of the sampling equipment and any adjustments made;
- Conditions observed in the work area;
- The location and activity of miner sampled; comments by the miner, verbatim if appropriate, regarding what the miner did since

the last check and the miner’s knowledge of any hazardous or unusual situations or incidents;

- Miner’s use of personal protective equipment (PPE) and any deficiencies of the personal protection program;
- The probable source(s) of the miner’s exposure to DPM and the miner’s proximity to each source listed;
- Engineering or administrative controls in use or tried by the operator to control the sampled miner's exposure and your evaluation of the condition and effectiveness of these controls; and
- Controls suggested by the inspector to the operator to reduce the sampled miner's exposure.

C. Recordkeeping

Submit the Diesel Particulate Matter Sampling Field Notes form with the addendum to the inspection report after laboratory results have been received and appropriate action has been taken.



Diesel Particulate Matter Sampling Field Notes
Metal and Nonmetal Mine Safety and Health

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

1. Mine name____________________________2.Company name___________________________3. Mine ID______________

4. Name of person conducting sampling______________________ 5. AR #__________6. Date___________7. Event #_____________

8. Commodity_________________9. Hours/Shift___________10. Production Shifts/Day_______11. Maintenance Shifts/Day ______

12. Type of fuel in use at the mine____________13. Fuel sulfur content(%)______14. Type of fuel additives used at the mine_______

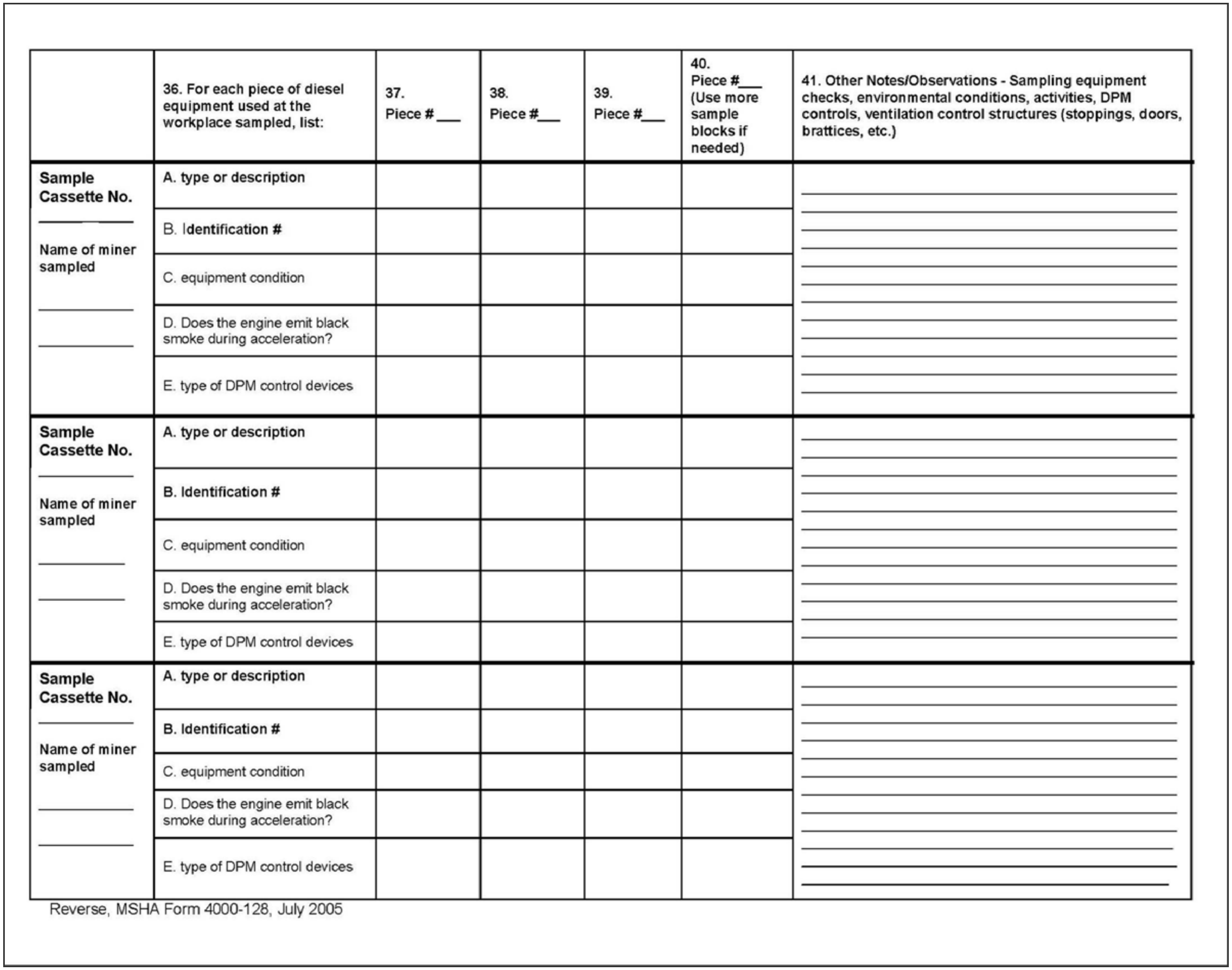
15. Is there a person authorized to maintain diesel equipment? Y N 16. Is there a planned maintenance program in place? Y N

17. Has diesel equipment inventory been reviewed? Y N 18. Has mine ventilation plan / map been reviewed? Y N

19. Sample Cassette No.			
20. Name of miner sampled			
21. Number of miners affected			
22. Occupation sampled			
23. If a respirator is worn: brand, model, type of filters			
24. If a respirator is worn: is there an acceptable respiratory protection program?	**Y N**	**Y N**	**Y N**
25. Equipment operated Type or description Identification #			
26. Location in mine			
27. Is person sampled inside an environmental cab or booth with filtered breathing air?	**Y N**	**Y N**	**Y N**
28. Temperature (°F) and humidity(%)			
29. Ventilation rate (CFM) in location sampled (measure if possible)			
30. Sample pump make/model			
31. Sample pump number			
32. Pre-calibration (average Lpm)			
33. Post-calibration (average Lpm)			
34. Sample pump time on			
35. Sample pump time off			

MSHA Form 4000-128, July 2005

Figure 21-2. MSHA Form 4000-128 (Front)



	36. For each piece of diesel equipment used at the workplace sampled, list:	37. Piece # ___	38. Piece #___	39. Piece #___	40. Piece #___ (Use more sample blocks if needed)	41. Other Notes/Observations - Sampling equipment checks, environmental conditions, activities, DPM controls, ventilation control structures (stoppings, doors, brattices, etc.)
Sample Cassette No. ______ **Name of miner sampled** ______ ______	**A. type or description**					
	B. **Identification #**					
	C. equipment condition					
	D. Does the engine emit black smoke during acceleration?					
	E. type of DPM control devices					
Sample Cassette No. ______ **Name of miner sampled** ______ ______	**A. type or description**					
	B. Identification #					
	C. equipment condition					
	D. Does the engine emit black smoke during acceleration?					
	E. type of DPM control devices					
Sample Cassette No. ______ **Name of miner sampled** ______ ______	**A. type or description**					
	B. Identification #					
	C. equipment condition					
	D. Does the engine emit black smoke during acceleration?					
	E. type of DPM control devices					

Reverse, MSHA Form 4000-128, July 2005

Figure 21-3. MSHA Form 4000-128 (Reverse)

V. Health Field Notes (MSHA Form 4000-31)

A. General Instructions

Health field notes must be completed when personal exposure samples are taken. All health field notes, sketches, photographs, and additional notes applicable to a single inspection shall be kept together and maintained as part of the official mine file at the District Office. A Health Field Notes form must be completed for each personal sample taken. See Figures 21-4 and 21-5 for a sample MSHA Form 4000-31.

B. Completing Health Field Notes

For each miner sampled, complete the following items on the Health Field Notes form:

1. **Inspector** - Record the name of the person conducting the sampling.
2. **AR Number** - Record the Authorized Representative number of the person conducting the sampling.
3. **Date** - Record the date of sampling.
4. **Mine ID** - Record the appropriate seven-digit identification number.
5. **Mine -** Record the name of the mine.
6. **Company -** Record the name of the company.
7. **Employee Sampled -** Record the name of the miner sampled, including first and last name.
8. **Hours/Shift** - Record the number of hours the miner worked during the shift sampled.
9. **Days/Week** - Record the number of days per week that the miner normally works at the mine.
10. **Number Persons Affected -** Record the number of other miners working in the same work area as the miner sampled. This would include other miners who perform the same task on other shifts.
11. **Job Title -** Record the job title or occupational classification of the miner being sampled.

12. **Assigned Work Area -** Record a description of the location(s) where the miner is assigned to work during the sampling. If more than one location, enter the approximate amount of time (in hours) the miner spends in each.

13. **Assigned Duties -** Record a description of the miner's assigned work activities during sampling for each work area described, and enter the approximate amount of time (in hours) the miner spends performing each activity.

When Sampling for Noise, fill out items 14 through 16. Otherwise, leave blank.

14. **Hearing Protector Mfg**. - Record the name of the manufacturer of the hearing protector worn by the miner during sampling. If none is worn, note that none was worn.

15. **Model** - Record the model name and number of the hearing protector.

16. **NRR -** Yes or No. Indicate whether the hearing protection has an NRR value. The NRR value itself is not used for enforcement purposes.

When Sampling for Contaminants:

17. **Respirator Mfg. -** Record the name of the manufacturer of the respirator issued to the miner during sampling. If no respirator is worn during the sampling, note that none was worn.

18. **Model -** Record the model, name, filter/cartridge used, and NIOSH approval number of the respirator.

19. **Respirator Program** - Record whether a respirator program is in effect in accordance with the respiratory requirements contained in ANSI Z88.2-1969 and if fit testing was done. Record any deficiencies in the program.

When Sampling for Noise:

20. **Noise Dosimeter Mfg**. - Record the manufacturer's name and model number for the noise dosimeter used to sample the miner.

21. **ID Number** - Record the serial number and/or MSHA property number of the noise dosimeter.

22. **Cell Number -** This section should be left blank.

23. **Time On** - Record the exact time the dosimeter was turned on, using a 24-hour (military time) clock.

24. **Time Off** - Record the exact time the dosimeter was removed from the miner. This would be the time the dosimeter was paused for final dose reading. Document using the 24-hour clock format.

25. **% Readout** - Record the percent dose exposures for the Action Level (AL) and the Permissible Exposure Level (PEL) obtained from the noise dosimeter.

26. **Dosimeter Calibrator Mfg**. - Record the manufacturer's name and model number for the acoustical calibrator used for pre- and post-calibration check of dosimeter.

27. **ID Number -** Record the serial number and/or MSHA property number of the noise acoustical calibrator.

28. **Readout or Indicator Mfg**. - Leave this item blank.

29. **ID Number** - Leave item blank.

30. **SLM Mfg. -** Record the manufacturer's name and model number for the sound level meter used.

31. **ID Number** - Record the serial number and/or MSHA property number of the sound level meter.

32. **SLM Calibrator Mfg. -** Record the name of the manufacturer of the sound level meter calibrator used to calibrate the sound level meter.

33. **ID Number -** Record the serial number and/or MSHA property number of the sound level meter calibrator.

When Sampling for Contaminants With a Pump:

34. **Pump Mfg**. - Record the manufacturer's name and model number for the pump used.

35. **ID Number -** Record the serial number and/or MSHA property number of the pump.

***Note**: Complete the following items 36 through 40 for each sample taken. If more than one sample is taken on the individual miner being sampled, fill out items 36 through 40 for each sample taken.

36. **Sample Number -** Record the field number assigned to the sample by the AR or the number that is preprinted on the dust cassette by Technical

Support. Each sample requires a permanent distinct number which must be clearly identifiable and that is unique for that event. The same number cannot be repeated even if it is associated with a different type of sample.

37. **Pre-Seal Number -** Indicate that the pre-seal was intact by writing "yes." If there is no pre-seal, such as sorbent tubes, write N/A (not applicable).

38. **Time On** - Record the exact time sampling started, using 24-hour clock.

39. **Time Off -** Record the exact time sampling stopped. Document using 24-hour clock.

40. **Post-Seal Number** - Write "yes" to indicate that a seal was placed on any sample submitted for analysis.

41. **Flow Rate** - Record the pump flow rate used during sampling.

42. **Sample Type -** Record the type of sample(s) collected (total dust, respirable dust, oil mist, welding fumes, elemental dust, charcoal tube, etc).

43. **Analysis Desired** - Record the type of analysis desired for the sample(s) collected (e.g., quartz, cristobalite, elemental scan, vanadium, lead, toluene, etc). Be as specific as possible.

44. **Blank Sample Number -** Record the assigned sample number for the blank or control.

45. **Blank Sample Seal Number** - Record the condition of the blank. Indicate "yes" if initially intact. A Sample Seal (MSHA Form 4000-30) must be attached to the blank after opening and resealing. Do not use this space for control filter cassettes.

46. **Bulk Sample Number -** Record the assigned bulk sample number. If a bulk sample is not provided, write "NA."

47. **Location Bulk Sample Taken -** Record the specific location where the bulk sample was collected and also note its content.

48. **Environmental Conditions -** Record any pertinent environmental conditions, such as temperature, relative humidity, elevation, wind, rain, snow, etc.

49. **Remarks -** Record any additional information or observations related to the inspection or the sampling.

(Reverse of Form 4000-31)

50. **Time** - Record each time that notes and observations were made, using 24-hour clock.

51. **Notes/Observations** - Record the following, using additional pages if necessary:

    - Conditions of the sampling equipment and any adjustments made;
    - Conditions observed in the work area;
    - The location and activity of miner sampled;
    - Manufacturer and company identification number of the equipment operating;
    - Comments by the miner, verbatim if appropriate, regarding what the miner did since the last check and the miner’s knowledge of any hazardous or unusual situations or incidents; and
    - Miner’s use and any deficiencies of the personal protection program.

52. **SLM Readings -** Record any SLM readings taken, including location and time.

53. **Sources of Employee Exposure** - Record the probable source(s) of the miner’s exposure to each hazard for which a sample is taken. Record the miner’s proximity to each source listed.

