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Hexavalent Chromium: Considerations for Feasible Engineering Controls

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Overview

- Feasible Engineering Controls
- Case Study
  - LNG Tank Construction
- Considerations for Local Exhaust Ventilation (LEV)

Welders represent nearly half of the workers covered by OSHA's final rule.

Alloys of stainless steel and chromium typically contain between 11.5% and 30% chromium.

Chromium-Containing Steels

- SS has valence state of zero.
  - Does not contain Cr(VI)

However:

- When heated at lower temperatures, Cr(III) oxides are formed.
- When heated at temperatures beginning at 1750 F in presence of water vapor, Cr(VI) gas is formed.
- At melting temperatures, Cr(VI) oxides are formed.

Chromium-Containing Steels

Composition of welding fumes depends largely on:

- Welding process
- Filler material used (major source)

FCAW

SMAW

GTAW

GMAW

Relative Fume Generation Rates of Common Processes

FCAW *(High)*

SMAW *(High)*

Arc Gouging *(High)*

GMAW *(Moderate)*

GTAW *(Low)*

SAW *(Low)*

Exposure Factors

1. Welding process
2. Amount of chromium in consumable/base metal
3. Chromate coatings on base material
4. Welding rate
5. Relative welding position
6. Use of local exhaust ventilation
7. Welding area (inside or enclosed space)
8. Other welding activities in area
9. General ventilation and natural air currents

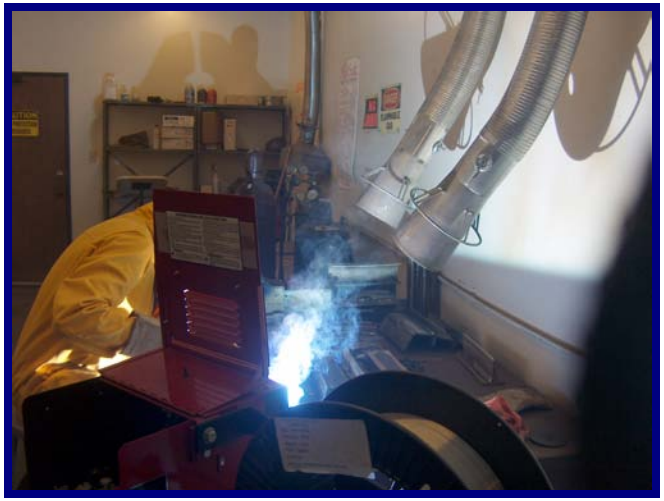
Feasible Engineering Controls

Effective: May 31, 2010

- Substitution
- Welding process
- Enclosures and/or mechanized equipment
- Pulsed arc welding
  - *GMAW only*
- Low fume consumables
  - *No AWS definition*
- Local exhaust ventilation (LEV)

