

# Responsible & Sustainable Weld Fume Management Practices





# Introduction

## **Bert Schiller, Certified Industrial Hygienist**

Bert Schiller is an industrial hygienist certified in the Comprehensive Practice of Industrial Hygiene (CIH). He has over 35 years of experience with a wide variety of industries. Bert also worked with OSHA in Michigan for five years and has taught industrial hygiene at Madonna University for the last 20 years.

## **Aaron Bischoff, Weld Engineer- Hobart Brothers Co.**

Aaron Bischoff is a graduate of the Welding Engineering program at Ferris State University. Aaron has held positions working in robotic integration for the heavy equipment industry, conducting research of weld fume, and developing and implementing welding process for the heavy equipment industry. Aaron is also a member of both the AWS SH1 committee on fumes and gases and the AWS D16 robotic welding committee.



# Introduction

## **Pete Lemke, Certified Environmental Auditor & Hazardous Materials Manager- The WORCS**

Pete Lemke is president of The WORCS where he provides compliance management systems and implementation strategies to eliminate waste. Pete is also a certified Environmental Auditor, a Masters Certified Hazardous Materials Manager, Instructor at OSHA Institute and teaches at over 126 Colleges and Universities . He has over 20 years experience in manufacturing industries.

## **Al Hilbert, Fume Extraction Product Specialist- Miller Electric Mfg. Co.**

Al Hilbert is a Product specialist with twenty years of experience in the welding industry. Al is currently responsible for the product development of Miller Electric's fume extraction business.

## **Eric Sommers, Respiratory Product Specialist- Miller Electric Mfg. Co.**

Eric Sommers is a product specialist responsible for respirator and welding helmet development within Miller Electric's Arc Armor™ line of welding protection. He has over five years of experience in the welding industry.

# Disclaimer

Every welding environment is different and needs to be evaluated by a qualified Industrial Hygienist to determine the appropriate course of action for fume controls.

This presentation is intended for awareness and educational purposes only and should not be used to replace professional consultation. No express or implied warranties of any kind are provided with this presentation.

# BACKGROUND

## WELDING FUMES AND REGULATION HISTORY

**“Health hazards from welding, cutting, and brazing operations include exposures to metal fumes and to ultraviolet (UV) radiation. Many of these can be controlled with proper work practices and personal protective equipment (PPE).” -OSHA**

# Welding Fumes

- Welding fumes consist of metallic oxides generated by the heating of the metal being welded, the welding consumables, or any coatings present on the base metal during arc or oxy-acetylene welding.



# Welding Fumes

- Different types of welding
  - Arc Welding
  - Shielded Metal Arc Welding (SMAW)
  - Metal Inert Gas (MIG)
  - Tungsten Inert Gas (TIG)
  - Plasma Arc Welding
  - Submerged Arc Welding



# Welding Fumes

- Over ½ million workers in the U.S. are involved with welding and related processes
- Exposures from a mix of metals & fine particulates (fumes) and gases
- Fumes are a complex mixture of metals and metallic oxides
- 90% of the fume is respirable, < 1 µm aerodynamic diameter



# OSHA-PELs: 1993 - Present

- Since 1993, OSHA has been enforcing the exposure limits for **each individual metal**, metal oxide or gas found in the weld plume.
  - There is no standard for general weld fume
  - Common metals in welding environments
    - Zinc, Iron, Chromium, Aluminum, Nickel, and Manganese (29 CFR 1910.1000 Table Z-1)
- In 2006, OSHA issued its standard for exposure to **hexavalent chromium** (29 CFR 1910.1026), setting a Permissible Exposure Limit (PEL) of **5 ug/m<sup>3</sup>** and an Action Level of **2.5 ug/m<sup>3</sup>**.
- OSHA has placed exposure to **manganese** (primarily from welding exposures) on its list of intended regulatory actions

# ACGIH-TLVs: 2006 - Present

- The American Conference of Governmental Industrial Hygienists (ACGIH) continues to review its list of Total Limit Values (TLV's) on an annual basis.
- In 2006, the ACGIH set a new TLV for manganese at  $0.2 \text{ mg/m}^3$  as total particulate.
- In 2009, the ACGIH established a “Notice of Intended Change” of its TLV for manganese to  $0.02 \text{ mg/m}^3$  as respirable particulate.