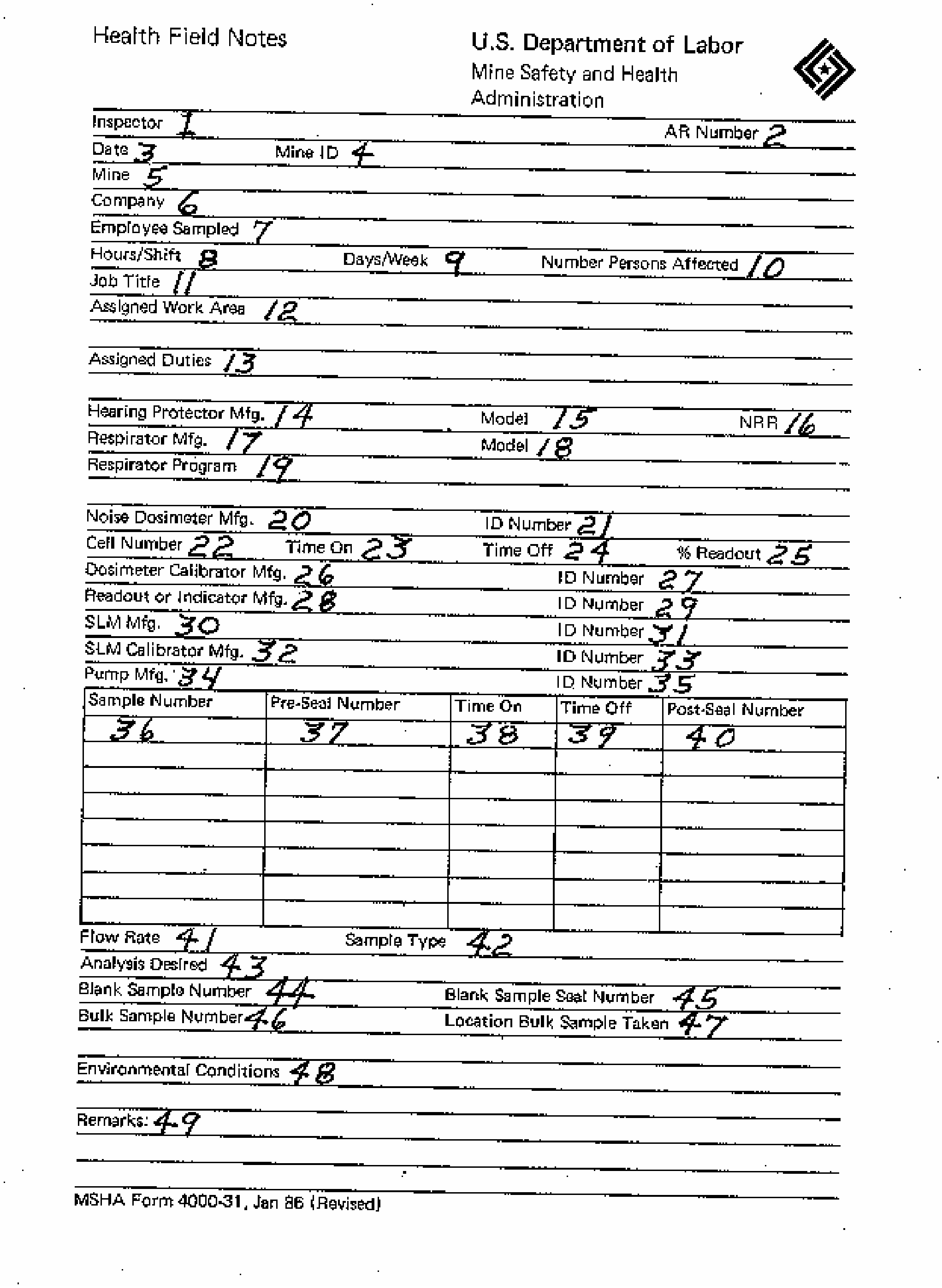
54. **Controls in Use or Tried by Operator -** Record any engineering or administrative controls in use or tried by the operator to control the sampled miner's exposure and your evaluation of the condition and effectiveness of these controls.

55. **Controls Suggested by Inspector -** Record controls suggested by the inspector to the operator to control the sampled miner's exposure.

C. Recordkeeping

When sample results have been determined in the field by the inspector, such as noise dose, detector tube readings, or the results from direct reading instruments and record in the health field notes. Pre- and post-calibration should also be recorded in the health field notes. Submit the health field notes with the inspection report to the district office unless samples are collected that require laboratory analysis. In that case, submit the Health field notes with the addendum to the inspection report after laboratory results have been received and appropriate action has been taken.

Figure 21-4 Health Field Notes, MSHA Form 4000-31, Front



Health Field Notes

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

Inspector 1 AR Number 2

Date 3 Mine ID 4

Mine 5

Company 6

Employee Sampled 7

Hours/Shift 8 Days/Week 9 Number Persons Affected 10

Job Title 11

Assigned Work Area 12

Assigned Duties 13

Hearing Protector Mfg. 14 Model 15 NRR 16

Respirator Mfg. 17 Model 18

Respirator Program 19

Noise Dosimeter Mfg. 20 ID Number 21

Cell Number 22 Time On 23 Time Off 24 % Readout 25

Dosimeter Calibrator Mfg. 26 ID Number 27

Readout or Indicator Mfg. 28 ID Number 29

SLM Mfg. 30 ID Number 31

SLM Calibrator Mfg. 32 ID Number 33

Pump Mfg. 34 ID Number 35

Sample Number	Pre-Seal Number	Time On	Time Off	Post-Seal Number
36	37	38	39	40

Flow Rate 41 Sample Type 42

Analysis Desired 43

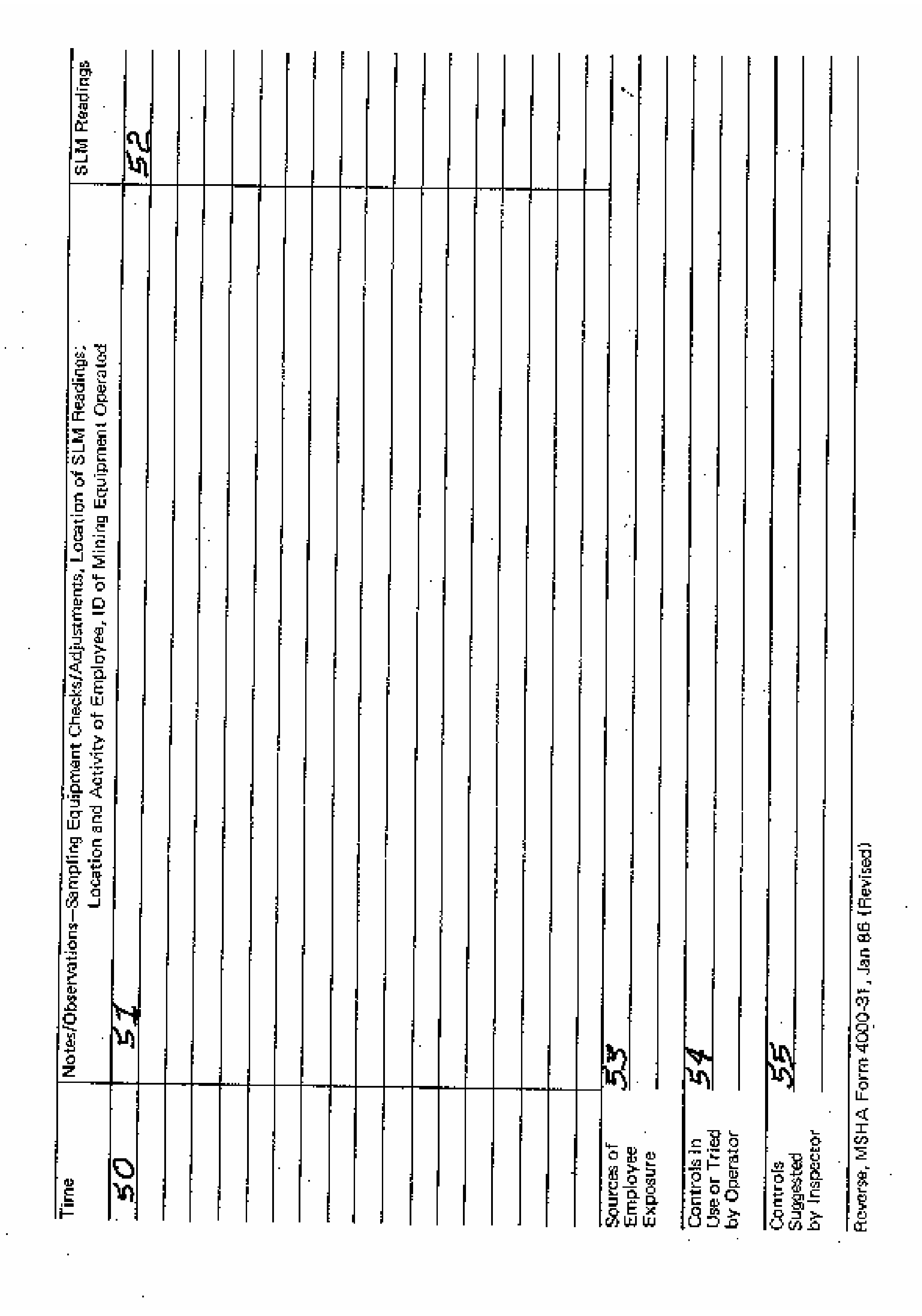
Blank Sample Number 44 Blank Sample Seal Number 45

Bulk Sample Number 46 Location Bulk Sample Taken 47

Environmental Conditions 48

Remarks: 49

MSHA Form 4000-31, Jan 86 (Revised)



Time	Notes/Observations—Sampling Equipment Checks/Adjustments, Location of SLM Readings; Location and Activity of Employees, ID of Mining Equipment Operated	SLM Readings
50	51	52

Sources of Employee Exposure 53

Controls In Use or Tried by Operator 54

Controls Suggested by Inspector 55

Reverse, MSHA Form 4000-31, Jan 86 (Revised)

Figure 21-5 Health Field Notes, MSHA Form 4000-31, Reverse

VI. Radon Daughter Sampling Data Form (MSHA Form 4000-21)

A. General Instructions

This form is completed when sampling is conducted at underground mines for ionizing radiation (radon or thoron daughters).

B. Completing the Radon Daughter Sampling Data Form

One form must be completed for each radon sample collected. The following information should be documented on this form:

1. **Mine Name** - Record name of the mine where samples were collected.
2. **Mine I. D.** - Record the identification number of the mine where samples were collected.
3. **Company Name** - Record name of mining company.
4. **Date** - Record the date sampling was conducted.
5. **AR Number** - Record AR number of person conducting sampling.
6. **Name** - Record name of person conducting sampling.
7. **Counter Number** - Record identification number of instrument used.
8. **Pump Number** - Record the number of the pump used to conduct sampling.
9. **Filter Number** - Record the unique number of the filter used to collect sample.
10. **LPM** - Record pump flow rate in Liters per minute (normally 2.0 Lpm).
11. **Sampling Time** - Record sampling time.
12. **Volume** - calculated volume: Lpm X 5 mins. (normally 2.0 Lpm X 5 mins. = 10.0 L).
13. **Time of Count** - Record the time of sample count using 24-hour clock.
14. **Sample End Time** - Record the time that sampling was stopped (with pump and filter) using 24-hour clock.

15. **Elapsed Time** (min) - Record the amount of time from when the sample was started to when it was stopped.

16. **CPM** - Counts per minute. Record the number of counts per minute. Note: The letters “CPM” may not appear in this space due to a printing error on some of the forms in circulation, but the value must still be entered to calculate the Working Level.

17. **Efficiency Factor** - Record unique efficiency factor from instrument used.

18. **Volume** - Record same volume as calculated in item 12.

19. **Time Factor** - Record time factor from chart (see chapter 10).

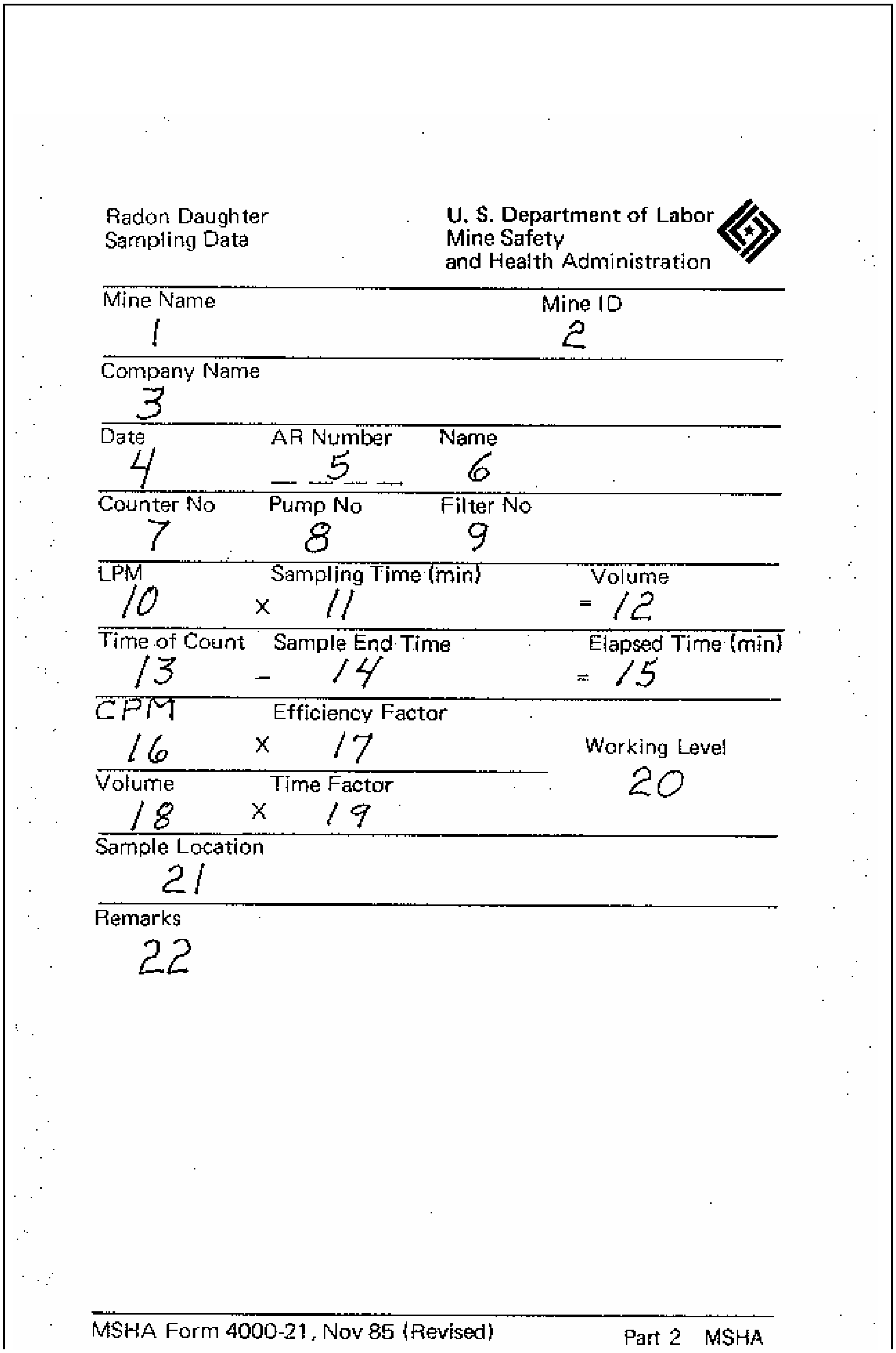
20. **Working Level** - Record calculated value for exposure of miners in area of sample.

