

## I. RECOMMENDATIONS FOR A STANDARD

The National Institute for Occupational Safety and Health (NIOSH) recommends that worker exposure to hazards associated with welding processes in the workplace be controlled by complying with the provisions presented in Chapter I of this document. Chapters VI and VII provide additional detail concerning the implementation of these provisions. Adherence to these recommendations should prevent or greatly reduce the risk of adverse health effects among exposed workers. These recommendations are designed to protect the health and provide for the safety of workers engaged in welding over a working lifetime; they are to be used as an adjunct to existing NIOSH recommendations. The following sections shall replace or modify the provisions for welding, cutting, and brazing contained in 29 CFR\* 1910.251-254, 1915.51-57, and 1926.350-354. Other specific requirements contained in those regulations and not addressed in the NIOSH recommended standard shall be retained.

### Section 1 - Definitions

- (a) **Worker** is any person who is or may reasonably be expected to be exposed to chemical and physical hazards associated with welding processes.
- (b) **Exposure Limit** is the concentration of a chemical or physical agent emitted during welding that shall not be exceeded in the workplace. The NIOSH recommended exposure limit (REL) shall be used when available for any chemical or physical agent. In the absence of a NIOSH REL, the Occupational Safety and Health Administration (OSHA) permissible exposure limit (PEL) shall be used unless a more restrictive limit has been recommended by a recognized voluntary consensus group or committee. When neither a NIOSH REL nor an OSHA PEL exists, an appropriate consensus-group- or committee-recommended exposure limit shall be used. Although NIOSH has not evaluated the adequacy of such exposure limits, their adoption would be a prudent public health measure and would afford a greater degree of protection than using no limit.

The OSHA PELs shall not be exceeded under any circumstances. Appendix A lists some of the more common chemical and physical agents that may be found in the workplace or near workers engaged in welding.

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\* Code of Federal Regulations. See CFR in References.

- (c) **Welding** includes those processes that join or cut pieces of metal by heat, pressure, or both. These processes differ in the way heat is created and applied to the parts being joined; they comprise a group of processes referred to as welding, brazing, and thermal cutting (see explanation of terms in Chapter III).

## **Section 2 – Recommended Exposure Limits**

Exposures to chemical and physical agents shall be controlled so that workers are not exposed to concentrations above the exposure limits (see Definitions, Section 1(b)).

An exposure limit for total welding emissions cannot be established because the composition of welding emissions (chemical and physical agents) varies for different welding processes and because the various components of a welding emission may interact to produce adverse health effects. Thus even compliance with specific chemical or physical agent exposure limits may not ensure complete protection against an adverse health effect. Therefore, as a prudent public health measure, the employer shall reduce worker exposures to all chemical and physical agents associated with welding to the lowest concentrations technically feasible using current state-of-the-art engineering and good work practice controls. Exposure limits for individual chemical or physical agents are to be considered upper boundaries of exposure.

## **Section 3 – Medical Monitoring**

The following requirements supplement existing medical monitoring measures that NIOSH recommends for workers exposed to specific chemical or physical agents. The objective of these requirements is to provide an additional level of monitoring for workers who may be exposed to welding emissions or who may have been adversely affected by them in the past. NIOSH recommended standards and existing OSHA standards shall be used to determine the need for specific medical tests. Appendix B lists published sources of NIOSH recommended standards for some specific chemical and physical agents.

### **(a) General**

- (1) The employer shall institute a medical monitoring program for all workers who are or may reasonably be expected to be exposed to hazards from welding processes.
- (2) The employer shall ensure that all medical examinations and procedures are performed by or under the direction of a licensed physician.
- (3) The employer shall provide the required medical monitoring without loss of pay or other cost to the workers, and at a reasonable time and place.

## **(b) Preplacement Medical Examination**

The preplacement medical examination shall include the following items at a minimum:

- (1) A comprehensive work and medical history that emphasizes identification of existing medical conditions and previous occupational exposure to chemical or physical health hazards, particularly those associated with welding processes.
- (2) A comprehensive physical examination.
- (3) A thorough examination of the respiratory system, including baseline pulmonary function tests (at a minimum, forced vital capacity [FVC] and forced expiratory volume in one second [FEV<sub>1</sub>]) using the current recommendations of the American Thoracic Society regarding testing procedures and equipment. Guidelines are given in Appendix C.
- (4) A postero-anterior chest radiograph that is interpreted by qualified B readers (i.e., those who have passed the NIOSH proficiency examination) using the current recommendations of the International Labour Office (ILO) regarding the classification of pneumoconiosis.
- (5) An examination of the skin and eyes for scars that appear to have been caused by burns. The locations of such scars should be noted.
- (6) A baseline cardiovascular evaluation.
- (7) A baseline audiogram.
- (8) A thorough ophthalmologic evaluation.

