Why can’t you just tell me if it’s ‘safe’?

Industrial Hygiene Considerations for Handling MERCURY-Containing Collections

Kerith Koss Schrager
AIC Annual Meeting 2025

SOME CONSIDERATIONS ON HOW A HAZARD CAN AFFECT YOUR HEALTH

FORM
- Chemical Composition
- Inorganic vs. Organic
- Physical State

ROUTES OF EXPOSURE
- Inhalation
- Ingestion
- Skin/Eye Absorption
- Injection

DOSE ("Dose make the poison")
- Amount absorbed by the body
- NOT the concentration in the air or on surfaces

DURATION
- Chronic (long-term exposure)
- Acute (short-term exposure)

INDIVIDUAL VARIABILITY
- Age
- Sex
- Ethnicity
- Health conditions
- Past exposures

AVAILABLE TOXICOLOGICAL INFORMATION
- Outdated resources, data sheets and exposure limits
- We don't know what we don't know

Precautionary Principle

In the absence of evidence that a material is safe, assume that it is hazardous and take appropriate steps to eliminate exposure

PHYSICAL FORMS

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Particles (Solids)

Dusts: collection of particles (surface contamination)

Aerosols: particles suspended in air (dusts, smokes, fumes) (air contamination)

Liquids

Liquid: a chemical that flows freely and has a definite volume but no fixed shape (surface contamination)

Aerosols: liquid suspensions (mists) (air contamination)

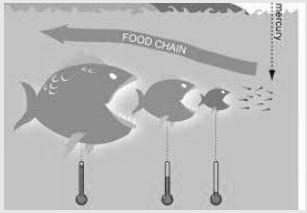
Gases and Vapors

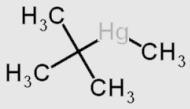
Gas: chemical exists in a gaseous state (air contamination)

Vapor: gaseous state of a chemical that exists in another state at standard temperature and pressure (air contamination)

CHEMICAL FORMS

ORGANIC

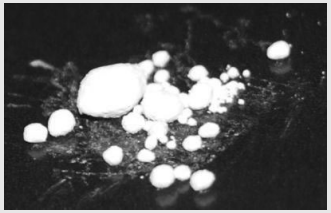


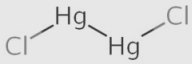


Methylmercury, ethyl mercury

Preservatives
Environmental contamination

INORGANIC





Mercury chloride (pesticide)
Mercury nitrate (felting hats)
Mercurous chloride (pharmaceuticals)
Mercury sulfide (cinnabar/mineral)

ELEMENTAL

Hg

Liquid Mercury

Thermometers, scientific equipment

ROUTES OF EXPOSURE

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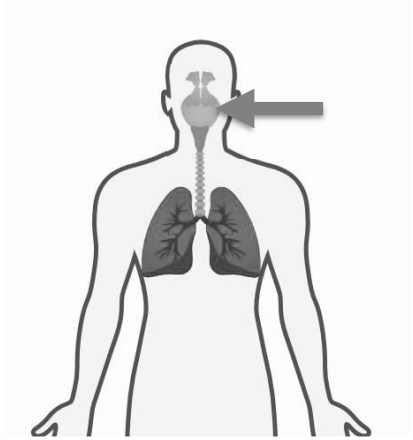
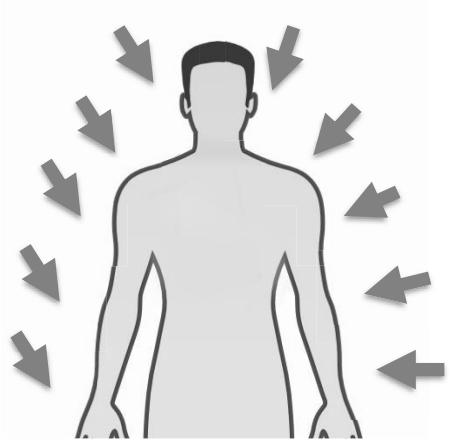