# Sampling for Welding Fumes

- Based on guidance from the OSHA Field Operations Manual (1984), the limits for specific metals in welding fumes are only to be applied to exposure samples taken inside of the welding helmet.



# OSHA-Mandated Steps for Fume Exposure Reduction

1. Engineering/Work Practice Controls
  - Process or material change
2. Engineering/Work Practice Controls
  - Isolation or ventilation
3. PPE/Respiratory Protection

# **ENGINEERING CONTROLS:**

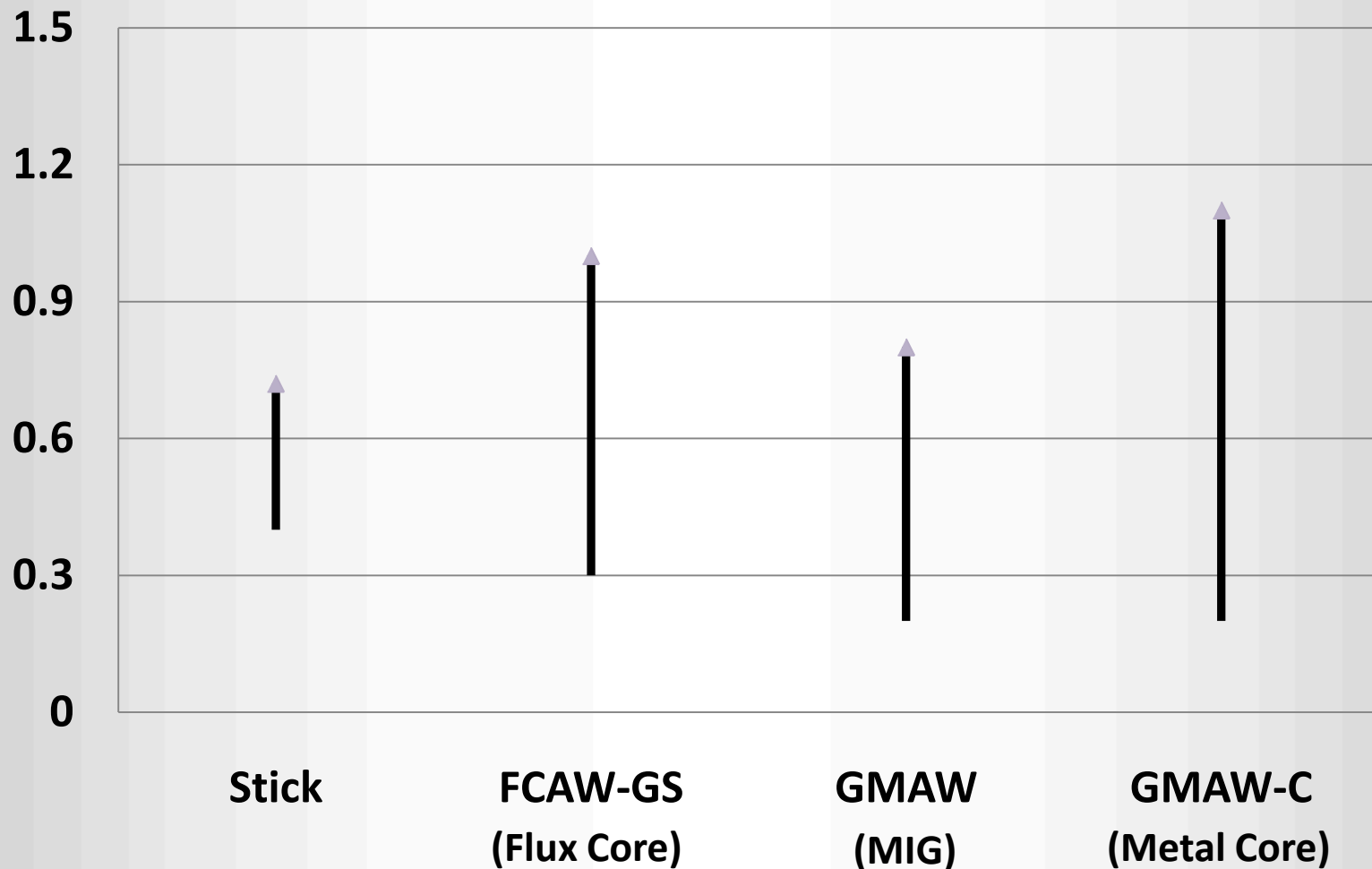
## **WELDING PROCESS MODIFICATION FOR REDUCED WELDING EMISSIONS**

**“Engineering controls include substitution (using a less toxic material or process that results in lower exposures)...” -OSHA**