21. **Sample Location** - Record the specific location of where the sample was collected.

22. **Remarks -** Observe and document relevant working environmental conditions and activities which may affect the sampling.

C. Recordkeeping

Include the completed forms with the inspection report and forward to the district office.



Radon Daughter
Sampling Data

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

Mine Name: 1
Mine ID: 2

Company Name: 3

Date: 4
AR Number: 5
Name: 6

Counter No: 7
Pump No: 8
Filter No: 9

LPM: 10 x Sampling Time (min): 11 = Volume: 12

Time of Count: 13 - Sample End Time: 14 = Elapsed Time (min): 15

CPM: 16 x Efficiency Factor: 17

Volume: 18 x Time Factor: 19

Working Level: 20

Sample Location: 21

Remarks: 22

MSHA Form 4000-21, Nov 85 (Revised)
Part 2 MSHA

Figure 21-6 Radon Daughter Sampling Data, MSHA Form 4000-21

VII. Request for Laboratory Analysis (MSHA Form 4000-29)

A. General Instructions

This form must be used when submitting industrial hygiene samples to the MSHA Laboratory for analysis. The Request for Laboratory Analysis (RLA) form replaces the old Air Sample Record (ASR) form. The RLA is used to request specific analyses. It provides information to the laboratory and assists the laboratory in determining which contaminants may be present. The RLA form will permit the MSHA Laboratory to calculate results and generate a complete report, including an "Analytical Report" and the applicable PEDS or ASDS, which is mailed directly back to the AR. For the process to be effective and a report to be generated, however, you must **complete the entire form** in advance and submit the original with the samples to the MSHA laboratory. Maintain a copy for your records.

B. Completing the Request for Laboratory Analysis (RLA) Form

This form provides space for five samples and one blank or control. When submitting more than six samples total, complete another form, noting the number of Request for Laboratory Analysis forms used per job, i.e., page 1 of X. Keep a copy for your records. Enter the control filter information in the left-most sample data column of the RLA form.

Use a separate Request for Laboratory Analysis form for each set of personal or area samples, or when requesting different types of analyses, or when conducting consecutive samples on different persons. Record consecutive samples collected for one person onto one RLA form. Record the sampling information for each group of samples on one RLA form as much as possible. A group of respirable dust filter cassettes and a group of welding fume cassettes can be mailed into the lab together, but should be listed on two separate Request for Laboratory Analysis forms.

For MSHA's laboratory to correctly analyze and send back a complete results package consisting of an "Analytical Report" and PEDS or ASDS, the inspector must complete all of the following items and submit the RLA with the samples:

1. **Event Number -** Enter the Event Number assigned to the inspection.

2. **Mine ID Number -** Enter identification number of mine or mill where samples were collected.

3. **Mine/Mill Name -** Enter legal name of the mine or mill where samples were collected.

4. **Company Name** - Enter full legal name of company owning the mine or mill.

5. **Contractor Name/Number** - Enter the contractor's name and ID number, if applicable.

6. **Commodity** - Enter mine or mill product.

7. **Collector** - Enter full name of MSHA representative collecting sample.

8. **AR Number -** Enter the AR number of the person who is responsible for the sample collection.

9. **Field Office Name -** Enter name of field office to which collector is assigned.

SAMPLING DATA

10. **Area/Personal** (A/P) - Enter A if the sample is an area sample, or P if a personal sample. Leave blank for Control/Blank.

11. **Date Collected** - Enter date of each sample collected: MM/DD/YY.

12. **Time Collected** - Enter the beginning and ending time of the sample, using 24-hour clock (military time) notation.

13. **Pre-seal Intact (Y/NA) -** Write "Y" if pre-seal was intact. The seal can be the plastic bag, package, or container in which the media is received. Charcoal tubes, passive monitors, vacuum bottles, vacutainers, and sorbent tubes will not have pre-seals. When submitting samples taken with these media, write N/A. **Note:** "VOID" the cassette if the seal is damaged or missing and use another cassette. Notify your district office of the voided cassette. Do not record information for voided cassettes on this form.

14. **Field Sample/Cassette No.** - Enter identifying sample number assigned by the Lab, or as in welding samples, by the AR. Normally this will be pre-stamped ID number on the pre-weighed filter cassette.

15. **Sample Type** - The new Sample Type letter identification system provides categories of media type associated with the specific analysis requested. The laboratory's automation system requires this information to correctly direct sample processing and analysis within the different sub-specialties of the lab. Enter appropriate letter(s) to describe type of sample collected:

B - Bulk (asbestos, silica, Hg, Pb, etc.)
CB - Control, Blank (required)
CT - Charcoal Tube (organics, solvents, other specific)
F - Fiber (asbestos)
G - Gas (vacuum samplers: CO, CH_4, O_2, CO_2, NO_2, etc.)
HG - Mercury Vapor (badge)
M - Mist (Oil, H_2SO_4, caustic, etc.)
MD - Metal Dust (single: lead, silver, copper, etc., or 14-element profile)
MF - Metal Fume (single: cadmium, silver, etc., or 14-element profile, Cr metal only - sample CrOx on PVC)
OV - Organic Vapor (badge: single, 16-solvent profile, unknowns screen, or other specific)
R - Respirable Dust (quartz, cristobalite, trydimite, silica)
ST - Silica Gel Tube (methanol, sulfuric, etc.)
T - Total Dust (nuisance; other)
W - Welding fume (14-element profile. Cr metal only - sample CrOx on PVC)
WS - Wipe Sample (mercury, lead, silver, PCB, etc.)
MISC - Other (not otherwise classified, Note: specify compound desired)

▪See reverse of RLA for more examples

16. **Analysis Requested** - Enter analysis desired. Be as specific as possible. The analysis request must match with the Sample Type category in block 15. See above for examples of elements/compounds analyzed by Sample Type.

17. **Flow Rate (LPM) -** Enter the flow rate of pump in Liters per minute (Lpm). Enter N/A if not applicable.

18. **Material Listed (Y/N)** - Applies to Respirable and Total dust sampling. Is the material **that was sampled** listed as a "Nuisance Particulate"* in Appendix E of the *TLVs© Threshold Limit Values for Chemical Substances in Workroom Air Adopted by ACGIH for 1973*? Answer Y (Yes), or N (No). Answer "Y" ONLY if the sampled material is a "Substance" in the TLV book on the Appendix E list:

a. Alundum (alumina, bauxite) Al_2O_3
b. Calcium Carbonate ($CaCO_3$), including:
    i. Limestone
    ii. Calcite
    iii. Dolomite (calcium magnesium carbonate)
c. Cellulose
d. Portland Cement
e. Corundum (Silicon carbide, Al_2O_3)

f. Emery (may also be known as: Silicon carbide, Al_2O_3, fine grained Corundum)
g. Glass, fibrous - when less than 5-7µm diameter, or dust
h. Glycerin Mist
i. Graphite (synthetic)
j. Gypsum (Calcium Sulfate - $CaSO_4$)
k. Vegetable oil mists (except castor, cashew nut, or similar irritant oils)
l. Kaolin (Aluminum silicate)
m. Limestone (see Calcium Carbonate - $CaCO_3$)
n. Magnesite (Magnesium, Magnesium carbonate)
o. Marble
p. Pentaerythritol
q. Plaster of Paris (Calcium Sulfate - $CaSO_4$)
r. Rouge
s. Silicon Carbide (Carborundum, see Emery, Corundum)
t. Starch
u. Sucrose
v. Tin Oxide
w. Titanium Oxide

***By definition, a "Nuisance" particulate/dust does not contain greater than 1% quartz or any other toxic ingredients.**

Note: "Stone" is used as a generic term and may or may not refer to materials on this list. Therefore, you must specifically identify the source material you are sampling. For example, mark an "N" when sampling stone or sand & gravel dusts <u>not</u> on this list.

19. **Job Code** - Enter the appropriate Job Code from the MSIS list.

20. **Job Description** - In addition to item 19, Job Code, briefly describe the work performed.

21. **Last Name** - Enter the last name of the person sampled.

22. **First Name** - Enter the first name of the person sampled.

23. **Location Code** - Enter the appropriate Location Code for the process or operation from the MSIS list.

24. **Location Description** - Identify the location of the process or operation where sampling occurred.

25. **Respiratory Protection (Y/N)** - Was respiratory personal protection worn? Enter Yes (Y) or No (N).

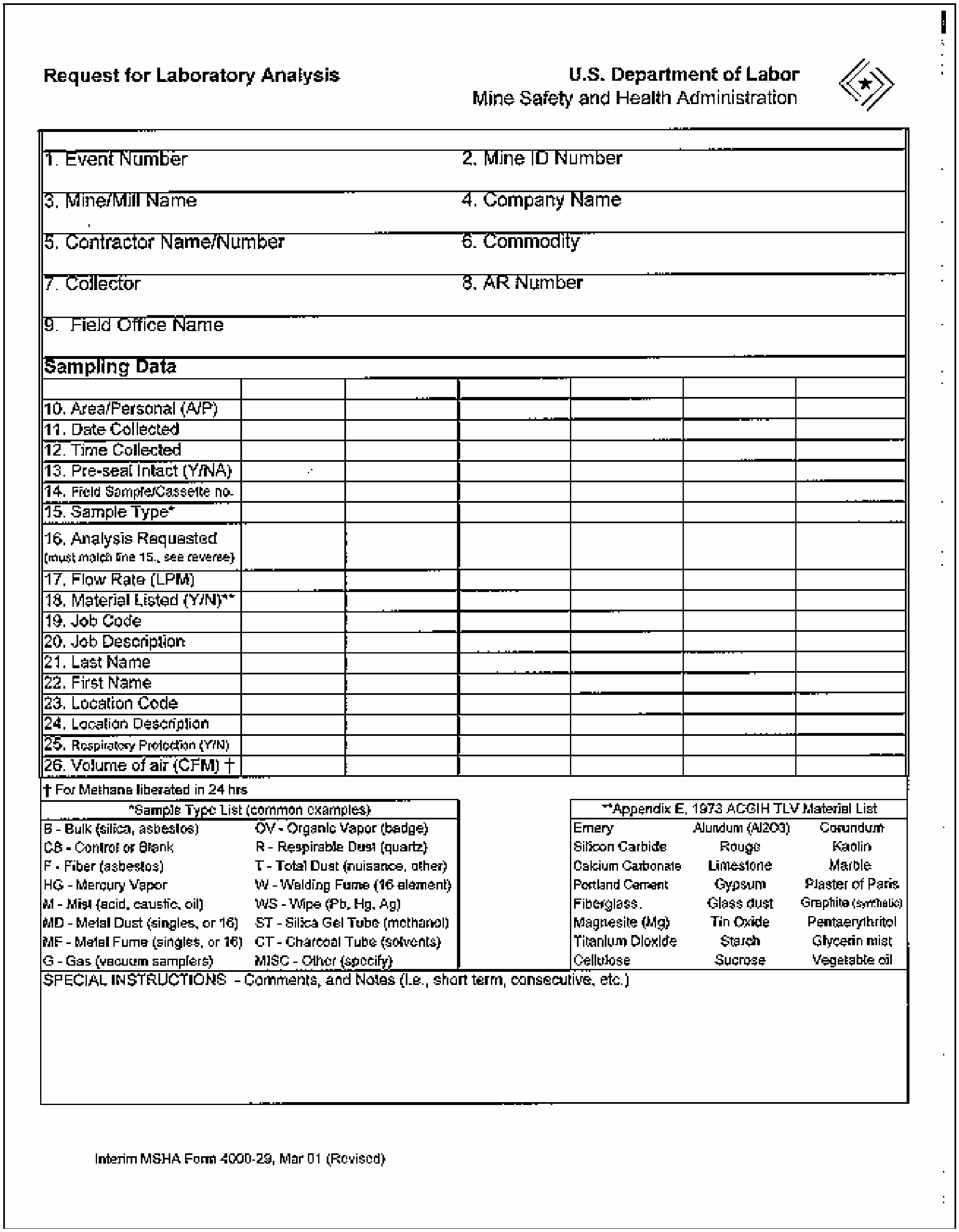
26. **Volume of Air (CFM)** - Fill out only for methane analysis to determine the amount of methane liberated in 24 hours. Enter the CFM of air calculated from a traverse. Otherwise, enter N/A or leave blank.

Special Instructions - Comments and Notes - Include any remarks that may impact the sample analysis and reporting, *e.g.*, short term sampling, consecutive sampling, screening only.

C. Recordkeeping

The inspector forwards the completed original to the MSHA Laboratory with the collected samples, and retains a photocopy for him/herself. When analysis of the sample(s) is completed, the MSHA Laboratory returns the results, an "Analytical Report", and an applicable PEDS or ASDS via e-mail directly to the collector, field office supervisor, and health specialist.

The inspector uses results contained on the Analytical Report to determine compliance and the appropriate action. For concentrations indicating overexposures exceeding the Enforcement TLV (Enf TLV), *i.e.*, a value greater than 1.0 in the C/TLV*EF column, a corresponding Action Code and Citation Number are required to be handwritten on the lab-generated PEDS. A copy of the RLA, the Analytical Report, and completed PEDS/ASDS package is sent to the District Office for review, MSIS data entry, and filing with the inspection report.



