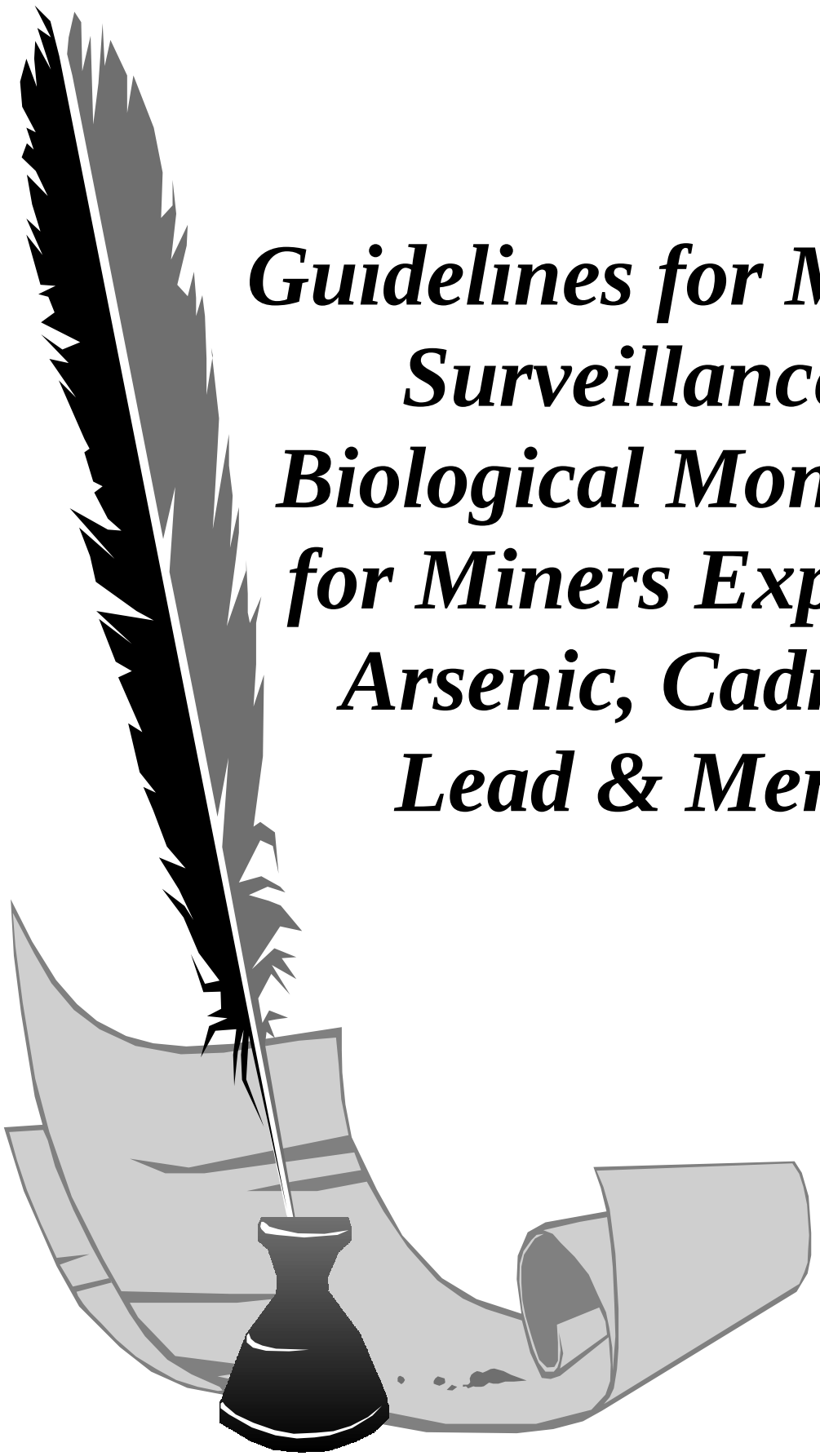

Guidelines for Medical Surveillance & Biological Monitoring for Miners Exposed to Arsenic, Cadmium, Lead & Mercury

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Miners working in a variety of environments can be exposed to toxic metals including mercury, lead, cadmium and arsenic. These exposures occur along the entire pathway of the mining process, from ore extraction and processing, through equipment maintenance, to the end-products. The U.S. Department of Labor's Mine Safety and Health Administration (MSHA) is concerned about miners' exposures to these toxic metals and has prepared this document to assist mine operators with their health surveillance efforts. This handbook may be provided to the health care professional who will be overseeing the medical surveillance program for your operation.

Medical surveillance and biological monitoring are longstanding key elements in programs to protect metal-exposed workers, but have been implemented less frequently in the mining industry. Unfortunately, the inherent toxicity of a metal is not influenced by the industry in which the exposure takes place, and some miners' health is suffering as a result. The risk to a miner's health is dependent on the circumstances of the exposure, the dose, duration of the exposure, the particle size in the case of some lung toxins, the exposure route and certain existing health conditions of the worker. It is appropriate for MSHA to provide this guidance to mine operators as an adjunct to their existing comprehensive industrial hygiene program.

Medical Surveillance and the Hierarchy Of Controls

The strategy used to prevent or minimize occupational exposure to any toxic substance is derived from the classical hierarchy of workplace hazard control technologies. (Soule, 1978) This approach applies a combination of interventions, with the more protective preventive strategies occurring first in the hierarchy. The control technologies are engineering controls, administrative and work practice controls, and personal protective equipment, with engineering controls being the most protective strategy.

Engineering controls include three elements: substitution, isolation and ventilation, which play a major role in minimizing a worker's exposure by physically isolating the hazard from the worker. Traditionally, engineering controls are the first intervention in the hierarchy of controls, used to control a hazard.

Substitution can be a fairly easy engineering control (i.e., using a less toxic substance for a more toxic one.) Some situations are more amendable to substitutions than others. A production process itself can also undergo a substitution by changing the way the work is performed, thereby reducing workers' exposures.

Isolation means using a physical barrier to separate a worker from a hazardous process. This

would include performing a hazardous task in a special designated or designed room.

Ventilation uses airflow to minimize workers' exposure. It can be applied locally, near the point source of the hazard or in a large area. Diluting of air contaminants with fresh intake air, or creating more sophisticated air flow patterns and filtering configurations, may enhance an engineering solution.

Administrative and work practice controls are ordinarily applied as an adjunct to engineering controls. They are programmatic policies or operating procedures which reduce the number of persons exposed and/or minimize the duration of the worker's exposure to the hazard. One example would be job rotation or job enlargement where the specific exposure is divided among a group of workers and work tasks are varied, presumably decreasing each individual's dose and duration of exposure to the hazard. Another example is limiting access to a specific high hazard work area to certain workers.

Personal protective equipment (PPE) includes protective clothing, eyewear and respirators. PPE may be necessary in some circumstances when engineering and administrative controls are not sufficiently protective. PPE is the least desirable method of controlling a worker's exposure to a hazard. It places the worker in a potentially hazardous environment, and requires the worker to ensure the constant and correct use of the PPE.

Medical surveillance is an element of a comprehensive program to protect workers' from safety and health hazards, along with engineering controls, administrative work practices, and PPE. A medical surveillance program is embedded within the hierarchy of controls.

Definitions Of Medical Surveillance

Medical surveillance complements industrial hygiene controls, especially when the hazard cannot be eliminated completely. Medical surveillance can be viewed as an administrative control, that is, a policy that is adopted by employers to assist in the health protection of workers.

Medical surveillance by definition is the collection and interpretation of data for the purpose of detecting trends and changes in the health status of populations (Weeks, et al., 1991, and Klaucke, et al., 1988) and has been widely applied to occupational settings. Medical surveillance aims to minimize adverse health effects in exposed persons through early detection of symptoms or other conditions. The results of medical surveillance may suggest the need for further investigation, remedial action, and/or an intervention that is unique to the individual.

Medical surveillance can also identify persons who may be at an increased risk of health harm due

to an existing risk factor. Medical surveillance provides feedback on engineering and other hygiene controls, especially when the toxic substance cannot be eliminated from use.

Medical surveillance programs involve the assessment of symptom complaints, physical findings, and laboratory values to determine whether there is a deviation from the expected norm or from a worker's previous value. In addition to following the health status of individual workers, medical surveillance programs look for trends in populations of workers. A small alteration in a population of workers could be obscured if only individual workers were followed. Ideally, group data from potentially exposed workers should be compared with data from non-exposed workers to see whether exposure has affected any health variables. Non-exposed groups from other areas of the same work place, or data from preplacement examinations of newly hired employees (if the employees have not been previously exposed) may be used for comparison purposes. Periodic examination of group data and comparison with data from non-exposed workers are extremely important in a surveillance program.

Elements of Medical Surveillance

There are four data-gathering elements in any medical surveillance program. These include the history (medical, occupational, and social/personal), the physical examination, laboratory studies, and biological monitoring.

History

Probably the best and most cost-effective source of useful information is the medical and occupational history of a worker which may be collected using a questionnaire. The medical history can assist health care professionals to interpret laboratory data obtained in the surveillance program or to identify a worker at potentially high risk in a particular exposure setting. Symptoms discovered in the medical history may serve as an early warning sign of a potential problem.

A detailed medical and work history, including past and present exposure to the metal or hazardous substance, should be obtained. Ask about exposure both on- and off-the job should. Include questions about organ-specific medical problems, in particular those related to the target organs for the metal in question. Inquire about any pre-existing health conditions.

As part of the occupational history, the occupational health professional should determine some measure of exposure to the toxic substance. In the absence of industrial hygiene data, the worker's length of employment in various exposure zones and the worker's use of PPE can provide a surrogate measure of the potential exposure dose. Documenting untoward events, such

as accidents or spills, also can assist the clinician in estimating the opportunity for exposure and interpreting other surveillance end points.

Physical Examination

A screening surveillance exam is different from an evaluation of a patient with a known health problem. The screening surveillance examination, like the history, should focus on target organs of the hazardous agent in question. It should also be made clear to the worker that surveillance exams do not take the place of annual comprehensive physicals or other periodic health assessments which they may obtain from their own primary care provider.

Laboratory Studies

Laboratory tests used in a surveillance exam should help to determine a worker's general health status. Other tests should be performed to assess the function of the presumed target organ of the toxic substances in question.

