

CLEARING THE AIR

Implementing Effective Welding Safety Programs

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GOAL:

TO IMPROVE OUR UNDERSTANDING OF WELDING FUME RISKS AND THE NECESSARY CONTROLS TO ENSURE A SAFE AND HEALTHY WORK ENVIRONMENT

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OR STATED ANOTHER WAY…
HOW DO WE TAKE SOMEONE FROM…



Apprentice



Journeyperson (Career)



Healthy Retirement

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WHY:

- Welding is critical for our economy
- Welding requires highly skilled workers
- Welders exposed to hazards with significant health outcomes

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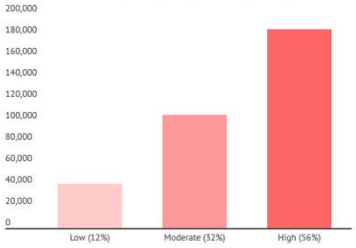
WELDING FUMES
IN CANADA

333,000
TOTAL WORKERS EXPOSED

Level of Exposure

In total, approximately 333,000 Canadians are exposed to welding fumes in their workplaces, with the majority of workers falling into the high (186,000) and moderate (106,000) exposure categories.

Workers exposed to welding fumes by exposure level in 2016



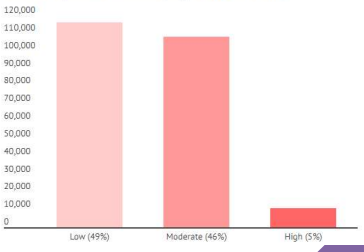
ASBESTOS
IN CANADA

235,000
TOTAL WORKERS EXPOSED

Level of Exposure

In total, approximately 235,000 Canadians are exposed to asbestos in their workplaces. The majority of workers exposed to asbestos are in the low and moderate exposure categories. A significant number of asbestos-exposed workers are at risk for high exposure.

Workers exposed to asbestos by exposure level in 2016



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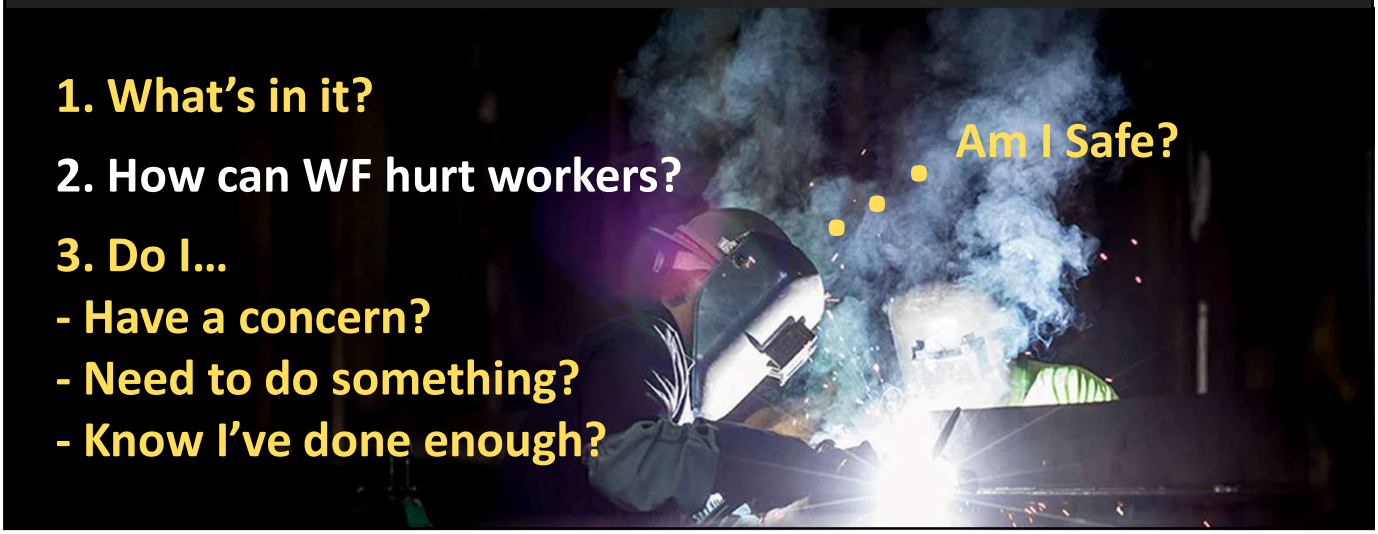


WHY…

- Health hazards are poorly understood
- Exposures can be incredibly complicated to assess
- Welding fumes can be hard to control

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AGENDA



1. What's in it?
2. How can WF hurt workers?
3. Do I…
- Have a concern?
- Need to do something?
- Know I've done enough?

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AGENDA – OUT OF SCOPE



- Ultra Violet Light
- Electrical Shock
- Burns
- Thermal Stress
- Falls
- Ergonomics
- Noise
- Cleaning Chemicals
- Etc

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1. What's in the Fume?

Intro to Welding

Welding Processes

Welding Fume



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What is Welding?



"A joining process that produces coalescence of materials by heating them to the welding temperature, with or without the application of pressure along and with or without the use of filler metal."

- Jefferson's Welding Encyclopedia, 18th ed.

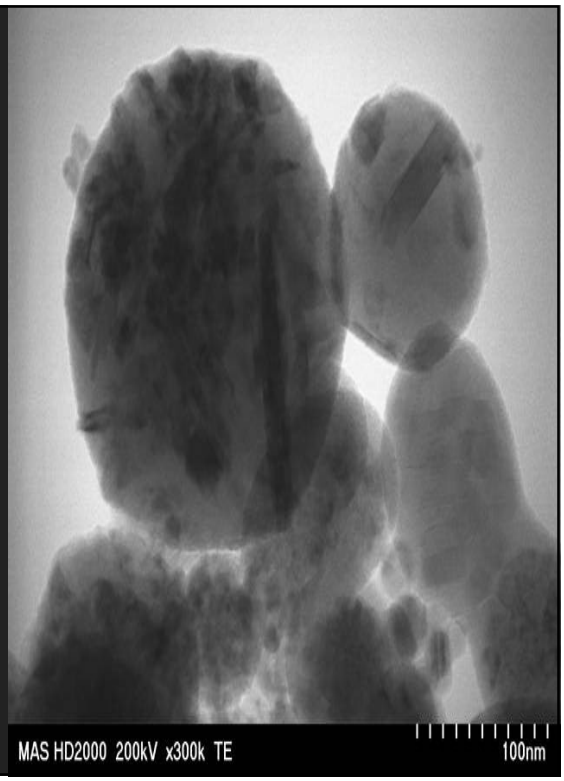
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Welding Fume

Fume is a particulate derived from the melting, volatization and condensation of solid-state materials.