## **(c) Periodic Medical Examination**

A periodic medical examination shall be provided at least annually to all workers. The following conditions may shorten the interval between examinations and the need for special medical tests:

- (1) Workers reporting signs or symptoms associated with exposure to welding emissions, and
- (2) Airborne concentrations of specific agents that exceed exposure limits.

Periodic medical examinations shall include the following:

- (1) Updates of medical and occupational histories. These shall include a description of the following items based on an interview of the worker and records maintained by the employer: the type of welding performed, metals worked and fluxes used, locations and

conditions (e.g., confined spaces and hot environments), and potentially hazardous exposures not directly related to welding (e.g., chlorinated hydrocarbons).

(2) An evaluation of the respiratory system. Because of the potential for chronic respiratory disease, this evaluation shall include spirometry at intervals indicated by the judgment of the examining physician. Workers with symptomatic, spirometric, or radiographic evidence of pulmonary impairment or disease shall be counseled about the risks of further exposure. Smokers shall be counseled about how smoking may enhance the adverse effects of other respiratory hazards.

(3) Postero-anterior chest radiographs interpreted by qualified B readers (i.e., those who have passed the NIOSH proficiency examination) using the current recommendations of the International Labour Office (ILO) regarding the classification of pneumoconiosis. These radiographs shall be performed at intervals determined by the examining physician. Periodic chest radiographs are recommended for monitoring workers exposed to fibrogenic respiratory hazards (e.g., quartz). At a minimum, chest radiographs should be obtained at 1- to 5-year intervals, depending on the nature and intensity of exposures and the related health risks. A recent chest radiograph obtained for other purposes (e.g., upon hospitalization) may be substituted for the periodic chest radiograph if it is made available and is of acceptable quality.

(4) An examination of the skin and eyes for scars that appear to have been caused by burns. The locations of such scars should be noted.

(5) An evaluation of the cardiovascular system.

(6) An ophthalmological evaluation.

(7) An audiogram.

(8) Other tests deemed appropriate by the attending physician.

#### **Section 4 - Labeling and Posting**

Workers shall be informed of exposure hazards, of potential adverse health effects, and of methods to protect themselves in accordance with 29 CFR 1910.1200, Hazard Communication. Manufacturers of welding materials shall warn employers and workers of the potentially hazardous components of the filler metals, electrodes, and flux materials by applying precautionary labels to the packing containers. Such labels shall indicate the identity of the hazardous agents and the adverse health effects that may result from exposure. In addition, the employer must comply with the labeling and posting requirements contained in the following subsections.

**(a) Labeling**

All labels and warning signs shall be printed in both English and in the predominant language of non-English-reading workers. Workers who cannot read the language used on labels and posted signs shall be identified so that they may receive information regarding hazardous areas and be informed of the instructions printed on labels and signs.

(1) Containers of filler metal, electrodes, and flux materials shall bear warning labels containing the following information at a minimum:

- The following warning:

**WARNING**  
**Welding produces hazardous fumes and gases.**  
**Avoid breathing them.**  
**Use adequate ventilation.**

- Instructions for emergency first aid
- Instructions for safe use
- Instructions for the type of personal protective clothing or equipment to be worn

(2) Labels shall identify the hazardous constituents of the container's contents.

(3) The following information shall be included on the labels of containers holding filler metal, electrodes, and flux materials that contain agents identified as carcinogens by NIOSH and OSHA:

- The name of the potential occupational carcinogen and a description of its health hazards. For materials containing carcinogens, the warning label listed in Section 3(a)(1) above shall include the following statement:

**Fumes or gases from this [filler metal, electrode, or flux material] may cause cancer.**

- Instructions for avoiding inhalation of fumes and excessive skin or eye contact with them.

(4) Base metals that contain or are coated with materials containing carcinogens or other toxic metals (e.g., lead or mercury) shall be clearly labeled or marked to indicate their contents before being welded.

**(b) Posting**

(1) In areas where welding is conducted, the following sign shall be posted in readily visible locations:

**WARNING**

**Welding produces hazardous fumes, gases, and radiation.  
Appropriate personal protective equipment is required.  
DO NOT LOOK AT ARC. EYE INJURY MAY OCCUR.**

(2) Signs posted in work areas where emissions contain carcinogens shall differ from the preceding example, as follows:

- The word "DANGER" shall be used instead of "WARNING."
- The name of the carcinogen shall be included along with a warning describing its health hazards. If a carcinogen is contained in the base or filler metals, electrodes, or fluxes, the warning shall include the statement, "Fumes or gases from [the base metal(s), filler metal, electrode, or flux] may cause cancer," with the type(s) of base or filler metals, electrodes, or fluxes specified.
- Any requirements for personal protective clothing and equipment shall also be stated.