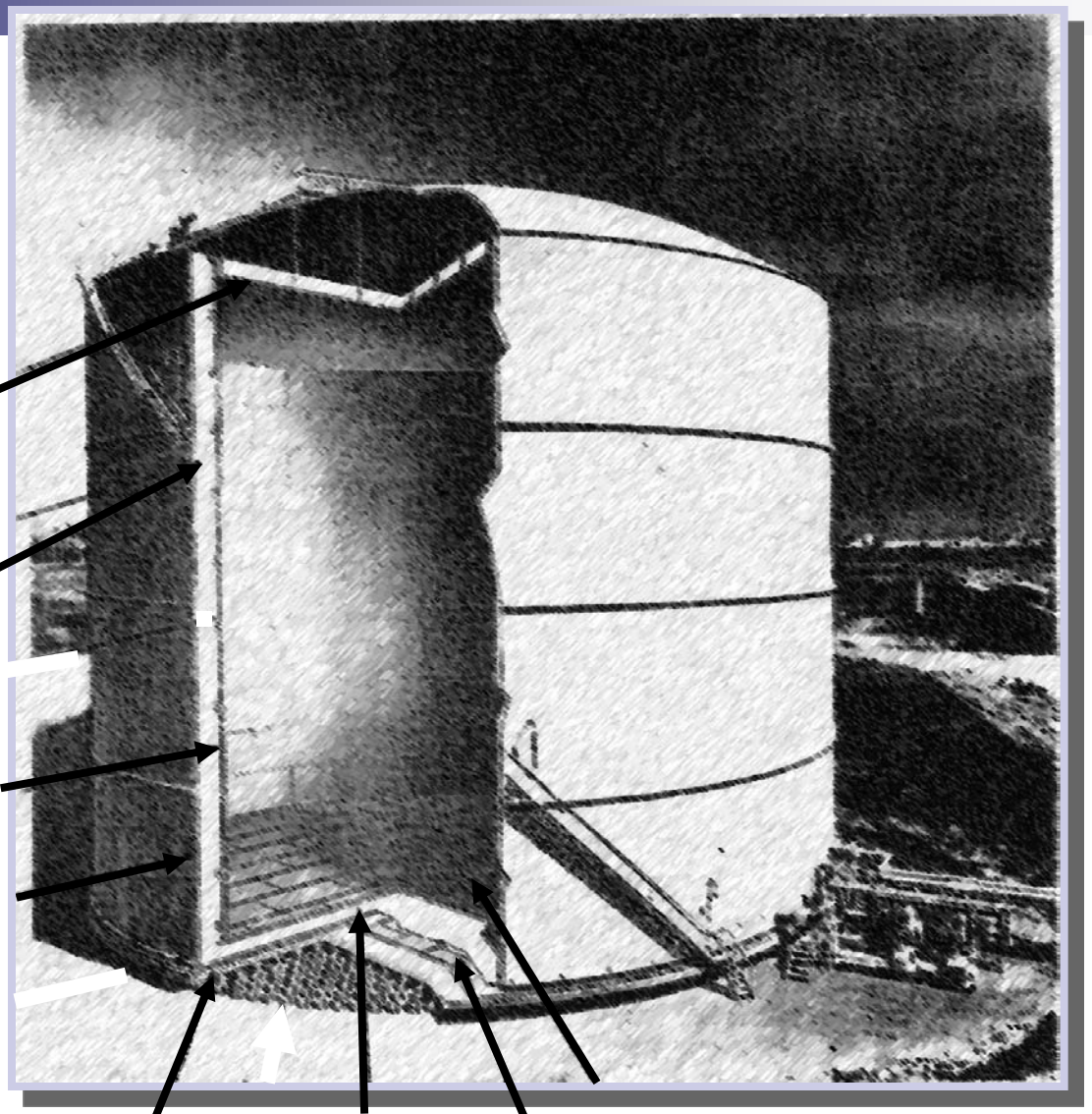
Welding fumes are greatly influenced by air currents.

LEV will not significantly reduce exposures when strong opposing air currents are present.



Case Study
Cr(VI) Exposure Assessments

- LNG Tank Construction Job Site (Texas)
  - Five full containment (double-wall) tanks
  - Outer tank (carbon steel, ~252 feet in dia.)
  - Inner tank (9% nickel and 20-23% Cr)
- 125 TWA Air Samples
- December 2007 to June 2008


Suspended Deck
Perlite Insulation
Inner Tank
Outer Tank
Foundation
Insulation
Inner Bottom
Outer Bottom

Scope of Cr(VI) Exposure Assessments

- Similar Exposure Groups (SEGs)
  - Welding bottom annular plates (LEV and no LEV)
  - Area perimeter sampling (annular plate welding)
  - Welding vertical seams (manual and mechanized)
  - Mechanized SAW girth seams
  - Manual FCAW girth seams
  - GTAW stainless steel pipe
  - Welding TCP plates to outer shell in annular space
  - Mixed processes (not categorized)

Limitations

- Sampled behind hood
  - Not kept fully behind hood in all cases
- SEGs only separated by predominate activity
  - No sequential sampling
- Arc time not consistently captured

Arc Timer

Welding Inner Bottom

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

Mechanized and Manual FCAW

Mechanized FCAW

Manual FCAW

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%
UCL$_{1,95\%}$ AM	3.14 μg/m^3	1.69 μg/m^3