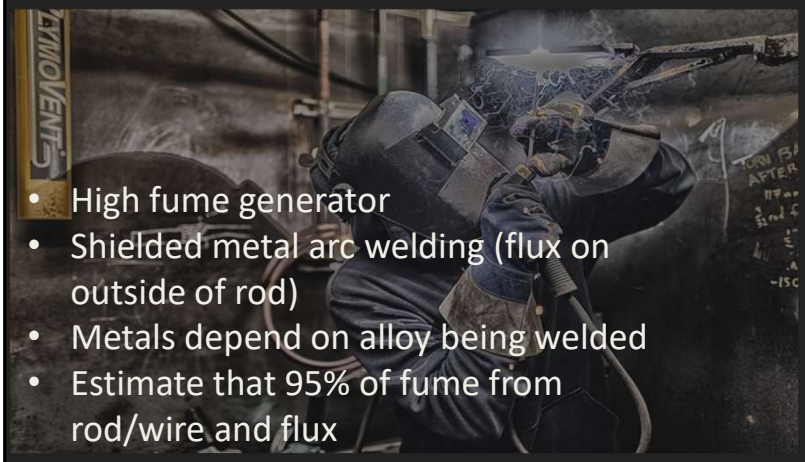
Fume particles are non-homogeneous.

- **Filler metal** (welding wire or electrode)
- **Weld Method** (SMAW, FCAW, TIG)
- **Coatings** (paint, plating, residue)
- **Base metal** (material being welded/cut)

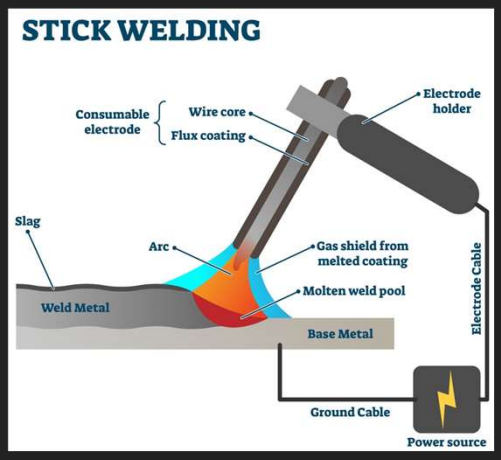


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Shielded Metal Arc Welding (SMAW)

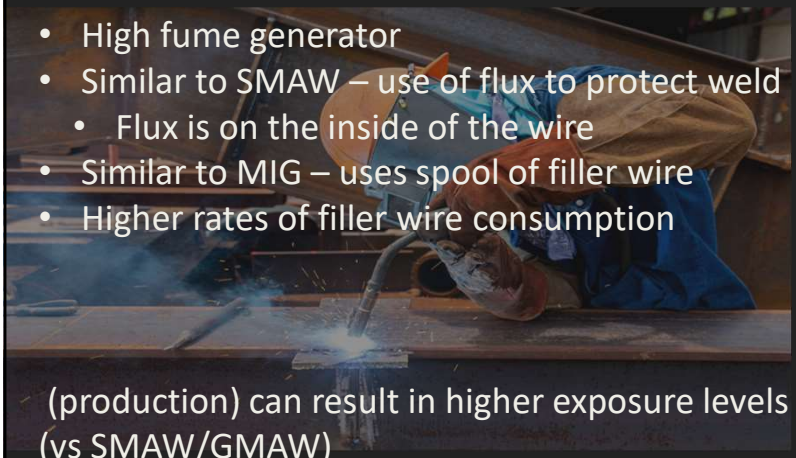


- High fume generator
- Shielded metal arc welding (flux on outside of rod)
- Metals depend on alloy being welded
- Estimate that 95% of fume from rod/wire and flux



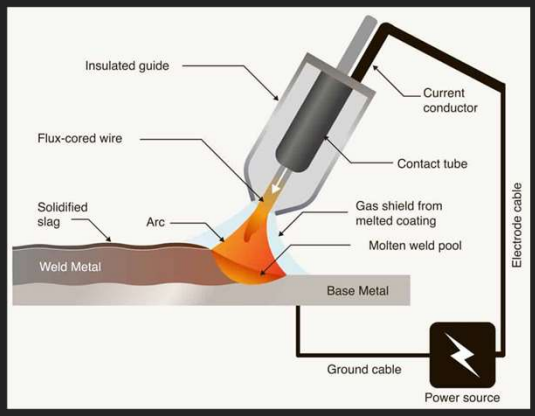
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Flux Core Arc Welding (FCAW)



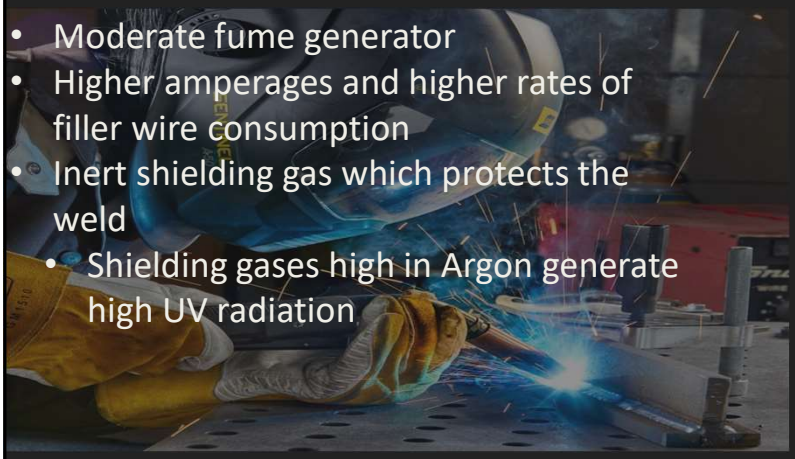
- High fume generator
- Similar to SMAW – use of flux to protect weld
  - Flux is on the inside of the wire
- Similar to MIG – uses spool of filler wire
- Higher rates of filler wire consumption

(production) can result in higher exposure levels (vs SMAW/GMAW)

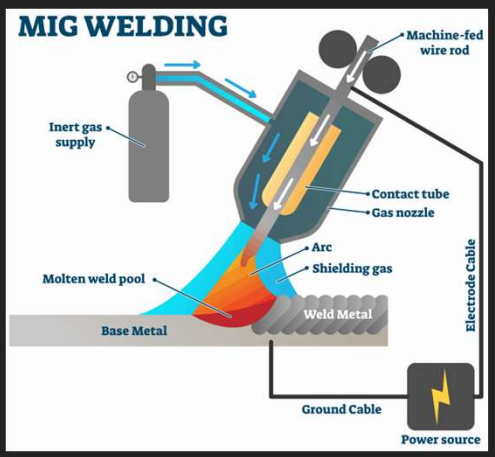


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Metal Inert Gas Welding (MIG)



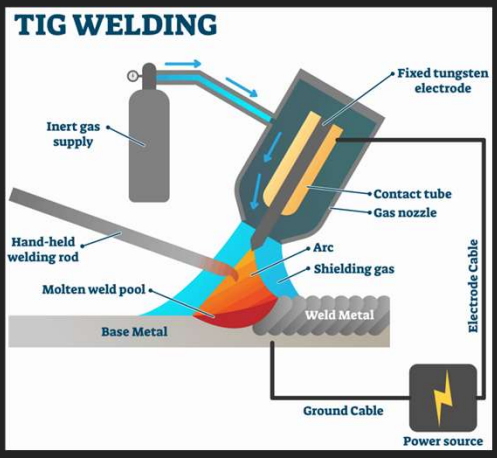
- Moderate fume generator
- Higher amperages and higher rates of filler wire consumption
- Inert shielding gas which protects the weld
  - Shielding gases high in Argon generate high UV radiation