**Section 5 - Protective Clothing and Equipment**

Engineering controls and safe work practices shall be used to keep the emissions from welding processes below the exposure limits specified in Chapter 1, Section 2 of this document. In addition, the employer shall provide protective clothing and equipment to workers as follows:

**(a) Clothing**

(1) The employer shall provide and require the use of appropriate protective clothing as follows:

- Fire-resistant gauntlet gloves and shirts with sleeves of sufficient length and construction to protect the arms from heat, UV radiation, and sparks. Wool and leather clothing are preferable because they are more resistant to deterioration and flames than cotton or synthetics.
- Fire-resistant aprons, coveralls, and leggings or high boots.
- Fire-resistant shoulder covers (e.g., capes), head covers (e.g., skullcaps), and ear covers for workers doing overhead work.

(2) The employer shall do the following for workers welding with highly toxic materials (e.g., carcinogens, lead, fluorides):

- Provide and require the use of work uniforms, coveralls, or similar full-body coverings.
- Provide lockers or other closed areas to store work clothing separately from street clothing.
- Collect work clothing at the end of each work shift and provide for laundering. Clothing treated for fire resistance may need to be retreated after laundering. Laundry personnel shall be adequately informed of the potential hazards and protected from any contaminants on the work clothing.

(3) The employer shall ensure that protective clothing is inspected, maintained, and worn to preserve its effectiveness.

- Clothing shall be kept reasonably free of oil or grease.
- Clothing treated for fire resistance shall be retreated after laundering if necessary.
- Upturned sleeves or cuffs shall be prohibited.
- Sleeves and collars shall be kept buttoned.

**(b) Eye and Face Protection**

(1) The employer shall provide and require the use of the following protective gear for the eyes and face:

- Welding helmets that meet the requirements of 29 CFR 1910.252(e)(2)(ii), Specifications for Protectors.
- Welding helmets with approved ultraviolet radiation (UV) filter plates, or safety spectacles with side-shields, or goggles for all workers exposed to arc welding or cutting processes.
- Goggles or similar eye protectors with filter lenses for workers exposed to oxyfuel gas welding, brazing, or cutting.
- Goggles or similar eye protectors with transparent lenses shall be used for workers exposed to resistance welding or to mechanical cleaning or chipping operations.

(2) The shade numbers used for filter plates or lenses shall meet the requirements of 29 CFR 1910.252(e)(ii).

(3) Eye and face protectors shall be maintained and periodically cleaned and inspected by the employer. Eye and face protectors shall be sanitized before being used by another worker.

### **(c) Respiratory Protection**

Engineering controls and good work practices shall be used to control respiratory exposure to airborne contaminants. Workers shall use respiratory protection only when controls are not technically feasible, when certain routine or nonroutine short-term operations (e.g., maintenance and repair or emergencies) are performed, or when engineering and work practice controls do not reduce the concentration of the contaminant below the exposure limit.

(1) When respirators are used, a complete respiratory protection program shall be instituted as set forth in 29 CFR 1910.134. This program shall include the following elements at a minimum:

- A written program for respiratory protection (e.g., standard operating procedures governing the selection and use of respirators).
- Regular worker training.
- Routine air monitoring and work surveillance.
- Routine maintenance, proper storage, inspection, cleaning, and evaluation of respirators.
- Testing of each respirator while it is worn by an individual to confirm that the protection factor expected for that class of respirators is being achieved.

(2) Selecting the appropriate respirator depends on the specific contaminants and their concentration in the worker's breathing zone. Before a respirator can be selected, an assessment of the work environment is usually necessary to determine the concentration of the specific metal fume and other particulates, gases, or vapors that may be present. Until an environmental assessment is completed, however, the employer should review the precautionary labels on filler metals, electrodes, and flux materials and make a best estimate of the appropriate class of respirators. Only the most protective types of respirators shall be used if exposure to a carcinogen is likely (e.g., cadmium, chromium, nickel contained in filler metals, electrodes, fluxes, or during stainless steel welding) or confirmed by environmental measurements. Respirators shall be selected in accordance with the most recent edition of the NIOSH Respirator Decision Logic [NIOSH 1987].

(3) When workers are exposed to a combination of contaminants in different physical forms, combination cartridge and particulate filter air-purifying respirators may be acceptable under specific



conditions as long as none of the agents are considered to be carcinogenic. In such cases, a qualified individual shall select the respirator, taking into account the specific use conditions, which include the interaction of contaminants with the filter medium, space restrictions caused by the work location, and the use of welding helmets or other face and eye protective devices.

