# The Impact of Lowering TLVs on the Welding Process

CHUBB®
Global Risk Advisors℠

Joseph N. Capuzzi, CSP, CIH
Chubb Global Risk Advisors

The information contained in this presentation is not intended as a substitute for legal, technical or other professional advice, nor is it intended to supplant any duty to provide a safe workplace, operation, product, or premises. Chubb Global Risk Advisors℠ makes no express or implied warranty that all accidents or incidents can or will be prevented, or that numbers of accidents or amounts of losses will be reduced. Chubb Global Risk Advisors is a service of ESIS®, Inc., a Chubb company. Chubb Global Risk Advisors provides claim and risk management services to a wide variety of commercial clients. ESIS' innovative best-in-class approach to program design, integration, and achievement of results aligns with the needs and expectations of our clients' unique risk management needs. With more than 65 years of experience, and offerings in both the US and globally, ESIS provides one of the industry's broadest selections of risk management solutions covering both pre- and post-loss services. Chubb is the marketing name used to refer to subsidiaries of Chubb Limited providing insurance and related services. For more information, visit us at www.chubb.com.

# 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

Welding fume is a complex mixture of metal oxides.

The predominant metal fume generated from mild, low alloy, and stainless steel welding is iron oxide.

Oxides of manganese are also typically present.

Fumes from stainless steel and some low-alloy steel welding also typically contain chromium and nickel.

# 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 Cr2O3 and complex compounds of Cr(III).

# Threshold Limit Value Changes

| Metal | Units | Prior TLV | 2018 TLV | Change |
|---|---|---|---|---|
| Chromium (0) | $mg/m^3$ | 0.5 | 0.5 I | -- |
| Chromium (III) | $mg/m^3$ | 0.5 | 0.003 I | 166 |
| Chromium (VI) Soluble | $mg/m^3$ | 0.05 | -- | -- |
| Chromium (VI) Insoluble | $mg/m^3$ | 0.01 | -- | -- |
| Chromium (VI) Inhalable | $mg/m^3$ | -- | 0.0002 I | 250 Soluble<br>50 Insoluble |
| STEL Chromium (VI) Inhalable | $mg/m^3$ | -- | 0.0005 I | New |
| Lead Chromate, as Cr | $mg/m^3$ | 0.012 | 0.0002 I | 60 |
| STEL Lead Chromate | $mg/m^3$ | -- | 0.0005 I | New |

# Threshold Limit Value Changes

| Metal | Units | Prior TLV | 2018 TLV | Change |
|---|---|---|---|---|
| Aluminum metal and insoluble compounds | $mg/m^3$ | 10 (1988-2007) metal | 1 R | 10 |
| Cadmium and compounds | $mg/m^3$ | 0.5 (1976-1992) dust | 0.01 "total" 0.002 R | 50 |
| Copper, fume | $mg/m^3$ | 0.1 (1965-1974) | 0.2 | -- |
| Iron Oxide | $mg/m^3$ | 5 (1996-2005) | 5 R | -- |
| Lead | $mg/m^3$ | 0.15 (1973-1994) | 0.05 | 3 |
| Manganese, elemental and inorganic compounds | $mg/m^3$ | 0.2 (1995-2012) | 0.02 R 0.1 I | 10 |
| Nickel, insoluble compounds as Ni | $mg/m^3$ | 1 (1986-1997) | 0.2 I | 5 |
| Tin, oxide and inorganic compounds as Sn | $mg/m^3$ | 10 (1978-1981) oxide | 2 | 5 |
| Zinc, Oxide | $mg/m^3$ | 5 (1962-2002) fume | 2 R | 2.5 |

CHUBB®

# 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

| Agent | TLV ($mg/m^3$) | RL (µg) | Air Volume (Liters) | ½ TLV ($mg/m^3$) | Method |
|---|---|---|---|---|---|
| Cr(III) | 0.003 | 1.8 | 1200 | 0.0015 | EHL 4170 |
| Cr(VI) | 0.0002 | 0.01 | 90 | 0.00011 | OSHA ID 215 |
| Cr(VI) STEL | 0.0005 | 0.01 | 40 | 0.00025 | OSHA ID 215 |
| Metal Scan | Varies | 0.04-30 | 300 | Varies | OSHA ID 125G |
| Manganese | 0.1 | 0.075 | 75 | 0.05 | |

