CM1 Thermal Cycle

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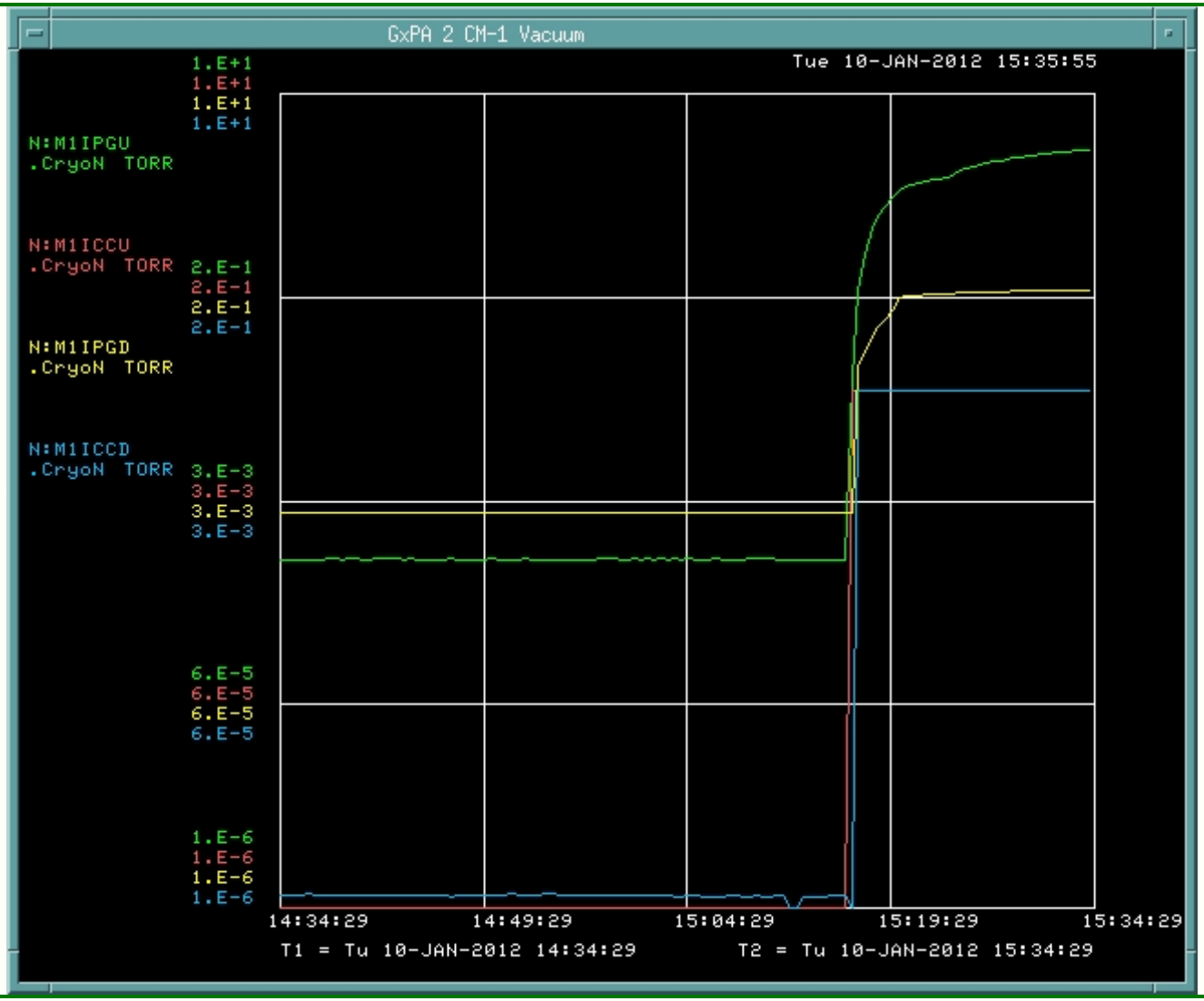
- **CM1 Warmup**
  - 1/4/12 (Wed.) to 1/6/12 (Fri.) (~50 hours)
  - Verified turbo interlock system works
- **CM1 Cooldown**
  - Began 1/9/12 (Monday)
  - At 15:16 on 1/10/12 a vacuum burst occurred while Nitrogen Shields were at ~ 120K and the insulating vacuum suddenly declined from 1E-6 to 3 Torr.
  - Safety interlock system closed gate valves, protecting turbo pumps and RGA.

