October 2007 Vol. 25. No. 6

JobHealth Highlights

Technical Information for Occupational Health and Safety Professionals

Respiratory Protection Basics for Welders

Clifford Frey, CIH

Technical Service Specialist
3M Occupational Health and Environmental Safety Division.

Filtering facepiece respirator

Introduction

Increasing awareness about health hazards linked to welding has changed the way welders work and the equipment they use to protect themselves. This article is intended to help welders understand the importance of selecting the correct respirator and using it properly.

First time respirator users are often surprised to learn how many steps are involved in the seemingly simple process of selecting and wearing a respirator. But the detailed procedures required by the Occupational Safety and Health Administration's (OSHA) respiratory protection standard 29 CFR 1910.134[1] are there for a good reason: the consequences of selecting the wrong respirator for a job, or using it incorrectly, can be fatal. If after reading this document, you are still in doubt about the respiratory hazards you may be exposed to, or how to select and use a respirator to protect yourself from those hazards, seek help from a qualified safety professional before proceeding.

Airborne Hazards Common to Welding

Studies show that full-time welders are at increased risk of bronchitis, airway irritation, lung function changes, pulmonary infections (pneumonia), and lung cancer. Recent studies suggest a possible link between welding fume and nerve disorders.[2] Respiratory hazards in welding can be divided into two main categories:

Welding Fume

The primary airborne contaminant found in arc welding is welding fume. Welding fume is a complex mixture of very small particles of metal oxides. The specific components depend on the composition of the welding electrode (stick, wire or filler rod), base metal, surface coatings and the type of shielding gas or flux.

Powered Air Purifying Respirator (PAPR) with Loose-Fitting Headpiece

Gases and Vapors

When electrode coatings, fluxes, shielding gases and surface coatings are burned or exposed to ultraviolet arc rays, they can generate potentially harmful gases such as carbon monoxide, ozone, nitrogen oxides, gaseous fluoride and phosgene.

Special consideration must be given to welding in enclosed areas or confined spaces. These locations may have poor ventilation, leading to very high exposure levels. In severe cases, gases can build up to levels that cause loss of consciousness and death in minutes. Even relatively benign shielding gases such as argon can accumulate to levels where there is no longer enough oxygen to support life. None of the respirators discussed here are suitable for use in such acutely toxic atmospheres. For more details on respiratory health hazards associated with welding, see "Don't Let Your Health Go Up in Smoke" in the January 2006 issue of Job Health Highlights.

Determining Exposure Levels

The generation rate of welding fume and other contaminants increases as welding amperage increases. In addition, fume generation is typically much higher for flux-shielded processes such as SMAW (stick) and FCAW (flux core) than gas-shielded processes such as GMAW (MIG) and GTAW (TIG). But the amount of fume being generated is only one factor influencing the amount of contaminant a welder might inhale. Other important factors include the position of the welder's face relative to the rising smoke plume and the effectiveness of ventilation systems. Because of the many variables involved, it is difficult to estimate exposure levels for welders. Therefore, exposure assessments typically involve the collection of air samples by a qualified occupational health specialist, such as a Certified Industrial Hygienist. Because each component of welding fume has unique toxic effects and varying exposure limits, the exposure level of each component must be measured independently. For example, exposure assessments for stainless steel welders usually focus on chromium, nickel and iron. Several resources offering more information on toxicity of welding fume and exposure assessment methods are listed at the end of this document.

Exposure Limits

Occupational exposure limits are typically presented as a time-weighted average concentration over a normal eight-hour workday (8-hour TWA). For more acutely toxic substances, the exposure limit may be presented as a "ceiling limit", which should not be exceeded during any part of the work shift, or a short-term exposure limit (STEL) which is a 15-minute time-weighted average. In the USA, OSHA's published Permissible Exposure Limits (PELs) are the legally enforceable standard.[3] However, many choose to follow more current advisory standards such as Threshold Limit Values (TLVs®) published by the American Conference of Governmental Industrial Hygienists (ACGIH).[4]

Selecting a Respirator

Whenever feasible, local and area ventilation systems should be used to remove harmful fumes and gases. However, in many cases, engineering controls alone cannot reduce exposure levels adequately. In such cases, it may be appropriate to use respirators. For most welding applications, an array of respirator options exist that offer specific benefits and limitations. A summary of the most common respirator categories for welding is presented in Table 1.

