Issues Dealing With Safe Handling of Mercury

Philip T. Spampinato
(spampinatop@ornl.gov, 865-576-5267)

Tony A. Gabriel
(gabrielta@ornl.gov, 865-574-6082)

Meeting on High-Power Mercury Jet Experiment

May 26-27, 2004

CERN
Geneva, Switzerland

NUCLEAR SCIENCE AND TECHNOLOGY DIVISION
OAK RIDGE NATIONAL LABORATORY
U.S. DEPARTMENT OF ENERGY

UT-BATTELLE

Outline

- Properties, Safety Limits and Standards
- SNS Target Test Facility/WNR
- Installing Hg into the TTF
- Standard Hg Containers/Pallets
- Monitoring Hg Vapors
- SNS Hg Experience Installing New Equipment
- Conclusions

Properties, Safety Limits, Standards

- Atomic Weight: 200.59
- Boiling Point: 357 degree C
- Specific Gravity: 13.6
- Vapor Pressure: 0.0012 mm Hg
- Vapor Density: 7.0
- Vapors: colorless, odorless
- Solubility: insoluble in water
- NIOSH/OSHA: 0.05 mg/m^3, 10 h/day; 40 h/wk
- Max. permissible exposure <0.10 mg/m^3

Mercury Health Effects

Exposure Route	*Acute Effects*	*Chronic Effects*
Ingestion	Acute poisoning following ingestion causes metallic taste, thirst, abdominal pain, vomiting, and diarrhea. May damage kidneys and central nervous system. Death may occur from uremia.	Chronic ingestion causes skin disorders, salivation, diarrhea, anemia, leukopenia, liver and kidney damage.
Skin Contact	May be absorbed through the skin causing effects similar to those of acute inhalation.	May be absorbed through the skin causing effects similar to those of chronic inhalation.
Eye Contact	May cause irritation.	None known.
Inhalation	Inhalation of vapor results in dyspnea, cough, fever, nausea, vomiting, diarrhea, stomatitis, salivation, and metallic taste. Pulmonary disturbances may follow. Anuria may occur. May damage the lungs, liver, kidneys, central nervous system and reproductive system.	Chronic inhalation may result in tremors, salivation, stomatitis, loosening of the teeth, blue gum line, peripheral neuropathy, nephritis, diarrhea, anxiety, headache, weight loss, anorexia, and psychic disturbances.
Most Likely Routes of Entry	Ingestion, skin absorption, inhalation of vapors	

Mercury First Aid Instruction

Exposure Route	***Treatment***
Ingestion	Induce vomiting. Get medical attention immediately.
Skin Contact	Remove contaminated clothing and shoes immediately. Wash affected area with soap or mild detergent and large amounts of water until no evidence of chemical remains (approx. 15-20 minutes). Get medical attention immediately.
Eye Contact	Wash eyes immediately with large amounts of water or normal saline, occasionally lifting upper and lower lids, until no evidence of chemical remains (approx. 15-20 minutes). Get medical attention immediately.
Inhalation	Remove from exposure area to fresh air immediately. If breathing has stopped, give artificial respiration if qualified personnel are available. Maintain airway and blood pressure and administer oxygen if qualified personnel are available. Keep affected person warm and at rest. Get medical attention immediately.