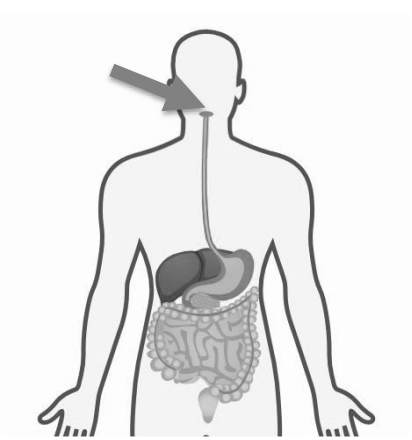
Inhalation

Absorption of chemicals and/or particles into the respiratory system



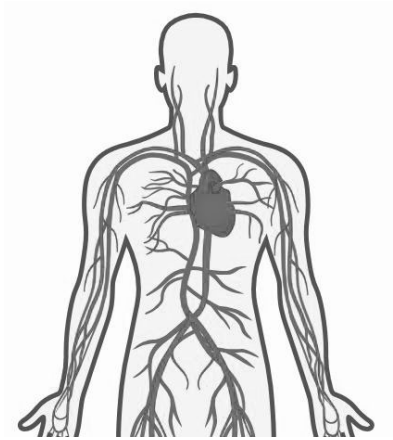
Absorption

Materials pass through membranes of skin or eyes



Ingestion

Materials pass through digestive tract



Injection

Materials enter the bloodstream from punctures with contaminated sharps

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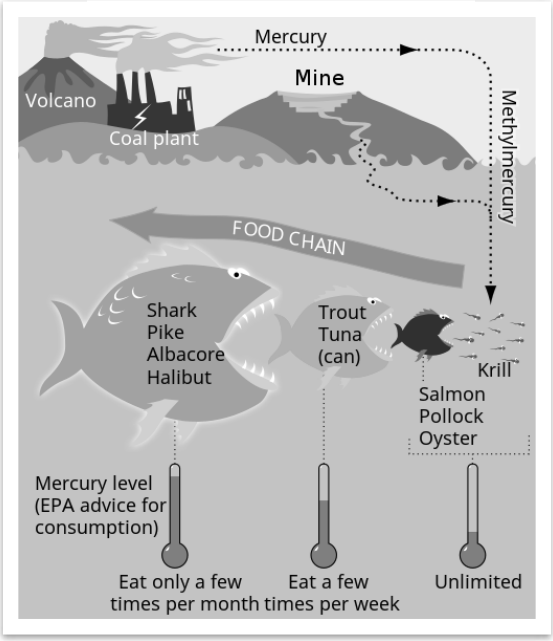
Inhalation

ELEMENTAL MERCURY

- Poorly absorbed through the skin and digestive system
- 80% of the inhaled **mercury vapor** produced when it is heated or agitated is absorbed by the lungs

Ingestion



METHYLMERCURY

- Organic methylmercury biomagnifies in the environment
- Readily absorbed by the digestive system

Absorption

DIMETHYLMERCURY

Karen Wetterhahn died several months after her gloved hand was exposed to dimethylmercury

Exposure Scenarios: Hazard ≠ Risk

HAZARD

Intrinsic property of a substance to cause harm

RISK

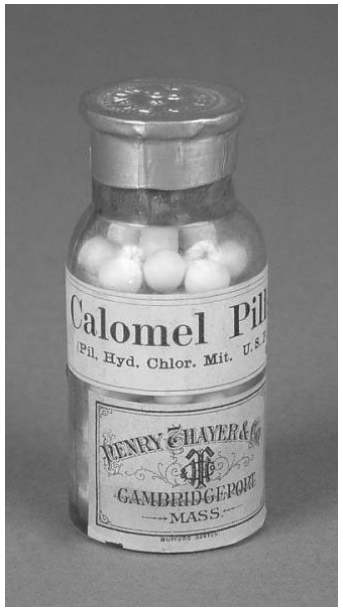
Probability that the hazard will cause harm and the degree to which it affects your system

