Welding Fume:
Clearing the air about the risk and how to mitigate it

The Respiratory Protection Brand.

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The International Agency for Research on Cancer's re-classification of welding fume as a Class 1 carcinogen has emphasized the very real health risks welders face on the job. Previously classified as "possibly carcinogenic to humans," this re-classification serves as a reminder that welders should take precautions consistent with the latest standards, regulations, and best practices to protect their health, even if the risk is not obviously visible.

Along with various forms of cancer, welding fume can cause a number of other serious, sometimes fatal diseases. This document provides some information about the danger of welding fume and the health risks it poses to welders, as well as information on how employers can help protect their welders alongside all relevant standards, regulations, and required work practices.

What is welding fume?

The exact composition of welding fume varies based on the application and welding method being used. In general, welding fume consists of two main components:

Extremely fine metal dust (particulates)

Metal dust particles caused by welding are so fine (approximately 0.0001mm) and highly concentrated that they appear like smoke, which can be inhaled without proper precautions. This dust can be made up of a number of toxic metals, including Aluminum, Antimony, Arsenic, Beryllium, Cadmium, Chromium, Cobalt, Iron, Lead, Manganese, Molybdenum, Nickel, Silver, Tin, Titanium, Vanadium and Zinc.

Gases

Welding can expose workers to a number of gases that are potentially harmful to humans. These include Argon, Carbon Dioxide, Carbon Monoxide, Helium, Hydrogen Fluoride, Nitric Acid, Nitrogen, Nitrogen Dioxide, Ozone, and Phosgene.

Why is welding fume dangerous?

According to the Occupational Safety and Health Administration (OSHA), the process of welding produces harmful metal fume and gas by-products that can easily enter the human respiratory system. Potential health effects associated with the inhalation of welding fume include a range of serious lung complications and diseases, as well as damage to the brain and nervous system. Some of the most common ones include:

- **Cancer:** Various types of cancer - commonly lung, larynx and urinary tract - can be caused by exposure to nickel and chromium.
- **Emphysema:** A long-term, progressive lung disease, emphysema causes shortness of breath and is incurable. Cadmium exposure can lead to emphysema.
- **Kidney Failure:** Acute kidney failure requires intensive treatment and can often be fatal. Exposure to cadmium and lead oxide may lead to kidney failure.
- **Lead Poisoning and Anemia:** Lead poisoning can result in severe mental and physical impairment. Though it is treatable, the damage cannot be reversed. In severe cases, it can lead to anemia, which can result in damaged organs. This can be caused by exposure to fumes containing lead oxide.
- **Manganism (Parkinson's disease-like syndrome):** Like Parkinson's, manganism symptoms affect the central nervous system and may include tremors, slowness of movement, muscle rigidity, and poor balance. According to the U.S. Centers for Disease Control and Prevention (CDC), this can be caused by chronic exposure to high concentrations of manganese fume.
- **Metal Fume Fever:** Symptoms of metal fume fever include chills, sweating and stomach pains. This can be caused by inhaling excessive zinc fumes during welding of galvanized metal.
- **Irritation of the nose, sinus, throat and lungs:** General irritation and discomfort across the respiratory system may be caused by inhalation of fumes containing iron oxide or chromium.
- **Asthma:** Those with asthma often suffer from coughing, wheezing, and shortness of breath. Exposure to nickel can worsen symptoms and increase the frequency of attacks.

Many harmful gases and particulates can have a cumulative effect on health without presenting immediate symptoms. To reduce welders' chances of being affected by such ailments, these substances should always be controlled in accordance with the latest standards, regulations, and best practices.

How can we protect welders?

The National Institute for Occupational Safety and Health (NIOSH) and the American Welding Society advocate a "hierarchy of controls" designed to help eliminate or minimize exposure to welding fume. First steps in this hierarchy include elimination and substitution, which are designed to prevent or reduce exposure. However, it's important to recognize that achieving this is not always possible.

In those cases, there are steps beyond elimination and substitution that both employers and workers can take to control exposure. All steps must be carried out in adherence with all relevant standards, regulations, and required work practices.

Elimination and Substitution

- Choose welding methods to minimize the production of welding fume.
- When possible, remove any coatings and paint from the metal prior to welding. This will avoid production of other toxic gases that may be produced under fusion of those coatings.

Engineering Controls

- Ventilation - including natural ventilation, mechanical ventilation, and local capture devices - can reduce concentrations of fume in the breathing zone.
- Isolating the welding process from workers - for example, in an enclosure - can reduce exposure.

Workplace/Administrative Practices

- Employers should introduce policies to run regular health checks on welders (i.e. vision tests) to ensure they haven't been overexposed.
- Workers should not stand in the way of air flow that pushes the fumes away from their workspace.
- Workers should position their face as far from the fumes as possible.

Personal Protective Equipment (PPE)

- Respiratory protection is required when other controls are in place or not practical, and the environment's permissible exposure limit (PEL) is above the OSHA standard. This can occur when welding in confined spaces, for instance. In these cases, workers must wear a NIOSH-approved respirator appropriate for the contaminants involved (refer to OSHA Standard 1926.353(c)(2)).
- Employers should establish and enforce a respiratory protection program.
- Proper training, including use of and knowledge around respirators, should be required.

Within this hierarchy, respirators are the welder's last line of defense, but their importance cannot be overlooked. OSHA standard 1910.134 states that where effective environmental engineering control measures are not feasible - or while they are being instituted - appropriate respirators shall be used. The standard elaborates that if assessment of the work environment has deemed that use of a respirator is required, employers must choose respirators that provide the appropriate level of protection. This is determined "by the respiratory hazard(s) to which the worker is exposed and workplace and user factors that affect respirator performance and reliability".

