# The Impact of Lowering TLVs on the Welding Process

**Written by:**

**Joseph N. Capuzzi, CSP, CIH**

**Presented to San Diego ASSP by:**

**J. Michael Strange, CIH**

**Chubb Global Risk Advisors**

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# Objectives

- Review Common Arc Welding Processes
- Examine TLVs Related to Welding Exposure - Specifically Metal Fume
- Discuss Exposure Sampling Considerations
- Review Exposure Controls

## Types of Welding

“Welding is the process of joining together two pieces of metal so that bonding takes place at their original boundary surfaces”. When two parts to be joined are melted together, heat or pressure or both is applied and with or without added metal for formation of metallic bond.

# Types of Welding

Welding is classified into two groups: fusion (heat alone) or pressure (heat and pressure) welding.

There are three types of fusion welding: electric arc, gas and thermit.

Electric arc welding is the most widely used type of fusion welding.

# Types of Welding

**Arc Welding**:

**Flux Core Arc Welding** (FCAW) filler metal electrode; flux shield

**Shielded Metal Arc** (SMAW) electrode provides both flux and filler material

**Gas Metal Arc** (GMAW or MIG) widely used; consumable electrode for filler metal, external gas shield

**Tungsten Inert Gas** (GTAW or TIG) superior finish; non-consumable electrode; externally-supplied inert gas shield

# Welding Fume

**Fume:** Airborne solid particulate, formed in air, by the vaporization and condensation of a metal.  A fume is formed when a solid metal is melted and re-condenses in the air (i.e. welding fume, metal fumes, etc.).  Because it is formed by condensation it is very small ($<1$ micron).

# Welding Fume

**Metals**
Aluminum, Antimony, Arsenic, Beryllium, Cadmium, Chromium, Cobalt, Copper, Iron, Lead, Manganese, Molybdenum, Nickel, Silver, Tin, Titanium, Vanadium, Zinc.

**Gases**
Shielding — Argon, Helium, Nitrogen, Carbon Dioxide.

Process — Nitric Oxide, Nitrogen Dioxide, Carbon Monoxide, Ozone, Phosgene, Hydrogen Fluoride, Carbon Dioxide.

## Welding Fume

**Metals**

Chromium metal is found in stainless steel and many low-alloy materials, electrodes, and filler materials.

High temperatures created by welding oxidize chromium in steel to the hexavalent state.

The majority of the chromium found in welding fume is typically in the form of $Cr_2O_3$ and complex compounds of Cr(III).

# Threshold Limit Value Changes

| Metal | Units | TLV Prior to 2018 | 2018 TLV | 2020 TLV |
|---|---|---|---|---|
| Chromium (0) | $mg/m^3$ | 0.5 | 0.5 I | 0.5 I |
| Chromium (III) | $mg/m^3$ | 0.5 | 0.003 I | 0.003 I<br>A4 DSEN, RSEN |
| Chromium (VI) Soluble | $mg/m^3$ | 0.05 | 0.0002 I TWA<br>0.0005 I STEL | 0.0002 I TWA<br>0.0005 I STEL<br>A1 Skin DSEN/RSEN |
| Chromium (VI) Insoluble | $mg/m^3$ | 0.01 | Withdrawn | -- |
| Chromium (VI) Inhalable | $mg/m^3$ | -- | 0.0002 I | 0.0002 I<br>A1 Skin DSEN/RSEN |
| STEL Chromium (VI) Inhalable | $mg/m^3$ | -- | 0.0005 I | 0.0005 I<br>A1 Skin DSEN/RSEN |
| Lead Chromate, as Cr | $mg/m^3$ | 0.012 | 0.0002 I | 0.0002 I<br>A1 DSEN/RSEN |
| STEL Lead Chromate | $mg/m^3$ | -- | 0.0005 I | 0.0005 I<br>A1 DSEN/RSEN |