(4) A self-contained breathing apparatus or a supplied-air respirator with an auxiliary self-contained breathing apparatus shall be used when welding in confined spaces. Such welding may reduce ambient oxygen concentration, especially if an inert-gas, shielded-arc welding process is used.

**(d) Hearing Protection**

The employer shall provide and require the use of ear protectors whenever there is a potential for noise levels to exceed the NIOSH REL or OSHA PEL.

- Insert-type ear protectors shall be fitted by a person trained in this procedure.
- Inspection procedures shall be established to assure proper issuance, maintenance, and use of ear protectors.
- Workers shall be trained in the proper care and use of all ear protectors.

**Section 6 – Informing Workers of the Hazard**

**(a) Frequency of Hazard Communication**

Before assignment and at least annually thereafter, the employer shall provide information about workplace hazards to all workers assigned to work in welding areas. In addition, employers shall follow the OSHA regulations in 29 CFR 1910.1200, Hazard Communication.

**(b) Training Program**

Hazard information shall be disseminated through a training program that describes how a task is properly done, how each work practice reduces potential exposure, and how it benefits the worker to use such a practice. Workers who are able to recognize hazards and who know how to control them are better equipped to protect themselves from unnecessary exposure. Frequent reinforcement of the training and supervision of work practices are essential.

**(c) File of Written Hazard Information**

Appropriate written hazard information and records of training shall be kept on file and made readily available to workers. This information shall include the following:

- (1) Identification of the various health hazards, including specific metal fumes, gases released or formed by the processes, heat, noise and vibration, optical radiation, and X-radiation.
- (2) Instructions for preventing accidents such as explosion, fire, and electrocution.
- (3) An explanation of the hazards of working in confined spaces, including the risk of oxygen-deficient atmospheres, exposure to toxic or explosive chemicals, and the potential for heat stress.
- (4) An explanation of the potential health effects of exposure to chemical and physical agents generated by welding (e.g., a warning of the increased cancer risk for workers exposed to carcinogens or fumes and gases during stainless steel welding).
- (5) Information on precautionary measures for minimizing hazards, including work practices, engineering controls, and personal protective equipment.
- (6) A description of the environmental and medical surveillance procedures and their benefits.

**(d) Instruction about Sanitation**

Workers shall also be instructed about their responsibilities for following proper sanitation procedures to protect their own health and safety and that of their fellow workers.

**(e) Tobacco Use**

Workers should be counseled against the use of tobacco products.

**Section 7 - Engineering Controls and Work Practices**

**(a) Engineering Controls**

The following engineering controls shall be used whenever welding is performed, unless they can be demonstrated to be infeasible.

**(1) Optical Radiation**

Welding shall be performed in booths or screened areas constructed of materials that are noncombustible, opaque, and minimally reflective to light in the range of 200 to 3,000 nm. The booths and screens shall be arranged in a manner that does not restrict ventilation. Such equipment shall conform to the requirements of 29 CFR 1910.252(f)(1)(iii), Screens.

**(2) Chemicals (Gases, Fumes, and Particulates)**

Fixed-station local exhaust ventilation shall be used whenever possible (e.g., at the workbench). In some situations where fixed

local exhaust is not feasible, a movable hood with a flexible duct may be used. For gas-shielded arc welding processes, contaminants can be removed by means of a low-volume, high-velocity exhaust (extracting gun).

General ventilation may be necessary where local exhaust ventilation cannot be used; it may also be used to supplement local exhaust ventilation.

When exhaust ventilation systems are used to control emissions, the following requirements shall apply:

- Exhaust hoods and ductwork shall be constructed of fire-resistant materials.
- Ventilation systems shall be equipped with alarms, flowmeters, or other devices to indicate malfunction or blockage of the systems. These systems shall be inspected at the beginning of each shift to ensure their effectiveness.
- The ventilating airflow shall be directed to carry contaminants from the process away from the breathing zone of the process operator or other workers. For local exhaust systems, this usually entails placement of the fume source between the operator and the face of the exhaust duct.
- The hood design, capture velocity, and flow rate must be chosen to capture the emissions effectively.
- Clean make-up air shall be provided in accordance with 29 CFR 1910.252(f)(4)(i).
- Local exhaust systems used to control welding fumes shall have in-line duct velocities of at least 3,000 feet per minute (fpm) to prevent particulates from settling in horizontal duct runs.
- Canopy hoods may be used under limited conditions. For example, they may be advisable for collecting the heated fumes from automated welding operations and preventing their dissipation into the general work environment. If a canopy hood is used, however, the worker must not work directly over the welding process and there must be no cross currents beneath the hood.
- Cooling fans shall be considered only when local exhaust is not possible (e.g., remote work areas or outdoor work settings). Cooling fans can remove welding fumes from the breathing zone when properly placed at the side of the

worker, but their use is rather limited and they may cause dispersion. Any use of a cooling fan at an indoor worksite requires supplemental general ventilation.