Even if exposures can be controlled adequately with other measures, respirator use is still encouraged to provide an extra measure of comfort and protection to workers (see 29 CFR 1910.134 Appendix D), and employers may provide respirators at the request of employees.

What kinds of respirators are used to protect welders?

OSHA standard 1910.134(d)(3)(ii) states that the selected respirator must be appropriate for the type and form of the contaminants present. Assessment of the environment, engineering control measures, and individual operator's preferences and circumstances will help determine which respirator is best suited for the work at hand.

Each respirator type offers varying levels of protection, referred to as the Assigned Protection Factor (APF). Below is a brief summary of the three types of respirators commonly used for welding:

Half-Face Respirator

Half-face respirators are worn under a standard welding shield and consist of a NIOSH-approved particulate filtering facepiece, which works by filtering particulates out of the air the user is breathing. These filters must have a minimum filtration level of 95% in order to be approved by NIOSH.

Most half-face respirators utilize an N100, R95, or P100 filter. The letter designation refers to oil resistance, and the number refers to the percentage of filtration. Note that these filters do not protect against exposure to certain gases that welders may encounter, such as Carbon Monoxide.

- N100 - filters at least 99.97% of airborne particles, not resistant to oil.
- R95 - filters at least 95% of airborne particles, somewhat resistant to oil.
- P100 - filters at least 99.97% of particles, strongly resistant to oil.

Half-face respirators work by negative pressure, which means that the air is pulled through the filter when the operator breathes in. This requires more effort on the lungs, so operators are required to pass a pulmonary function test to ensure their lungs can physically withstand this extra exertion. Typically, these respirators offer a maximum APF of 10 if fitted correctly.

Because these are classified as tight-fitting respirators, operators are required to be fit tested annually. In some cases, different sizes and/or models may be necessary to ensure a positive fit. To maintain protection, operators cannot have anything that may obstruct the seal of the respirator to their face, including facial hair. An August 2018 notice from NIOSH clarified that employers cannot allow employees with facial hair to wear tight-fitting respirators, as even just the presence of stubble can break the seal, rendering the respirator ineffective.

Powered Air Purifying Respirators (PAPRs)

PAPRs pull air from the welder's environment, filter it through a battery-powered filter unit worn on the operator's body, and deliver it directly into a welding hood that encloses the operator's head.

When ventilation controls work to create an environment that meets the appropriate PEL for gases, then a HEPA (high efficiency particulate air) filter alone in the PAPR for protection against particulates is sufficient. To be NIOSH-approved, HEPA filters must be at least 99.97% efficient in removing particulates of 0.3 micrometers in diameter.

HEPA filters do not protect against exposure to gases that welders may encounter. If working in areas with insufficient ventilation that results in unacceptable PELs for gases, an organic gas or organic vapor filter must be added to the PAPR filter unit. However, there is no single gas or vapor filter that will protect against all substances, and there are certain vapors and gases - such as carbon monoxide and argon - that cannot be filtered out. Therefore, welders working in poorly ventilated spaces may still risk exposure to these gases. Filters must also be changed regularly in accordance with the specific work environment and exposures it produces.

Because PAPRs draw air in from the welder's environment, they create positive pressure and do not rely on the operator having to use their lungs to draw air through the filter. This helps reduce operator fatigue and means they can still be used by an operator who fails a pulmonary function test. These respirators can provide a maximum APF of 1000.

PAPRs are classified as loose-fitting respirators and do not need fit testing. This makes them more accommodating for things like piercings and facial hair, eliminating the risk of any stubble breaking the seal.

Supplied Air Respirators (SARs)

SARs supply air to the respirator from an external source using a compressor located outside the work zone. The supplied air is filtered to remove moisture, particulates, and odors and is monitored for carbon monoxide and other gases to ensure that levels remain within the OSHA-specified safe range.

This type of system often provides a greater level of protection than PAPRs because the air supply is continuously being drawn from an external source outside of the contaminated environment. As a result, SARs are often selected for welding in confined spaces. They are also useful for contaminants that can't be removed by PAPR filters, such as carbon monoxide (although many models are still not suitable for atmospheres that are immediately dangerous to life and health).

Because SARs draw air from an external source, operators have the option to heat or cool the incoming air using a climate control device. This helps make the environment more comfortable for the operator, which can be especially useful in extremely hot or cold environments. Supplied air respirators are also loose-fitting to accommodate facial hair and piercings, and do not require fit testing.

Other items to consider when choosing a respirator

Selection of welding respirators should be based not only on the respiratory protection required, but also on the other features and capabilities required for the job. The best choice depends on workers' specific situations, and should enhance their safety, productivity, and comfort. When choosing, it's important to consider the options, features, and capabilities offered by different respirator types. Considerations include:

- **Comfort:** Padding, air flow, and heating/cooling are all features that help increase operator comfort.
- **Climate Control:** Supplied air respirators have the ability to provide heating and/or cooling to the operator. This can be of great benefit if they are working in extremely hot or cold environments, as it can increase comfort and alleviate fatigue.
- **Facial Hair:** If operators cannot or will not shave, loose-fitting respirators can be used without risk of breaking the seal. They also eliminate the need for fit-testing.
- **Weight:** Respirator weight is important and can play a large role in operator comfort, especially on long shifts. Padding inside respirators can evenly distribute the weight of the helmet over the operator's entire head, making for a lighter, more ergonomic feel that can alleviate aches and strains.
- **Other PPE Needs:** Hearing protection, hard hat protection, and eye protection options are all available with loose-fitting PAPR and supplied air respirators.

As always, when choosing respiratory protection, employers must adhere to the legal requirements around providing appropriate PPE. Selecting a respirator should involve consideration of all relevant regulations, standards, guidelines, and best practices for the specific work environment.

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