



Water & Environmental
TECHNOLOGIES

Manganese: Exposure, Health Effects and Controls

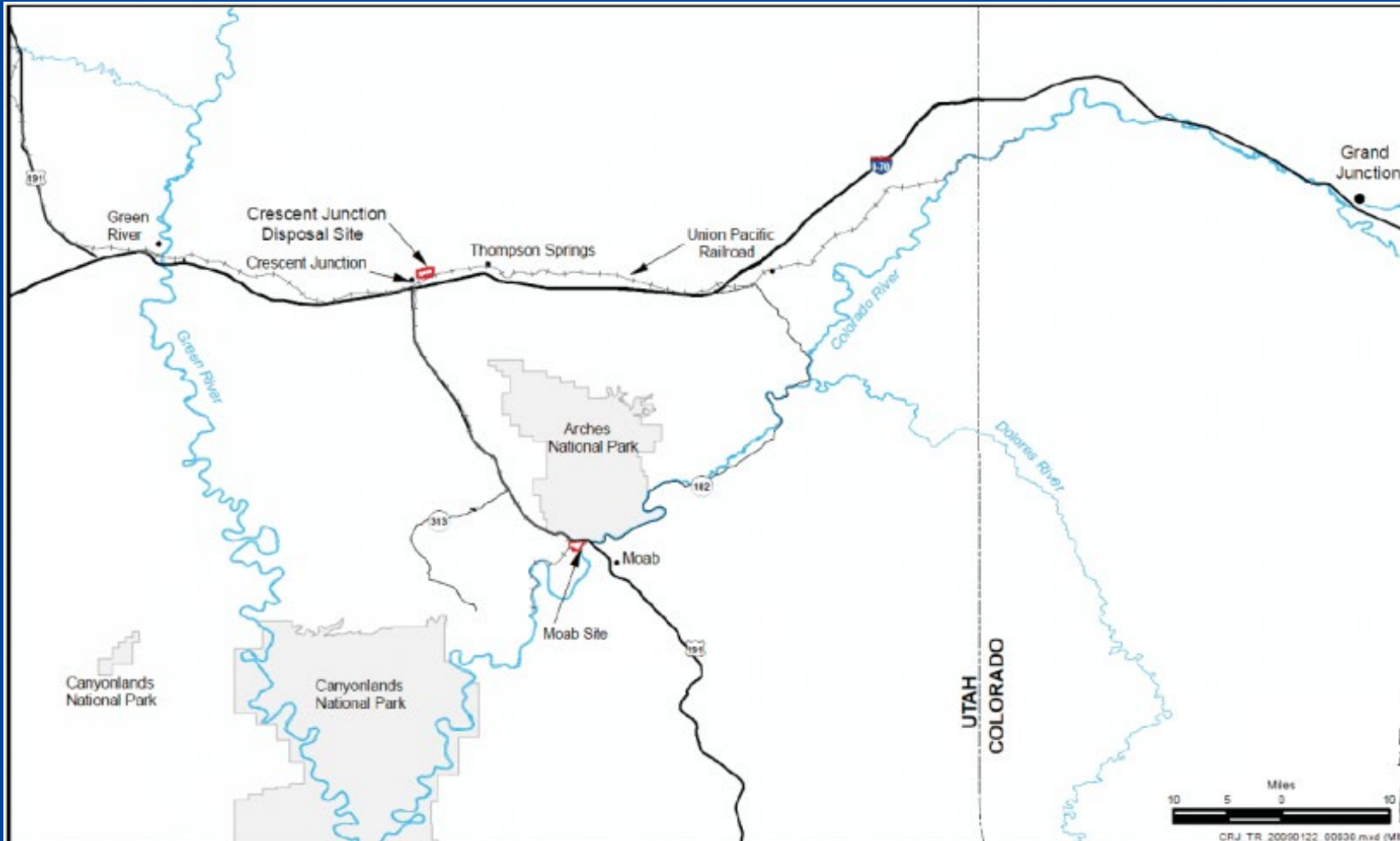
Brie Meyer, CIH and Dr. John Schumpert, MD, MPH



Presentation outline

- Site overview
- Shipping containers and welding
- Exposure evaluation
- Occupational exposure limits
- Manganese toxicity
- Welding fume exposure controls
- Final air monitoring results

Site Overview – Moab, UT



(Department of Energy, 2024)