# Fume Generation Common Terms

- Fume Generation Rate (FGR)
  - Typically reported in grams per minute (g/min)
- Fume Formation Rate (FFR)
  - Typically reported in grams per minute (g/min)
- % Fume
  - % of Electrode Weight that becomes fume

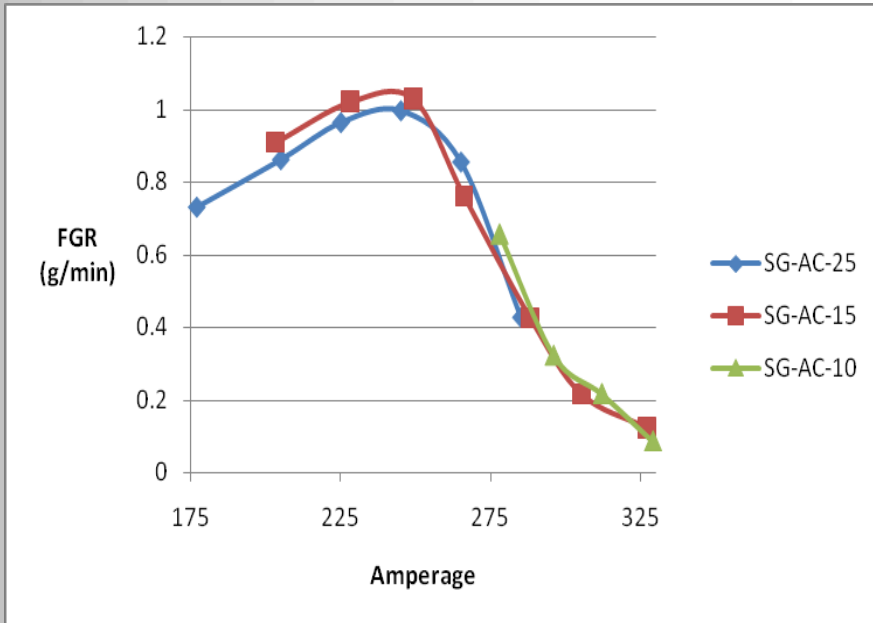
## Fume Generation Rates in g/min



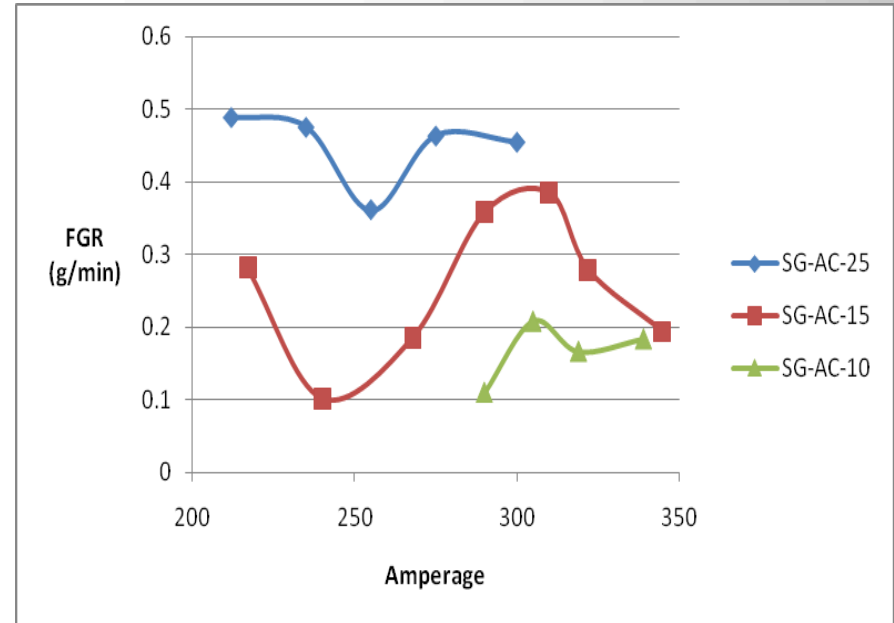
# Fume Generation Factors

- FGR one piece of the equation
- Other factors to consider:
  - Deposition Rate/Welding Settings
  - Gas Shielding Type
  - Filler Metal Type
  - Welder Technique