Request for Laboratory Analysis

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

1. Event Number	2. Mine ID Number
3. Mine/Mill Name	4. Company Name
5. Contractor Name/Number	6. Commodity
7. Collector	8. AR Number
9. Field Office Name	

Sampling Data

10. Area/Personal (A/P)							
11. Date Collected							
12. Time Collected							
13. Pre-seal Intact (Y/NA)							
14. Field Sample/Cassette no.							
15. Sample Type*							
16. Analysis Requested (must match line 15., see reverse)							
17. Flow Rate (LPM)							
18. Material Listed (Y/N)**							
19. Job Code							
20. Job Description							
21. Last Name							
22. First Name							
23. Location Code							
24. Location Description							
25. Respiratory Protection (Y/N)							
26. Volume of air (CFM) †							

† For Methane liberated in 24 hrs

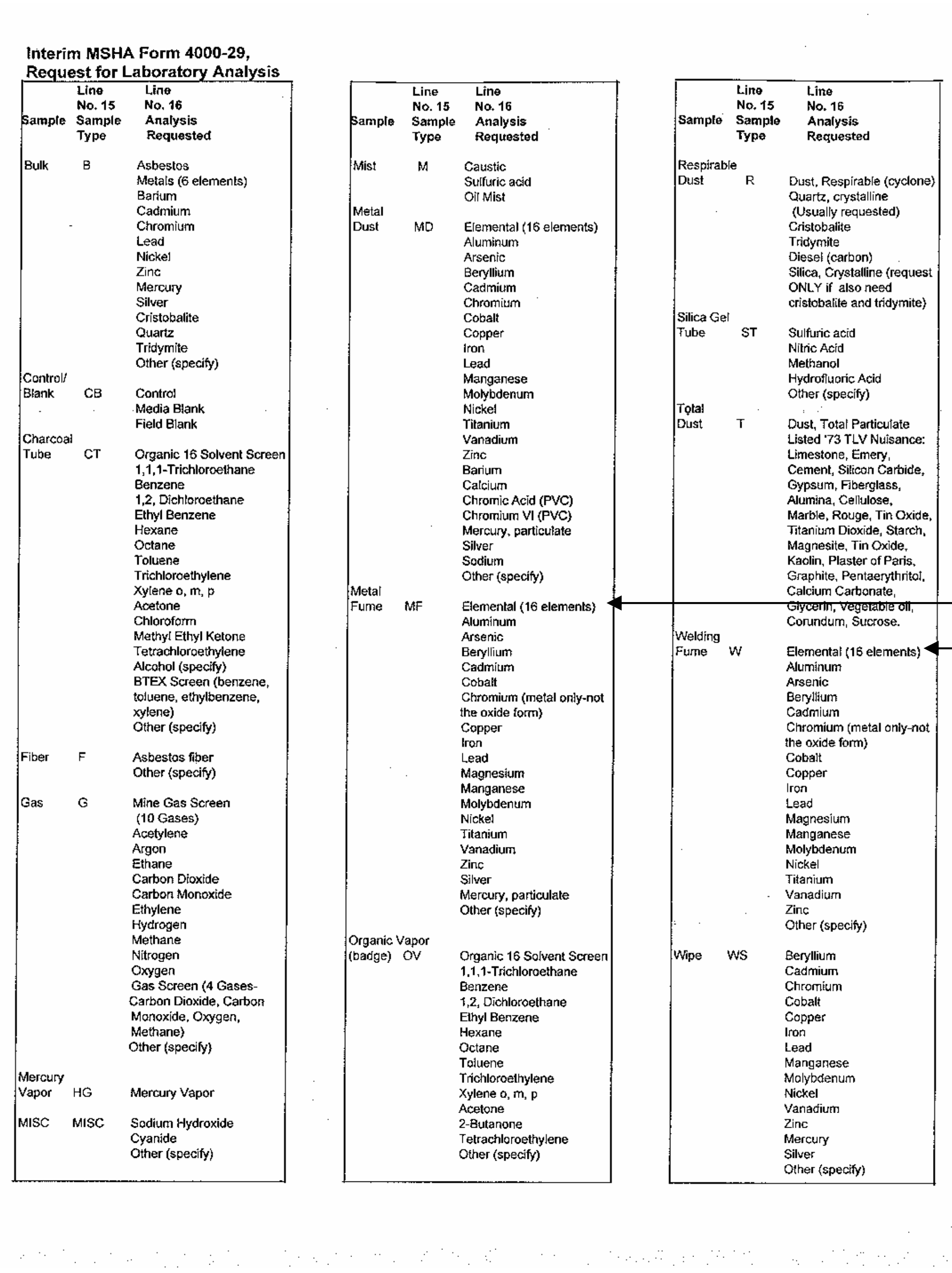
*Sample Type List (common examples)	
B - Bulk (silica, asbestos)	OV - Organic Vapor (badge)
CB - Control or Blank	R - Respirable Dust (quartz)
F - Fiber (asbestos)	T - Total Dust (nuisance, other)
HG - Mercury Vapor	W - Welding Fume (16 element)
M - Mist (acid, caustic, oil)	WS - Wipe (Pb, Hg, Ag)
MD - Metal Dust (singles, or 16)	ST - Silica Gel Tube (methanol)
MF - Metal Fume (singles, or 16)	CT - Charcoal Tube (solvents)
G - Gas (vacuum samplers)	MISC - Other (specify)

**Appendix E, 1973 ACGIH TLV Material List		
Emery	Alundum (Al2O3)	Corundum
Silicon Carbide	Rouge	Kaolin
Calcium Carbonate	Limestone	Marble
Portland Cement	Gypsum	Plaster of Paris
Fiberglass.	Glass dust	Graphite (synthetic)
Magnesite (Mg)	Tin Oxide	Pentaerythritol
Titanium Dioxide	Starch	Glycerin mist
Cellulose	Sucrose	Vegetable oil

SPECIAL INSTRUCTIONS - Comments, and Notes (i.e., short term, consecutive, etc.)

Interim MSHA Form 4000-29, Mar 01 (Revised)

Figure 21-7 Request for Laboratory Analysis, MSHA Form 4000-29



Interim MSHA Form 4000-29, Request for Laboratory Analysis

Sample	Line No. 15 Sample Type	Line No. 16 Analysis Requested
Bulk	B	Asbestos
		Metals (6 elements)
		Barium
		Cadmium
		Chromium
		Lead
		Nickel
		Zinc
		Mercury
		Silver
		Cristobalite
		Quartz
		Tridymite
		Other (specify)
Control/ Blank	CB	Control
		Media Blank
		Field Blank
Charcoal Tube	CT	Organic 16 Solvent Screen
		1,1,1-Trichloroethane
		Benzene
		1,2, Dichloroethane
		Ethyl Benzene
		Hexane
		Octane
		Toluene
		Trichloroethylene
		Xylene o, m, p
		Acetone
		Chloroform
		Methyl Ethyl Ketone
		Tetrachloroethylene
		Alcohol (specify)
		BTEX Screen (benzene, toluene, ethylbenzene, xylene)
		Other (specify)
Fiber	F	Asbestos fiber
		Other (specify)
Gas	G	Mine Gas Screen (10 Gases)
		Acetylene
		Argon
		Ethane
		Carbon Dioxide
		Carbon Monoxide
		Ethylene
		Hydrogen
		Methane
		Nitrogen
		Oxygen
		Gas Screen (4 Gases-Carbon Dioxide, Carbon Monoxide, Oxygen, Methane)
		Other (specify)
Mercury Vapor	HG	Mercury Vapor
MISC	MISC	Sodium Hydroxide
		Cyanide
		Other (specify)
Mist	M	Caustic
		Sulfuric acid
		Oil Mist
Metal Dust	MD	Elemental (16 elements)
		Aluminum
		Arsenic
		Beryllium
		Cadmium
		Chromium
		Cobalt
		Copper
		Iron
		Lead
		Manganese
		Molybdenum
		Nickel
		Titanium
		Vanadium
		Zinc
		Barium
		Calcium
		Chromic Acid (PVC)
		Chromium VI (PVC)
		Mercury, particulate
		Silver
		Sodium
		Other (specify)
Metal Fume	MF	Elemental (16 elements)
		Aluminum
		Arsenic
		Beryllium
		Cadmium
		Cobalt
		Chromium (metal only-not the oxide form)
		Copper
		Iron
		Lead
		Magnesium
		Manganese
		Molybdenum
		Nickel
		Titanium
		Vanadium
		Zinc
		Silver
		Mercury, particulate
		Other (specify)
Organic Vapor (badge)	OV	Organic 16 Solvent Screen
		1,1,1-Trichloroethane
		Benzene
		1,2, Dichloroethane
		Ethyl Benzene
		Hexane
		Octane
		Toluene
		Trichloroethylene
		Xylene o, m, p
		Acetone
		2-Butanone
		Tetrachloroethylene
		Other (specify)
Respirable Dust	R	Dust, Respirable (cyclone)
		Quartz, crystalline (Usually requested)
		Cristobalite
		Tridymite
		Diesel (carbon)
		Silica, Crystalline (request ONLY if also need cristobalite and tridymite)
Silica Gel Tube	ST	Sulfuric acid
		Nitric Acid
		Methanol
		Hydrofluoric Acid
		Other (specify)
Total Dust	T	Dust, Total Particulate Listed '73 TLV Nuisance: Limestone, Emery, Cement, Silicon Carbide, Gypsum, Fiberglass, Alumina, Cellulose, Marble, Rouge, Tin Oxide, Titanium Dioxide, Starch, Magnesite, Tin Oxide, Kaolin, Plaster of Paris, Graphite, Pentaerythritol, Calcium Carbonate, Glycerin, Vegetable oil, Corundum, Sucrose.
Welding Fume	W	Elemental (16 elements)
		Aluminum
		Arsenic
		Beryllium
		Cadmium
		Chromium (metal only-not the oxide form)
		Cobalt
		Copper
		Iron
		Lead
		Magnesium
		Manganese
		Molybdenum
		Nickel
		Titanium
		Vanadium
		Zinc
		Other (specify)
Wipe	WS	Beryllium
		Cadmium
		Chromium
		Cobalt
		Copper
		Iron
		Lead
		Manganese
		Molybdenum
		Nickel
		Vanadium
		Zinc
		Mercury
		Silver
		Other (specify)

Welding and metal dust is now a 14 metal profile, not 16 elements. Aluminum and vanadium may be requested separately

Figure 21-8 Request for Laboratory Analysis, MSHA Form 4000-29, Reverse

VIII. Personal Exposure Data Summary (MSHA Form 4000-43)

A. General Information

The Personal Exposure Data Summary (PEDS) form is used to report personal sample results to MSHA’s computer center information database. This form is completed whenever personal sampling has been conducted to evaluate an individual's exposure, to screen for potential sampling, or to report corroborative data collected during sampling. A separate form must be completed for each day's sampling at the same operation. When samples are submitted to the MSHA Laboratory with a Request for Laboratory Analysis form, a completed PEDS will be returned except for action code and citation number when a citable overexposure is reported on the analytical report. All PEDS are submitted to the district office for input into the MSHA MSIS database.

Note: Sound level meter readings used for screening or collecting corroborative data are not reported on this form. Record them in the Health Field Notes.

B. Completing the Personal Exposure Data Summary

The Personal Exposure Data Summary form will be completed by hand for personal samples where results are determined at the time of the sampling (e.g., noise, diffusion tubes, and direct reading instruments). MSHA laboratory-generated PEDS require additional handwritten information, *i.e.* action code and citation number, when a citable overexposure result is reported. In addition to the inspection and mine/contractor information, the form can accommodate information for seven samples and should be completed as follows:

1. **Add, Change, Delete –** Check the appropriate box if information previously put into the MSIS was incomplete or incorrect and complete or correct data needs to be entered or re-entered.

2. **Office Code -** Enter the four-digit field office code. Refer to Appendix 21-A.

3. **Mine ID -** Enter the 7-digit mine identification number of the mine or mill where samples were collected,.

4. **Event Number -** Enter the event number as assigned on the corresponding Inspection and Investigation Data Summary form.

5. **Contractor ID -** Enter the 7-digit alpha/numeric identification number of the contractor, if applicable.

6. **AR Number -** Enter the AR Number of the person conducting the sampling.

7. **Date -** Enter the date that the sampling was conducted.

Sampling Information

8. **Sequence Number** - This field establishes the link of the citation to the sample. The data for this field is obtained from the inspector's notes. When entering Sequence Number, enter any combination of numbers and letters. The date, AR number and sequence number make up the unique key on the MSIS**. The Sequence Number can not be repeated on any date for any given AR.** For instance, for a specific AR number, the same sequence ID of ABC can be used for different samples taken on 1/1/2006 and 1/2/2006, but cannot be used to identify different samples taken on 1/1/2006.

9. **Location Code** - Enter the code for the location where the sample was collected. Refer to Appendix 21-B.

10. **Job Code -** Enter the job code of the miner being sampled. Refer to Appendix 21-C.

11. **Contaminant Code** - Enter the code for the contaminant sampled. Refer to Appendix 21-D or Chapter 3 of this Handbook.

12. **Concentration -** Enter the contaminant concentration measured in the appropriate units as taken from the sampler. Refer to Appendix 21-D or Chapter 3 of this Handbook.

13. **Exposure Limit** - Enter the exposure limit in the appropriate units. Refer to Chapter 3.

14. **Short-Term -** Enter "Y" if sampling for a short-term exposure for comparison with STELs, ceiling limits, or excursion limits. Leave blank if sample was full-shift.

15. **Protection** - Enter "Y" if respiratory or hearing protection was worn, "N" if not.

16. **Action** - Indicate action taken as a result of the sampling. Refer to Appendix 21-E. This field must be completed any time the concentration exceeds the exposure limit or when a compliant sample is used to terminate an existing citation.

17. **Employee Name –** Enter the name of the miner who was personally sampled.

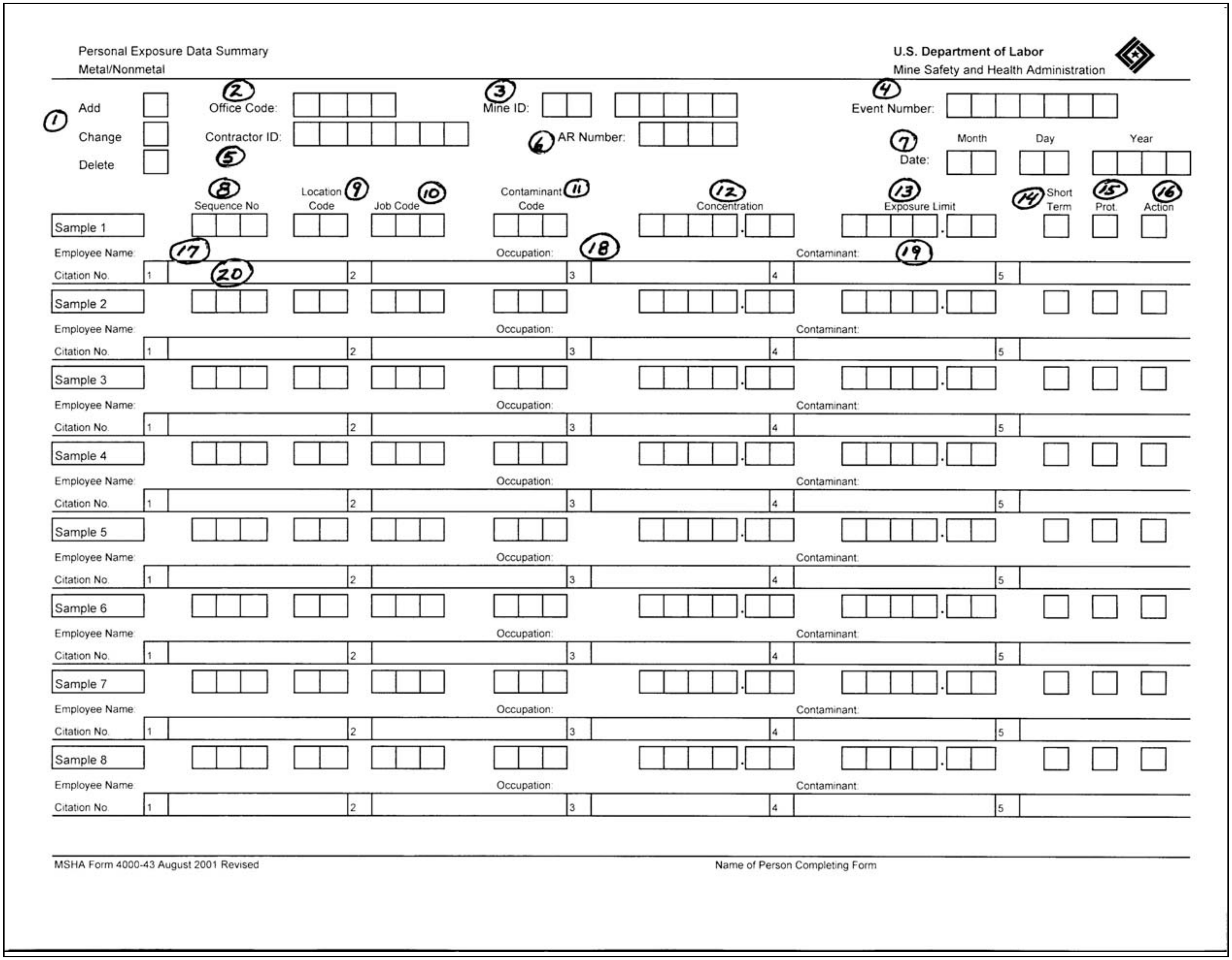
18. **Occupation –** Enter the title of the miner who was personally sampled.