**(3) X-Rays**

Electron beam welding processes shall be enclosed and shielded with lead or other suitable materials of sufficient mass to prevent the emission of X-rays. All doors, ports, and other openings shall be checked and maintained to ensure that they have proper seals that prevent X-ray emission.

**(4) Oxyfuel Equipment**

Oxyfuel equipment for welding shall be installed, maintained, and used in a manner that prevents leakage, explosion, or accidental fire. Such equipment shall conform to the requirements of 29 CFR 1910.252(a), Installation and Operation of Oxygen-Fuel Gas Systems for Welding and Cutting.

**(5) Fires or Electric Shocks**

Arc and resistance welding equipment shall be installed, maintained, and used in a manner that prevents fire or electric shock. Such equipment shall conform to the requirements of 29 CFR 1910.252(b), Application, Installation, and Operation of Arc Welding and Cutting Equipment, and to 29 CFR 1910.252(c), Installation and Operation of Resistance Welding Equipment.

**(b) Work Practices**

Work practices shall, at a minimum, conform to 29 CFR 1910.251-254, Welding, Cutting, and Brazing. Specific work requirements include the following:

- (1) Workers shall use welding helmets. Hand-held screens shall be prohibited during welding.
- (2) Workers shall adhere to the following safety procedures:
  - Workers shall observe the fire precautions prescribed in 29 CFR 1910.252(d).
  - Workers shall not conduct welding on materials that may produce toxic pyrolysis or combustion products.
  - Workers shall use personal protective clothing and equipment selected specifically for the hazard. Whenever possible, the workpieces to be welded should be positioned to minimize worker exposure to molten metal, sparks, and fumes.

## **Section 8 - Sanitation**

### **(a) Food, Cosmetics, and Tobacco**

The storage, preparation, dispensing, or consumption of food or beverages; the storage or application of cosmetics; and the storage or use of all tobacco products shall be prohibited in areas where welding is conducted.

### **(b) Handwashing**

The employer shall provide handwashing facilities and encourage workers to use them before eating, smoking, using the toilet, or leaving the worksite.

### **(c) Cleaning of Clothes and Equipment**

Protective clothing, equipment, and tools shall be cleaned periodically.

### **(d) Toxic Waste Disposal**

Toxic wastes shall be collected and disposed of in a manner that is not hazardous to workers or others.

### **(e) Cleanup of Work Area**

The work area shall be cleaned at the end of each shift (or more frequently if needed) using vacuum pickup. Dry sweeping or air hoses shall not be used to clean the work area. Collected wastes shall be placed in sealed containers with labels that indicate the contents. Cleanup and disposal shall be conducted in a manner that prevents worker contact with wastes and complies with all applicable Federal, State, and local regulations.

### **(f) Showering and Changing Facilities**

Workers shall be provided with and advised to use facilities for showering and changing clothes at the end of each work shift.

### **(g) Flammable Materials**

Work areas shall be kept free of flammable debris. Flammable work materials (rags, solvents, etc.) shall be stored in approved safety containers.

## **Section 9 - Exposure Monitoring**

### **(a) General**

(1) Exposure monitoring shall be conducted as specified in parts (b), (c), and (d) of this section for all workers performing welding and for all other workers who may be occupationally exposed through their proximity to these processes.

(2) Air from the worker's breathing zone shall be sampled for fumes and gases. Samples for workers performing welding shall be collected in the welding helmet; samples for other workers shall be collected as close to the mouth and nose as possible.

(3) Results of all exposure monitoring (e.g., of fumes, gases, and physical agents) shall be recorded and retained as specified in Chapter I, Section 10 of this document.

**(b) Determination of Exposures**

(1) The employer shall conduct industrial hygiene surveys to determine whether exposures to any air contaminant exceed the applicable exposure limit (see definition in Section 1(b)).

(2) The employer shall keep records of these surveys as defined in Chapter I, Section 10 of this document. If the employer concludes that exposures are below NIOSH exposure limits, the records must show the basis for this conclusion.

(3) Surveys shall be performed semiannually or whenever changes in work processes or conditions are likely to produce increased concentrations of any air contaminant.