Plot of Vacuum Event



Diagnosis of Problem

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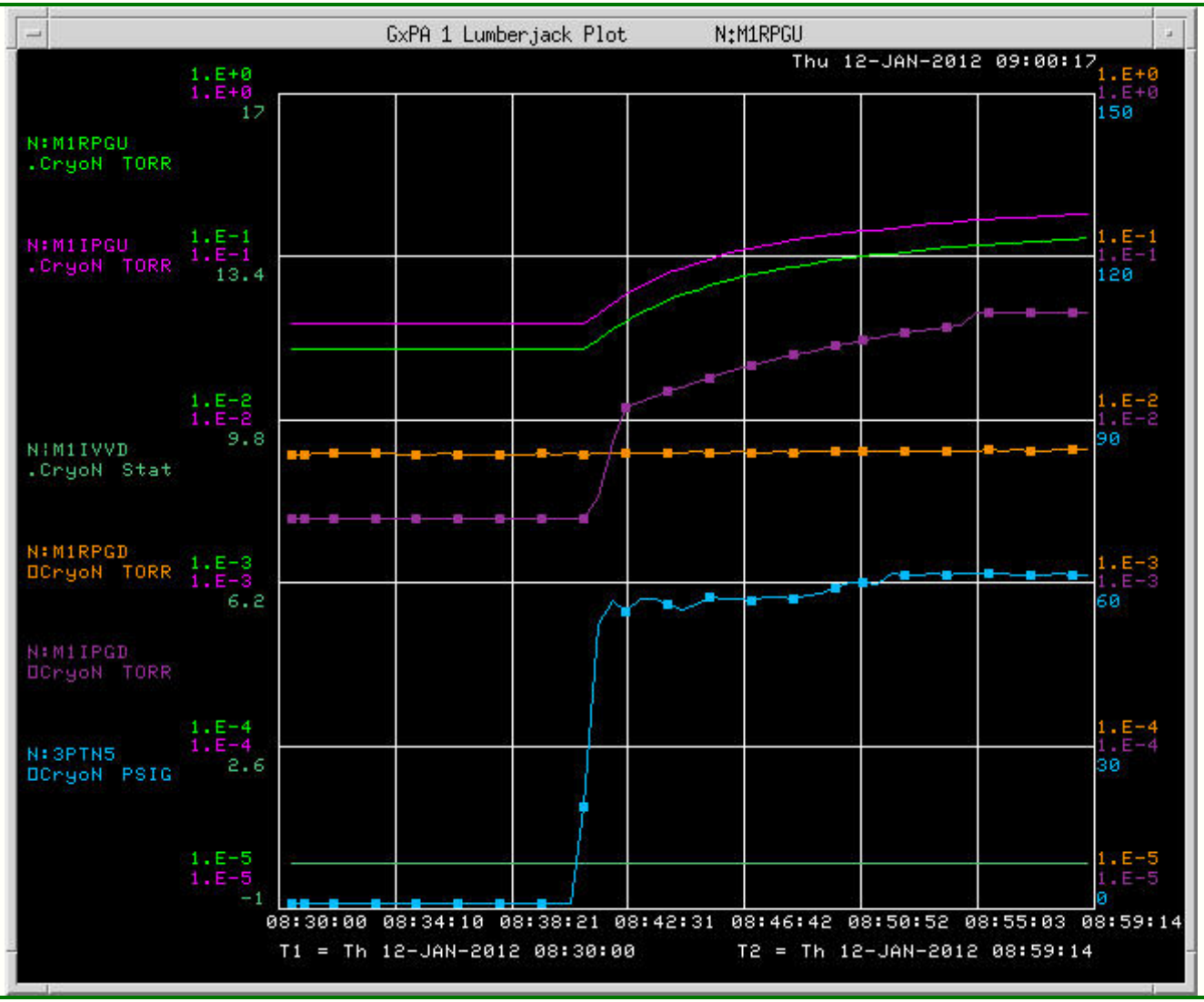
- **Investigation**
  - 1/10 evening shift and 1/11 day shift conducted studies that determined it was a leak from Nitrogen circuit to insulating vacuum
    - Installed roughing pumps on insulating vac. and connect RGA via bypass line to insulating vacuum space.
    - Used RGA and vacuum gauges to test each of the circuits (2 He. And 1 Nitrogen)
- **Results**
  - Both Helium circuits showed no response (Good)
  - Nitrogen circuit showed a direct vacuum and RGA response
  - Vacuum was worse at upstream end of CM1

