Laboratory Operating Procedure:
Single Tank Fill Test at SURF

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Building/Room:	Davis Campus, Sanford Underground Research Facility
Date Approved:	Click or tap to enter a date.

Approved by: [Approver's name. Should be the person in charge of the space you will be performing the procedure in.]	Signature:

1. Description

The purpose of this test is to affirm the integrity of the plumbing system for the LZ outer detector fill system. This prototype system, made of the same teflon tubing and flare fittings as the final system, will be thoroughly cleaned, leak-checked, and examined for any plumbing or logistical problems throughout the test.

2. Hazards Overview

- Explosive depressurization from nitrogen cylinder failure
- Liquid leaks from overpressure/faulty bulkhead connections
- Fumes from construction epoxies and cleaning fluids

3. Required Personal Protective Equipment (PPE)

- Safety glasses
- Gloves for handling LAB
- Barrier lab coat
- Clean room attire (if working in the LN Alcove clean tent)

4. Waste Disposal

After the test is complete, the LAB will be sampled to determine if it is still of suitable quality for use with the full-scale experiment. If it is not suitable for use, or if no such sampling test is conducted, the LAB drum will be labelled as waste and disposed of in accordance with EH&S procedure.

5. Accident and Spill Procedure

- Nitrogen leak, as indicated by an unexpected drop in flow rate:
    - Restore all valves to their nominal positions
    - Using a leak checker, such as Snoop or a handheld device, inspect all valve joints and unions by turning on select nitrogen purge valves (GV1, GV6, GV7)
    - If a leak is identified, tighten valve connection or seal the source
- LAB leak, found by inspection:
    - Turn off all pumps, if on
    - Restore all valves to nominal positions
    - Contain the leak by applying local secondary containment (a beaker, a dish, etc.)
    - Empty the line or receptacle the leak is coming from
    - Clean the area and seal the source of the leak

6. Engineering Controls

- Pressure regulators and knob-controlled flowmeters
- Filling and drainage pumps
- Valves
- Reservoir liquid bubbler