Rail Load
Out Area

Former Mill

Tailings Pile

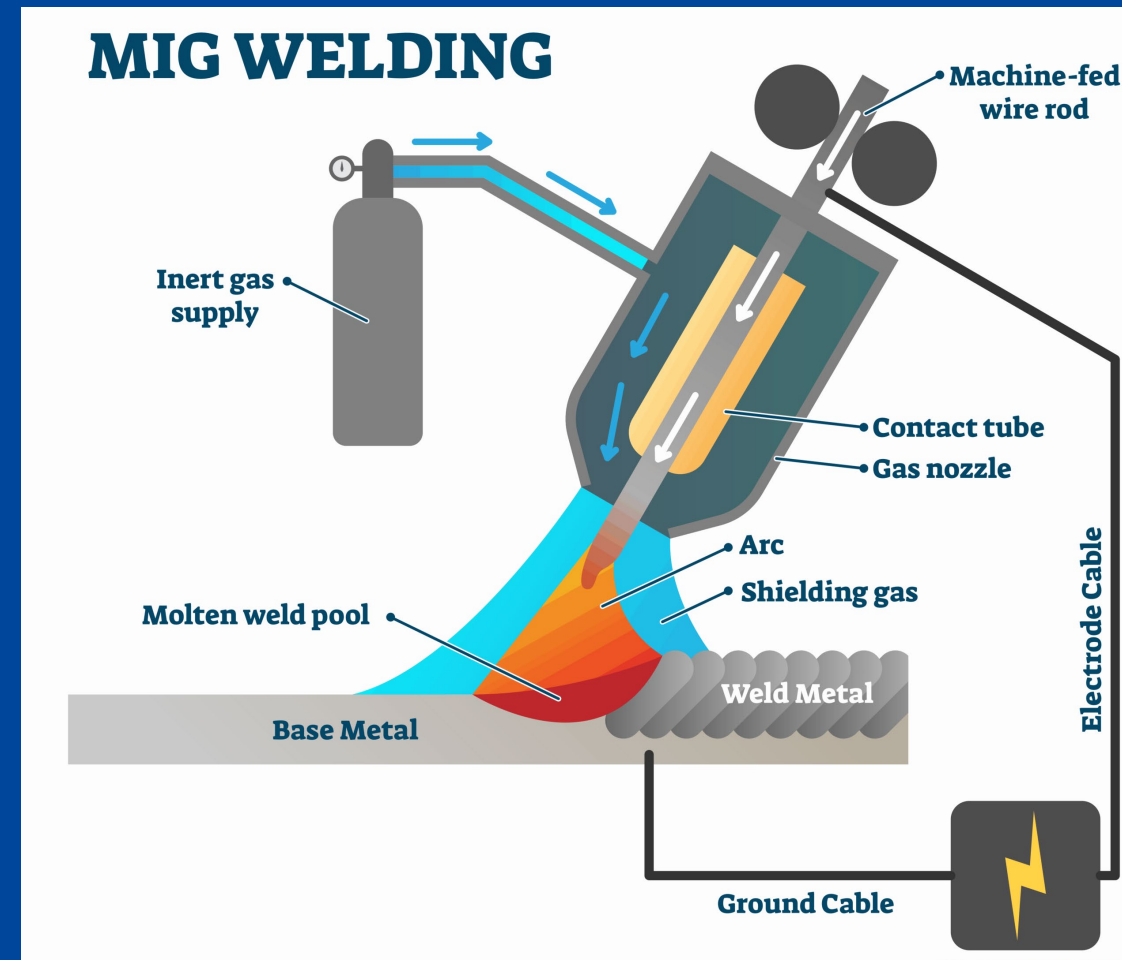
Well Field

Colorado
River



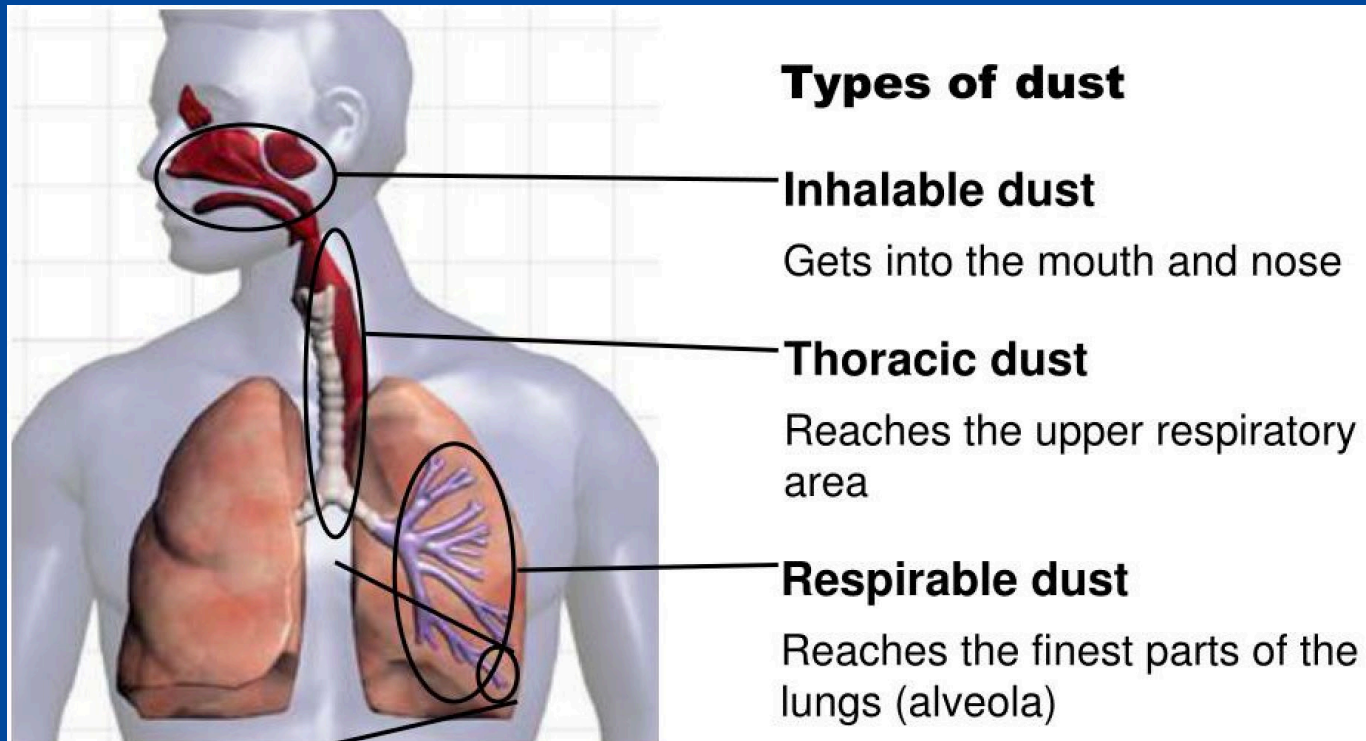
Shipping Containers & Welding

- Inspected to meet specific thickness requirements
- New rolled steel panels welded if thickness requirements not met
- Metal inert gas (MIG) welding used

