NCPWB
National Certified Pipe Welding Bureau

Technical Bulletin

October 2022

Welding Fumes

Welding fumes consist of visible particulate and gases that are generated by the electric arc used during welding. That arc is hot – 15,000 to 20,000°F. That is hot enough to melt, vaporize or decompose anything that gets in its way. The metal in the welding electrode melts, the base metal being welded melts, the flux coating on E7018 (mostly minerals) melts while the flux coating on E6010 (mostly organic stuff) decomposes into carbon monoxide or carbon dioxide and other gases, while any water that gets into the arc decomposes into hydrogen and oxygen. Paint, rust, lubricants, cutting fluids and anything else that gets into the arc also breaks down into constituent elements or other compounds, including carbon dioxide, carbon monoxide, nitrogen oxides, and ozone. These lightweight compounds rise into the air with the hot air generated by the arc creating the fume plume.

Fumes and gases from welding and cutting cannot be classified simply due to the complexity of the decomposition and reforming that occurs. The composition and quantity of fumes and gases are dependent upon the metal being worked, the process and consumables being used, coatings on the work such as paint, galvanizing, or plating, contaminants in the atmosphere such as halogenated hydrocarbon vapors from cleaning and degreasing activities. In welding and cutting, the composition of the fumes is normally different from the composition of the electrode or consumables.

These decomposition products arise from the arc mixing with the oxygen or nitrogen in the air; because these compounds are usually unstable, they form new compounds with oxygen and nitrogen as they cool down. For example, when welding on galvanized steel, the zinc vaporizes in the arc and turns to zinc oxide as it rises into the air. The white powder that rises in the fume plume when galvanized steel is welded is zinc oxide. Zinc oxide, while not toxic, will make the welder temporarily sick if they inhale the particulate in the fume plume. Other compounds that are formed in the arc and become the fume plume may be less benign if inhaled.

Obviously, the first and the most effective actions that a welders can take to avoid breathing welding fumes is to keep their heads out of the fume plume. That means keeping the head to the side of the plume and positioning himself so that any air movement will carry the plume to the left or to the right. Wind coming towards the welder obviously carries the plume directly into the welder's shield and breathing zone. Similarly, the air coming from behind the welder will circulate around both sides of the welder creating a smokestack effect – again bringing the fumes directly into the welder's breathing zone.

The second step that protects the welder from the fumes is a simple mask similar to what painters use. These masks will filter particulates such as zinc or other metal oxides and, if the mask contains activated charcoal, it will collect some other gases such as ozone and organic gases. Masks

that are not properly fitted will not be effective in protecting the welder since the fume can be pulled through any openings between the mask and the welder's face. Welders who are given masks or any other kind of personal protection equipment have to be trained on how to adjust them so that they work correctly. In addition, OSHA regulations (29CFR Part 1910.134(b)) require:

- that fabricators have a written procedure for the use of personal protective equipment such as respirators and masks
- that the equipment must be approved by the Mine Safety and Health Administration and the National Institute for Occupational Safety and Health
- that the equipment selection be based on the hazard to which the welder is exposed
- that only employees who are physically capable of doing the job and know how to use the safety equipment are assigned to perform work
- that respirators are cleaned and disinfected regularly, stored in a convenient, sanitary location and kept in good repair
- that the work area be monitored for changes in exposure
- that the medical status of employees is reviewed regularly
- and that the program be reviewed on a regular basis to appraise its effectiveness.

Disposable masks eliminate some of the hassle associated with meeting these OSHA regulations. Masks that use replaceable cartridges provide a better seal and better filtering of the air, but they are less comfortable and more hassle for both the welder and the contractor than the disposable masks.

More complex and expensive than masks are the “personal environment systems” in which the welder has air supplied to a loose-fitting helmet and outer shroud which drapes over his/her shoulders. Battery-powered fans or filtered compressed air is supplied to each welder, keeping any welding fumes out of his breathing area by maintaining a slight positive pressure inside the shroud.

It should be noted that any compressed air supply has to be "oil-free" air; normal shop air contains oil that, if inhaled, will coat the lungs in a short period of time, causing irreversible blockage of air absorption followed by death.

