WARNING

WELDING

- fumes and gases may cause irritation of the eyes, nose, and throat
- fumes and gases may cause chest pain/pulmonary edema
- fumes and gases may cause chronic lung diseases/lung cancer
- fumes and gases may cause metal fume fever/lead poisoning
- polyester and other man-made fibers may melt and cause severe burns if struck by welding spark
- may result in asphyxiation in confined spaces
INTRODUCTION

This guideline is intended as a source of information for employees, employers, physicians, industrial hygienist, and other occupational health professionals who may have a need for such information. It does not attempt to present all data; rather, it presents pertinent, information and data in summary form.

SUBSTANCE IDENTIFICATION

Formula: Variable
Appearance and odor: Smoky cloud

*The information below summarizes the potential effects of overexposures to substances associated with welding.

I. GASES

Acetylene is a colorless gas with a garlic-like odor. Short-term effects at high concentrations include anesthesia, primarily due to lack of available oxygen. No information is presently available as to acetylene's long term effects. Acetylene may contain small quantities of toxic impurities such as arsine, carbon disulfide, carbon monoxide, hydrogen sulfide and phosphine.

Carbon Monoxide is a colorless, odorless gas formed by incomplete combustion of various carbon-containing fuels, fluxes, and other shields. Short-term effects include headache, nausea, dizziness, and collapse. Overexposure to high levels of carbon monoxide in confined spaces can be fatal. Long term effects of carbon monoxide include cardiovascular effects (cardiosympathy, exacerbates existing coronary artery disease).

Nitrogen Oxides are colorless to reddish brown gases produced by gas metal arc welding (GMAW or short-arc), gas tungsten arc welding (GTAW or heli-arc) and plasma arc cutting. Short-term exposure effects are pneumonitis and pulmonary edema; long-term effects include chronic bronchitis, emphysema and pulmonary fibrosis.

Ozone (O₃) is a blue-colored gas possessing a characteristic odor. It is produced by ultraviolet, light, from the welding arc. It is produced in greater quantities by gas metal arc welding (GMAW or short-arc), gas tungsten arc welding (GTAW or heli-arc), and plasma arc cutting. Short-term effects include respiratory tract irritation (cough, chest tightness), dryness of mucous membranes, headache, sleepiness, fatigue, pulmonary edema and wheezing. Long-term exposure may produce pulmonary insufficiency.

Phosgene is a colorless gas which can cause bronchitis and damage to the capillaries and alveoli of the lungs by decomposition to hydrochloric acid. The short-term effects of phosgene cause pneumonitis and pulmonary edema. Long-term exposure causes emphysema and pulmonary fibrosis.
II. METALS

A. Arsenic (as arsenic trioxide) is a white amorphous powder. It is produced from smelting of copper sulfide ores of widely varying arsenic content. Short-term effects include dermatitis and gastrointestinal symptoms (nausea, vomiting and diarrhea). Various cancers (lung, lymphatic, skin) have been found due to long term effects of exposure along with anemia, leukopenia, cardiomyopathy, hepatic cirrhosis, peripheral neuritis (numbness, weakness & ataxia). Long term skin exposure can result in hyperpigmentation, palmar/plantar warts & hyperkeratosis.

B. Beryllium fumes are produced from the refining and manufacturing process. Short-term effects include ulcers and dermatitis of the skin, conjunctivitis, rhinitis, pharyngitis, tracheobronchitis and chemical pneumonitis. Long-term or chronic effects include lung cancer, pulmonary symptoms (cough, chest pain, cyanosis), systemic weakness and enlargement of the liver and spleen.

C. Cadmium fumes are produced from the refining and manufacturing process. Short-term or acute effects include pulmonary edema (cough, dyspnea, and chest tightness), nasal irritation and ulceration. Chronic exposure may lead to prostate and lung cancer, pulmonary fibrosis, emphysema, honeycomb lung: kidney (proteinuria-low molecular); hematopoietic disturbance (anemia); skeletal (suspected osteomalacia), and anosmia (loss of sense of smell).

