WELDING OPERATIONS

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PROCESS DESCRIPTION:

Many industrial and manufacturing facilities regularly use a variety of welding processes and materials. The processes include;

- Gas Metal Arc Welding (GMAW) - a. k. a. Metal Inert Gas Welding (MIG),
- Gas Tungsten Arc Welding (GTAW) - a. k. a. Tungsten Inert Gas Welding (TIG),
- Shielded Metal Arc Welding (SMAW) - a. k. a. Manual Metal Arc Welding (MMA),
- Flux Core Arc Welding (FCAW),
- Submerged Arc Welding (SAW),
- Arc Spot Welding,
- Electrogas Welding,
- Electrostag Welding,
- Brazing,
- Thermal Cutting,
- Resistance Welding,
- Plasma Arc Welding,
- Electron Beam Welding,

- Laser Beam Welding

The majority of the common welding processes can be classified as either gas metal arc welding (GMAW) or shielded metal arc welding (SMAW). GMAW generally uses an electrical current to melt and apply a filler metal under a blanket of inert gas. SMAW traditionally uses an electrical current to melt specially coated electrodes which form a protective flux over the weld during application. Both processes use electrodes, filler metals, wire, coatings, and/or gases that may contain and emit several listed substances including NOx, CO, cadmium, cobalt, copper, chromium, manganese, nickel, lead, zinc, and fluorides.

Welding operations release fumes and particulates with diameters of 0.001 to 100 microns. Previous studies of welding emissions have been primarily focused on worker exposure and safety. Many technical difficulties have been identified regarding proper sampling and analytical procedures due, in part, to the wide variety of processes, welding materials, and field conditions. The majority of existing test data which can be used to quantify welding emissions is based on studies performed by the American Welding Society (AWS).

The District, ARB, and NASSCO made several unsuccessful attempts to arrange confirmation testing of the AWS data in 1994 and 1995. Richard Bode of ARB reviewed the AWS data in 1993 and recommended default fume generation rates and hexavalent chromium conversion ratios. NASSCO's consultant, Dr. Richard Bell (Luce, Forward, Hamilton, & Scripps), reviewed the AWS information in 1992 & 1995 and concluded a "fume composition correction factor" was necessary to account for the nonmetallic portion of the released fumes. EPA published Section 12.19 of AP-42 for "Electric Arc Welding" in 1995 and based their set of incomplete emission factors on the same AWS studies. Until more confirmation test results are available, a combination of the above research resulting in the following estimation techniques will be used by the District to quantify welding emissions:

1) Where complete AP-42 (Section 12.9) information exists: If emission factors are listed in AP-42 for the welding rod (w/ correct welding process) and the trace metal component, the following procedure will be used;

Ea = Ua x EF x (1 - e)

Eh = Uh x EF x (1 - e)

Where:

Ea = Annual emissions of each listed toxic air contaminant per device, (lbs/year)

Eh = Maximum hourly emissions of each listed toxic air contaminant per device, (lbs/hour)

Ua = Annual usage of each welding rod, (lbs/year)

Uh = Maximum hourly usage of each welding rod, (lbs/hour)

EF = Listed substance emission factor from AP-42, (lbs listed substance/lb rod consumed)

e = Control equipment PM10 collection and removal efficiency, (%)

2) Where incomplete AP-42 (Section 12.9) information exists: If an emission factor is listed in AP-42 for the welding rod (w/ correct welding process) fume generation rate but not for the trace metal component, the following procedure will be used;

Ea = Ua x EF x FCF x Ci x (1 - e)

Eh = Uh x EF x FCF x Ci x (1 - e)

Where:

Ea = Annual emissions of each listed toxic air contaminant per device, (lbs/year)

Eh = Maximum hourly emissions of each listed toxic air contaminant per device, (lbs/hour)

Ua = Annual usage of each welding rod, (lbs/year)

Uh = Maximum hourly usage of each welding rod, (lbs/hour)

EF = Particulate (PM10) emission factor from AP-42, (lbs fume/lb rod consumed)

FCF = Fume correction factor per NASSCO - Richard Bell, (lbs metal/lb fume)

= 0.5464 for GMAW

= 0.2865 for SMAW

Ci = Concentration of listed substance in each welding rod, (lbs substance/lb metal)

e = Control equipment PM10 collection and removal efficiency, (%)

* If a hexavalent chromium emission factor does not exist, A Cr to Cr+6 conversion rate of 5% for GMAW and 63% for SMAW will be applied per ARB - Richard Bode. It is assumed that MIG and TIG welding are similar to GMAW. It is also assumed that FCAW is similar to SMAW.

