

Containerized Elemental Mercury – Above Ground Storage Considerations

Bill Hermes

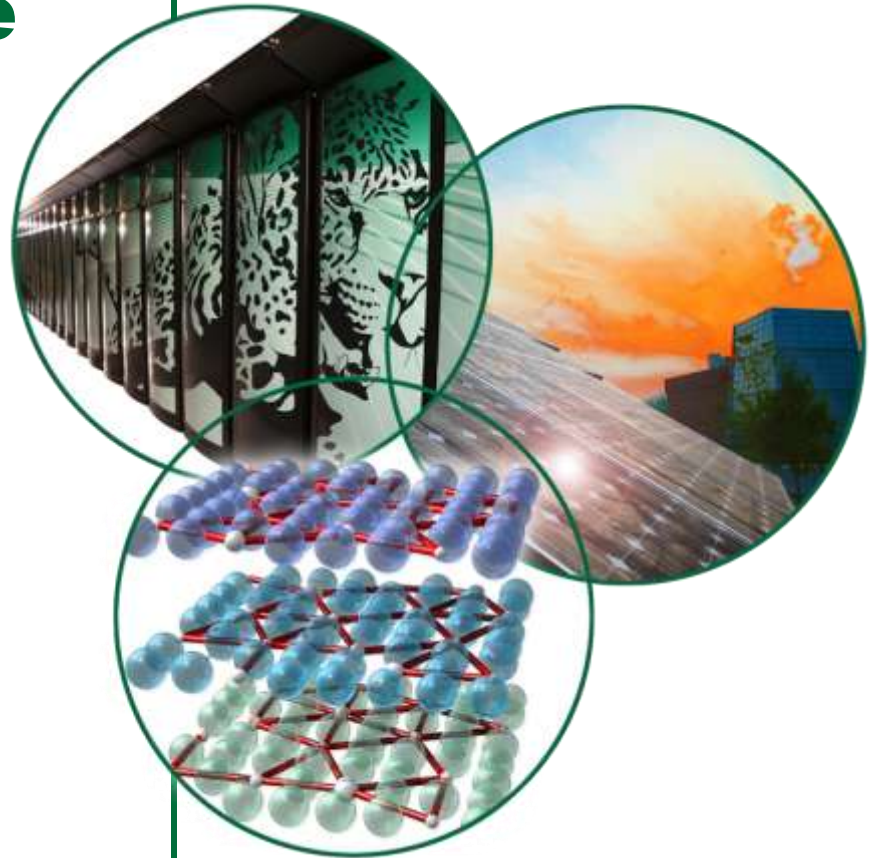
**Radiochemical Process and
Facility Design Group**

**Nuclear Science & Technology Division
Oak Ridge National Laboratory**

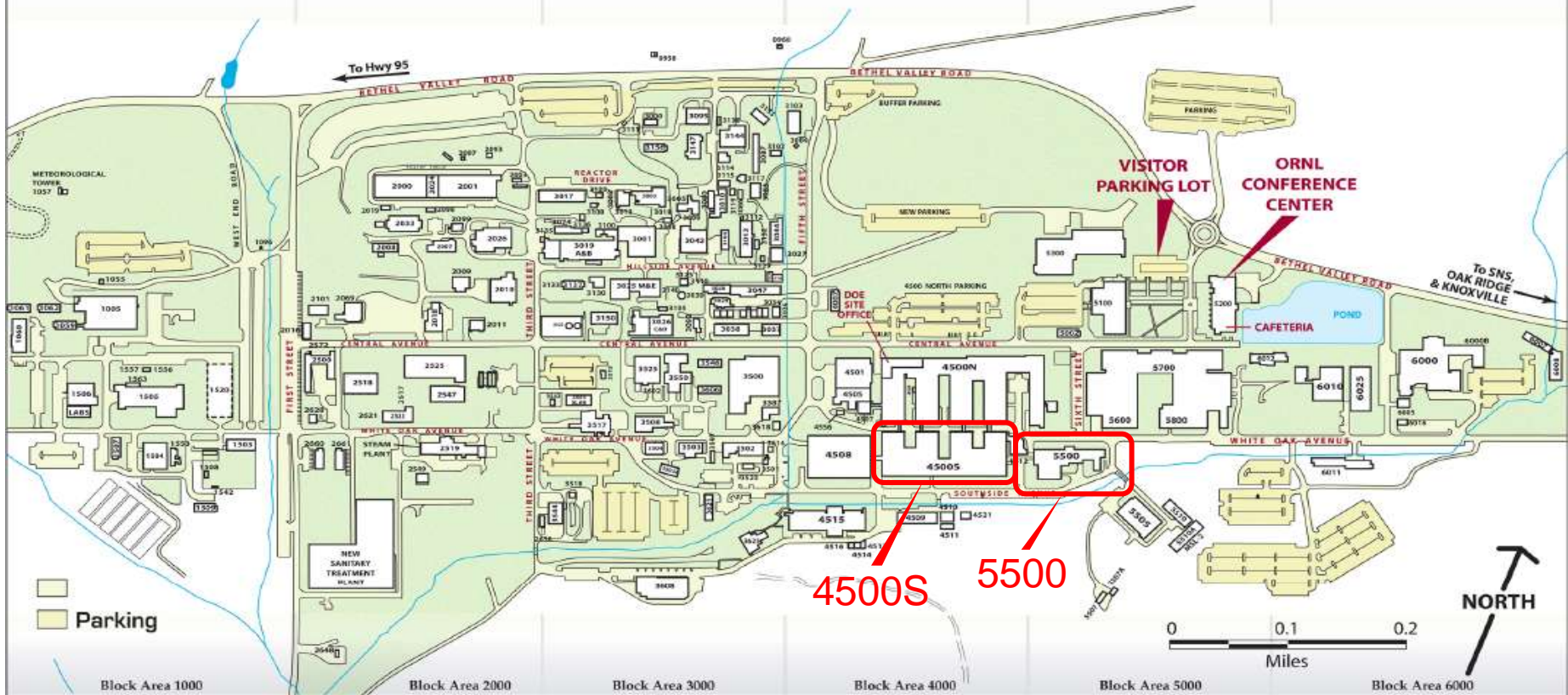
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Oak Ridge National Laboratory Main Campus



1005 Laboratory for Comparative and Functional Genomics
 1503 Emergency Operations Center
 1505 Environmental Sciences
 1520 Joint Institute for Biological Sciences (under construction)
 2518 Fire Station
 3001 Graphite Reactor
 4500N/4500S Chemical and Material Sciences Facility

4508 Metals and Ceramics Facility
 4512 Laboratory Shift Superintendent Office
 4515 High Temperature Materials Laboratory
 5100 National Institute for Computational Sciences/Oak Ridge Center for Advanced Studies
 5200 Research Support Center - Visitor Center/Conference Center/Cafeteria
 5300 Multipurpose Research Facility (under construction)
 5600 Computational Sciences