# Threshold Limit Value Changes

| Metal | Units | TLV<br>Prior to 2018 | 2018 TLV | 2020 TLV |
|---|---|---|---|---|
| Aluminum metal and insoluble compounds | $mg/m^3$ | 10<br>(1988-2007) metal | 1 R | 1 R A4 |
| Cadmium and compounds | $mg/m^3$ | 0.5 (1976-1992) dust | 0.01 “total”<br>0.002 R | 0.01 Total A4<br>0.002 R |
| Copper, fume | $mg/m^3$ | 0.1 (1965-1974) | 0.2 | 0.2 |
| Iron Oxide | $mg/m^3$ | 5 (1996-2005) | 5 R | 5 R A4 |
| Lead | $mg/m^3$ | 0.15 (1973-1994) | 0.05 | 0.05 A3 |
| Manganese, elemental and inorganic compounds | $mg/m^3$ | 0.2<br>(1995-2012) | 0.02 R<br>0.1 I | 0.02 R<br>0.1 I A4 |
| Nickel, insoluble compounds as Ni | $mg/m^3$ | 1<br>(1986-1997) | 0.2 I | 0.2 I A1 |
| Tin, oxide and inorganic compounds as Sn | $mg/m^3$ | 10<br>(1978-1981) oxide | 2 | 2 |
| Zinc, Oxide | $mg/m^3$ | 5<br>(1962-2002) fume | 2 R | 2 R |

# TLV BASIS

| | |
|---|---|
| Metallic chromium, as Cr(0) | Respiratory tract irritation |
| Trivalent chromium compounds as Cr(III) | Respiratory tract irritation, asthma. DSEN:RSEN (water soluble compounds only), A4 |
| Hexavalent chromium compounds (Cr(VI) | Lung & sinonasal cancer, respiratory tract irritation, asthma. RSEN:DSEN, Skin (water soluble only), A1 |
| Manganese, elemental and inorganic compounds as Mn | CNS impairment |

## Sampling Considerations

OSHA PELs for many metals including Cr(VI) are based on Total Particulate.

TLVs for Chromium and Nickel are based on Inhalable fraction.

Some TLVs based on Respirable Fraction (e.g. Aluminum, Iron Oxide and Zinc.

Manganese TLVs for both R and I Fractions.

# Sampling Considerations

## Inhalable Particulate Mass

- Hazardous when deposited anywhere in the respiratory system.
- Typically greater than total particulate mass.
- How much greater will depend on particle size.
  - Larger particles generate inhalable particulate mass greater than total particulate mass.
  - Smaller particles generate inhalable and  total particulate mass comparable to total particulate mass.

# Sampling Considerations

Lower TLVs Require Increased Air Volumes

- Increased Sample Time
- Increased Flow Rates

## Sampling Considerations

Multi-fraction Samplers

- IOM Sampler
  - Plastic or Stainless Steel
  - 2 L/min (personal sampling)
  - 25-mm filters
  - Add MultiDust Foam Disc (PUF) to sample both inhalable and respirable fractions simultaneously.

## Sampling Considerations

### Multi-fraction Samplers

- Conical Inhalable Sampler (CIS)
- 3.5 L/min.
- 37mm filters
- Simultaneously collect both Respirable and Inhalable Fractions
- Includes conical inlet with 8 mm opening.

# Sampling Considerations

Traditional Sampling – "Total Particulate"

- Not Size Selective
- 37 mm or 25 mm Cassettes (fits under helmet).

Respirable Sampling

- Cyclone vs. Assuming Metal Fume is Respirable Size.
- Cyclone Flow rates vary.
- Will not fit under welding helmet.

