Metals Madness

Keep Your Sanity by Understanding Worker Exposures

Eric Pylkas, CIH, CSP, CHMM - Insight IH Consulting LLC
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Introduction

The intent of this presentation is to:

- Define the considerations in metals IH sampling
  - Exposure Limits
  - Sampling Methods
  - Data Interpretation
- Show examples of reasonably considered sampling scopes and the serious exposures that could be missed
- Provide information that attendees can consider when ensuring worker safety at their facilities.

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Introduction

The primary things that will be covered in this talk include the following:

- Methods, Limits, and Other Considerations
  - Exposure limits, size selective devices, fume/dust
- Metals with OSHA Standards
  - Arsenic, Beryllium, Cadmium, Hexavalent Chromium, Lead
- Other Metals of Interest
  - Manganese
- Case Studies
  - What was targeted, what were the results, what was missed
- Best Practices
  - Hints for setting a scope, reviewing old data

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Definitions - Exposure Limits

There are multiple organizations that publish exposure limits.

- Occupational Safety and Health Administration (OSHA)
  - Most limits were established in OSH Act of 1970
  - Update attempted 1988 (failed)
  - OSHA has since mostly focused on standard making.
  - Regulatory limits, so citations can be issued when violated.

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Definitions - Exposure Limits

There are multiple other organizations that publish exposure limits that are updated frequently.

- National Institute of Occupational Safety and Hygiene (NIOSH)
- American Conference of Governmental Industrial Hygienists (ACGIH)
- American Industrial Hygiene Association (AIHA)

These are recommended limits and are not regulatory (note that OSHA can enforce under the general duty clause)

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Definitions – Dust and Fume

Fumes are particles formed when a volatilized solid, such as a metal, condenses in cool air, often accompanied by a chemical reaction like oxidation, and are typically less than one micron in diameter.

- Dust samplers collect both fume and particles.
- The OSHA limits differ between fume and dust for some metals:
  - Copper – 1.0 mg/m^3 (dust), 0.1 mg/m^3 (fume)
  - Iron Oxide – No limit (dust), 10 mg/m^3 (fume)
  - Zinc Oxide – No limit (dust), 5 mg/m^3 (fume)
- Distinguishing between fume and particulate can be difficult.
- Many employees can create both dust and fume (welders)

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Definitions - Differing Particle Sizes

When discussing exposure limits for metals. OSHA, ACGIH, and other institutions may utilize different particulate fractions:

- Total Dust (OSHA)
- Respirable fraction (ACGIH)
  - 50% cut point at 4 microns
- Inhalable fraction (ACGIH)
  - 50% cut point at 100 microns

This shows that: Inhalable dust > total dust > respirable dust

Thus, a total dust sample would not show compliance to an inhalable dust limit, but if assumed to be a worst-case exposure it could show compliance with a respirable dust limit.

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Metals with OSHA Standards

Metals of Concern

Metals that exceed OSHA PELs require respiratory protection until controls reduce the exposures.

OSHA Standards have many additional requirements for exposures over the applicable limits:

- Quarterly air monitoring
- Written compliance plans
- Regulated areas
- Signage
- Medical Surveillance (Action Level)
- Employee notification
- Training

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OSHA Standard - Arsenic

Metals of Concern

OSHA Standard 1910.1018

- OSHA PEL (5 µg/m^3, 1/3000 the nuisance dust PEL)
- OSHA Action Level (2.5 µg/m^3, 1/6000 the dust PEL)
- Common Uses: wood preservative, metal alloys (particularly lead and copper), lead-acid batteries, semi-conductor manufacturing, pesticides, residual impurity in steel.

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OSHA Standard - Beryllium

Metals of Concern

OSHA Standard 1910.1024

- OSHA PEL (0.2 µg/m³, which is 1/75,000 the nuisance dust PEL)
- OSHA Action Level (0.1 µg/m³, which is 1/150,000 the dust PEL)
- Common Uses: fly ash, metal alloys (most often with copper, aluminum, magnesium, or nickel), die casting, non-sparking tools, electronics

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OSHA Standard - Cadmium

Metals of Concern

OSHA Standard 1910.1027

- OSHA PEL (5 µg/m³, 1/3000 the nuisance dust PEL)
- OSHA Action Level (2.5 µg/m³, 1/6000 the dust PEL)
- Common Uses: nickel-cadmium rechargeable batteries, corrosion-resistant coating for metals, plastic stabilizers, solar panels

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OSHA Standard - Hexavalent Chromium

Metals of Concern

OSHA Standard 1910.1026

- OSHA PEL (5 µg/m³, 1/3000 the nuisance dust PEL)
- OSHA Action Level (2.5 µg/m³, 1/6000 the dust PEL)
- Common Uses: pigments, electroplating, wood preservatives, pigments, paints/coatings, created during stainless steel welding or plasma cutting (typically ~0.01% of the total fume).

