

## CHAPTER VIII — EXAMPLES OF THE METHOD

The following text of the guide presents information on fourteen selected disease-producing agents to illustrate the use of the decision-making method previously described. The examples presented are antimony, inorganic arsenic, asbestos, benzene, carbon monoxide, coke oven emissions, cotton dust, inorganic lead, inorganic mercury, nitrogen dioxide, noise, crystalline silica, sulfur dioxide, and toluene diisocyanate.

Different and additional agents could have been presented, and consideration will be given to such publication if experience with the guide indicates a demand for such agent information. As a group, however, the above agents exemplify both acute and chronic effects. They represent different physical forms: Solid fibers, physical agents, particulates, fumes, and vapors. In their health effects these agents involve many organ systems: Respiratory system, central nervous system, hepatic system, genitourinary system, blood forming (hematopoietic) organs, and other systemic effects, as well as carcinogenic action. The organization of the agent material presented in the following pages can serve as a guide for collecting and recording pertinent information about other disease-producing agents.

# ANTIMONY AND ITS COMPOUNDS (EXCEPT STIBINE)

## *Introduction*

Antimony is a silvery, lustrous metal or gray lustrous powder; its chief ore is stibnite. Antimony may cause adverse health effects through inhalation, ingestion, and skin absorption. Dust and fumes of antimony and its compounds are sources of the hazard.

Antimony is frequently encountered as a fine dust in industry with inhalation being the usual route of entry. Dust may be ingested by swallowing accumulations which have been deposited in the upper respiratory tract.

Nonoccupational exposure may occur through ingestion (i.e., antimony dissolved from enamel glazed utensils used for acidic foods and fluids such as lemonade) or inhalation and/or skin absorption (i.e., clothing impregnated with antimony trioxide for flameproofing). However, exposures are low, except in industry.

The symptoms of early antimony poisoning are similar to arsenic (NOTE: See Arsenic Guide), and the two elements are often encountered together in nature. Antimony compounds are irritating to the skin and mucous membranes often resulting in dermatitis, gingivitis, rhinitis, inflammation of the upper and lower respiratory tracts including pneumonitis, gastritis, conjunctivitis, and ulceration of the nasal septum (cartilage separating the nostrils) and larynx. The weakness and fatigue characteristic of the chronic poisoning may be due to anemia caused by antimony. Cardiac injury and cases of sudden death have been reported in persons exposed to antimony.

Antimony has been found to cause pneumoconiosis in workers exposed to the ore stibnite. Antimony may produce changes in the lung detectable by X-ray; lung function may also be affected.

**“Antimony spots” is a dermatitis caused by antimony trioxide in which there is intense itching followed by skin eruption. Lesions tend to occur in hot weather due to dust accumulating on moist skin areas.**

**Chromosome damage in human cells has been induced by antimony (Patton and Allison, 1972).**

**Antimony can form many compounds, most of which are less toxic than antimony. The following is a listing of common compounds and some common names, followed by a listing of occupations with potential exposure to antimony:**

<b>Chemical Name</b>	<b>Common Names</b>
antimony	antimony black, antimony regulus, stibium
antimony arsenate	
antimony arsenite	
antimony dioxysulfate	
antimony ethoxide	triethyl antimonite
antimony $\alpha$ -mercaptoacetamide	antimony thioglycolamide
antimony lactate	antimonine, antimony salt of lactic acid
antimonyl pyrogallol	
antimony oxychloride	algaroth powder, antimonyl chloride, antimony chloride oxide, basic antimony chloride, mercurius vitae
antimony oxysulfide	cathusian powder, kermes mineral, kermesite, pyrostibnite antimony blend, sulfurated antimony

<b>Chemical Name</b>	<b>Common Names</b>
antimony pentachloride	antimonie chloride, antimony perchloride, butter of antimony
antimony pentafluoride	antimony fluoride
antimony pentaiodide	antimony iodide
antimony pentasulfide	antimonie sulfide, antimonial saffron, antimony red, antimony persulfide, antimony sulfide, golden antimony sulfide
antimony pentoxide	antimonie anhydride, antimonie acid, antimonie oxide, antimony pentaoxide, stibic anhydride
antimony potassium dimethyl cysteino tartrate	
antimony potassium oxalate	potassium-antimony oxalate, potassium oxalatoantimonate
antimony potassium tartrate	antimony potassium salt of tartaric acid, potassium antimony tartrate, potassium antimonyl tartrate, tartrated antimony, tartar emetic, tartarized antimony
antimony sodium dimethylcysteino tartrate	
antimony sodium gluconate	antimony gluconate complex sodium salt, antimony gluconate sodium, gluconic acid antimony sodium derivative, sodium antimony gluconate, sodium stibogluconate, triostam, T.S.A.G.
antimony sodium tartrate	antimony sodium oxide L-tartrate, Emeto-Na, sodium antimonyl tartrate, stibunal

<b>Chemical Name</b>	<b>Common Names</b>
<b>antimony sodium thioglycollate</b>	<b>antimony sodium thioacetate, mercaptoacetic acid antimony derivative sodium salt</b>
<b>antimony sulfate</b>	<b>antimony salt of sulfuric acid, antimonous sulfate, antimony trisulfate</b>
<b>antimony tetroxide</b>	<b>antimony oxide</b>
<b>antimony tribromide</b>	<b>antimonous bromide, antimony bromide</b>
<b>antimony trichloride</b>	<b>antimonous chloride, antimony chloride, butter of antimony, caustic antimony, mineral butter</b>
<b>antimony trichloride solution</b>	<b>antimony chloride solution, liquid butter of antimony</b>
<b>antimony trifluoride</b>	<b>antimonous fluoride, antimony fluoride</b>
<b>antimony triiodide</b>	<b>antimonous iodide, antimony iodide</b>
<b>antimony trioxide</b>	<b>antimony oxide, antimony white, antimony bloom, diantimony trioxide, Exitelite, flowers of antimony, Senarmontite, sulfuret of antimony, black antimony, Valentinite Weisspiess-glanz</b>
<b>antimony triselenide</b>	
<b>antimony tritelluride</b>	<b>antimony telluride</b>
<b>antimony trisulfide</b>	<b>antimony glance, antimony orange, antimony sulfide, antimonous sulfide, antimonite, crimson antimony, gray antimony, needle antimony, stibnite</b>