# Sampling Considerations

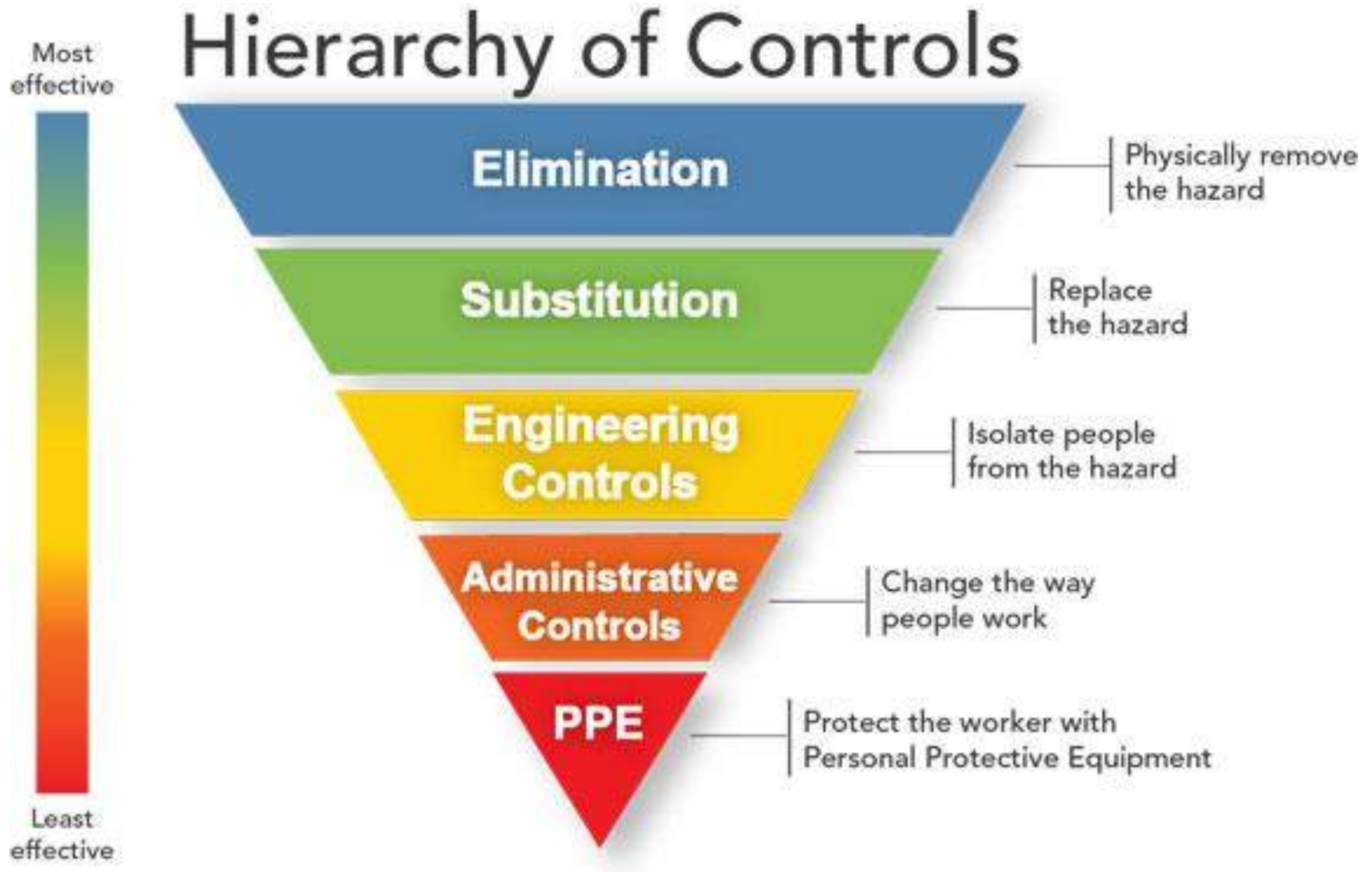
## Sampling Cassette Location

- OSHA Letter of Interpretation February 3, 1999.
  - "If the employee is wearing a welding helmet and either no respirator or a negative pressure respirator, sampling should be done inside the helmet."

- Can be difficult with welding helmets currently worn that fit close to the face.

- Both IOM and CIS are fairly large and difficult to place under helmet.

# Hierarchy of Control Methods



## Substitution

SMAW (stick) produces more fume per unit of weld metal than FCAW or GMAW (MIG).

FCAW produces more fume per unit of weld metal than GMAW.

GMAW produces less fume per unit of weld than either FCAW or SMAW.

**However,** due to the increased efficiency of the wire-fed processes:

FCAW produces more fume per unit time than SMAW

GMAW may equal the fume per unit time from SMAW

## Substitution

### Modify the Process

- Argon Shielding Gases < Fume than 100% Carbon Dioxide and Gases High in Helium.
- Reduced Current and Voltage
- Change Consumable Metal Content
- GMAW Pulse Transfer < Fume than Spray Transfer

## Isolation

Is it feasible and practical to isolate and separate your welding operation by moving it to a regulated area, by automating/ventilating the welding process and/or by placing a barrier between the employee and the source?

