4kg Chamber Operations and Experience

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4kg Operations Overview (veni, vidi, vici…)

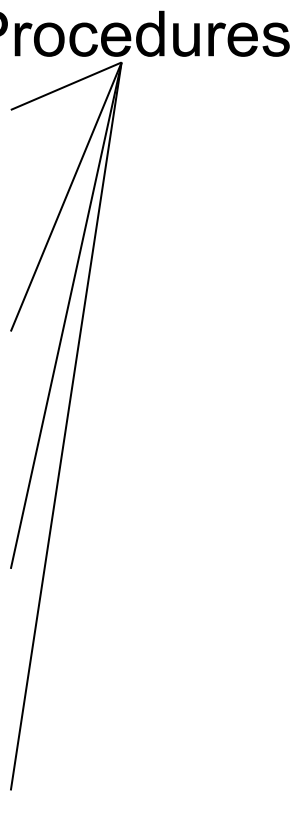
- We filled
- We ran
- As we were conquering, the DAQ failed
- We recovered, but chose to end the run
- We emptied

Define “Initial Condition”

- Inner jar installed in pressure vessel
  - Inner jar sealed, leak-checked
  - Pressure vessel flange sealed, leak-checked
  - Ports with necessary valves/filters installed
- Water distilled in inner jar
  - Jar evacuated above water
- DAQ and Controls complete
  - Hydraulic cart commissioned
  - Cameras commissioned
  - Temperature control commissioned

Fill Overview

- Hydraulic Cart Glycol Fill
  - http://coupp-docdb.fnal.gov:8080/cgi-bin/ShowDocument?docid=155
- Pressure Vessel Glycol Fill
  - http://coupp-docdb.fnal.gov:8080/cgi-bin/ShowDocument?docid=160
- Inner Vessel CF_3I Fill
  - http://coupp-docdb.fnal.gov:8080/cgi-bin/ShowDocument?docid=162
- Temperature Ramp-up
  - http://coupp-docdb.fnal.gov:8080/cgi-bin/ShowDocument?docid=164



4kg Fill Experience

- Hydraulic Cart Glycol Fill
  - Crisler + Ruschman, 1 day
- Pressure Vessel Glycol Fill
  - Crisler + Ruschman, 1 day
- Inner Vessel CF_3I Fill
  - Crisler + Dahl, 2 days
- Temperature Ramp-up
  - Crisler + Dahl, 1 day

Fill Summary

- All operations performable by
  - 1 scientist / post-doc +
  - 1 scientist / post-doc / grad-student / technician
- Procedures exist for each step
  - Procedures need to be updated with valve labels from piping note
  - Some minor steps missing (e.g. accumulator tank fill)
- 1 week from “Initial Condition” to working chamber

Run Overview

- Normal data taking
  - Procedure at http://coupp-docdb.fnal.gov:8080/cgi-bin/ShowDocument?docid=165
  - Completely Automated
    - Expansion/Compression cycles
    - Pressure (threshold) scanning
    - Data copy to surface (FNAL) computers
    - Event reconstruction, analysis
    - Data backup to tape
  - Remotely Operable
    - Start/Stop automated running
    - Change pressure setpoint/scanning
    - Switch neutron source on/off
    - Ramp temperature
    - Monitor detector health
    - Enter Safe state

Run Overview

- In case of problems
  - Enter Safe mode
    http://coupp-docdb.fnal.gov:8080/cgi-bin/ShowDocument?docid=165
    - Maintains chamber at high (non-superheated) pressure
    - Compensates for thermal expansion/contractio n
    - Can normally be entered remotely
    - In case remote control fails, power off (single switch, available to local technicians) is also safe mode
  - Chamber can remain in safe mode indefinitely, until COUPP personnel are available to address problem

4kg Run Experience

- Normal running
  - Bi-monthly (every 2 weeks) access to top off coolant in chiller
  - No other routine access required for 4 months

- Non-routine access (complete list)
  - Veto installation and commissioning (N/A for SNOLAB)
  - Acoustic noise troubleshooting (see upcoming slides)
  - DAQ failure and recovery (see upcoming slides)

Acoustic failures

- Three of four acoustic sensors failed by end of run
  - One suffered an immediate out-of-range DC offset when immersed in glycol
    - Recovers when removed, repeatable
    - Likely due to poor encapsulation of transducer (consequence of awkward geometry requirements and short delivery time)
  - One developed out-of-range DC offset, ~3 months into run
  - One became an intermittent source of high frequency acoustic noise, ~3 months into run

Acoustic fixes

- IUSB is producing new transducers with
  - AC coupling in preamp
    - Treats DC offset symptom
  - Complete encapsulation
    - Prevents instant exposure to glycol
  - HDPE instead of Teflon coated wires
    - Prevents possible slow exposure to glycol
- This is part of the general COUPP acoustic program, not specific to 4kg

DAQ Failure

- 4 months into run, a failure in the DAQ damaged the chamber
  - A driver failure disabled or severely impaired all triggers
  - The failure was not detected, so pressure regulation continued
  - Over several hours and multiple bubble nucleations, the chamber approached a state where
    - The inner vessel was maintained at the CF_3I vapor pressure (80 psia)
    - The pressure vessel was maintained at the set point (28 psia)
    - The resulting differential pressure caused a severe overextension of the bellows

DAQ Failure

- This failure was a known possibility
  - Hard stops on the slow-piston range would have prevented damage, but made the system vulnerable to temperature shifts
  - Because of the poor architecture of the temperature control, temperature shifts were deemed the greater threat

- This failure is understood and preventable
  - See incident report:
    http://coupp-docdb.fnal.gov: 8080/cgi-bin/ShowDocument?docid=151
  - More in the Re-Deployment Plan

End of Run

- Bellows was restored to operating position, but decision was made to end run
- CF_3I drain
  - Preparation of CF_3I transfer bottle and plumbing
    - Crisler + Hall + Dahl, 1 day
  - CF_3I transfer and depressurization of pressure vessel
    - Crisler + Hall + Dahl, 1 day

Summary

- 4kg experience in MINOS
  - From assembled detector to operating chamber in 1 week with 2 people
  - Normal operations are completely automated from data acquisition through analysis
  - All normal operating procedures can be done remotely
  - Safe state can be entered remotely, or by a single switch accessible to local technicians
  - Two issues appeared during the 4 month MINOS run, both are addressed in the Re-Depolyment Plan