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Tungsten Inert Gas Welding (TIG)

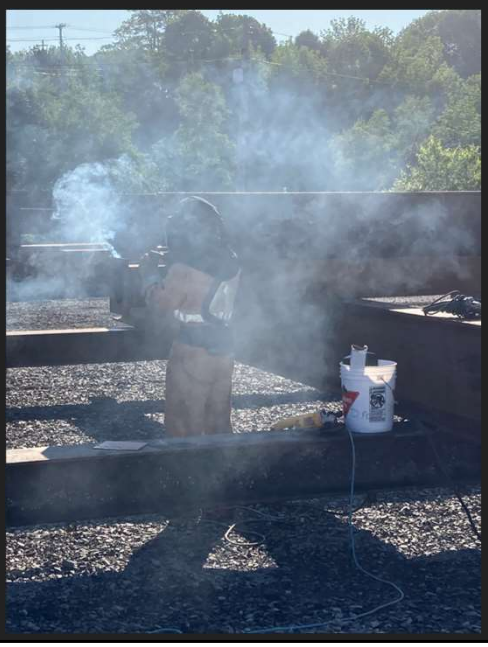
- Low fume generator
- Non-consumable electrode
- Inert shielding gas to protect the weld
  - High UV will create ozone and nitrogen dioxide



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Base / Filler Metals and Electrodes

- Carbon Steel aka Mild Steel
- Aluminum
- Galvanized
- Stainless Steel
- High Alloy
  - Chrome-moly
  - Inconel
  - Hastalloy
  - Stellite
- Electrode composition
  - Contaminants (e.g. lead)



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2. How Can WF Hurt Workers

Health Outcomes

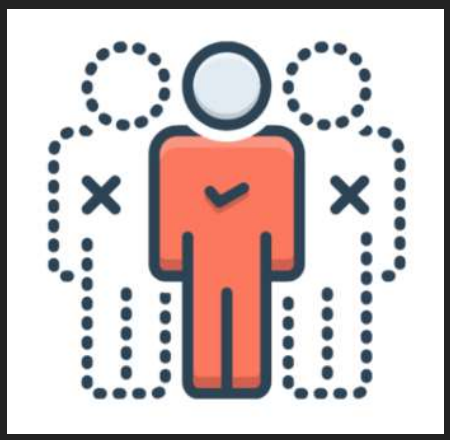
Welding Hazard Summary



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Metal Fume Fever

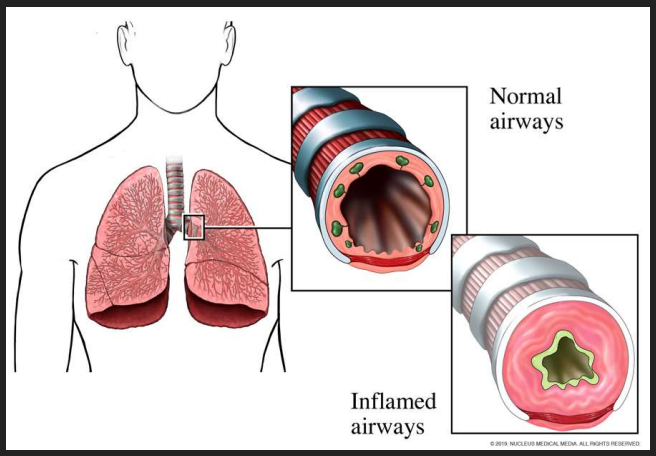
- Acute condition with flu-like symptoms
- Cough, fever, chills, chest pain and nausea
- Symptoms typically worsen with increased exposure (through the day and week) and improve the longer the welder is removed from exposure (end of a weekend)
- Typically goes away after exposure cease (24-48hrs)
- Presents as end of week absenteeism
- **Zinc, Copper, Manganese**



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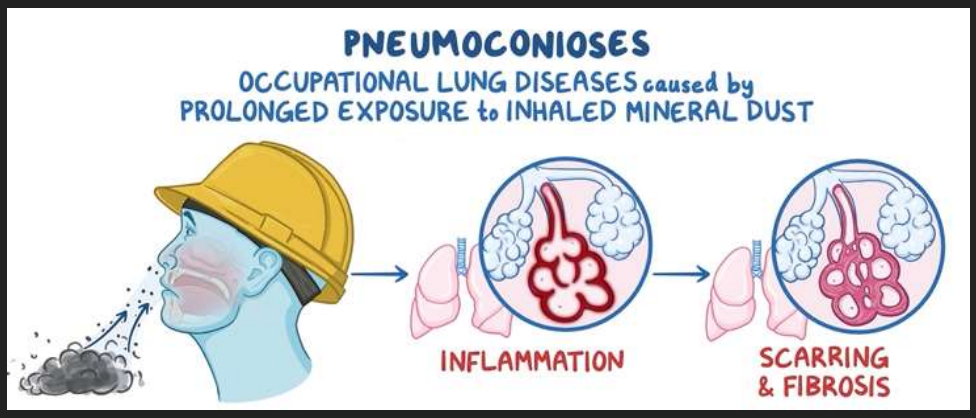
Asthma/Sensitization

- Typically takes weeks to months to form
- Asthma-like symptoms are triggered by extremely small exposure to sensitized agent
- Wheezing, coughing, shortness of breath
- **Nickel, Chromium, Vanadium, Beryllium**



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Pneumoconiosis

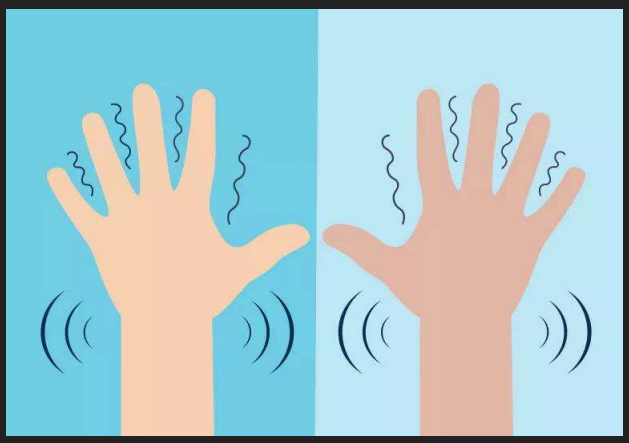


- Irreversible hardening / scarring of the lungs resulting in shortness of breath, dry cough, fatigue and weight loss
- **Aluminum, Iron, Tin**

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Central Nervous System

- Parkinson's like disorder
- Slowed visual reaction times
- Reduced hand-eye coordination
- Mood disorders
- Impaired ability to learn
- **Lead, Manganese, Aluminium**