# GMAW Solid Wire FGR with varying amounts of CO<sub>2</sub> in shielding Gas

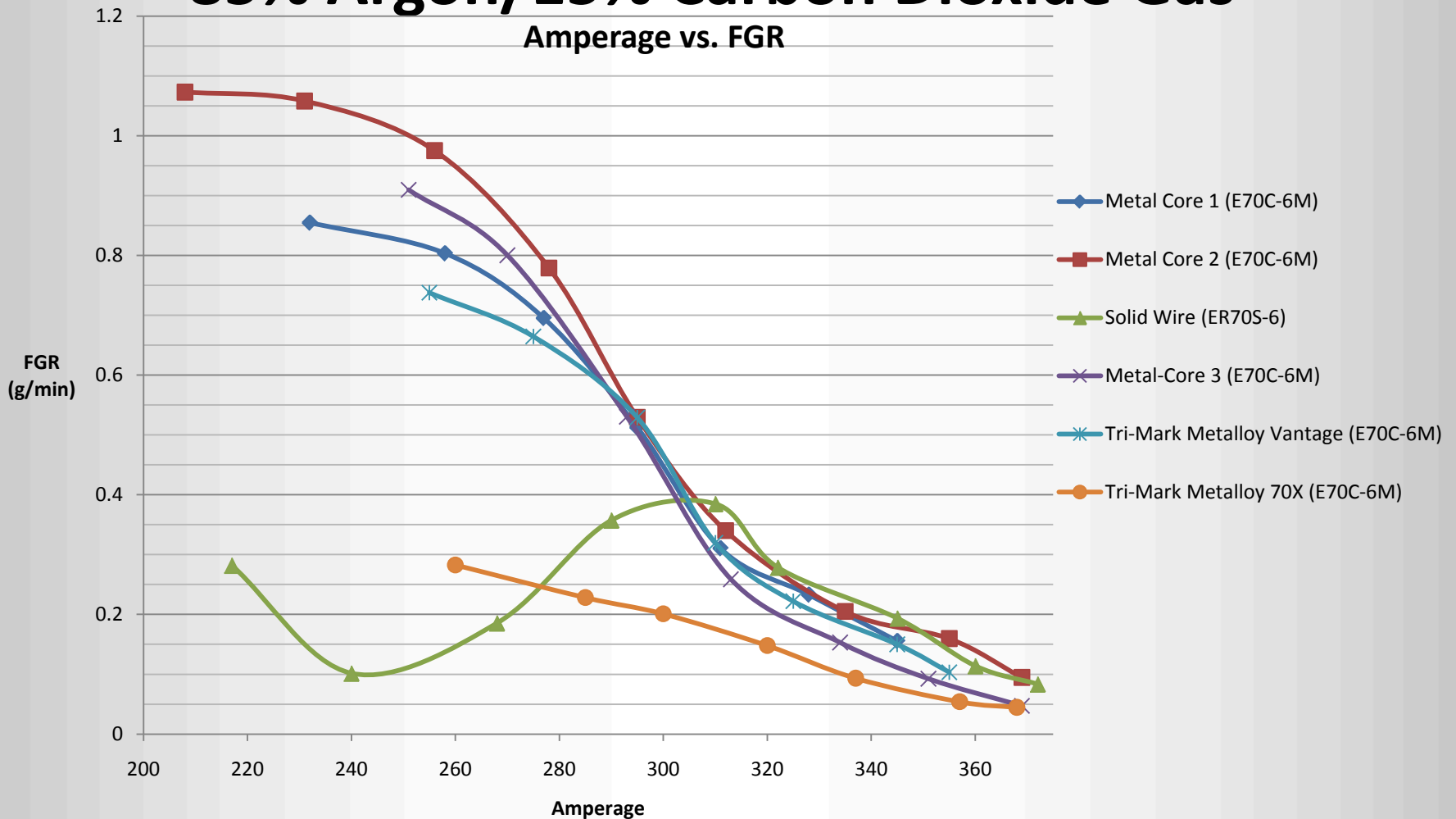


E70C-6M .045" Metal Cored Electrode with Varying Levels of CO<sub>2</sub> in the Shielding Gas