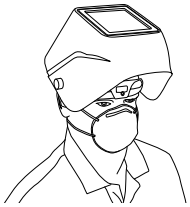
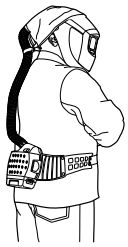
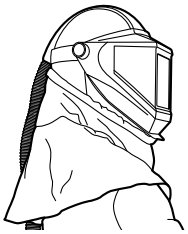
Assigned Protection Factors

Assigned Protection Factor (APF) is the level of protection a class of respirator is expected to provide when selected and used properly under real-world conditions. APFs for each respirator class listed in the table on the next page. To determine the maximum concentration of a substance in which a respirator can be used, multiply its APF by the exposure limit of the substance.

For example, consider a disposable half facepiece respirator for a stainless steel welder whose highest exposure is 25 micrograms per cubic meter ($\mu g/m^3$) of hexavalent chromium as an 8-hour average. This respirator class has an APF of 10, and the PEL for hexavalent chromium is 5 micrograms per cubic meter ($\mu g/m^3$). So the maximum concentration of hexavalent chromium a welder could safely work in with this respirator is 10 x 5 = 50 $\mu g/m^3$. Since the actual exposure (25 $\mu g/m^3$) is less than the calculated maximum, this would be an appropriate respirator selection. This calculation would then be repeated for each contaminant present.

Confined spaces may have poor ventilation, leading to very high exposure levels

Table 1

Description		APF	Benefits	Limitations
Disposable Half Facepiece		10	No maintenance Low unit cost Fits under any welding helmet Light weight	Not compatible with facial hair Increased heat retention and stuffiness Fit-test required
Elastomeric Half Facepiece		10	Replaceable filters More filter options More size options Moderate unit cost Light weight	Not compatible with facial hair May not fit all welding helmets Increased heat retention and stuffiness Fit-test required
Powered-Air, Loose-Fitting		25	Reduced stuffiness Cooling effect No breathing resistance No fit testing Hard hat options Accommodates limited facial hair	Increased weight Higher unit cost Increased maintenance Increased user training Need cartridges specific to contaminants
Powered-Air, Helmet (Hard Hat)		1000*	Same as Loose-Fitting plus: Hard hat included Higher protection factor Better neck protection Accommodates facial hair including some beards	Same as Loose-Fitting
Supplied-Air, (Loose-Fitting or Helmet)		25 or 1000	Maximum contaminant versatility Chilled or heated air No breathing resistance No filters to change No batteries to charge	Attachment to airline Increased weight Higher unit cost Requires compressor

*Check respirator specifications - depending on manufacturer's test results APF may be 1,000 or 25.

Selecting a Filter

Welding Respirator Helmet

Particulate Filters

As mentioned above, welding fume consists of solid particles which can only be captured with particulate filters. Table 2 lists particle filter classifications defined by the National Institute for Occupational Safety and Health (NIOSH). Always look for the NIOSH mark and classification code when selecting a particulate filter.

Table 2

	Resistance to oil mist		
Efficiency	**N-Series (not resistant)**	**R-Series (medium resistance)**	**P-Series (high resistance)**
95%	N95	R95	P95
99%	N99	R99	P99
99.97%	N100	R100	P100

The first letter refers to the filters resistance to liquid oil mist. The number that follows refers to the filters efficiency in laboratory tests. N95 class filters are recommended for most welding applications because welding fume is relatively easy to filter and oil mist is seldom a factor. There is no harm in using a higher class filter. When lead or cadmium exposures are involved, special regulations require the use of 100 class filters. Particulate filters must be replaced when they become soiled, damaged or difficult to breathe through.