Biologic Monitoring

Biologic monitoring is defined as the measurement of internal exposure of a primary agent or its metabolite in a biological specimen such as urine or blood. (Zielhuis, 1978) There is some controversy over what constitutes normal blood or urinary concentrations for many biologic samples. Generally, laboratories compare the results they analyze to criteria established by professional bodies such as the World Health Organization (WHO) and the American Conference of Governmental Industrial Hygienists (ACGIH), which publish recommended exposure levels for biologic monitoring results. The ACGIH publishes biological exposure indices (BEI) for a number of work place toxic substances. (ACGIH, 1998)

A health care professional working with an individual's biologic monitoring results is challenged because it is not clear how to interpret the results with respect to long-term health effects. For most agents, detecting a hazardous agent in a worker's blood or urine indicates exposure and documents a break or failure of an engineering control or other control measure. It does not necessarily imply that a worker is at increased risk of developing disease or other health harm. (Lauwerys, 1980; Hernberg and Aitio, 1987; Zielhaus, 1978)

Developing a Medical Surveillance Program

The need for a medical surveillance and biologic monitoring program is determined by conducting an environmental exposure assessment. When the level of a hazardous substance is found to be unacceptably high, a control plan is developed which may include medical surveillance and biologic monitoring.

The environmental exposure assessment is usually conducted by an industrial hygienist, an expert in the recognition, evaluation and control of hazards in the work environment. The hygienist uses a systematic approach to evaluate the environment, including a walk-through survey, environmental monitoring and a final evaluation of results. The walk-through survey includes a review of the facility, an examination of the work flow or processes, interviews with workers, and an evaluation of the control measures in place. The industrial hygienist will usually conduct environmental sampling using pumps to determine the concentrations of the toxic substance in the air of the work environment. The hygienist may also sample specific processes or work areas (i.e., area sampling) or workers at higher risk of exposure (e.g. personal sampling.)

There are a number of technical issues related to environmental surveys which are beyond the scope of this handbook. These include sampling strategies, instrument calibration, variability of results and laboratory proficiency. You may want to refer to a technical manual such as Leidel, et al., 1977; Plog, 1988; Roach, 1987, which are listed in the reference section, for more detailed information.

The results of the environmental exposure assessment provide health care professionals with information to assist in developing a comprehensive safety and health program. This would include the decision to establish a medical surveillance program and perform biologic monitoring.

In some industrial settings, environmental sampling results that are above a predetermined "action level" can trigger action, such as medical surveillance, based on the hierarchy of controls. For many Occupational Safety and Health Administration (OSHA) health standards, the action level occurs at or near one-half of the permissible exposure limit (PEL) for an eight-hour time-weighted average (TWA) sampling result. Some employers use more stringent voluntary action levels, such as one quarter the PEL, to trigger certain actions.

When developing a medical surveillance program, one must consider issues such as employee participation, confidentiality, quality, action triggers, and professional recommendations.

Employee Participation

Employee participation in surveillance programs is generally voluntary and cannot be mandated except where provided for in a labor-management contract. Even surveillance required by OSHA standards, for example, are not mandatory and rely on workers' voluntary participation. High employee participation however, will improve the chance of discovering subtle abnormalities in the worker population and minimize participation bias.

Employers and health care professionals can encourage workers to participate in the medical surveillance program by emphasizing its value. The benefits of medical surveillance can be explained and discussed during hazard communication training or at other appropriate times. Participation may increase if workers are allowed to provide input on the design and implementation of the surveillance program. This gives workers a sense of ownership of the program but more importantly, gives managers the workers' point of view on logistics, handling of test results and the action to be taken based on the test results.

One reason workers decline to participate in surveillance programs is the fear of job loss because of unfavorable test results. Employers must provide assurance to the employees on matters such as employment retention, seniority, and salary rate and benefits. Employees must understand and see evidence that there will not be a penalty for participating in the surveillance program, even if they must be removed from work exposure for medical reasons.

Confidentiality of Medical Test Results

The health care professional and employer must develop a system to ensure the confidentiality of medical test results, as with all medical records. This will help to boost employees' trust of the surveillance program and increase participation. In some circumstances, medical test results will be made known to an industrial hygienist or to the employer (e.g., the need for medical removal of an employee), and employees must understand that this may occur. They should understand that their individual test results will be given and explained to them. Group results should also be provided and explained to the affected workers.

Quality

The program should be designed and supervised by a health care professional with extensive training and preferably board certification in occupational medicine, with experience in the mining industry or in related industries and occupations. The art, as well as science, of interpreting biologic monitoring results from metal exposures makes this recommendation especially true. The American College of Occupational and Environmental Medicine (ACOEM) and the Association of Occupational and Environmental Clinics (AOEC) can provide assistance in identifying a qualified occupational medicine physician or clinic in his/her geographic area.

The laboratory used to perform biologic monitoring should be subject to quality assurance proficiency specifications as has been required by OSHA in the lead and cadmium standards. Proficiency programs are a type of quality assurance which evaluates analytical accuracy and reliability of laboratory results. More details on these programs are described below.

Actions Triggers

The following steps should be taken after abnormal medical surveillance or biologic monitoring results are reported:

1. A reassessment of the worker's job, work practice, and personal hygiene including eating, drinking, and smoking on the job.

2. A check of the respirator the worker is using and the respiratory protection program.

3. A review of the hygiene facilities.

4. A review of the effectiveness of the engineering controls and maintenance history.

5. An analysis of any changes in work practices, production changes, or vendor or product changes since the last surveillance, as well as any notation of workload or production changes.

6. A list of interventions made to mitigate exposure.

These steps may be taken while the laboratory value or biologic monitoring parameter is repeated and verified, which will ensure the workers are protected from continued exposure.

Determining Medical Clearance to Wear a Respirator

Respiratory protection may be an element of a comprehensive safety and health program when other interventions, such as engineering controls, are not sufficient to protect the worker. Although not technically part of a medical surveillance program, many employers arrange to evaluate a worker’s fitness to wear a respirator at the same time. An individual’s fitness to wear a respirator can be influenced by the type of respirator used, the job and workplace conditions present, and the worker’s medical status. Using a respirator can place a physical burden on the worker which can be compounded by these factors. The purpose of medical evaluation is to determine the worker’s fitness to tolerate the physical burden related to wearing a respirator. The evaluation also can determine if the worker has existing health conditions which would place

him/her at increased risk of health harm or injury while wearing a respirator. The health care professional should conduct a health history and inquire about the worker's previous respirator use. A health history would assess any existing health conditions such as hypertension, lung or heart problems, seizures, diabetes, medications and smoking history. A physical examination would be performed based on the answers obtained in the health history. As is true for the actual medical surveillance exams, the health physician who is performing or supervising the workers' fitness to wear a respirator should be supplied with the following information from the employer:

1) The type and weight of the respirator to be used by the worker.
2) The duration and frequency of respirator use, including for rescue and escape.
3) The expected physical work effort.
4) Any additional protective clothing and equipment to be worn.
5) The temperature and humidity extremes that may be anticipated.
6) A copy of the company's respiratory protection program.
7) Any other company or job-specific parameters which may affect respirator use.

The physician uses this information to supply the employer with one of the following determinations:

A) No respirator use restrictions.

B) Some respirator use restrictions, describing limitations on type of respirator use (i.e., no SCBA use), or limiting the duration of use (i.e., use only during a described task taking 30 minutes and occurring once a week)

or, C) No respirator use permitted.

There are a number of resources available to review the medical aspects of respiratory protection programs including: ANSI, 1992; OSHA 1910.134 (1998); Beckett, 1986; Hodous, 1986; Harber, 1984.

Medical Surveillance Recommendations

Ambient air limits, including the ACGIH Threshold Limit Values (TLV) and/or the OSHA permissible exposure limits (PEL) and action levels are provided in this handbook to help employers determine if a medical surveillance program is necessary. This determination is often triggered at the action level or by other industrial hygiene survey findings.

The ACGIH Biological Exposure Indicies (BEI) are reference values intended as a guide for the evaluation of the potential health hazards through industrial hygiene methods. BEIs represent the levels of determinants (i.e., the substance being measured) which are most likely to be observed in specimens collected from a healthy worker, who has been exposed to a chemical to the same extent as a worker with an inhalation exposure to the TLV.

BEIs apply to eight hour exposures, five days a week. (ACGIH,1998) BEI values may be given for levels in blood usually expressed as micrograms per deciliter (mcg/dl) or per liter (mcg/L). They can also be expressed for urine as micrograms per gram creatinine in urine (mcg/gm creatinine.) A skin notation may also be designated by ACGIH for those substances which possess a potential significant contribution to the overall exposure by the cutaneous route. This includes exposure via mucous membranes and the eyes, by vapors or direct skin contact, although the greater concern and significance is direct skin contact with the substance. (ACGIH, 1998)

Arsenic

PEL 10 mcg/m^3
AL 5 mcg/m^3
BEI 50 mcg/gm creatinine (urine)

Health Effects:
Workers who are overexposed to inorganic arsenic can have local and systemic non-cancer health risks, but the principal concern for workers is lung cancer. The local effects primarily involve corrosive reactions to the skin and mucous membranes, where prolonged contact causes redness, vesicles and other skin eruptions. Mucous membranes are sensitive to the irritant action of arsenic and perforations of the nasal septum may also occur. Arsenic trioxide and pentoxide are skin sensitizers. Arsenic may also produce keratoses, especially of the palms and soles.

Systemic effects may result from both acute and chronic exposure. The acute toxic effects of arsenic are generally due to ingestion which is very uncommon in an occupational setting. Acute inhalation exposure is more likely but still uncommon. With acute inhalation exposure, respiratory tract symptoms predominate, including cough, chest pain, shortness of breath and headache. The symptoms may progress into gastrointestinal symptoms.

Chronic arsenical poisoning may occur through ingestion due to poor hygiene practices at work such as hand-to-mouth contamination by, eating, drinking and smoking at work before washing one's hands. Symptoms include weight loss, nausea, diarrhea or constipation, pigmentation and skin eruptions, hair loss and peripheral neurologic problems. Polyneuropathy may also be seen with numbness and paresthesias in a stocking-glove distribution. Skin lesions may evolve into squamous cell cancer. Horizontal white lines (mees lines) may be seen on finger and toe nails in chronic arsenic poisoning.

The most common occupational route of chronic arsenic intoxication is inhalation. Many of the symptoms are similar to those already described in the other exposure scenarios, including respiratory and mucous membrane irritation, nasoseptal perforation, general weakness and gastrointestinal symptoms. The health care professional may also see peripheral neuropathy, primarily sensory (but which can include motor findings) in hands and feet. Inhalation exposure to inorganic arsenic is also the principal exposure route with regard to the lung cancer risk.

A detailed review of the health effects related to arsenic exposure is found in Ishineshi, etal, 1986.

An elevated arsenic level is reportable to the health

Medical Surveillance:
The data gathering elements of a surveillance protocol should emphasize the target organ systems discussed in the health effects section. The health care professional should inquire during the medical history about signs and symptoms of arsenic exposure. The presence and frequency of respiratory symptoms including cough, sputum production and shortness of breath should be elicited. A smoking history should also be included.

The physical examination should emphasize the respiratory system and a skin and nasoseptal exam. Special laboratory tests, including a chest x-ray and possibly sputum cytology to survey for lung cancer, should be considered.