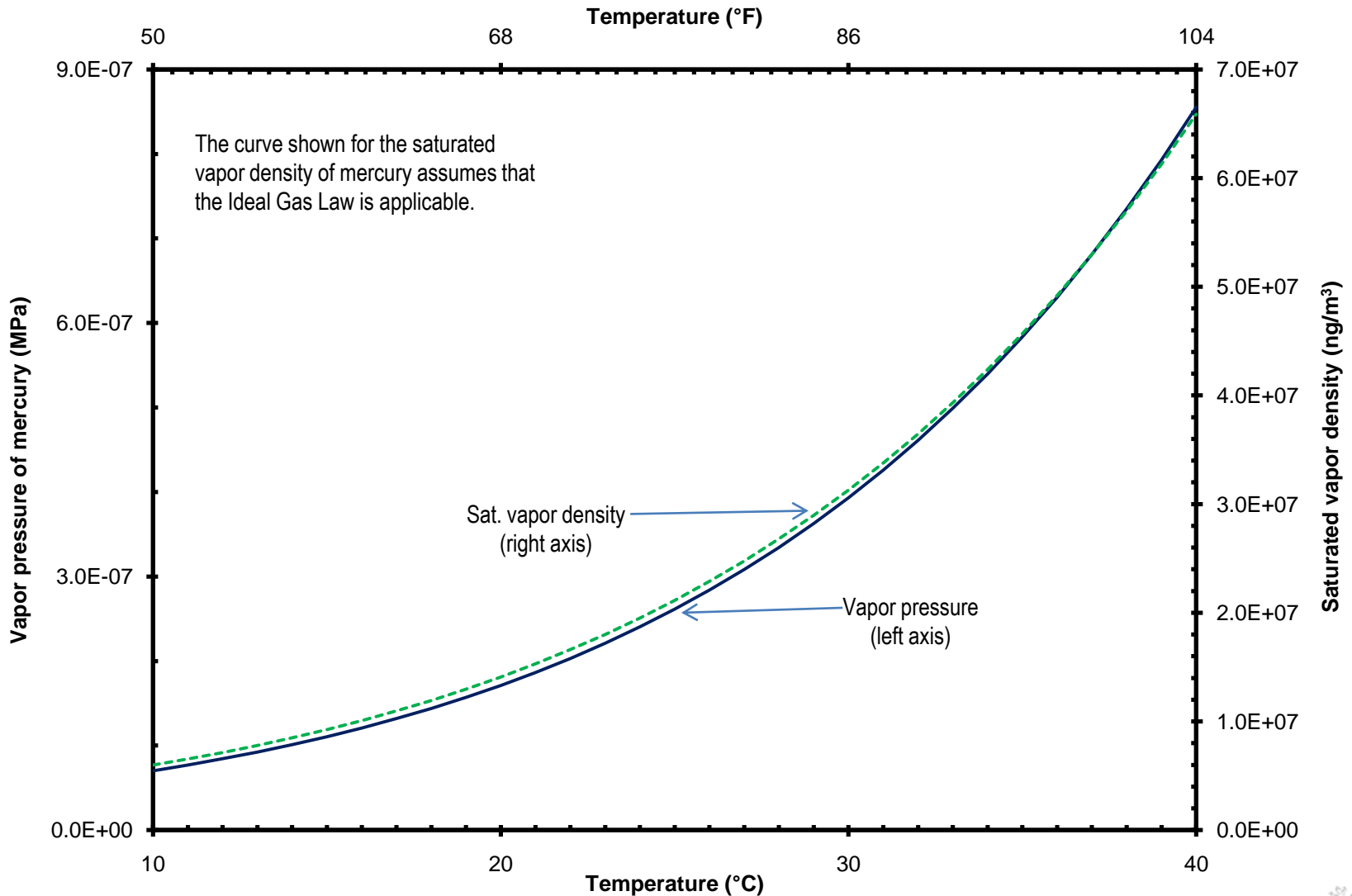
5700 Research Office Building
 5800 Engineering Technology Facility
 6000 Holifield Radioactive Ion Beam Facility
 6008 Joint Institute for Heavy Ion Research

ORNL 2007-G00360A/asg

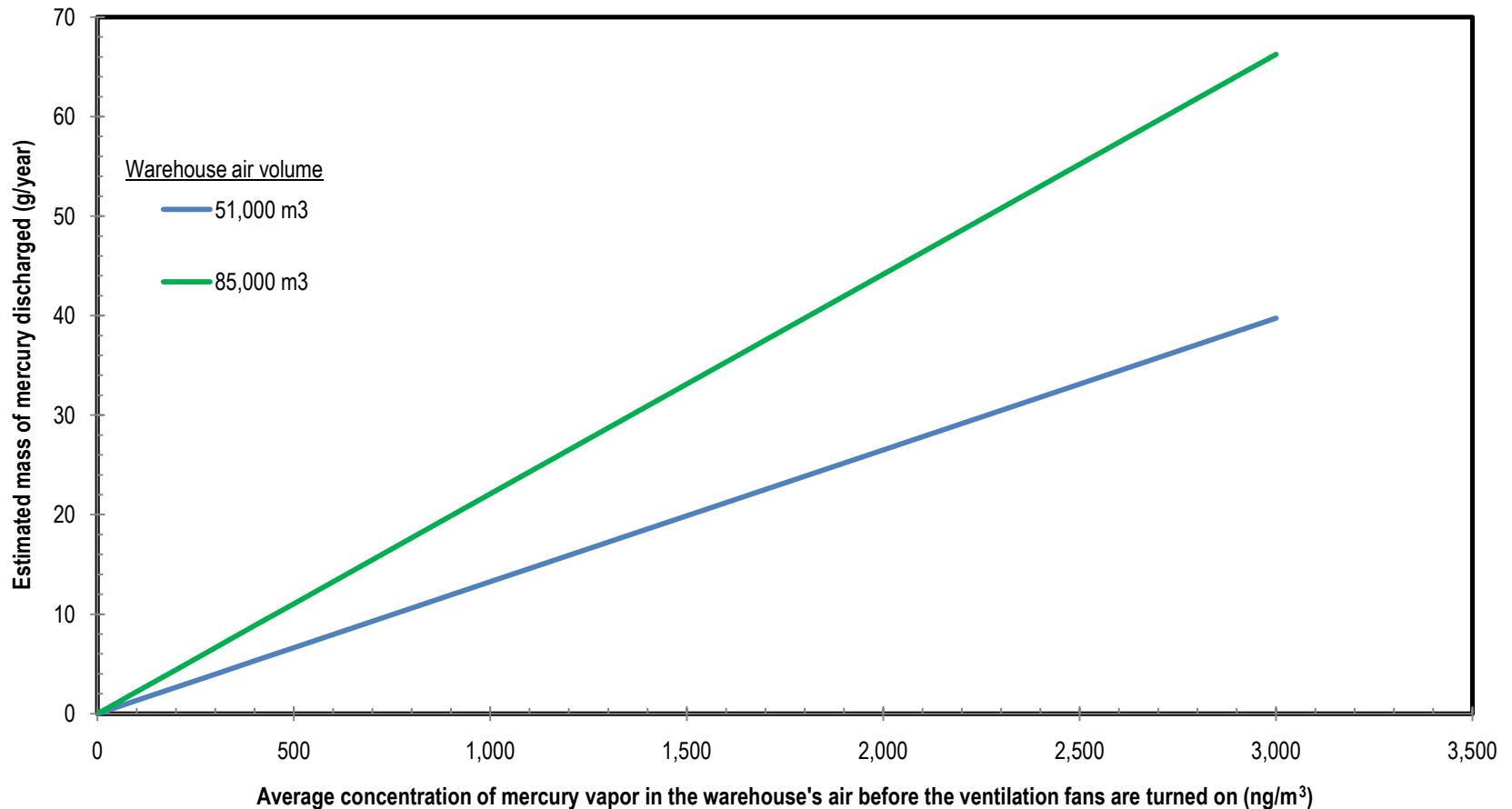
Mercury Stockpile Research Team – Principal Investigator Team

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Facility Inspections, Analyzers, Drum Laboratory Investigator	Stockpile History, Inventory, Containers, Environmental, co-PM
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Lead - Chemistry, Flask Laboratory Investigator	
Catherine Mattus e-mail: mattusch@ornl.gov phone: 865-574-6793	

Saturated Mercury Vapor and Temperature (10 – 40°C)



Emissions Model – Graph for the two building sizes



ORNL Energy Systems Test Complex

(Historically, also referred to as “EGCR”, “Fuel Recycle” and “Robotics”)



Assess the Integrity of the Flasks from the Government Mercury Stockpile?