<b>Chemical Name</b>	<b>Common Names</b>
emetine antimony iodide	antimony emetine iodide
lead antimonate	antimony yellow, Naples yellow
oxo (tartrato) antimonate (1-) aniline	aniline antimonyl tartrate, antimonyl aniline tartrate
sodium antimonate	antimony sodiate
sodium antimonyl adonitol	
sodium antimonyl D-arabitol	
sodium antimonyl biscatechol	
sodium antimonyl tert-butyl catechol	
sodium antimonyl catechol thiosalicylate	sodium antimonous-3-catechol thiosalicylate, stibsol
sodium antimonyl citrate	
sodium antimonyl erythritol	
sodium antimonyl D-funcitol	
sodium antimonyl gluco- guloheptitol	
sodium antimonyl glycerol	
sodium antimonyl 2,5-methylene D-mannitol	
sodium antimonyl 2,4-methylene D-sorbitol	
sodium antimonyl xylitol	

## Occupations with Potential Exposures to Antimony

antimony ore smelters	cable splicers
antimony workers	ceramic makers
babbitt metal workers	compositors
battery workers, storage	copper refiners
brass founders	dye makers
britannia metal workers	electroplaters
bronzers	explosives makers
burnishers	fireworks makers
flameproofers	pewter workers
foundry workers	pharmaceutical workers
glass makers	phosphor makers
glaze dippers, pottery	pigment makers
gold refiners	plaster cast bronzers
insecticide makers	porcelain workers
insulators, wire	pottery workers
lake color makers	printers
lead burners	pyrotechnics workers
lead hardeners	rubber makers
lead shot workers	semiconductor workers
linotypers	solder makers
match makers	stereotypers
metal bronzers	stibnite miners
miners	storage battery workers
monotypers	textile dryers
mordanters	textile flameproofers
organic chemical	textile printers
synthesizers	type metal workers
paint makers	typesetters
painters	vulcanizers
perfume makers	zinc refiners

## *Medical Evaluation and Differential Diagnosis*

(See also Decision-Making Process)

The following should be considered:

- Inflammation of several nerves (polyneuritis) due to other industrial poisons (e.g., lead) or in chronic excessive alcohol intake,

- diseases of the heart muscles caused by toxins (toxic cardiomyopathies),
- diseases of the stomach,
- rashes due to food and drug sensitivity (urticaria), and
- jaundice due to phosphorus or arsenic poisoning

## *Signs and Symptoms*

### **Acute Poisoning**

Acute poisoning from antimony seldom occurs as an occupational exposure. Signs and symptoms of acute antimony poisoning are chiefly gastrointestinal and include:

- Violent vomiting,
- continuous diarrhea with mucus,
- hepatitis,
- kidney involvement with blood in the urine (hematuria),
- shock may be associated with slow, irregular respiration and a subnormal temperature, and
- death may occur in several hours.

### **Chronic Poisoning**

Chronic antimony poisoning can result from the inhalation of dusts or fumes, by ingestion, or by skin absorption. General complaints are:

- Irritability,
- fatigue,
- numbness and tingling (neuritis),
- muscular aches,
- loss of appetite (anorexia),
- gastrointestinal symptoms such as nausea or constipation,
- headache,
- dizziness, and
- chest pain.

Respiratory symptoms are:

- Inflammation of the larynx (laryngitis),
- inflammation of the trachea (tracheitis),
- cough, and
- difficulty in breathing (dyspnea).



Antimony and its compounds are generally regarded as primary skin irritants. Lesions usually appear on exposed, moist area of the body but rarely on the face. Skin disorders include:

- Sores resembling chickenpox (pustular, covered with a crust),
- blistering of the lips,
- perforation of the nasal septum (cartilage separating the nostrils), and
- nodular ulcers on the neck and/or moist areas of the body, e.g., axilla or groin.

Other symptoms of chronic poisoning are:

- Inflammation of the gums (gingivitis),
- inflammation of the mouth (stomatitis),
- inflammation of the membrane that lines the eyelids and the front of the eyeball (conjunctivitis),
- inflammation of the cornea (keratitis),
- constipation,
- joint pains (arthralgia), and
- possible diseases of the skeletal, voluntary, or cardiac muscles.

Either liver or kidney failure or both can occur in the late stages of the disease, and death may result.

## *Laboratory and Clinical Evaluations*

Additional data which will assist in arriving at a correct diagnosis are:

### *Blood*

- antimony level above 6.0 milligrams per deciliter
- white blood count may show a shift to the left (a preponderance of less mature white cells)

### *Urine*

- antimony level above 1.0 milligram per liter

### *Liver*

- liver function studies may reveal hepatic injury

### *Electrocardiogram*

- acute poisoning may induce ST and T wave changes, auricular fibrillation, and possibly ventricular arrhythmias

### *Chest X-ray*

- may indicate pneumonitis or pneumoconiosis (small opacities in all regions of the lung)

## *Epidemiology*

A great variety of signs and symptoms associated with industrial exposure to antimony has been detailed in the scientific literature. Epidemiologic studies have demonstrated the relationship between antimony and myocardial changes, transient pneumonia, chronic dermatitis, irritation of the mucous membrane, and irritation of the digestive tract among workers in trades and occupations such as mining antimony-containing ores, flameproofing, abrasives, and the printing industry. The data demonstrate that worker exposure is dependent on the specific antimony compound present in the work environment. This should be considered when reviewing the following information:

Brieger et al.<sup>1</sup> reported a 2-year study of 125 workers in an abrasives industry (using antimony trisulfide) who had been exposed to air concentrations of antimony ranging from 0.58 to 5.5 milligrams per cubic meter, with most values over 3.0 milligrams per cubic meter. During the study, 6 workers died suddenly in addition to 2 other workers who died of chronic heart disease. Four of the deceased were under 45 years of age. Since no autopsies were performed, the cause of death was not determined definitely but in all but 1 case heart disease was suspected. Fourteen had a blood pressure of over 150/90 mm of mercury, and 24 of under 110/70 mm of mercury. Thirty-seven out of 75 showed changes in the electrocardiogram, mostly of the T-waves; 7 out of 111 had ulcers. Irritation of the skin, mucous membranes, or respiratory tract was not found. Urine samples contained 0.8 to 9.6 milligrams of antimony per liter of urine. (Elkins suggested that 1 milligram of antimony per liter of urine is a safe level.) When the use of antimony trisulfide was discontinued, no further deaths from heart disease or abnormal increase of cardiovascular disorders occurred. Electrocardiographic changes were reported to persist in 12 of 56 workers who were re-examined. When unattended, evidence showed that injury to the heart may remain undetected during the long latency periods.