Biologic Monitoring:
A health care professional can obtain a urinary arsenic determinations from some clinical laboratories. You must request an inorganic arsenic level rather than total arsenic levels. A total arsenic level will include dietary contributions which may obscure the interpretation of the clinically important inorganic arsenic concentrations. The arsenic concentration should be expressed as micrograms of arsenic per gram of creatinine in urine. The measure expressed this way will account for the body's hydration status when measuring the urinary concentration.

Worker Education:
As part of a hazard communication or health education program, workers should be encouraged to stop smoking and understand their increased risk of lung cancer due to their exposure to arsenic.

The OSHA arsenic standard issued in 1978 required twice yearly chest x-rays and sputum cytology for lung cancer surveillance of workers who were older and exposed to arsenic for greater than ten years. In the twenty years since that standard was promulgated, medical research does not support the use of sputum cytology as an effective means of enhancing the early detection of lung cancer. In addition, medical evidence does not demonstrate an improvement in mortality for twice yearly over annual chest x-rays for high risk for lung cancer study subjects (male smokers over 45 years of age).

OSHA is currently requiring annual chest x-rays for arsenic-exposed workers. Physician's discretion should be used to determine chest x-ray frequency and should consider duration and intensity of the worker's exposure, use of respiratory protection, age of the worker, history of cigarette smoking, and other host risk factors to assist in this determination.

Lead

PEL 50 mcg/m^3
AL 30 mcg/m^3
BEI 30 mcg/dl(blood)

Health Effects:
Lead may cause acute symptoms due to high-dose short-duration exposures, but in workplace setting, it is more common to encounter health effect related to chronic, longer-term exposure. Lead affects many organ systems of the body, including the central and peripheral nervous systems, the gastrointestinal system, the blood forming system, as well as the kidneys and the reproductive system. Lead intoxication can take place over a short number of days or take months or years to develop depending on the dose and duration of the overexposure.

Acute effects of high-dose exposure may lead to central nervous system damage including encephalopathy, causing alterations in consciousness and possibly seizures. Other symptoms include loss of appetite, dulled sensorium, depression, weakness, irritability, insomnia, memory problems, headache and nervousness. Muscle and joint pain, as well as tremor, may also occur. In classic lead colic, neurologic and constitutional symptoms are usually predominant, but there may also be severe abdominal pain. In the U.S. today, classic lead colic is seldom seen in patients.

Chronic exposure to lead can manifest with the same constitutional symptoms listed above. Typically, peripheral neuropathy and reduced neurobehavioral performance are prominent. Kidney function may also be impaired, particularly in advanced cases, and blood pressure may be elevated.

Reproductive function in both men and women is affected by lead overexposure. In exposed men, sperm abnormalities have been reported at fairly low blood lead levels (Lancrajan, 1975) which result in subfertility or possibly birth defects. More subtle symptoms including depressed libido and impotence may be seen. Neuroendocrine hormone effects, such as alterations in testosterone, have been reported. (Braunstein, 1978) In women, miscarriage and stillbirth have been reported both in those overexposed directly as well as women who are secondarily exposed by their husbands who carried lead home on work clothes and shoes. (Rom, 1976) Lead may also cause subfertility and menstrual abnormalities in women.

Lead is known to cross the placental barrier and, therefore, may affect the developing fetus. Behavior disorders and detrimental effects on IQ have been reported in the offspring of lead-exposed parents. Lead has been called a "behavioral teratogen" because of these observed behavioral effects.

Lead's effects on blood forming are seen primarily in the formation of red blood cells (RBCs).

The earliest biochemical test affected by lead overexposure is one of the enzyme steps involved in hemoglobin (the oxygen-carrying protein of RBCs) synthesis. This step can be altered at blood lead levels as low as 10 mcg/dl of whole blood cells. Later, anemia may be evident with classically, a hypochromic (pale) hemoglobin deficient red cell microcytic (small) red cell picture.

Medical Surveillance:
In the medical and work history, the health care professional should include questions about the target organs discussed in the health effects section. This should include questions about symptoms of central and peripheral nervous system impairment, the constitutional symptoms (e.g., irritability, headache) and questions related to blood, kidney, gastrointestinal and reproduction. The history should also inquire about pre-existing health problems which may place the worker at increased risk of health harm, such as anemia or kidney disease.

The physical exam should emphasize the teeth and gum (i.e., looking for a "lead line"), hematologic, gastrointestinal, renal, cardiovascular, (i.e., high blood pressure), and neurologic systems.

Laboratory Studies:
The health care professional should conduct laboratories studies on hemoglobin, hematocrit and red blood cell indices. In addition, test kidney function including blood urea nitrogen (BUN) and serum creatinine levels as well as a routine urinalysis. The clinician should examine a peripheral blood smear to look for "basophilic stippling," a distinctive feature of some white blood cells (basophils) which develop small aggregates of stained material inside the cell due to the lead effect.

Biologic Monitoring:
The clinician should obtain a blood lead level which measures recent lead exposure, and a zinc protoporphyrin (ZPP) or free erythrocyte protoporphyrin (FEP) which measures the integrity of the hemoglobin synthesis pathway. Elevations of ZPP or FEP remain high for approximately four months (the life of a red blood cell.) This can give the clinician an indication of past lead poisoning prior to the window of time the blood lead itself will be elevated (days to weeks depending on the exposure scenario.)

The frequency of biologic monitoring depends on the results of previous biologic monitoring tests. A worker with a blood lead levels above 40 mcg/dl should be tested at least every two months. A worker with a blood lead level at 60 mcg/dl or greater, must be removed from the exposure, under an OSHA regulation. OSHA also requires medical removal of the worker to a non-lead exposed job, if three consecutive blood lead levels (usually performed two months apart) are over 50 mcg/dl. Many clinicians would medically remove a worker at blood levels lower than 50 mcg/dl, especially if the worker has symptoms.

By legal definition, removal to a non-lead exposed job is interpreted to mean to a job with a lead exposure at or below the action limit of 30 mcg/m^3 of lead. A health care professional may ask for medical removal to a truly non-exposed lead environment given specific circumstances of the clinical manifestations of the lead overexposure. The professional may assist the employer in identifying a satisfactory job placement for the affected worker. After the clinician is satisfied with the decline in biologic monitoring parameters to normal levels and the improvement of symptoms, a worker may return to the lead exposed job (presumably with engineering controls and personal protective equipment in place.)

Elevated blood lead levels are required to be reported to the health department in many states.

Chelation:

Chelation is the use of a drug to bind (i.e., chelate) the heavy metal to enhance elimination through the urine. Chelation may be part of the therapeutic treatment for a worker who has been overexposed to lead. This procedure is performed by or under the supervision of a physician and may help provide symptomatic relief.

To minimize laboratory error in blood lead testing, it would be prudent for mine operators to use laboratories which have received a satisfactory performance grade in such a proficiency testing program. A list of such laboratories is available from the OSHA website (www.osha.gov/technicalinks/index/lead).

Diagnostic chelation may also be used to clarify the existence of a lead body burden when the blood lead itself may be normal. Here, the chelating drug is given, urine is collected and analyzed for an elevated lead content that results from mobilizing or moving the lead from other body stores such as the kidney or bone.

Therapeutic and diagnostic chelation should NOT take place while the worker is still exposed to lead, even if the employee is using personal protective equipment. Chelation may actually enhance lead absorption in the body if exposure exists while the chelation is taking place.

Prophylactic chelation is the process of giving chelating drugs or milk while lead exposure is ongoing supposedly to manipulate lead related health effects and/or blood lead level. This process is unacceptable and may result in enhanced lead absorption in certain situations.

Worker Education:

The target organ of lead overexposure as well as the symptoms of overexposure should be part of a worker education program. The education program should stress the importance of following safe work practices, using personal protective equipment when appropriate and participating in medical surveillance and biological monitoring programs. Information should be presented to workers which explains the benefits of avoiding overexposures to lead for their own health and possibly of their children (i.e., take-home toxicant.)

Cadmium

PEL 5 mcg/m^3
AL 2.5 mcg/m^3
BEI 5 mcg/gm creatinine (urine)
5 mcg/L (blood)

Health Effects:
In the mining industry, elemental cadmium may be found in lead, copper, and zinc sulfide ores as a blue-white metal or a gray-white powder. As with other heavy metals, cadmium may enter the body by ingestion or inhalation. The more common, clinically significant exposure route is by inhalation.

Acute short-term exposure via inhalation may occur in jobs with exposure to large concentrations of cadmium dust or fume, and in the heating, welding, or soldering of cadmium-containing or cadmium-coated materials. Early symptoms include upper respiratory irritation and cough. After one to ten hours, shortness of breath may intensify, and chest pain and a flu-like syndrome with fever, headache, and chills may begin. Acute pulmonary edema develops within one day and may heighten at three days. Death may occur at this point, or symptoms may resolve with treatment.

A medical surveillance program related to cadmium is usually implemented to identify the health effects from long-term chronic exposure. The kidney is the main target organ and workers who are exposed to cadmium may develop tubular disease and ultimately impaired kidney function. Tubular kidney disease is characterized by excretion in the urine of small (i.e., low molecular weight) proteins, as well as loss of enzymes, uric acid, amino acids and phosphate. Several of these small proteins, including beta-2-microglobulin (B_2M) and retinal binding protein (RBP) have been incorporated into the surveillance protocol for cadmium-exposed workers.

Problems with the body's metabolism of calcium and related bone effects have also been attributed to cadmium toxicity. There is also an increased risk of lung and prostate cancer associated with cadmium overexposure. The prostate cancer evidence is obtained from observation of slight elevations in mortality in several cadmium-exposed working groups, but the number of cases is small. The evidence for lung cancer excess is more substantial, based on both animal and human data. Many public health agencies in the 1980s listed cadmium as a probable human carcinogen, including the Environmental Protection Agency (EPA), the International Agency for Research on Cancer (IARC), the American Conference of Governmental Industrial Hygienists (ACGIH), and the National Institute for Occupational Safety and Health (NIOSH). Chronic cadmium exposure has been related to development of emphysema and possibly high blood pressure.

There is substantial evidence for cadmium involvement in developmental toxicity, causing various

birth defects in multiple animal species and also causing direct testicular and ovarian toxicity in animals. Human data are sparse, and long-term low-dose exposure appears to result in less severe or absent findings compared to the animal findings. Because cadmium is known to cross the placental barrier in humans, the occupational health community believes cadmium is a developmental and possibly a reproductive toxicant in humans.

Medical Surveillance:
The health care professional should obtain a detailed medical and work history of cadmium-exposed workers. It should include past and present exposure to cadmium and a smoking history. When obtaining the history, place emphasis on the lungs, the kidneys, the reproductive system, the cardiovascular and the musculoskeletal systems. The clinician should also inquire about any medication which could potentially affect the kidneys.