19. **Contaminant** - Enter the name of the contaminant for which the miner was personally sampled. Refer to Appendix 21-D or Chapter 3 of this Handbook.

20. **Citation No. –** This field is also used to link a citation to the related sample. Record the citation number(s) if a citation is written for over-exposure to a given contaminant.

C. Recordkeeping

Submit all Personal Exposure Data Summaries (PEDS), along with inspection reports, to the district office. If the inspector must wait for sample results, submit the laboratory-generated PEDS to the district office later as an addendum to the inspection report.



Personal Exposure Data Summary
Metal/Nonmetal

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

① Add ☐
Change ☐
Delete ☐

② Office Code: ☐☐☐☐
⑤ Contractor ID: ☐☐☐☐☐☐☐
③ Mine ID: ☐☐ ☐☐☐☐☐
⑥ AR Number: ☐☐☐☐
④ Event Number: ☐☐☐☐☐☐☐
⑦ Date: Month ☐☐ Day ☐☐ Year ☐☐☐☐

	⑧ Sequence No	⑨ Location Code	⑩ Job Code	⑪ Contaminant Code	⑫ Concentration	⑬ Exposure Limit	⑭ Short Term	⑮ Prot.	⑯ Action
Sample 1	☐☐☐	☐☐	☐☐☐	☐☐☐	☐☐☐☐.☐☐	☐☐☐☐.☐☐	☐	☐	☐
Employee Name:	⑰			Occupation: ⑱		Contaminant: ⑲			
Citation No.	1 ⑳		2	3	4		5		
Sample 2	☐☐☐	☐☐	☐☐☐	☐☐☐	☐☐☐☐.☐☐	☐☐☐☐.☐☐	☐	☐	☐
Employee Name:				Occupation:		Contaminant:			
Citation No.	1		2	3	4		5		
Sample 3	☐☐☐	☐☐	☐☐☐	☐☐☐	☐☐☐☐.☐☐	☐☐☐☐.☐☐	☐	☐	☐
Employee Name:				Occupation:		Contaminant:			
Citation No.	1		2	3	4		5		
Sample 4	☐☐☐	☐☐	☐☐☐	☐☐☐	☐☐☐☐.☐☐	☐☐☐☐.☐☐	☐	☐	☐
Employee Name:				Occupation:		Contaminant:			
Citation No.	1		2	3	4		5		
Sample 5	☐☐☐	☐☐	☐☐☐	☐☐☐	☐☐☐☐.☐☐	☐☐☐☐.☐☐	☐	☐	☐
Employee Name:				Occupation:		Contaminant:			
Citation No.	1		2	3	4		5		
Sample 6	☐☐☐	☐☐	☐☐☐	☐☐☐	☐☐☐☐.☐☐	☐☐☐☐.☐☐	☐	☐	☐
Employee Name:				Occupation:		Contaminant:			
Citation No.	1		2	3	4		5		
Sample 7	☐☐☐	☐☐	☐☐☐	☐☐☐	☐☐☐☐.☐☐	☐☐☐☐.☐☐	☐	☐	☐
Employee Name:				Occupation:		Contaminant:			
Citation No.	1		2	3	4		5		
Sample 8	☐☐☐	☐☐	☐☐☐	☐☐☐	☐☐☐☐.☐☐	☐☐☐☐.☐☐	☐	☐	☐
Employee Name:				Occupation:		Contaminant:			
Citation No.	1		2	3	4		5		

MSHA Form 4000-43 August 2001 Revised

Name of Person Completing Form

Figure 21-9 Personal Exposure Data Summary, MSHA Form 4000-43

IX. Area Sample Data Summary (MSHA Form 4000-42)

A. General Information

This form is completed whenever area sampling has been conducted to evaluate mine conditions, to screen for potential sampling, or to report corroborative data collected during sampling. A separate form must be completed for each day's sampling at the same operation. Each sample taken for that event must have a unique identifier. This form is used to report samples which are not used to determine personal exposure to a contaminant or physical agent. When samples are submitted to the MSHA laboratory with a Request for Laboratory Analysis form, a completed Area Sample Data Summary (ASDS) will be returned except for Action Code and Citation Number when a citable overexposure is reported on the Analytical Report. All ASDS are submitted to the district office for input into the MSHA MSIS database.

B. Completing the Area Sample Data Summary

The Area Sample Data Summary form will be completed by hand where results are determined at the time of the area sampled (*e.g.*, noise, detector tubes, direct reading gas instruments). MSHA laboratory-generated ASDS require additional hand-written information, *i.e.* action code and citation number, when a citable overexposure result is reported. In addition to the inspection and mine/contractor information, the form can accommodate information for 12 samples and should be completed as follows:

1. **Add, Change, Delete –** Check the appropriate box if information previously put into the MSIS was incomplete or incorrect and complete or correct data needs to be entered or re-entered.

2. **Office Code** - Enter the four-digit field office code. Refer to Appendix 21-A.

3. **Mine ID -** Enter the 7-digit mine identification number of the mine or mill where samples were collected.

4. **Event Number** - Enter the Event Number as assigned on the corresponding Inspection and Investigation Data Summary.
5. **AR Number -** Enter the AR Number of the person conducting the sampling.

6. **Mine ID -** Enter the 7-digit identification number of the contractor, if applicable.

7. **Date -** Enter the date that the sampling was conducted.

8. **Sequence Number** - This field links a citation to the related sample. The data for this field is obtained from the inspector's notes. When entering Sequence Number, enter any combination of numbers and letters. The date, AR number and sequence number make up the unique key on the MSIS**. The Sequence Number can not be repeated on any date for any given AR.** For instance, for a specific AR number, the same sequence ID of ABC can be used for different samples taken on 1/1/2006 and 1/2/2006, but cannot be used to identify different samples taken on 1/1/2006.

9. **Location Code -** Enter the location code where the sample was taken. See Appendix 21-B.

10. **Area** - Write the name of or identify the area where the sample was taken.

11. **Time On** - Enter the time the sample was started.

12. **Contaminant Code -** Enter the code for the contaminant sampled. Refer to Appendix 21-D or Chapter 3 of this Handbook.

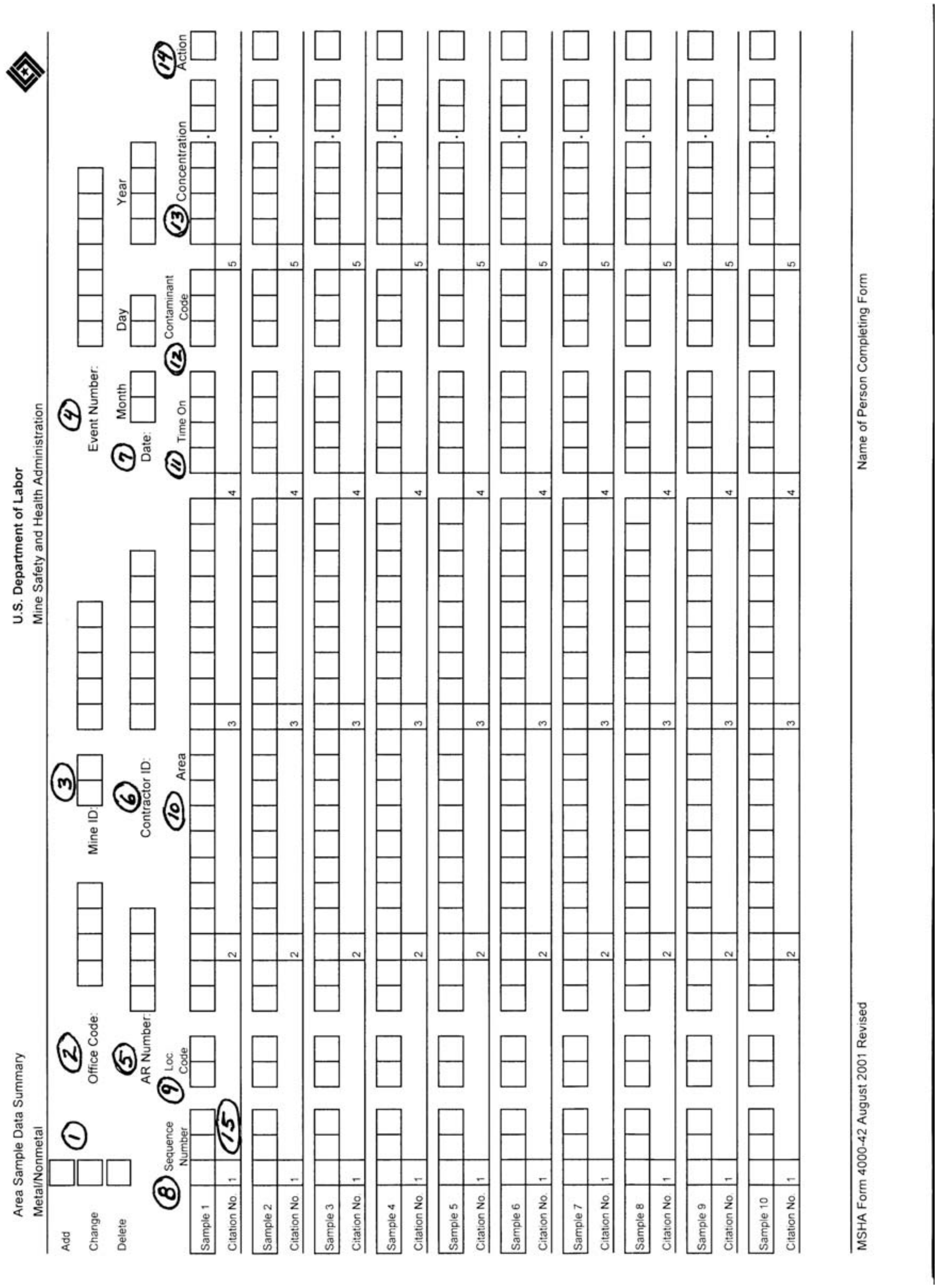
13. **Concentration** - Enter the concentration measured in the appropriate units. Refer to Appendix 21-D or Chapter 3 of this Handbook.

14. **Action** - Enter the action code that represents the action take. Refer to Appendix 21-E.

15. **Citation No. –** This field is also used to link a citation to the related sample. Record the citation number(s) if a citation is written for over-exposure to a given contaminant.

C. Recordkeeping

When sample results have been determined real time in the field by the inspector such as: noise, detector tubes, or with direct reading instruments, the inspection report is submitted to the district office including the completed Area Sample Data Summary (ASDS). If the inspector must wait for receipt of sample results submitted to the MSHA laboratory for analysis, submit the completed laboratory-generated ASDS to the district office later as an addendum to the inspection report.



Area Sample Data Summary
Metal/Nonmetal

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

① Add ☐
Change ☐
Delete ☐

② Office Code:
③ Mine ID:
④ Event Number:
⑤ AR Number:
⑥ Contractor ID:
⑦ Date: Month Day Year

⑧ Sequence Number		⑨ Loc Code	⑩ Area				⑪ Time On	⑫ Contaminant Code		⑬ Concentration	⑭ Action
Sample 1	⑮										
Citation No.	1		2	3		4			5		
Sample 2											
Citation No.	1		2	3		4			5		
Sample 3											
Citation No.	1		2	3		4			5		
Sample 4											
Citation No.	1		2	3		4			5		
Sample 5											
Citation No.	1		2	3		4			5		
Sample 6											
Citation No.	1		2	3		4			5		
Sample 7											
Citation No.	1		2	3		4			5		
Sample 8											
Citation No.	1		2	3		4			5		
Sample 9											
Citation No.	1		2	3		4			5		
Sample 10											
Citation No.	1		2	3		4			5		