- The stockpile contains ~ 128,000 mercury flasks that are over 40 years old and for which little data exist
- Assess the long term storage integrity of the existing mercury stockpile
- A test plan to characterize the flasks was defined and executed on 240 flasks
- Data collected during the past inventory inspections was used to select flasks

Typical DNSC mercury drums on drip pans on pallets banded for shipping



Flasks of mercury stored in a drum



Building 7604



List of major tests performed to assess the flasks' integrity included:

- Measurement of vapor [Hg] in drum headspace,
- Checking the flask surface contamination with Lumex (ES&H),
- Flask visual observation – pictures,
- Wiping flask for analytical purpose, then cleaning them for ES&H,
- Analyses of selected wipes for contamination quantification,
- Physical measurements using calipers,
- Thickness of the flask walls by ultrasonic technique --UTT,
- Composition of the metal from the flask walls -- XRF,
- Weighing of full flask,
- Mercury emptying from selected flasks,
- Observation of some emptied flasks by radiography -- X-RAYS,
- Determination of emptied flasks' volume,
- Hydropressure testing of some flasks to failure,
- Flasks cutting for internal observation – CUT,
- Examination of cut pieces for internal corrosion,
- Confirmatory wall thickness measurements using a caliper; laser scan
- Metallography on selected flasks (Steve Pawel et al)
- Total chemical analyses by burn test

Procedures for Handling and Lifting 76-lb flasks



4351.jpg



4353.jpg



4355-1.jpg



4355-2.jpg



4355-3.jpg



4356.jpg

Transfer Operations and Intermediate Container for Inspecting Transferred Mercury



Mercury Vapor Concentrations in Drums

- Mercury evaporates slowly
- Liquid leak causes spike in vapor concentration, but evaporation soon stops
- Surfaces adsorb most of mercury from air
- Adsorbent capacity of drum contents is large; much larger than vapor capacity
- *Conclusion:* It is impractical to detect leaks inside the drum by measuring head space vapor concentration

Flasks and welds do not comply with today's state of the art construction but the flasks lasted > 40 years



Flasks size and volume are not uniform in the stockpile (here are the extreme found)

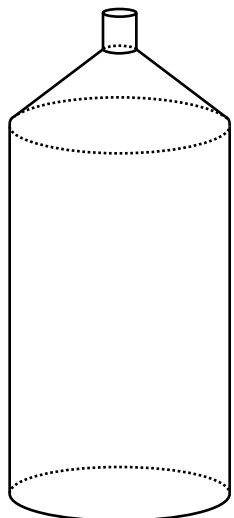


**NH-02612-E-T11B
~ 220 mm tall and 140 mm dia.**

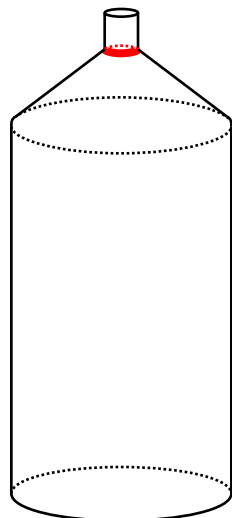


**NH-02149-A-T7
~ 490 mm tall and 100 mm dia.**

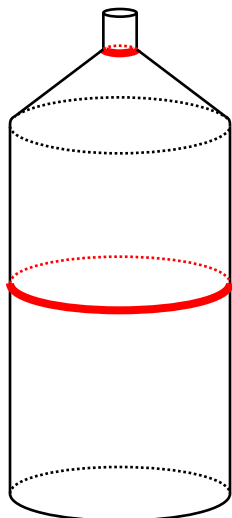
Six different types of flasks construction