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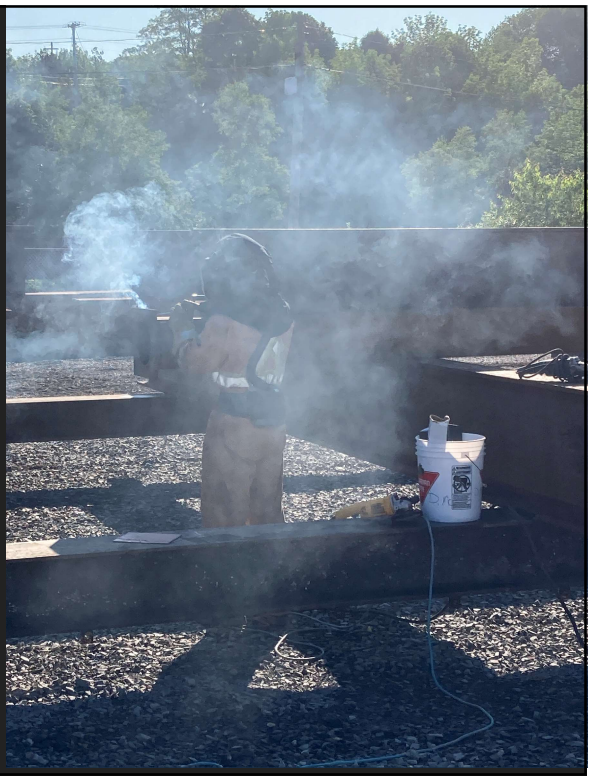
Cancer

- **Hex. Chrome** – Lung Cancer
- **Nickel** – Lung and Nasal Cancer
- **Cadmium** – Lung Cancer
- **Beryllium** – Lung Cancer
- **Welding Fume** – Lung Cancer (2017)
  - Iron Oxide?



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What's in the plume?



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Gases

Gas Type	Source
Acetylene	Fuel for cutting
Argon	Shield gas
Carbon Dioxide	Shield gas, decomposition of fluxes, combustion
Carbon Monoxide	Formed in the arc.
Fluorides	SMAW Fluxes
Nitrogen Oxides	Formed in the arc.
Oxygen Deficiency	Welding in confined spaces, and air displacement by shielding gas.
Ozone	Formed in the welding arc, especially during plasma-arc, MIG and TIG processes.

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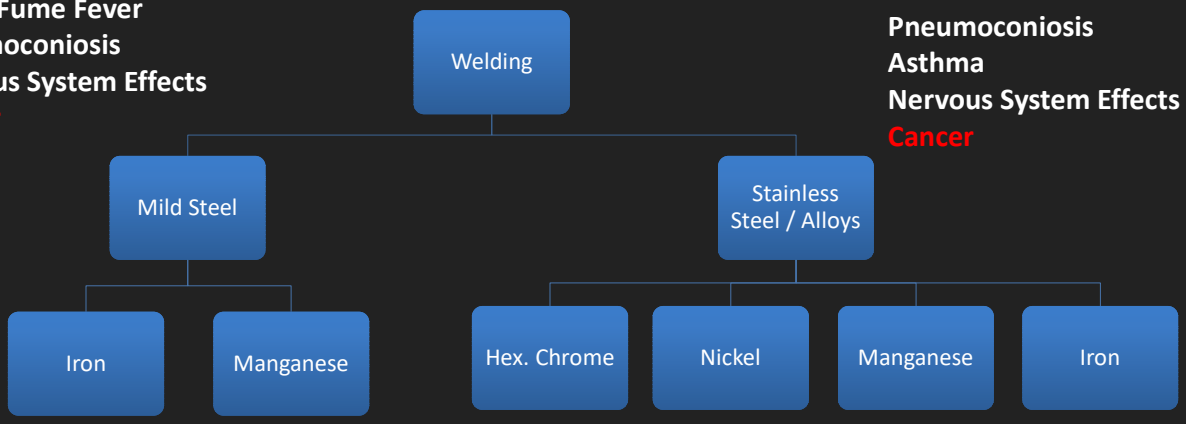
Fumes

Fume Type	Source
Aluminium	Alloys; Consumables
Chromium (6+)	Most stainless steel and high alloy materials, some aluminium; Consumables
Cobalt	High temperature applications and hard facing
Copper	Monel, brass, bronze; Consumables (arc gouging, filler wire coatings)
Iron Oxides	Major component of all iron or steel welding processes
Lead	Solder, brass, bronze alloys; Coatings; Consumables (arc gouging) <1% not on SDS
Manganese	Most welding processes (base metal and consumable)
Nickel	Stainless steel, some steel alloys (Inconel, Monel, Hastelloy);; Consumables
Vanadium	Iron, Stainless steel, some alloys; Contaminant inside heavy oil boilers
Zinc	Galvanized coating and paints

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Simplified Welding Hazard Overview

Metal Fume Fever
Pneumoconiosis
Nervous System Effects
Cancer



Metal Fume Fever
Pneumoconiosis
Asthma
Nervous System Effects
Cancer

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Reminder!



It’s NOT just mild steel

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3. Do I…



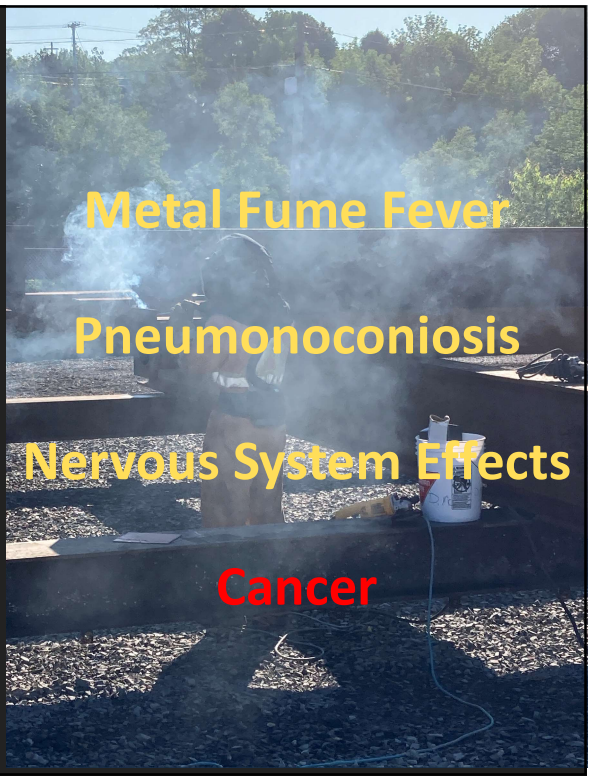
- Have a concern? YES
- Need to do something?
- Know I’ve done enough?

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Exposure Assessment

All welding is hazardous.

- Allows us to determine if we have a problem (risk vs compliance), if something needs to be done and if it was enough.
- Art/Science – nuance and context
- Qualitative or Quantitative
- Can be leveraged to understand risk and required controls for similar groups



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Measuring Stick (how much is too much?)



