STI/SPFA

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Cr(VI) Update:
Considerations for Feasible Engineering Controls

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Feasible Engineering and Work Practice Controls

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- Welding process
- Enclosures and/or mechanized equipment
- Relative welding positions
- Substituting consumable materials
- Local exhaust ventilation (LEV)

Relative Fume Generation Rates of Common Processes

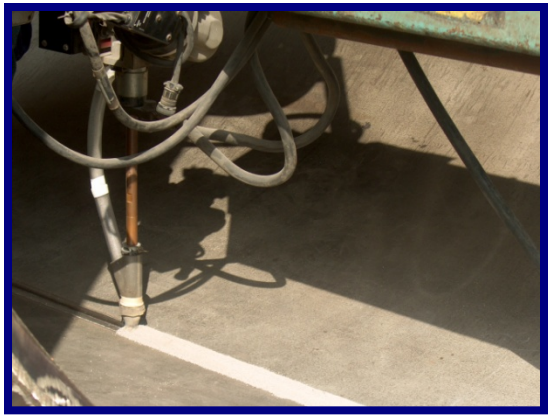
FCAW *(High)*

SMAW *(High)*

Arc Gouging *(High)*

GMAW *(Moderate)*

GTAW *(Low)*



SAW *(Low)*

Common Welding Processes

	SMAW	GMAW	FCAW	GTAW	SAW
FGR	High	Moderate	High	Low	Low
Cost	Low	High	High	Low	High
Portability	High	Moderate	Moderate	High	Low
Welding Speed	Moderate	High	High	Low	High
Deposition Rate	Moderate	Moderate	High	Low	High

	SMAW	GMAW	FCAW	GTAW	SAW
Shielding	Coated electrodes	Ext. shielding gas	Flux-core wire & ext. shielding	Ext. shielding gas	Granular flux
Slag Covering	Yes	No	Yes	No	Yes
Welding Position	All	All	All	All	Down-flat & horizontal
Mechanized or Auto. Modes	No	Available	Available	Not common	Auto. (Typ.)

Welding Speed

- Significant exposure factor
- Not consistently captured in precise manner, if at all
- When estimated, arc-on % is typically over-estimated

Arc Timer

Pulsed Power GMAW

- 24% reduction in total weld fumes air sampling results for pulsed GMAW for mild steel.
- Metal fume constituents from conventional GMAW were higher than pulsed GMAW.

(Wallace et al., 2001)

Pulsed power welding is only viable option for GMAW operations.

Mechanized Welding

- Increases operator's breathing zone from welding zone
- Increases welding rate, thus, increases FGR
- Multitude of variations and applications
- May not be practical in many situations due to setup time and cost of equipment

Horizontal FCAW, Carbon Steel (E71T Wire)				
Measures	Manual FCAW (No LEV)		Mechanized FCAW (No LEV)	
	PNOS	Mn	PNOS	Mn
Samples (n)	9	9	3	3
Max	8.8	0.22	11.0	0.85
Max/PEL	1.8	1.1	2.2	4.25
Median	3.1	0.09	9.4	0.53
% > PEL	33.3%	22.2%	100%	66.7%
$UCL_{1,95\%}$ AM	7.9 mg/m^3	0.3 mg/m^3	NE	NE

Welding vertical seams, FCAW (15-22% Cr)		
Measures	Manual FCAW vert. seams of inner tank in annular space	Mechanized vertical welding (FCAW)
Samples (n)	6	4
Max.	2.5 μg/m^3	0.98 μg/m^3
Max./PEL	0.5	0.2
Median	0.78	0.5
% > PEL	0.0%	0.0%
$UCL_{1,95\%}$ AM	3.14 μg/m^3	1.69 μg/m^3

Mechanized and Manual FCAW

Mechanized FCAW

Manual FCAW

Welding Positions

Position of workpiece relative to body (e.g., breathing zone, hands, etc.)