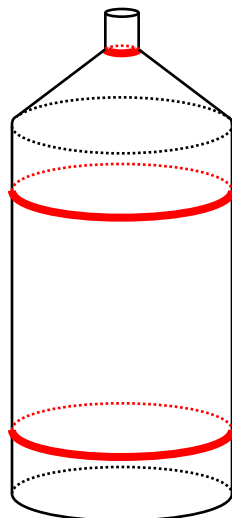
Seamless
22.494%



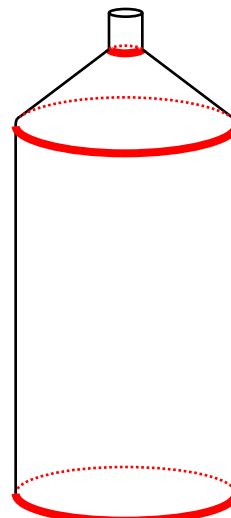
1 weld
15.65%



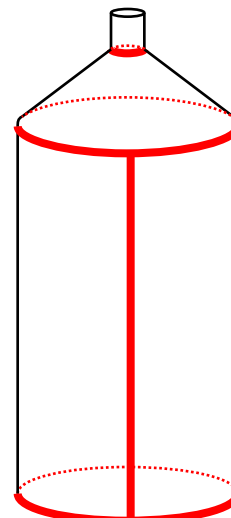
2 welds
1.84%



3 welds
6.09%



3 welds
0.412%



4 welds
44.65%

T4* - 0.36%

T8-T8B-1.15%

T12-0.10%

T13-15.97%

T15-4.65%

T17-<0.005%

T19-0.18%

T31-0.08%

T3*-15.55%

T10-0.05%

T17B-<0.005%

T28-0.009%

T30-0.04%

T1-1.71%

T20-0.13%

T2-6.09%

T7-T7B-0.12%

T9-0.15%

T11-0.01%

T14-0.07%

T22-0.002%

T27-0.06%

T5-44.55%

T11B-0.01%

T16-T16B-0.06%

T24-0.03%

* T3 AND T4 HAVE A BOTTOM PLUG

Special Equipment



Band Saw Containment Tent

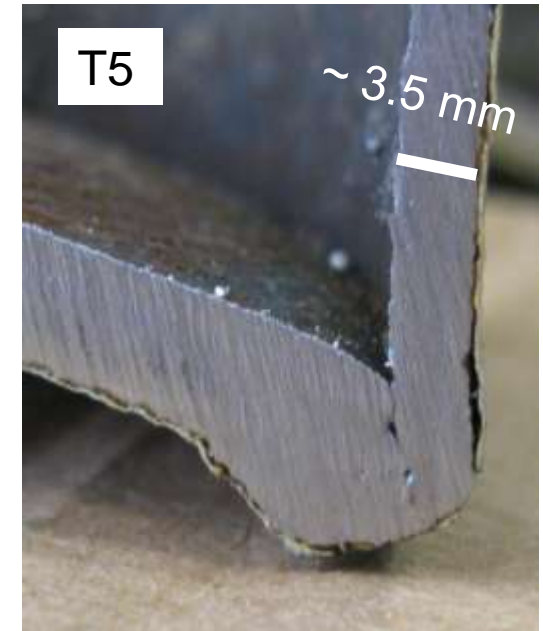
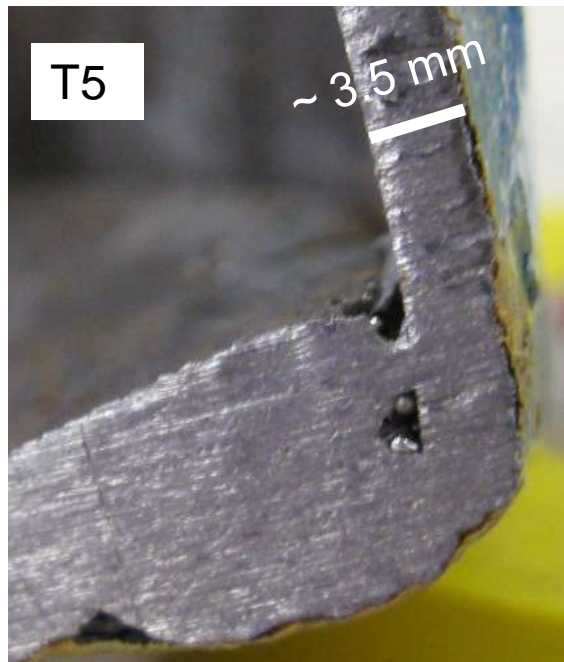
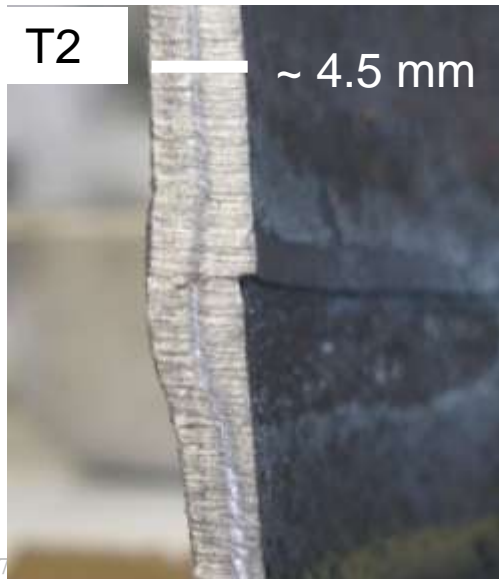
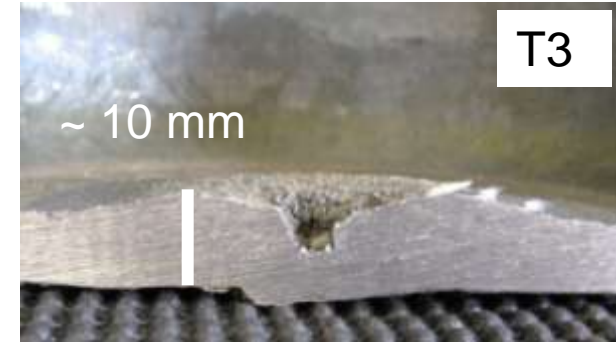
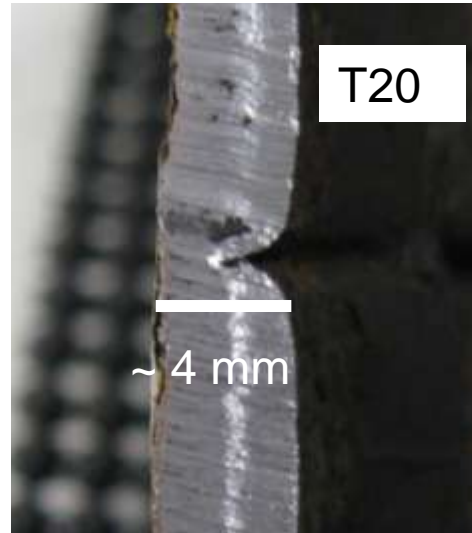
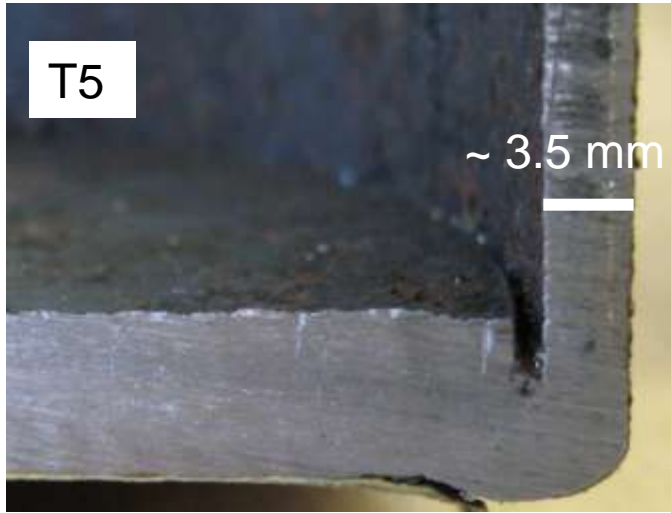


Portable Snorkel Containing Sulfide Impregnated Filters

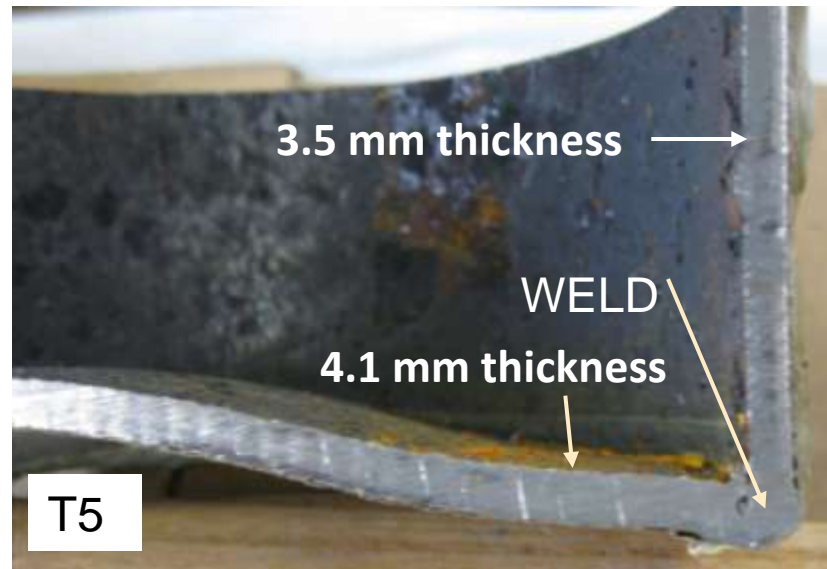
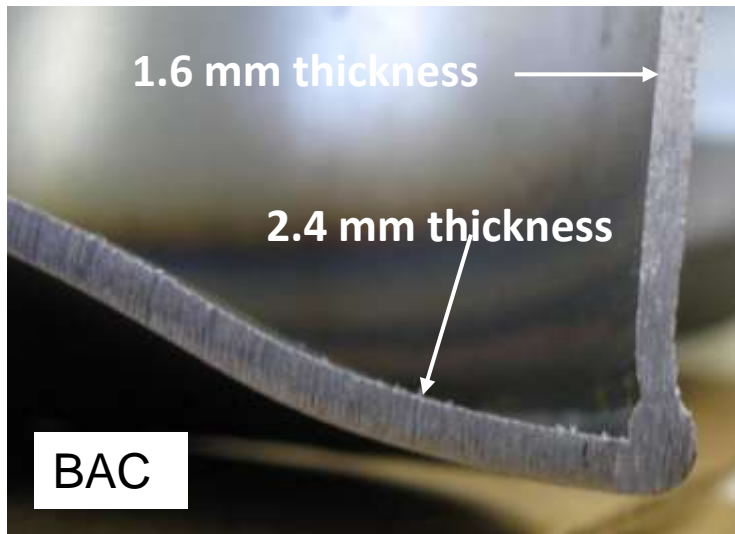
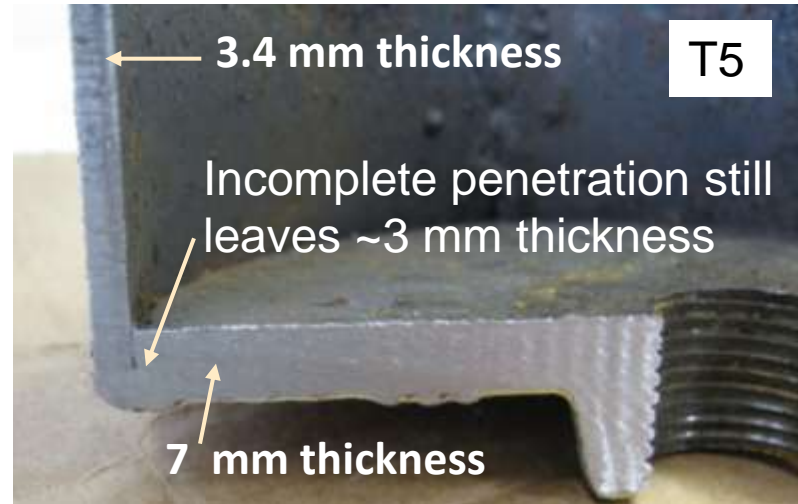
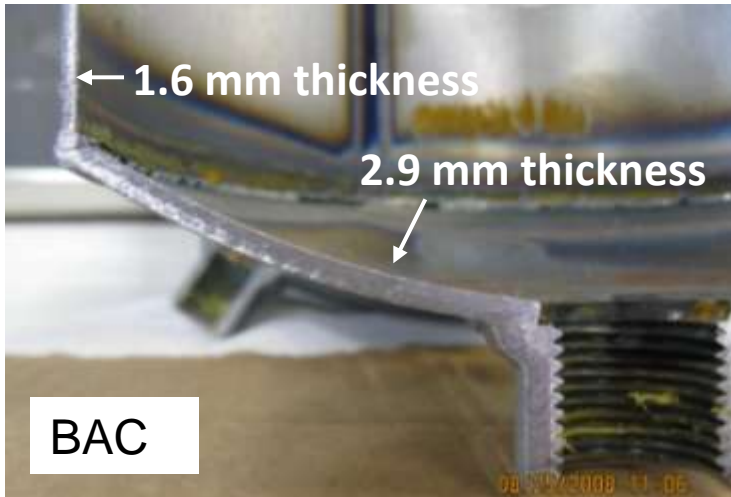