**(c) Routine Monitoring**

(1) If the occupational exposure to any air contaminant is at or above the exposure limit (see definition in Section 1(b)), a program of personal monitoring shall be instituted to permit calculation of each worker's exposure. Source and area monitoring may be a useful supplement to personal monitoring. In all personal monitoring, samples representative of a time-weighted average (TWA) and/or ceiling exposure (depending on the specific agent) shall be collected in the breathing zone of the worker. Sampling and analysis shall be done in accordance with the methods given in Chapter VI, Table VI-1. For each determination of an occupational exposure, a sufficient number of samples shall be collected to characterize each worker's exposure during each work shift. Though not all workers have to be monitored, sufficient samples should be collected to characterize the exposures of all workers who may be potentially exposed. Variations in work habits and production schedules, worker locations, and job functions shall be considered when deciding on sampling locations, times, and frequencies.

A worker exposed to any specific fume or gas at concentrations below its exposure limit shall be monitored at least once every 6 months; more frequent monitoring may be indicated by a professional industrial hygienist.

If a worker is exposed to any specific fume or gas in excess of the exposure limit, controls shall be initiated as specified in Chapter I, Section 7 of this document. In addition, the worker shall be notified of the exposure and of the control measures being

implemented. The worker's exposure shall be evaluated at least once a month. Such monitoring shall continue until two consecutive determinations at least 1 week apart are below the exposure limit. After that point, monitoring shall be conducted at least semiannually or whenever the work process or conditions change.

**(d) Physical Agent Monitoring**

(1) Exposure to UV radiation shall be prevented by means of a management control program. The program shall require the use of barriers wherever possible. Where barriers cannot be used, workers shall use personal protective devices, including proper clothing, sunscreens with a sun protection factor (SPF)  $\geq 15$ , and body and face shields. The use of barriers and protective devices shall be evaluated every month.

(2) Noise exposures shall be evaluated for all workers performing welding. Plasma arc, metal spraying, and arc air gouging processes are likely to result in excessive noise exposures. Employers shall meet the requirements of 29 CFR 1910.95(c), Hearing Conservation Program, whenever a worker's noise exposure is  $\geq 85$  decibels measured on the A scale (dBA) as an 8-hr TWA. All monitoring instruments shall conform to the requirements of 29 CFR 1910.95(d)(2), Monitoring; they shall have a Type II microphone at a minimum. Such noise monitoring surveys must be repeated whenever a change in the work process or environment increases the potential for worker noise exposures.

(3) Electron beam welding equipment shall be surveyed periodically to detect any leakage of X-radiation. A preliminary survey shall be conducted at the time of installation while operating at maximum current and voltage levels. Subsequent surveys should be made whenever the equipment is moved or repaired. Operators of such equipment shall use film badges or some other means of monitoring X-ray exposure.

(4) Environmental heat exposures shall be assessed whenever the potential exists for workers to be exposed to elevated ambient temperatures (e.g., when working in confined spaces or subjected to poor ventilation). Monitoring practices shall be those specified in Criteria for a Recommended Standard...Occupational Exposure to Hot Environments [NIOSH 1986].

**Section 10 - Recordkeeping**

**(a) Exposure Monitoring**

The employer shall establish and maintain an accurate record of all exposure measurements as required in Chapter I, Section 9 of this document. These records shall include the name of the worker being monitored, social security number, duties performed and job locations,

dates and times of measurements, sampling and analytical methods used, type of personal protection used (if any), and number, duration, and results of samples taken.

**(b) Medical Monitoring**

The employer shall establish and maintain an accurate record for each worker subject to the medical monitoring specified in Chapter I, Section 3 of this document.

**(c) Record Retention**

In accordance with the requirements of 29 CFR 1910.20(d), Preservation of Records, the employer shall retain the records described in Chapter I, Sections 3, 6, and 9 of this document for at least the following periods:

- (1) Thirty years for exposure monitoring records, and
- (2) Duration of employment plus 30 years for medical surveillance records.

**(d) Availability of Records**

(1) In accordance with 29 CFR 1910.20, Access to Employee Exposure and Medical Records, the employer shall upon request allow examination and copying of exposure monitoring records by the subject worker, the former worker, or anyone having the specific written consent of the subject or former worker.

(2) Any medical records that are required by this recommended standard shall be provided upon request for examination and copying to the subject worker, the former worker, or anyone having the specific written consent of the subject or former worker.

**(e) Transfer of Records**

The employer shall comply with the requirements for the transfer of records as set forth in 29 CFR 1910.20(h), Transfer of Records.



## II. INTRODUCTION

### A. Scope

NIOSH has formalized a system for developing criteria on which to base standards for ensuring the health and safety of workers exposed to hazardous chemical and physical agents. The criteria and recommended standards are intended to enable management and labor to develop better engineering controls and more healthful work practices.

This document presents the criteria and recommended standards for preventing health impairment from exposures associated with welding. The criteria document was developed by the National Institute for Occupational Safety and Health (NIOSH) in response to Section 20(a)(3) of the Occupational Safety and Health Act of 1970. In this act, NIOSH is charged with the responsibility of developing criteria for toxic materials and harmful physical agents to describe exposure concentrations at which no worker will suffer impaired health or functional capacities or diminished life expectancy as a result of work experience.