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PEI – ACGIH Threshold Limit Values

Hazard	8-hour TLV	10-hour adjusted TLV	12-hour adjusted TLV	Units
Aluminum	1	0.7	0.5	mg/m^3
Cadmium	0.01 0.002 (R)	0.007 0.0014	0.005 0.001	mg/m^3
Chromium (III)	0.5	0.35	0.25	mg/m^3
Chromium (VI)	0.0002	0.00014	0.0001	mg/m^3
Cobalt	0.02	0.014	0.01	mg/m^3
Copper, fume	0.2	0.14	0.5	mg/m^3
Iron Oxide	5 (R)	3.5	2.5	mg/m^3
Lead, Inorganic	0.05	0.035	0.025	mg/m^3
Manganese	0.02 (R) 0.1 (I)	0.014 (R) 0.07 (I)	0.01 (R) 0.05 (I)	mg/m^3
Nickel, inorganic	0.2 (I)	0.14	0.1	mg/m^3
Vanadium	0.05 (I)	0.035	0.025	mg/m^3
Zinc Oxide	2 (R)	1.4	1	mg/m^3
Welding Fume	N/a	N/a	N/a	N/a

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Welding Fume Exposure Risk Factors



SIMILAR EXPOSURE GROUPS

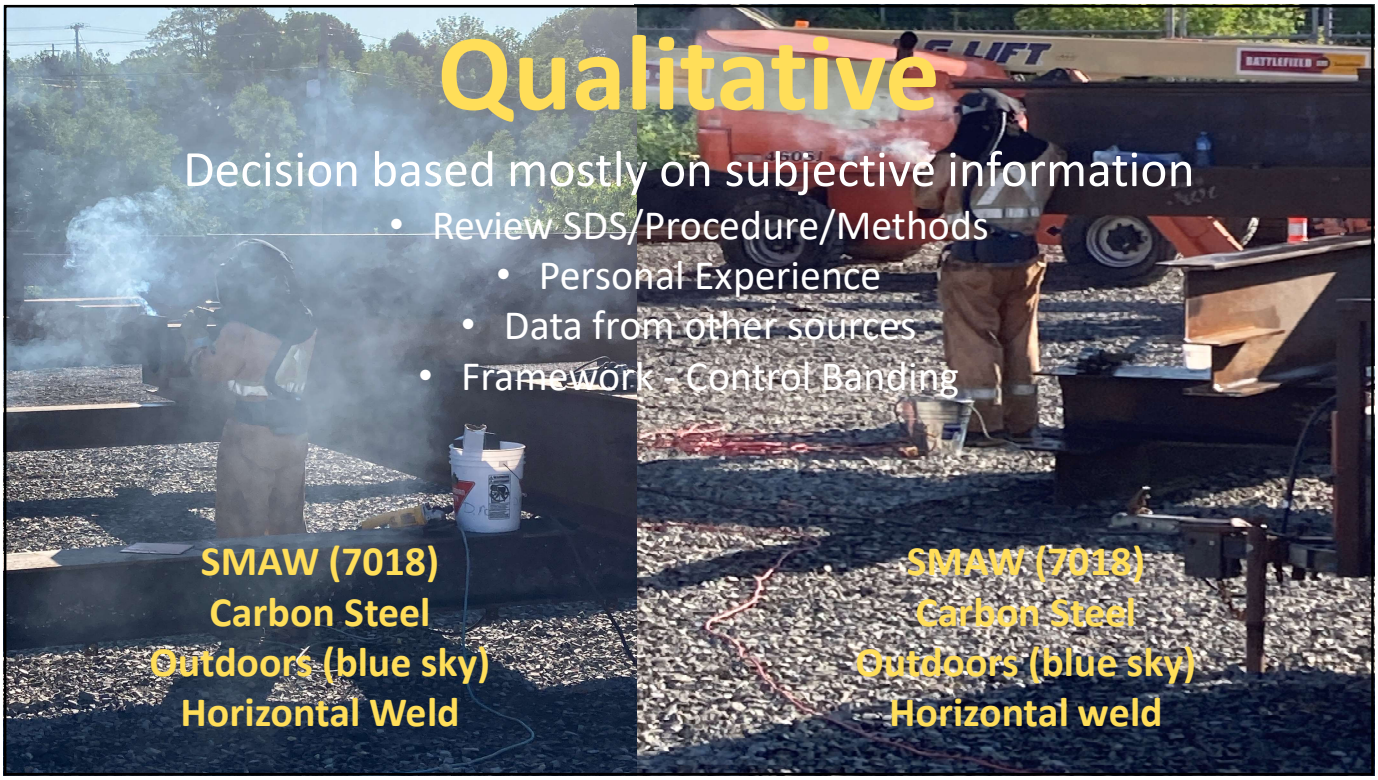
TLVs (Measuring Stick)

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Welding Exposure Assessment

- The hot work/weld process
- Base metal
- Consumables
  - Length, diameter, coatings
- Shift/Task Duration
- Dispersion/Environmental Factors
  - Work environment
  - Ventilation
  - Space configuration and size
- Respirator (APF)
- Current, voltage, wire feed speed
- Shielding gas composition
- Workpiece/weld orientation
  - Flat, horizontal, vertical, overhead
- Welder position
  - Body/head/welding hood position relative to plume

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Qualitative

Frequency and Duration of Welding	Type of Welding	Good Control Practice
Infrequent or occasional low intensity welding < 1 hour of arc time/welder/day	OFW, SMAW, FCAW, GMAW	LEV where practical or good general ventilation plus RPE
Infrequent or occasional low intensity welding < 1 hour of arc time/welder/day	TIG and Resistance Spot Welding	General ventilation
Regular high intensity welding > 1 hour of arc time/welder/day indoors	OFW, SMAW, FCAW, GMAW	Enclosure plus RPE Eng Control plus RPE LEV plus RPE
Regular high intensity welding >1 hour per day of arc time outdoors	OFW, SMAW, FCAW, GMAW, TIG	RPE where LEV is not practical
Regular high intensity welding >1 hour of arc time/welder/day indoors	TIG and Resistance Spot Welding	LEV plus RPE