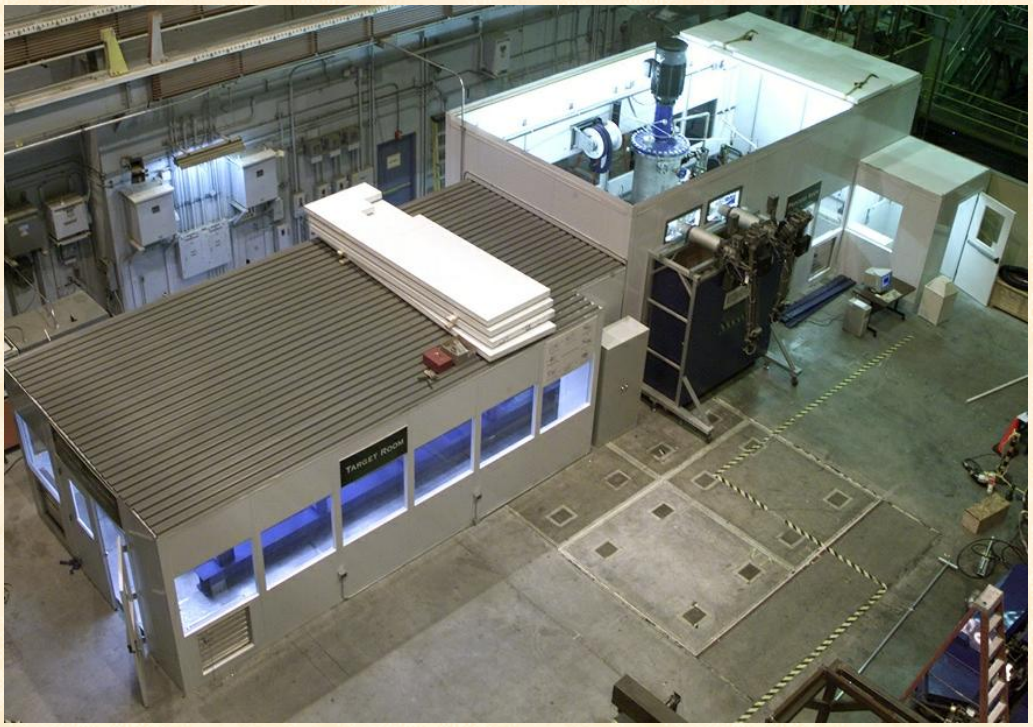
Mercury Vapors

- Look at video clip that shows Hg vapors

http://www.deq.state.mi.us/documents/deq-ead-p2-mercury-bb-Vapors.wmv

The Target Test Facility (TTF) Background Information

- Full scale, prototype of SNS Hg flow loop
- 1400 liters of Hg
- Used to determine flow characteristics
- Develop hands on operating experience
- Assess key remote handling design issues



TTF Pump Room and Target Room

- 75 Hp centrifugal pump
- Nominal flow at 1450 liters/min (380 gpm)
- Completed several equipment upgrades to the piping and target configuration

Mercury Containers/Shipping

- Standard flask is 2 liters
- Flask + Hg weighs ~35 kg

TTF Operations – Hg Filling

- Peristaltic pump was successfully tested
- Tipping fixture was tested but not used

Filling (cont.)

- TTF vacuum pump was used to transfer Hg directly into the storage tank
  - Lower risk than using the peristaltic pump
  - Faster operation, ~ 1-1/2 minutes per flask

TTF Access and Personal Protective Equipment – Minimum Requirements

Category[1]	Activity	**Hg Vapor Level (mg/m^3)**	**Access & PPE Requirements**	**Hg Vapor Level (mg/m^3)**	**Access & PPE Requirements**
I	Visitor / walkthrough	< 0.012	Shoe Covers Gloves Lab coat	≥0.012	No Visitor Access
II	Light hands-on (target room sensor adjustments, vacuum pump operation, etc.)	< 0.012	Cat I Requirements	≥0.012	Shoe Covers Gloves Lab coat over Company-issued clothing Respirator[2]
III	Opening "minor" (≤1" in diameter) components in mercury system	< 0.012	Cat I Requirements + Company Clothing	≥0.012	Cat II Requirements
IV	Maintenance / cleanup activities (opening flanges, spill containment, etc.)	< 0.012	Cat I Requirements + Company Clothing + Coveralls in lieu of lab coat	≥0.012	Cat II Requirements + Coveralls in lieu of lab coat

Notes:

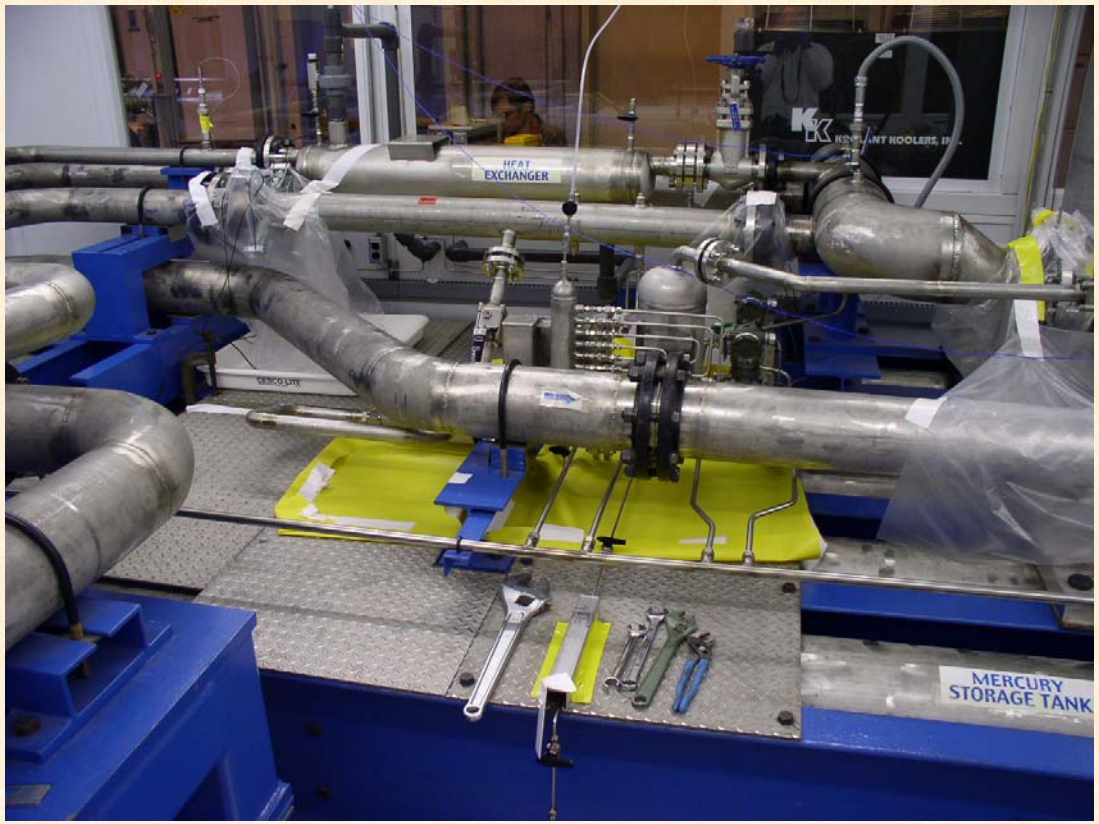
1. Access requirements for any activities not clearly falling into one of the above categories or if the Hg vapor level is at or exceeds 1.25 mg/m^3 will be evaluated on a case-by-case basis
2. Respirator usage not required if portable Hg vapor monitor readings in the immediate work area are less than 0.012 mg/m^3
3. Portable Hg vapor monitoring shall be performed for all Category III & Category IV operations. Local ventilation also required.

Mercury Monitoring

- TTF Uses Three Jerome 431-X Vapor Analyzers
  - One monitor dedicated to each room, connected to the Target Test Facility PLC
  - A portable monitor used during interventions
- The Jerome analyzer has a range of 0.000 – 0.999 mg/m^3
  - Sensitivity is 0.003 mg/m^3
  - Measures the change in resistance across a gold film as a function of Hg vapor
- Many other monitors are available

Equipment Experience: Installation of He Bubbler

- Bubbler test equipment was recently added to TTF
- He leak tested all joints at 25 psig before filling with Hg