The physical examination should emphasize blood pressure, the respiratory system and the kidneys. Prostate palpation for males over 40 should be done. While controversial, the use of prostate specific antigen (PSA) should be considered.

Special Laboratory Tests:
For the initial baseline exam, a chest x-ray is appropriate as part of surveillance for lung cancer. The frequency of follow-up chest x-rays should be a function of the duration and dose of cadmium exposure, the age of the worker and their smoking status.

The health care professional should consider a pulmonary function study to clarify any development of emphysema. A urinalysis including determination of albumin, glucose, and total and low molecular weight proteins is appropriate. Blood studies of kidney function including blood urea nitrogen (BUN), serum creatinine, and a complete blood count should be considered. A prostate screening test such as prostate specific antigen (PSA) should be considered.

Biologic Monitoring:
The clinician should conduct test for cadmium in urine (CdU) and a beta-2-microglobulin in urine, both standardized per gram creatinine with pH specified or specific gravity noted. Obtain a cadmium in blood (CdB), standardized to liters of whole blood.

(Proper Urine Collection)
Urinary cadmium determinations based on spot urine collection require some special consideration. After urine collection, the sample should be checked for specific gravity to ensure that it is not too dilute, which would render the result, corrected per gram creatinine falsely high. To avoid this, a specimen should have a specific gravity of greater then 1.008 to be submitted to the lab for analysis. The specimen should also be screened for pH. A sample too acidic (pH below 5.5) will affect B2-microglobulin results. Pre-screening samples prior to submission to the lab will reduce the number of specimens that are not usable.

Management of Biologic Monitoring Results:
The frequency of follow-up examinations and their content, and other interventions, such as medical removal, depend on the results of the biologic monitoring. If the cadmium in urine value is at or below 3 mcg per gram creatinine; the cadmium in blood at or below 5 mcg per liter of whole blood; and the beta-2-microglobulin at or below 300 mcg per gram creatinine, (i.e., all are considered the upper limit of normal) then the frequency and content of exams may be less frequent and comprehensive. Any elevation above these values should trigger the actions presented earlier in this guide. The biologic monitoring tests should be repeated and other medical testing should be considered.

OSHA considers cadmium in urine greater than 7 mcg per gram creatinine; or cadmium in blood greater than 10 mcg per liter of whole blood; or beta-2-microglobulin greater than 750 mcg per gram creatinine with either the cadmium in urine above 3 mcg per gram creatinine or the cadmium in blood greater than 5 mcg per liter of whole blood, to be indication for medical removal from a cadmium-exposed job. The management of values between the upper limit of normal and these medical removal trigger values is a matter of clinical judgment. The health status of the worker, other risk factors, symptoms and biologic monitoring values should be considered. Frequent follow-up, even every 3-6 months, is appropriate until the biologic monitoring indices return to normal values.

Elevated cadmium levels are required to be reported to the health department in some states.

Laboratory Issues:

The commercial laboratories used to perform the biologic monitoring tests should be participants in a proficiency testing program. A proficiency program in the analysis of cadmium in blood, cadmium in urine, and beta-2-microglobulin in urine is performed by the Centre de Toxicologie du Quebec (CTQ). Currently, no U.S. laboratory performs proficiency testing for these end points. Proficiency testing for creatinine in urine is performed by the College of American Pathologists (CAP). For more details on lab data quality assurance, see OSHA cadmium standard 29CFR 1910.1027, (Appendix F).

Mercury

PEL 100 mcg/m3
TLV 25 mcg/m3 (skin)
BEI 35 mcg/gm creatinine (urine)
15 mcg/L (blood)

Health Effects:
Mercury exists in nature in three chemical (valence) states, the elemental metallic form (Hg^0), the mercurous form (Hg^{++}) and the mercuric form (Hg^{+++}). It can also form organic compounds from carbon-based molecules.

Elemental mercury vapor is the form most often encountered by workers in gold and silver mining. High intensity exposures to mercury over brief periods of time may cause pneumonitis, bronchitis, chest pain, cough, shortness of breath and gastrointestinal damage. This reflects mercury's ability to chemically react with cellular enzymes, damage cell membranes and potentially lead to cell death and tissue damage. (Clarkson, 1972) Mouth sores, skin rashes and tremors have also been reported among people exposed to high doses of mercury. (Lien, et al., 1983; Seaton and Bishop, 1978; Lillis, et al., 1985; Levin, 1988) In these reports, urine mercury concentrations ranged from 200 to 900 mcg per liter.

Among gold and silver miners and workers in other occupational settings, health care professionals are more likely to see symptoms of chronic exposures to mercury rather than acute exposure. These chronic exposures usually occur over a long period of time. The central nervous system is the critical target organ, meaning the first organ to be adversely affected. (Berlin, 1986) The principal route for exposure to mercury is respiratory.

A number of studies have documented the physical signs of mercury-exposed workers. These most commonly include some type of tremor, and reported symptoms such as feelings of depression, fatigue and irritability. Differences in hand tremor prevalence in workers have been studied with increases in tremor frequency seen with urinary mercury concentrations as low as 40 mcg per liter (Fawer, 1983) and at slightly higher urinary mercury concentrations. (Roels, 1985; and Roels, 1989)

Several types of kidney effects can be caused by mercury exposure. Mercury affects the proximal tubule of the kidney, as evidenced by increases in markers of tubule damage in urine, including the enzyme beta-galactosidase at mean urinary concentrations as low as 20 mcg per gram creatinine. (Bouchet, et al., 1980) Generally, a clinician would find tubular effects when the mean urinary mercury values are greater than 50 mcg per gram creatinine. (Bouchet, 1980) Other types of kidney effects including glomerular involvement may also be observed, but usually at higher exposure concentrations.

Among workers exposed to mercury, no effect on fertility has been observed, however other reproductive effects have been reported. For example, an increase in the rate of spontaneous abortion has been reported involving fathers exposed to metallic mercury in chlorakali plants before the pregnancy. There was a significant increased risk of spontaneous abortion with a rate of 18.4 percent when fathers had more than 50 mcg per liter of mercury in the urine compared to a rate of 8.6 percent when fathers were not exposed. (Cordier, et al., 1991)

Female workers exposed to metallic mercury vapors (e.g., dentists and dental assistants) had more reproductive failure (i.e., spontaneous abortions, stillbirths, congenital malformations) than a control group of women not exposed to mercury. (Sikorski, et al., 1987) The developing fetus may be at increased risk of mercury toxicity due to metabolism of mercury vapor. Mercury vapor easily crosses the placenta but is oxidized to the less easily diffusible divalent ionic mercury form by fetal catalase, thus trapping the mercury, allowing fetal accumulation. (Clarkson, et al., 1985)

Several studies designed to look for reproductive health effects from mercury exposure have failed to find any adverse effects. However, given the biologic plausibility of mercury's ability to chemically react with the cell's proteins and membrane structures, the animal evidence of mercury's reproductive toxicity, and those limited human health effects, it is reasonable and prudent to consider mercury capable of reproductive health harm.

Ingestion can be a factor when a worker eat or drink without washing their hands and by smoking on the job. Mercury vapor is absorbed through the human skin, although much less efficiently than through the respiratory route. (Hursh, et al., 1989) There are certain situations, however, where the skin absorption may contribute to systemic toxicity including when mercury droplets are trapped in boots or clothing. Mercury is a take-home toxic and can be transported from the worksite on contaminated clothes, shoes and tools. A very stringent worksite hygiene program should be in place to prevent mercury from being transported to a worker’s home.

Medical Surveillance:
Signs and symptoms of mercury overexposure, such as irritability, fatigue, nervousness, personality or memory changes and tremor, should be included in the health care professional’s questionnaire. Many clinicians also obtain a handwriting sample from the worker to assess tremor. Periodic reassessment, usually annually, may be performed. More sophisticated devices to assess tremor are also available.

Physical examination should emphasize the target organs. A very thorough neurologic examination should also be performed to look for tremor and any other neurologic findings. An examination of the oral cavity is also recommended to observe a divalent cation or identify the "lead line,” which can be seen at the interface of the gum and tooth in workers exposed to mercury. Results of exams must be explained to the workers and maintained in a confidential

manner.

Biologic Monitoring:
Biologic monitoring for chronic exposure to inorganic mercury is best accomplished using a urine sample. Urinary mercury concentrations reflect mercury exposure over the previous several months, thus allowing an assessment of the integrated systemic mercury concentration.

A 24-hour urine collection provides the most precise measure of mercury concentration because there can be variability in mercury excretion throughout the day. A spot urine determination (corrected per gram creatinine) may suffice as a measure of mercury, provided the spot collection is obtained at the same time of day and the collection is corrected for urinary concentration. The worker should also have worked long enough to reach a steady state. (Piatroski, et al., 1975)

Urinary mercury concentration is usually expressed per gram creatinine (a normal constituent in urine) which corrects for a worker's degree of body hydration. The concentration of mercury in urine in non-occupationally exposed persons is 5 mcg per gram creatinine. (Lauwerys and Hoet, 1993)

Nearly twenty years ago, the WHO proposed a unit of 50 mcg per gram creatinine as a limit. The ACGIH has proposed a biologic exposure index of 35 mcg per gram creatinine for mercury. A worker whose urinary mercury result is above 35 mcg per gram creatinine should have the test repeated. The worker's job and work practices should be examined, and other exposure sources of mercury should be investigated. A medical history should be taken and, based on these results, removing the worker from further exposure should be considered.

Mercury in Blood
Mercury in blood reflects exposure to elemental and inorganic mercury (the types of exposures typically found in the mining industry) as well as organic mercury. Because dietary intake-- especially of some fish-- contains organic mercury, a blood mercury value can reflect this dietary contribution, making interpretation difficult. Therefore, blood tests are not appropriate for surveillance for elemental and inorganic mercury.

REFERENCES

American Conference of Governmental Industrial Hygienists (ACGIH), Threshold Limit Values for Chemical Substances and Physical Agents, 1998.

American National Standards Institute (ANSI), Physical Qualification for Respirator Use, Z88, 1992.

Beckett, W.S., "Certifying the Worker for Respirator Use," Sem. Occupation Med., 1:119-124, 1986.

Berlin M., Mercury: Handbook on the Toxicology of Metals (Ed.; Friberg L; Nordberg G.F. and Vouk, VB). Elsevier/North Holland, Amsterdam, 1986.

Braunstein G.D., Dahlgren J., Loriaux L., "Hypogonadism in chronically lead-poisoned men," Infertility 1:33, 1978.

Brodsky, J.B., Cohen E.N., Whitcher C., et al., "Occupational Exposure to Mercury in Dentistry and Pregnancy Outcome," J Am. Dent Assoc. 111:797-780, 1985.

Buchet J.P., Roels H., Bernard A., et al., "Assessment of Renal Function of Workers Exposed to Inorganic Lead, Cadmium or Mercury Vapor", J Occupation Med. 22: 741-751, 1980.