MSHA Form 4000-42 August 2001 Revised

Name of Person Completing Form

Figure 21-10. Area Sample Data Summary MSHA Form 4000-42

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CHAPTER 21

APPENDICES

MSIS CODES AND CONTACT INFORMATION

APPENDIX 21-A
OFFICE CODES

Appendix 21-A

OFFICE CODES

1. Alphabetical

Code	Office
2881	Albany, NY Field Office (NE)
7651	Albany, OR Field Office (W)
5641	Albuquerque, NM Field Office (RM)
7621	Anchorage, AK Field Office (W)
3611	Bartow, FL Field Office (SE)
2641	Beckley, WV Field Duty Station - Charlottesville, VA Field Office (NE)
3661	Birmingham, AL Field Office (SE)
7611	Boise, ID Field Office (W)
7841	Boulder City, NV Field Office (W)
5631	Carlsbad, NM Field Office (SC)
2641	Charlottesville, VA Field Office (NE)
3851	Columbia, SC Field Office (SE)
5671	Dallas, TX Field Office (SC)
5651	Denham Springs, LA Field Office (SC)
6642	Denver, CO Field Office (RM)
4661	Duluth, MN Field Duty Station - Hibbing, MN Field Office (NC)
7851	Elko, NV Field Office (W)
4671	Fort Dodge, IA Field Office (NC)
3811	Franklin, TN Field Office (SE)
2851	Geneva, NY Field Office (NE)
6831	Green River, WY Field Office (RM)
6821	Helena, MT Field Office (RM)
4661	Hibbing, MN Field Office (NC)
7641	Kent, WA Field Office (W)
3861	Knoxville, TN Field Office (SE)
4631	Lansing, MI Field Office (NC)
3821	Lexington, KY Field Office (SE)
5871	Little Rock, AR Field Office (SC)
4851	Newark, OH Field Office (NC)
3631	Macon, GA Field Office (SE)
2861	Manchester, NH Field Office (NE)
4641	Marquette, MI Field Office (NC)
6861	Mesa, AZ Field Office (RM)
5861	Norman, OK Field Office (SC)
4821	Peru, IL Field Office (NC)
6621	Rapid City, SD Field Office (RM)
7831	Redlands, CA Field Office (W)
5851	Rolla (N), MO Field Office (SC)
5852	Rolla (S), MO Field Office (SC)
6851	Salt Lake City, UT Field Office (RM)
5611	San Antonio, TX Field Office (SC)
3651	San Juan, PR Field Office (SE)
3871	Sanford, NC Field Office (SE)
6651	Topeka, KS Field Office (RM)
4861	Vincennes, IN Field Office (NC)
2682	Warrendale, PA Field Office (NE)
2621	Wyomissing, PA Field Office (NE)
7821	Vacaville, CA Field Office (W)

Abbreviations:

NE - Northeast District
SE - Southeast District
W - Western District
SC - South Central District
NC - North Central District
RM - Rocky Mountain District

2. Numerical

Code	Office
2000	**NORTHEAST DISTRICT**
2621	Wyomissing, PA Field Office
2641	Charlottesville, VA Field Office
	Beckley, WV Field Duty Station
2681	Warrendale, PA Field Office
2851	Geneva, NY Field Office
2861	Manchester, NH Field Office
2881	Albany, NY Field Office
3000	**SOUTHEAST DISTRICT**
3611	Bartow, FL Field Office
3631	Macon, GA Field Office
3651	San Juan, PR Field Office
3661	Birmingham, AL Field Office
3811	Franklin, TN Field Office
3821	Lexington, KY Field Office
3851	Columbia, SC Field Office
3861	Knoxville, TN Field Office
3871	Sanford, NC Field Office
4000	**NORTH CENTRAL DISTRICT**
4631	Lansing, MI Field Office
4641	Marquette, MI Field Office
4661	Hibbing, MN Field Office
	Duluth, MN Field Duty Station
4671	Fort Dodge, IA Field Office
4821	Peru, IL Field Office
4851	Newark, OH Field Office
4861	Vincennes, IN Field Office
5000	**SOUTH CENTRAL DISTRICT**
5611	San Antonio, TX Field Office
5631	Carlsbad, NM Field Office
5641	Albuquerque, NM Field Office
5651	Denham Springs, LA Field Office
5671	Dallas, TX Field Office
5851	Rolla (N), MO Field Office
5852	Rolla (S), MO Field Office
5861	Norman, OK Field Office
5871	Little Rock, AR Field Office
6000	**ROCKY MOUNTAIN DISTRICT**
6621	Rapid City, SD Field Office
6642	Denver, CO Field Office
6651	Topeka, KS Field Office
6821	Helena, MT Field Office
6831	Green River, WY Field Office
6851	Salt Lake City, UT Field Office
6861	Mesa, AZ Field Office
7000	**WESTERN DISTRICT**
7611	Boise, ID Field Office
7621	Coeur d'Alene, ID Field Office
7641	Kent, WA Field Office
7651	Albany, OR Field Office
7821	Vacaville, CA Field Office
7831	Redlands, CA Field Office
7841	Boulder City, NV Field Office
7851	Elko, NV Field Office
7861	Anchorage, AK Field Office

Abbreviations:

NE - Northeast District
SE - Southeast District
W - Western District
SC - South Central District
NC - North Central District
RM - Rocky Mountain District

APPENDIX 21-B
LOCATION CODES

Appendix 21-B

LOCATION CODES

1. Alphabetical

Code	Location	Area(s)
31	Surface	Active Mining (production)
01	Underground	Active Mining (production)
83	Mill or Plant	Bagging or Packaging
85	Mill or Plant	Construction
51	Surface	Construction
21	Underground	Construction
61	Mill or Plant	Crushing
37	On Water	Dredges or Barges
67	Mill or Plant	Dry Screening
69	Mill or Plant	Drying and Roasting
33	Surface	Exploration and Development
03	Underground	Exploration and Development
79	Mill or Plant	Flotation and Reagent Areas
77	Mill or Plant	General (i.e., employee works in a number of areas)
49	Surface	General (i.e., employee works in a number of areas)
19	Underground	General (i.e., employee works in a number of areas)
63	Mill or Plant	Grinding
09	Underground	Hoistrooms
99	Anywhere	Laboratories
71	Mill or Plant	Load-in/out, Stockpiles, Other Ore Transfer Points
43	Surface	Load-in/out, Stockpiles, Other Ore Transfer Points
13	Underground	Load-in/out, Stockpiles, Other Ore Transfer Points
75	Mill or Plant	Offices, Lunchrooms, Storerooms
47	Surface	Offices, Lunchrooms, Storerooms
17	Underground	Offices, Lunchrooms, Storerooms
41	Surface	Ore Processing (primary crushing)
11	Underground	Ore Processing (crushing, grinding, washing, screening, bagging, etc.)
81	Mill or Plant	Pelletizing
35	Surface	Roads (haulage, access, other travelways)
39	Surface	Tailings Ponds or Dams
05	Underground	Travelways and Haulageways
07	Underground	Shafts and Stations
73	Mill or Plant	Shops
45	Surface	Shops
15	Underground	Shops
65	Mill or Plant	Washing and Screening

2. Numerical

Code	Location	Area(s)
01	Underground	Active Mining (production)
03	Underground	Exploration and Development
05	Underground	Travelways and Haulageways
07	Underground	Shafts and Stations
09	Underground	Hoistrooms
11	Underground	Ore Processing (crushing, grinding, washing, screening, bagging, etc.)
13	Underground	Load-in/out, Stockpiles, Other Ore Transfer Points
15	Underground	Shops
17	Underground	Offices, Lunchrooms, Storerooms
19	Underground	General (i.e., employee works in a number of areas)
21	Underground	Construction
31	Surface	Active Mining (production)
33	Surface	Exploration and Development
35	Surface	Roads (haulage, access, other travelways)
37	On Water	Dredges or Barges
39	Surface	Tailings Ponds or Dams
41	Surface	Ore Processing (primary crushing)
43	Surface	Load-in/out, Stockpiles, Other Ore Transfer Points
45	Surface	Shops
47	Surface	Offices, Lunchrooms, Storerooms
49	Surface	General (i.e., employee works in a number of areas)
51	Surface	Construction
61	Mill or Plant	Crushing
63	Mill or Plant	Grinding
65	Mill or Plant	Washing and Screening
67	Mill or Plant	Dry Screening
69	Mill or Plant	Drying and Roasting
71	Mill or Plant	Load-in/out, Stockpiles, Other Ore Transfer Points
73	Mill or Plant	Shops
75	Mill or Plant	Offices, Lunchrooms, Storerooms
77	Mill or Plant	General (i.e., employee works in a number of areas)
79	Mill or Plant	Flotation and Reagent Areas
81	Mill or Plant	Pelletizing
83	Mill or Plant	Bagging or Packaging
85	Mill or Plant	Construction
99	Anywhere	Laboratories

APPENDIX 21-C
JOB CODES

Appendix 21-C

JOB CODES

1. Alphabetical

Code	Job
649	Administration personnel
420	Aerial tram operator
778	Backhoe operator
879	Bagger/bagging operations worker
372	Barge attendant
261	Battery station operator
154	Belt cleaner/belt picker
612	Belt vulcanizer
669	Bin puller
342	Bit grinder/bit sharpener
807	Blaster - Development and Production
372	Boat operator
825	Bobcat operator
513	Building repair & maintenance
368	Bulldozer operator
616	Bullgang
920	Cager/cage attendant
344	Car shake-out operator
394	Carpenter
716	Cement man
607	Chipping hammer operator
833	Chuck tender
434	Churn drill operator
045	Chute blaster
331	Clamshell operator
613	Cleanup man
679	Concentrator operator/worker
716	Concrete worker
035	Continuous miner helper
036	Continuous miner operator
601	Conveyor belt crew
079	Crusher operator/worker
037	Cutting machine helper
038	Cutting machine operator
379	Kiln operator/worker
399	Dimension stone cutter/sawyer/ splitter/trimmer/finisher
678	Dragline operator
372	Dredge operator
058	Drift miner
833	Drill helper
488	Dry-screening plant worker
379	Dryer operator
622	Dump operator
602	Electrician
603	Electrician helper
456	Engineer (ventilation/electric/mining)
679	Flotation mill operator
389	Forklift operator
782	Front-end loader operator
043	Gathering arm loader operator
618	Greaser
726	Grizzly man/grizzly tender
710	Ground control
706	Gunite man
279	Hammer mill operator/worker
039	Hand loader (load only)
739	Hand trammer (load & dump)
045	Hangup man
921	Hoist operator
479	Hydrating plant operator/worker
352	Iron worker
607	Jackhammer operator
534	Jackleg/stoper drill operator
041	Jacksetter
413	Janitor
134	Jet piercing channeler operator
234	Jet piercing drill operator
934	Jumbo percussion drill operator
614	Lab technician

514	Laboratory technician
616	Laborer
385	Lampman
673	Leaching operations worker
728	Load-Haul-Dump - complete cycle
660	Machinist
649	Management personnel
608	Mason
604	Mechanic
352	Metal worker
179	Mill operator (rod/ball/pebble)
804	Millwright
579	Mixing operations worker
378	Mobile crane operator
969	Motorman
029	Mucking machine operator
609	Mipper
618	Oiler
878	Overhead crane operator
979	Packaging operations worker
894	Painter
079	Pan-feeder operator
779	Pelletizing operator/worker
804	Pipefitter
804	Plumber
807	Powder man/powder gang
579	Pumping operations worker
759	Raise borer operator
059	Raise miner
850	Ram car operator
514	Refiner/laboratory technician
375	Road grader operator
046	Rock bolter
399	Rock sawyer
046	Roof bolter
048	Roof bolter, mounted
387	Rotary bucket excavator operator
622	Rotary dump operator
634	Rotary electric drill operator
734	Rotary pneumatic drill operator
416	Salvage worker
619	Welder
397	Yard engine operator/engineer
614	Sampler, dust
765	Sand filler (dry)
766	Sand filler (wet)
393	Scale man
747	Scaler (hand)
847	Scaler (mechanical)
388	Scalper-screen operator
048	Scoop tram operator
763	Shaft repairer
807	Shooter/shotfirer
706	Shotcrete man
367	Shovel operator
750	Shuttle car operator (diesel)
950	Shuttle car operator (elec.)
588	Sizing operations worker
392	Skip dumper
930	Skip tender
579	Slurry operations worker
030	Slusher
930	Station attendant
057	Stope miner
674	Supply handler
609	Supply man
623	Surveyor/survey crew
962	Swamper
516	Tamping machine operator
456	Technical services
710	Timberman
392	Tipple operator/toplander
216	Track man/track gang
668	Tractor operator
623	Transit man
962	Trip rider
376	Truck driver
669	Truck loader
053	Utility man
708	Ventilation crew
334	Wagon drill operator
674	Warehouse man
588	Washing operations worker
393	Weighman

2. Numerical

Code	**Job**
028	Scoop tram operator
029	Mucking machine operator
030	Slusher operator
032	Brattice man (ventilation man)
034	Diamond drill operator (surface/UG)
035	Continuous miner helper
036	Continuous miner operator
037	Cutting machine helper
038	Cutting machine operator
039	Hand loader (load only)
041	Jacksetter
043	Gathering arm loader operator
045	Chute blaster
046	Rock bolter/roof bolter
048	Roof bolter, mounted
053	Utility man/laborer
057	Stope miner
058	Drift miner
059	Raise miner
079	Crusher operator/pan-feeder operator
134	Jet piercing channeler operator
154	Belt cleaner/beltpicker/conveyor crew
179	Mill operator (rod/ball/pebble)
216	Track man/track gang
234	Jet piercing drill operator
261	Battery station operator
279	Hammer mill operator
331	Clamshell operator
334	Wagon drill operator
342	Bit grinder/bit sharpener/machinist
344	Car shake-out operator/car dumper
352	Iron worker/metal worker
367	Shovel operator
368	Bulldozer operator
372	Barge attendant/boat operator/ dredge operator
375	Road grader operator
376	Truck driver
378	Mobile crane operator
379	Dryer operator/kiln operator
385	Lampman
387	Rotary bucker excavator operator
388	Scalper-screen operator
389	Forklift operator
392	Toplander/skip dumper/tipple operator
393	Weighman/scale man
394	Carpenter/plumber/painter
397	Yard engine operator/fireman
399	Dimension stone cutter/sawyer/splitter/ trimmer/finisher
413	Janitor
416	Salvage worker
420	Aerial tram operator
434	Churn drill operator
456	Engineer (ventilation/electric/mining)
479	Hydrating plant operator
488	Dry screening-plant operator
513	Building repair & maintenance
514	Laboratory technician/Refiner
516	Tamping machine operator
534	Jackleg operator/stoper drill operator
579	Slurry operator/mixing operator/ pumping operator/pumper
588	Sizing/washing operations worker
601	Conveyor belt crew
602	Electrician/wireman
603	Electrician helper

604	Mechanic
607	Jackhammer operator/chipping hammer operator
608	Mason/bricklayer
609	Supply man/nipper
612	Belt vulcanizer
613	Cleanup man
614	Sampler/lab technician
616	Laborer/utility man
618	Greaser/oiler
619	Welder
622	Dump operator
623	Surveyor/transit man
634	Rotary electric/hydraulic drill operator
649	Administration/supervisory personnel
660	Machinist
663	Shaft miner/shaft repairer
668	Tractor operator
669	Bin puller/truck loader
673	Leaching operations worker
674	Warehouseman/supply handler
678	Dragline operator
679	Flotation/concentrator operator
682	Pan scraper operator
706	Shotcrete man/gunite man
708	Ventilation crew
710	Ground control/timberman
716	Cement man/concrete worker
726	Grizzly man/grizzly tender
728	Load-Haul-Dump - complete cycle
734	Rotary pneumatic drill operator
739	Hand trammer (load & dump)
747	Scaler (hand)
750	Shuttle car operator (diesel)
759	Raise borer operator
763	Shaft miner/shaft repairer
765	Sand filler (dry)
766	Sand filler (wet)
778	Backhoe operator
779	Pelletizing operations worker
782	Front-end loader operator
804	Plumber/pipefitter/millwright
807	Powder man/shotfirer/shooter/blaster
825	Bobcat operator
833	Drill helper/chuck tender
847	Scaler (mechanical)
850	Ramcar operator
878	Overhead crane operator
879	Bagger/bagging operations worker
894	Painter
921	Hoist operator/hoistman-engineer
930	Skip tender/cager/station attendant
934	Jumbo percussion drill operator
950	Shuttle (elec.) car operator
962	Trip rider/swamper
969	Motorman
979	Packaging operations worker