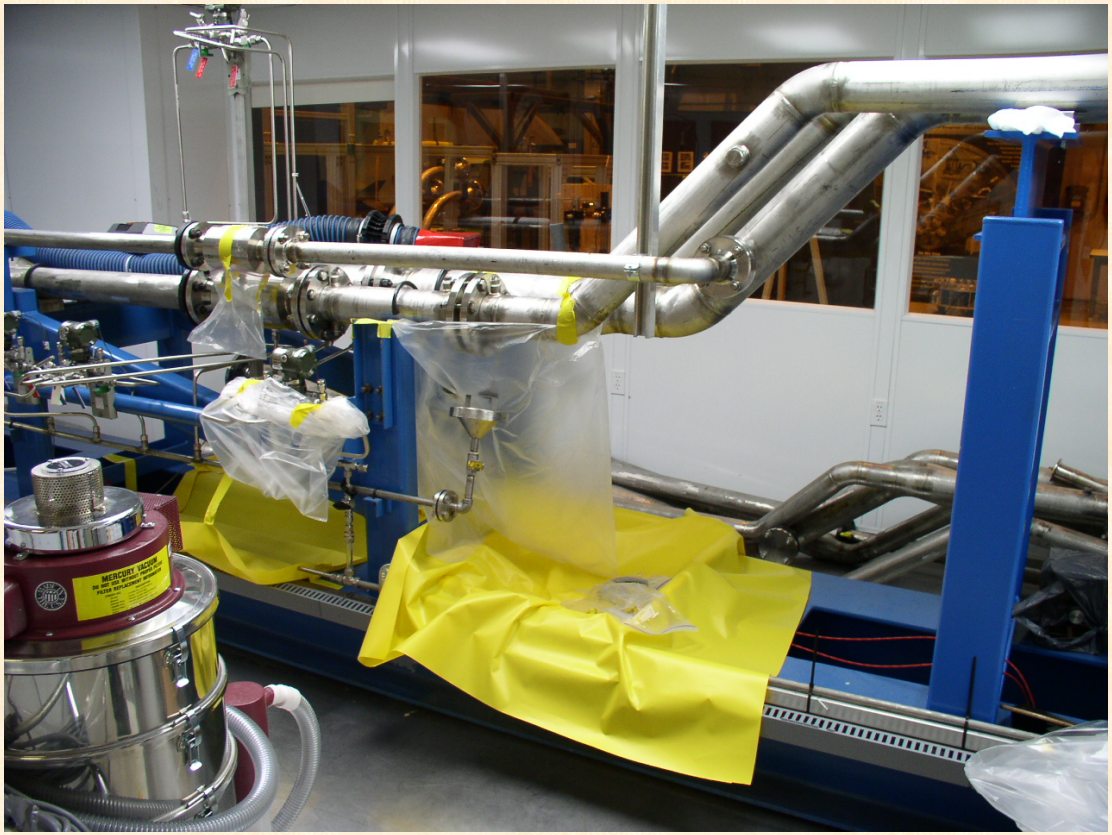


Proper Dressing Is Mandatory

- Overalls, gloves, and overshoes are the minimum requirement

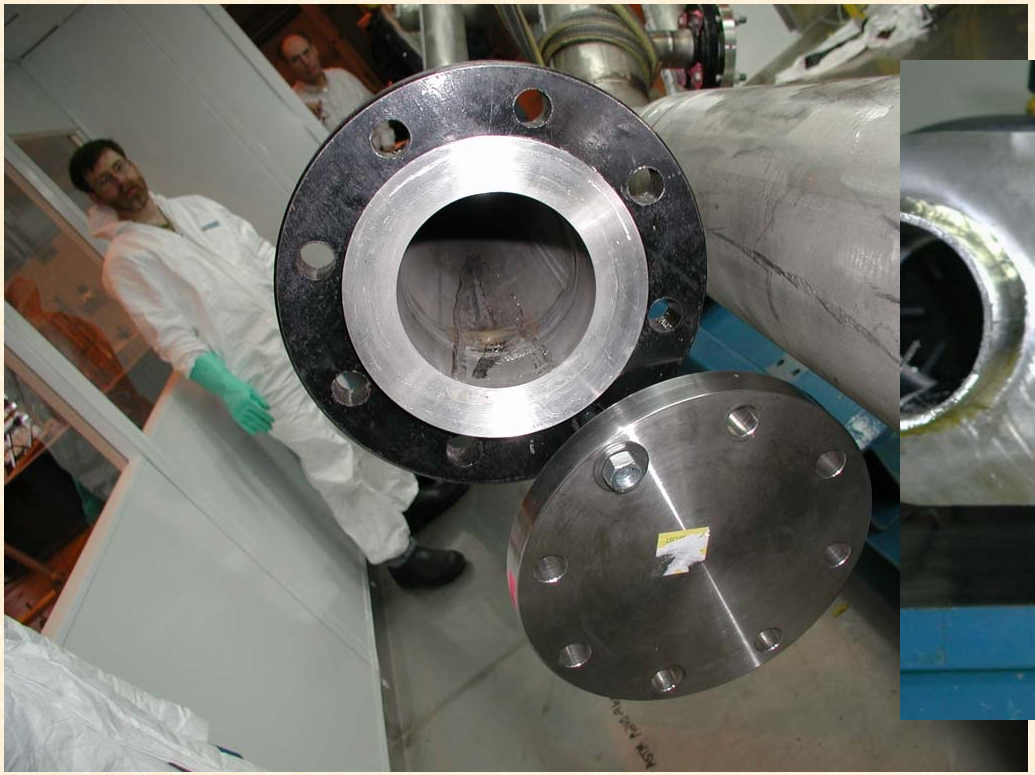
TTF Operations - Containment

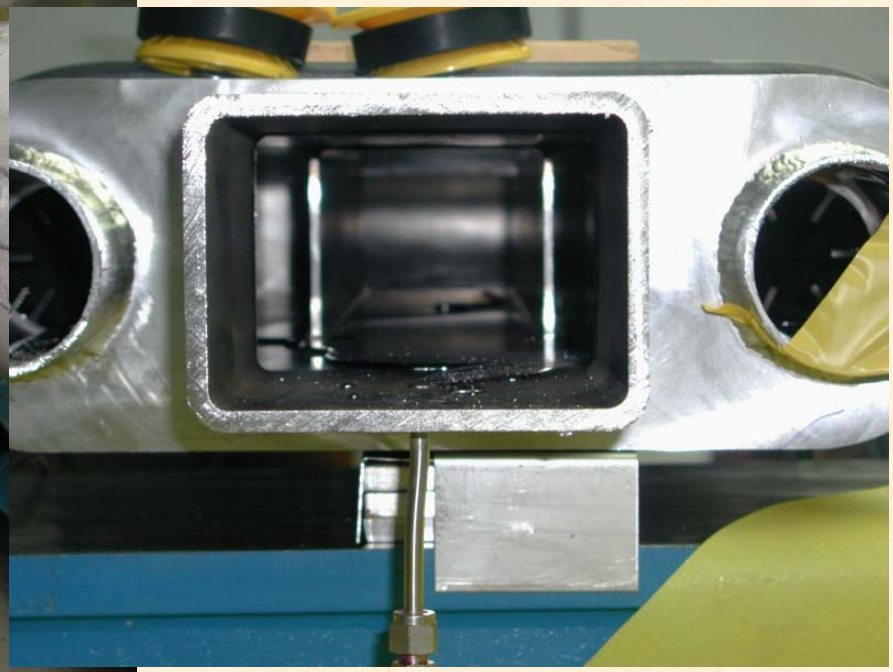
- You cannot have too much containment!



Mercury Puddling

- Mercury will collect into small droplets and large puddles even in pipes sloped at 1 degree





Mercury Decontamination/Cleanup

- HgX is a water soluble, metallic-mercury/sulfide converting powder with a chelating compound and dispersing agent
  - Forms a film over finely divided Hg beads, producing a non-vaporizing sulfide
  - Mix with water as needed
  - Apply with sponge
  - Low cost

Mercury Decon/Cleanup (cont.)