Down-flat or Down-hand
Highest Exposure

Vertical
Lowest Exposure

Welding Positions

Difference between vertical and horizontal position is travel path.

Horizontal
High Exposure

Overhead
High/Low Exposure

Exposure largely depends on airflow patterns. Vertical welding affected least by airflow patterns.

Horizontal and vertical welding inside annular space (No LEV) SMAW (15-40% Cr) and FCAW (15-22% Cr)		
Measures	**Horizontal**	**Vertical**
Samples (n)	12	6
Max.	38.0 μg/m^3	2.5 μg/m^3
Max./PEL	7.6	0.5
Median	4.45	0.78
% > PEL	41.7%	0.0%
$UCL_{1,95\%}$ AM	36.6 μg/m^3	3.14 μg/m^3

Substituting Consumables

- 90-95% of the fume is from the electrode
- “Low fume” consumables
  - No AWS definition
  - More research needed
- Development of Cr-free consumables for SS welding
  - Not currently available
- Composition of the flux can be a factor in stabilizing Cr(VI)
  - More significant factor in coated electrodes (SMAW)

A Systems Approach

OSHA believes that 60% of current SS SMAW operations may need to switch to GMAW as the cheapest and most effective method to reduce Cr(VI) exposures. *[OSHA Preamble to Cr(VI) Final Rule, 2006]*

Reducing fume exposure by changing welding processes should certainly be considered. But local exhaust ventilation (LEV) tends to be the primary method for fume control.

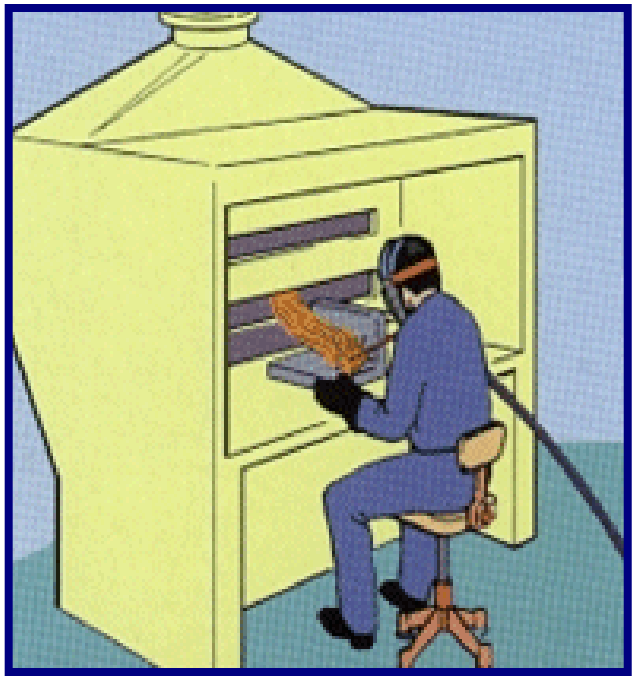
Implementing LEV tends to have far fewer constraints than controlling fume exposure by welding process changes.

In many cases, changing welding processes alone will not reduce exposures below the PEL. However, there are also challenges with implementing LEV.

Types of Ventilation

- LEV
  - Captures at source (preferred)
- General/Dilution
  - Does not capture at source
  - Unpredictable plume travel path
  - May cause opposing air currents to limit effectiveness of LEV or other unfavorable airflow patterns
  - More likely to affect shielding gas

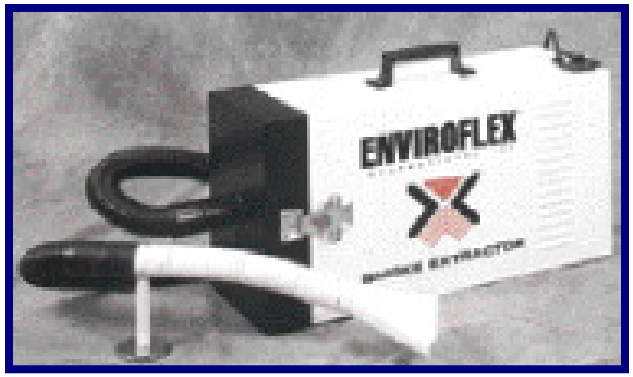
Fixed Systems



- Initial setup cost is relatively high.
- Object being welded may obstruct airflow.
- Backdraft welding booths limited to welding small parts.