The other approach to removing the air from the welder’s breathing space is to capture it so that the fumes never rise into the welder’s face. Source capture devices are usually flexible ducts attached to an exhaust system. GMAW welding guns with fume capture suction tubes integrated directly into the gun are also available to capture the fumes at the source. Finally, an open grid surface work table with a plenum beneath it attached to an exhaust duct provides a downdraft that pulls the fumes downward away from the welder.

Elements of Particular Concern

A high ceiling and open shop or an outdoor environment provide adequate general removal of fumes during welding if the welder avoids the fume plume. When the following materials are vaporized during welding, special ventilation directly at the source or suitable masks or hoods must be provided: Antimony, Arsenic, Barium, Beryllium Cadmium, Cobalt, Copper, Lead,

Manganese, Mercury, Selenium, Silver, and Vanadium. Refer to material safety data sheets and precautionary labels provided by the manufacturer to identify any of these materials. If the contractor is in doubt about air quality, the air should be sampled at the welder's breathing zone and in the general work area if indoors or confined area.

Of lesser concern are fumes associated with manganese, nickel and chromium. These elements vaporize in the air and form compounds that produce effects similar to the effects produced by fumes from zinc described above, including nausea, headaches, dizziness, and respiratory irritation. Some persons may develop sensitivity to chromium or nickel which can result in dermatitis or skin rash.

The chronic effects of exposure to fumes containing manganese, chromium and nickel are not yet firmly established. However, the National Institute for Occupational Safety and Health (NIOSH): believe that some forms of hexavalent chromium and nickel and manganese and their inorganic compounds should be considered occupational carcinogens (cancer-causing agents). No conclusive determination has yet been made concerning the health effects on welders or users of alloys containing these elements.

Thoriated tungsten electrodes are a different concern because one grade contains thorium, a radioactive material that can pose health and environmental risks when concentrated or inhaled. Thorium is a low-level radioactive material that emits mostly alpha particles and some beta and gamma radiation. Radiation from external contact with tungsten (i.e. carrying it around in one's pocket) presents no risk. Although some tungsten vaporizes during welding, not enough of it is carried into the fume plume to be of concern. However, welders should avoint inhaling tungsten grinding dust since the dust created during grinding can cause internal radiation exposure if ingested or inhaled, increasing risk of cancer. Also, although the grinding dust settles to the ground, it should be collected using a bag vacuum system and the dust disposed of in accordance with federal, state, and local regulations.

Sources of Additional Guidance

The American Welding Society website, https://www.aws.org/standards/page/free-downloads includes ANSI Z49.1 *Safety in Welding, Cutting and Allied Processes* and the Health and Safety Data sheets. The following fact sheets are of interest to contractors:

No. 1 Fumes and Gases
No. 2 Radiation
No. 3 Noise
No. 4 Chromium and Nickel in Welding Fumes
No. 5 Electrical Hazards
No. 6 Fire and Explosion Prevention
No. 7 Burn Prevention
No. 8 Mechanical Hazards
No. 9 Tripping or Falling
No. 11 Confined Spaces
No. 12 Contact Lens Wear

No. 14 Graphic Symbols for Precautionary Labels
No. 16 Pacemakers and Welding
No. 17 Electric and Magnetic Fields (EMF)
No. 24 Fluxes for Arc Welding and Brazing: Safe Handling and Use
No. 26 Arc Viewing Distance
No. 27 Thoriated Tungsten Electrodes
No. 28 Oxyfuel Safety: Check Valves and Flashback Arrestors
No. 29 Grounding of Portable and Vehicle-mounted Generators
No. 30 Cylinders: Safe Storage, Handling and Use

Portions of this article are based on information from Z49.1 and these data sheets.

Minimize Health Risks

- Direct welders to keep their heads out of the fume plume and to not breath those fumes and gases.

- Direct welders to be sure that there is enough ventilation or exhaust at the arc to keep fumes and gases away from their breathing zones.

- Make simple respirators suitable for particulate filtering available for welders to use them and train them to fit them properly particularly when welding stainless steel or nickel alloys.

- Review MSDS sheets to identify the dangerous elements noted previously in the product being used.

- If in doubt about air quality, the air should be sampled at the welder's breathing zone and in the work area.

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