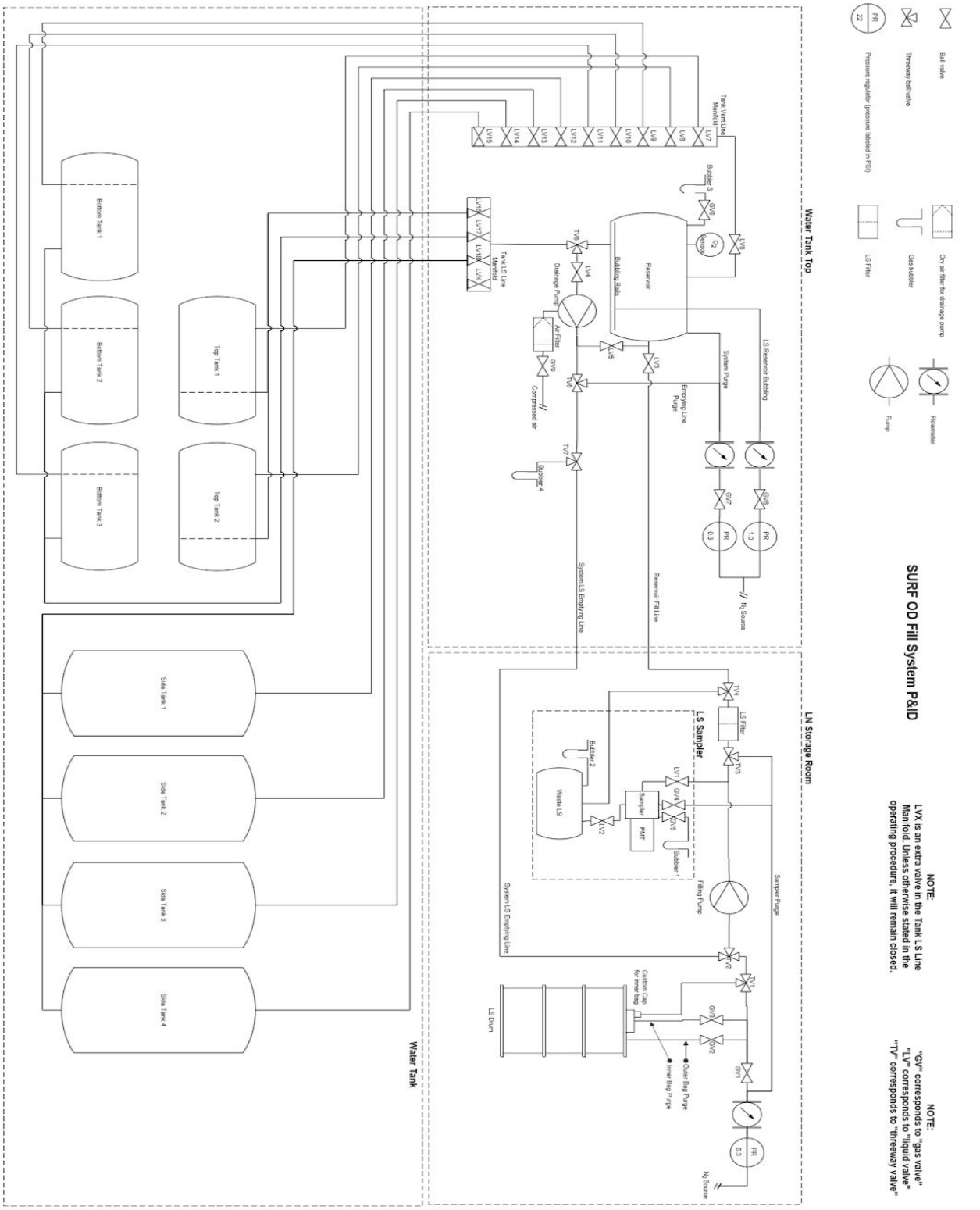
7. Equipment

- Nitrogen source(s)
- LN Alcove control panel
- Filling pump
- High-flow gas regulators
- Flowmeters
- Reservoir
- Tank
- Drainage pump
- Gas bubblers
- LS Filter
- Air filter for drainage pump
- Custom cap for inner drum bag

8. Approvals Required

- Susanne Kyre -- UCSB
- Dano Pagenkopf -- UCSB
- Scott Haselschwardt -- UCSB
- Relevant SURF personnel

9. P&ID


SURF OD Fill System P&ID
Ball valve
Threeway ball valve
Pressure regulator (pressure labeled in PSI)
Dry air filter for drainage pump
Gas bubbler
LS Filter
Flowmeter
Pump
NOTE:
LVX is an extra valve in the Tank LS Line Manifold. Unless otherwise stated in the operating procedure, it will remain closed.
NOTE:
"GV" corresponds to "gas valve"
"LV" corresponds to "liquid valve"
"TV" corresponds to "threeway valve"
Water Tank Top
LN Storage Room
Water Tank
Tank Vent Line Manifold
Bubbler 3
Reservoir
Bubbling Rate
Tank LS Line Manifold
Drainage Pump
Air Filter
Compressed air
System Purge
LS Reservoir Bubbling
Emptying Line Purge
Bubbler 4
System LS Emptying Line
Reservoir Fill Line
N2 Source
LS Filter
LS Sampler
Bubbler 2
Waste LS
Sampler
Bubbler 1
Filling Pump
Sampler Purge
System LS Emptying Line
Custom Cap for inner bag
LS Drum
Inner Bag Purge
Outer Bag Purge
Bottom Tank 1
Bottom Tank 2
Bottom Tank 3
Top Tank 1
Top Tank 2
Side Tank 1
Side Tank 2
Side Tank 3
Side Tank 4

10. Procedure

Note: Nominal valve positions are closed for two-way valves (GVs and LVs), and open to all three ports for three-way valves (TVs).

Purge

- Open GV1, GV2, GV3, and direct TV1 from GV1→drum, purging all lines to the drum
- Place the outer bag purge line into the outer bag of the drum, creating a locally nitrogen-rich environment around the inner drum cap
- After one minute, replace the inner drum cap with the custom cap and plumb the inner bag purge and the drum LS line into the inner bag
- After the bag inflates, close GV2 and direct TV1: GV1→TV2 to encourage N_2 flow through the rest of the system
- Direct TV2: TV1→Filling Pump and direct TV4: Filter→LV3. Open GV8 and LV3 to purge the reservoir fill line through Bubbler 3
- After five minutes, close LV3, then direct TV5: Reservoir→LV4, and TV6: System Purge→Drainage Pump.
- Open LV4, LV5, then open GV6 and GV7 to purge the reservoir and its surrounding lines.
- Turn the Drainage Pump on and operate at a rate of 60 cycles/minute for one minute.
- After one minute of pump operation, turn the Drainage Pump off and close GV6, GV7, GV8, and LV5.
- Direct TV5: Tank LS Line Manifold→LV4, TV6: Drainage Pump→TV7, and TV7:TV6→Bubbler 4
- Open LV6, LV7, and LV16, and reopen GV7 to purge the tank and its vent line & fill line
- Power on the Drainage Pump and operate at 60 cycles/minute for five minutes
- After five minutes, turn off the Drainage Pump and close GV7.
- Direct TV7:TV2→Bubbler 4 and TV2: TV1→TV7 to purge the System LS Emptying Line for two minutes
- Reset all valves to nominal positions

Fill

- Open GV1, GV2, and GV3
- Direct TV1: Drum→TV2 and TV2: TV1→Filling Pump
- Direct TV3: Filling Pump→Filter and TV4: Filter→LV3
- Open GV7, and direct TV5: Reservoir→LS Line Manifold
- Open LV3, then turn on the Filling Pump and operate until the drum contents are almost entirely in the Reservoir
- Turn off the pump, close LV3, and close GV7. Open GV6 to bubble the Reservoir contents for five to ten minutes
- Close GV6 and reopen GV7, then open LV6 and LV7.

- To drain the Reservoir contents into the tank, open LV16.

Drain

- To drain the tank, direct TV5: LS Line Manifold→LV4
- Open LV4, direct TV6: Drainage Pump→TV7, and TV7: TV6→TV2
- Direct TV2: TV7→TV1 and TV1: TV2→Drum
- Close GV3, turn on the Drainage Pump and operate at 40 cycles/minute until the tank has drained completely
- Once the tank is drained, turn off the Drainage Pump and set all valves to their nominal positions