Pressurizing Nitrogen



Detailed Investigation

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- **Next Step**
  - Since leak was big enough that there was no hope of recovering insulating vacuum and/or cooling down 80K shields, decision was made to warm up, locate leak, and repair.

- **Pinpoint Leak**
  - Cryo (Jerry Makara), TEV (Scott McCormick), and NML vacuum (Ron Kellett) experts led leak checking and repair efforts.
    - At Room temp., first verified warm leak, then connected (3) leak detectors (upstream, downstream, and on feedbox) tied into TEV chart recording cart, to give real-time comparison of response by each detector.
    - Flowed trace amount of helium into Nitrogen circuit from upstream feedbox and monitored response on leak detectors.

Leak Check of CM1

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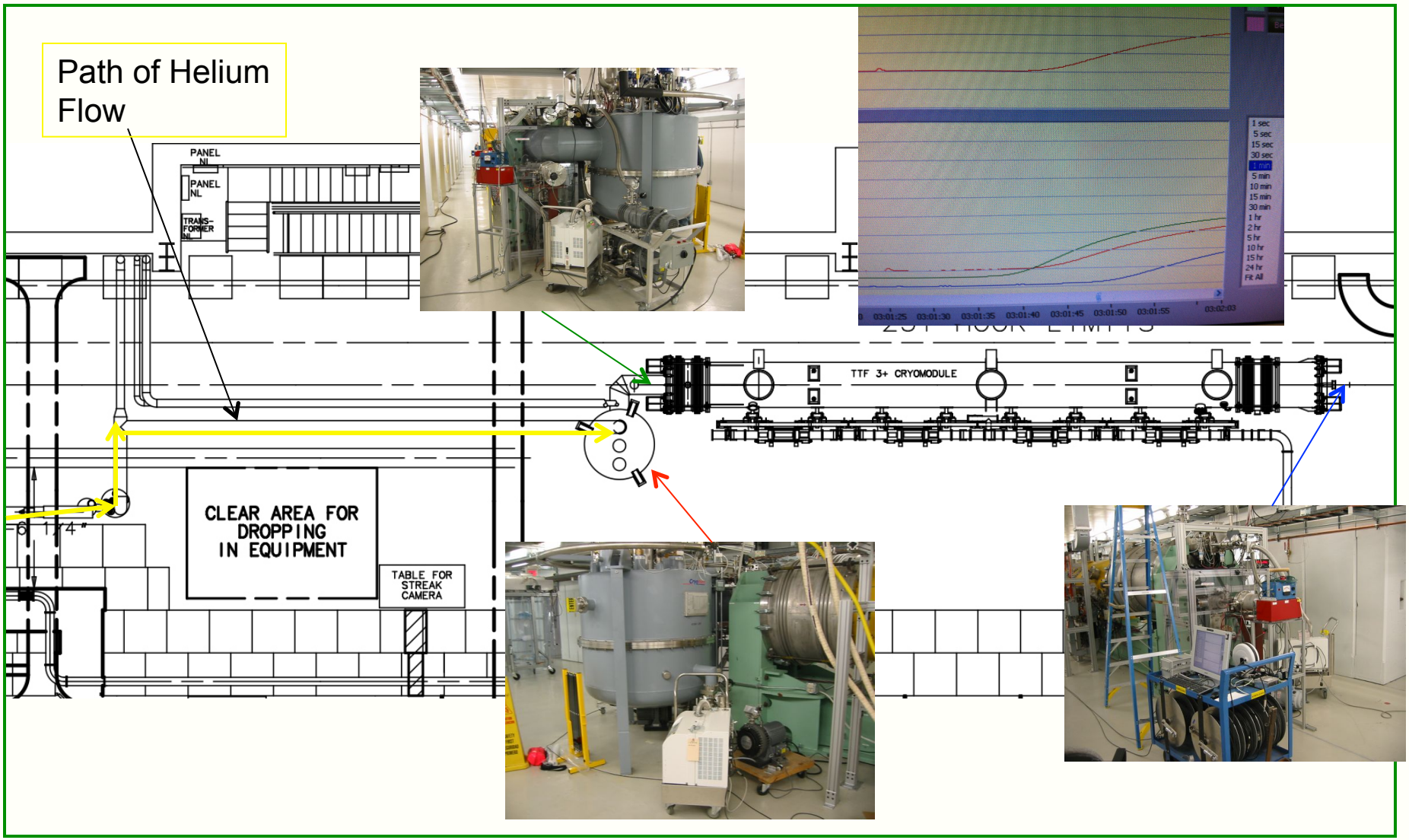
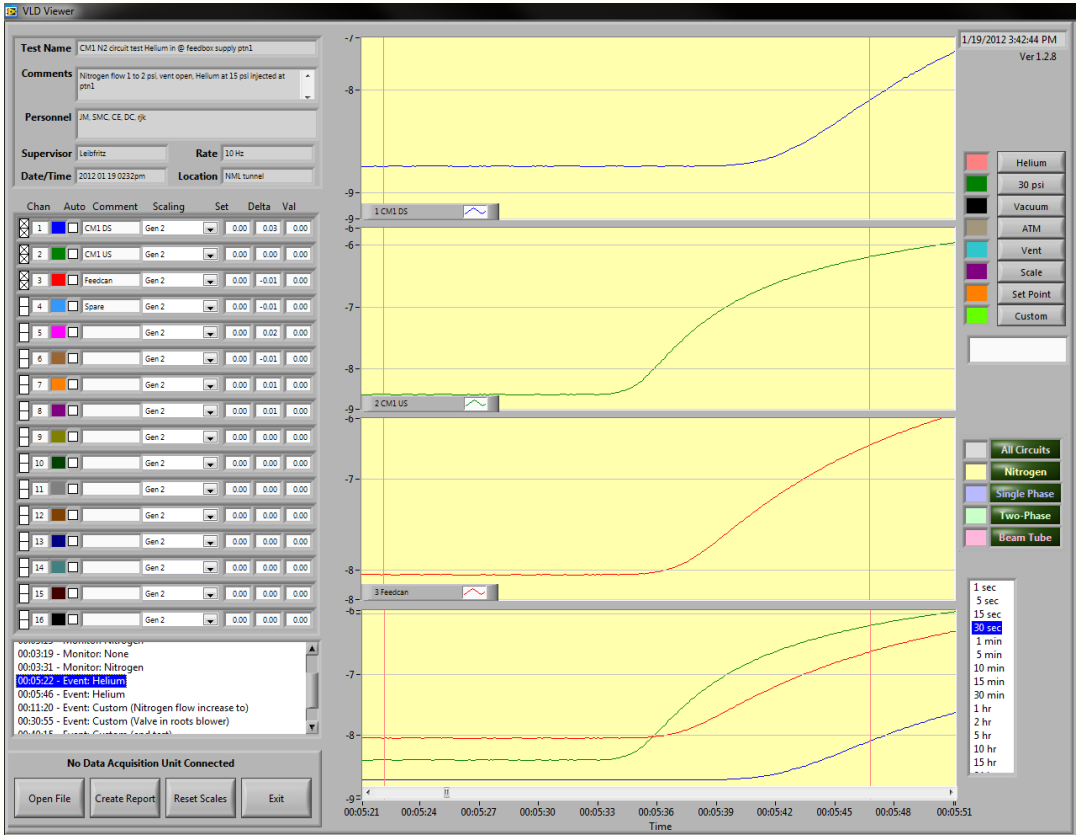