# 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.

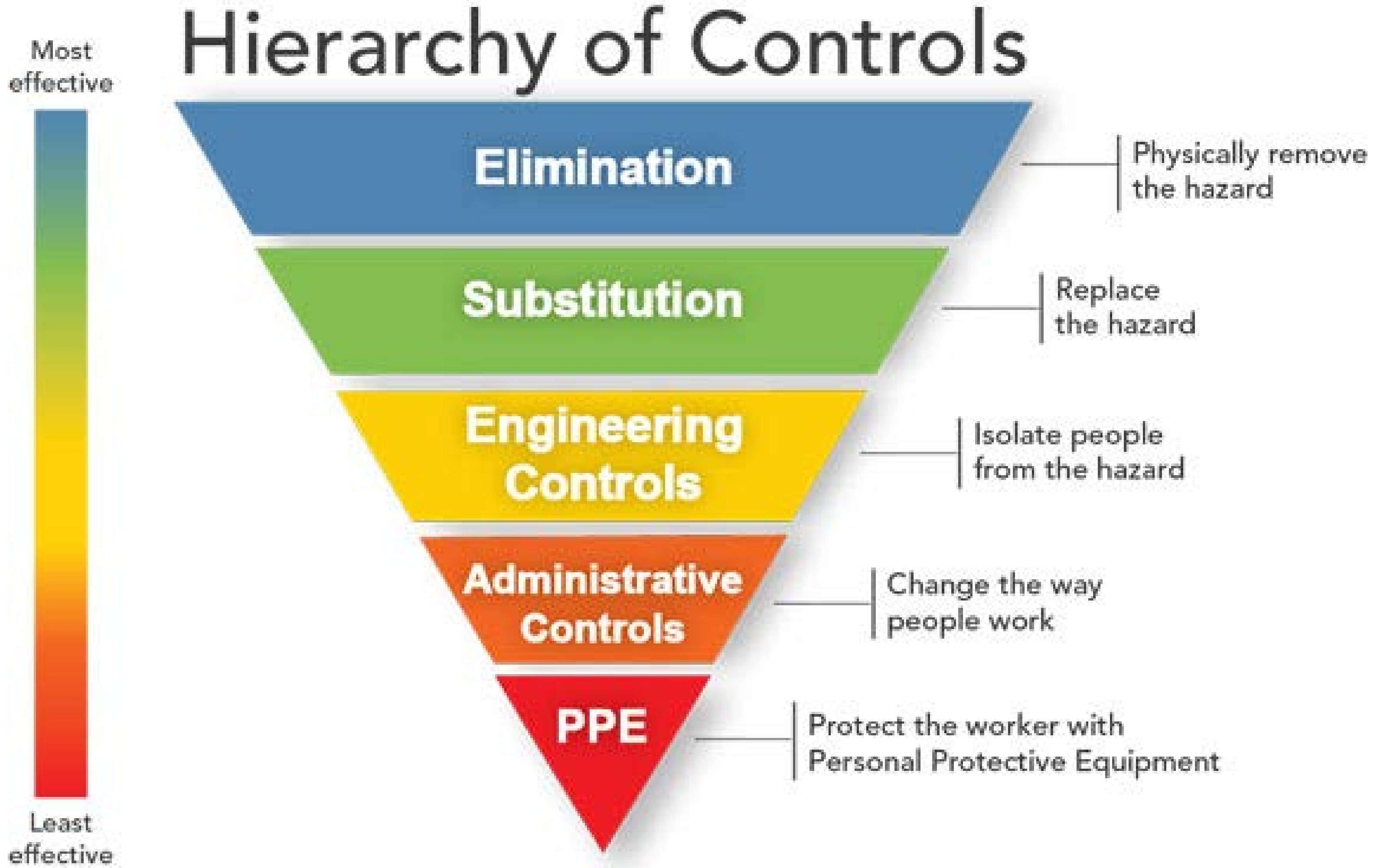
- Both IOM and CIS are fairly large and difficult to place under helmet.

