

- Hazards associated with the gas system and how to mitigate them
- Do not enter the gas shack if the rotating red light at the entrance is on. This warns of an oxygen deficiency.
- **In General the Gas Mixing shack can be a hazardous place – BE AWARE OF YOUR ENVIRONMENT.**
- There are hazardous gas detectors that will cut off any gas flow at 10% of the lower explosive limit and oxygen deficiency monitors that will alarm if there is a less than 19% oxygen level.
- **Gas bottles are a hazard to move. Breaking the stem on a gas bottle can cause flying debris**
- Never move a bottle without the cap fastened. Always earthquake brace bottles at two points in the place they are to be used or stored. Always keep control of the bottle with two hands while moving.
- **The gases used in the calibration routine present a cryogenic hazard.**
- Be certain that the bottle is plumbed into the correct gas circuit and the fittings are tight before opening. When removing a bottle be certain to valve off the gas; At the bottle first, at the gas panel second. Slowly bleed the lines before disconnecting.
- **There is a marked step up both on to the gas pad and into the gas shack.**
- Be aware. It easy to trip while making a step into empty space when coming out of either one.
- **Side of racks must be removed.**
- To access some of the valves the side of the rack should be removed. This can fall rapidly and cause alarm or an injury. The rack side panel should be supported by one hand while turning the locking screw. Two hands should be used to lift and carry the side panel out of the way.

Gas System Alarm Checklist

This procedure is used to verify that safety sensors and passive safety devices are functioning correctly. It is performed once per year, prior to the start of a run. Two people are required for many of the tests. A separate procedure is used to test chiller alarms and to calibration hazardous atmosphere detectors.

Names: _____

Date: _____

Preliminary

- Inform Shift supervisor and anyone else in control room and electronics hut that sensor testing is under way and that false alarms will occur. Post sign on annunciator panel with your name, date and gas hut phone number (both DCh gas and gas hut alarms).
- Check that Rest Mode light on electrical rack is on.
- Close VVM-77, 78, 79, 80, 81 (Flowmeter inputs)
- Open VVM-44 (circulation purification bypasses)
- Close VVM-101 (purification input)
- Bypass analyzers (back of B636-05)
- Isobutane content from return line sensor: _____ (must be < 5% LEL)
- Close VVM-90 (gain chamber valve)

- You will need ice in step 5 to test the isobutane temperature sensor.*

Test Bubblers

- The bubblers are designed to protect the chamber against overpressure under the maximum possible flow possible from the security line (which is not shut off by a gas alarm). The test is performed using the purging rotameters. *THIS STEP REQUIRES DISABLING THE OVERPRESSURE ALARM AND MUST BE PERFORMED BY AN EXPERT ONLY.*
- Check that water levels are OK on bubblers
- Check that Rest Mode light on electrical rack is on.
- Current "DCh Pressure" alarm 1 threshold on DPRT 9 and DPRT 10 (code = 0010): _____
- Current "alarm 2 threshold on DPRT 9 and DPRT 10 (needed later): _____
- Raise "DCh Pressure" alarm 1 to 15 mbar.
- Current "Input DCh" alarm thresholds. alarm 1 _____ alarm 2 _____
- Set "Input DCh" alarm to 15 mbar if necessary.
- Select VME mode.
- Open VVPC-2, 3, 4, 7 to allow helium to flow into, but not out of, the chamber.

- Open Helium Hi-flow rotameter to 10 lt./min.
- Verify bubblers are bubbling.
- Maximum pressure in chamber: _____. If this is not between 10 and 14 mbar, adjust the water level in the bubblers.
- Reduce flow to zero on rotameter.
- Select Rest Mode
- Slowly open VVM_41 until chamber pressure drops to 4 mbar.
- Return "DCh pressure" alarm to original value
- Return "input DCh" alarm to original value if necessary.

The bubblers maintained the chamber pressure within safe limits for up to 10 lt./min flow. Initials: _____

Test Relief Valves and Gas Line Pressure Sensors

Five relief valves ensure that line pressures remain at safe levels at all times. They are tested in VME mode by closing manual valves and increasing regulator pressures until the relief valve opens. The pressure sensors on the helium, isobutane and recirculation lines are tested at the same time.

Check that Rest Mode light on electrical rack is on.