Peristaltic Pump Set Up

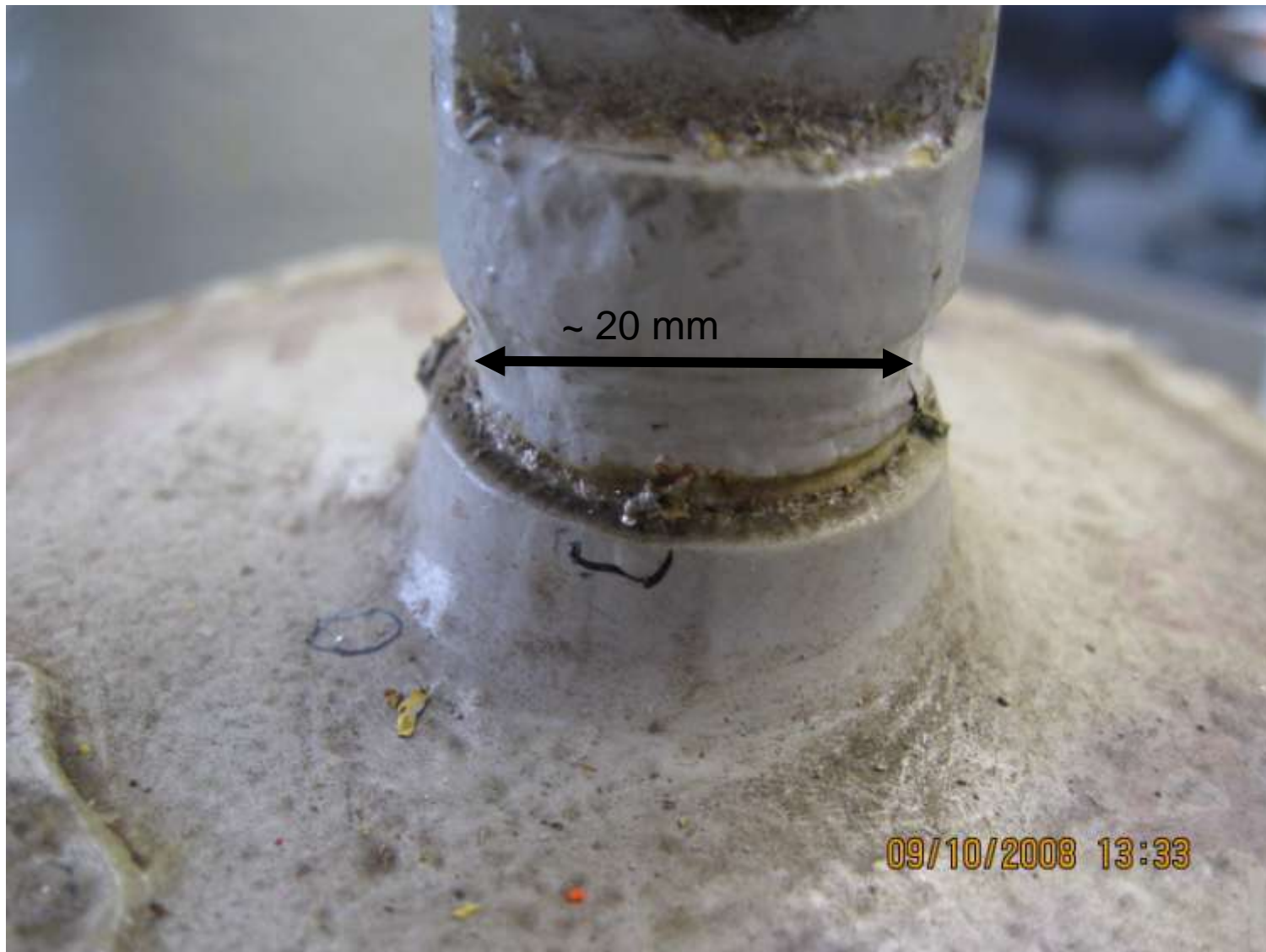
Questionable welds and flask construction were presented in Steve Pawel's presentation



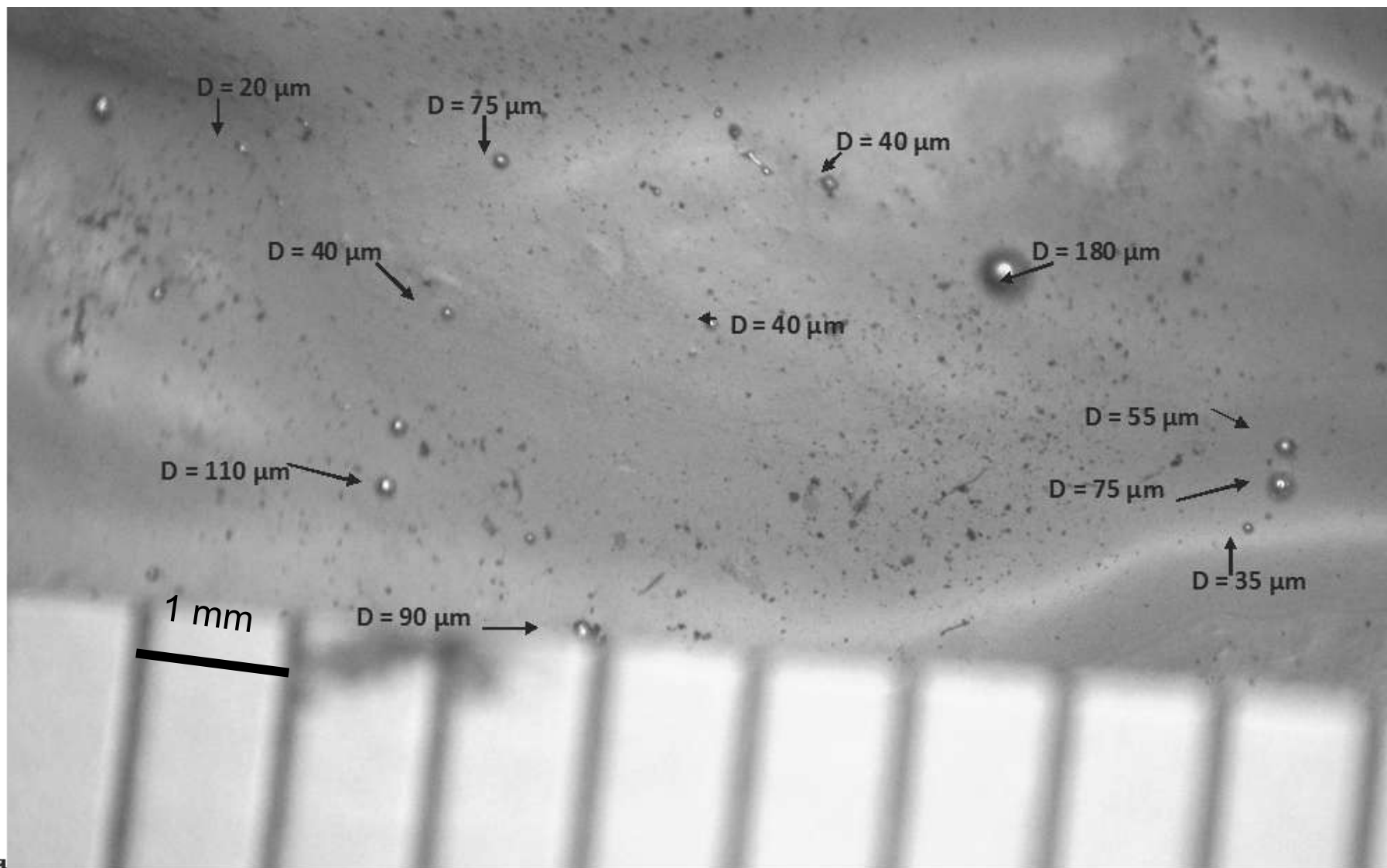
Thickness of the material used for flask construction is at minimum twice of today's flasks



Microbeads found at the neck and on the roof of the flask...