Cooper et al.<sup>2</sup> reported a study of 28 workers who had been engaged in processing antimony from a crude ore for 1 to 15 years. Workers were exposed to dusts of antimony trioxide and antimony ore; antimony concentrations in air ranged from 0.081 to 138 milligrams per cubic meter with the heaviest concentration being in bagging operations. Of the workers

with abnormal pulmonary function, 1 had definite small opacities, 1 had very early changes, and 2 had negative chest X-rays. Three workers with either suspicious or definite chest X-ray abnormalities had normal pulmonary function. Electrocardiograms were obtained from 7 workers (3 had antimony pneumoconiosis); 6 workers had normal tracings; and 1 showed a slight bradycardia. Antimony in the urine samples ranged from 0 to 1.02 milligrams per liter of urine. These low values correspond to the low solubilities of antimony oxides. In contrast, Brieger et al. reported that workers exposed to lower air concentrations of the more soluble antimony trisulfide had higher urinary levels of antimony.

Renes<sup>3</sup> published a report on a 5-month study of 69 smelter workers who were exposed to antimony trioxide; antimony levels in air ranged from 4.69 to 11.81 milligrams per cubic meter. (Antimony, arsenic, and caustic soda were present in the air of the smelter but antimony was the predominating aerial contaminant.) Six workers showed definite pneumonitis which cleared after removal from exposure and treatment. The pathological conditions most frequently diagnosed were dermatitis and rhinitis, next in frequency were inflammation of the upper and lower respiratory tract (including pneumonitis), and less than 4% of the cases had conjunctivitis, gastritis, and septal perforations reported.

McCallum<sup>4,5,6</sup> reported a study of 268 process workers. Twenty-three workers (8.5%) exhibited simple pneumoconiosis changes (Categories 1-3, I.L.O. International Classification, Geneva 1958); associated defects in lung function were not present. One furnace worker with antimony pneumoconiosis who had retired at age 65 had 0.055 milligram of antimony per liter of urine 7 months after leaving work and 0.028 milligrams per liter 4 years after leaving work.

Karajovic et al.<sup>7</sup> reported a study of 160 men employed at an antimony smelter for 5 to 12 years. No symptoms were found which could be related to systemic antimony poisoning but skin changes and pneumoconiosis were present. Thirty-one out of 62 smelter workers had simple pneumoconiosis. No massive lesions were observed. In 20 workers of the total studied, 8 had pneumoconiosis, 13 had emphysema, and 9 had chronic bronchitis.

Taylor<sup>8</sup> reported a study of 7 workers who were accidentally exposed to the fume of antimony trichloride. Air contained up to 73 milligrams of antimony per cubic meter when leaks developed during the refining of the ore. After 24 hours, 5 men had symptoms of gastrointestinal disturbance including abdominal pain and persistent anorexia (loss of appetite). All cases reported an absence of abdominal tenderness and a return of normal appetite by the tenth day. The urine antimony content exceeded 1.0 milligram of antimony per liter of urine during the incident and fell rapidly to less than 0.02 milligram 24 hours after exposure. No lung changes or evidence of persistent intoxication were observed after exposure.

Rodier and Souchere<sup>9</sup> reported chronic poisoning which resulted from occupational exposure in Moroccan antimony mines. Workers complained of mild symptoms including headaches, sleeplessness, vertigo, appetite loss, and muscular pains. Antimony was detected in the urine and hair. Although the blood-cell picture was altered, antimony was not detected in the blood. Gallina and Luvoni<sup>10</sup> reported cases of antimony poisoning among workers exposed to antimony pentasulfide in a Milan glass factory. Among symptoms reported were nausea, vomiting, diarrhea, bitter taste in the mouth, and a characteristic leucocyte count shift.

## *Evidence of Exposure*

### Sampling and Analysis

The NIOSH approved air sampling method uses mechanical filtration. Two methods previously used are:

1. Impingement and
2. electrostatic precipitation.

The NIOSH approved method for air sample analysis uses atomic absorption spectrophotometry. Two methods previously used are:

1. Rhodamine B and
2. 9-methyl-2,3,7-trihydroxyfluor-6-one.

The above are not intended to be exclusive, but alternative methods should be justified.

## *Allowable Exposure Limits*

The Federal standard for antimony and its compounds is 0.5 milligram per cubic meter of air based on an 8-hour time-weighted average exposure. Occupational exposure to antimony in amounts greater than this is evidence of a possible causal relationship between disease and occupation.

## *Conclusion*

Diagnostic criteria for occupational antimony poisoning are based on the following:

1. Confirmed history of occupational exposure to antimony or one of its compounds,
2. clinical findings compatible with antimony poisoning,
3. urine antimony levels in excess of 1.0 milligram per liter, and
4. blood antimony levels in excess of 2.0 milligrams per 100 grams.

# Inorganic Arsenic (Except Arsine)

## *Introduction*

Arsenic is found in small amounts in soils and waters and in foods, particularly seafoods. For industrial and commercial uses, it is removed from ores during smelting operations as arsenic trioxide, which is used in the manufacture of most other arsenic compounds.

Exposure to arsenic can be through ingestion (swallowing accumulations of dust deposited in the upper respiratory tract), inhalation, or percutaneous (absorbed through the skin) as arsenic can be widely distributed throughout body tissues. It is also found in hair, nails, urine, and feces. Nonoccupational exposures to arsenic have resulted in average urinary arsenic levels of 0.014 to 0.25 milligram of arsenic per liter with the highest reported levels being attributed to probable seafood consumption (Dinman, 1960). Therefore, when evaluating occupational exposure to arsenic, nonoccupational exposure of the individual must also be carefully examined.

Arsenic is an irritant to the skin and to mucous membranes and can cause acute and chronic poisoning. Acute arsenic poisoning rarely occurs in industry.

The corrosive action of arsenic may cause perforation of the nasal septum (cartilage separating the nostrils). NOTE: There can be other causes of perforation.