APPENDIX 21-D
CONTAMINANT CODES

Appendix 21-D

CONTAMINANT CODES

1. Alphabetical

Code	Unit	Contaminant
443	ppm	Acetaldehyde
243	ppm	Acetone
995	ppm	Acetic acid
801	WL	Alpha radiation
151	mg/m^3	Aluminum oxide dust
703	mg/m^3	Aluminum oxide fume, as Al_2O_3
401	ppm	Ammonia
611	$\mu g/m^3$	Antimony dusts, as Sb
705	$\mu g/m^3$	Antimony fume, as Sb
707	$\mu g/m^3$	Arsenic fume, as As
313	ppb	Arsine
501	fibers/mL	Asbestos, fibers >5 µm in length
537	mg/m^3	Asphalt (petroleum) fumes
641	$\mu g/m^3$	Barium, soluble compounds
603	ppm	Benzene
541	$\mu g/m^3$	Beryllium dusts
709	$\mu g/m^3$	Beryllium fume
161	mg/m^3	Boron oxide
483	ppb	Bromine
251	ppm	2-Butanone (MEK)
245	ppm	n-Butyl alcohol
623	$\mu g/m^3$	Cadmium, metal dusts and soluble salts, as Cd
711	$\mu g/m^3$	Cadmium oxide fume, as Cd
451	mg/m^3	Calcium oxide
533	mg/m^3	Carbon black
105	%	Carbon dioxide, CO_2
631	ppm	Carbon disulfide
111	ppm	Carbon monoxide, CO
601	ppm	Carbon tetrachloride
485	ppm	Chlorine
605	$\mu g/m^3$	Chlorodiphenyl (42% chlorine)
607	$\mu g/m^3$	Chlorodiphenyl (54% chlorine)
995	ppm	Chloroform
543	$\mu g/m^3$	Chromic acid and chromate dusts, as CrO_3

713	µg/m^3	Chromic acid and chromate fume, as CrO$_3$
545	µg/m^3	Chromium, soluble chromic and chromous salts, as Cr
547	mg/m^3	Chromium, metal and insoluble salts
531	mg/m^3	Coal dust, respirable fraction, <5% quartz
649	µg/m^3	Cobalt dusts
715	µg/m^3	Cobalt fume
171	mg/m^3	Copper, dusts and mists
717	µg/m^3	Copper fume
447	ppm	Cresol
525	mg/m^3	Cristobalite, respirable fraction
419	mg/m^3	Cyanides, as CN
995	ppm	Cyclohexanone
995	ppm	1,2-Dichloroethane
555	µg/m^3	Elemental Carbon, EC
995	ppm	Ethyl alcohol
995	ppm	Ethyl Benzene
261	ppm	Ethylene glycol
505	fibers/mL	Fibers, >5 µm in length (non-asbestos, non-talc, not Identified)
173	mg/m^3	Ferrovanadium dust
441	ppm	Formaldehyde
417	mg/m^3	Fluoride dusts, as F
719	mg/m^3	Fluoride fume, as F
487	ppm	Fluorine
803	mR/hr	Gamma radiation
517	mppcf*	Graphite (natural)
659	ppm	Hexane (n-hexane)
249	ppm	Hexone (MIBK)
411	ppm	Hydrogen bromide
413	ppm	Hydrogen chloride
309	ppm	Hydrogen cyanide
415	ppm	Hydrogen fluoride
305	ppm	Hydrogen sulfide
175	mg/m^3	Iron, soluble salts, as Fe
721	mg/m^3	Iron oxide fume
723	µg/m^3	Lead fume
635	mg/m^3	Lead, inorganic dusts
101	%	Oxygen, O$_2$
255	ppm	n-Propyl alcohol
647	mg/m^3	Manganese dusts, as Mn
727	mg/m^3	Manganese fume, as Mn
725	mg/m^3	Magnesium oxide fume
307	ppb	Mercaptans (alkylthiols)

625	µg/m^3	Mercury, all dusts, fumes and vapors (except alkyl) from sources other than welding, cutting, brazing, hard surfacing, or soldering, as Hg
729	µg/m^3	Mercury fume and vapor from welding, cutting, brazing, hard surfacing, or soldering, as Hg
995	ppm	Mesitylene (Mesityl oxide)
103	%	Methane, CH_4
231	ppm	Methanol
205	ppm	Methyl chloroform
233	ppm	Methyl isobutyl carbinol
201	ppm	Methylene chloride
513	mppcf	Mica
995	Varies	Miscellaneous contaminants
999	Varies	Mixed contaminants
731	mg/m^3	Molybdenum fume
163	mg/m^3	Molybdenum, insoluble dusts
645	mg/m^3	Molybdenum, soluble compounds
253	ppm	Naphtha
733	mg/m^3	Nickel fume, as Ni
621	mg/m^3	Nickel, metal and insoluble dusts, as Ni
491	ppm	Nitric acid
301	ppm	Nitric oxide
493	ppm	Nitrogen dioxide
811	%	Noise, dosimeter (permissible exposure levels)
813	dBA	Noise, sound level meter (115 maximum permissible sound level)
880	%	Noise, dosimeter (action level)
121	mg/m^3	Nuisance dust, listed, respirable fraction, less than (<)1% silica
995	ppm	Octane
535	mg/m^3	Oil mist, total particulate
481	ppb	Ozone
218	ppm	Perchloroethylene
515	mppcf*	Perlite
445	ppm	Phenol
495	ppb	Phosgene
315	ppb	Phosphine
435	mg/m^3	Phosphorus pentasulfide
651	µg/m^3	Platinum, soluble salts, as Pt
453	mg/m^3	Potassium hydroxide

257	ppm	n-Propyl acetate
523	mg/m^3	Quartz $\geq$1% respirable fraction
521	mg/m^3	Respirable dust (not analyzed)
627	µg/m^3	Selenium compounds, as Se
519	mppcf	Silica (amorphous)
653	µg/m^3	Silver, metal and soluble compounds
735	µg/m^3	Silver fume
455	mg/m^3	Sodium hydroxide
311	ppb	Stibine
241	ppm	Stoddard solvent
259	ppm	Styrene
421	ppm	Sulfur dioxide
423	mg/m^3	Sulfuric acid mist
503	fibers/mL	Talc, fibers >5 µm in length
511	mppcf*	Talc, nonfiberous, <1% quartz
321	µg/m^3	Tellurium
655	µg/m^3	Thallium, soluble compounds, as Tl
325	mg/m^3	Tin, inorganic dusts (except SnH_4 and SnO_2), as Sn
157	mg/m^3	Tin oxide dust
737	mg/m^3	Tin oxide fume
153	mg/m^3	Titanium dioxide dust
739	mg/m^3	Titanium dioxide fume, as TiO_2
551	µg/m^3	Total Carbon, TC
553	µg/m^3	Total Carbon, calculated from Elemental Carbon
123	mg/m^3	Total dust, nuisance, listed particulate
133	mg/m^3	Total dust, unlisted particulate
211	ppm	Trichloroethylene
207	ppm	1,1,2-Trichloroethane
221	ppm	Toluene
527	mg/m^3	Tridymite, respirable fraction
741	mg/m^3	Tungsten fume, as W
155	mg/m^3	Tungsten, insoluble dusts, as W
323	mg/m^3	Tungsten, soluble compounds, as W
131	mg/m^3	Unlisted dust, respirable fraction, <1% silica
657	µg/m^3	Uranium and compounds (natural), as U
471	µg/m^3	Vanadium (V_2O_5) Dusts, as V
743	µg/m^3	Vanadium fume, (V_2O_5), as V
223	ppm	Xylene
995	ppm	m-Xylene
995	ppm	o-Xylene

995	ppm	p-Xylene
745	mg/m^3	Zinc oxide fume
643	mg/m^3	Zirconium compounds, as Zr

2. Numerical/ Health Effect Listing

Code	Unit	Contaminant
Low Risk Health Effects		
101	%	Oxygen, O_2
103	%	Methane, CH_4
105	%	Carbon dioxide, CO_2
111	ppm	Carbon monoxide, CO
121	mg/m^3	Nuisance dust, listed, respirable fraction, <1% silica
123	mg/m^3	Total dust, nuisance, listed particulate
131	mg/m^3	Unlisted dust, respirable fraction, <1% silica
133	mg/m^3	Total dust, unlisted particulate
151	mg/m^3	Aluminum oxide dust
153	mg/m^3	Titanium dioxide dust
155	mg/m^3	Tungsten, insoluble dusts, as W
157	mg/m^3	Tin oxide dust
161	mg/m^3	Boron oxide
163	mg/m^3	Molybdenum, insoluble dusts
171	mg/m^3	Copper, dusts and mists
173	mg/m^3	Ferrovanadium dust
175	mg/m^3	Iron, soluble salts, as Fe
Narcosis		
201	ppm	Methylene chloride
205	ppm	Methyl chloroform
207	ppm	1,1,2-Trichloroethane
211	ppm	Trichloroethylene
218	ppm	Perchloroethylene
221	ppm	Toluene
223	ppm	Xylene
995	ppm	m-Xylene
995	ppm	o-Xylene
995	ppm	p-Xylene
231	ppm	Methanol
233	ppm	Methyl isobutyl carbinol
241	ppm	Stoddard solvent
243	ppm	Acetone

245	ppm	n-Butyl alcohol
247	ppm	Ethyl alcohol
249	ppm	Hexone (MIBK)
251	ppm	2-Butanone (MEK)
253	ppm	Naphtha
255	ppm	n-Propyl alcohol
257	ppm	n-Propyl acetate
259	ppm	Styrene
261	ppm	Ethylene glycol
995	ppm	1,2-Dichloroethane
995	ppm	Cyclohexanone
995	ppm	Ethyl Benzene
995	ppm	Mesitylene (Mesityl oxide)
995	ppm	Octane

Acute Toxicity

301	ppm	Nitric oxide
305	ppm	Hydrogen sulfide
307	ppb	Mercaptans (alkylthiols)
309	ppm	Hydrogen cyanide
311	ppb	Stibine
313	ppb	Arsine
315	ppb	Phosphine
321	µg/m^3	Tellurium
323	mg/m^3	Tungsten, soluble compounds, as W
325	mg/m^3	Tin, inorganic dusts (except SnH_4 and SnO_2), as Sn

Acute Toxicity/Marked Irritation

401	ppm	Ammonia
411	ppm	Hydrogen bromide
413	ppm	Hydrogen chloride
415	ppm	Hydrogen fluoride
417	mg/m^3	Fluoride dusts, as F
419	mg/m^3	Cyanides, as CN
421	ppm	Sulfur dioxide
433	ppm	Acetic acid
423	mg/m^3	Sulfuric acid mist
435	mg/m^3	Phosphorus pentasulfide
441	ppm	Formaldehyde
443	ppm	Acetaldehyde
445	ppm	Phenol
447	ppm	Cresol
451	mg/m^3	Calcium oxide
453	mg/m^3	Potassium hydroxide

455	mg/m^3	Sodium hydroxide
471	$\mu g/m^3$	Vanadium (V_2O_5) Dusts, as V
481	ppb	Ozone
483	ppb	Bromine
485	ppm	Chlorine
487	ppm	Fluorine
491	ppm	Nitric acid
493	ppm	Nitrogen dioxide
495	ppb	Phosgene

Pulmonary Disease

501	fibers/mL	Asbestos, fibers >5 µm in length
503	fibers/mL	Talc, fibers >5 µm in length
505	fibers/mL	Fibers, >5 µm in length (non-asbestos, non-talc, not identified)
511	mppcf*	Talc, nonfiberous,<1% quartz
513	mppcf	Mica
515	mppcf*	Perlite
517	mppcf*	Graphite (natural)
519	mppcf	Silica (amorphous)
521	mg/m^3	Respirable dust (quartz not analyzed)
523	mg/m^3	Quartz $\geq$1%, respirable fraction
525	mg/m^3	Cristobalite, respirable fraction
527	mg/m^3	Tridymite, respirable fraction
531	mg/m^3	Coal dust, respirable fraction, <5% quartz
533	mg/m^3	Carbon black
535	mg/m^3	Oil mist, total particulate
537	mg/m^3	Asphalt (petroleum) fumes
541	$\mu g/m^3$	Beryllium dusts
543	$\mu g/m^3$	Chromic acid and chromate dusts, as CrO_3
545	$\mu g/m^3$	Chromium, soluble chromic and chromous salts, as Cr
547	mg/m^3	Chromium, metal and insoluble salts
551	$\mu g/m^3$	Total Carbon, TC
553	$\mu g/m^3$	Total Carbon, calculated from Elemental Carbon
555	$\mu g/m^3$	Elemental Carbon, EC
557	$\mu g/m^3$	TC@350
559	$\mu g/m^3$	EC@350

Chronic Toxicity

601	ppm	Carbon tetrachloride
603	ppm	Benzene
605	µg/m^3	Chlorodiphenyl (42% chlorine)
607	µg/m^3	Chlorodiphenyl (54% chlorine)
611	µg/m^3	Antimony dusts, as Sb
613	µg/m^3	Arsenic dusts, As
621	mg/m^3	Nickel, metal and insoluble dusts, as Ni
623	µg/m^3	Cadmium, metal dusts and soluble salts, as Cd
625	µg/m^3	Mercury, all dusts, fumes and vapors (except alkyl) from sources other than welding, cutting, brazing, hard surfacing, or soldering, as Hg
627	µg/m^3	Selenium compounds, as Se
631	ppm	Carbon disulfide
635	mg/m^3	Lead, inorganic dusts
641	µg/m^3	Barium, soluble compounds
643	mg/m^3	Zirconium compounds, as Zr
645	mg/m^3	Molybdenum, soluble compounds
647	mg/m^3	Manganese dusts, as Mn
649	µg/m^3	Cobalt dusts
651	µg/m^3	Platinum, soluble salts, as Pt
653	µg/m^3	Silver, metal and soluble compounds
655	µg/m^3	Thallium, soluble compounds, as Tl
657	µg/m^3	Uranium and compounds (natural), as U
659	ppm	Hexane (n-hexane)
995	ppm	Chloroform