D. Chromium is an important alloying agent in stainless steels, which may contain as much as 35% chromium. This produces hexavalent chromium or chromium trioxide. Short-term effects include skin irritation (dermatitis), ulcer, respiratory tract irritation and effects on nose (epistaxis, septal perforation), eyes (conjunctivitis), and ears (tympanic membrane perforation). Chronic or long-term effects include lung cancer and suspected kidney and liver damage.

E. Cobalt is a steel gray, shining, hard, ductile and malleable metal. Used in the production of cobalt bearing alloys, its fumes may produce acute pulmonary sensitization (asthma-like reaction), skin sensitization and irritation.

F. Copper is a major component, of some non-ferrous alloys, such as monel and bronze. It is sometimes used in "pure" form as an overlay. Acute health effects include metal fume fever (fever, chills, cough, joint and muscle pains) and nasal mucosa irritation. No information is presently available for long-term exposure.

G. Iron (as iron oxide fume) is the major component in steel, and iron oxide is the major substance to which welders are exposed. Iron oxide fumes may cause some irritation of the nose, throat, and lungs. Chronic exposure may lead to siderosis (pulmonary deposition of iron dust).

H. Lead is a component of some non-ferrous alloys (e.g., certain brass alloys and some paints). Welding on lead containing alloys and on metal that has been coated with lead-based paint can generate excessive concentrations of lead. Common symptoms of acute lead poisoning include loss of appetite, metallic taste in the mouth, anxiety, constipation, nausea, pallor, tiredness, weakness, muscle and joint pain and colic. Long-term exposure may lead to nervous system disorders such as neuropathy-extensor palsy, chronic gastrointestinal disorders, nephropathy, reproductive effects (on fetal brain) and hematopoietic effects (porphyrin metabolism disturbance).

I. Magnesium (as magnesium oxide fume) is a component of some metal alloys. Short-term exposure to its fume may lead to irritation of nasal mucosa and conjunctiva and metal fume fever. Other acute effects due to magnesium toxicity include nausea, malaise, general depression and paralysis of respiratory, cardiovascular and central nervous system.

J. Manganese (as manganese oxide) is a component in many electrodes and some steels. Short-term exposures may lead to chemical pneumonitis. Chronic manganese toxicity may lead to nervous system disorders (irritability, drowsiness, impotence, muscular rigidity, spasmodic laughing/weeping, speech and gait disturbances).

K. Molybdenum is used as an additive to some non-ferrous alloys and special steels. Acute exposure to molybdenum fumes are generally of low toxicity, with some irritation of mucous membranes (eyes and nose). No chronic exposure has been noted.

L. Nickel is present in stainless steel and alloys such as monel, inconel and incoloy. Some alloys such as monel, contain as much as 70% nickel. Acute exposure may lead to dermatitis and asthma-like lung disease. Long-term toxicity leads to nose, larynx and lung cancer, upper and lower respiratory tract, irritation (nose bleeding, ulcer and septal perforation) and renal dysfunction.

M. Silver is a component of some brazing alloys and solders, as well as some electroplated wares. Generalized argyria or argyrosis (pigmentation of skin and eyes resulting from silver deposition) develops when silver oxide or other salts are inhaled. This is mainly seen as chronic exposure, as all forms of silver are extremely cumulative (little is excreted).
N. Tin (as tin oxide) is a component of soldering alloys, tinplate for steel containers, bronze and brass alloys, babbitt and type metals, tinning, tin-coated copper wire and other miscellaneous alloys. Short-term exposure may cause irritation to the upper respiratory tract; chronic exposure may lead to stannosis (pneumoconiosis resulting from long-term inhalation).

0. Titanium (as titanium dioxide) is found in some stainless and high strength steels, and electrode fluxes and coatings. Titanium fumes are not known to have any short-term effects on man, however, chronic exposure may lead to pneumoconiosis.