Chronic arsenic poisoning induces numerous skin manifestations which include overgrowth of the horny layer of the epidermis (hyperkeratosis), sensitization, and possibly loss of hair and nails. In addition, skin cancer may be associated with chronic arsenic poisoning. These include squamous cell carcinoma, epithelioma which may arise at sites of keratoses (most common), basal cell carcinoma, and the chronic precancerous dermatitis referred to as Bowen's disease.

Arsenic may also have a depressant effect on bone marrow erythropoiesis and myelopoiesis (the process of blood cell formation).

Epidemiologic data (experience with groups of people) show a relationship between exposure to arsenic and the development of cancer in the lung, lymphatic system, and/or skin.

Arsenic can form many compounds. The following is a list of common compounds and some common names followed by a listing of occupations with potential exposure to inorganic arsenic:

<b>Chemical Name</b>	<b>Common Names</b>
ammonium arsenate	ammonium acid arsenate, diammonium salt of arsenic acid, diammonium arsenate, dibasic ammonium arsenate, secondary ammonium arsenate
arsenic	gray arsenic, metallic arsenic
arsenic acid	orthoarsenic acid, true arsenic acid
arsenic acid, magnesium salt	magnesium arsenate
arsenic acid, sodium salt	sodium arsenate, sodium metaarsenate
arsenical nickel	niccolite, nickel arsenide
arsenic acid, trisodium salt, heptahydrate	trisodium arsenate heptahydrate
arsenic bisulfide	arsenic sulfide, realgar
arsenic diiodide	arsenic iodide
arsenic disulfide	arsenic bisulfide, arsenic monosulfide, arsenic sulfide, realgar, red arsenic, red arsenic sulfide, red arsenic glass, ruby arsenic
arsenic hemiselenide	
arsenic oxychloride	

<b>Chemical Name</b>	<b>Common Names</b>
arsenic pentachloride	arsenic chloride
arsenic pentafluoride	arsenic fluoride
arsenic pentaselenide	
arsenic pentasulfide	diarsenic pentasulfide
arsenic pentoxide	arsenic acid anhydride, arsenic oxide, arsenic anhydride, arsenic pentaoxide, ZOTOX
arsenic phosphide	
arsenic tribromide	arsenic bromide, arsenous bromide
arsenic trichloride	arsenic butter, arsenic chloride, arsenious chloride, arsenous chloride, butter of arsenic, caustic arsenic chloride, fuming liquid arsenic
arsenic trifluoride	arsenic fluoride, arsenious fluoride, arsenous fluoride
arsenic triiodide	arsenic iodide, arsenious iodide, arsenous iodide
arsenic trioxide	arsenic sesquioxide, arsenious acid, arsenious oxide, arsenolite, arsenious trioxide, arsenite, arsenous acid, arsenous acid anhydride, arsenous anhydride, arsenous oxide, arsenous oxide anhydride, claudite, claudetite, crude arsenic, white arsenic
arsenic triselenide	arsenious selenide, arsenous selenide



<b>Chemical Name</b>	<b>Common Names</b>
<b>arsenic trisulfide</b>	arsenic persulfide, arsenic sulfide, arsenic tersulfide, arsenic yellow, arsenious sulfide, arsenous sulfide, auripigment, orpiment, ping's gold, ping's yellow, yellow arsenic sulfide
<b>arsenious acid, monosodium salt</b>	sodium arsenite, sodium metaarsenite
<b>arsenious acid, sodium salt</b>	sodium salt polymers of arsenious acid, sodium orthoarsenite
<b>arsenious acid, potassium salt</b>	Fowler's solution, potassium arsenite, potassium metaarsenite
<b>arsenopyrite</b>	aronarsenousulfide, arsenical pyrites, mispickel
<b>beta-arsenic</b>	black arsenic
<b>calcium arsenate</b>	calcium-o-arsenate, calcium orthoarsenate, Chip-Cal, Fen Cal, Kalo, Spracal, tricalcium ortho-arsenate
<b>copper arsenite</b>	acid copper arsenite, arsenious acid, copper, copper arsenide, cupric arsenite, Scheele's green, Scheele's mineral, Swedish green
<b>disodium arsenate</b>	disodium salt of arsenic acid, sodium acid arsenate, sodium arsenate dibasic anhydrous

<b>Chemical Name</b>	<b>Common Names</b>
lead arsenate	acid lead arsenate, arsenate of lead, lead salt of arsenic acid, dibasic lead arsenate, lead orthoarsenate, plumbous arsenate
lead arsenite	lead m-arsenite, lead o-arsenite, lead metaarsenite
mercuric arsenate	mercury arsenate, mercury arsenite
metaarsenic acid	
orthoarsenic acid	acid-true arsenic acid, arsenic acid, arsenic acid 75, arsenic acid hemihydrate, liquid arsenic, meta-arsenic acid, orthoarsenic acid hemihydrate
nickel arsenate	nickel o-arsenate, nickelous arsenate
sodium arsenite	disodium salt of arsenious acid

### **Occupations with Potential Exposure to Inorganic Arsenic**

acetylene workers	electroplaters
acid dippers	electrolytic copper workers
alloy makers	enamellers
aniline color makers	enamel makers
aniline workers	etchers
arsenic workers	exterminators
artificial flower makers	farmers
babbitt metal workers	feather workers
bleaching powder makers	ferrosilicon workers
boiler operators	fertilizer makers
book binders	fireworks makers
brass makers	flypaper makers
bronze makers	galvanizers
bronzers	glass makers
cadmium workers	gold extractors

candle (colored) makers  
canners  
carpet makers  
carroters, felt hat  
cattle dip workers  
ceramic makers  
ceramic enamel workers  
commercial artists  
copper smelters  
crop dusters  
defoliant applicators  
defoliant makers  
dimethyl sulfate makers  
disinfectant makers  
drug makers  
dye makers  
metal cleaners  
metal refiners  
miners  
mordanters  
nitrocellulose makers  
ore smelters  
organic chemical synthesizers  
paint makers  
painters  
paper hangers  
paper makers  
petroleum refinery workers  
pharmaceutical makers  
pigment makers  
plastic workers  
plumbers  
preservative makers  
printing ink workers  
pyrotechnics workers  
rayon makers  
rodenticide makers  
sealing wax makers  
semiconductor compound  
makers  
sheep dip workers  
sign painters  
silver refiners  
gold refiners  
hair remover makers  
herbicide makers  
hide preservers  
ice makers  
illuminating gas workers  
ink makers  
insecticide makers  
japan makers  
japanners  
jewelers  
lead burners  
lead shot makers  
lead smelters  
leather workers  
lime burners  
soda makers  
soil sterilizer makers  
solderers  
submarine workers  
sulfuric acid workers  
tanners  
tar workers  
taxidermists  
textile printers  
tinnern  
tree sprayers  
type metal workers  
varnish makers  
vine dressers  
wallpaper printers  
warfare gas makers  
water weed controllers  
weed sprayers  
wine makers  
wire drawers  
wood preservative makers  
wood preservers  
zinc chloride makers  
zinc miners  
zinc refiners