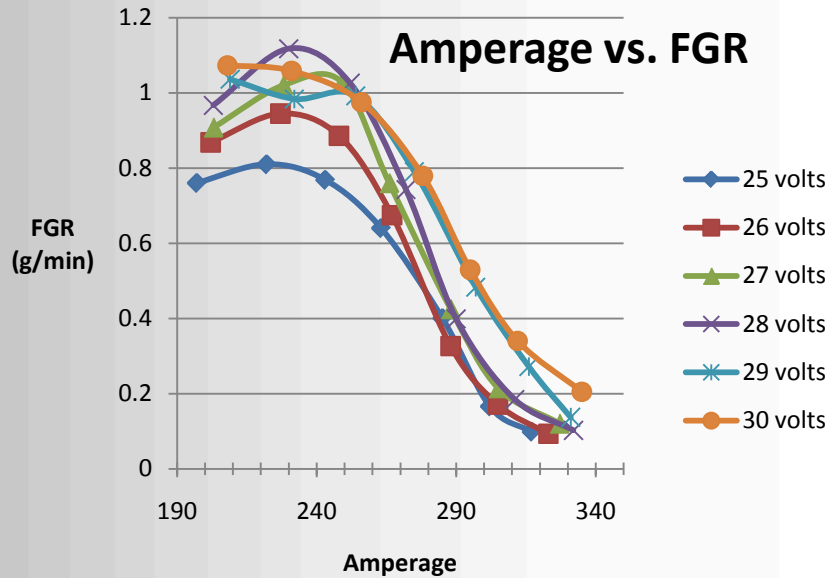


ER70S-6 .045" Solid Wire with Varying Levels of CO<sub>2</sub> in the Shielding Gas

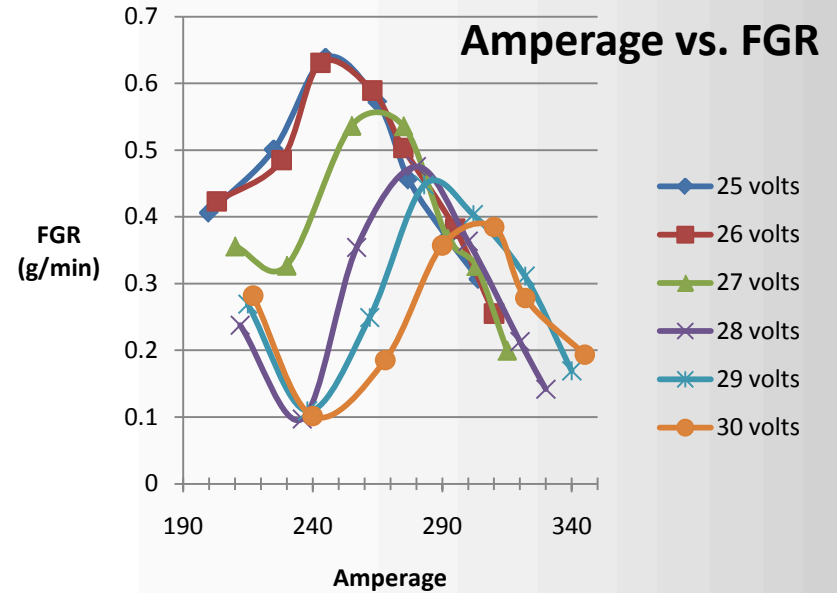
# FGR Rates for Various products using 85% Argon/15% Carbon Dioxide Gas



# Effects of Varying Voltages on FGRs



E70C-6M Metal Cored Electrode Amperage vs. Fume Generation Rate for Various Voltages



