UT-BATTELLE

Target System Operations and Hg Handling

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MERIT Hg System Safety Review

CERN

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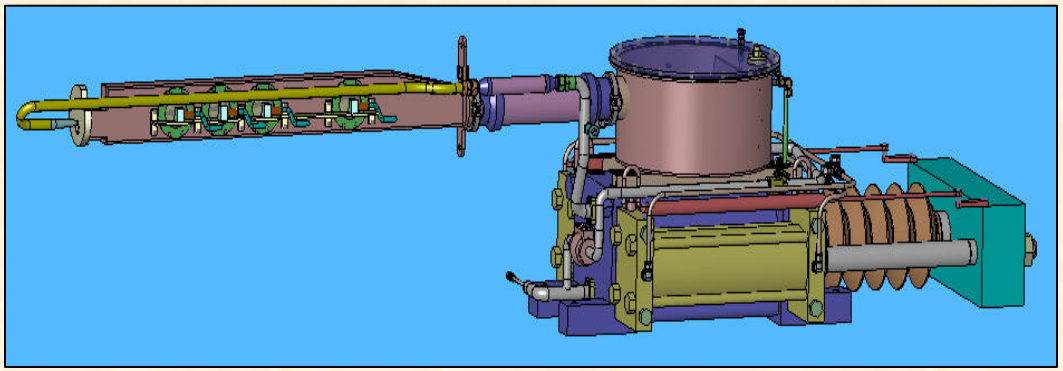
OAK RIDGE NATIONAL LABORATORY
U. S. DEPARTMENT OF ENERGY

Outline

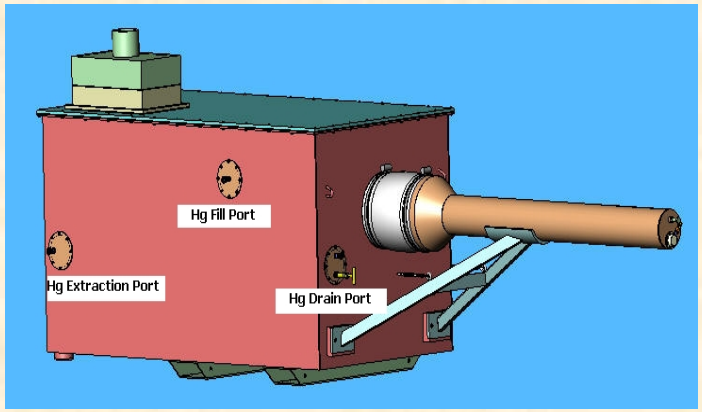
- **Containment Boundary Leak Check**
- **Filling and Draining Hg**
- **Air Filtration (Hg Vapor)**
- **Off-Normal Conditions**
- **Equipment for Hg Handling**
- **Equipment Maintenance**

Containment Leak Check

- **Primary containment will be pressurized at ORNL with 1-atmos nitrogen prior to water tests**
  - **Each fitting and welded joint will be soap-bubble checked followed by 24-h pressure decay**
- **Secondary containment will be pressurized with 2-3 psig nitrogen**
  - **Bulkhead penetrations, joints, and both filter/vent ports will be soap-bubble checked**



Primary Enclosure



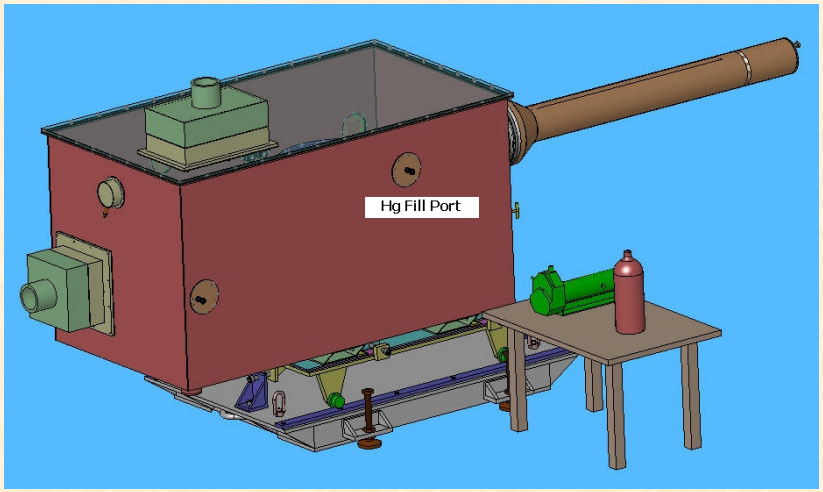
Secondary Enclosure

Containment Leak Check (cont.)