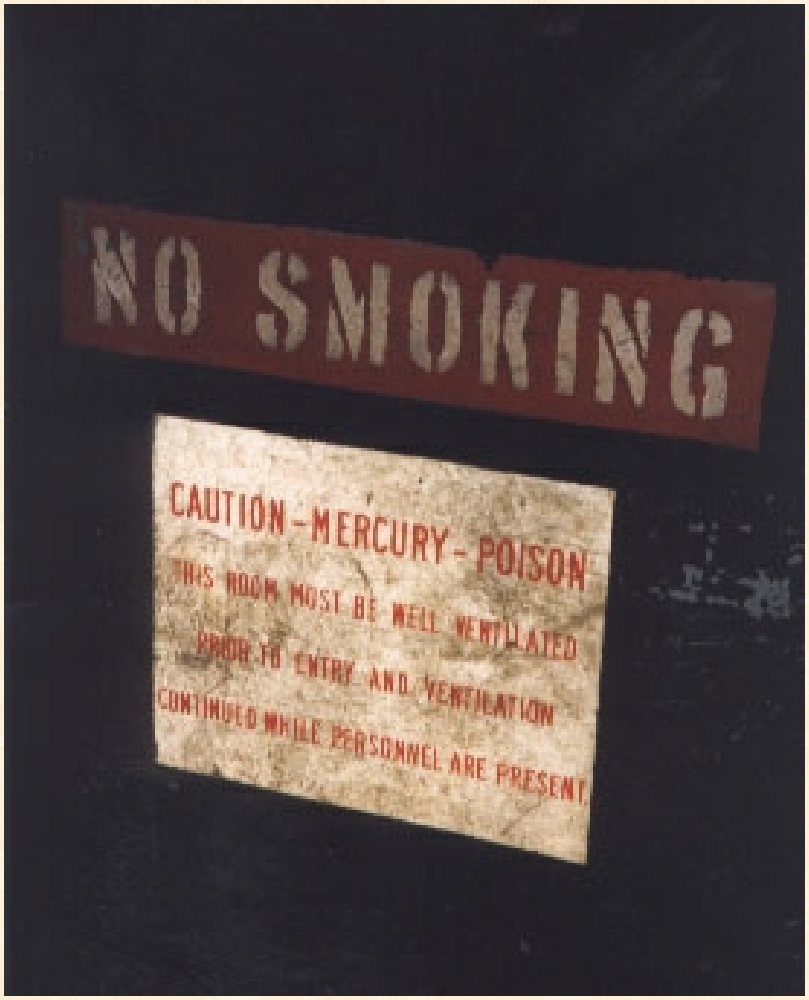
- HEPA Vacuum
- RCRA and non-RCRA waste collection

TTF Ventilation System

- 5 air changes/h
- Flow velocity at 25-32 ft/s (~9 m/s)
- Sulfide-impregnated charcoal filter in-line with the building ventilation

Hg Was Used As An Anti-Friction Medium

- Example of late 19th century precaution
- Hg was used as bearing material in lighthouse lamp mechanisms
  - the rotating mechanism was floated in a Hg pool



Handling Activated Hg Adds Another Level of Concern

- Small quantity of Hg was released somehow from handling the target
- Vapor monitor would have alerted the presence of Hg
- Herculite taped to floor area
- ~3 x 10^3 dpm/100 cm^2 contamination level

Activated Hg (cont.)

- One person's clothing was given up
- Everyone's shoes were given up

- Contamination level although very low, was reportable
- Calculated to be micro- or pico-grams ??

Conclusions

- ORNL has extensive experience handling Hg based on operating the TTF and other smaller test loops
  - 1400 liters, full scale SNS flow loop
  - Hg was installed with a vacuum pump; extensive use of spill containment; He leak check before operating
  - Developed procedures for operating TTF and safe handling of Hg
- Numerous interventions have been undertaken to add/modify TTF test equipment
  - Experience with dismantling pipe flanges, pipe cutting, and welding
  - Vapor monitors always in use; decontamination using HgX and HEPA vacuum
- Handling activated mercury requires these same precautions and procedures, but at an even higher level of alertness