Portable/Mobile Units

- Requires welder to make frequent adjustments to exhaust hood
- Available with or without air cleaner (e.g., filtering system)
- Typically equipped with flexible ducts
- Bends in ducts and long duct runs reduce airflow



Fume Extraction Guns

- Limited to GMAW and FCAW
- Could create ergonomic issues
- Welding in positions other than horizontal reduces capture efficiency
- Position of exhaust collar affects capture efficiency
- Exhaust rate must be fine tuned for each fit-up
- Does not control residual fumes

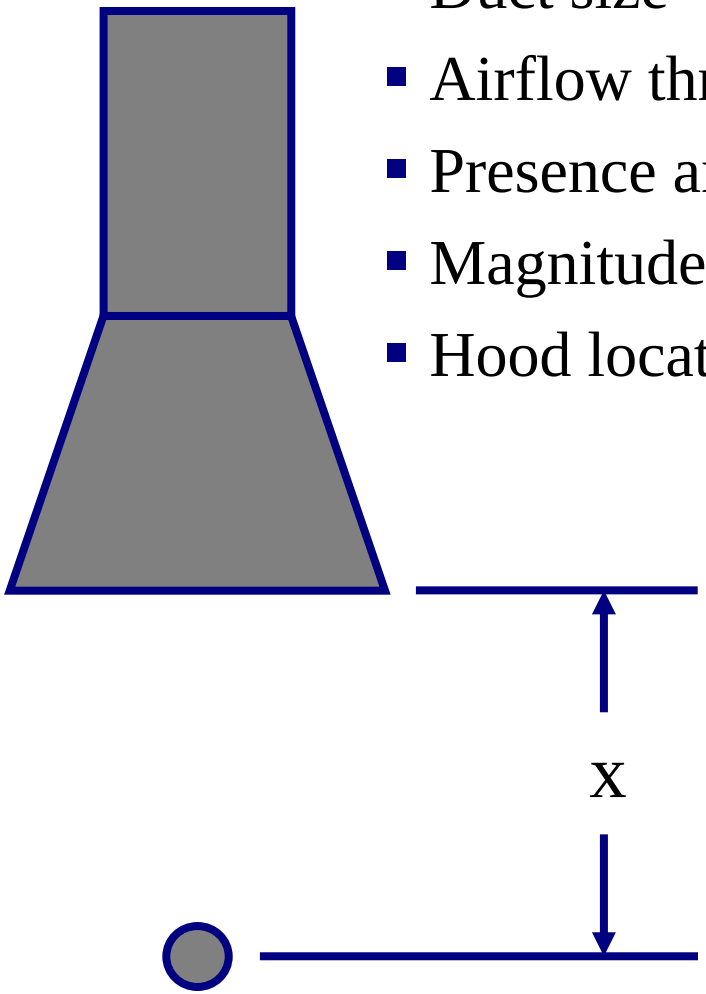
Capture Velocity

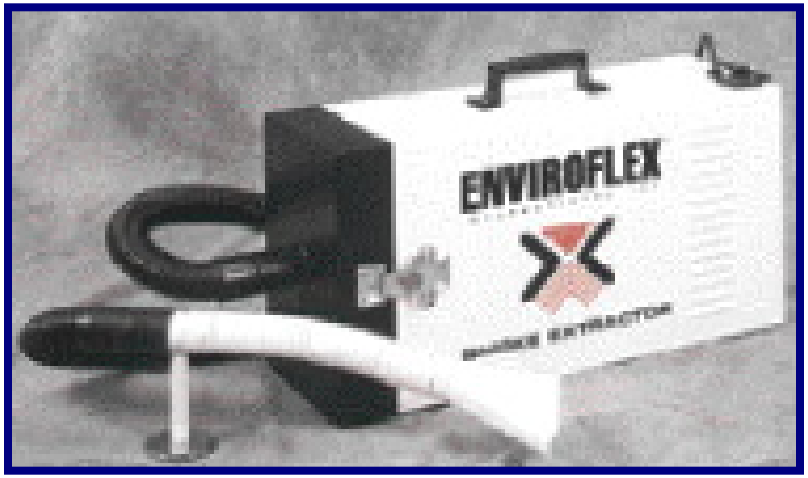
Velocity necessary to overcome opposing air currents to allow the welding fumes to be captured

Capture Velocity

- For welding fumes, between 100 to 200 fpm *(ACGIH)*
- Hood within 12 inches
  - May need to be within a few inches from welding zone
  - 1 ½ duct dia. (Rule of Thumb)

- Maximum acceptable distance is dependent on:
  - Duct size
  - Airflow through the duct/hood
  - Presence and type of hood
  - Magnitude and direction of other air currents
  - Hood location in relation to natural plume travel





Typical Airflow Rates and Capture Distances

High vacuum Low volume

High volume Low vacuum

Q (cfm)	Duct Diam. (in.)	Capture Distance (in.)	Weld Length Before Repositioning (in.)
50	1 ½ – 2	2 – 3	4 – 6 for duct 8 – 12 with flange
160	3	5 – 6	9 – 12
500 – 600	4 – 6	6 – 9	12 – 18
800 – 1000	6 – 8	9 – 12	18 – 24

Reference: Reduction of worker exposure and environmental release of welding emissions. NSRP report, EWI, 2003.

Welding Inner Bottom (9% Ni.) (LNG Tank Construction)

SMAW (15-40% Cr) and FCAW (15-22% Cr) annular plates inside inner tank		