P. Tungsten increases hardness, toughness, elasticity and tensile strength of steels. It is also used in the manufacture of alloys and metal evaporation work. Short-term exposure may lead to conjunctivitis and upper respiratory tract irritations such as cough and dyspnea. Chronic exposure can lead to extrinsic asthma, pneumoconiosis, diffuse interstitial pneumonitis and fibrosis.

Q. Vanadium is a component in electrode coatings and steels and is present in some fuel oils. Short-term exposure may lead to upper and lower respiratory tract irritation (nose bleeding, cough, conjunctivitis & dermatitis). Symptoms of long-term vanadium toxicity include chronic bronchitis, emphysema, pneumonia, chronic eye irritation, dermatitis and possible skin and/or respiratory allergy.

R. Zinc is a major component in galvanized coatings and in some paints. Acute exposure may lead to metal fume fever, skin eruption (oxide pox), conjunctivitis and gastrointestinal disturbances. Effects of chronic exposure are presently unknown.

III. OTHER MINERALS

A. Asbestos is used in thermal and electrical insulation, as well as fire smothering blankets and safety garments. Chronic exposure may lead to lung and mesothelium cancer, pleural thickening and asbestosis, a progressive disease which may develop fully in 7-9 years and may cause death as early as 13 years after the first exposure.

B. Fluorides are found in many electrode fluxes and coatings. Short-term exposure may lead to respiratory irritation; gastrointestinal symptoms; excessive salivation, thirst, sweating; stiff spine and dermatitis. Chronic exposure effects include osteosclerosis, pulmonary insufficiency and kidney dysfunctions.

C. Silica is present in some powdered and granular fluxes. Occupational exposure to free silica has long been known to produce silicosis, a chronic disabling lung disease characterized by the formation of silica containing nodules of scar tissue in the lungs.

IV. PHYSICAL AGENTS

A. Electricity exposure may lead to electrocution and burns. Chronic exposure to electricity is unknown.

B. Hot environments are encountered in welding operations and may lead to heat rash, heat cramps, heat, exhaustion (irritability, mental dullness and general weakness) and heat, stroke. Long term exposure effects are not known.

C. Noise levels are high in welding, cutting or metallizing operations. Acute exposure may lead to temporary auditory threshold shift, with chronic exposures leading to possible hearing loss.

D. Vibration levels are also generally high in welding, cutting or metallizing operations. While acute exposure symptoms are not observed, chronic exposure may lead to vibration white finger syndrome, Raynaud’s phenomenon resulting from localized vibration (tingling numbness, blanching of fingers.)

E. Ionizing radiation is normally not produced in most welding processes (electron beam welding is the exception). However, industrial radiography is often used to inspect the integrity of the weld joint, and the use of these x-ray machines or radioisotopes may produce ionizing radiation. Short-term exposure may lead to erythema, radiodermatitis, nausea, vomiting, diarrhea, weakness, bone marrow depression, shock & death. Long term exposure may lead to cancer, cataracts and reproductive effects.

F. Ultraviolet radiation (200-400 nm) is a by-product of welding and lead to photokeratitis, conjunctivitis, skin erythema and burns in short, term exposure. Chronic exposure may lead to skin cancer and cataracts.

G. Visible light (400-760 nm) from light, sources produced by arc welding can be extremely intense to the point, of both acute and chronic eye discomfort, fatigue, headache and retinal burn.
PERMISSIBLE EXPOSURE LIMITS (PELs) - The current OSHA standards for various welding air contaminants are listed in the following table:

<table>
<thead>
<tr>
<th>Substance</th>
<th>CAS #</th>
<th>TWA mg/M³</th>
<th>TWA ppm</th>
<th>STEL mg/M³</th>
<th>STEL ppm</th>
<th>CEILING mg/M³</th>
<th>CEILING ppm</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acetylene</td>
<td>74-86-2</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Carbon Monoxide</td>
<td>630-08-0</td>
<td>40</td>
<td>35</td>
<td>-</td>
<td>-</td>
<td>229</td>
<td>200</td>
</tr>
<tr>
<td>Nitrogen Oxides</td>
<td>Varies with Compound</td>
<td>-</td>
<td>-</td>
<td>1</td>
<td>1.8</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Ozone</td>
<td>10028-15-6</td>
<td>0.1</td>
<td>0.2</td>
<td>0.3</td>
<td>0.6</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Phosgene</td>
<td>75-44-5</td>
<td>0.1</td>
<td>0.4</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Arsenic</td>
<td>7440-38-2</td>
<td>0.01</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Beryllium</td>
<td>7440-41-7</td>
<td>0.002</td>
<td>-</td>
<td>0.005</td>
<td>-</td>
<td>0.025</td>
<td>-</td>
</tr>
<tr>
<td>Cadmium Fume</td>
<td>7440-43-9</td>
<td>0.1</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>0.3</td>
<td>-</td>
</tr>
<tr>
<td>Chromium VI</td>
<td>Varies with Compound</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>0.1</td>
</tr>
<tr>
<td>Cobalt</td>
<td>7440-48-4</td>
<td>0.05</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Copper</td>
<td>7440-50-8</td>
<td>1.0</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Iron</td>
<td>1309-37-1</td>
<td>10</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Lead</td>
<td>7439-92-1</td>
<td>0.05</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Magnesium Oxide</td>
<td>1309-48-4</td>
<td>10 TD 5 RF</td>
<td>5 RF</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Manganese Fume</td>
<td>7439-96-5</td>
<td>1</td>
<td>-</td>
<td>3</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Molybdenum (insol)</td>
<td>7439-98-7</td>
<td>10 TD 5 RF</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Molybdenum (sol)</td>
<td>7439-98-7</td>
<td>5</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Nickel Fume (insol)</td>
<td>7440-02-0</td>
<td>1.0</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Nickel Fume (sol)</td>
<td>7440-02-0</td>
<td>0.1</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Substance</td>
<td>CAS #</td>
<td>TWA</td>
<td>STEL</td>
<td>CEILING</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>----------------------------</td>
<td>----------</td>
<td>------</td>
<td>-------</td>
<td>---------</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>mg/m³</td>
<td>ppm</td>
<td>mg/m³</td>
<td>ppm</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Silver Fume</td>
<td>7440-22-4</td>
<td>0.01</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tin Fume</td>
<td>7440-31-5</td>
<td>2</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Titanium (as TiO₂)</td>
<td>13463-677</td>
<td>10 TD 5 RF</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tungsten (insol)</td>
<td>7440-33-7</td>
<td>5</td>
<td>-</td>
<td>10</td>
<td>-</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tungsten (sol)</td>
<td>7440-33-7</td>
<td>1.0</td>
<td>-</td>
<td>3.0</td>
<td>-</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vanadium Oxide</td>
<td>1314-62-1</td>
<td>0.05</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Zinc Oxide</td>
<td>1314-132</td>
<td>5</td>
<td>-</td>
<td>10</td>
<td>-</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Asbestos**</td>
<td>1332-21-4</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fluorides</td>
<td>Varies with Compound</td>
<td>2.5</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Silica***</td>
<td>Varies with Type</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

TWA - Time weighted average  
STEL - Short term exposure limit  
CEILING - Ceiling  
mg/m³ - milligrams per cubic meter  
ppm - parts per million  
T.D. - Total dust.  
R.F. - Respirable fraction

Sources for this information include:


** TWA's for asbestos are given in fibers per cubic centimeter (f/cc) - 0.1 f/cc

*** TWA's for Silica are given below:

Quartz - 0.1 mg/m³, Respirable Dust  
Cristobalite - 0.05 mg/m³, Respirable Dust  
Tridymite - 0.05 mg/m³, Respirable Dust  
Tripoli - 0.1 mg/m³, Respirable Dust  
Amorphous - 6.00 mg/m³, Respirable Dust
RESPIRATORS

Good industrial hygiene practices recommend that engineering controls be used to reduce environmental concentrations to the permissible exposure level. However, there are some exceptions where respirators may be used to control exposure. Respirators may be used when engineering and work practice controls are not technically feasible, when they fail and need to be supplemented. Respirators may also be used for operations that require entry into tanks or closed vessels, and in emergency situations. If the use of respirators is necessary, the only respirators permitted are those that have been certified by the National Institute for Occupational Safety and Health (NIOSH).