# Sampling Considerations

## Sampling Cassette Location

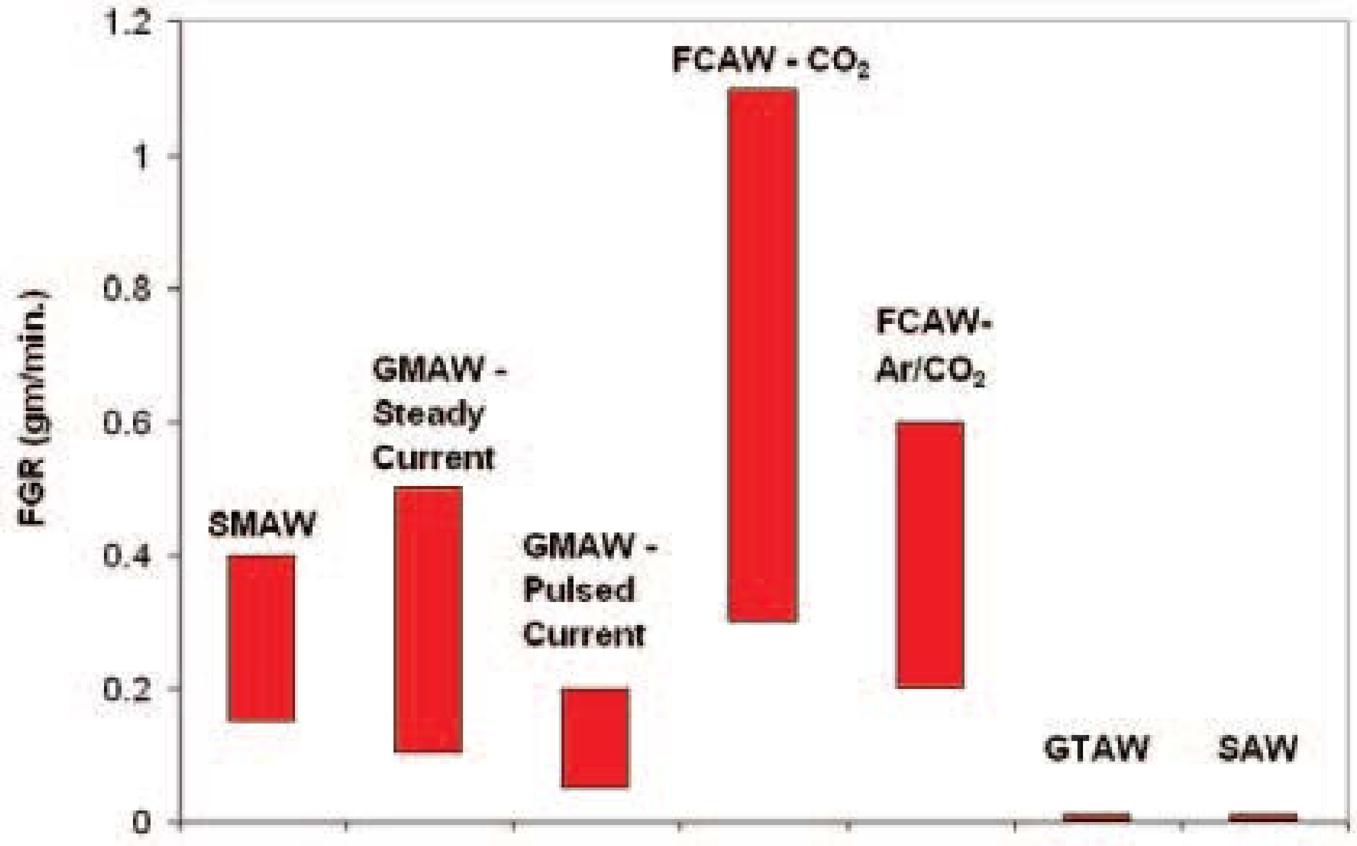
- Swedish OEL for Manganese – Decreased by 50% in 2007.
- Mimi sampler developed with a 13-mm filter mounted on a headset to fit under helmet.
- Collects inhalable fraction.
- 1 LPM in testing by HSE.
- Swinnex sampling cassette is available for welding fumes.

# Hierarchy of Control Methods



# Substitution

Change Welding Process




Fume Generation in grams per minute

# 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

CHUBB®

# Substitution

## Case Study

The purpose of this study was to determine if welders' exposure to manganese welding fume is reduced by substituting low manganese (Mn) emissions flux core wire for the standard flux core wire.