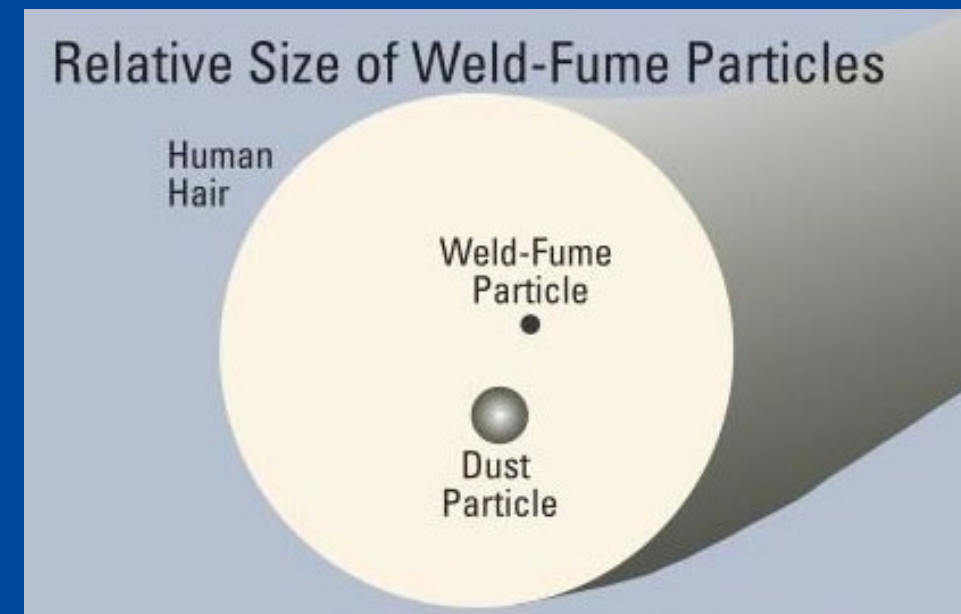


(<https://www.technoxmachine.com/blog/mig-vs-tig-welding/>)

Welding Fume



<https://www.euroenvironmental.co.uk/news/item/dust>



<https://www.wilhelmsen.com/ships-service/welding--surface-preparation/welding-fumes---a-known-carcinogen/>

Exposure Evaluation

1. Respirators
2. Monitoring plan
3. Air monitoring
4. Comparison to OELs



(https://www.3m.com/3M/en_US/p/d/b00040378/)

Occupational Exposure Levels

Agency	Manganese OEL
NIOSH REL	1 mg/m ³ (TWA), 3 mg/m ³ (STEL), 500 mg/m ³ (IDLH)
OSHA PEL	5 mg/m ³ (ceiling)
ACGIH TLV	Respirable fraction: 0.02 mg/m ³ (TWA) Inhalable fraction: 0.1 mg/m ³ (TWA)