SMAW (7018)
Carbon Steel
Outdoors (blue sky)
Horizontal Weld

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Quantitative

Decision based mostly on data

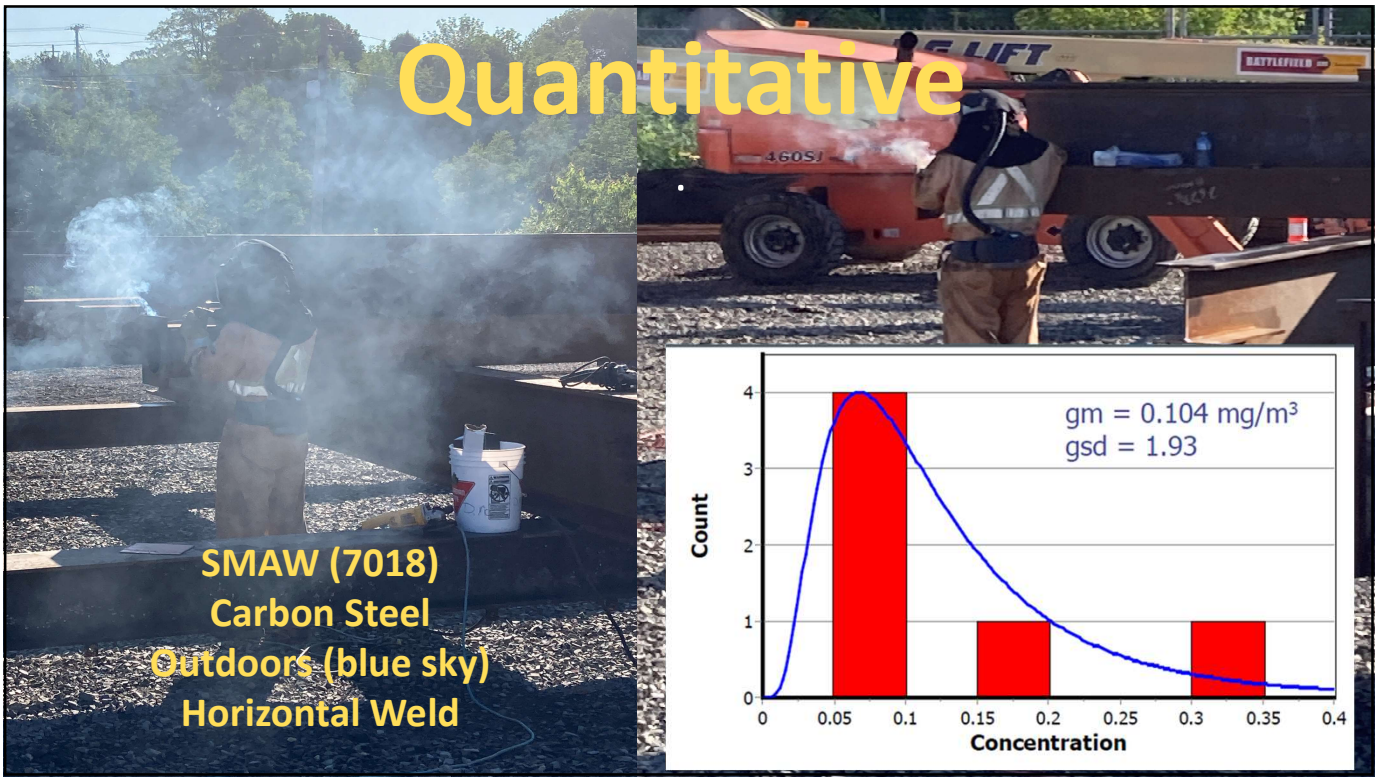
- Review SDS/Procedure/Methods
- Personal Experience
- Accurate and representative Data
- Statistical Analysis and Interpretation e.g. Bayesian Stats

SMAW (7018)
Carbon Steel
Outdoors (blue sky)
Horizontal Weld

SMAW (7018)
Carbon Steel
Outdoors (blue sky)
Horizontal weld

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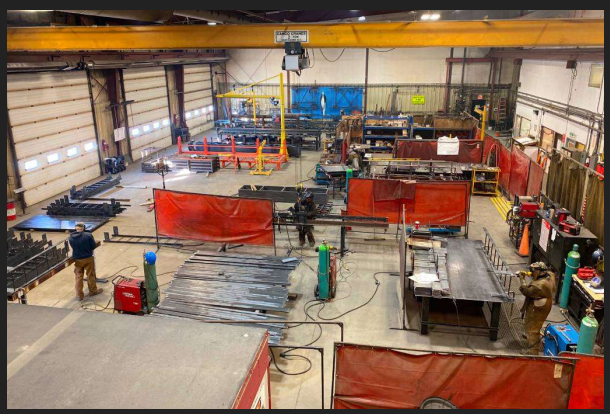
Quantitative



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Realistic Exposure Assessment

- **Fabrication / Assembly**
  - Easier to get quality data
  - Data more likely to be predictive
  - **Consider Data First Route**



- **Maintenance / Repair**
  - Hard to get good quality data
  - Data may not be predictive
  - **Consider Protect First Route**



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Exposure Assessment Thoughts

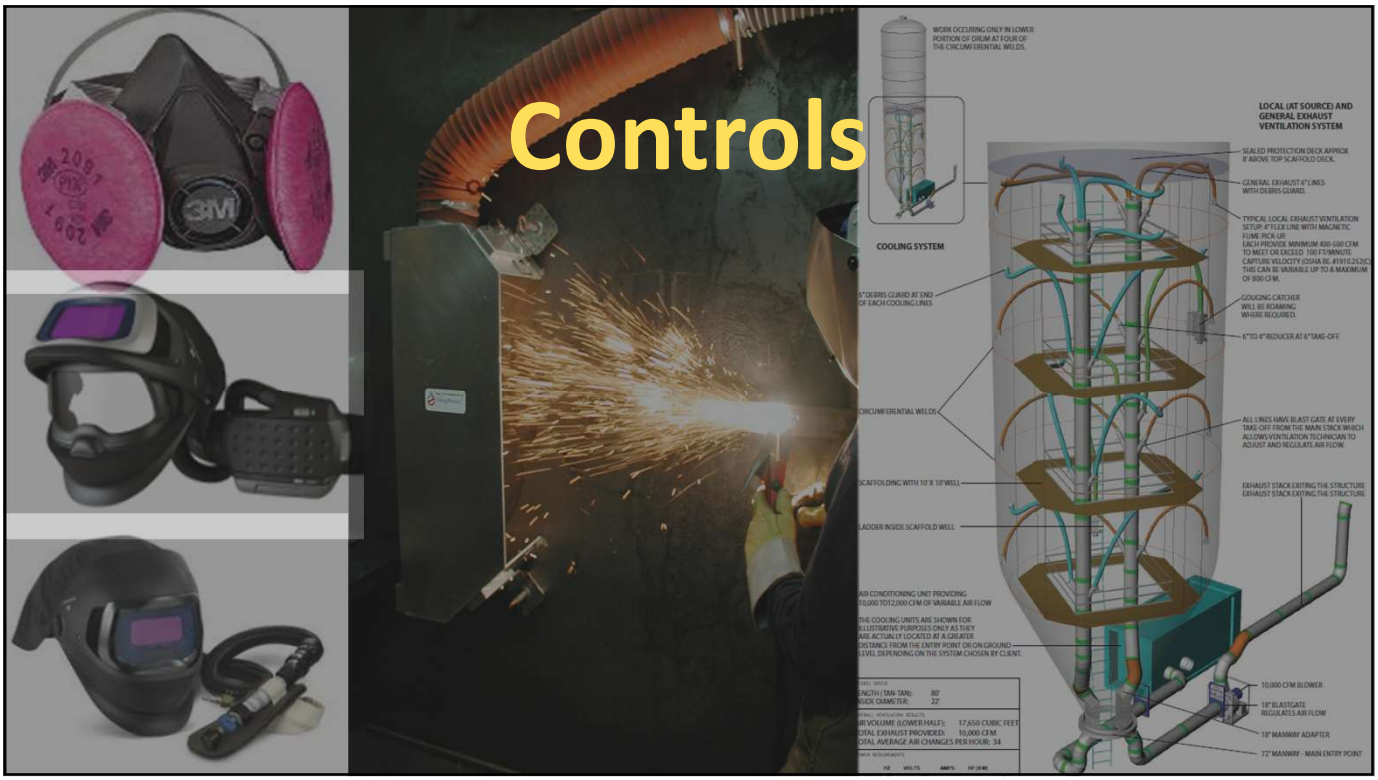
- Quantitative Exposure Assessment is the GOLD STANDARD
- Done well, it can provide statistically validated answers to most questions (CYB)
- It can be expensive, time consuming and results can lag exposure by days/weeks.
- Most exposure assessments are done with ZERO data. Think about how you can support your decisions
- If you pursue quantitative assessments, hire a professional who has experience with welding fume.
  - CIH, ROH, Trusted Consultant
- Protect first, validate after.