Type of Object

How mercury is used in the object and its condition

Work Practices

How we work with the object during exhibition, handling and treatment

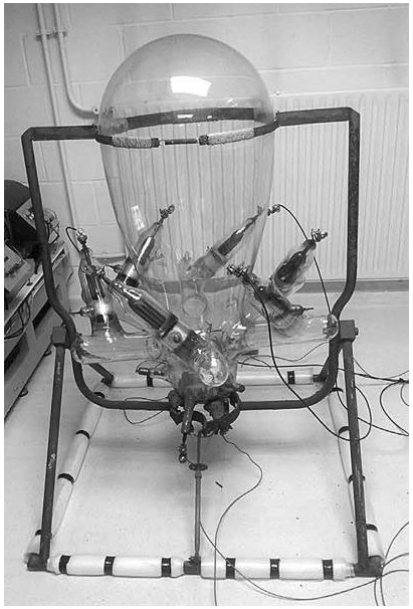


Smithsonian, AMNH


Allen Memorial Art Museum


Winterthur Museum


LACMA


The Valve Museum

Exposure Scenarios: Hazard ≠ Risk

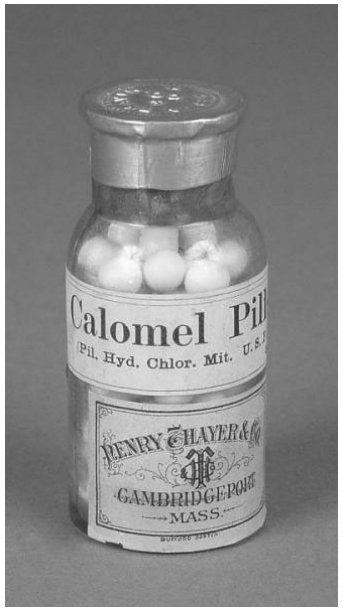
HAZARD

Intrinsic property of a substance to cause harm

RISK

Probability that the hazard will cause harm and the degree to which it affects your system

You may not be able to change the nature of the *HAZARD*, but you can control *RISK* by limiting *EXPOSURE*



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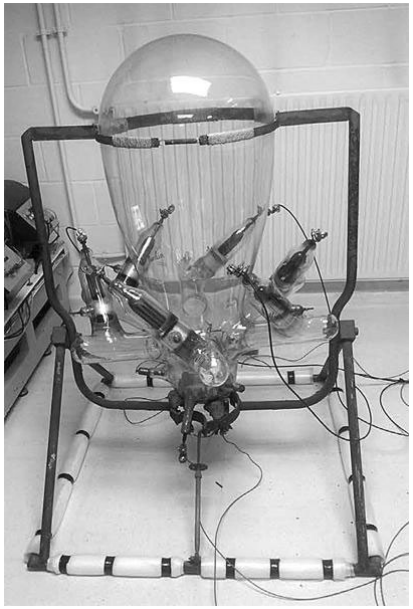
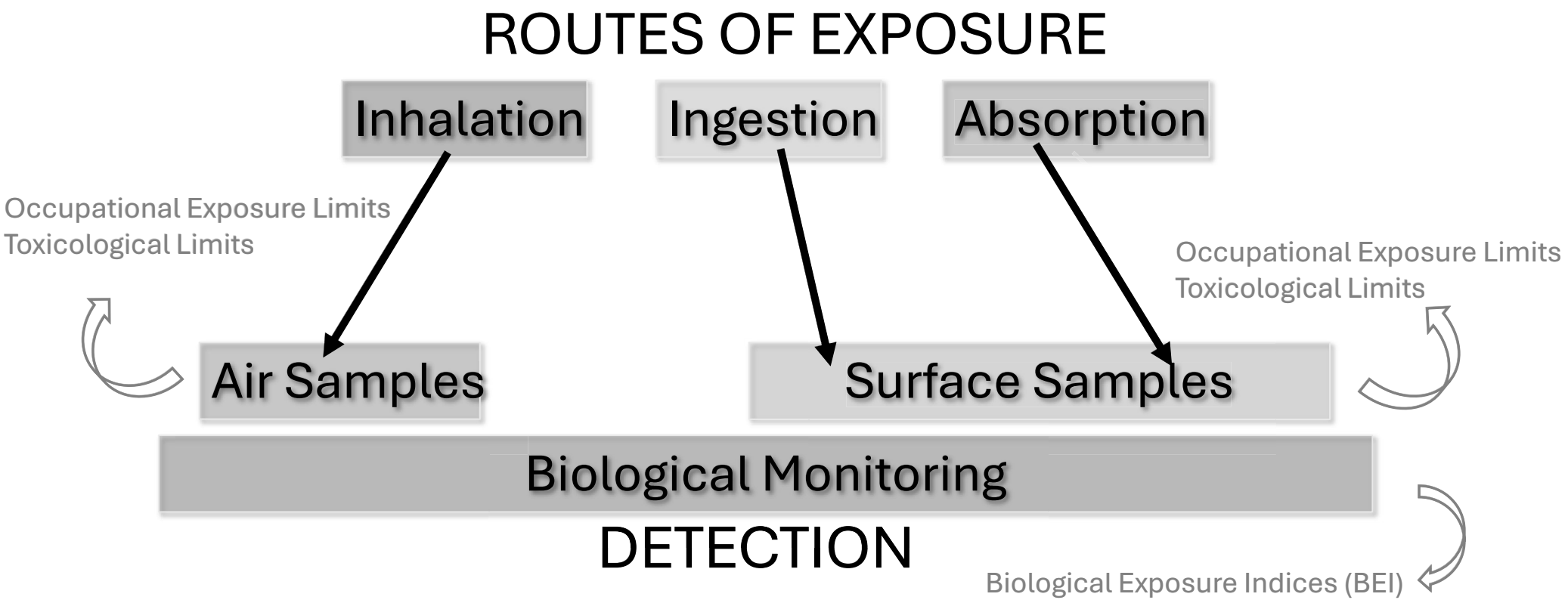