Measures	**No LEV**	**LEV**
Samples (n)	32	29
Max.	91 μg/m^3	110 μg/m^3
Max./PEL	18.2	22.0
Median	15.0	8.4
% > PEL	65.6%	58.6%
$UCL_{1,95\%}$ AM	NE	53.4 μg/m^3

Horizontal welding TCP plates SMAW (15-40% Cr) and FCAW (15-22% Cr)		
Measures	**No LEV**	**LEV**
Samples (n)	12	7
Max.	38.0 μg/m^3	31.3 μg/m^3
Max./PEL	7.6	6.3
Median	4.45	9.8
% > PEL	41.7%	85.7%
UCL$_{1,95\%}$ AM	36.6 μg/m^3	22.8 μg/m^3

Practical Considerations

- Minimize airflow losses:
  - Keep duct runs as short as possible
  - Use smooth ducting and avoid sharp bends or elbows
  - Avoid use of plain hoods (especially with small duct diameters)
  - Perform frequent maintenance of filters or air cleaners

Practical Considerations

- Assess/control opposing air currents:
  - Limited LEV effectiveness outdoors or even semi-enclosed areas
  - Shield welding zone from opposing air currents
  - Locate capture hood in plume's natural path of travel, where possible

Providing LEV units is not enough

- Establish and enforce LEV policies and procedures
- Train welders and supervisors
- Check airflow and capture velocities periodically

OSHA Inspections

- General Industry Inspections (Federal OSHA, 10/07-9/08)
  - 127 Cr(VI) inspections, 295 citations, $172,770 in penalties (42% fabricated metal products)
- Construction Inspections (Federal OSHA, 10/07-9/08)
  - 3 Cr(VI) inspections, 11 citations, $10,800 in penalties (90% special trade contractors)
- More emphasis on enforcement and less on voluntary compliance
  - OSHA plans to hire 150 new inspectors
  - Increase number of annual inspections from 38,000 to 44,000

Additional References Available

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