This document contains information on workplace exposures that may occur during welding and the adverse health effects associated with these exposures (e.g., gastrointestinal disorders, cancer, and ocular, dermatological, reproductive, musculoskeletal, and chronic and acute respiratory diseases). For the purpose of this recommended standard, "welding" is defined as those processes that join or cut pieces of metal by heat, pressure, or both (e.g., arc welding, brazing, and cutting) [ILO 1972]. These processes differ only in the way heat is created and applied to the parts being joined and in the type of filler material used. Chapter III describes these processes.

Table II-1 lists specific welding processes and some of the potentially hazardous agents associated with them. This table should be used as a reference guide and not as a complete inventory of possible emissions. Chapter III contains more complete discussion of these agents. Laser and underwater welding processes are not included since they require specific control procedures that are beyond the scope of this document.

### B. Number of Workers Potentially Exposed to Welding

The 1972-74 National Occupational Hazard Survey showed that an estimated 176,000 workers had a primary occupation of welder, brazer, or thermal cutter [Sundin 1972]. A follow-up survey in 1981-83 indicated that 185,000 workers were employed in these occupations [Sundin 1981]. These NIOSH surveys were limited to facilities that employed eight or more workers and

did not account for any welding conducted at mining sites or government facilities.

Estimates indicate that the duties of more than 700,000 U.S. workers involve the welding of various types of materials within many different industries (e.g., manufacturing and construction) [Bureau of the Census 1984]. Census data from 1980 [Bureau of the Census 1984] indicated that 673,357 males and 39,242 females were employed as welders and cutters. Note that brazers were classified along with solderers in the census data and thus are not included in these employment figures.

### **C. Special Considerations for Controlling Welding Hazards**

The hazards associated with welding can be divided into two categories: (1) the hazardous chemicals (e.g., fumes and gases) that are formed or released by the processes, and (2) the physical hazards such as ionizing and nonionizing radiation, noise, vibration, high temperatures, and electricity. Because of the many techniques applied in welding and the various types of materials used, it is often difficult to characterize exposures completely at any given time. However, as noted in Table II-1, specific gases and fumes are typically generated when certain welding processes are applied to known base metals. This knowledge can be used to implement good industrial hygiene practices before any comprehensive evaluation of the workplace is initiated.

This document discusses the adverse health effects that have been observed among workers who perform welding, but many of these effects cannot be attributed to any specific agent because of the possible additive or synergistic effects from mixed exposures. For example, welders have historically been exposed to asbestos as a result of using asbestos-containing materials or working in industries where asbestos was used as an insulation material. Many of the morbidity and mortality studies conducted on welders demonstrate an increased risk in respiratory diseases, including cancer. Because of the absence of exposure data for many of these studies, the etiology of the reported disease is unknown but often clinically resembles the diseases associated with workers exposed to asbestos. Although the potential for an asbestos exposure has decreased with the elimination of asbestos-containing materials used by welders, it still remains a possible concomitant exposure in some work environments (e.g., asbestos insulation around pipes).

Thus the recommendations developed from evaluating available data are intended to reduce exposures to chemical and physical agents by conformance with NIOSH RELs, OSHA PELs, or exposure limits set by other voluntary consensus groups (see Chapter I, Section 1, Definitions). To enable employers and workers to control exposures within the specified limits, criteria are provided for appropriate work practices, engineering controls, workplace monitoring, and personal protective equipment. Other recommendations include the establishment of comprehensive programs for medical surveillance and worker training.

Table II-1.--Specific welding processes and associated hazardous agents

Process	Hazardous agent
Brazing/cadmium filler	Cadmium
Flame cutting, welding	Carbon monoxide Nitric oxide (NO) Nitrogen dioxide (NO <sub>2</sub> )
Gas metal arc welding (GMAW)/aluminum (Al) or aluminum-magnesium (Al-Mg)	Ultraviolet (UV) radiation Ozone
GMAW/stainless steel	Hexavalent chromium(VI) Nickel Ozone
GMAW, all types using carbon dioxide	Carbon monoxide
Gas tungsten arc welding/Al or Al-Mg	UV radiation
Shielded metal arc welding (SMAW), low-hydrogen electrodes	Fluorides UV radiation
SMAW/iron or steel	Iron oxide UV radiation
SMAW/stainless steel	Chromium(VI) Nickel UV radiation
Plasma cutting/aluminum	Noise Ozone

#### **D. Existing Occupational Safety and Health Standards for Welding**

The complexity and scope of welding processes have made them subject to many standards and regulations. The first welding standard was initiated in 1943, when the Division of Labor Standards of the U.S. Department of Labor, the International Acetylene Association, the National Electrical Manufacturers Association, and the American Welding Society (AWS) asked the American Standards Association (now the American National Standards Institute [ANSI]) to develop the American War Standard for Safety in Electric and Gas Welding and Cutting Operations. This American War Standard was published in 1944 as a guideline for health and safety during World War II, when large numbers of relatively inexperienced workers were employed as welders [AWS 1973a].