In addition to respirator selection, a complete respiratory protection program should be instituted which includes regular training, maintenance, inspection, cleaning, and evaluation.

EMERGENCY FIRST AID PROCEDURES

In the event of an emergency, institute first aid procedures and send for first aid or medical assistance.

Breathing - If a person breathes in large amounts of welding fumes, move the exposed person to fresh air at once. If breathing has stopped, perform artificial respiration. Keep the affected person warm and at rest. Get medical attention as soon as possible.

Rescue - Move the affected person from the hazardous exposure. If the exposed person has been overcome, notify someone else and put into effect the established emergency rescue procedure. Do not become a casualty. Understand the facility’s emergency rescue procedures and know the locations of rescue equipment before the need arises.

STORAGE, CLEANUP AND DISPOSAL

The work area should be well ventilated, or if impractical, respirators should be worn. Oxygen should never be used to "sweeten" the air in a confined space. Safety goggles and leather vests should be worn to protect from splattering and burns. Light-filtering goggles should be worn to shield the eyes against the intense ultraviolet light of the flame.

HEALTH HAZARD INFORMATION

Routes of Exposure - The principle route of exposure is by inhalation.

Effects of Overexposure

1. Short Term Exposure - Inhalation of high concentrations of metal oxide fumes can result in an allergic type industrial disease known as Metal Fume Fever. Symptoms are similar to flu-like symptoms, including dryness of the nose and throat, metallic taste in the mouth, weakness, fatigue, aches in muscles and joints, fever, chills, and nausea. The symptoms develop a few hours after exposure and usually last 24-48 hours. Brief exposure to fumes containing cadmium can result in severe lung irritation. Inhalation of fumes containing lead may cause lead poisoning. Ozone, a toxic gas formed during electric arc welding, produces irritation of the upper respiratory tract. If welding in an enclosure without proper ventilation, carbon monoxide intoxication may occur.

2. Long Term Exposure - Chronic inhalation of ozone gas may result in an impairment of pulmonary function.

3. Reporting Signs and Symptoms: A physician should be contacted if anyone develops signs and symptoms and suspects that they are caused by exposure to welding fumes.

Recommended Medical Surveillance

Medical surveillance should be made available to all workers occupationally exposed to welding fumes.

1. Initial Medical Examination: A complete medical history and physical examination to detect, pre-existing conditions that might predispose the exposed employee to an increased risk and to establish a baseline for future health monitoring. Examination of the central and peripheral nervous systems, the respiratory system, and the eyes should be stressed. Information should be obtained concerning any past history of allergic reactions.
2. Periodic Medical Examination: Medical Examinations should be repeated on annual basis.

Summary of Toxicology - The composition of welding fumes depends on the alloy being welded and the process or electrodes used. Fume components may include oxides of iron, zinc, or aluminum; manganese, silicon, copper, or arsenic. Additionally, the flammable asphyxiants used in welding may produce toxic gases of ozone, carbon monoxide, fluorides, and phosgene. Therefore, the threshold limit values are determined using the total fume concentration. When welding iron, mild steel, or aluminum, the TLV should not exceed 5 mg/m³ in the breathing zone of the welder and others in the area. The TLV of more toxic fumes from copper, nickel, stainless steel, and cadmium or lead coated steel should be kept at lower levels depending on the TLVs of the metals involved (Cd. - 0.05 mg/m³; Pb - 0.10 mg/m³; Cu - 0.1 mg/m³; Ni - 1.0 mg/m³).

The inhalation of iron oxide may result in siderosis, the permanent deposition of a substantial amount of iron in the lungs.