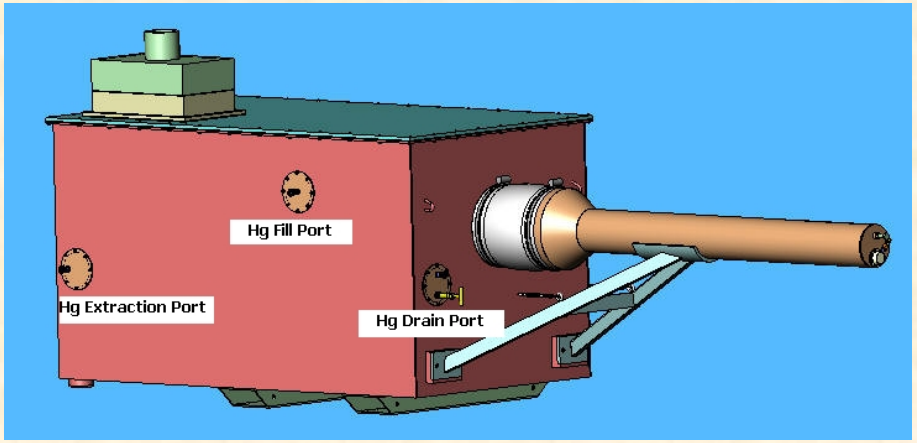
- **Leak check will be done again at MIT for primary and secondary but only the pressure decay test for primary containment**
- **Same for CERN … but**
- **… adjustments to laser optics may be required after transport**
  - **Requires opening secondary containment**
  - **Could this be done prior to installation in the MIT magnet lab, and installation in TT2A tunnel ??**

Filling and Draining Hg

- **Basic Requirement: filling and draining must be achieved without opening secondary containment**
- **Equipment Needed**
  - **Peristaltic pump**
  - **Tygon® tubing**
  - **Steel flasks/plastic bottles**



Pump/Flask Setup



Secondary Enclosure

Hg Transfer By Pumping

- **Peristaltic pump tests with water and Hg were successfully conducted for TTF (Appendix I)**
- **Pump flow rate for water was a maximum of ~ 0.15 liters/sec**
- **Pump flow rate for mercury was 0.03 l/s based on ~volume and ~time measurements**
- **The measured flow rate for Hg equates to emptying a flask in ~75 seconds**

Hg Fill Procedure

- **Place the pump and flask at an elevation higher than the fill port if possible**
  - **Flask is in a gauze-lined tray**
- **Weigh and record weight of each flask before the fill operation**
- **Siphon Hg from the flask until suction in the tube is lost**
- **Record the weight of the empty flask**
- **Displaced air is vented through primary filter (and then into snorkel)**
- **Local air is continuously sampled with the Jerome monitor**
- **Secondary enclosure is unopened**

Hg Drain Procedure

- **Place a 3-liter bottle in a gauze-lined tray under the drain port**
- **Using the hand valve for flow control, gravity-drain Hg up to the 2-liter mark**
  - **Air will be allowed to vent into the Fill Port during the operation**
- **Transfer 2-liters of Hg from the bottle into a flask**
- **Install the steel plug and weigh the flask**
- **Remove Hg remaining in the sump tank or drain line using the pump**