Clarkson T.W., "Recent Advances in the Toxicology of Mercury with Emphasis on the Alklylmercurials", in Critical Reviews in Toxicology, Volume 2, March 1972, pp. 203-234.

Clarkson T.W., Nordberg G.F., Sager P.R., "Reproductive and Developmental Toxicity of Metals," Scand J. Work Environ Health, 11:145-154, 1985.

Clayton,Clayton, In, Patty's Industrial Hygiene and Toxicology, 4th ed. Vol. 2, Part A, 1994 p. 2128.

Cordier S, Deplan F, Mandereau L. et al., "Paternal Exposure to Mercury and Spontaneous Abortions," Br. J. Industrial Medicine 49 (6): 375-381, 1991.

Ehrenberg, R.L., Vogt RL, Smith AB et al. "Effects of Elemental Mercury Exposure at a Thermometer Plant," American Journal Industrial Medicine, 46:370-375, 1991.

Fawer, R.F., Deribaupierre Y, Guillernin, M.P. et al., "Measurement of Hand Tremor Induced by Industrial Exposure to Metallic Mercury," Br. J. Ind. Med. 40: 204-208, 1983.

Friberg, L., Vostal, J. "Mercury in the Environment - a Toxicological and Epidemiological Appraisal," CRC Press, 1972.

Harber, P., "Medical Evaluation for Respirator Use," J. Occup.Med. 26:496-502,1984.

Hernberg,S. and Aitio,A. "Validation of Biological Monitoring," Occupational and Environmental Chemical Hazards-cellular and Biochemical Indicies for Monitoring Toxicity, John Wiley & Sons, New York, pp. 41-49, 1987.

Hodous, T.K., "Screening Prospective Workers for the Ability to Use Respirators,", J. Occup. Med., Vol. 28:1074-1080, 1986.

Hursh, J.B.; Clarkson, T.W.; Miles E.F.; Goldsmith, L.A., "Percutaneous Absorption of Mercury Vapor by Humans," Arch of Environ Health, 44: 120-129, 1989.

Ishinishi, N., Tsuchiya, K., Vahter, M.., Fowler, B., "Arsenic in: Handbook on the Toxicology of Metals" 2nd Ed., Vol. II: Specific Metals, Eds. Friberg, L., Nordberg, G.F., Vouk, V.B., Elsevier, New York, 1986.

Klaucke, D.N., Buehler, J.W., Thacker, S.B. et al. Guidelines for Evaluating Surveillance Systems MMWR 37 (Suppl 5): 1-18, 1988.

Knight, A.L., "Mercury and its Compounds In: Occupational Medicine, Principles and Practical Applications," ed. C. Zenz. Year Book Medical Publishers Inc., 1988.

Lancranjan, I., Popescu, H.I., Gavanescu, O., Klepsch, I., Serbanescu, M., "Reproductive Ability of Workmen Occupationally Exposed to Lead," Arch. Environ Health. 30:396-401,1975.

Langworth, S., "Renal Function in Workers Exposed to Inorganic Mercury. In: Occupational Health in the Chemical Industry," ICOH Conf. Sydney, Australia. (WHO Copenhagen), 1987.

Lauwerys, R., "Current use of Ambient and Biological Monitoring: Reference Workplace Hazards Cadmium. In: Assessment of Toxic Agents in the Workplace, Roles of Ambient and Biological Monitoring," (A. Berlin, R.A. Yodaiken, and B.A. Henman, eds.) pp.109-119. Martinus Nijhoff Publishers, Luxembourg, 1980.

Lauwerys, R., Roels, H., Genet, P., et al "Fertility of Male Workers Exposed to Mercury Vapor or to Manganese Dust. A Questionnaire Study," Am. J. Ind. Med. 7:171-176, 1985.

Lauwerys, R.R., Hoet, P., "Industrial Chemical Exposure," Guidelines for Biological Monitoring. Lewis Publishers. 1993.

Leidel, N.A., Busch, K.A., Lynch, J.R., "Occupational Exposure Sampling Strategy Manual," Cinn. NIOSH, Pub. No. 77-173,1977.

Levin, M., Jacobs, J., Polos, P.G., "Acute Mercury Poisoning and Mercurial Pneumonitis from Gold Ore Purification," Chest 94: 554-556, 1988.

Lien, D.C., Todoruk, D.N., Rajani, H.R., et al. "Accidental Inhalation of Mercury Vapor: Respiratory and Toxicologic Consequences," Can Med. Assoc. J. 129: 591-595, 1983.

Lillis, R., Miller, A., Lernan, Y., "Acute Mercury Poisoning With Severe Chronic Pulmonary Manifestation," Chest 82:306-309, 1985.

Mishonova, V.N., Stepanova, P. and Zarudin, U.V., "Characteristics of the Course of Pregnancy and Births in Women with Occupational Contact with Small Concentration of Metallic Mercury Vapors in Industrial Facilities," Gig Trudo Prof. Zabol 24 (2): 1-23, 1980.
Mutti, A., Lucertini, S., Fornari, M., et al. "Urinary Excretion of Brush Border Antigen Revealed by Monoclonal Antibodies in Subjects Occupationally Exposed to Heavy Metals," In Proceedings of the Int. Conf. on Heavy Metals in the Environment Luxembourg. Comm. of Env. Comm. Vol. 1 565-567, 1985.

North American Contact Dermatitis Group. "Epidemiology of Contact Dermatitis in North America," Arch. Derm. 108: 537-540, 1972.

Piotrowski, B., Trojanowska, B., Mogilnicka, E., "Excretion Kinetics and Variability of Urinary Mercury in Workers Exposed to Mercury Vapor," Int. Arch Occup. Environ Health 35:245, 1975.

Plog, B.A. (ed.): "Fundamentals of Industrial Hygiene," 3rd ed. Chicago, National Safety Council, 1988.

Roach, S.A., "A commentary on December 1986 workshop on strategies for measuring exposure," Am Ind Hyg J. 48:A822-832, 1987.

Rom, W.N., "Effects of Lead on the Female and Reproduction: A Review," The Mt. Sinai J Med.

43:542, 1976.

Roels, H., Gennert, S.P., Lauwerys, R., et al "Surveillance of Workers Exposed to Mercury Vapor: Validation of a Previously Proposed Biological Threshold limit Value for Mercury Concentration in Urine," Am J. Ind Med. 7:45-71, 1985.

Roels, H., Abdeladim, S., Braun, M., et al. "Detection of Hand Tremor in Workers Exposed to Mercury Vapor: a Comparative Study of Three Methods," Environ. Res. 49: 152-165, 1989.

Rowland, A.S., Baird, D.D., Weinberg, C.R., et al. "The Effect of Occupational Exposure to Mercury Vapor on the Fertility of Female Dental Assistants," Occup. Environ. Med. 51-28-34, 1994.

Seaton, A., Bishop, C.M.,. "Acute Mercury Pneumonitis," Br. J. Ind Med. 35: 25 -265, 1978.

Sikorski, R., Juszkiewiczt, Paszkowski, T., et al. "Women in Dental Surgeries: Reproductive Hazards in Occupational Exposure to Metallic Mercury," Int. Arch. Occup. Environ. Health 59:551-557, 1987.

Silbergeld, E.K., "Behavioral Teratology of Lead In Neurobehavioral Teratology," ed. J. Yanai, Elsevier Inc., Holland pp. 433-445, 1984.

Soule, R.D., "Industrial Hygiene Engineering Controls," In: Clayton GH, Clayton FE, eds. Pattys Industrial Hygiene and Toxicology. 3rd ed. New York, NY: John Wiley & Sons; 1:707-771, 1978.

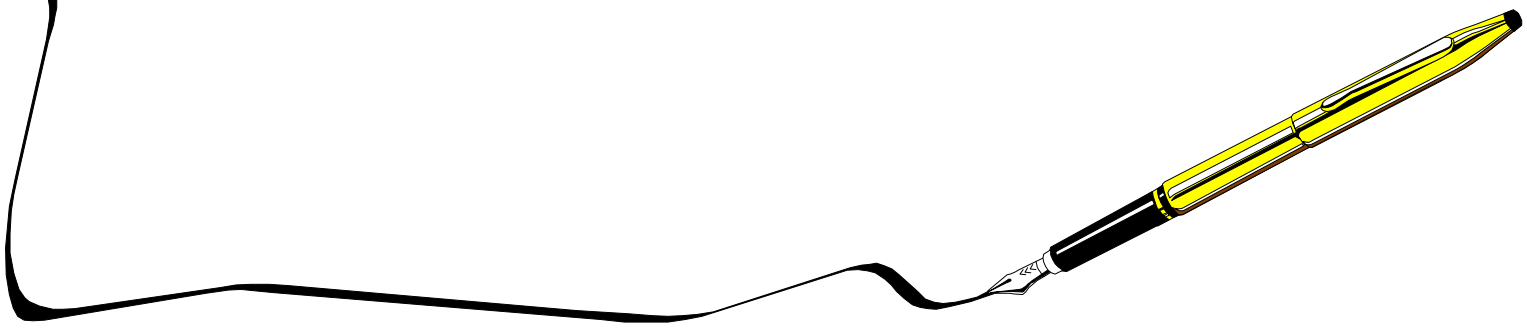
"U.S. Occupational Safety and Health Administration. Respiratory Protection Final Rule," CFR 1910.134, 1998.

Weeks, J.L., Levy, B.D., Wagner, G.R. (ed). "Preventing Occupational Disease and Injury," Am Public Health Assoc. Wash. DC. 1991.

White, R.R., and Brandt, R.I., "Development of Mercury Hypersensitivity Among Dental Students," J. Am. Dent. Assoc. 92: 1204-1207, 1976.

Zielhaus, R., "Biological Monitoring," Scand. J. Work Environ. Health. 4: 1-18, 1978.

Appendix A



A

Practical Information for Employers About Contracting for Medical Surveillance Services

The power of medical surveillance to fully achieve the objective of minimizing adverse impact on health in exposed persons is, to a very large extent, in the management and communication of the medical surveillance results. The employer should consider using a health care professional with experience in managing and communicating the results of occupational surveillance to both employers and employees. An inexperienced provider may view the medical surveillance contract as just a number of physical exams, medical tests and lab work. A skilled and competent health care professional who provides occupational medical surveillance services will provide summary data. This information can be used to assess the effectiveness of the engineering controls such as ventilation, the work practices such as the personal hygiene procedures and/or the personal protective equipment such as respirators.

The employer should use a health care professional with specialized training and experience to make fitness for duty determinations, to assess fitness for respirator use and to monitor biological trends by exposure category in the workforce.

The following specific requirements and guidelines should be provided to the in-house or contract health care professional who is managing the medical surveillance program. This will ensure that the medical surveillance program works as it should — alerting the employer to early exposure problems, and educating and informing the employees about the steps they can take to protect their health.

