



Effects of Welding on Health, XIII



American Welding Society



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Abstract

This literature review, with 176 citations, was prepared under contract to the American Welding Society for its Safety and Health Committee. The review deals with studies of the health effects of fumes, gases, radiation, and noise generated during various welding processes. Section 1 summarizes recent studies of occupational exposures, Section 2 contains information related to human health effects, and Section 3 discusses the effects of exposures in animals.



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Glossary*

ACGIH	American Conference of Governmental Industrial Hygienists
BALF	Bronchoalveolar lavage fluid
CI	Confidence Interval
Cr(VI)	Hexavalent chromium
ELF- EMF	Extremely low frequency electromagnetic field
Dyspnea	Difficulty breathing; shortness of breath
Erythema	Reddening of the skin
FCAW	Flux cored arc welding
GMAW	Gas metal arc welding
GTAW	Gas tungsten arc welding
IgA	Immunoglobulin A
IgG	Immunoglobulin G
IgM	Immunoglobulin M
Leukocyte	White blood cell
LEV	Local exhaust ventilation
MAC	Maximum Allowable Concentration
MAL	Maximum Admissible Limit
n	Number
nm	Nanometer
NIOSH	National Institute for Occupational Safety and Health
NO	nitric oxide
OEL	Occupational exposure limit
OR*	Odds ratio
OSHA	Occupational Safety and Health Administration
PAH	Polycyclic aromatic hydrocarbons
PEL	Permissible Exposure Limit
PAC	Plasma arc cutting
PMN	Polymorphonuclear leukocyte
RR*	Relative risk
SIR*	Standardized incidence ratio
SMAW	Shielded metal arc welding
SMR*	Standardized mortality ratio
TLV	Threshold Limit Value
TWA	Time-weighted average
µm	Micrometer
µg	Microgram
UV	Ultraviolet

*Abbreviations for commonly used pulmonary function tests and for epidemiological terminology used in this document are found in Appendices A and B, respectively. The appendices describe the derivation of these terms and how they are used.

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Introduction

The health of workers in the welding environment is a major concern of the American Welding Society. To stay abreast of this subject, the health literature is periodically reviewed and published in the report *Effects of Welding on Health*. Twelve volumes have been published to date; the first covered data published before 1978, while the remainder covered 2-year to 3-year periods between 1978 and December, 1999. The current report includes information published between January, 2000 and December, 2002. It should be read in conjunction with the previous volumes for a comprehensive treatment of the literature on the *Effects of Welding on Health*. Included in Section 1 of this volume are studies of the characteristics of welding emissions that may have an impact on the control technologies necessary to protect the welder. In keeping with previous volumes, health reports and epidemiological studies of humans are discussed in Section 2 and organized according to the affected organ system. Research studies in animals are discussed in Section 3.

Many of the studies on the effects of welding on health published during the current report period focused on matters that have been explored in the older literature. The effects of welding on the respiratory tract continue to be examined and attention has been paid to the increased potency of respiratory tract infections in active welders. The number of investigations of the association of asthma with welding has increased as the prevalence of both occupational and non-occupational asthma increases in industrialized countries worldwide. As in the past, attention is focused on the incidence of lung cancer in welders. Four of the five studies conducted on lung cancer during this report period showed no statistically significant associations between welding and the incidence of this disease. Two reports showed that the effects on the skin and eyes of ultraviolet radiation from the welding arc can be exacerbated by the use of photosensitizing or photo-allergenic medications. The neurological effects of aluminum and manganese continued to receive attention during this report period.

Executive Summary

Electromagnetic Radiation

Blue Light. Exposure to intense blue light in the visible range of 400 nm to 500 nm can cause photoretinitis with symptoms of decreased visual acuity, blurred vision, and scotoma (blind spot). Okuno et al. (Ref. 104) examined the blue-light hazard associated with GMAW, SMAW, and plasma arc cutting and found that the effective radiance increased with the welding current for both GMAW and SMAW. CO₂-shielded GMAW had the highest effective radiance of the arc welding and cutting procedures examined. The permissible daily exposure times for GMAW ranged from 0.63 to 2.7 seconds at different welding currents and those for SMAW ranged from 2.9 to 5.3 seconds. While plasma arc cutting was less hazardous than GMAW and SMAW, it still had a high effective radiance with a permissible exposure time of 10 seconds. Okuno et al. concluded that the arc welding and cutting processes examined are capable of producing photoretinitis with short exposures and considered them to be very hazardous to the retina.

Ultraviolet Light. Acute effects of exposure to ultraviolet (UV) light include erythema (reddening of the skin) and photokeratitis (welder's flash or arc eye). The symptoms of photokeratitis, a common injury among welders, include ocular pain, photophobia, and a sensation of sand in the eyes. Okuno et al. (Ref. 103) determined the effective radiance and corresponding permissible exposure time for UV light generated by CO₂-shielded FCAW and GMAW. The effective radiance was found to be inversely proportional to the square of the distance from the arc and varied with the angle, reaching a maximum between 50° and 60°, where the most intense UV radiation would be directed to the face when the worker assumes a typical welding position. At a distance of 1 meter from the arc, the permissible exposure time varied from 4 to 100 seconds depending on the welding current. Since welders are generally closer than 1 meter to the weld, the permissible exposure time would be lower than this and the exposures received by the unprotected eye would be higher. Okuno et al. noted that UV radiation may also present a hazard to nearby workers since, at a distance of 10 meters from the arc, the permissible

exposure time measured under different test conditions ranged from 6 minutes to 3 hours.

In a similar study, Kozlowski (Ref. 71) determined effective radiances and safe exposure times for welding processes based on Polish Threshold Limit Values. For these studies, welding was conducted at currents that ranged from 40 A to 60 A and measurements were taken at 0.75 meters from the arc. A safe exposure time of 3 seconds was determined for daily exposures to argon-shielded GMAW. For SMAW, the safe exposure times ranged from 2.3 to 7.2 seconds for three different electrodes. Oxyfuel gas welding and cutting presented a much lower UV hazard as the respective safe exposure times were 2.5 hours and 1.43 hours.

Ventilation

The use of local exhaust ventilation (LEV) can reduce exposure to welding fumes, but its effectiveness varies with the type of LEV unit (Ref. 155), the upkeep of the LEV unit (Ref. 46), and the welding habits and posture of the welder (Ref. 157). Guffey and Simcox (Refs. 46, 132) demonstrated that, even when they are not well maintained, LEV systems can still offer some protection to the welder. They found that high individual exposures were usually attributed to welding posture, work practices, or improper use of the LEV device. Wallace et al. (Ref. 157) described an incident in which a welder, using an LEV device that was attached to the welding gun, moved the device upwards to avoid disturbing the weld. He had much higher exposures than another welder who, when using the same device, left the exhaust hood close to the weld but increased the shield gas flow to protect the weld. Wallace and Fishbach (Ref. 155) noted that local exhaust devices are less effective when welding is performed outdoors because of the disruption of air flow by natural wind currents. They suggested that the ability of the welder to stand upwind of the welding plume may be more important than the use of LEV.

Smargiassi et al. (Ref. 137) examined manganese exposures during welding operations in a factory where accessories for heavy excavation machinery were assembled.