Gas and Vapor Cartridges

Gases and vapors cannot be removed by particulate filters. They must be removed by adsorption in a bed of activated carbon. Certain vapors require specially treated carbon, so it is important to select a cartridge that is approved by NIOSH for the specific vapors present. The approved contaminants will be listed on the label on each cartridge. The most common cartridges used in welding applications are organic vapor (black label), acid gas (white label) and organic vapor/acid gas (yellow label). The service life of gas and vapor cartridges will vary depending on the chemicals being removed and their concentration. Gas and vapor cartridges do not clog like particle filters—they simply become saturated and allow contaminants to flow through. In some cases, harmful levels can be exceeded without being detected by the user. Therefore, it is critical that a service life estimate be calculated for each application and a change schedule established as part of the maintenance routine. Respirator manufacturers can help with this calculation.

Powered Air Purifying Respirators (PAPRs)

Powered respirators, or PAPRs, use a battery-powered blower to pull air through filters and/or cartridges. The blower units are usually belt-mounted and push filtered air through a breathing tube connected to the helmet. Because filtered air is constantly flowing into the headpiece under pressure, leakage of contaminants into the helmet is greatly reduced, increasing the level of protection for these respirators. The movement of air over the face also helps keep the welder cool and comfortable.

Supplied Air Respirators

Some gases and vapors, such as argon or carbon monoxide, cannot be effectively filtered. In these cases, a supplied-air respirator may be the only alternative. Supplied-air respirators require a compressor, located in an uncontaminated area, to pump clean air into the respirator headpiece through an airline. Air used for breathing-air must meet the requirements specified in the OSHA Respiratory Protection standard 29 CFR 1910.134(i). The main disadvantage of supplied-air respirators is the limited mobility afforded by the airline. However, an important advantage of supplied-air is the ability to cool the incoming air -- a popular feature in hot welding environments.

Other Factors

- Individual preferences are important. An uncomfortable respirator will be worn less consistently. Removal of the respirator, even for short periods of time, dramatically reduces the protection afforded by the respirator.
- Welders with facial hair must shave or use certain powered or supplied air respirators. Even one-day stubble can cause tight fitting respirators to leak significantly.
- Not all respirators are flame and spark resistant. Welders should select a respirator recommended for welding.

Respirator Program

Before respirators can be used in a workplace, a written Respiratory Protection Program must be established covering the basic requirements outlined in the OSHA standard. Key elements of the program include:

Some gases and vapors cannot be effectively filtered

Training

Training must include instruction on respirator use, maintenance, cleaning and storage. Respirator users must be trained prior to use and at least annually thereafter.

Medical Evaluation

Certain lung or heart conditions can make respirator use dangerous. Medical clearance must be obtained before using a respirator.

Fit Testing

The OSHA standard requires fit testing for all tight-fitting respirators. Whether you select a maintenance-free or a reusable respirator, the wearer must obtain a satisfactory fit. Fit tests must be repeated for each model of respirator used and when any physical changes occur that could affect the fit of the respirator to the face.

Respirator Selection

How respirators were selected for each task.

Program Evaluation

A process must be established for regularly evaluating the effectiveness of the program.

References:

1. Occupational Safety & Health Admin (OSHA), 1910.134, Respiratory Protection
2. Health Effects of Welding, James M. Antonini, Critical Reviews in Toxicology, 33(1) (2003)
3. Occupational Safety & Health Admin (OSHA), 1910, Sub Part Z, Toxic and Hazardous Substances Threshold Limit Values for Chemical Substances and Physical Agents, ACGIH (published annually)
4. Occupational Safety & Health Admin (OSHA), Technical Manual, Respiratory Protection
5. AWS F1.1, Method for Sampling Airborne Particles Generated by Welding and Allied Processes
6. AWS F1.5M, Methods For Sampling And Analyzing Gases From Welding And Allied Processes

Subscribe

If you would like to be notified by e-mail when each new issue of JHH becomes available, register at www.3M.com/jhh

For more information, please contact Health and Safety Services
Technical Assistance: 1-800-243-4630
Fax-on-Demand: 1-800-646-1655
Internet sites:
www.3M.com/OccSafety
www.respexam.com

3M

Occupational Health and Environmental Safety Division
3M Center, Building 235-2E-91
St. Paul, MN 55144-1000
U.S.A.
1-800-243-4630
www.3M.com/OccSafety