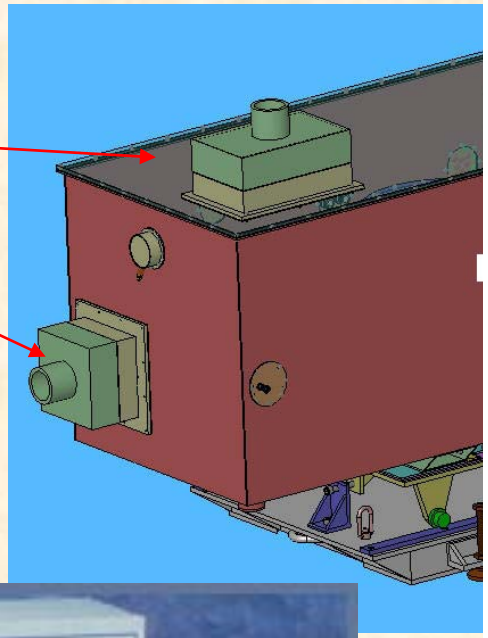
Waste Materials

- **All waste materials generated during Hg fill and drain operations … gloves, gauze, drip shields, etc. will be double-bagged, taped and placed in the Satellite Accumulation Area (SAA)**
  - **The SAA is a 55-gal. drum, properly marked, and having a locking cover**

Satellite Accumulation Area

Air Filtration (Hg Vapor)

- **Secondary containment has two sulfur-impregnated charcoal filter assemblies**
  - **Primary filter is 432 x 255 x 51 mm**
  - **Secondary filter is 267 x 267 x 38 mm**
- **Same filter as the Scavenger® snorkel**
- **Filter ports (5”diam.) normally closed**
- **Filter efficiency 99.9% per mfgr.**
  - **ORNL tests will verify filter effectiveness**
- **Double filtration is possible if needed using the snorkel**



Dose Rate Summary Table

Component	Absorbed Dose (Gray/3*10^{15} protons)	Residual Dose Rate – at Shut Down (mSv/h 3*10^{15} protons/30day)	Residual Dose Rate – at Shut Down (mrem/h)	Residual Dose Rate – 100 Hrs Cool Down (mSv/h 3*10^{15} protons/30day)	Residual Dose Rate – 100 Hrs Cool Down (mrem/h)
Equipment in solenoid bore	$10^4 – 10^6$	1	100	-	-
Equipment in secondary enclosure	$10^2 – 10^4$	-	-	-	-
Syringe Pump	-	$10^{-2} – 10^{-3}$	1.0 – 0.1	-	-
Top of secondary enclosure	-	$10^{-2} – 10^{-4}$	1.0 – 0.01	-	-
Hg vapor monitor (top of enclosure)	14.0 (<5-10 krad for electronics)	0.95	95.0	$<2.70 \times 10^{-3}$	<0.27
Hydraulic fluid	125	0.023	2.30	$<1.13 \times 10^{-4}$	<0.01
Ventilation filter in secondary encl. (1)	505	1.55	155.0	$<9.70 \times 10^{-4}$	<0.09
Mercury	$10^1 – 10^2$	$10^{-1} – 10^{-2}$	10.0	30×10^{-3} (2)	3.0 (2) (3)

(1) Pure carbon material used for calculation; impregnated sulfur not included.
(2) 1 day of decay at 1 meter distance; M. Magistris and M. Silari, EDMS No. 601754, CERN Technical Note CERN-SC-2005-049-RP-TN, June 16, 2005.
(3) After 1 month, dose rate at 1 meter distance is 0.1 mrem/h.

Off-Normal Conditions

1) Vapor leak into secondary containment

- **Secondary enclosure is continuously monitored for vapor with Jerome 431-X**
  - **Monitor located in TT2 (verify remote operation with ORNL tests)**
  - **Threshold warning set for 0.0125mg/m^3**
- **If threshold level is exceeded**
  - **Check conductivity probe and other sensors incl. vapor monitor for tunnel area**
  - **If reading ok, may conclude**
    - **Minor leak from primary containment, or**
    - **False-positive signal from vapor monitor**
- **Visually inspect w/ health physics oversight … continue beam tests**

Off-Normal Conditions (cont.)