ER70S-6 Solid Wire Amperage vs. Fume Generation Rate for Various Voltages

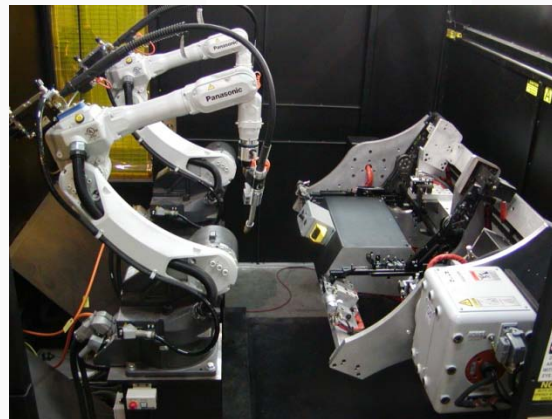
# ENGINEERING & WORK PRACTICE CONTROLS

## ISOLATION/ENCLOSURE OR VENTILATION

**“Employers must use engineering and work practice controls as the primary means to reduce and maintain exposures to regulated contaminants to or below the PEL.” -OSHA**

# ISOLATION/ENCLOSURE

Process Enclosure can be an effective means of engineering control by isolating or enclosing contaminant generating operation so that the fumes may be safely captured.



# Types of Ventilation

- General (Ambient)
  - General ventilation is an engineering control that uses an HVAC system and/or high powered fans to move large quantities of air and dilute contaminants based on an air change schedule.
- Local Exhaust Ventilation (Source Capture)
  - LEV is an engineering control that captures and removes contaminants at their source, before they reach a worker's breathing zone.

# Engineering Control – General Ventilation

- Advantages
  - Removes contaminants from the entire facility
  - Used where local ventilation is not practical
- Disadvantages
  - Does not always protect the immediate worker's breathing zone

# Engineering Control – Local Exhaust Ventilation

- Advantages
  - Captures and removes contaminated air at the source before reaching a worker's breathing zone
- Disadvantages
  - Hooded systems are less feasible on large weldments with no fixed position



# Types of Source Capture

- Fume Extraction Arms
- Canopy/Top/Slot Hoods
- Fume Extraction Torches



# Local Exhaust Ventilation Considerations

- Can the extraction hood get close enough to the source unobstructed?
- Is the capture velocity enough to move the fumes away from the welder?
- Is the extraction device portable enough to reach all portions of the weld when working?

# Proper Worker Positioning

- Always keep your head out of the fumes.
- Position yourself so that the airflow is moving from your back to front when possible. Gentle air movements can push fumes into the breathing zone.
- Keep in mind welding fumes have a natural thermal rise.

# Recommended Hood Positioning

- When using a movable hood, position it above the arc and angled at approximately 45° so that the fume is pulled away from the breathing zone.
- The hood distance will vary depending on the velocity and volume of air movement into the extraction device.
  - In general it's approximately the distance of 1 ½ duct diameters away.

# RESPIRATORY PROTECTION

## RESPIRATORS

**“When effective engineering controls are not feasible, or while they are being instituted, appropriate respirators shall be used pursuant to this standard (29 CFR 1910.134).” -OSHA**

# PPE- Respirators

- Respirator Use
  - Engineering/workplace controls must be used to reduce exposure as low as possible and then supplement with respiratory protection.
  - Respirators can be used if engineering controls have been proven to be unfeasible.
  - Respirators should also be used while controls are being implemented.

# Respiratory Program

- A formal written respiratory program needs to be enacted any time a respirator above the classification of dust mask is used(29 CFR 1910.134)
  - Includes details such as fume reduction steps taken, why the respirators are being used, who will use the respirators, where they are being used, fit testing, maintenance, who is in charge of the respiratory program, etc.
  - Small Entity Compliance Guide:  
[http://www.osha.gov/Publications/SECG\\_RPS/secgrev-current.pdf](http://www.osha.gov/Publications/SECG_RPS/secgrev-current.pdf)

# Choosing the Right Respirator

- Information Needed
  - Actual exposure levels of regulated metals
    - Determined through sampling by a certified industrial hygienist
  - Permissible Exposure Limits of metals discovered in sampling
    - Found in OSHA regulations
      - General respiratory standard 29 CFR 1910.1000 Table Z-1
      - Hexavalent Chromium 29 CFR 1910.1026

# Choosing the Right Respirator

- Respirators are classified in categories and Assigned Protection Factors (APF) are given to each classification