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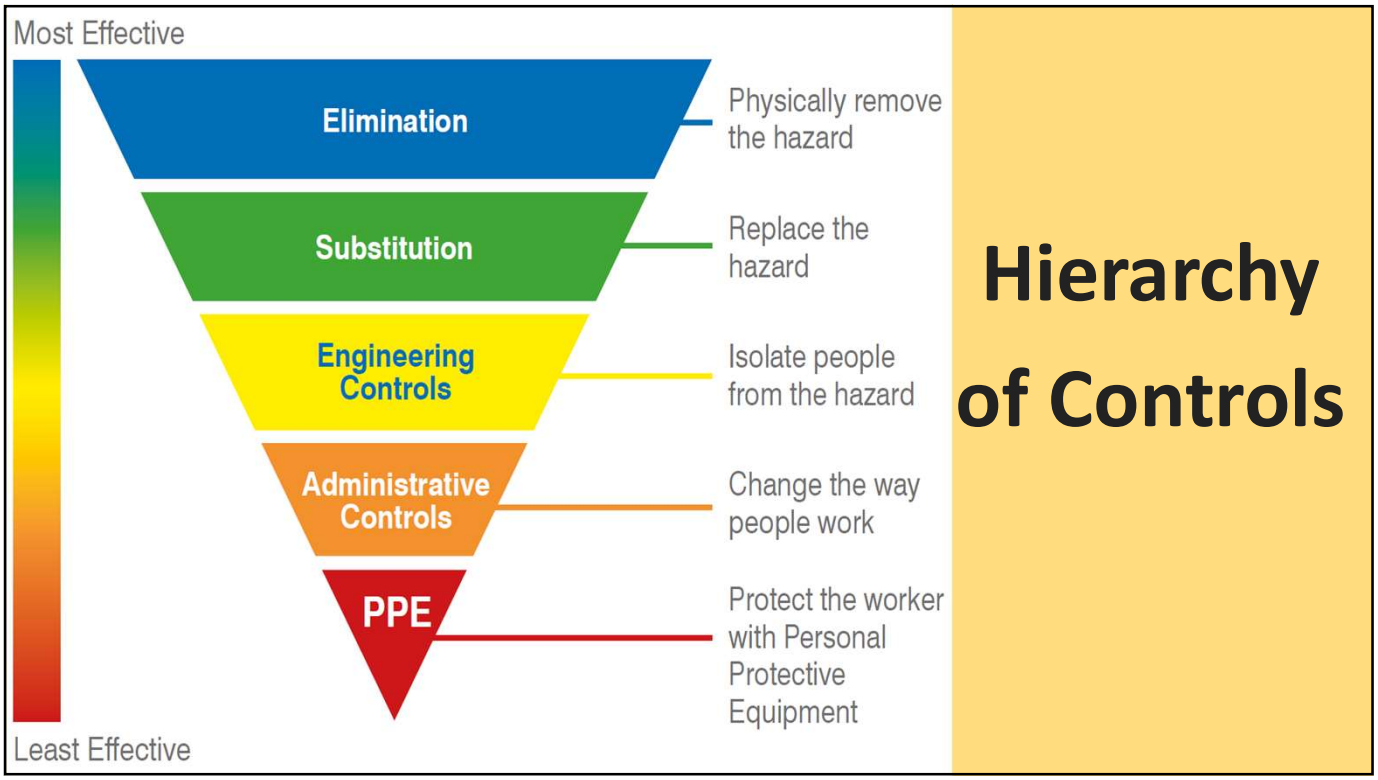
3. Do I….



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Controls
LOCAL (AT SOURCE) AND GENERAL EXHAUST VENTILATION SYSTEM
COOLING SYSTEM

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Most Effective
Elimination
Physically remove the hazard
Substitution
Replace the hazard
Engineering Controls
Isolate people from the hazard
Administrative Controls
Change the way people work
PPE
Protect the worker with Personal Protective Equipment
Least Effective
Hierarchy of Controls

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Engineering Controls

Purposes

- Remove air contaminants from a worker's breathing zone and work area
- Prevent the accumulation of flammable/combustible gases/vapours
- Prevent oxygen rich/deficient atmospheres

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Engineering Controls

Challenges

- Cost and technical feasibility
- Set up and management
- Adaptability/logistics during changing work conditions
- Relevant/understanding of occupational health in pre-planning
- Poor (non-existent) exposure control plan

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Engineering Controls



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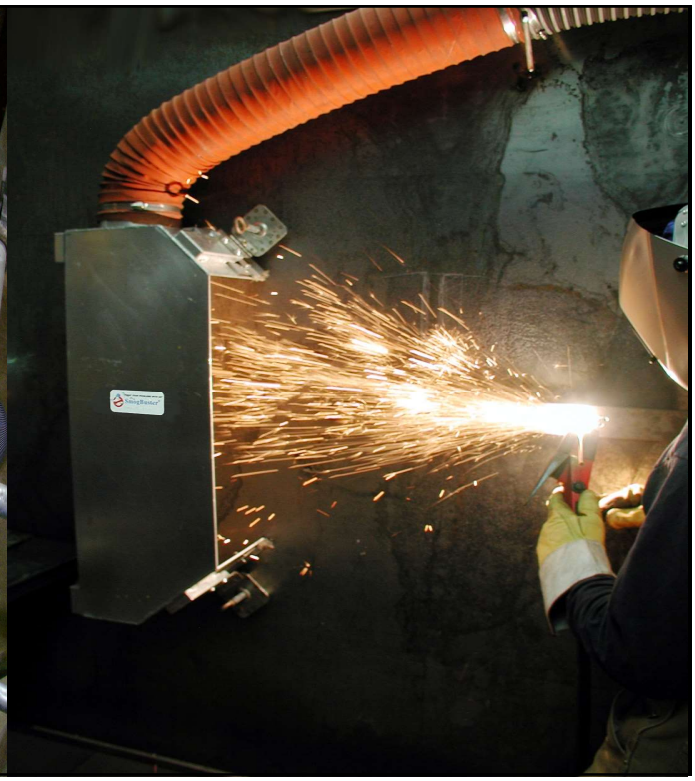
Engineering Controls



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Engineering Controls





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Engineering Controls - Challenges





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It doesn't matter how good your LEV is if you don't use it properly