2) Hg leak into secondary containment

- **Detected by vapor monitor, conductivity probe**
- **Confirm with visual inspection after suitable cool down period … 1 week …**
- **Cease test operations … wait up to 1 month for Hg cool down to <10^{-2} mSv/h (<1 mrem/h)**
- **Extract Hg from target loop and refill flasks**
- **Health Physics surveillance will be required**

Off-Normal Conditions (cont.)

3) System Overpressure

- **Nozzle blockage is the only reason for a system overpressure**
  - **Not a very credible occurrence, but …**
- **Hydraulic system pressure would increase above its nominal level of 200 bar**
  - **Pump relief valve set for 220 bar would open**
  - **Hydraulic fluid would divert from pump directly in the reservoir preventing overpressure of either the hydraulic loop or the Hg loop**

Off-Normal Conditions (cont.)

4) Power Failure

- **Loss of electric power to Hg delivery system or hitting the "E-Stop" immediately shuts down the pump system**
  - **Flow of jet ceases**
- **The possibility of a "water hammer" shock caused by the separation of flowing Hg will be investigated at ORNL**

Off-Normal Conditions (cont.)

5) Loss of Network Connectivity

- **Labview® hardware has an internal system controller that provides network connectivity to the laptop computer**
- **A "watchdog" timer detects loss of communication**
- **If loss is detected the system is configured to power down the pump system and place the equipment in an inoperable state**

Equipment to Support Hg Operations

Item	Comments
Vacuum Cleaner - Tiger Vac®	At Princeton; will be sent to MIT
Portable Snorkel - Scavenger®	At Princeton; will be sent to ORNL
Spare Filters	Sulfur impregnated charcoal & HEPA
	at Princeton; will be sent to ORNL
Vapor Monitor	Procurement by Princeton
Vapor Monitor Calibration Kit	Procurement by Princeton
55-gal. Drum	Satellite Accumulation Area (SAA)
Plastic Sheeting - roll	Heavy gauge plastic sheeting - 10-ft. wide
Peristaltic Pump	Available from ORNL
Tygon Tubing	
Hg Flasks (qty. TBD)	U.S. Dept. of Transportation approved; standard 76-lb. steel flask
Merc-X Cleaning Solvent	
Sponges	
Plastic Buckets	
Plastic Pans	
Teflon Tape (yellow)	Sealing flasks; yellow tape is more durable than white
Gauze - roll	
Small Tools	Wrenches, screwdrivers, …
Bungee Cords	Assorted lengths
Vinyl Tape	Yellow, 4 rolls
Plastic Bags	Assorted sizes - 1 gal. to 20 gal.
Plastic Bottles	1-, 2-, 3-liter sizes - 4 of each required
Lab Coats	
Shoe Covers	
Safety Glasses	
Ear Plugs	
Tyvek Hooded Suits	
Nitrile Gloves	
Full Face Mask w/ Hg Cartridges	
Miniature Aspirator Pump	
Flashlights	
Swagelok Quick Disconnect Fittings	
Scale	Digital - weighing Hg
Hand Pump	Transfer hydraulic fluid
Plastic Bin - 50 gal.	Storage chests for misc. equip. - 2 required
Berm Material	30-ft. required

Equipment Maintenance

- **There is no scheduled maintenance for the target system**
- **Visual inspections, check performance of sensors, and test the emergency stop in the control system, will be made routinely**
- **Initial assembly of the equipment and qualification will be done hands on at ORNL**
- **After beam operations commence, the equipment design allows for minimal personnel contact to achieve ALARA**

Summary and Conclusions

- **Experience and the procedures developed over 6 years of operating SNS/TTF are the basis for the design and operation of the MERIT target system**
- **Target system has features that allow Hg fill/drain without opening secondary containment**
- **Secondary containment provides the boundary for liquid Hg or vapors if a primary containment failure occurs**
  - **Contains filter assemblies to deal with displaced air during fill and drain operations**
  - **Visual inspection capability**
- **System operating characteristics will be quantified during ORNL and MIT testing**