The Valve Museum

Evaluating Exposure

EXPOSURE the opportunity for the body to receive a dose substantial enough to result in an adverse health effect



Testing Methods

QUANTITATIVE

provides concentrations using accepted protocols for measuring exposure

- **Air sampling**

  (Volume:µg/m^3 or mg/m^3 or ng/m^3, ppm or ppb)
  - Particles
  - Chemical vapors

- **Wipe sampling**

  (Surface area: µg/cm^2 or µg/100cm^2 or µg/ft^2)
  - Particles

- **Bulk sampling**

  (Weight/Volume: mg/kg or ppm or mg/L)

QUALITATIVE

provides +/-, relative concentrations, and/or identification

- **X-ray Fluorescence (XRF)**
- **Spot Testing**
- **Analytical Testing**
  (not following standard industrial hygiene protocols)

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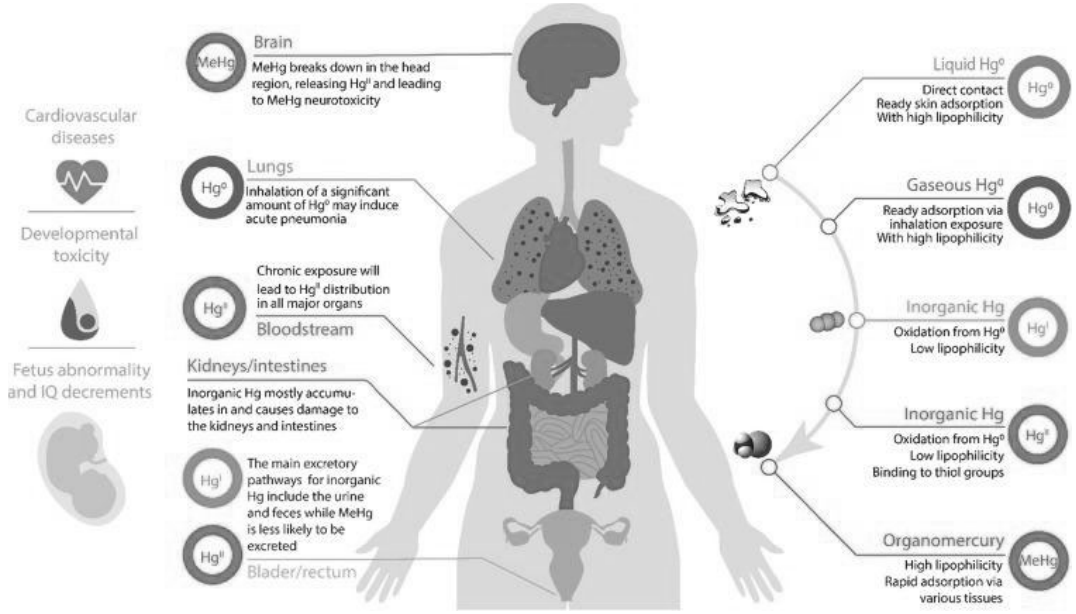
Health Effects

- Kidney, nervous system and heart toxicity
- Lung and eye irritation
- Chest pain
- Nausea, vomiting, diarrhea
- Skin rashes
- Memory loss
- Headache
- Sleeplessness
- Tremors
- Personality changes
- Mercuric chloride and methylmercury are possible carcinogens (EPA)
- Passes through placenta and blood brain barrier



Chengjun Li, et. al. (2021) The silver linings of mercury: Reconsideration of its impacts on living organisms from a multi-timescale perspective, Environment International, Volume 155.