Information the Employer Should Furnish the Health Care Professional:

- **Exposure Assessment Results**

  The health care professional will want the results of exposure assessments, such as air monitoring. This critical information should be provided by job title or work area, allowing the professional to assess actual and potential exposures. This is vital for assessing early exposure and determining a worker's fitness for duty.

- **Safety and Health Procedures**

  The health care professional will want information about safety and health procedures at the worksite. For example, provide descriptions of the engineering controls in place to reduce exposures such as ventilation or enclosures. Outline any administrative controls such as work rotation or restricted duty options.

A

- **Personal Protective Equipment**

  The health care professional will want information about the types and purposes of the personal protective equipment in use at the worksite. Provide the levels of respiratory protection which will be in use. It is essential that the professional know about the various respirators available to the workers, such as half-face, full-face, powered air purifying and self-contained breathing apparatus.

- **Training and Education**

  The health care professional will want information about the training and education programs at the worksite. This includes training on hazard communication, personal protective equipment and respirators, heat stress, confined space entry and emergency procedures.

- **Emergency Policies**

  The health care professional will want information about the worksite's policies for emergencies, including medical emergencies, fires, hazardous spills and explosions. The professional may or may not be involved in your emergency plan, however, the plan may provide important information to the health care professional.

- **Tour of the Workplace**

  The health care professional may want a tour of the operation. Plan a time when the surveillance team can observe a typical operational day. Invite a worker representative to participate in the tour which will foster an open and cooperative relationship between workers and the medical surveillance professionals. Most occupational health professionals will consider a tour of the worksite an essential part of their professional responsibilities to make fitness-for-duty determinations.

- **Biological Monitoring Protocol**

  The health care professional will want the protocol for the biological testing (i.e, blood lead, urine cadmium or mercury.) The protocol should include a lists of tests, the scheduled intervals for testing, any lab or method requirements, the expected normal ranges, the ranges for action and the ranges for medical removal. An experienced provider of occupational health services can assist the employer in designing a protocol for site-specific exposures.

A

Information the Health Care Professional Should Provide to the Employer and\or Workers:

- **Fitness for Duty Notification to Employer**

  The employer should receive notification from the health care professional of employee's fitness for the job within 48 hours of the medical exam. There may be exceptions to this time frame, in particular for borderline or abnormal test results which need further medical follow-up. In those cases, the employer should be notified that the fitness for duty determination is pending and receive an estimate of the time it will take to resolve the issues. *(See sample "Fitness for Duty Form" - Appendix B)*

- **Written and Verbal Explanation of Results**

  The health care provider should explain all tests to the employer and provide the employees with test results. Ideally, the medical provider will communicate results to the employee in-person, as well as sending a letter to the employee's home address. The employer should not expect to see this letter. The employer should encourage the employees to deal directly with the health care professional if they have questions or concerns. *(See sample "Letter to Employee" - Appendix C)*

- **Periodic Summary Report**

  The employer should receive an overall summary of the medical status of their workforce with respect to biological monitoring of exposures. An operation with multiple work sites may want summary reports for each site. Biological data, such as blood lead or urine cadmium levels, should be analyzed over time for changes which may reflect earlier over exposures.

Other Requirements for the Health Care Professional:

- **Confidential Storage of Medical Records**

  The health care professional must be willing to maintain the surveillance records indefinitely, in an accessible but confidential manner. The professional should agree to forward the medical records to another health care professional upon written request from the employee. If the employer changes medical surveillance providers, the records from the initial provider must be transferred to the new provider in a confidential manner.

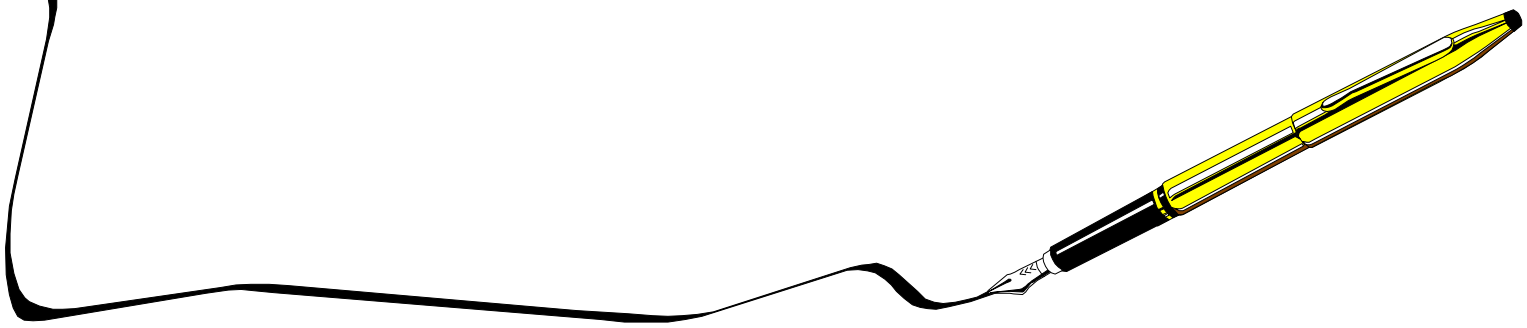
A

- **Communication Assistance**

  The health care professional may be willing to assist the employer by communicating to the employees information about the medical surveillance program or changes to an existing program. The health care professional should work with the employer to schedule an appropriate time to meet with employees, such as before the employees shift. The health care professional will explain the purpose of the surveillance program, the logistical procedures, such as scheduling, and allow employees to ask questions.

(See "Sample Questionnaires" - Appendix D)

Appendix B



B

Employer Notification of Examination Results
"Fitness for Duty Form"

Company:

Employee Name:_____ Job Title:_____

SSN: ____/____/____ DOB:_____

Type of Exam:
G Initial Exam **G** Periodic **G** Exit **G** Other (Describe)_____

Exposure Exam Type:
G Arsenic **G** Cadmium **G** Lead **G** Mercury **G** Other_____
G Respirator User **G** Other _____

Physician's Diagnosis:_____

Physician's Opinion:

G Medically fit for work - No medical condition which would place the employee at increased risk of material impairment to health from further exposure to:
G Arsenic **G** Cadmium **G** Lead **G** Mercury.

G Medically fit to wear respiratory protection.

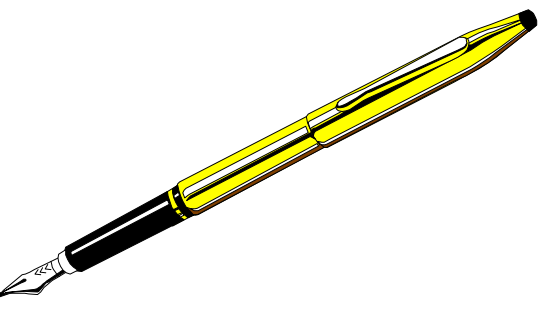
G Fitness Determination Pending_____
G Medically fit with the following restrictions:
_____
_____
_____

G Not Medically Fit - See attached explanation

G The physician has clearly and carefully explained the results of the medical examination to the worker, including all biological monitoring results and any medical conditions related to the above indicated exposures that require further evaluation or treatment, and any limitations.

_____ 00/00/00
Physician's Signature **Date**
Physician's Typed/Printed Name

Appendix C



Appendix

C

Sample "Letter to Employee"

Date

Mr./Ms Employee
Employee Street Address
City, State and Zip

Dear Mr./Ms Employee:

Thank you for participating in the **[Name of Mining Company]** Medical Surveillance Program. This joint effort between your employer, **[Name of Health care professional]** and you is part of an overall effort to prevent over exposures to arsenic, cadmium, lead and mercury from affecting your health.

Enclosed are the results from your recently completed evaluation. You completed a **[Exam Type i.e. initial or periodic exam**] on **[Date of Examination]** for your work as a **[Job Title i.e. Process Engineer].** Your specific results are as follows:

Physical Exam:	**Within Normal Limits.**
Laboratory Tests (Blood):	**Within Normal Limits except …..We discussed this, <u>but bring to the attention of your primary care provider.</u>**
Laboratory Tests (Urine):	**Within Normal Limits**
Pulmonary Function Tests:	**Within Normal Limits**
Respiratory Protection:	**Medically fit to wear respiratory protection.**
Physician's Opinion:	**Medically fit.**

Biological Exposure Results:

Test	Your Level	Expected Level	Change	Next Test*
Urine Arsenic		**Less than 50mcg/g creatinine**	**Unchanged/Improved /Worsened**	**6 months***
Urine Cadmium		**Less than 5 mcg/g creatinine**	**Unchanged/Improved /Worsened**	**3 months***
Blood Lead		**Less than 30 mcg/dl**	**Unchanged/Improved /Worsened**	**2 months***
Urine Mercury		**Less than 35 mcg/g creatinine**	**Unchanged/Improved /Worsened**	**3 months***

2

***The frequency of testing will be determined by the supervising physician who will consider the level itself (ie, high vs low), the worker's health status and the rate of change in the level.**

If you have specific questions about your medical results or would like to request a copy of your tests for your family doctor please call **[Health care professional name and phone number]**

Attached also is a copy of the report sent to your employer. If you have questions about your exposures or personal protection equipment, please contact the **[Health and Safety contact person for company].**

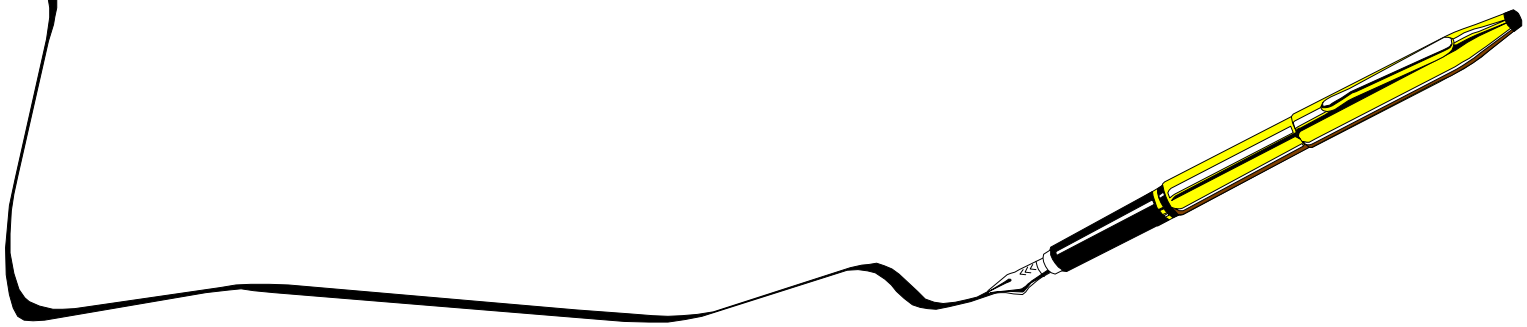
Sincerely,

Physician Name, M.D., .