IDLH: immediately dangerous to life or health concentration

PEL: permissible exposure limit

REL: recommended exposure limit

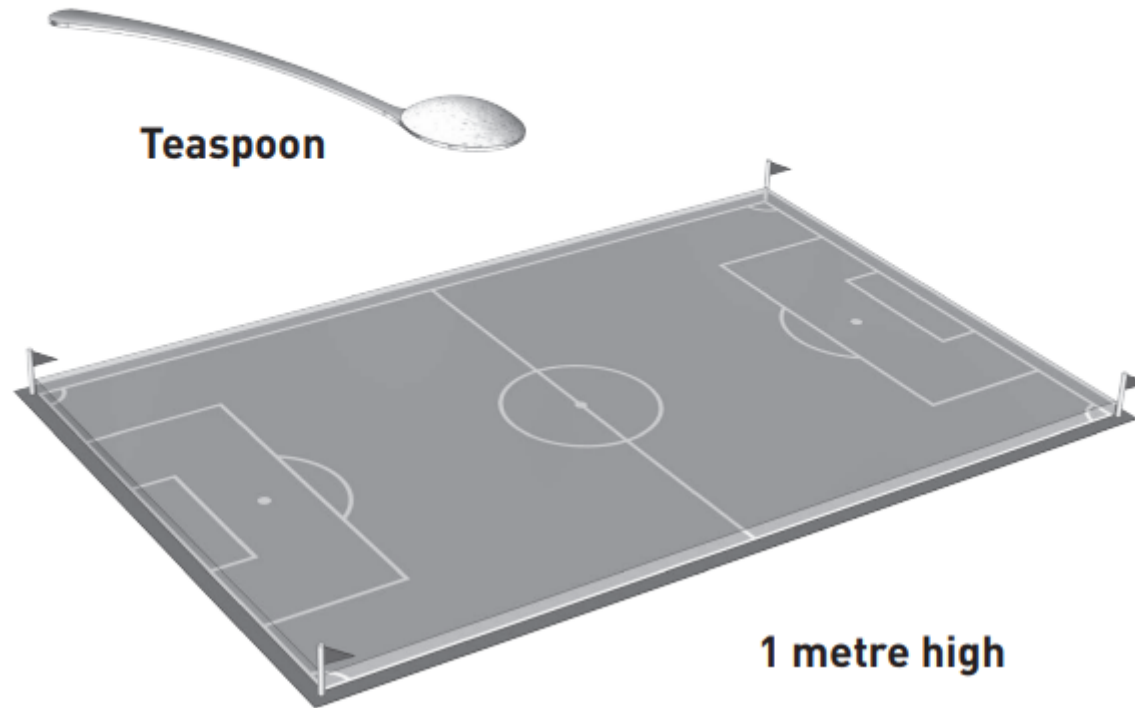
STEL: short-term exposure limit

TLV: threshold limit value

TWA: 8-hour time-weighted average

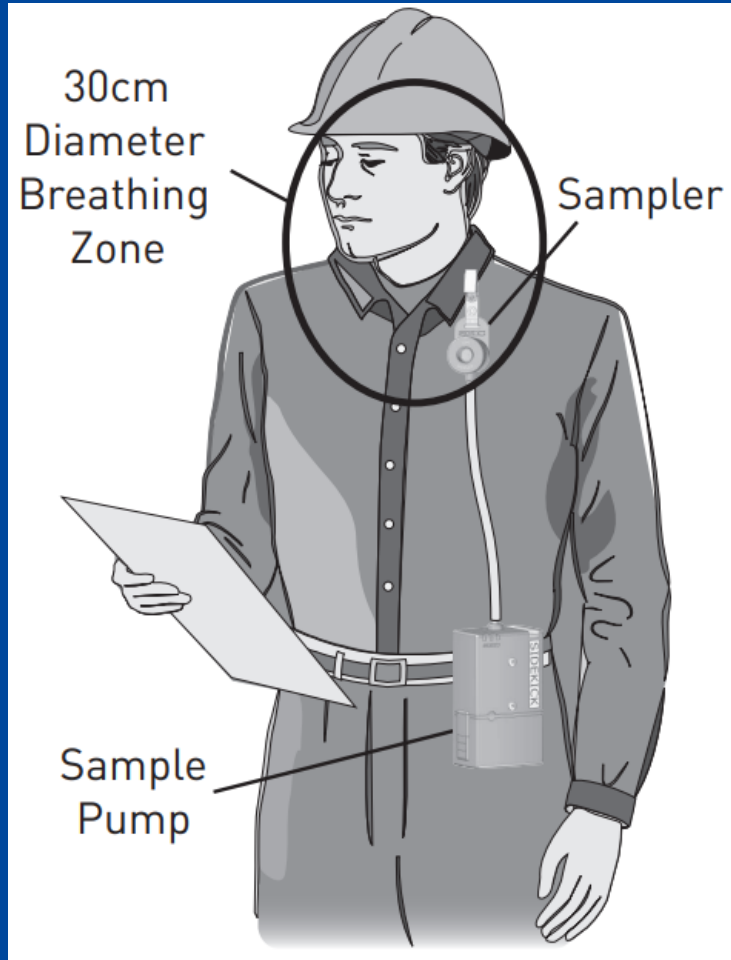
Occupational Exposure Levels

1 milligram per cubic metre (mg/m³)
is approximately the same as one teaspoon of dust spread in the
volume of air 1 metre above the area of a football (soccer) field



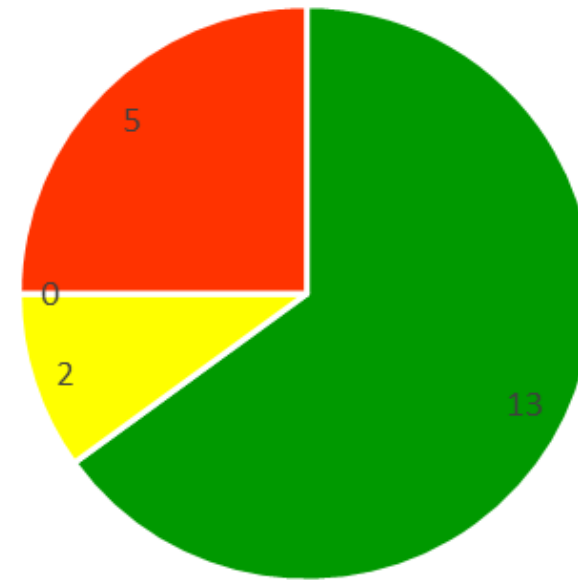
<https://www.skcltd.com/images/pdfs/224-G1.pdf>

Initial Air Monitoring



(<https://www.skcltd.com/images/pdfs/224-G1.pdf>)

Respirable Metals Results, December 2015



■ <10% OEL ■ 10-50% OEL ■ 50-100% OEL ■ >100% OEL

Manganese Uses

- Manganese was first isolated in the 1770s.
- Manganese is a chemical element; its chemical symbol is Mn and atomic number 25.
- It is a hard, brittle, silvery metal, often found in minerals in combination with iron.
- Manganese is a transition metal with a multifaceted array of industrial alloy uses, particularly in stainless steels.