Exposure Limits

The upper limit of the acceptable concentration of a hazardous substance for a particular material or class of materials, based on **available toxicological literature**

Exposure limits, if they exist, are based on <u>known</u> health effects, how particular target populations are most commonly exposed, and can vary by source/agency

Occupational (worker populations are generally male, healthy, younger, and chronically exposed over their worker hours/lifetime)

- Occupational Safety and Health Administration (OSHA)
- National Institute of Occupational Safety and Health (NIOSH)
- Environmental Protection Agency (EPA) under Toxic Substances Control Act (TSCA)
- American Congress of Governmental Industrial Hygienists (ACGIH)
- MAK Commission by the German Research Foundation (DFG)
- Employers

Environmental/Residential (all populations including children, elderly and health compromised that are exposed indoor and outdoor environments)

- Environmental Protection Agency (EPA)
- Agency for Toxic Substances and Disease Registry (ATSDR)
- World Health Organization (WHO)
- Food and Drug Administration (FDA)

Exposure Limits (Mercury)

The upper limit of the acceptable concentration of exposure to a hazardous substance, based on **available toxicological literature**

INHALATION

OSHA PEL: **100 µg/m³** (8-hour time weighted average)

NIOSH REL: **50 µg/m³** (10-hour time weighted average)

ACGIH TLV: **25 µg/m³** (8-hour time weighted average)

CEIL: **1000 µg/m³**

ATSDR: **< 1 µg/m³** (Residential occupancy level); **10 µg/m³** (Isolate residents from exposure); **3 µg/m³** (Occupational exposure)

MAK: **20 µg/m³**

Inhalation regulations focus largely on worker exposure in industrial settings such as gold miners and hat makers

INGESTION

ATSDR/CDC Minimal Risk Level (MRL): **0.1 µg/kg/day** chronic (>1 year) Methyl Mercury
0.3 µg/m³ chronic (>1 year) Mercury vapor
2 µg/kg/day (acute) Inorganic Mercury
0.01 µg/kg/day (acute) Inorganic Mercury

EPA/FDA: **2 ppb** (drinking water)
WHO: **6 ppb** (drinking water)

Ingestion regulations focus largely on the general population exposure to mercury through environmental contamination of food and water

ABSORPTION

No US established surface contamination exposure limits

MAK: **Skin absorption (H):** Cannot rely on exposure limit alone, because if skin contact occurs you may be over exposed; **Skin sensitization (SH)**