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OSHA Standard - Lead

Metals of Concern

OSHA Standard 1910.1025

- OSHA PEL (50 µg/m³, 1/300 the nuisance dust PEL)
- OSHA Action Level (30 µg/m³, 1/180 the dust PEL)
- Common Uses: batteries, ammunition, radiation shielding, pigments, leaded alloys, soldering

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Surface Sampling

Metals of Concern

All the OSHA standards for these metals also address surface contamination.

- Typically, standard language states that employers should ensure that all surfaces be maintained as free as practicable accumulations of these metals.
- No limit is given for arsenic, beryllium, cadmium, or hexavalent chromium.
- OSHA uses the 200 ug/ft2 HUD level as a workplace guideline for keeping surfaces as free as practicable of lead accumulation.
- Commonly targeted locations include areas where employees eat/drink (lunchrooms), drinking fountains, the inside of respiratory protection, and surfaces in work areas.

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Manganese

Metals of Concern

No OSHA Standard

- OSHA PEL (5 mg/m³, ceiling limit)
  – *several state plans have adopted the 1988 limit*
- ACGIH TLV (0.02 mg/m³ respirable, 0.2 mg/m3 inhalable)
  – *most mild steel welders will exceed the respirable limit*
- NIOSH REL (1 mg/m³)
- Common Uses: steelmaking, dry cell batteries, paint pigments, glass

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Manganese
Metals of Concern

For manganese, the OSHA PEL from 1970 is a ceiling limit of 5 mg/m3 for both dust and fume. Common industrial mild steel processes with manganese exposure (welding, grinding, melting) are unlikely to exceed this number, due to the low typical manganese content (<2%).

The ACGIH TLV established in 2013 is comparably low for both respirable fractions (0.02 mg/m3) and inhalable fraction (0.2 mg/m3) of manganese.

If the TLV is utilized as the limit, total dust samplers can be interpreted with assumptions. (*i.e.* all fume is respirable from welding, or that total manganese >0.2 mg/m3 likely will exceed the inhalable limit, given that in inhalable samplers will capture total fraction particulate.

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Sampling Strategy - Metals

Several sources can be used by hygienists to craft a IH sampling scope for metals:

- Safety Data Sheets – The quality of the data reported in these varies widely
- Alloy Specification Sheets – These set the required ranges of select metals, trace metals may not be specified
- Melt Sheets – Foundries often receive scrap from a variety of sources…is contamination possible?
- Historical Data – Be careful with *"We'll do what we did last year"*

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Laboratory Costs - Metals
The Misnomer of Total Dust, cont.

Laboratories typically set differing pricing plans.

- Individual Metals: First metal - $42, Each additional - $10
- Basic Metal Scan: Al, **As**, **Cr**, Cu, Fe, Mg, Mn, Ni, **Pb**, Zn - $95
- Expanded Metal Scan: Basic Metals + **Be**, **Cd**, Co, Mo, Sb, Ti, V - $135
- Full Metal Scan: Expanded Metals + Ba, Bi, B, Ca, Li, Se, Sr, Tl, Sn - $200

At these prices, an assessment of ten employees would incur analytical costs anywhere from $462 to $2,200.

Most hygienists will strive to minimize this price using experience and assumptions about the job to be sampled.

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Case Studies – IH Adventures

A hygienist arrives at the following plan for some select jobs.

- Metal Grinder – Total Dust and a Basic Metal Scan, cost effective and quantifies the metals listed in the alloy spec sheet.
- Walk-in Blast Booth – Total Dust and a Basic Metal Scan, covers metals in the SDS for the blast media and the alloy.
- Electronics Recycling – Lead is known hazard with the process. This metal was targeted to both continue previous efforts and meet regulatory requirements.
- Scrapping Large Equipment – The employee torch metal for various equipment. These are all made of steel, so a Basic Metal Scan is sufficient.
- Maintenance Stainless Steel Welding – An employee has two welders in the shop for small repair jobs. They decide they should sample for hexavalent chromium, since the SDS for the weld wire includes warning information.

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Case Study #1 - Metal Grinder

The Metal Grinder is being sampled because of concerns regarding the amount of dust settling on surfaces. This employee is sampled for total dust and basic metals.