Observation of Hg contamination on a flask using a stereo microscope ($\times 40$)



Comparison [Hg] in drum's headspace (vapor) with measured internal contamination from flasks (liquid)

Drum I.D.	Field data obtained by Earth Tech – [Hg] in headspace at the bung - $\mu\text{g}/\text{m}^3$	Laboratory data obtained at ORNL -[Hg] in headspace at the bung - $\mu\text{g}/\text{m}^3$	Cumulative quantity of Hg collected on all flasks of the drum μg * \diamond
SO-07570	27	63	284
WN-04664	9	120	1781
WN-03381	14	140	1423
SO-07073	501	1600	899
SO-07808	462	1600	6795
NH-02391	286	5200	5697
SO-08931	257	5500	8326
SO-09110	1186	6000	6237
SO-07137	34	6200	459

* This quantity is a minimum because all the mercury present could not be captured on the wipe

\diamond Theoretically, $\sim 3000 \mu\text{g}$ of Hg should saturate the drum's headspace

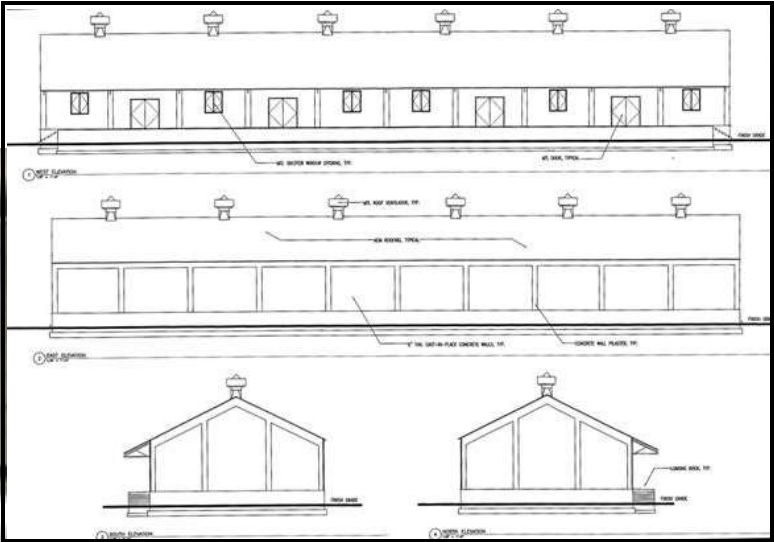
Conclusion

While considering:

- **the actual state of the flasks,**
- **their history,**
- **the minimal corrosion observed inside and outside, and**
- **the thickness of the construction,**

The flasks should be able to maintain their integrity for multiple decades (~ 50 years) static storage.

Interior View of Warehouse 110-Z-66

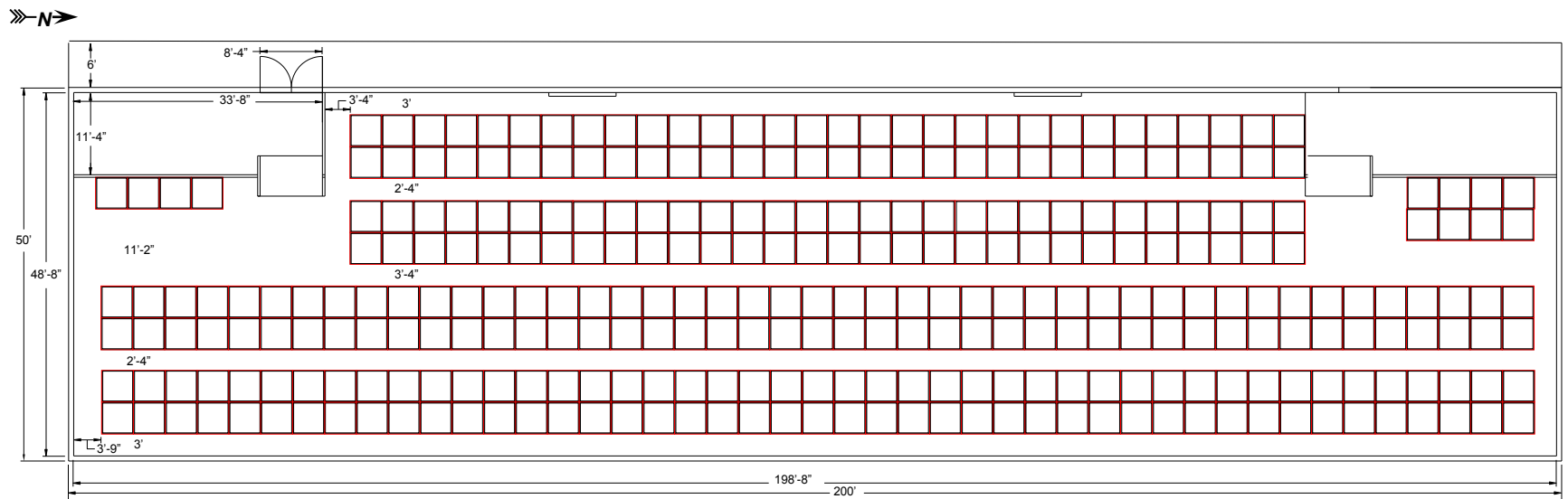


Elevation Views

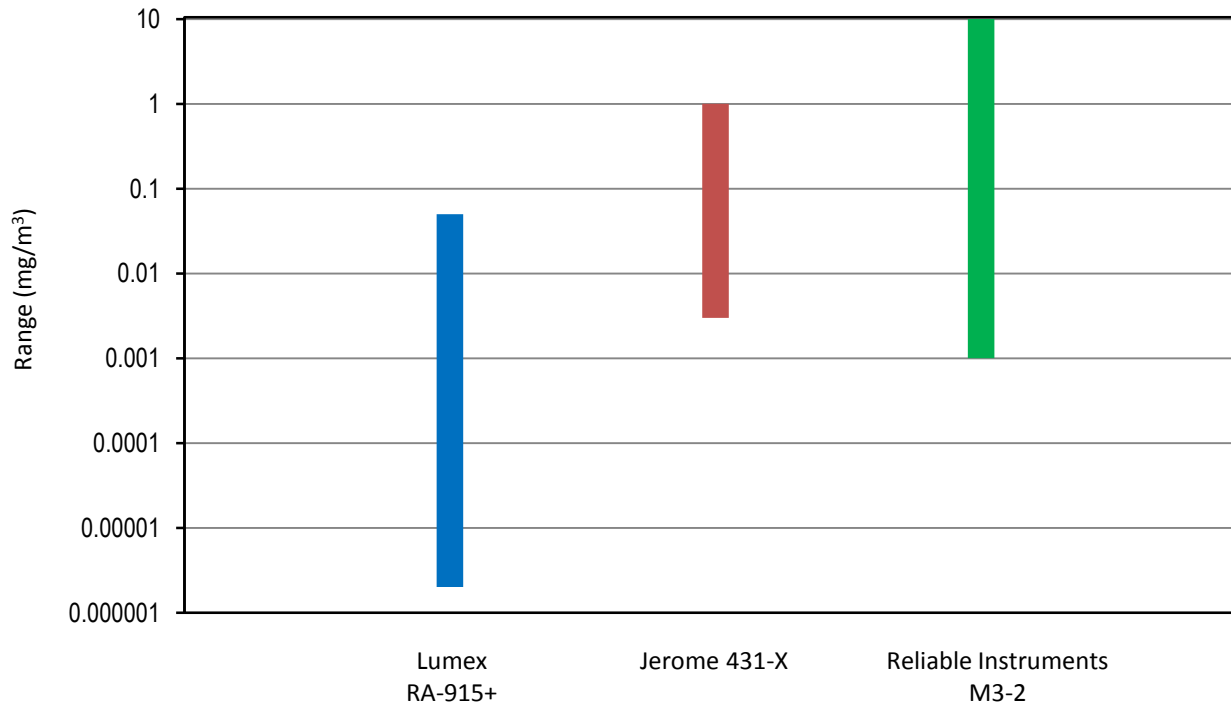


Warehouse loading dock

Planned single-level arrangement of pallets in a typical warehouse



Comparison of concentration measurement ranges of various mercury vapor analyzers



Storage Facility Requirements

- Capable of safely storing 10,000 MT of elemental mercury (99.5% or better) using three liter flasks and metric ton containers
- Mercury transfer structure with engineered ventilation
- Resource Conservation and Recovery Act (RCRA) Certified

DOE/EM-11

**U.S. Department of Energy
Interim Guidance on Packaging,
Transportation, Receipt, Management,
and Long-Term Storage of Elemental
Mercury**

October 2009

Prepared for
U.S. Department of Energy
Office of Environmental Management
Washington, D.C.