(<https://en.wikipedia.org/wiki/Manganese>)

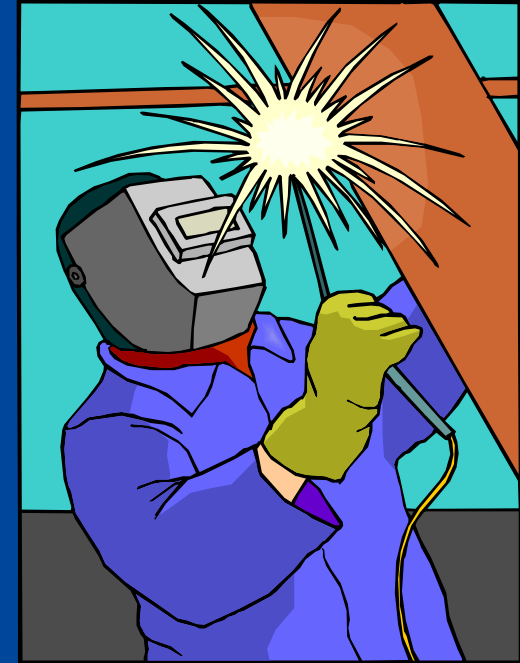
Manganese Uses (cont.)

- Only 3% to 5% of ingested manganese is absorbed.
- Manganese-rich foods include grains, nuts, tea, and legumes.
- The daily dietary intake ranges from 2 to 5 mg, with some macrobiotic diets exceeding 10 mg/d.
- An essential element for humans, manganese is necessary for several enzymes including arginase, glutamine synthetase, and superoxide dismutase.

Occupational Groups Potentially Exposed to Manganese (Mn)

- Inorganic Mn compounds:
 - Mn miners
 - Producers of Mn alloys (e.g., steel)
 - Dry alkaline battery manufacturers
 - Aluminum-Mn can producers
 - Smelter and foundry workers (Mn processing and ferro-Mn operations)
 - **Welders**
- Organic Mn compounds:
 - Agrochemical/pesticide workers (e.g., Maneb, Mancozeb)
 - Methylcyclopentadienyl manganese tricarbonyl (MMT) gasoline additive workers

- U.S. Bureau of Labor Statistics (BLS) reports around 408,990 total welders, cutters, solderers and brazers in US
- 1%–2% of workforce are welders



(US Bureau of Labor and Statistics Occupational Employment and Wages, May 2023)

Welding Exposures

- 80%–95% of fume is absorbable
- Fumes originate from electrodes, wires, base metals, coatings, and contaminants
- Gases released from heat of arc and UV radiation



Health Effects of Welding

- Pulmonary function changes
- Metal fume fever
- Pulmonary edema
- Pulmonary fibrosis
- Asthma
- Bronchitis
- Lung cancer
- Dermatological effects
- Reproductive effects
- Ocular effects
- **CNS effects**