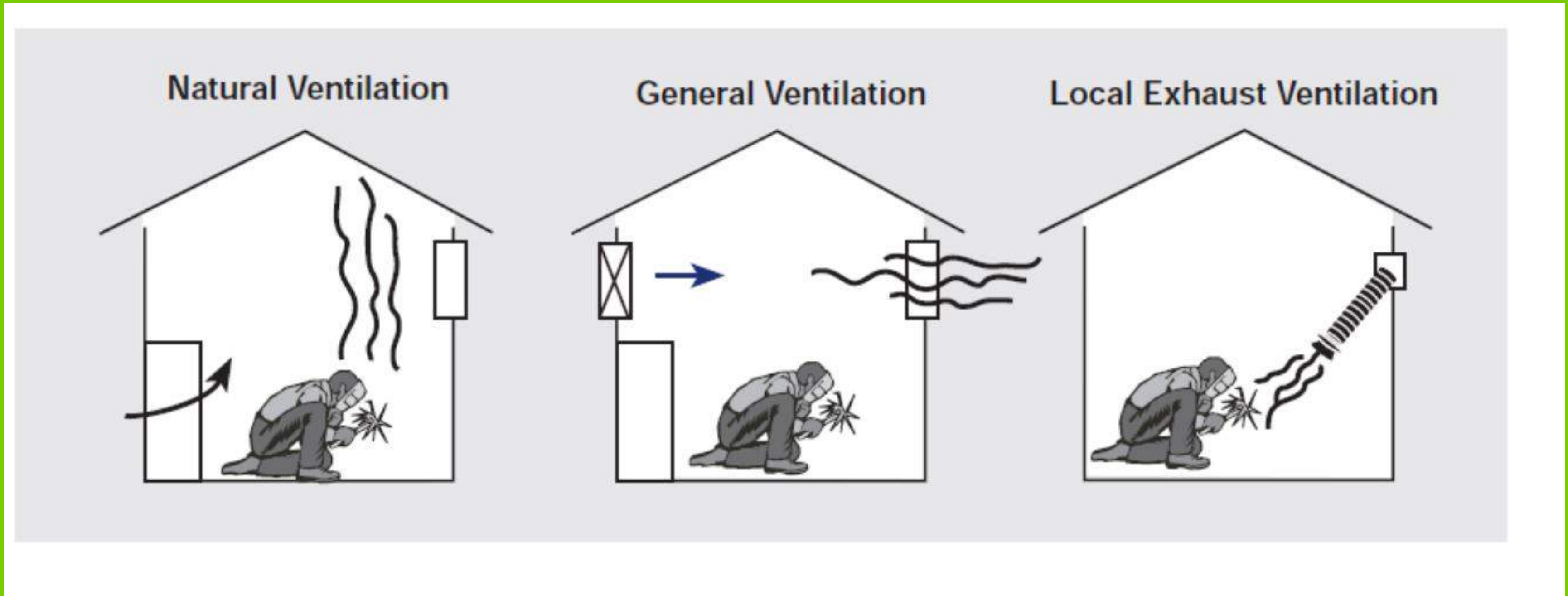
# Engineering Controls

ANSI Z49.1:2012 – Safety in Welding, Cutting and Allied Process requires that adequate ventilation be provided for all welding, cutting, brazing and related operations.

Adequate is enough to maintain hazardous concentrations of contaminants below the allowable limits specified by the AHJ. (TLVs)

If natural ventilation is not sufficient to maintain contaminants below the allowable limits then mechanical ventilation or respirators shall be provided.

# Engineering Controls



## Engineering Controls

- **Dilution Ventilation**
- Fume control is used to protect:
  - Welder
  - Others in area
  - Plant and Equipment
- Source Capture is recommended for effective fume control. However, welding often mobile.
- Dilution ventilation or area control is sometimes the alternative required in large fabrication bays where overhead cranes and large weldments preclude the fixed or mobile control devices.