BEI: 15 µg/dL

Risk Management Strategies

Health & Safety Priorities

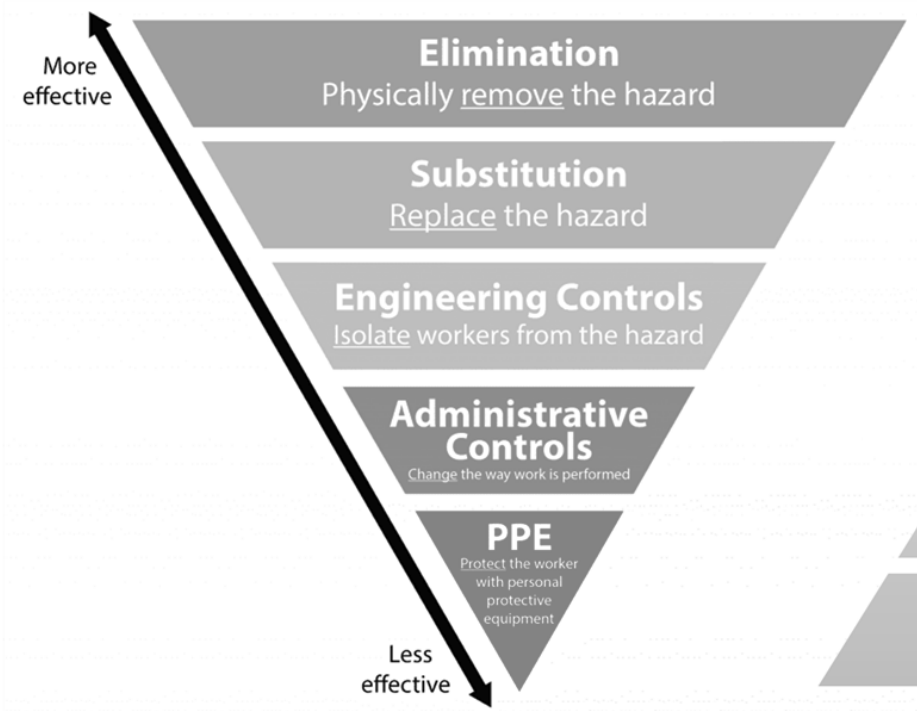


Image: CDC

Collections Priorities

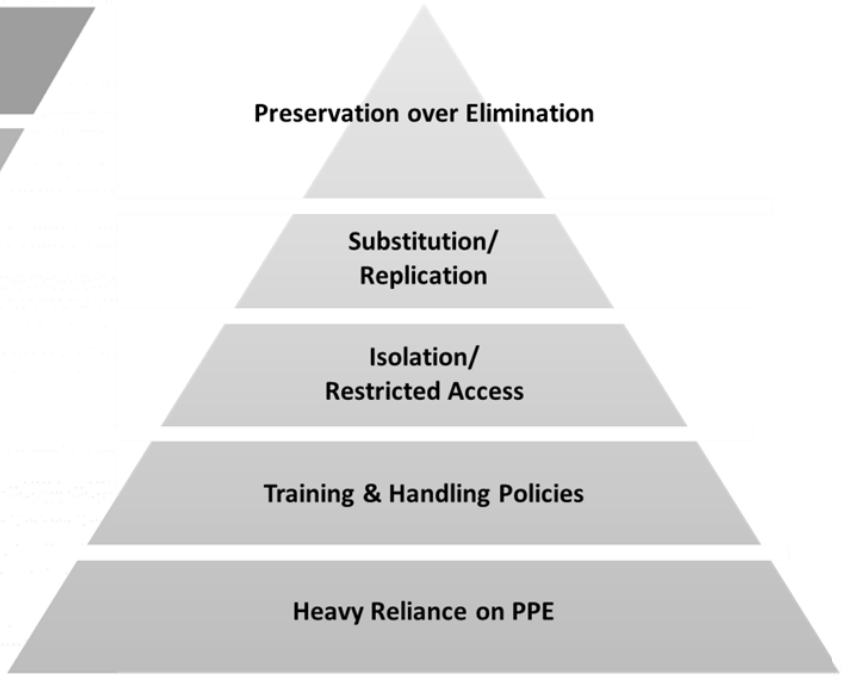


Image: Kerith Koss Schrager

Risk Management Strategies for Conservation

Hazardous collections can be safely handled and exhibited with the appropriate investment of resources:

- Time
- Funding
- Personnel
- Equipment
- Knowledge
- Training
- Purpose/Mission

Risk Management Strategies for Conservation

- Inhalation of vapor or resuspended particles can occur if objects or surfaces are disturbed
- Particles contaminating surfaces can be absorbed through the skin or accidentally ingested.
- Exposure controls should focus on:
    - Preventing contamination of surfaces
    - Proper personal hygiene
    - Providing appropriate ventilation and respiratory protection.

Cinnabar ore with mercury -indicating powder slide inside a bag with control slide on the outside of the bag after two weeks.
[Image: Donna Strahan/Taylor & Francis]

Risk Management Strategies for Conservation

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Elimination, Substitution & Isolation

- Properly dispose of hazardous materials
- Rapidly process incoming collections/specimens
- Decontaminate objects, if possible
- Use scavenger products
- Replicate, digitize, or replace
- Enclose in well-sealed containers, bags, drawers, or vitrines

Engineering & Administration

- Ventilation controls (e.g., fume hoods)
- Proper hygiene (e.g., handwashing)
- Minimize dust and resuspension of hazardous particles
- Use only mercury collection vacuums
- Clean storage containers and surfaces after use
- Cover surfaces with removable and/or disposable materials
- Segregate hazardous materials to prevent cross-contamination
- Transport in closed containers
- Minimize travel distances and agitation during handling
- Train users on proper handling

Personal Protective Equipment

- **HEPA particulate and mercury vapor cartridge**
- Gloves
- Goggles
- Protective clothing (disposable or easily cleanable such as Tyvek)

MOST EFFECTIVE

Provide universal protection regardless of the composition of the hazard, will protect the entire workplace, and do not rely on worker compliance

LEAST EFFECTIVE

May be hazard specific and only protects the user

Cleaning up Mercury Spills

Source: Melissa King

Small liquid mercury spills can be safely handled using appropriate precautions.