Under the Occupational Safety and Health Act of 1970, standards were promulgated covering welding, cutting, and brazing under Title 29 of the Code of Federal Regulations. The standards apply to workers in construction [29 CFR 1926.350-54], ship repairing [29 CFR 1915.31-36], shipbuilding [29 CFR 1916.31-36], longshoring [29 CFR 1917.31-36], and general industry [29 CFR 1910.251-54]. Most of the Federal standards were adopted from consensus standards developed by a variety of organizations, including the American Conference of Governmental Industrial Hygienists (ACGIH), AWS, ANSI, the National Fire Protection Association (NFPA), the Compressed Gas Association (CGA), the American Petroleum Institute (API), and the Rubber Manufacturers Association (RMA).

The Federal standards covering welding, cutting, and brazing are generally process- or design-oriented rather than performance- or exposure-limit-oriented. That is, though the standards refer to allowable limits of exposure, they actually prescribe work procedures or practices that are intended to minimize health and safety risks. Some of the potential hazards to which the standards are directed include fire, explosion, electric shock, UV radiation, infrared (IR) radiation, oxygen-deficient atmospheres, decomposition products of chlorinated solvents, fluorides, nitrogen dioxide, and toxic metals such as beryllium, cadmium, chromium, lead, mercury, and zinc [29 CFR 1910.1915-17, 1910.1926].

Environmental monitoring is prescribed to evaluate confined spaces for sufficient oxygen, to monitor exposures resulting from the heating of greased metals, and to check for the presence of flammable gases. Labeling is required on the packages holding fluoride-containing flux or filler metals to warn that ventilation is required to control the fumes and gases that may be produced. No sanitation procedures are specified. Some types of personal protective equipment are specified, including eye protectors, helmets, gloves, boots, aprons, and other clothing. Requirements for specific work practices are covered for a number of particularly hazardous operations, including working in confined spaces, handling compressed-gas cylinders, welding or cutting metal containers, and working on elevated surfaces. The engineering controls required are screens or booths to protect against UV radiation, and ventilation for enclosed areas and confined spaces. The general industry standards for welding, cutting, and brazing [29 CFR 1910.251-54] refer to the PELs as stated in 29 CFR 1910.1000. The construction standards for welding and cutting

[29 CFR 1926.350–54] incorporate by reference the ACGIH Threshold Limit Values (TLVs®). The maritime employment standards for welding, brazing, and thermal cutting [29 CFR 1915.31–36, 1916.31–36, 1917.31–36] do not specify or refer to environmental limits.

Since 1970, the ACGIH has recommended a TLV of 5 mg/m<sup>3</sup> for total particulates in welding fumes. In addition, the ACGIH recommends that specific constituents of the fumes and toxic gases also be considered in assessing airborne exposures from welding [ACGIH 1987–88]. For example, a TLV of 0.05 mg/m<sup>3</sup> (as Cr) is recommended for exposures to chromium(VI) by the ACGIH.

NIOSH has RELs for individual substances and physical agents found in the welding environment. These RELs are listed in Appendix A along with the current OSHA PELs and ACGIH TLVs.

#### **E. NIOSH Recommendations That Differ From Current OSHA Regulations**

Many of the exposure limits and program requirements recommended in this document are not currently required by OSHA, and other recommendations are intended to augment existing OSHA requirements. NIOSH recommendations that differ from current OSHA regulations include those that pertain to the following items:

- Adoption of NIOSH RELs (or in some instances, other limits proposed by voluntary consensus groups) for specific chemical and physical agents (see Chapter 1, Section 1, Definitions).
- Initial and periodic medical surveillance.
- Labeling and posting for potential carcinogens.
- Warning of eye damage from looking at a welding arc.
- Warning of high noise areas.
- Criteria for heat stress.
- Recommendations for personal protective clothing and equipment, including the criteria for selecting appropriate types of respirators.
- Information to supplement the Hazard Communication Standard (29 CFR 1910.1200).
- Engineering controls and work practices.
- Requirements for food storage and consumption, use of tobacco products, use of cosmetics, and personal hygiene (availability of shower and locker facilities).
- Exposure monitoring, both initial and periodic.
- Recordkeeping.