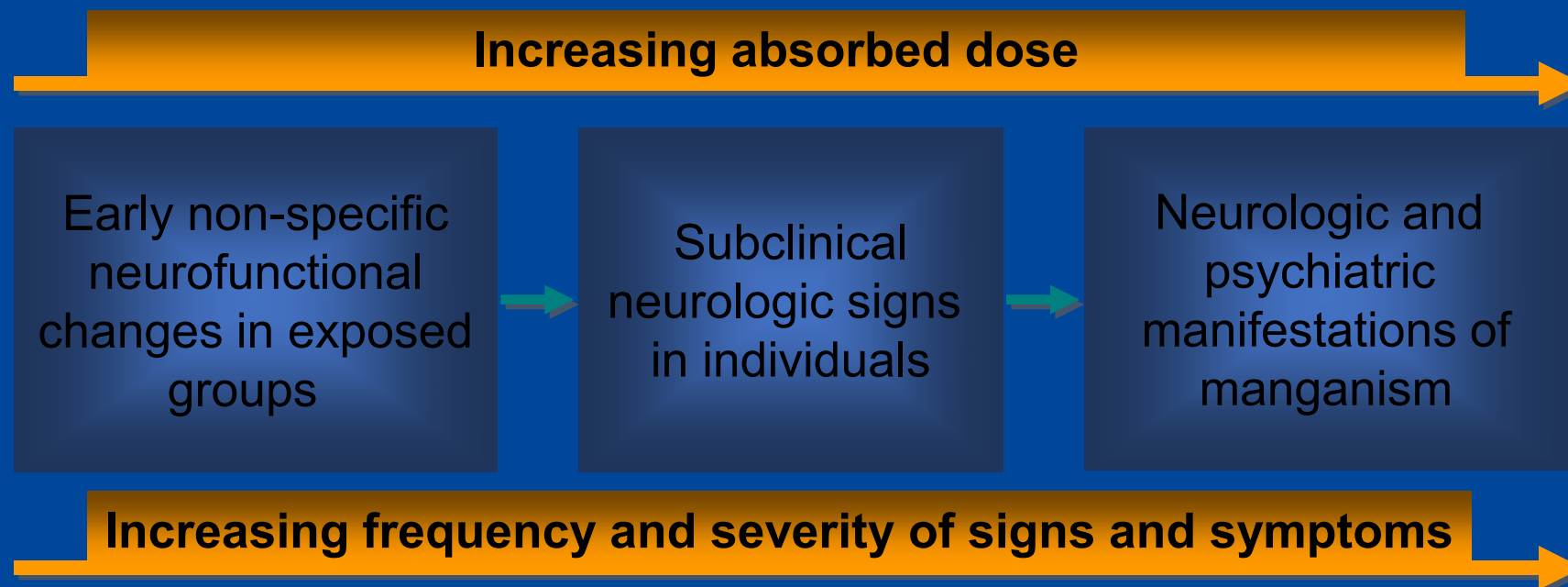
Health Effects of Welding

- Prolonged exposure to high manganese concentrations (>1 mg/m³) in air may lead to a Parkinsonian syndrome known as "manganism."
- Parkinson-like symptoms may include tremors, slowness of movement, muscle rigidity, and poor balance.

Manganism

- Manganism was first described in the 19th and 20th centuries in several studies of miners by Couper and Rodier, respectively.
- Three possible routes of absorption proposed:
 - Mucosal: Retrograde axonal transport of Mn particles via olfactory and trigeminal nerve endings
 - Inhalational: Direct transport across the pulmonary epithelium for absorption into the circulatory or lymphatic system
 - Gastrointestinal: Ingestion via mucociliary clearance and swallowing of respiratory secretions

Manganese Neurotoxicity: Progression of Effects



Nonspecific changes in Mn-exposed groups



ALTERED MOTOR
FUNCTIONS



REDUCED HAND
STEADINESS



PROLONGED REACTION
TIME



DECREASE IN COGNITIVE
FUNCTIONS



INCREASED REPORTING
OF FATIGUE, TENSION,
ANGER, AND CONFUSION

Manganism vs Parkinson's Disease

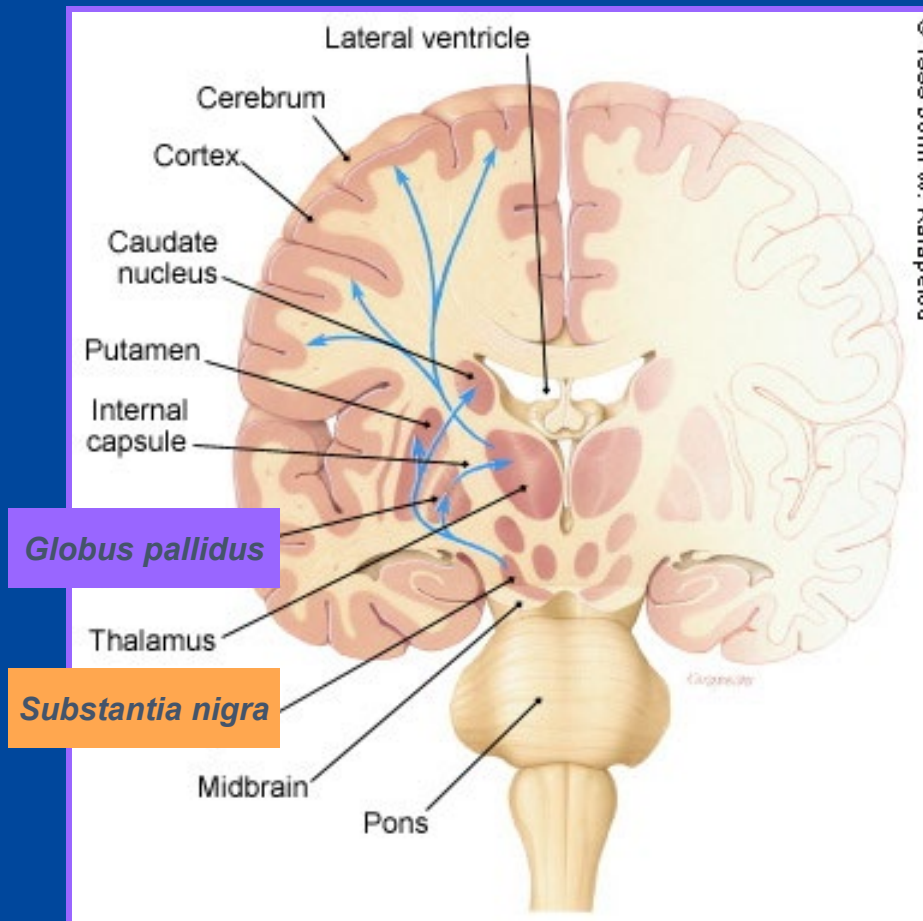
Manganism

- Confusion
- Unusual behavior
- Hallucinations
- Apathy
- Difficulty with speech
- Cock-walk gait
- Difficulty with fine motor movement
- Anxiety
- Pain

Parkinson's disease

- Freezing, involuntary movements
- Muscle stiffness
- Tremors
- Inability to stand or walk
- Four times more likely to develop dementia than the general population
- Difficulty swallowing
- Dizziness and vertigo
- Erectile dysfunction
- Excessive sleepiness, fatigue
- Inability to smell
- Incontinence

Manganism vs. Parkinson's Disease (cont.)