## ***Medical Evaluation and Differential Diagnosis***

(See also Decision-Making Process)

The following should be carefully evaluated to determine if present symptoms are in fact associated with a previous disease or injury:

- History of Addison's disease,
- hemolytic anemia,
- viral infections,
- upper respiratory tract infections,
- gastrointestinal irritants,
- gastritis or lower gastrointestinal diseases, and
- non-obstructive kidney failure (anuria) from lead or mercury poisoning.

### **Nonoccupational Exposure**

Arsenic poisoning may occur from a home hobby or other activities such as:

- Farming (use of pesticides),
- gardening
- wine making,
- diets very heavy in seafood (a high intake of lobster, oysters, and mussels may elevate blood arsenic levels),
- wood preserving, and
- living near industrial plants which utilize arsenic compounds.

## ***Signs and Symptoms***

### **Acute Poisoning**

Acute poisoning usually occurs from exposure to arsenic-containing dust. However, it rarely occurs in industry. High exposure may be tolerated without symptoms of systemic poisoning.

In acute poisoning following ingestion of inorganic arsenic, symptoms develop within 1/2 to 4 hours and are characterized by constriction of the throat followed by:

- Inability to swallow or difficulty in swallowing (dysphagia),
- epigastric pain,
- vomiting and abdominal pain,
- watery diarrhea, and
- shock may occur with severe fluid loss, and death may ensue in 24 hours.

If the acute effects are survived, the following may develop:

- Inflammation of the skin involving redness and flakiness (exfoliative dermatitis) and
- inflammation of the nerves, mainly of the hands and feet (peripheral neuritis).

Acute poisoning due to inhalation is extremely rare in industry. When it occurs, respiratory and central nervous system symptoms predominate. Gastrointestinal symptoms are less frequent and occur later.

Respiratory and central nervous system symptoms occurring initially are:

- Cough,
- chest pain,
- difficult or labored breathing (dyspnea),
- giddiness,
- headache, and
- extreme general weakness.

Signs and symptoms which may occur later include:

- Nausea,
- vomiting, and
- colic.

## **Chronic Poisoning**

The signs and symptoms of chronic arsenic exposure resemble many diseases, including early lead poisoning, and are characterized by:

- Insidious onset of malaise,
- abdominal complaints,
- severe itching (pruritis),
- weakness,
- loss of appetite (anorexia),
- weight loss,
- inflammation of the gums (gingivitis) and/or mouth (stomatitis),
- inflammation of the mucous membrane of the nose (rhinitis),
- inflammation of the kidney (nephritis), and
- decreased pulmonary function.

Inorganic arsenical compounds are primary cutaneous (skin) irritants, and signs and symptoms include:

- Redness which may be more intense around hair follicles and give the skin a mottled appearance,
- brittle nails,
- loss of nails and hair,
- a broad white transverse line (called Mee's lines) can also be found in association with polyneuritis,
- pustular, ulcerative, or gangrenous lesions,
- overgrowth of the horny layer of the epidermis (hyperkeratosis) associated with thick, dry, cracking skin, often with excessive sweating of the palms and soles of the feet (hyperhidrosis),
- deposits of black pigments in different body parts (melanosis),
- hyperpigmentation of a "rain-drop" configuration (believed to be a sign of systemic, not local toxicity), and
- jaundice, which may be secondary to liver involvement.

Signs and symptoms associated with the nervous system are less common and occur in fewer than 5% of all cases:

- Inflammation of the peripheral nerves (peripheral neuritis),
- numbness, tingling, "pins and needles", heightened sensation,
- symmetrical weakness in feet and legs,
- fasciculation and gross tremors, muscular incoordination (ataxia), shuffling gait,
- decreased deep tendon reflexes with foot and wrist drop, and
- mental confusion.

In chronic arsenic poisoning, the liver may be involved resulting in:

- Enlargement of the liver (hepatomegaly),
- excessive accumulation of serous fluids in the abdominal (peritoneal) cavity, and
- cirrhosis (liver fibrosis).

Perforation of the nasal septum (the cartilage separating the nostrils) is common in workers chronically exposed to arsenic.

Persons exposed to chronic arsenic absorption have been reported to develop carcinoma of the lung, larynx, and viscera (the abdominal organs) as well as skin. However, the relationship of arsenic to nondermal cancer is much more of an open issue.

## *Laboratory and Clinical Examinations*

Additional tests which will assist in arriving at a correct diagnosis are:

- Electrocardiographic abnormalities which indicate a direct toxic effect,
- liver function studies may indicate liver cell injury,
- decreased white blood cell count,
- decreased red blood cell count (anemia),
- basophilic stippling of the red blood cells,
- chest X-ray may reveal lung cancer, and
- pulmonary function may be decreased.

The normal range of urinary arsenic levels is less than 0.1 milligram of arsenic per liter in 24-hour specimens. Levels greater than 0.2 milligram of arsenic per liter suggest exposure to limits greater than those stated on page 52. However, acquired tolerance may allow levels greater than 0.2 milligram of arsenic per liter without evidence of arsenic poisoning. Conversely, persons with urine arsenic levels less than 0.2 milligram of arsenic per liter may in fact have arsenic poisoning. An additional test that will aid in arriving at a correct diagnosis is a bioassay of nails. For fingernails, maximum arsenic levels are 0.82 to 3.5 parts per million (ppm), and for toenails, 0.52 to 5.6 ppm.

## *Epidemiology*

The relationship between occupational exposure to arsenic and chronic poisoning signs and symptoms including malaise, abdominal complaints, anorexia, hyperkeratosis, and pruritis has been well documented in scientific literature.