1. Railroad Tank Car Manufacturing Plant
2. Barge Yard

# Substitution

The mean employee exposure using the low manganese flux core wire was 0.278 $mg/m^3$ which represent a 63% reduction from the baseline XL-550 wire mean of 0.784 $mg/m^3$.

TLV for manganese is 0.02 $mg/m^3$ R or 0.1 I $mg/m^3$as an 8-hour time-weighted average.

# 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?

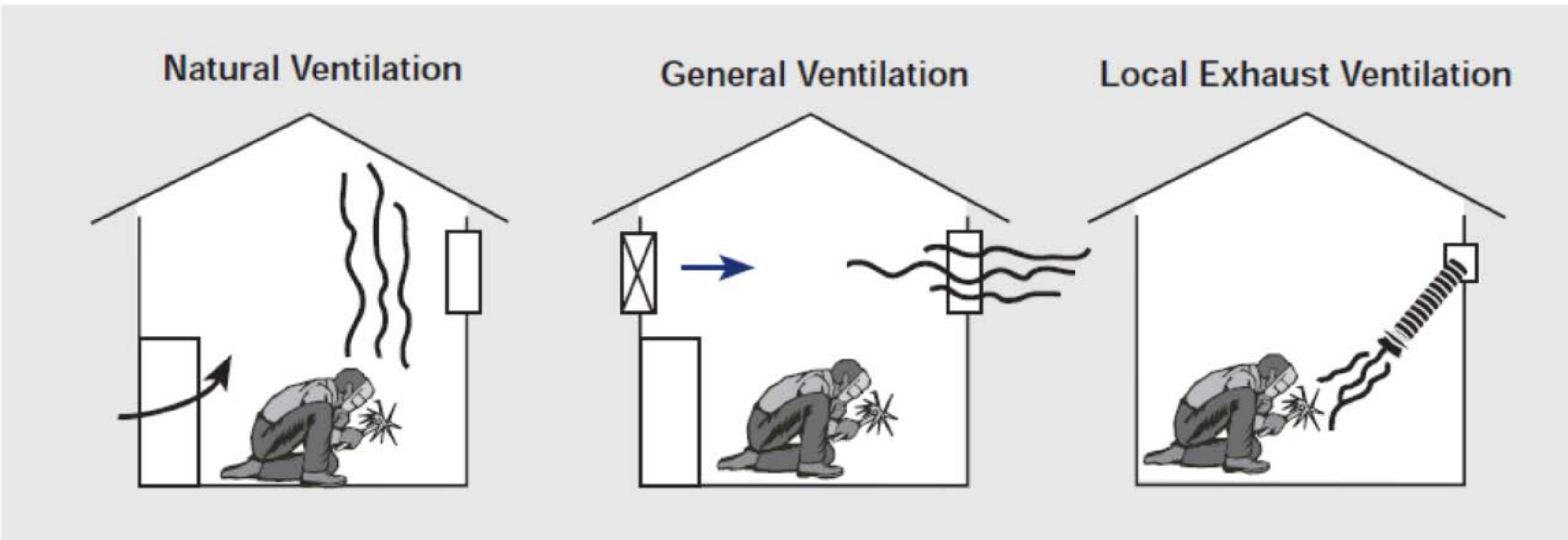
# Engineering Controls

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

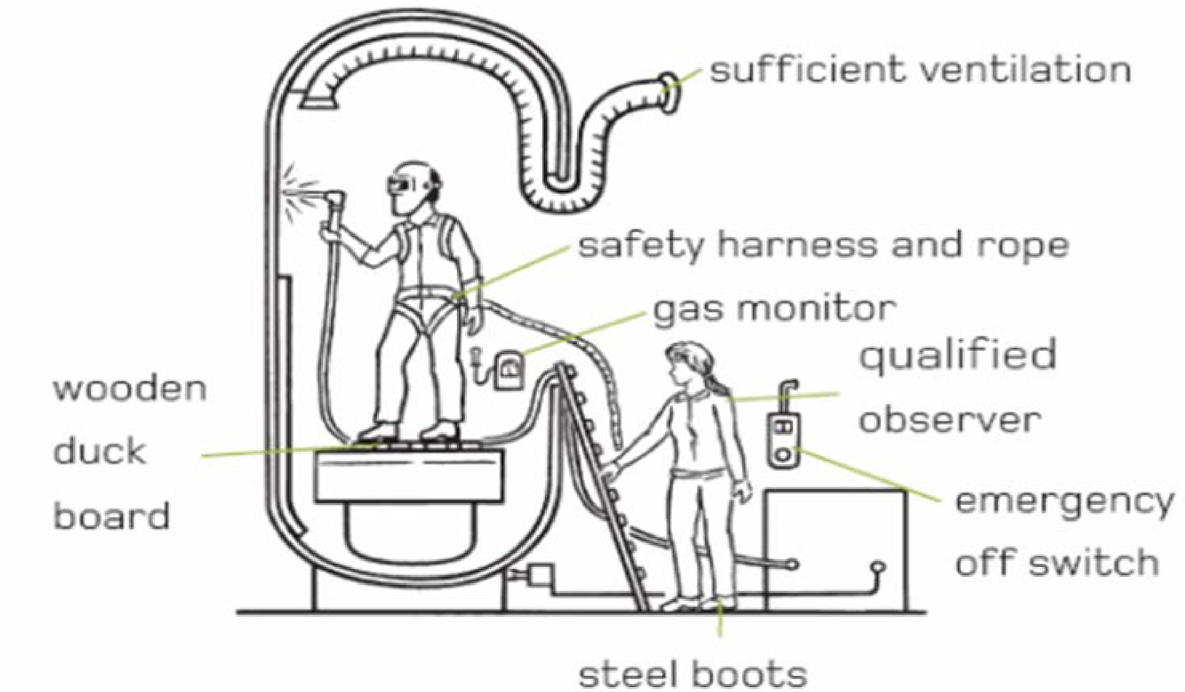
## Dilution Ventilation

- 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.