Observations include:

- Equipped with an exhaust hood
- Pneumatic cup grinder
- Zirconia-Alumina abrasive
- Lots of dust is created
- A haze forms in the general
- Wears supplied air respirator

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Case Study #1 - Metal Grinder

Upon collection, the hygienist notes that the filter cassette is heavily loaded with particulate. The results were as follows:

Position	Analyte	Time (Minutes)	Concentration	OSHA PEL	ACGIH TLV
Metal Grinding	Total Dust	480	44 mg/m³	15 mg/m³	- -
	Aluminum		0.75 mg/m³	15 mg/m³	1 R mg/m³
	Arsenic		<0.88 µg/m³	10 µg/m³	10 µg/m³
	Beryllium		0.21 µg/m³	0.2 µg/m³	0.1 µg/m³
	Chromium		0.016 mg/m³	1 mg/m³	- -
	Copper dust		<0.0018 mg/m³	1 mg/m³	1 mg/m³
	Iron oxide		0.32 mg/m³	- -	- -
	Lead		<0.0021 µg/m³	50 µg/m³	50 µg/m³
	Magnesium oxide		0.012 mg/m³	15 mg/m³	- -
	Manganese		0.0011 mg/m³	- -	0.02 R mg/m³
	Nickel		0.055 mg/m³	1 mg/m³	- -
	Zinc oxide dust		0.0084 mg/m³	- -	- -

The chosen sampling scope (total dust plus a basic metal scan) missed a critical exposure to beryllium! Beware of instances with high dust exposures.

The beryllium is 0.0005% of the dust result.

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Case Study #2 - Blast Booth Operator

The Blast Booth Operator is being sampled because the type of blast media was changed from recycled slag to steel shot. In addition to silica, a sample for total dust and a basic metal scan was selected, as the SDS identifies the metals in the shot.

Observations include:

- Down-draft exhausted blast booth.
- Parts are large and occupy most of the booth.
- Employee wears supplied air blast helmet.
- Cannot observe blast with doors closed.
- Significant particles accumulate.

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Case Study #2 - Blast Booth Operator

At the lunch break, the hygienist noted that the filter cassette was heavily loaded, so a second sample covered the afternoon work.

Position	Analyte	Time (Minutes)	Concentration	OSHA PEL	ACGIH TLV
Walk-in Blast Booth	Total Dust	480	232 mg/m³	15 mg/m³	- -
	Aluminum		0.21 mg/m³	15 mg/m³	1 R mg/m³
	Arsenic		11 µg/m³	10 µg/m³	10 µg/m³
	Beryllium		0.21 µg/m³	0.2 µg/m³	0.1 µg/m³
	Cadmium		5.1 µg/m³	5 µg/m³	10 µg/m³
	Chromium		0.52 mg/m³	1 mg/m³	- -
	Copper dust		0.46 mg/m³	1 mg/m³	1 mg/m³
	Iron oxide		0.32 mg/m³	- -	- -
	Lead		<0.0021 µg/m³	50 µg/m³	50 µg/m³
	Magnesium oxide		0.012 mg/m³	15 mg/m³	- -
	Manganese		2.7 mg/m³	- -	0.2 I mg/m³
	Nickel		0.055 mg/m³	1 mg/m³	- -
	Zinc oxide dust		0.0084 mg/m³	- -	- -

The chosen sampling scope (total dust plus a basic metal scan) found the arsenic exposure but missed critical exposures to beryllium and cadmium. Beware of instances with high dust exposures.

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Case Study #3 - Electronics Recycling

The electronics recycling department is within a new addition to the facility. Employees mostly disassemble common household devices including radios, VCRs, TVs though other uncommon electrical equipment of all sizes is processed. The biggest concern is lead, as previous tests were high, and controls have been put in place.

Observations include:

- Work done at a series of waist-height tables
- Adjustable arm exhaust units at each table
- Some components are taken apart on the floor
- Parts are sorted into various totes
- Visible dust accumulates on work surfaces

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Case Study #3 - Electronics Recycling

Upon collection, the sample cassette was discolored, but not concerningly loaded with particulate.

Position	Analyte	Time (Minutes)	Concentration	OSHA PEL	OSHA Action Level
Electronics Recycling	Total Dust	480	23 mg/m³	15 mg/m³	- -
	Beryllium		0.11 µg/m³	0.2 µg/m³	0.1 µg/m³
	Cadmium		2.7 µg/m³	5 µg/m³	2.5 µg/m³
	Lead		43 µg/m³	50 µg/m³	30 µg/m³

The targeted sampling for lead was appropriate, but other standard metals were also present that were not selected. Uncertain exposures necessitate caution.