It has been shown that arsenic may be absorbed through the skin, from the tracheobronchial tree, and from the gastrointestinal tract. For this reason, nonoccupational exposure to arsenic which can be present in the air, water, and food should be reviewed since it can also elicit a toxicological response. Arsenic absorption, however, does not necessarily indicate poisoning. These facts should be kept in mind when considering the epidemiologic data.

Pinto et al.<sup>11</sup> reported a study of 24 smelter workers who were exposed to an average airborne arsenic concentration range of 0.003 to 0.295 milligram per cubic meter with a mean value of 0.053 milligram per cubic meter. The workers were exposed to arsenic trioxide. Average urinary arsenic values ranged from 0.038 to 0.539 milligram of arsenic per liter of urine with an overall average of 0.174 milligram of arsenic per liter. The Pearson correlation factor between airborne arsenic concentrations and urinary arsenic levels over the range studied was 0.530 ( $P < 0.01$ ) which demonstrates a statistically significant correlation. There was evidence that nonoccupational arsenic absorption from the consumption of seafood resulted in elevated urinary arsenic levels.

The following sections in quotes are from the National Institute for Occupational Safety and Health:<sup>12</sup>

Butzengeiger<sup>13</sup> reported a study of "180 vinedressers and cellar-men who were exposed to arsenical insecticides while tending the vineyards and from consuming homemade wine believed to be contaminated with arsenic. All had symptoms of chronic arsenic intoxication, and in 41, there was evidence of vascular disorders in the extremities. Of 15 cases described in detail, all had varying degrees of hyperpigmentation, and 13 had palmar and plantar keratosis; all 15 had cold hands, feet, or both which seemed to precede the development of gangrene on toes or fingers in 6 of the 15. Urinary arsenic levels ranged from 0.076 to 0.934 milligram of arsenic per liter with a mean value of 0.324 milligram per liter. Average arsenic content in hair was 0.039 milligram of arsenic per 100 grams of hair."



In a more recent study of the electrocardiograms (ECGs) from 192 vinegrowers suffering chronic arsenic intoxication, Butzengeiger<sup>14</sup> reported that "55 (28.7%) revealed definite changes with 36 cases of these having no possible cause other than arsenic poisoning. ECG abnormalities included Q-T prolongation and flattened T-waves. Further study showed a decline in ECG abnormalities associated with attenuation of other symptoms of arsenic intoxication."

Lee and Fraumeni<sup>15</sup> reported a study of 8047 copper smelter workers who were exposed to arsenic trioxide over a 25-year period. Worker exposure data is summarized as follows:

**1965 SMELTER SURVEY  
ATMOSPHERIC ARSENIC CONCENTRATIONS  
(milligrams of arsenic per cubic meter of air)**

	Heavy	Medium	Light
<b>Range</b>	0.10 to 12.66	0.03 to 8.20	0.001 to 1.20
<b>Mean</b>	1.47	1.54	0.206
<b>Median</b>	0.185	0.79	0.010
<b>Work Area</b>	Roaster, Kitchen, Cottrell	Reverberatory, Treater Building, Loading	Transfer System, Flue Station, Reactor Building

(Lee and Fraumeni, 1969)

Overall mortality of the exposed workers was significantly higher than expected when compared to an unexposed population with the cause of excess deaths mainly due to malignant neoplasms of the respiratory system and diseases of the heart. They further reported the excess of respiratory cancer to be as high as eight-fold among workers who were employed for more than 15 years in "heavy" exposure areas.

Perry et al.<sup>16</sup> reported a 1-year study of 31 chemical workers who were exposed to sodium arsenite at an English sheep-dip factory. Air concentrations of arsenic ranged from 0.110 to 4.038 milligrams of arsenic per cubic meter with a mean value of 0.562 milligram per cubic meter. Twenty-eight workers exhibited hyperpigmentation, and 9 had wart-like lesions. The

average urinary arsenic concentration was 0.23 milligram of arsenic per liter; average arsenic concentration in hair was 108 parts per million.

Birmingham et al.<sup>17</sup> emphasized that the cutaneous effect of exposure to arsenic occurs more frequently than the rare systemic toxicities. Milham and Strong<sup>18</sup> reported a study of smelter workers in which "80% of the workers excreted 1.0 to 3.0 milligrams of arsenic per liter of urine and had dermatitis. All workers excreting over 3.0 milligrams of arsenic per liter had dermatitis."

## *Evidence of Exposure*

### Sampling and Analysis

The NIOSH approved air sampling method uses mechanical filtration. Two methods previously used are:

- Impingement and
- electrostatic precipitation.

The NIOSH approved method for air sample analysis uses atomic absorption spectrophotometry. Four methods previously used are:

- Gutziet method,
- silver diethyldithiocarbamate method,
- iodine microtitration, and
- molybdenum blue method.

The above methods are not intended to be exclusive but other methods used should be justified.

## *Allowable Exposure Limits*

Arsenic is a confirmed occupational carcinogen with the target organ/tissue being the lung and skin; it is a suspect lymphatic tissue carcinogen (Ket et al., eds., 1977).

The standard adopted by the Occupational Safety and Health Administration (OSHA) establishes a permissible exposure limit of 10 micrograms per cubic meter air. This represents the lowest level which OSHA believes is feasible. The existence of a safe level of exposure to inorganic arsenic has

not yet been demonstrated. In the absence of a demonstrated safe level, OSHA will not assume that one exists because of the irreversibility and long latency period for lung cancer.

## *Conclusion*

Diagnostic criteria for occupational arsenic poisoning are based on meeting the following:

1. Confirmed history of occupational exposure to arsenic or one or more of its compounds,
2. clinical findings compatible with arsenic poisoning, and
3. analysis of urine (or nails) for arsenic is of value in confirming exposure but is not diagnostic in itself.

# Asbestos

## *Introduction*

Asbestos is a mineral fiber, and is the name given to about thirty silicate compounds. Of these, only the following 5 are of significance in industry:

Chrysotile (white asbestos)	Crocidolite (blue asbestos)
Amosite	Anthophyllite
Tremolite	

Chrysotile accounts for about 97 percent of all the asbestos used in this country.

Asbestos is widespread in the environment because of its extensive use in industry and the home. Over 3,000 products contain asbestos.

Because of this wide usage, it may be difficult at times to determine if a disease arising from asbestos is occupational in origin. For example, the air of some relatively new apartment buildings has been found to contain more asbestos fibers than the maximum recommended levels in industry. The source of the fibers in the apartment buildings is the insulating materials used in the ventilation system.