Air-Purifying Respirators: Remove contaminants from the air



**Half mask/Dust mask**  
APF=10  
*Needs to be fit tested*



**Half mask (Elastomeric)**  
APF=10  
*Needs to be fit tested*



**Full facepiece (Elastomeric)**  
APF=50  
*Needs to be fit tested*



**Loose-Fitting Powered  
Air-Purifying Respirator (PAPR)**  
APF= 25

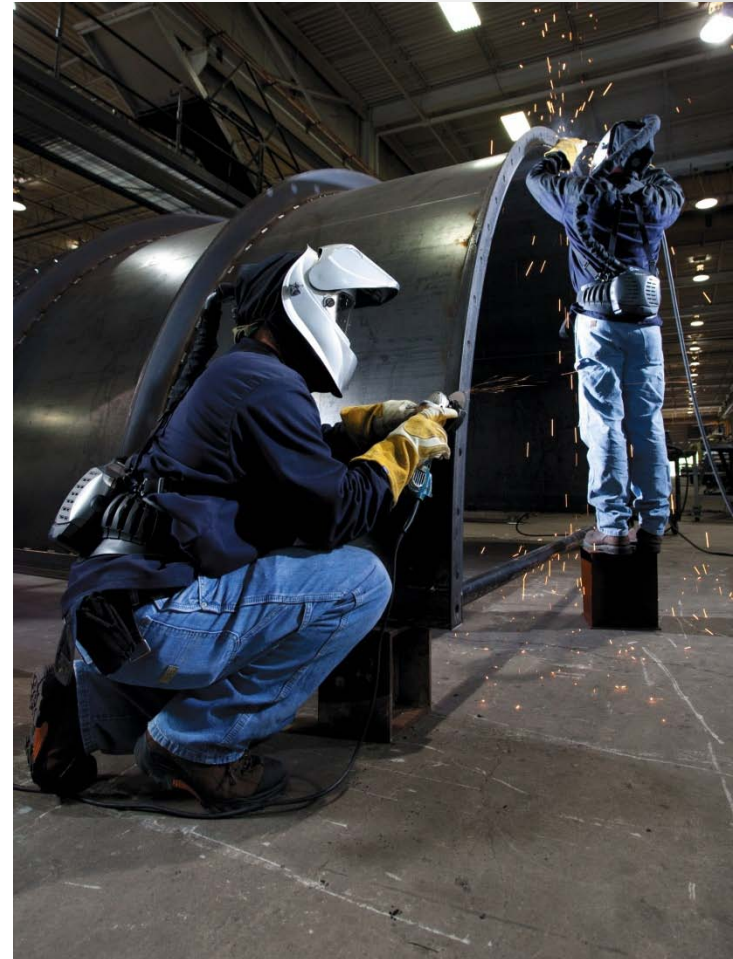


**Hood Powered Air-Purifying  
Respirator (PAPR)**  
APF= 25

# Common Welding Respirators



Half-Mask Respirator (APF 10)



PAPR with Weld Hood (APF 25)

# Determining the Right Respirator

- Respirator classification continued:

Atmosphere Supplying Respirators: Provide clean air from an uncontaminated source



**Full Facepiece Supplied-Air Respirator (SAR)  
with an auxiliary Escape Bottle**  
APF=1,000  
APF = 10,000 (if used in "escape" mode)  
*Needs to be fit tested*



**Full Facepiece Abrasive Blasting  
Continuous Flow**  
APF=1,000  
*Needs to be fit tested*



**Full Facepiece Self-Contained  
Breathing Apparatus (SCBA)**  
Pressure demand mode is APF=10,000  
*Needs to be fit tested*

# Choosing the Right Respirator

- Use Permissible Exposure Limits (PEL) and Assigned Protection Factors (APF) to calculate the Maximum Use Concentration (MUC)
  - Find the OSHA PEL for a given substance (Ex: Hexavalent Chromium  $5 \mu\text{g}/\text{m}^3$ )
  - Multiply PEL by Assigned Protection Factor of respirator (Ex: PAPR with loose fitting head seal- APF 25)
    - $5 \mu\text{g}/\text{m}^3 \times \text{APF } 25 = 125 \mu\text{g}/\text{m}^3$  (MUC)