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Case Study #4 - Scrapping Large Equipment

Another department in the facility disassembles various pieces of large equipment including dump trucks, excavators, bulldozers, and old military vehicles. Instead of shredding the equipment, manual disassembly yields some parts of value that can either be reused or sold. The sample is total dust and a basic metal scan.

Observations include:

- Workers use mostly battery and pneumatic tools
- Employees use cut-off saws and torches
- The saws create airborne dust, used more often
- The torches create smoke/fume, used sparsely
- Most employees wear N95 filtering facepieces voluntarily.
- There are no controls in place, largely due to a lack of space

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Case Study #4 - Scrapping Large Equipment

Upon collection, the filter was observed to be discolored, with loose particulate present in the cassette.

Position	Analyte	Time (Minutes)	Concentration	OSHA PEL	ACGIH TLV
Walk-in Blast Booth	Total Dust	480	14 mg/m³	15 mg/m³	- -
	Aluminum		0.21 mg/m³	15 mg/m³	1 R mg/m³
	Arsenic		<0.88 µg/m³	10 µg/m³	10 µg/m³
	Cadmium		7.2 µg/m³	5 µg/m³	10 µg/m³
	Chromium		0.41 mg/m³	1 mg/m³	- -
	Copper dust		0.77 mg/m³	1 mg/m³	1 mg/m³
	Iron oxide		11 mg/m³	- -	- -
	Lead		<0.0021 µg/m³	50 µg/m³	50 µg/m³
	Magnesium oxide		0.012 mg/m³	15 mg/m³	- -
	Manganese		0.19 mg/m³	- -	0.2 I mg/m³
	Nickel		0.055 mg/m³	1 mg/m³	- -
	Zinc oxide dust		0.0084 mg/m³	- -	- -

The sample for total dust and a basic metal scan found nuisance dust near the OSHA PEL, but nothing else exceeded limits. Cadmium (a coating on torched bolts) was present above the OSHA PEL. Uncertain exposures require caution.

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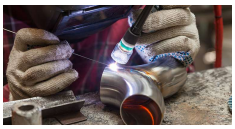
Case Study #5 - Stainless Steel Welding - Maintenance

One final department in this expansive facility is the pickle plant. This department receives cucumbers and jars them with brine and spices for sale. A hearing conservation program is in place here, and acetic acid is not an exposure issue. Everything is stainless steel, but an outside vendor takes care of large welding projects welding projects. The maintenance department has one MIG welder and one TIG welder for small jobs.



Observations include:

- Only one employee in the shop uses the welders.
- The employee wears a flip up welding mask.
- They do not wear a respirator.
- They only weld one-two times/week, up to an hour per day.
- There are not controls, welding is done either on a table in the shop or on the floor.
- The weld table is tucked under a mezzanine in the corner of the room.

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Case Study #5 - Stainless Steel Welding - Maintenance

The hygienist chooses to sample both processes, just to ensure there are no exposure issues. Little fume emanated from TIG. The MIG created visible fume, which drifted past the sitting welder's breathing zone.

Position	*Analyte*	*Time (Minutes)*	*Concentration*	*8-hour TWA*	*OSHA PEL*
Stainless Steel Welding - TIG	Hexavalent Chromium	30	<1.7 µg/m³	<0.11 µg/m³	5 µg/m³
Stainless Steel Welding - MIG	**Hexavalent Chromium**	30	**24 µg/m³**	1.5 µg/m³	5 µg/m³

TIG welding showed little exposure, but MIG welding had a concentration well above the PEL. The 8-hour TWA was below the PEL and AL….but didn't that welder say they could weld up to an hour?

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Lessons Learned

Several lessons can be learned from the case studies:

- Lots of dust can result in lots of unwelcome exposures
  - Even if a metal is <0.0005% of a product, high dust exposures can result in exposures above an OSHA PEL.
- Sampling uncertain exposures where there isn't good information available can lead to surprises.
  - Hazards have been eliminated from most modern products, but what about things created before the limits existed? Lead was once commonly added to paints.
  - Information is often sparse on the contents of these products.

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Conclusion

Ensuring that employees are protected against metals can be a more complicated effort than it initially seems. There are questions to be answered of the metals to be targeted, the type of samplers to use, the interpretation of the results, all while keeping costs in check.

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Questions?

Feel Free to Contact Me!

Eric Pylkas, CIH, CSP, CHMM
Industrial Hygienist
Insight IH Consulting, LLC
300 Cottonwood Avenue, Suite #2
Hartland, WI 53029
(262) 347-6599
Eric.Pylkas@insightIHconsulting.com
www.insightIHconsulting.com

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