Exposure to asbestos can produce a lung fibrosis called *asbestosis*. The onset of asbestosis is usually gradual, developing over a period of 10 to 30 years of exposure to significant concentrations of asbestos. Occasionally, from very massive exposures, it may develop more quickly.

Asbestos is also a *cancer* producing agent (bronchogenic carcinoma, mesothelioma) and can cause certain specific skin diseases (asbestotic subcutaneous granulomatosis and asbestotic cutaneous verruca). Heavy exposure to dust containing asbestos can cause *skin irritation*. Epidemiologic studies (experience with groups of people) and animal studies have shown that increased exposure to any of the types of asbestos increases the risk of lung cancer (bronchial carcinoma). This carcinoma appears to be related to the degree of exposure to asbestos, the type of asbestos, and cigarette smoking. It is also

significant that cigarette smoking in men and women greatly increases the risk of lung cancer in those who are exposed to asbestos. Smoking is a factor that should be considered when determining whether lung cancer is caused, wholly or in part, by an occupational exposure to asbestos.

Mesothelioma, a rare malignant tumor of the membrane which lines the chest cavity and the abdominal cavity, is occurring with increasing frequency in workers with exposure to asbestos. The development of this tumor apparently is not related to the amount of asbestos inhaled and it is found in persons not having asbestosis. Levels of exposure which are within accepted standards for protection against asbestosis may not protect against mesothelioma.

An increased incidence of malignancy of the stomach and colon has been reported among insulation workers using asbestos.

### **Occupations with Potential Exposure to Asbestos**

acoustical product makers	crushers (asbestos)
acoustical product installers	fiberizers (asbestos)
air filter makers	fireproofers
asbestos-cement products makers	firemen
asbestos-cement product users	furnace filter makers
asbestos-coating makers	gasket makers
asbestos-coatings users	heat resistant clothing makers
asbestos-grout makers	insulation workers
asbestos-grout users	inert filter media workers
asbestos-millboard makers	ironing board cover makers
asbestos-millboard users	laboratory hood installers
asbestos-mortar makers	ladders
asbestos-mortar users	paint makers
asbestos millers	pipe insulators
asbestos miners	plastics makers
asbestos-paper makers	pump packing makers
asbestos-paper users	roofers
asbestos-plaster makers	roofing materials makers
asbestos-plaster users	rubber compounders
asbestos sprayers	shingle makers

asbestos workers  
asphalt mixers  
automobile repair  
garage workers  
brake lining makers  
building demolition workers  
carders (asbestos)  
caulking compound makers  
caulking compound users  
clutch facing makers  
cobblers (asbestos)  
construction workers

ship builders  
ship demolition workers  
spinners (asbestos)  
talc miners  
talc workers  
textile flameproofers  
textile workers  
undercoaters  
vinyl-asbestos tile makers  
vinyl-asbestos tile installers  
weavers (asbestos)

## *Medical Evaluation and Differential Diagnosis*

(Also, See Decision-Making Process)

In addition to the usual medical history, the following should be considered:

1. Any history of diseases of the heart or lung or abnormal tissue growth should be carefully evaluated to determine the relationship between the previous disease and the claimant's present condition.
2. A respiratory questionnaire, a sample of which is shown in Appendix C, can be useful in evaluating the extent and importance of respiratory symptoms such as:
  - Breathlessness,
  - phlegm (sputum) production,
  - chest pain,
  - cough, and
  - wheezing.

### **Asbestosis**

Shortness of breath upon exertion is usually the first symptom, frequently accompanied by a dry cough. This symptom develops after several years of progressive pulmonary fibrosis. As asbestosis progresses, the following signs and symptoms are observed:

- Cough with production of sputum,
- anorexia (loss of appetite),

- secondary respiratory infections that are difficult to control,
- rapid breathing,
- repetitive end-inspiratory crackles (crackling sounds heard in the lower part of the lungs through stethoscope when employee completes each of a series of inhaled breaths),
- orthopnea (breathing difficulty in a recumbent position),
- cyanosis (change in skin color to bluish, grayish, slate-like or dark purple),
- decrease of chest expansion,
- digital clubbing (rounding of the ends, and swelling of the fingers and/or toes), and
- sequelae (other resultant diseases) including cor pulmonale (right heart failure), bronchogenic carcinoma (lung cancer), stomach or intestinal cancer, or pleural carcinoma (cancer of the membrane lining the chest).

Fibrosis results in alveolo-capillary block (impaired ability of the lungs to transfer oxygen into the blood). This impairment is often more severe than is indicated by chest X-rays.

## **Mesothelioma**

In cases of mesothelioma, the rare malignancy noted above, there may be a long latent period, as much as 40 years, between initial exposure to asbestos and the development of the tumor.

Mesothelioma of the *peritoneum* (membrane surrounding the abdominal organs) is usually accompanied by abdominal swelling and pain that is not concentrated in a particular area. Signs and symptoms of this type of tumor (which *may* be associated with asbestos exposure) include:

- Weight loss,
- obstruction of the bowel, and
- excessive accumulation of fluid in the abdominal cavity (ascites) is almost always present.

This malignant tumor of the peritoneum may spread to the chest cavity.

With mesothelioma of the *pleura*, complaints include chest pain and breathlessness. Signs and symptoms of pleural mesothelioma include:

- Pleural effusion (accumulation of fluid in the space around the lungs),
- the tumor may grow outward through the chest wall in the form of a lump beneath the skin (subcutaneous lump),
- the tumor may spread to involve bone, lymph glands (nodes), mediastinum (area between the right and left lungs), and pericardium (the sac enclosing the heart). As a result, the supraclavicular nodes may become enlarged, ribs may develop tumors, and obstruction of the superior vena cava (major vein draining the upper portion of the body) may occur, and
- in addition, pericardial effusion (fluid in the heart cavity) may occur, causing tamponade (acute compression of the heart).

## ***Laboratory and Clinical Examinations***

(See Decision-Making Process)

Additional data which will assist in arriving at a correct diagnosis are:

### ***Chest X-rays***

Findings should be classified according to the ILO/UC 1971 Classification of the Radiographs of the Pneumoconioses.

Findings for asbestosis vary, but the usual picture shows a density in both lungs, with the lower one-third of the lungs involved. In the affected area there is a "ground glass" appearance.