Plot of He Leak Check



- **The leak detector test with helium showed the feed cap interface (green) responding first, followed by the feed can (red), and the end cap (blue). The delay is ~10 sec.**

Additional Leak Checks

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- **Leak detector positions were swapped and test was repeated**
  - **To verify the results were not equipment dependent (slower response time, etc.)**
  - **Results were consistent with first test**

- **Additional tests were done to try to pinpoint if leak was in supply or return line**
  - **Introduced He from downstream end, with supply line pressurized with Nitrogen and return line venting (to force He to only go through return-line path)**
  - **Introduced He into downstream end, with Nitrogen supply off (to repeat initial test, but with He coming from other end)**

Repair

- Leak check and vacuum readings were all consistent and point towards leak at upstream interconnect region, supply side (possibly weld, bellows, or feedthru?)
- Repair Plan
  - Isolate all gas sources ✔
  - Vent CM1 insulating vacuum ✔
  - Open upstream bellows ✔
  - Remove insulation and shields to expose Nitrogen interconnects ✔
  - Inspect and leak check as necessary to find leak ✔
  - Repair leak ✔
  - Certify repair ✔
  - Close up and cooldown ✔

Repair – Update (1/27/12)

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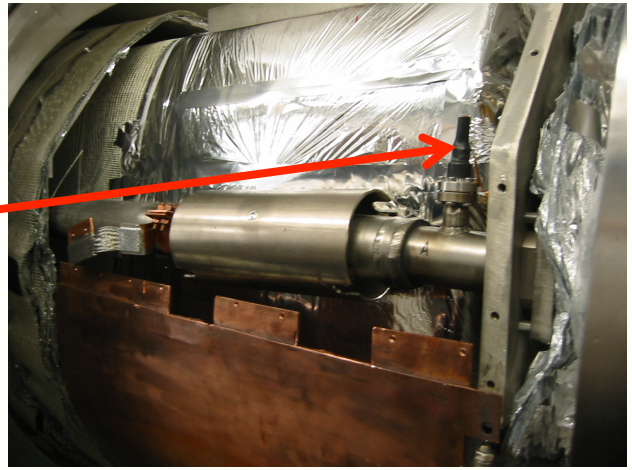
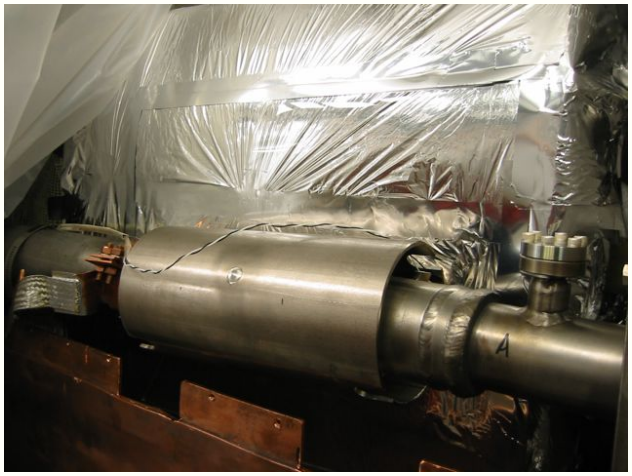
- **Large bellows on upstream end was opened and insulation and shields were removed.**
  - **Initial visual inspection did not show any obvious problem.**
  - **Leak check of Nitrogen circuit by pressurizing with Nitrogen and using "Snoop" showed a leak at the supply side temperature sensor feedthrough.**
- **Upstream Supply and Return temp. probes were removed and flanges blanked. New surface mounted sensors were installed at each location.**
- **Helium leak check was conducted to verify there were no leaks in Nitrogen circuit, and feedthru flanges were thermal shocked using liquid Nitrogen to verify they are leak tight.**