Welding in confined spaces

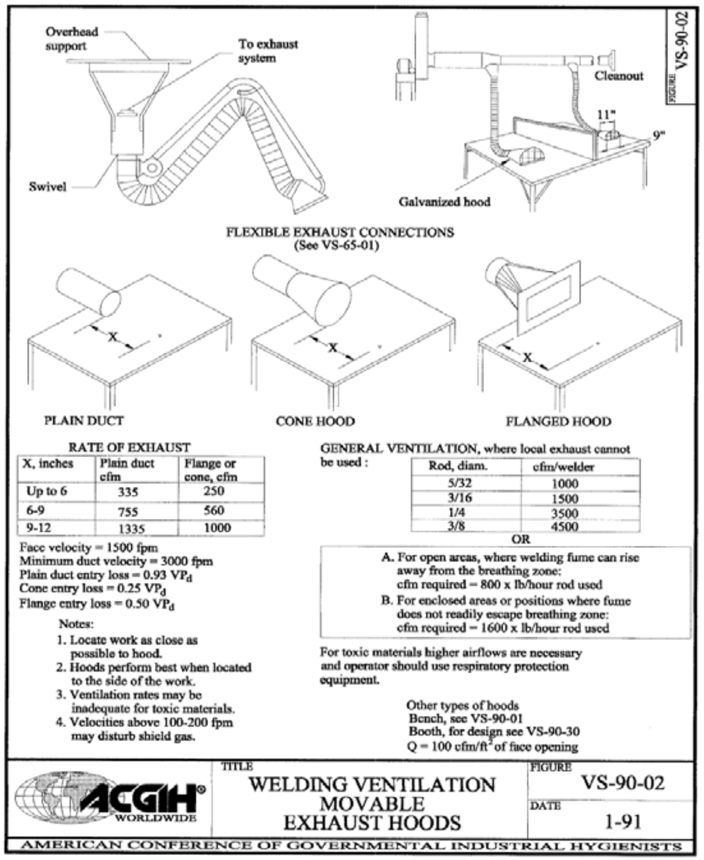
# Engineering Controls

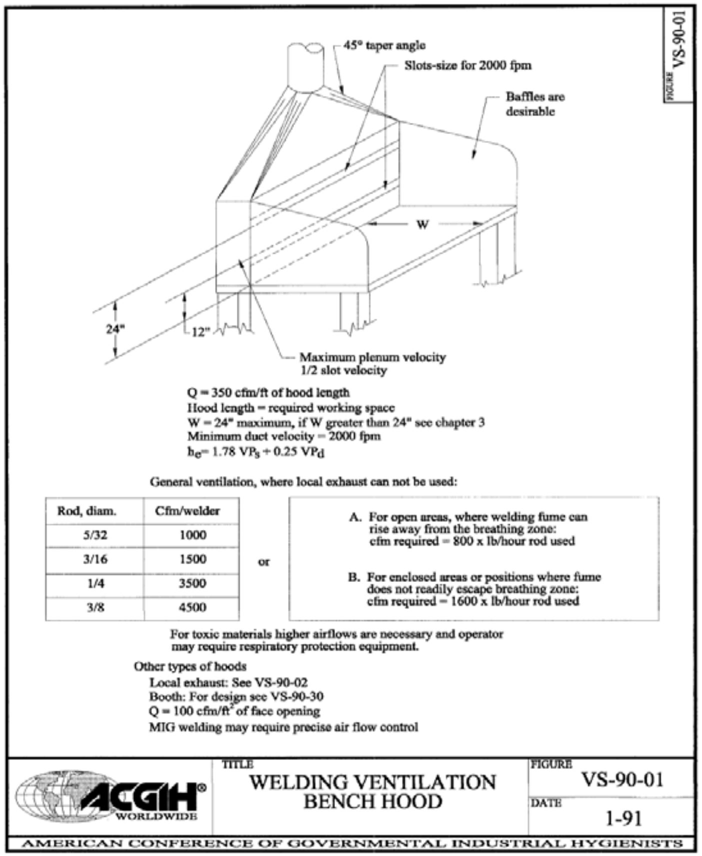
## Local Exhaust Ventilation

- 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



# Engineering Controls

## Local Exhaust Ventilation

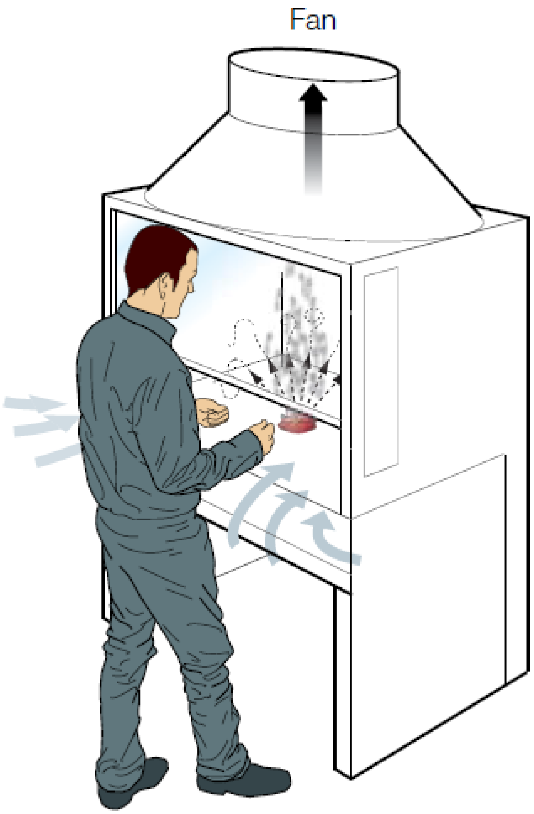



**Figure 11** Enclosing hood

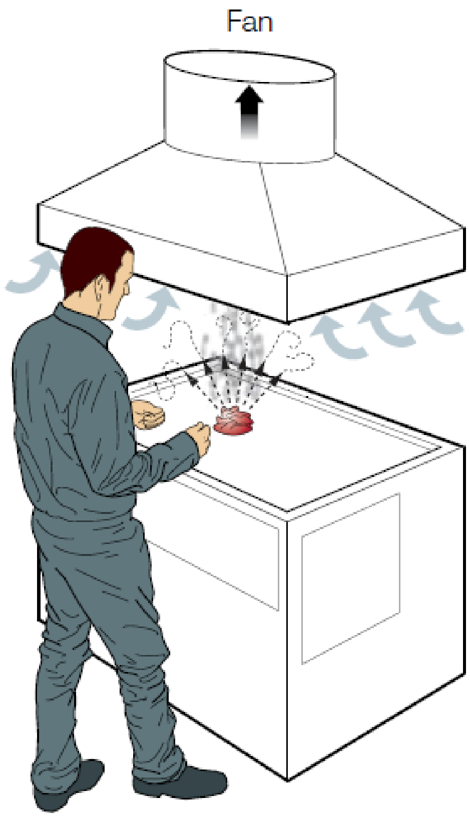



**Figure 12** Receiving hood

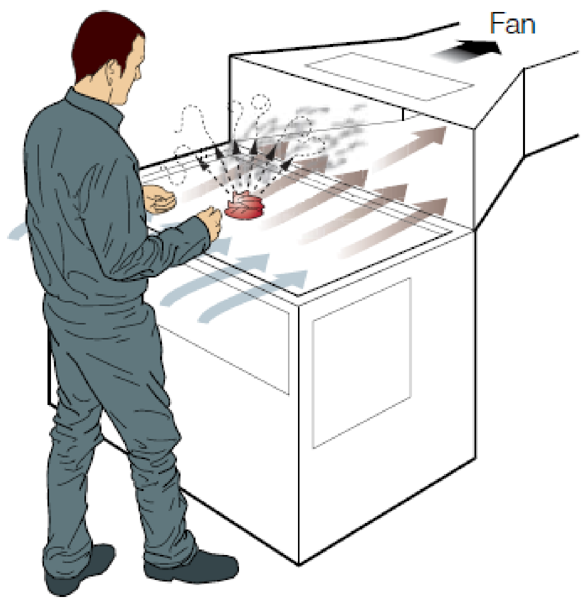



**Figure 13** Capturing hood

# Engineering Controls

## Local Exhaust Ventilation

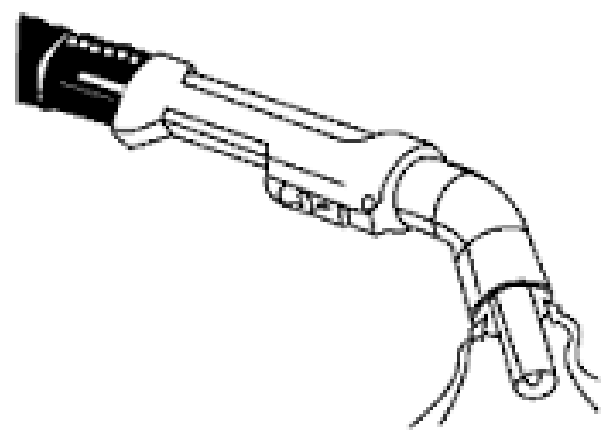
# Engineering Controls

## Local Exhaust Ventilation

### Two Common Types of LEV

- Low Volume/High Vacuum
- Welding guns with built-in extraction
- Separate suction nozzles
- Advantages
  - Can be place within inches of arc.
  - No need to reposition gun.

**Figure 5 - Portable high vacuum/ low volume extraction unit.**



# Engineering Controls

## Local Exhaust Ventilation

***Low Vacuum (High Volume)***

- For hard to reach areas, exhaust the fume
- Connect to 6 in. diameter, 16 ft. long hose set with magnet mounted hood exhaust or extension hose set.
- Does not provide filtration.