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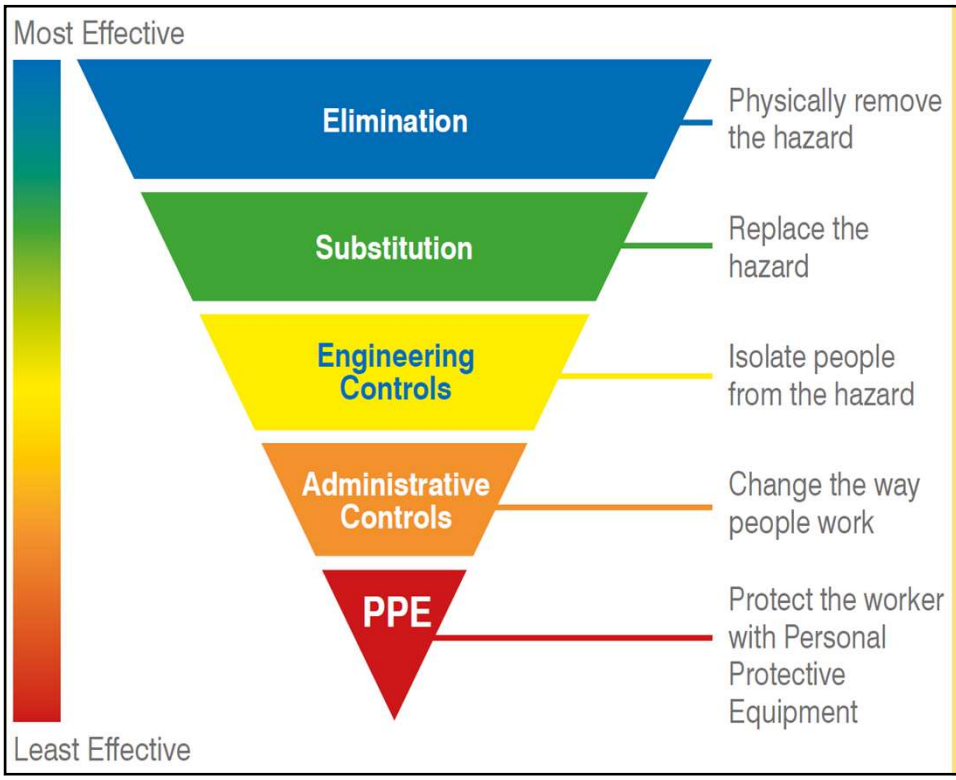
One (1) Diameter Away

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One and a Half (1.5) Diameter Away

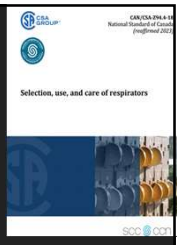
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Hierarchy of Controls

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Respirators



- Different respirators offer different levels of protection (CSA Z94.4)



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Half Face



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Loose Fitting
PAPR or SAR



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Full-face
(Quantitative Fit Test)



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Hoods, Helmets and Full Faces – PAPR or SAR

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3. Do I….



- Have a concern? YES
- Need to do something? YES
- Know I've done enough???

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Welding Fume as a Carcinogen

- No Welding Fume specific TLV
- Metal specific TLVs that do not reflect current science (e.g. Iron Oxide)
- This gap will exist for years until science catches up.
- In the meantime
  - welding remains critical work
  - welders remain high skilled workers
  - Welders continue to be exposed to significant health hazards
- What do we do?

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Welding Fume as a Carcinogen

- **NIOSH recommended OEL for carcinogens not otherwise addressed**
  - 0.01 mg/m3
  - Would apply to all welding fume, but still have specific metals for which carcinogenicity is addressed and TLVs are lower…?
- **Mixtures Formula**
  - Accepted practice but does not address carcinogenicity
- **Control Banding – Protect first**
  - Level of protection conservative to account to ensure workers are protected

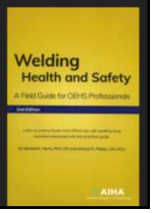
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Control Banding – Draft Recommendations

Frequency and Duration of Welding	Type of Welding	Good Control Practice
Infrequent or occasional low intensity welding < 1 hour of arc time/welder/day	OFW, SMAW, FCAW, GMAW	LEV where practical or good general ventilation plus RPE
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Regular high intensity welding >1 hour per day of arc time outdoors	OFW, SMAW, FCAW, GMAW, TIG	RPE where LEV is not practical
Regular high intensity welding >1 hour of arc time/welder/day indoors	TIG and Resistance Spot Welding	LEV plus RPE

Welding or Thermal Cutting Process	Welder and Helper	Bystander or Co-worker
High Fume	 PAPR plus cape, HEPA filter	 Half-face, air-purifying respirator plus P100
Low Fume (GTAW/TIG, SAW, RW)	 Half-face, air-purifying respirator plus P100	 N95, air-purifying respirator

Table 1. Chart showing PPE control strategies for welding fumes.



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Key Takeaways:

- All welding has the potential to cause serious health effects such as cancer
  - Its NOT just mild steel
- All welding requires control.
- Respiratory protection should be the norm.
- Due to variability and lack of predictability - consider controlling first, assessing later

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Resources

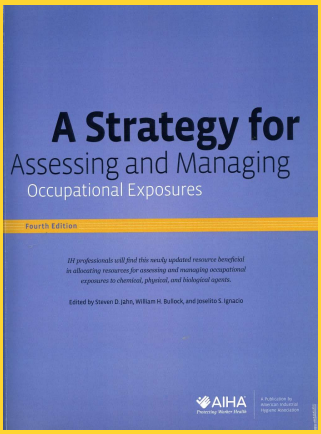


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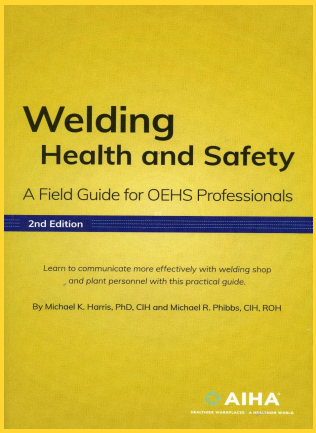
WELDING HEALTH & SAFETY RESOURCES



AIHA CONTROL BANDING GUIDE



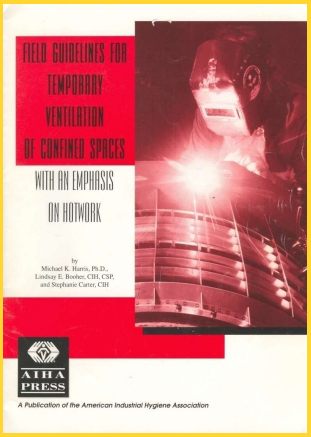
AIHA SEG GUIDE



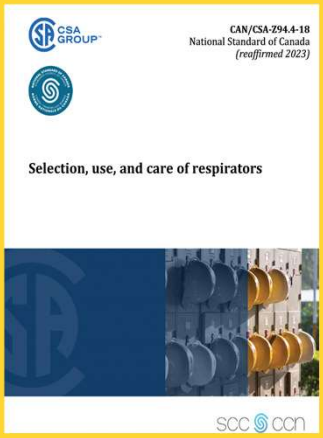
AIHA

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WELDING HEALTH & SAFETY RESOURCES



AIHA VENTILATION GUIDE



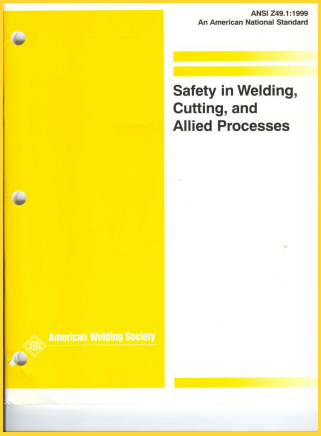
CSA Z94.4



CSA W117.2

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WELDING HEALTH & SAFETY RESOURCES



AWS/ANSI Z49.1.2021



AWS WELDING JOURNAL



CWB Journal

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QUESTIONS?
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