Mechanized girth seam welding, SAW (16% Cr)		
Measures	**Annular Space Side**	**Inner Tank Side**
Samples (n)	1	3
Max.	18.0 μg/m^3	1.7 μg/m^3
Max./PEL	3.6	0.3
Median	N/A	0.84
% > PEL	100%	0%
UCL$_{1,95\%}$ AM	NE	NE

Horizontal FCAW

Measures	Manual FCAW (15-22% Cr) girth seams, LEV used	GTAW Stainless Steel Pipe
Samples (n)	4	4
Max.	53.0 μg/m^3	0.12 μg/m^3
Max./PEL	10.6	0.02
Median	22.0	0.09
% > PEL	100%	0%
$UCL_{1,95\%}$ AM	NE	NE

Welding TCP Plates

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

Conclusions and Generalizations

- LEV reduced variability but often did not reduce exposures below PEL.
- LEV during bottom welding resulted in less variability but $UCL_{1,95\%}$ of AM still >10x PEL.
- Manual horizontal welding is typically >PEL and has the potential to be >10x PEL.
- Vertical welding is typically <PEL.

Conclusions and Generalizations

- Mechanized SAW is expected <PEL but operator's helper on annular space side (and others in annular space) may be >PEL depending on proximity of other welding activities.
- GTAW typically below Action Limit.
- Diligent maintenance of LEV equipment and enforcement of proper use is required.

Portable/Mobile Units

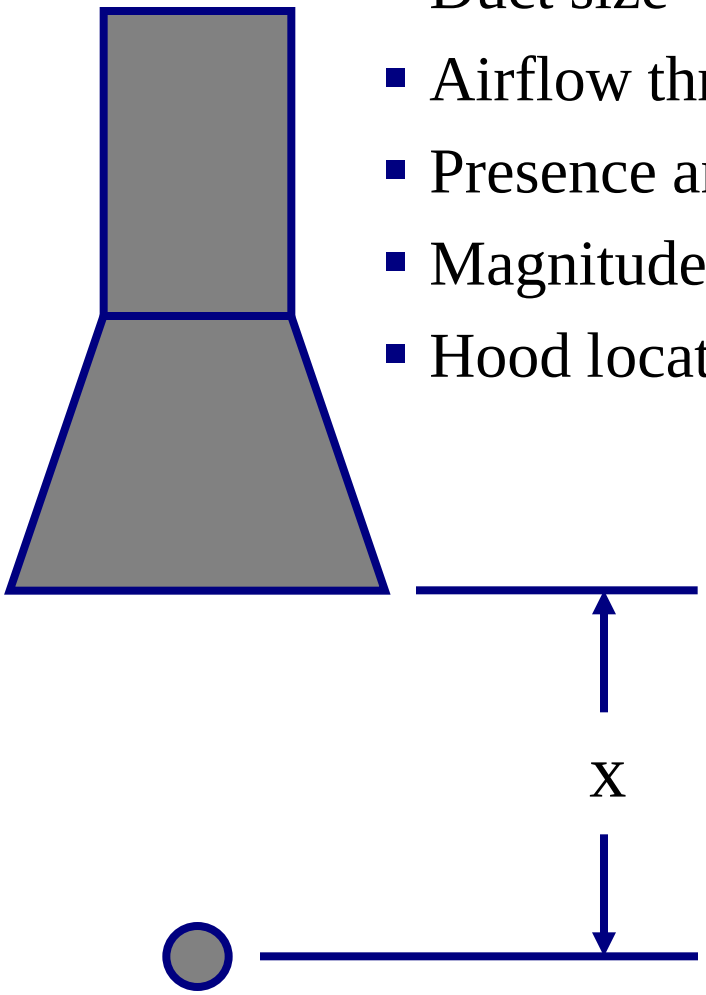
- Requires welder to make frequent adjustments to exhaust hood
- Available with or without air cleaner (e.g., filtering system)
- Typically equipped with flexible ducts
- Bends in ducts and long duct runs reduce airflow

Capture Velocity

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

- For welding fumes, between 100 to 200 fpm *(ACGIH)*
- Hood within 12 inches
  - May need to be within a few inches from welding zone

- 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.

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

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