- ✓ Notify anyone in the immediate area of spill and evacuate individuals as necessary.
- ✓ Wear appropriate Personal Protective Equipment.
- ✓ Ventilate contaminated areas.
- ✓ Never use a broom or vacuum to collect liquid mercury, unless it is a specially designed mercury recovery vacuum.
- ✓ Commercial mercury spill kits, sponges and powders that sequester and contain the liquid should be used for collection.
- ✓ Sprays, powders and papers are also produced for controlling mercury vapor levels.
- ✓ If spill kits are not available, gently collect beads of mercury into sealed containers using disposable materials.
- ✓ Never pour liquid mercury down the drain.
- ✓ Dispose of clothing and any absorbent materials that have come in contact with mercury and do not launder contaminated material in a washing machine.
- ✓ Be particularly aware of tracking liquid mercury on shoes.
- ✓ All contaminated items should be placed in sealed containers, clearly labeled and disposed of according to state, local, and institutional regulations.

Cleaning up Mercury Spills

Source: Melissa King

Spills of more than the amount in a thermometer, but less than one pound

- ✓ Ventilate and restrict access to area
- ✓ Call your local health or fire department as soon as possible.

Spills of one pound or more (~ two tablespoons or more)

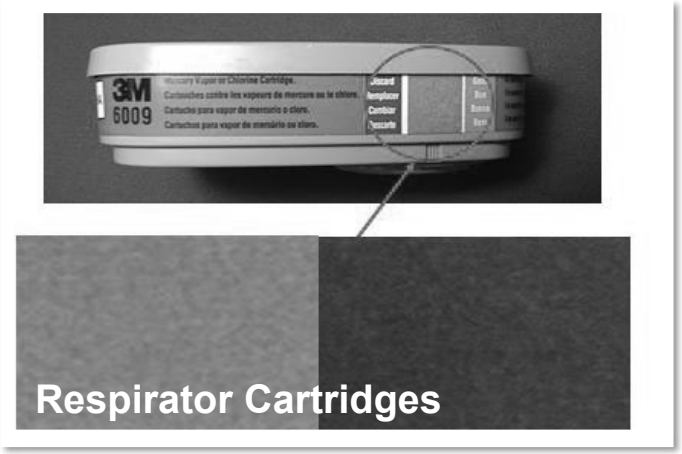
- ✓ Any time one pound or more of mercury is released to the environment, it is mandatory to call the

National Response Center (NRC) (800) 424-8802

All hazardous or *potentially* contaminated materials may be considered Regulated Hazardous Waste.

Mercury-Specific Supplies [Monitoring, Clean up, PPE]

Vapor Monitor (Real-Time)



SUPPLIERS

Spill Kits
- Grainger
- New Pig
- Flynn Scientific
- Sigma-Aldrich
- Amazon
- Etc.

Vapor Monitors (Real-Time)
- Environmental Health Equipment Rental Companies

Wipes & Passive Monitors
- Assay Technologies
- SKC
- Chemteq
- Etc.

HAZARD COMMUNICATION

Consider exposure for not only you, but everyone in your immediate workspace, within the entire organization as well as borrowing institutions.

2.2 GHS Label elements, including precautionary statements

Pictogram

Signal Word	Danger
Hazard Statements	
H300	Fatal if swallowed.
H314	Causes severe skin burns and eye damage.
H341	Suspected of causing genetic defects.
H361	Suspected of damaging fertility or the unborn child.
H372	Causes damage to organs through prolonged or repeated exposure.
H410	Very toxic to aquatic life with long lasting effects.

- **Hazard & Safe Practice Alerts** to all staff and visiting researchers
- **Warning signs** and labels on objects, storage rooms doors and/or shelves
- **Catalog entries and treatment records** should be updated and clearly disclose hazards on new acquisitions or newly discovered hazards on existing collection items
- **Access restrictions** for cases or storage areas that may require special ventilation or other pre-retrieval measures
- **Loan and accession documentation** *must* disclose known or suspected hazardous materials.
- **Training** for anyone who encounters hazardous materials to understand proper handing, disposal and treatment protocols