Enclosure: 1

Appendix D

For use by health care professional providing medical surveillance services to mine operators.



Appendix

D

Sample "Questionnaire"

To the employee:

Please answer the questions following as completely and carefully as you can. These are the kinds of questions that are asked of people who works with cadmium, lead, arsenic, mercury or other metals. You will also be asked to give blood and urine samples. The doctor will give your employer a written opinion on whether you are physically capable of working with these metals. Legally, the doctor cannot share personal information you may tell him/her with your employer. The following information is considered strictly confidential. The results of the tests will go to you, your doctor and your employer.

You will also receive an information sheet explaining the results of any biological monitoring or physical examinations performed.

If you are just being hired, the results of this interview and examination will be used to:

- Establish your health status and see if working with cadmium, arsenic, lead and/or mercury might be expected to cause unusual problems,
- Determine your health status today and see if there are changes over time,
- See if you can wear a respirator safely.

If you are not a newly hired employee, everyone who works with cadmium, lead, arsenic and/or mercury may be offered a periodic medical examinations performed by a health care professional licensed to practice in this state. The reasons for this are:

- To identify early any changed in your because of exposure to heavy metals.
- To prevent kidney, lung, nervous system and reproductive system damage.

Please sign below.

I have read these directions and understand them:

_____ _____

Employee signature Date

[ ] Please send a copy of my medical surveillance results to my primary care provider:

Name of Provider or Clinic:_____

Address:_____

_____

Phone:_____FAX:_____

Initial Visit Questionnaire

Today's Date:_____

Name:_____

Age: ____ Date of Birth: ____/____/____ Social Security Number: ____/____/____

Your gender: [ ] Male [ ] Female

Marital Status: [ ] Single [ ] Married [ ] Divorced [ ] Widowed

Number of years of school completed: _____.

Company:_____ Your Job:_____

How long have you worked at the job listed above?

[ ] Not yet hired [ ] _____Months [ ] _____Years

To be filled out by clinic staff:

Height: _____ft. _____in. Weight: _____ lbs.

Blood Pressure # 1: _____/_____ Lying/Sitting (Circle One) Heart Rate: _____

Blood Pressure # 2: _____/_____ Lying/Sitting (Circle One) Heart Rate: _____

(Second blood pressure only if needed)

Type of Preplacement Exam:

[ ] Periodic [ ] Termination [ ] Initial [ ] Other_____

Please list your job duties:_____
_____
_____

Please mark if you are exposed to any of the following in your work:

[ ] Cadmium [ ] Lead [ ] Mercury [ ] Arsenic

Have you been issued a respirator for your job? Yes No

If yes, check the type of respirator you will use (you can check more than one category)

G **N, R, or P disposable respirator (filter-mask, non-cartridge type only).**

G **Other type (for example, half-or full-face piece type, powered-air purifying, supplied-air, self-contained breathing apparatus).**

Have you worn a respirator (circle one): Yes No

If yes, what type(s):_____

General Health Questions - Please answer each question!	**Circle One**	
1. Do you currently smoke tobacco, or have you smoked tobacco in the last month?	**Yes**	**No**
If yes, year started smoking:_____		
Average number of cigarettes smoked per day:_____		
If no, have you ever smoked?	**Yes**	**No**
If yes, year that you quit:_____		
If yes, year started smoking:_____		
Average number of cigarettes smoked per day:_____		
2. Do currently chew tobacco, or have you chewed tobacco in the last six months?	**Yes**	**No**
3. Do you drink alcohol?	**Yes**	**No**
If yes, [ ] Beer [ ] Wine [ ] Liquor		
How may days/week do you drink?_____		
How may drinks/day? _____		
At what age did you start drinking alcohol?_____		
If stopped, at what age did you stop?_____		
4. Do you currently take any **medications?**	**Yes**	**No**
If yes, list all medications here:		
_____		
_____		
_____		
5. Have you ever been hospitalized?	**Yes**	**No**
If yes, describe:		
Date_____Reason for Hospitalization:_____		
Date_____Reason for Hospitalization:_____		
Date_____Reason for Hospitalization:_____		
Date_____Reason for Hospitalization:_____		
6. Has a doctor ever told you that you have any of the following conditions:		
Seizures (fits)?	**Yes**	**No**
Diabetes (sugar disease)?	**Yes**	**No**
Allergic reactions that interfere with your breathing?	**Yes**	**No**
Thyroid problem?	**Yes**	**No**
Gout?	**Yes**	**No**
Arthritis or Joint Disease?	**Yes**	**No**
Head injury with loss of consciousness?	**Yes**	**No**

7. Have you ever been told by a doctor that you had any of the following **pulmonary or lung problems**?

Asbestosis?	**Yes**	**No**
Asthma?	**Yes**	**No**
Chronic bronchitis?	**Yes**	**No**
Emphysema?	**Yes**	**No**
Pneumonia?	**Yes**	**No**
Tuberculosis?	**Yes**	**No**
Silicosis?	**Yes**	**No**
Pneumothorax (collapsed lung)?	**Yes**	**No**
Lung cancer?	**Yes**	**No**
Broken ribs/	**Yes**	**No**
Any **chest injuries** or **surgeries?**	**Yes**	**No**
Any **other lung problems** that you've been told about?	**Yes**	**No**

If you marked "yes" to any of these questions please describe:

_____
_____
_____
_____

8. Do you currently have any of the following **symptoms of pulmonary or lung illness?**

Shortness of breath?	**Yes**	**No**
Shortness of breath when walking fast on level ground or walking up a slight hill or incline?	**Yes**	**No**
Shortness of breath when walking with other people at an ordinary pace on level ground?	**Yes**	**No**
Have to stop for breath when walking at your own pace on level ground?	**Yes**	**No**
Shortness of breath when washing or dressing yourself?	**Yes**	**No**
Shortness of breath that interferes with your job?	**Yes**	**No**
Coughing that produces phlegm (thick sputum)?	**Yes**	**No**
Coughing that wakes you early in the morning?	**Yes**	**No**
Coughing that occurs mostly when you are lying down?	**Yes**	**No**
Coughing up blood in the last month?	**Yes**	**No**
Wheezing?	**Yes**	**No**
Wheezing that interferes with your job?	**Yes**	**No**
Chest pain when you breath deeply?	**Yes**	**No**
Any other symptoms that you think may be related to lung problems?	**Yes**	**No**

If you marked "yes" to any of these questions please describe:_____
_____

9. Have you ever been told by a doctor that you had any of the following **cardiovascular or heart** problems?

Heart attack?	**Yes**	**No**
Stroke?	**Yes**	**No**
Angina (chest pain)**?**	**Yes**	**No**
Heart failure?	**Yes**	**No**
Swelling in your legs or feet (not caused by walking)?	**Yes**	**No**
Heart arrhythmia (heart beating irregularly)?	**Yes**	**No**
High blood pressure?	**Yes**	**No**
Anemia (low blood count)	**Yes**	**No**

Any other **heart problem** that you've been told about? **Yes** **No**

If you marked "yes" to any of these questions please describe:

_____
_____
_____
_____

10. Have you ever had any of the following **cardiovascular or heart symptoms?**

Frequent pain or tightness in your chest? **Yes** **No**

Pain or tightness in your chest during physical activity? **Yes** **No**

Pain or tightness in your chest that interferes with your job? **Yes** **No**

In the past two years, have you noticed your heart skipping or missing a beat? **Yes** **No**

Heartburn or indigestion that is not related to eating? **Yes** **No**

Any other symptoms that you think may be related to heart or circulation problems? **Yes** **No**

If you marked "yes" to any of these questions please describe:

_____
_____
_____

11. Have you ever been told by a doctor that you had a **kidney or urinary tract disease or disorder?** **Yes** **No**

Have you ever had any of these disorders?

Kidney stones? **Yes** **No**

Protein in urine? **Yes** **No**

Blood in urine? **Yes** **No**

Difficulty urinating? **Yes** **No**

If you marked "yes" to any of these questions please describe:_____
_____

12. If you/ve used a respirator, have you ever had any of the following problems? If you have never used a respirator, check here: [ ].

Eye irritation? **Yes** **No**

Skin allergies or rashes? **Yes** **No**

Anxiety? **Yes** **No**

General **weakness or fatigue**? **Yes** **No**

Any other problem that interferes with your **use of a respirator**? **Yes** **No**

Claustrophobia (fear of closed-in places)? **Yes** **No**

Trouble smelling odors? **Yes** **No**

Ruptured ear drum? **Yes** **No**

Serious hearing problem? **Yes** **No**

Current Symptoms:

13. Do you now or in the last week have any of the following symptoms:

Feel more **tired** than usual**?** **Yes** **No**

Feel unusually **irritable?** **Yes** **No**

Have difficulty **remembering things?** **Yes** **No**

Have difficulty **concentrating?** **Yes** **No**

Feel **sad** or **depressed?** **Yes** **No**

Have **trouble sleeping** at night? **Yes** **No**

Less interested in **sex?** (Reduced sex drive?) **Yes** **No**

Dizziness? **Yes** **No**

Headaches?	**Yes**	**No**
Numbness (or tingling) in **hands?**	**Yes**	**No**
Numbness (or tingling) in **feet?**	**Yes**	**No**
Trouble with **constipation?**	**Yes**	**No**
Trouble with **diarrhea?**	**Yes**	**No**
Pain or cramps in your **abdomen?**	**Yes**	**No**
Pain in your joints?	**Yes**	**No**
Experienced a **recent weight loss?**	**Yes**	**No**
Personality changes?	**Yes**	**No**
Shaking or tremors?	**Yes**	**No**
Reduced coordination?	**Yes**	**No**

The following questions pertain to your reproductive history.

14. Do you have children? **Yes** **No**

Please list the dates of birth of your children:

First Child: _____

Second Child: _____

Third Child _____

Fourth Child _____

Fifth Child _____

Sixth Child _____

15. Have you or your partner ever had a problem having a child? **Yes** **No**

If yes, specify:

[ ] Self

[ ] Present partner

[ ] Previous partner

16. Have you or your partner consulted a physician for a fertility or other reproductive problem? **Yes** **No**

If yes, specify who consulted the physician:

[ ] Self

[ ] Spouse/partner

[ ] Self and partner

If yes, specify diagnosis made:

_____

17. Have you or your partner ever had a miscarriage, still birth or baby with a **Yes** **No**

medical problem/birth defect?