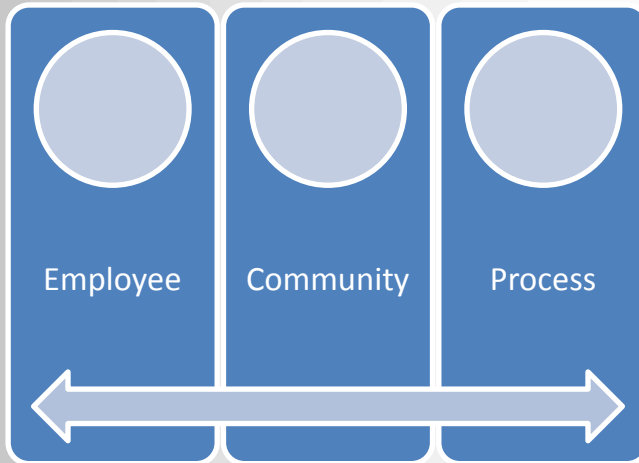
# Choosing the Right Respirator

- Determining the Proper Respirator after finding the Maximum Use Concentration (MUC)
  - OSHA states that “The MUC is the upper limit at which the class of respirator is expected to provide protection. Whenever the exposures approach the MUC, then the employer should select the next higher class of respirators for the employees.”  
<http://www.osha.gov/Publications/3352-APF-respirators.pdf>
  - Example:
    - Hexavalent Chromium sample result of  $65 \mu\text{g}/\text{m}^3$
    - MUC of PAPR with Hexavalent Chromium:  $125 \mu\text{g}/\text{m}^3$

# Long-term Maintenance/Testing

- On-going process
  - Workplace or regulation changes
- Fume levels need to be re-tested anytime there is a “workplace change.”
  - “These changes may include alterations in the production process, raw materials, equipment, personnel, work practices, or control methods used in the workplace.” -OSHA

# Welding Fume Management



Building Code:  
Ventilation  
Compress Gas Storage  
Stack Configuration  
Fire System

Environmental Code:  
Air : HAPS  
TRI  
Storm Water  
Waste  
Radioactive

Safety Codes:  
Indoor Air Quality  
Cylinder Handling & Storage  
Welding Training  
Respirator  
PPE Determination  
Eye and Face  
Gloves and Clothing  
Shoes  
Sub Part Z  
Hazard Communication  
Medical Records  
Fire Watch  
Fire Prevention  
Radiation  
Equipment Maintenance  
Electrical  
Confined Space  
Process Safety  
Lockout

Transportation  
Codes:  
Cylinder  
Battery  
Fuel  
Radioactive



- Process Enclosures
- Local Exhaust
- General Dilution Exhaust
- PPE

Capture Systems: booths, hoods, fume extractors, flexible ducts, portable ducts, high efficiency filters, electrostatic precipitators, particulate scrubber, activated carbon filters.

- PM10: Welding PM .005 to 20 micrometers ... less than 10% of fume is larger than 1 micrometer
- PM (HAP): Mn, Ni, Cr(oxidation state), Co and Pb
- Gas Phase: CO<sub>2</sub>, CO, Nox, O<sub>3</sub> (argon, helium, CO<sub>2</sub> and oxygen (low percent)
- Fume dependant upon these factors: process, electrode type, base metal, voltage, current, arc length, shielding gas, travel speed, electrode angle, cleaning cpds.

Irritant: eye, nose, lung, and throat

- Mild Steel: 1% Silicon, 1% Carbon and 1% Manganese
- Stainless Steel: 15-25% Cr, 8-15% Ni and 3% Molybdenum
- Galvanized: High fume due to zinc coat
- GTAW: Most common tungsten is 2% thoriated (fume predominately magnetite of which 10% is in the form of Manganese)
- SMAW(mild steel): (Fume) FE=27%, Mn= 10%, K=28%, S=10% and Ca=25%

MIG/TIG: More Ozone especially on aluminum

Stick creates less fume than Flux Core

# Engineering Controls Examples:

- Grind galvanized prior to welding or galvanize after fabrication
- 16 Foot Ceiling Heights and Ventilation
- Work Area Markings
- Welding Type Hazard Determination
- Joint Design and Set Up ( strength, position, thickness, accessibility)
  
- Administrative: Breathing Zone Awareness, Welding Training
  
- PPE



# Questions/Discussion



[MillerWelds.com](http://MillerWelds.com)



[HobartBrothers.com](http://HobartBrothers.com)