Repair – Update (1/27/12)

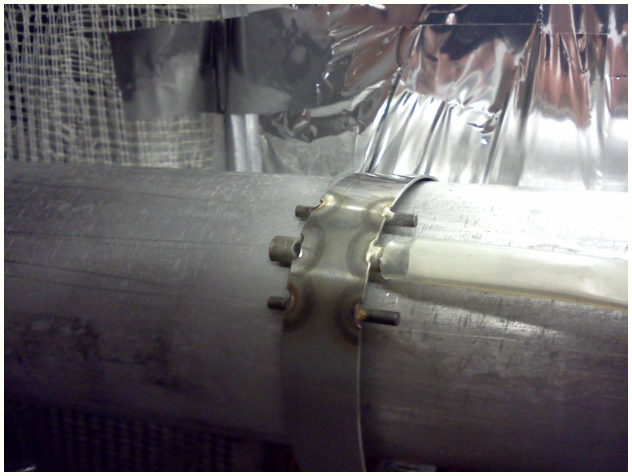
Leak indicated by bubbling “Snoop”



Upstream LN2 Supply Line



Blanked Feedthru



Surface Mounted Sensor

Repair – Update (2/1/12)

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- Surface mounted sensors were tested.
- Copper shields and superinsulation were installed on upstream end. Large bellows was closed and secured.
- Pump down of insulating vacuum and leak check was conducted. Nitrogen line and insulating vacuum space leak tight.
- Turbo pumps turned on.
- Cooldown started.

Timetable

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- 1/4 – 1/6: Warmup (~ 50 hours)
- 1/7 – 1/8: Weekend
- 1/9: Began Cooldown
- 1/10: Vacuum burst at 15:16, spent night shift troubleshooting
- 1/11: Troubleshooting during day shift (using RGA and vacuum levels), determined it was a Nitrogen leak, decision to warm up, began warm-up in evening
- 1/12: warm-up continued
- 1/13: warm-up continued, installed 3 leak detectors
- 1/14 – 1/16: Holiday weekend
- 1/17: warm-up complete, leak checked, determined problem at upstream interconnect
- 1/18-1/19: leak check continued, problem suspected at upstream supply interconnect

Timetable

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- 1/20: Isolated gas supplies, vented insulating vacuum
- 1/21-1/22: Weekend
- 1/23: Upstream bellows opened, shielding & insulation removed, visual inspection
- 1/24: “Snoop” leak check found leak in upstream supply temp. feedthru, Nitrogen supply isolated
- 1/25: Removed supply and return side temp. probes and blanked-off feedthrus. He leak check of Nitrogen circuit to verify no leaks.
- 1/26: Repeated leak check and thermal shocked blanked feedthrus with liquid Nitrogen.
- 1/27: Completed installation of surface mounted sensors
- 1/28-1/29: Weekend
- 1/30: Tested temp. sensors, installed shield and insulation, closed large bellows, turned on pumps and did initial leak check

Timetable

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- 1/31: Turbo pumps turned on, final leak checks conducted. Ready for cooldown
- 2/1-2/3: Cooldown
- 2/4-2/5: Weekend
- 2/6: Cooldown completed