If yes, specify:

[ ] Miscarriage

[ ] Still birth

[ ] Birth Defect/medical problem

If birth defect/medical problem, please specify type:

_____

Where were you working when child with medical problem/birth defect was born?_____

Where was your partner working?_____

Was this pregnancy of:

[ ] Yours with present partner

[ ] Yours with a previous partner

For Women Only

18. Do you have menstrual periods? **Yes** **No**

19. Have you had menstrual irregularities? **Yes** **No**

If yes, specify type:

_____

_____

If yes, what was the approximate date this problem began? _____

_____

Approximate date problem stopped? _____

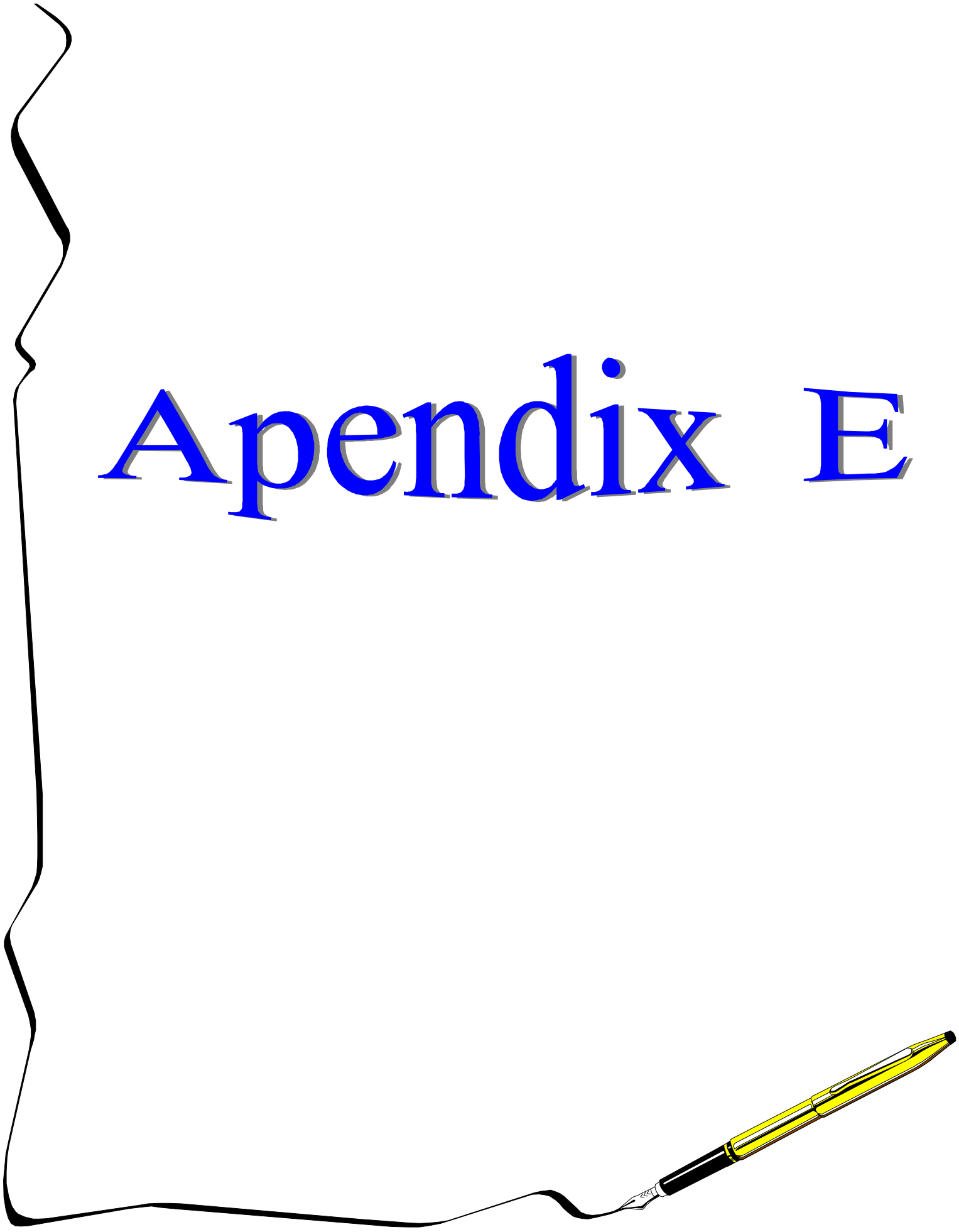
For Men Only

20. Have you ever been diagnosed by a physician as having prostate gland problem(s)? **Yes** **No**

21. If yes, please describe type of problem(s) and what was done to evaluate and treat the problem(s) :

_____

Apendix E



E

Frequently Asked Questions and Answers

What heavy metals can miners be exposed to?

*Miners may be exposed to arsenic, cadmium, lead, mercury or combinations of these heavy metals. In order to know for sure what metals are in your work environment, environmental sampling must be carried out to determine the **type** and **amount** of exposures in a job area. Your employer can show you the results of the environmental sampling from your job.*

What are the potential health effects of exposure to these metals?

*As with any poison or toxic substance, it is the dose that makes the poison. That is, the health effects of exposure to these metals will depend on **how much** exposure you have and for **how long** you are exposed.*

There are both acute and chronic effects for each of these metals:

Metal	Acute Effects	Chronic Effects
Arsenic	cough, chest pain, shortness of breath, headache and stomach distress, nasal septum perforation	weight loss, nausea, stomach problems, skin effects, numbness in hands and feet, lung cancer, skin cancer
Cadmium	respiratory irritation, cough then shortness of breath, chest pain and flu-like symptoms such as fever, headache and chills may begin, acute pulmonary edema requiring emergency room treatment	kidney disease, increased risk of lung and prostate cancer, also possible bone effects, emphysema and high blood pressure, possible reproductive effects.
Lead	headache, loss of appetite and stomach pain, irritability, fatigue, memory problems, joint pain, depression	headache, loss of appetite and stomach pain, irritability, fatigue, memory problems, joint pain, depression, reduced sex drive and impotence and other reproductive problems; kidney problems, high blood pressure and stroke
Mercury	acute lung effects, chest pain, cough shortness of breath and stomach problems; mouth sores, tremors and skin rashes	central nervous system effects such as tremor, depression, fatigue, irritability, kidney effects, reproductive effects such as miscarriages

How can I avoid exposure while at work?

- *Participate in your company's hazard communication and respirator training program.*
- *Use personal protective equipment (PPE) including a respirator, if indicated and if you have been trained.*
- *Perform daily fit checks on your respirator prior to using it.*
- *Clean daily and store your respirator in clean area.*
- *Change cartridges in your respirator as you have been trained.*
- *Do not eat, drink or smoke in work areas; wash your hands thoroughly before eating.*
- *Change your work clothes and shower before leaving work.*

What tests can be done to check for overexposure to these metals?

If you are exposed to any of these metals at work you should participate in your company's medical surveillance program. Such a program will include a physical examination, questions about symptoms and other tests such as breathing tests, blood and urine tests or x-rays. In addition, you may also be checked for levels of the substance in your body.

Metal	Test	How Often to Get Each Test
Arsenic	Urine Arsenic	Baseline Every 6 months if low More often if elevated
Cadmium	Urine Cadmium Blood Cadmium Beta2-microglobulin	Baseline Every year if low, every six months if moderately high, every 3 months if high
Lead	Blood lead Free Erythrocyte Protoporphyrin (FEP) Hemoglobin	Baseline Every 2 months for six months Every 6 months if low More often if elevated
Mercury	Urine Mercury Blood Mercury Hair Analysis	Baseline Every 3 months if low More often if elevated

Can these substances harm my family?

As mentioned above, you should change your clothes and shower before leaving work. Do not bring any soiled clothing or equipment from work to home. There are documented cases of families becoming ill from arsenic, cadmium, lead and mercury being transported from work to home.

What should I tell my family doctor about these exposures?

Tell your family doctor about your occupation, and alert him\her about any exposures. Forward all medical results from the medical surveillance program to your family doctor for your medical file. It is essential that your family doctor be aware of your work exposures and have access to your medical surveillance records. If you or someone in your family becomes sick, it will probably be your primary health care professional who sees you first.

Where can I get more information?

Your local MSHA office or call (703) 235-8307.

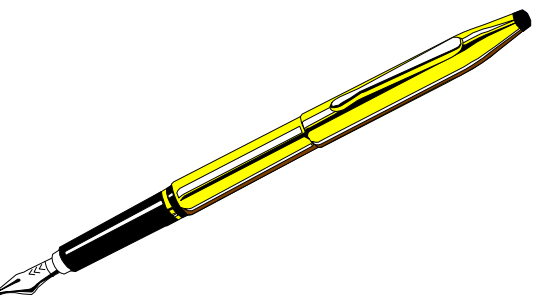
To report a hazardous condition at a mine to MSHA, call (800) 746-1554. You do not need to identify yourself.

American Association of Occupational and Environmental Clinics (AOEC)

CCII.(**phone?)** 347-4976 - Can assist you to locate a clinic with experience dealing with work exposures.

> AOEC, a non-profit organization, is committed to improving the practice of occupational and environmental health through information sharing and collaborative research.
>
> website: **gilligan.mc.duke.edu/oem/aoec.html**

Appendix F



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Resources

Mine Safety and Health Administration (MSHA)

- To notify MSHA of a mine accident or emergency, call your local MSHA office. If you are unable to contact your local MSHA office, call (800) 746-1553.
- To report a hazardous condition at a mine to MSHA call (800) 746-1554. You do not need to give your name.
- For general information about MSHA, call the Office of Information and Public Affairs on (703) 235-1452.
- website: **www.msha.gov**

The National Institute for Occupational Safety and Health (NIOSH)

Providing education and training to individuals preparing for or actively working in the field of occupational safety and health

website: **www.cdc.gov/niosh/homepage.html**

The Association of Occupational & Environmental Clinics (AOEC)

AOEC, a non-profit organization, is committed to improving the practice of occupational and environmental health through information sharing and collaborative research.

website: **gilligan.mc.duke.edu/oem/aoec.html**

American College of Occupational and Environmental Medicine (ACOEM)

Phone: 847/228-6850 • Fax: 847/228-1856

website: **www.acoem.org**

American Association of Occupational Health Nurses (AAOHN,)

Phone: (770) 455-7757 • Fax (770) 455-7271

website: **www.aaohn.org**

Agency for Toxic Substances and Disease Registry (ATSDR)

The ATSDR Information Center / ATSDRIC@cdc.gov / 1-800-447-1544

website: **atsdr1.atsdr.cdc.gov:8080/**

Occupational Safety and Health Administration (OSHA)

website: **www.osha.gov**

ACGIH is the American Conference of Governmental Industrial Hygienists, Inc.,

Phone: 513-742-2020 • Fax: 513-742-3355

website: **www.acgih.org**

American Industrial Hygiene Association

Phone: (703) 849-8888 • Fax: (703) 207-3561

E-Mail: infonet@aiha.org | InfoFax Service: (703) 641-INFO

website**: www.aiha.org**

Society of Toxicology

Phone: (703)-438-3115 •(fax) 1-703-438-3113

E-Mail: sothq@toxicology.org

website: **www.toxicology.org**