Metal Fumes

703	mg/m^3	Aluminum oxide fume, as Al_2O_3
705	µg/m^3	Antimony fume, as Sb
707	µg/m^3	Arsenic fume, As
709	µg/m^3	Beryllium fume
711	µg/m^3	Cadmium oxide fume, as Cd
601	ppm	Carbon tetrachloride
713	µg/m^3	Chromic acid and chromate fume, as CrO_3
715	µg/m^3	Cobalt fume
717	µg/m^3	Copper fume
719	mg/m^3	Fluoride fume, as F
721	mg/m^3	Iron oxide fume

723	µg/m^3	Lead fume
725	mg/m^3	Magnesium oxide fume
727	mg/m^3	Manganese fume, as Mn
729	µg/m^3	Mercury fume and vapor from welding, cutting, brazing, hard surfacing, or soldering, as Hg
731	mg/m^3	Molybdenum fume
733	mg/m^3	Nickel fume, as Ni
735	µg/m^3	Silver fume
737	mg/m^3	Tin oxide fume
739	mg/m^3	Titanium dioxide fume, as TiO_2
741	mg/m^3	Tungsten fume, as W
743	µg/m^3	Vanadium fume, (V_2O_5), as V
745	mg/m^3	Zinc oxide fume

Physical Agents

801	WL	Alpha radiation
803	mR/hr	Gamma radiation
811	%	Noise, dosimeter (90 dBA permissible exposure level)
813	dBA	Noise, sound level meter (115 dBA maximum sound level)
880	%	Noise, dosimeter (action level)

Miscellaneous

995	Varies	Misc. contaminants

Mixed

999	Varies	Mixed contaminants

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APPENDIX 21-E
ACTION CODES FOR ASDS AND PEDS

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Appendix 21-E

ACTION CODES FOR ASDS AND PEDS

Code	**Explanation**
C	Citation (or order) issued.
E	Overexposure occurred, but does not meet or exceed permissible limit and applicable error factor.
H	PEDS only - the Action Level for noise exposure was exceeded, but not the PEL, and an adequate Hearing Conservation Plan was in effect.
N	ASDS only - no citation (or order) issued, even though contaminant level exceeded applicable standard (reasons must be in health field notes, MSHA form 4000-31).
P	PEDS only - citable overexposure occurred, but all feasible engineering and administrative controls have been implemented and a fully adequate HCP program is in place. **Note:** This code cannot be used without approval from the District and must be clearly documented in the notes.
T	Citation (or order) terminated.
X	Citation extended, or existing citation not yet due for abatement.
L	Lab only – Denotes overexposure conditions exist and enforcement action required
D	Citable overexposure of 551/553 (Carbon, Total) or 555 (Elemental Carbon) occurred, but all feasible engineering controls have been implemented and a fully adequate PPE program is in place.

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APPENDIX 21-F
ADDRESSES AND CONTACT INFORMATION FOR MSHA LABORATORIES AND OFFICES

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Appendix 21-F

ADDRESSES AND CONTACT INFORMATION FOR MSHA LABORATORIES AND OFFICES

1. For questions concerning noise, organic and solvents analysis, heat stress, vapors, mists, and gases, call or write:

   Chief, Physical and Toxic Agents Division
   Pittsburgh Safety and Health Technology Center
   P.O. Box 18233
   Cochrans Mill Road
   Pittsburgh, PA 15236
   Phone: (412) 386-6980
   FAX: (412) 386-6154

   Note: Add to the address, ATTN: Bldg. 38, Room 137 - for the Acoustical Calibration Laboratory which calibrates personal noise dosimeters and acoustical calibrators.

   Add to the address, ATTN: Bldg. 38 - for Toxic Materials Laboratory, which analyzes sorbent media for mists and vapors or vacuum samples for mine gases.

2. For questions concerning ionizing radiation, call or write:

   Chief, Physical and Toxic Agents Division
   R.R. 1, Box 251
   Industrial Park Road
   Triadelphia, WV 26059
   Phone: (412) 386-6980 or (304) 547-2308
   FAX: (412) 386-6154 or (304) 547-2071

3. For questions concerning dusts, fibers, and fumes, call or write:

   Chief, Dust Division
   Pittsburgh Safety and Health Technology Center
   P.O. Box 18233
   Cochrans Mill Road
   Pittsburgh, PA 15236
   Phone: (412) 386-6858
   FAX: (412) 386-6928

   Note: This division will also analyze and report the results of sampling analyses for dusts (respirable and total), metal fumes and dusts, mineral fibers, bulk samples, etc., and provide technical assistance for conducting midget impinger sampling.

4. For questions concerning ventilation call, or write:

   Chief, Ventilation Division
   Pittsburgh Safety and Health Technology Center
   P.O. Box 18233
   Cochrans Mill Road
   Pittsburgh, PA 15236
   Phone: (412) 386-6936
   FAX: (412) 386-6851

5. For ordering all health-related sampling supplies, or for questions concerning the availability of specific sampling items contact your District Office.

   Please note items must be ordered by the field office supervisor.

Chapter 22
DIESEL PARTICULATE MATTER SAMPLING

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Chapter 22
DIESEL PARTICULATE MATTER SAMPLING

I. Diesel Particulate Matter (DPM) Sampling Equipment

A. **DPM Cassette** - Diesel particulate samples must be collected with the diesel particulate sampler manufactured by SKC, Inc. This sampler uses a submicron impactor which has a cut point of 0.9 micrometer when the flow rate is 1.7 Lpm in conjunction with a cassette-mounted filter. Particles greater than 0.9 micrometer are impacted and removed from the sample. The sample is analyzed for elemental carbon using the NIOSH Analytical Method 5040. Figure 22-1 shows the DPM cassette, cyclone, and holder assembly.

Figure 22-1. DPM Cassette, Cyclone and Holder Assembly

B. **Sampling Pump -** Flow for the sampling assembly can be induced by any of the pumps commonly used for respirable or total dust sampling. Pumps must be calibrated at 1.7 Lpm in accordance with the standard pump calibration procedures.

C. **DPM Sampling Train** - The DPM sampling train consists of the standard 10-mm Dorr-Oliver cyclone and SKC DPM cassette, mounted in the MSA holder assembly, and a sampling pump. The only difference from the set-up for respirable dust sampling is that the vortex finder is inserted directly into the SKC sampler instead of being connected to the cassette with the plastic barrel connector. Figure 22-2 shows a typical DPM sampling train.

II. Diesel Particulate Matter Sampling Procedures

A. **Personal Samples** - Personal samples should be collected to determine a miner's exposure to diesel particulate matter. For this type of sampling, the holder assembly (with DPM cassette and cyclone) is attached to the worker's lapel.

Figure 22-2. DPM Sampling Train

B. **Sampling Time** - The standard requires that diesel particulate matter concentrations be expressed as average eight-hour full-shift equivalent concentrations (shift-weighted average). Samples should therefore be collected for the full shift. As with other particulate samples, a 480-minute time will be used to calculate the concentration of diesel particulate matter.

C. Pre-survey Calibration of Sampling Pump - Prepare and calibrate the sampling pump using the procedures in Chapter 4, Sampling Pumps, of the Metal and Nonmetal Health Inspection Procedures Handbook.

D. Control Filter - The DPM filter cassette contains a control filter, therefore a separate control filter should not be prepared.

NOTE: Record all information on the DPM Sampling Field Notes form. It is not necessary to fill out the Health Field Notes form when sampling for DPM.

E. Assemble the Sampling Train

1. Remove the cassette from the box. Do not use the cassette if it is damaged or past the expiration date.

2. Remove the plugs from the cassette and place them in a clean, convenient location.

3. Attach the cassette to the cyclone. Refer to Figures 22-1 and 22-2. When properly assembled, the cyclone will lock into the steel holder and the cyclone inlet will face forward.

4. Tighten the set screw on the lapel holder so that all fittings are tight and the cassette is secured.

5. When assembling and disassembling the DPM cassette and the MSA breastplate, check the following:

   - The parts fit tightly enough together that some resistance can be felt between the cyclone and the cassette and at the cassette connection to the steel outlet hose connector of the holder assembly.

   - Rotate the cassette to verify that the steel outlet hose connection rotates with the cassette.

   Both of these tests indicate that the O-rings are in place and providing a leak-tight seal. This is especially important in the holder assembly since it is reused many times. The O-ring in the lower part of the cassette is part of the cassette.

6. With the tubing connected to the holder, attach the other end of the tubing to the sampling pump inlet. See Figure 22-2.

F. Instructions to the Miner

1. Explain to the miner what you are doing, what the sampling device does, and the reason for the sampling (*i.e.*, the hazard).

2. Instruct the miner not to remove the sampling pump or sampling train at any time or cover the sampler or cyclone inlet with a coat or anything else. If the miner does not spend the full shift in the work area, note the time spent elsewhere in the DPM field notes.

3. Instruct the miner not to bump, drop, abuse, or tamper with the sampling pump or sampling train.

4. Emphasize the need for the miner to continue to work in a routine manner and report to you any unusual occurrences, work conditions, or problems encountered during the sampling period.

5. Inform the miner when and where the sampler will be removed and that you will be checking the equipment throughout the shift.

6. When conducting diesel particulate matter sampling, instruct the miner not to invert the cyclone holder. If this occurs, it should be reported immediately to the inspector, recorded in the DPM field notes, and the sample should be voided.

G. Attach the Sampling Train to the Miner

1. Attach the sampling pump and sampling train to the miner in such a manner that it will not create a safety hazard to the miner or anyone else performing normal work activities. Clip, pin, or tape the tubing to the clothing in such a manner that it does not interfere with the miner's job performance and does not present a safety hazard (such as, tubing catching on moving machine parts or railings). If the miner is not wearing a shirt or belt, the inspector should provide a belt or vest to facilitate sampling.

2. Attach the sampler to the miner’s clothing within the breathing zone. For diesel particulate sampling, attach the sampling train so that the cyclone's grit pot is on the bottom of the assembly. Be certain that the cyclone inlet is facing away from the body of the miner.

H. Collect the Sample

1. Start the sampling pump.

2. Record the following information on the DPM Sampling Field Notes form:

    - Time the sampling pump was started;

    - Pump and DPM cassette identification numbers;

    - Miner’s name, job title, and work location(s);

    - Shift hours per day and days per week worked;

    - Any respirator worn or expected to be worn (brand, model, type of filters); and

    - Whether an acceptable respiratory protection program exists.

3. During each full-shift sample, the inspector must observe the miner being sampled as frequently as is necessary to determine that a representative sample is being conducted of the normal activities. Check the sampling pump and sampling train to make sure that the sampling pump is operating properly, and to make sure the tubing and connections are not leaking. Do not adjust the flow rate at any time during sampling. Record what tasks the miner has performed in the time between subsequent checks so that the completed DPM Sampling Field Notes form will describe the miner’s full work shift. This requirement does not necessarily preclude the inspector from doing other inspection work while sampling.

4. Throughout the shift, record other pertinent information:

    - The quantity and velocity of ventilating air at the location where samples are collected;

    - Condition of ventilation control structures (stoppings, doors, brattices, etc.);

    - The type of DPM control devices being used and their condition;

    - Type of fuel, such as diesel or biodiesel, in use at the mine;

    - Fuel sulfur content;

- Type of fuel additives used at the mine;
- Information on the diesel equipment used at the workplace sampled, including:
  - the company equipment number or serial number;
  - the condition of the equipment;
  - whether there is a planned maintenance program in place;
  - whether the engine emits black smoke during acceleration; and
  - whether there is a person authorized to maintain diesel equipment.
- List other equipment that may contribute to the miner's DPM exposure.

5. Collect the sampling train from the miner.

a. Turn off the sampling pump before removing the sampling train or pump.

b. Record the time that the pump was turned off.

c. Carefully remove the sampling train:

- Keep the cyclone upright to prevent the non-respirable dust in the grit pot from falling back through the cyclone onto the filter.
- Remove the filter cassette from the lapel holder and replace the cassette plugs. Place a sample seal on the filter cassette.
- Record the sample number on the sample seal. Date and sign the sample seal.

III. Post-Inspection Procedures

A. **Review the DPM Sampling Field Notes form** - Check that all the necessary information is included on the DPM Sampling Field Notes form.

B. **Post-survey Calibration of Sampling Pump** - Check the sampling pump calibration using the procedures in Chapter 4 of the Metal and Nonmetal Health Inspection Procedures Handbook.

C. Cyclone Cleaning and Assembly

1. Unscrew the grit pot from the cyclone. Empty the grit pot by turning it upside down and tapping it gently on a solid surface.

2. Gently wash cyclone, grit pot, and the vortex finder (cyclone cap) by agitating in warm soapy water or, preferably, wash in an ultrasonic bath. <u>Do</u> <u>not</u> insert <u>anything</u> which can score or scratch the inner lining walls of the cyclone (such as a pipe cleaner).

3. Rinse thoroughly in clean water, shake off excess water, and set aside to dry before reassembly.

4. Inspect the cyclone and filter holder parts for damage or excessive wear, for a loose coupler or vortex finder, and for scoring or rifling (which can trap respirable particles, preventing them from reaching the filter). Pay special attention to the top internal surfaces of the cyclone when inspecting for scoring and rifling. Replace defective parts.

5. Reassemble the cyclone, vortex finder (cyclone cap), and grit pot.

D. Transport the Samples for Analysis

1. Complete the Request for Laboratory Analysis (MSHA Form 4000-29) for the samples taken. In Item No. 15 on the form, designate “R” for respirable samples. In Item No. 16, fill in the analysis desired, diesel (carbon). Sample cassettes from different lots, used on the same day, should be listed on separate Request for Laboratory Analysis (RLA) forms. Be sure to provide all the information the laboratory will need to fill out the Personal Exposure Data Summary (PEDS).

2. Ship the Request for Laboratory Analysis form(s) with the samples to the MSHA laboratory.

IV. Exposure Determination

The laboratory will complete the analysis and return an Analytical Report that will include the concentration, concentration limit, error factor, and calculated enforcement concentration limit (concentration limit times error factor). A PEDS will also be generated as appropriate. For each sample, the corrected elemental carbon concentration will be reported. The formula the Laboratory uses for calculating diesel particulate concentration is:

$$\text{Carbon Concentration } (\mu g/m^3) = \frac{C(\mu g/cm^2) * A(cm^2) * 1{,}000\ L/m^3}{1.7\ \text{Lpm} * 480\ \text{min}}$$

Where:

C = The corrected Elemental Carbon (EC) concentration measured in the thermal/optical carbon analyzer.
A = The deposit area of the filter media used in the DPM cassette.

A citation for an overexposure to the DPM limit of 350 ug TC/m^3 of air will be issued when the total carbon (TC=OC + EC) exceeds 350 ug/m^3 of air x the error factor of 1.13 and when the elemental carbon (EC x 1.3) concentration exceeds 350 µg/m^3 x the error factor of 1.11.