# Engineering Controls

## Local Exhaust Ventilation

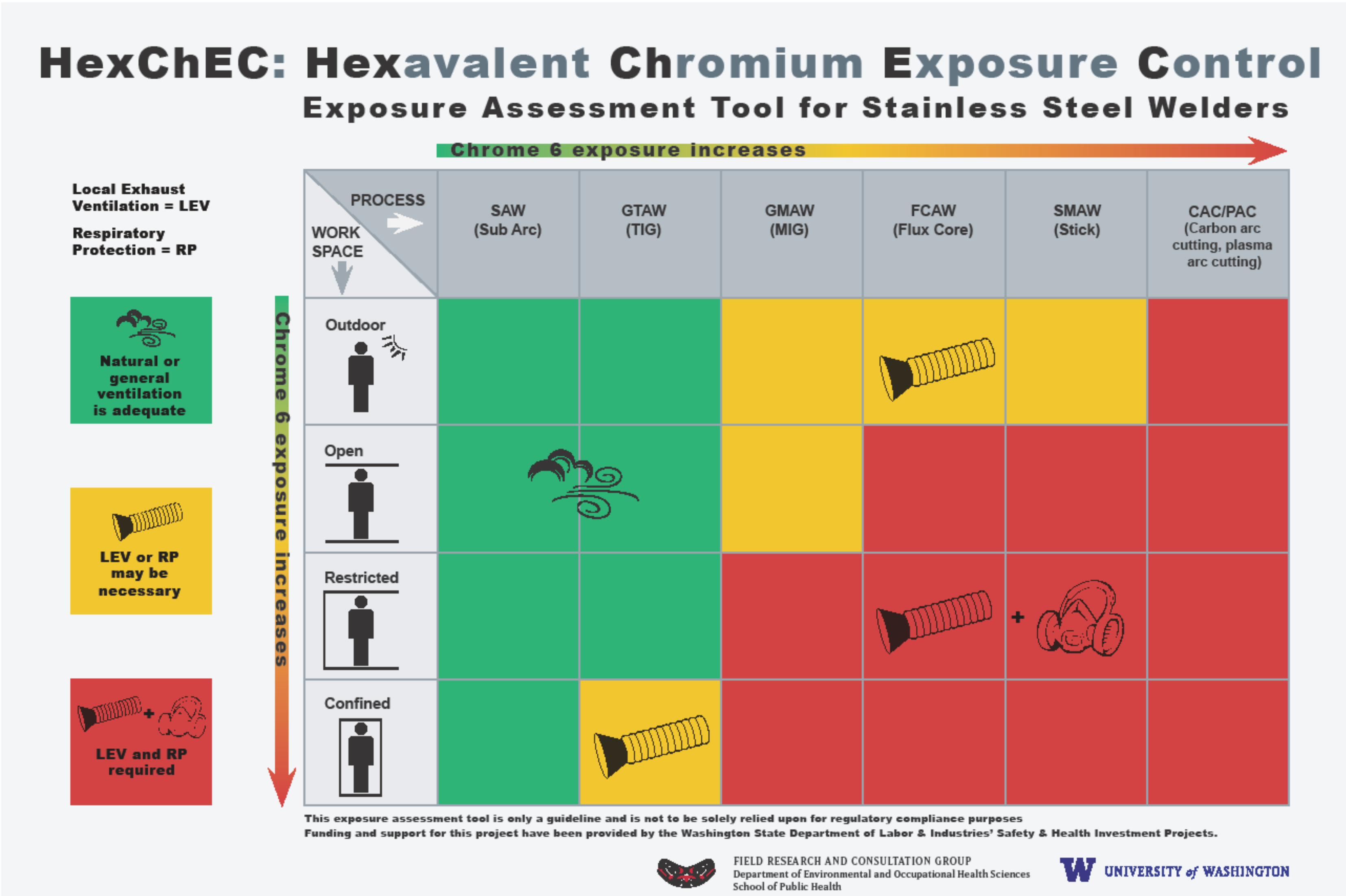
### *Low Vacuum (High Volume)*

- 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

# Training



HexChEC: Hexavalent Chromium Exposure Control
Exposure Assessment Tool for Stainless Steel Welders
Chrome 6 exposure increases
Local Exhaust Ventilation = LEV
Respiratory Protection = RP
Natural or general ventilation is adequate
LEV or RP may be necessary
LEV and RP required
Chrome 6 exposure increases
PROCESS
WORK SPACE
SAW (Sub Arc)
GTAW (TIG)
GMAW (MIG)
FCAW (Flux Core)
SMAW (Stick)
CAC/PAC (Carbon arc cutting, plasma arc cutting)
Outdoor
Open
Restricted
Confined
+
This exposure assessment tool is only a guideline and is not to be solely relied upon for regulatory compliance purposes
Funding and support for this project have been provided by the Washington State Department of Labor & Industries' Safety & Health Investment Projects.
FIELD RESEARCH AND CONSULTATION GROUP
Department of Environmental and Occupational Health Sciences
School of Public Health
UNIVERSITY of WASHINGTON

# 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.

CHUBB®

# 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.

CHUBB®