Prepared by
Oak Ridge National Laboratory

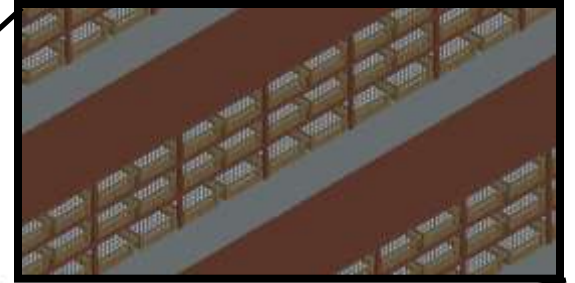
Managed by UT-Battelle, LLC, for the
U.S. Department of Energy under
contract DE-AC05-00OR22725

Split Layout Concept

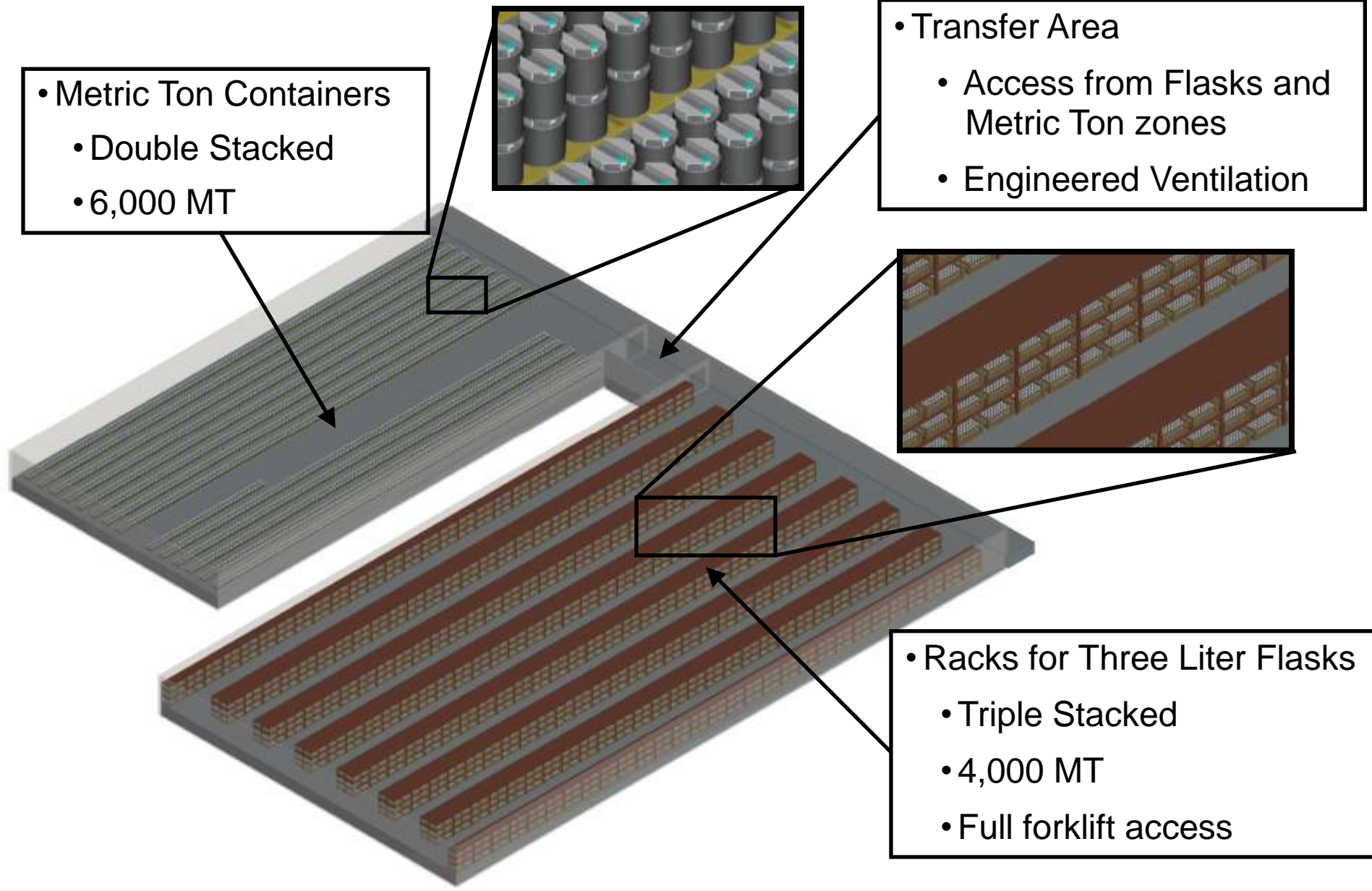
- Metric Ton Containers
 - Double Stacked
 - 6,000 MT



- Transfer Area
 - Access from Flasks and Metric Ton zones
 - Engineered Ventilation

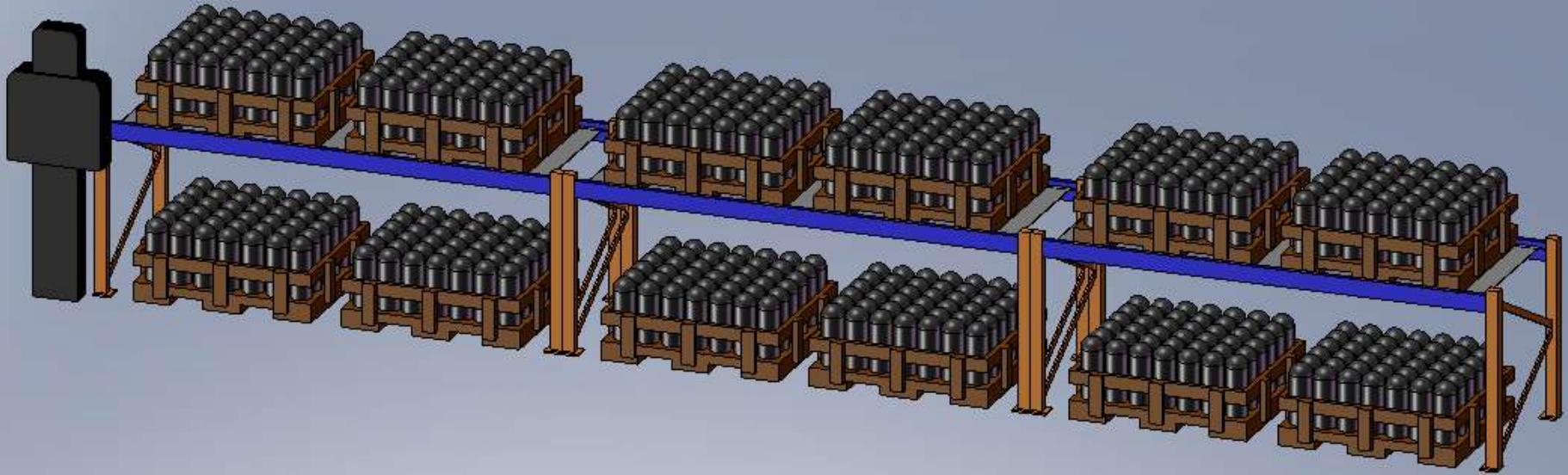


- Racks for Three Liter Flasks
 - Triple Stacked
 - 4,000 MT
 - Full forklift access