As asbestosis progresses, more and more of the lung is involved, except the apices (tips of the lungs). The X-rays will show gradual obscuring of the border between the lungs and the diaphragm. It may show shadows from the presence of nodules.

X-ray findings usually will show the following as the asbestosis progresses:

- Reduced radiographic volume and
- formation of cysts combined with increased size of the heart, dilation (enlargement) of the proximal pulmonary arteries (arteries which lead from the heart to the lungs).



## *Lung Function Tests*

Reduced lung capacities and other lung changes do not differ from those resulting from other forms of lung fibrosis, both occupational and nonoccupational. Therefore, the results of lung function tests alone or chest X-ray findings alone do not lead to diagnosis of asbestosis. Asbestos bodies in lymph nodes indicate exposure, but not necessarily asbestosis.

- Asbestosis causes a reduction in the vital capacity (VC) of the lungs and a reduction in total lung capacity (TLC). These capacities are further reduced as the disease progresses.
- The residual volume (RV) of the lungs will be normal or slightly increased.
- The lungs' diffusing capacity for carbon monoxide ( $D_L$ ) will be reduced.

Other lung function test results which are found in asbestosis include:

- Increased minute ventilation (amount of air breathed in one minute),
- reduced oxygenation of the arterial blood (arterial hypoxemia),
- increased static transpulmonary pressures, and
- decreased lung compliance.

An exercise test will result in an increased amount of air required during physical effort and decreased oxygen in the blood, leading to cyanosis.

## *Sputum Examination*

Asbestos fibers or bodies may be found in the sputum. These indicate asbestos exposure, but not necessarily asbestosis. Where cancer cells are present in the sputum, and chest X-ray findings are normal, bronchoscopy may be necessary to confirm and locate the lung tumor.

## *Skin Tests*

The following tests should be performed by the physician to exclude possible infectious diseases:

1. PPD (tuberculin test)
2. blastomycin
3. histoplasmin
4. coccidioidin

## *Epidemiology*

Various epidemiologic studies have demonstrated the relationship between asbestos and lung disease, including mesothelioma, in such trades and occupations as mining, insulation installation, textiles, paint, electrical industries, and many other occupations as a result of the widespread use of this substance.

The available information indicates evidence of a dose-response relationship for asbestos exposure and the risk of asbestosis and/or bronchogenic carcinoma. However, much of this information is epidemiologic in nature and there is little correlation between epidemiologic data and environmental exposure data. For this reason and others, including the long latent period for the development of carcinomas, it is difficult to develop a specific dose-response relationship. This should be taken into consideration when referring to the following material:

Enterline<sup>19</sup> has reported an exposure-response relationship between asbestos exposure (evaluated as millions of particles per cubic foot years) and the risk of malignant and nonmalignant respiratory disease. Enterline's data indicate that the risk of respiratory cancer increased from 166.7 (standardized mortality ratio) at minimum exposure to 555.6 at cumulative exposures exceeding 750 million particles per cubic foot years. Enterline's data is summarized in a table by NIOSH<sup>20</sup>.

Murphy<sup>21</sup> reported that asbestosis was 11 times more common among pipe coverers in new ship construction than in a control group. The first asbestosis was found after 13 years of exposure to an estimated cumulative dose of about 60 million particles per cubic foot years. After 20 years, asbestosis prevalence was 38%. Murphy reported no asbestosis for men exposed to 60 mppcf years but 20% asbestosis in men exposed to 75-100 mppcf years. Murphy reports atmospheric dust concentrations ranged from 0.8 - 10.0 mppcf depending on the different operations evaluated. Asbestosis was considered present if the worker had at least three of the following: Vascular rales in two or more sites, clubbing of the fingers, vital capacity of less than 80% predicted, roentgenography consistent with moderately advanced or advanced asbestosis, and shortness of breath on climbing one flight of stairs.

The Pennsylvania Department of Health<sup>22</sup> reported a study of asbestos dust concentrations in two plants (one from 1930-1967 and the other from 1948-1968). Sixty-four cases of asbestosis were reported. In the two plants, the study indicates that the air concentrations of particulates were generally less than five mppcf and in many cases less than two mppcf.

Epidemiologic evidence is also available relating the development of mesothelioma with exposure to asbestos. Selikoff<sup>23,24</sup> reported 14 deaths from mesothelioma in 532 asbestos insulation workers from 1943-1968. No deaths from mesothelioma would be expected from the same number of individuals in the general population.

## *Evidence of Exposure*

Historically, there have been two air sampling and analysis methods to determine the quantity of asbestos in the workplace environment. The earlier light field impinger count method allowed only a measure of the overall dust level in the air rather than focusing on the amount of asbestos fibers in the air. The current fiber count method satisfactorily determines the amount of asbestos fibers in the air. It is performed by collecting airborne materials on a membrane filter and then counting the fibers using a phase contrast microscope at a 400 to 450 times magnification ratio (400X-450X).

Asbestos fibers occur in varying lengths and diameters. As of the publication of the guide, the Occupational Safety and Health Administration (OSHA) establishes maximum allowable limits for asbestos fibers greater than five micrometers (um) in length. OSHA limits such asbestos fibers to no more than 2 fibers per cubic centimeter of air (based on an eight-hour time-weighted average exposure).

OSHA further requires that no workers be exposed to more than 10 asbestos fibers (greater than five um in length) during any one 15-minute period of time.

For samples collected by the field impinger count method, results may be compared to the pre-1970 limit (TLV) of five million particles per cubic foot of air.

Occupational exposure to asbestos fibers five um in length or greater, at quantities averaging more than 2 fibers per cubic centimeter of air or frequent exposures to more than 10 such fibers during a 15-minute period of time is evidence of a possible causal relationship between disease and occupation.

## **Toxicological**

(See References 19-24 Appendix A)

## ***Conclusion***

The diagnosis of occupational asbestosis is based on meeting the following criteria:

1. Confirmed history of occupational exposure to asbestos.
2. X-ray findings compatible with those indicating asbestosis according to ILO/UC 1971 "Classification of Radiographs of the Pneumoconioses."
3. Pulmonary impairment, particularly a decrease in lung diffusing capacity and an increase in alveolar-arterial oxygen difference, as demonstrated by lung function tests.

The diagnosis of occupational mesothelioma is based on meeting the following criteria:

1. Confirmed history of occupational exposure to asbestos.
2. Pathological evidence of mesothelioma.