Region of brain affected:

Manganism

Striatum

Globus pallidus

Parkinson's Disease

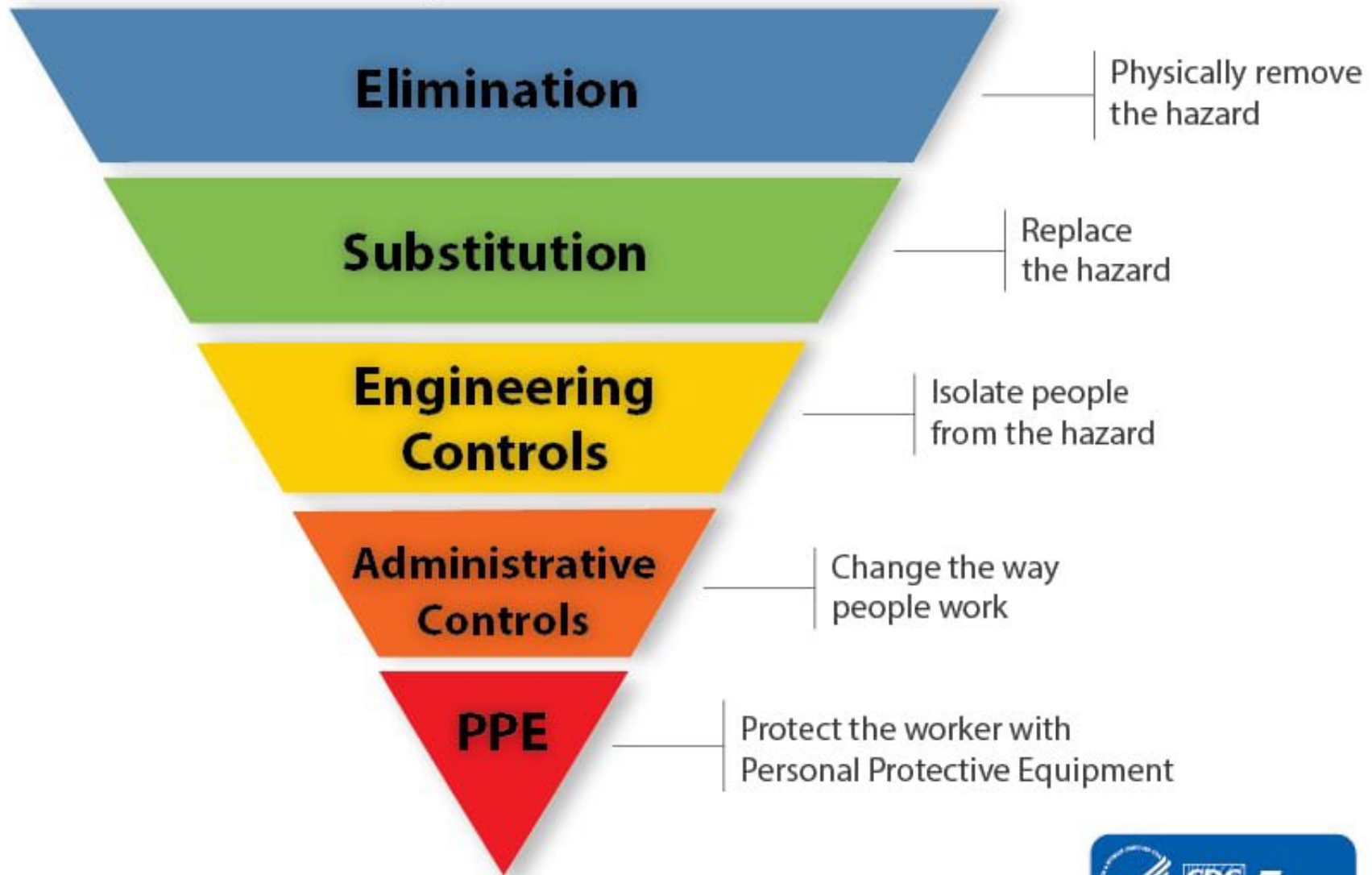
Substantia nigra

Hierarchy of Controls

Most effective



Least 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



Image by NIOSH

Controls

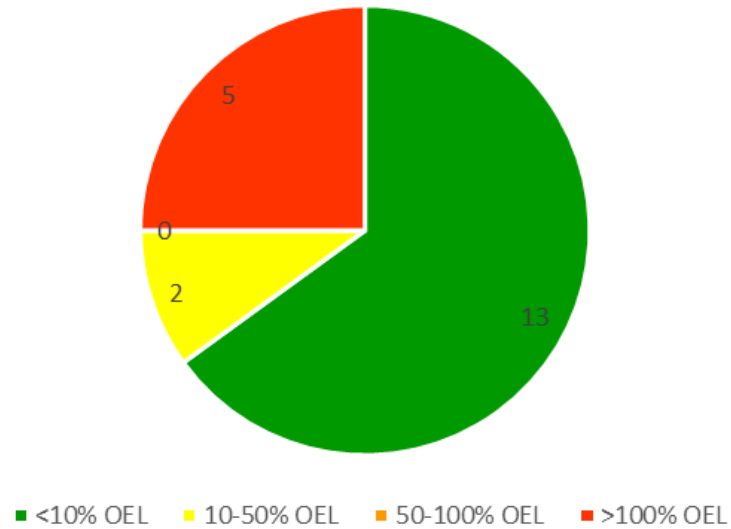
- Evaluated substituting electrodes or changing welding type
- Reconfigure hot work areas
- Added area ventilation
- Added local exhaust ventilation
- Discussed work practices with welders