3) Where no AP-42 information exists but the welding process is identified: If no emission information is listed in AP-42 but the type of welding process is identified by the site (i.e.; GMAW, SMAW, etc.), the following procedure will be used;

Ea = Ua x EF x FCF x Ci x (1 - e)

Eh = Uh x EF x FCF x Ci x (1 - e)

Ea = Annual emissions of each listed toxic air contaminant per device, (lbs/year)

Eh = Maximum hourly emissions of each listed toxic air contaminant per device, (lbs/hour)

Ua = Annual usage of each welding rod, (lbs/year)

Uh = Maximum hourly usage of each welding rod, (lbs/hour)

EF = Fume emission factor per ARB - Richard Bode, (lbs fume/lb rod consumed)

= 0.01 for GMAW

= 0.02 for SMAW

FCF = Fume correction factor per NASSCO - Richard Bell, (lbs metal/lb fume)

= 0.5464 for GMAW

= 0.2865 for SMAW

Ci = Concentration of listed substance in each welding rod, (lbs substance/lb metal)

e = Control equipment PM10 collection and removal efficiency, (%)

** A Cr to Cr+6 conversion rate of 10% will be assumed by the District for unidentified welding processes.

4) Where no AP-42 information exists and the welding process is unidentified: If no emission information is listed in AP-42 and the type of welding process is not identified by the site (i.e.; GMAW, SMAW, etc.), the following procedure will be used;

Ea = Ua x EF x Ci x (1 - e)

Eh = Uh x EF x Ci x (1 - e)

Ea = Annual emissions of each listed toxic air contaminant per device, (lbs/year)

Eh = Maximum hourly emissions of each listed toxic air contaminant per device, (lbs/hour)

Ua = Annual usage of each welding rod, (lbs/year)

Uh = Maximum hourly usage of each welding rod, (lbs/hour)

EF = Fume emission factor, (lbs fume/lb rod consumed)

= 0.05 for unidentified welding processes (District default assumption)

Ci = Concentration of listed substance in each welding rod, (lbs substance/lb metal)

e = Control equipment PM10 collection and removal efficiency, (%)

* If a hexavalent chromium emission factor does not exist, A Cr to Cr+6 conversion rate of 5% for GMAW and 63% for SMAW will be applied per ARB - Richard Bode. It is assumed that MIG and TIG welding are similar to GMAW. It is also assumed that FCAW is similar to SMAW.

EMISSIONS INFORMATION:

MSDS documentation contains information regarding welding rod material composition. While past studies indicate a difference in particulate emission rates between GMAW and SMAW, this may be due to flux coatings, flux cores, particulate dimensions, sampling techniques, and/or analytical procedures. Past test results also indicate welding emissions are generally composed of the same compounds as the consumed material.

Fumes may also include oxygen in a metallic oxide form that is created during the welding process. The fume correction factor proposed by Dr. Bell is intended to account for this added mass balance component. While it is highly unlikely that a single fume correction factor would accurately apply to the wide variety of welding rods used in a given process, this is the best emission estimation approach currently available given the minimal test data which exists. Additional studies to determine accurate fume generation rates are needed.

Measured fume weights for various welding processes have varied from 0.1% to 15% of the consumed electrode. Additionally, 1% to 50% of the electrodes was not either not recovered or discarded as unweighed slag. The hexavalent fraction of collected chromium emissions varied from 0.1% to 95% by weight and may have been affected by the sampling and/or analytical techniques used. In general, GMAW produced smaller quantities of collectable particulates and had a lower proportion of hexavalent chromium in collected fume samples than SMAW. Additional studies to determine accurate component specific emission factors are needed.

ASSUMPTIONS / LIMITATIONS:

- Welding emission rates depend upon process type, materials used, current, voltage, electrode angle, weld speed, arc length, deposition rate, and operator technique. Sufficient test data does not currently exist to adjust emission estimates for the many field variables that affect fume generation rates and compositions. Actual emissions may differ by an order of magnitude or more dependent upon site specific field conditions.

- Emissions from the host part are generally assumed to be negligible and/or indistinguishable from the consumed electrode. Typically, the host part and the consumed electrode have similar metallic compositions and the source of specific emissions cannot be confirmed. This assumption does not apply to cutting and brazing operations.

- The proportion of hexavalent chromium in the released fumes is critical to the overall significance of a facility's welding emissions in a health risk assessment. Previous studies have investigated the interference of other fume components (especially iron) in the collection, preparation, and analysis of hexavalent chromium emissions. Sample collection and preparation methods using acidic solutions ($pH < 5$) apparently reduce hexavalent chromium to the trivalent state before quantification. Dry filters may have the same effect. The ability of various inert gases and shielding materials to limit the formation of hexavalent chromium is not known.

- The District has not received any reports of studies involving control device efficiencies for welding. While welding emission particle sizes and size distributions are critical to determining control device efficiencies, little information apparently exists. Some studies speculated particle sizes of 2+ microns for coating and flux materials and <0.2 microns for metallic emissions. Removal efficiencies for filters and scrubbers may vary considerably for different pollutants. Low capture efficiencies are expected for all but enclosed operations based upon reported plume configuration studies. The effectiveness of HEPA filters for controlling welding fumes has not been quantified.

- The NASSCO AB2588 file contains a detailed review of each document received by the District regarding welding emissions.

- Welding and cutting torch processes which do not consume electrodes are unquantifiable at this time. These processes may include; submerged arc welding, arc spot welding, braze welding, thermal cutting, electron beam welding, and laser welding. Emissions from these processes should be identified by the facility and District as unquantified until preliminary estimation techniques are developed.

FORMS:

Individual reporting forms must be completed for each electrode used in each welding operation on site.