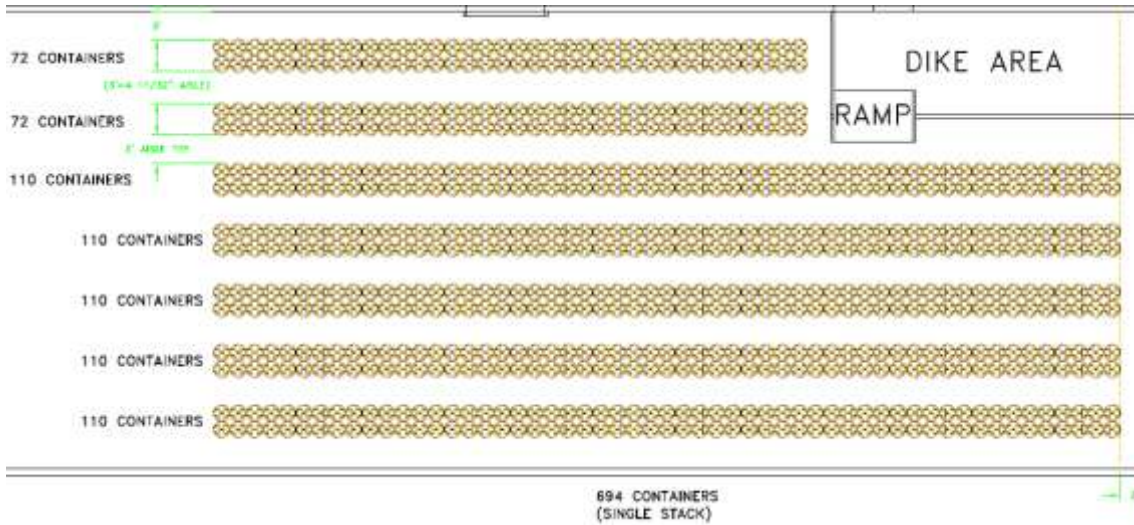
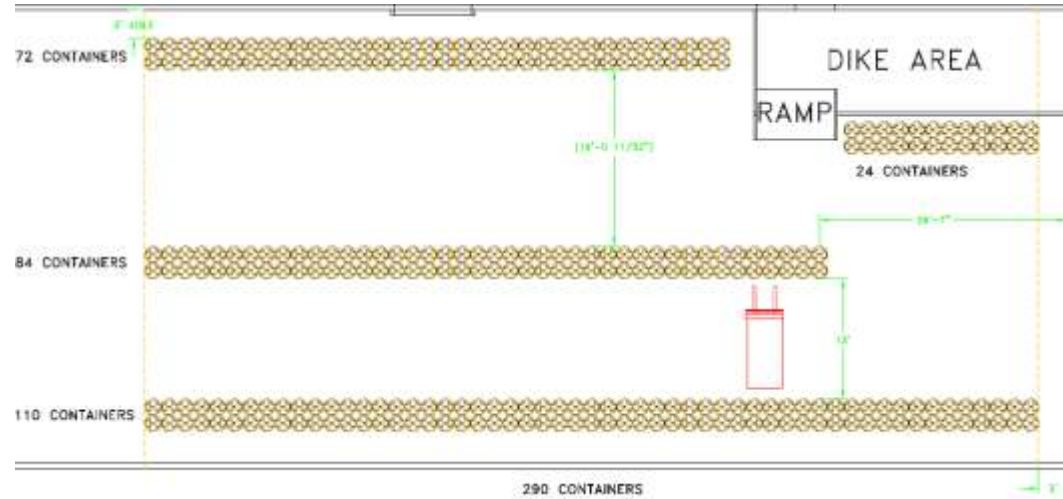
Multiple Pallets End to End

- The racks can be connected using off-the-shelf clips to increase stability and minimize space between



Storage Options

Full Access with Fork Truck



A Frame Lift and Table for In Place Inspection

Above Ground Containerized Mercury Storage Requirements

Topic	Recommendations
Assigning Mercury Facility Manager	(1) A person be assigned to be the facility manager. (2) Responsible for controlling personnel entries into the warehouses, scheduling facility repairs, scheduling periodic inspections, specifying and reviewing training requirements, and managing records.
External Warehouse Facility Inspections	Performing external warehouse inspections on a monthly basis and after unusual events.
Internal Warehouse Facility Inspections	Perform internal warehouse inspections on a six-month basis and after unusual events.
Warehouse closure procedure	Perform list of activities upon leaving the warehouse following the internal warehouse facility inspection. {Note: the plan should have also specified following the site's procedures (e.g., notifying security).
Mercury Inventory Location Inspections – General	(1) Inspecting all containers and pallets that have been moved and all adjacent containers or pallets for damage and/or mercury leaks. (2) Performing a full container and pallet identification location verification every 6 months.
Mercury Inventory Condition Inspections	Performing inventory condition inspection every six months and following unusual events.

Above Ground Containerized Mercury Storage Requirements Cont.

Topic	Recommendations
Warehouse Mercury Inventory Air Monitoring	<ul style="list-style-type: none"> (1) Use Jerome 431-X as the mercury vapor analyzer for providing personnel protection. (2) Personnel perform a qualitative performance check on the instrument prior to taking it to the field. (3) Upon completion of the work activity, the instrument should be returned to its storage location and recharged. (4) Also, if the instrument uses the gold foil sensor methodology, the gold-foil sensor should be regenerated. <p>NOTE: battery powered temperature/humidity monitors could be placed at select locations, for routinely downloading data for trending, in conjunction with more sensitive mercury analyzers targeting hundreds of ng/m³ range.</p>
Instrument Calibration	<ul style="list-style-type: none"> (1) Follow manufacturer's recommendation for frequency of calibration (typically 1 year). (2) Have backup instruments available for use when instruments are returned for calibration.
Personnel Health and Safety – General	<ul style="list-style-type: none"> (1) Specifies no eating, drinking, smoking, or chewing in the mercury storage area. (2) Personnel wash their hands upon exiting the mercury storage area. (3) If clothing is contaminated, it should be changed.
Personnel Health and Safety – General	<ul style="list-style-type: none"> (1) Have two persons present at a warehouse except for short periods of time. (2) Personnel must have method of calling for assistance if needed (e.g., two-way radio, cell phone).

Above Ground Containerized Mercury Storage Requirements Cont.

Topic	Recommendations
Actions Prior to Warehouse Entry	<ol style="list-style-type: none"> (1) Obtain approval from the mercury facility manager for entry [includes obtaining replacement TID(s) for the door(s)]. (2) Inspect the doors and windows for damage and verifying that the TID number on the door matches the number that is on record.
Actions During Warehouse Inspections and Monitorings	<ol style="list-style-type: none"> (1) Slightly opening the door and sampling the air with the mercury vapor analyzer. (2) Monitoring the mercury vapor concentration at floor level (ankle height) and breathing zone (shoulder height) for two locations in each of the five aisles. (3) Repeat the mercury vapor concentration measurements every 60 minutes if the work activity is still on-going. (4) Repeating the mercury vapor concentration measurements more often if the work activity involves moving or handling pallets or containers.
Actions Upon Exiting a Warehouse	<p>Actions include:</p> <ol style="list-style-type: none"> (1) Turn off lights, lock door, apply TID, notify security, etc. (2) Return mercury vapor analyzers to storage location. (3) Reconnect mercury vapor analyzers to AC power supply (recharges battery). (4) Regenerate gold-foil sensor.

Documentation Contacts (sponsor control issuance)

The Draft Interim Guidance on Packaging, Transportation, Receipt, Management, and Long-term Storage of Elemental Mercury is being done for our Department of Energy (DOE) sponsor.

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(voice: 202.586.6570).

Numerous technical reports describing testing of flasks and drums and results, and other special mercury related handling and storage questions, have been completed for the Defense National Stockpile Center (DNSC).

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