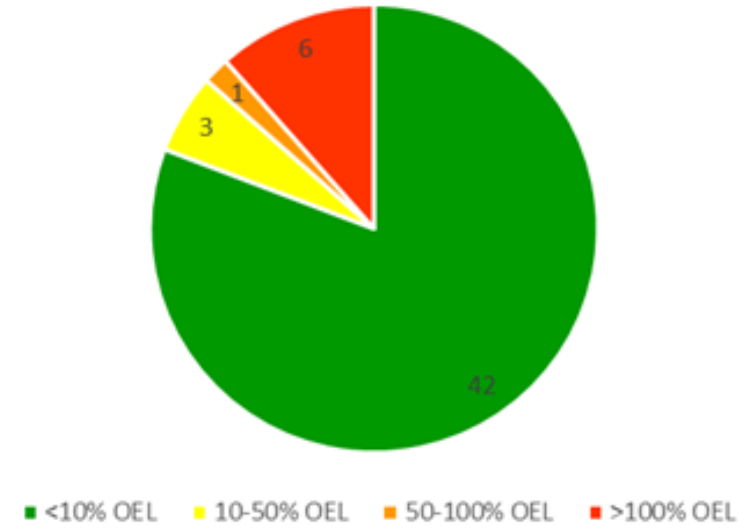
[\(https://portacool.com/p/hazardous-location-270-evap-cooler/\)](https://portacool.com/p/hazardous-location-270-evap-cooler/)

Final air monitoring results

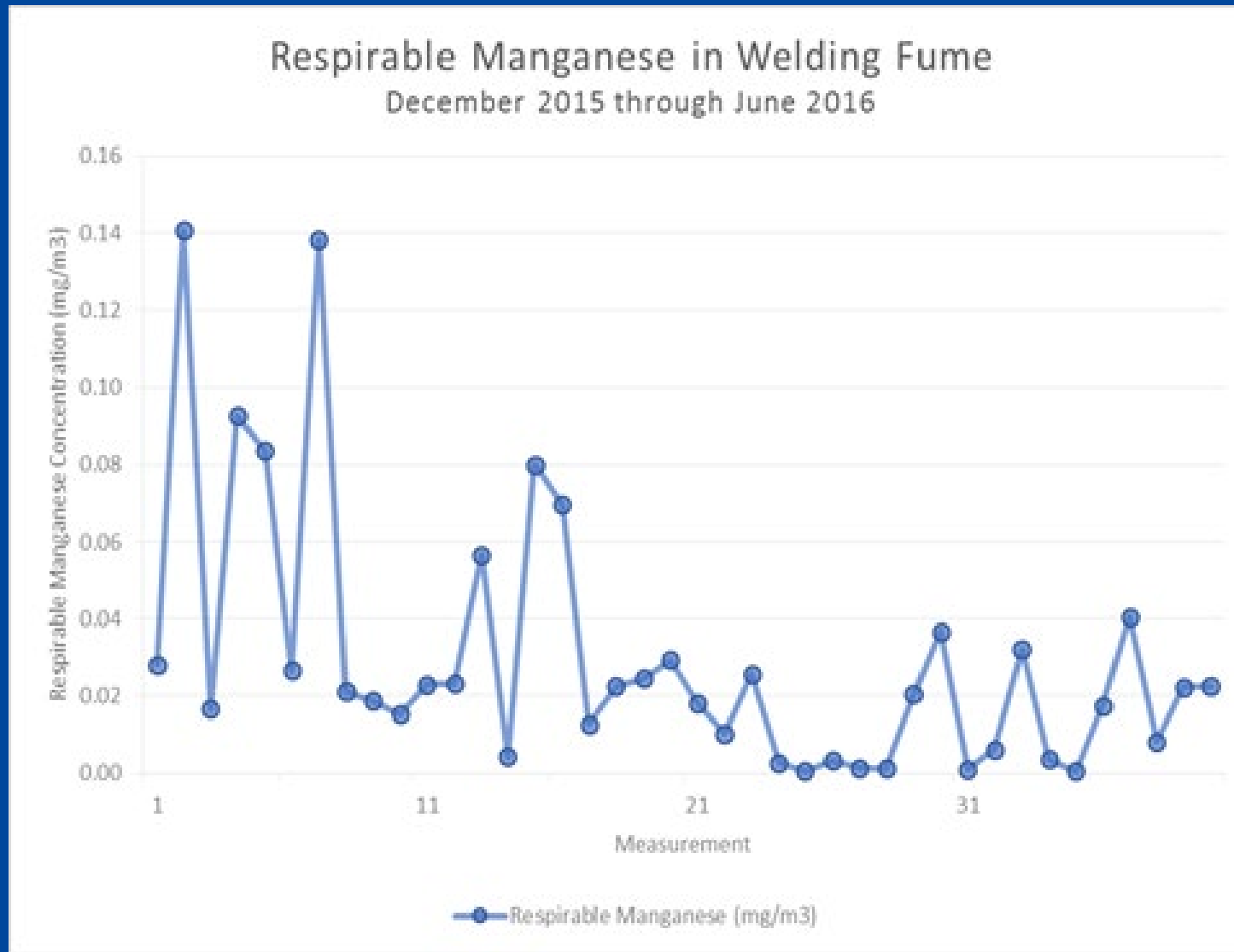
Respirable Metals Results, December 2015



Respirable Metals Results, June 2016



Final air monitoring results (cont.)



Questions?

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