# Engineering Controls

## Dilution Ventilation

- Federal regulations 1910.252(c) and 1926.353 establish several criteria for ventilation confined spaces for hot work.
- 1910.252 defines spaces that require ventilation:
  - <16ft high
  - Volume <10,000 cubic ft. per welder
  - Areas where there are partitions, structural barriers or other barriers that significantly obstruct airflow (such as baffles, trays, or limited access openings).

# Engineering Controls

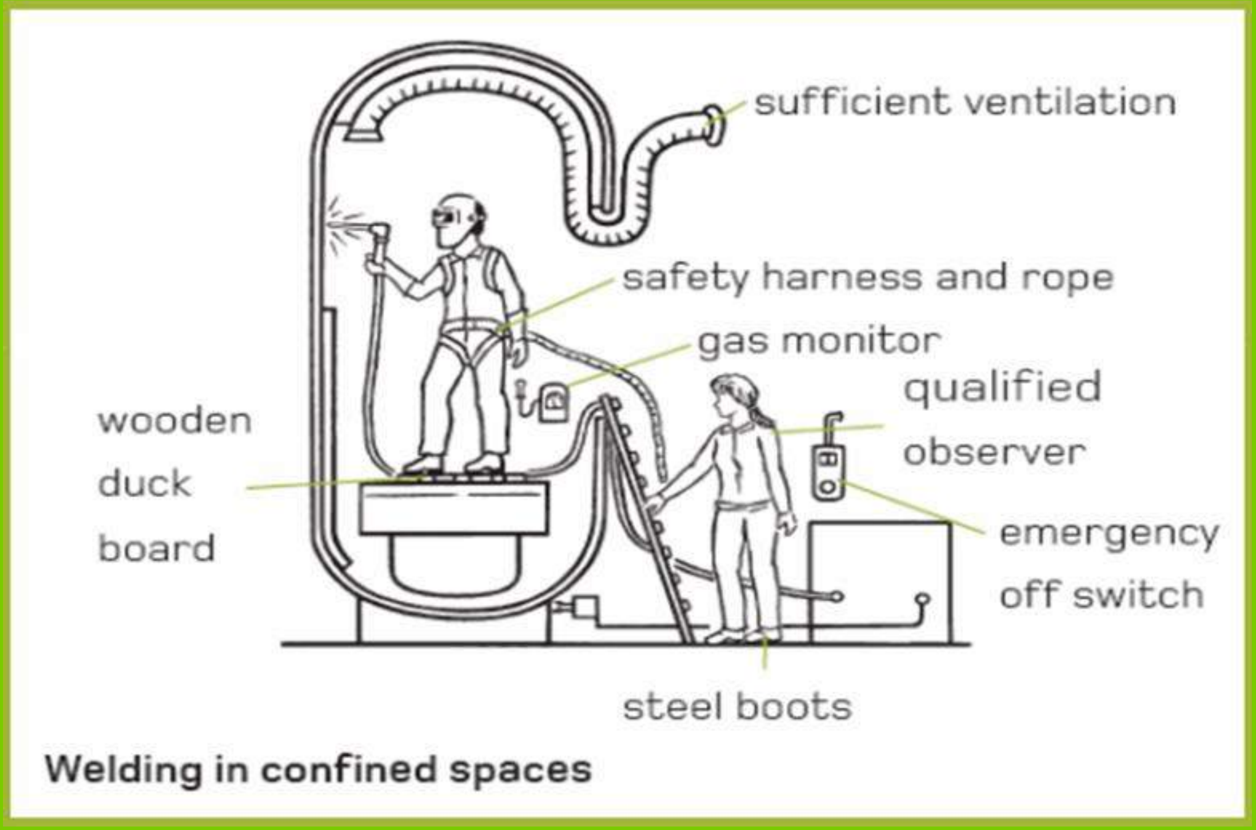
## Dilution Ventilation

- OSHA 1910.252 requires 2000 cfm of airflow for each active welder when relying on dilution ventilation in a confined space.

# Engineering Controls

## Dilution Ventilation

Welding on stainless steel in a confined space may require both exhaust ventilation and the use of respiratory protection.



## Engineering Controls

# Local Exhaust Ventilation

Capture the welding fume at its source.

Effectiveness of LEV is highly dependent upon its proximity to the source of the fume.

Fixed LEV can be either flexible or stationary.

100 fpm Capture Velocity at the Work Zone.

# Engineering Controls

## Local Exhaust Ventilation


**Figure 11** Enclosing hood

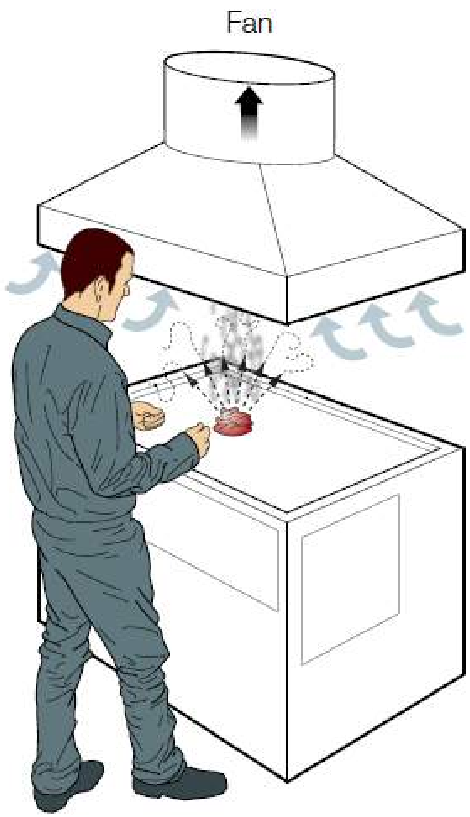



**Figure 12** Receiving hood

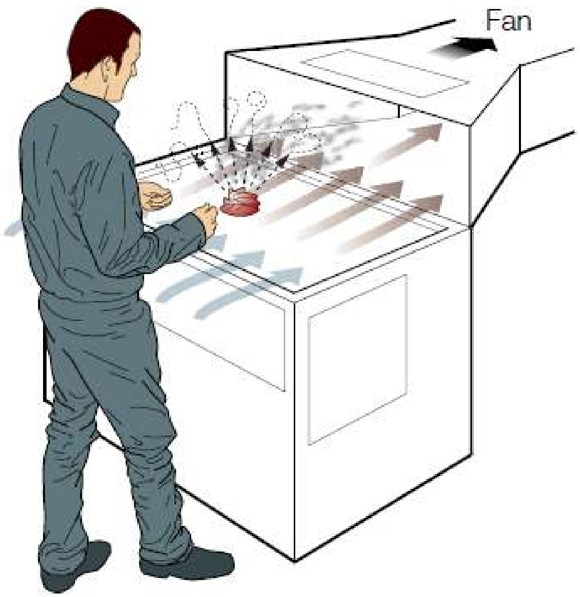



**Figure 13** Capturing hood

# Engineering Controls

## **Local Exhaust Ventilation**

# Engineering Controls

## Local Exhaust Ventilation

### *Low Vacuum (High Volume)*

A portable, low vacuum/high volume disposable filtration system designed for intermittent or continuous extraction and filtration of welding fumes.

On-board internal extraction fan and is designed specifically for weld applications.

The particulate is collected on the inside of the cartridge, minimizing exposure to particulate during filter maintenance and disposal.

## Administrative Controls

- Reduce work times in contaminated areas
  - –Job rotation
  - –Schedule work to reduce number of employees exposed
- Other work rules
  - –Keep head out of fumes
  - –Stand upwind of direction of fumes

## Personal Protective Equipment

## Last Resort

When exposure to hazards cannot be engineered completely out of normal operations or maintenance work, and when safe work practices cannot provide sufficient additional protection, a further method of control is using protective clothing or equipment.

## Personal Protective Equipment

### Respirators

Must be specific to the hazard.

Must be fitted, cleaned, stored and maintained in accordance to regulation and manufacturers specifications.

Respiratory Protection Program.

# Questions?

**J. Michael (Mike) Strange, CIH**
Principal Consultant, Industrial Hygiene and Safety
Chubb Global Risk Advisors
**Michael.strange@chubb.com**