Select VME mode

Fresh gas relief valve (using helium line)

Examine DPM (B636-02) for helium inlet pressure :
Current value: _____ Alarm 1 level: _____ Alarm 2 level: _____

Increase helium inlet alarm to 2500 mbar.

Current setting on interior helium regulator: _____

Adjust interior helium regulator to 100 kPa.

Open VVPC-7 & VVPC-2 (to allow helium flow to manifold).

Select isobutane sample point VVPC-12.

Close helium and fresh gas sample points VVPC-10 and VVPC-11.

Open helium low-flow rotameter to approximately 2 l/min (value is not important).

DPM pressure (B636-02) : _____

Pressure reading on "mixer" analog gauge(B636-06): _____

Above two pressure readings are consistent. Initial _____

Monitor mixer pressure (B636-02), while increasing helium pressure at regulator panel. Record pressure at which relief valve RV-F releases, or maximum pressure achieved if it does not release: (2.0 bar) _____

Open "Fresh Gas" sample point to reduce pressure.

- Return interior regulator to previous value; open VVM-47 if necessary.
- Once helium inlet is below alarm value, close VVPC-7 and VVPC-2
- Close helium low-flow rotameter.
- Close Fresh Gas sample point
- Return helium inlet alarm to original value.

Helium inlet relief valve and pressure sensor

- Open VVPC-7
- Select Helium Sample Point in EPICs analyzer panel to vent helium line
- Close helium sample point and open isobutane sample point.
- Current pressure setting on interior helium regulator: _____
Helium inlet(B636-06): _____
- Current value for helium inlet pressure DPM (B6336-02): _____
- Above three pressure-readings are consistent. Initial _____
- Increase pressure on external regulator to 39 psi.
- Increase pressure at regulator panel beyond Alarm 1 level.
Verify input 2-0 goes OFF and corresponding indicator LED on gas rack goes RED. (system will go into alarm mode).
- Monitor Helium pressure, while increasing helium pressure at interior regulator panel. Record pressure at which relief valve RV-H releases or maximum pressure achieved if it does not release: (2.4bar) _____
- Return interior regulator to previous value (open VVM-47 to vent line, if necessary)
- Clear alarms via Rest mode.
- Select VME mode.
- Open VVPC-7
- Open VVPC-11, helium sample point.
- Reduce helium pressure at interior regulator below Alarm 2 level. Verify input nanoautomate input 2-0 goes OFF and corresponding indicator LED on gas rack goes RED.
- Verify that gas system is in Alarm Mode 2: nanoautomate outputs 2-3, 3-5 and 3-9 ON, all others OFF.
- Return helium pressure to nominal value.
- Select REST mode (clear alarm)
- Return outside helium regulator to 35 psi; open VVM-47 if necessary.

Air inlet relief valve

- Verify that VVM-104 is closed (Chamber input, B636-04 back)
- Record current setting of "Dry Air" interior regulator: _____
- Record current setting of front bulkhead flow: _____

- Switch front bulkhead flow to air and verify flow is >14 l/min.
- Increase Dry Air pressure at regulator panel. Record approximate pressure at which relief valve RV-B releases: (250 kPa or ~2.5 bar) _____
- Return Dry Air regulator to earlier value.

Isobutane inlet relief valve — there must either be no oxygen present in return line or the O2 alarm must be temporarily bypassed. (O2 alarm is interlocked with VVPC-8)

- Select VME mode
- Open VVPC-8
- Open isobutane sample point VVPC-12
- Record current regulator setting: _____
- Record current setting of isobutane pressure on B636-06: _____
- Examine DPM for isobutane inlet pressure:
Current value: _____ Alarm 1 level: _____ Alarm 2 level: _____
- Above two pressure readings are consistent. Initial _____
- Reduce pressure on regulator panel below alarm level 2. Verify input 2-1 goes OFF and corresponding indicator LED on gas rack goes RED. It may be easier to adjust the regulator in rack B636-06.
- Return pressure to normal value. Verify 2-1 is ON.
- Close isobutane analyzer sample point
- Close VVPC-8

Recirculation line relief valve using Compressor and rack bypass

- Examine DPM for circulation pressure DPRT-6 (circulation line pressure):
Current value: _____ Alarm 1 level: _____ Alarm 2 level: _____
- Verify current value is below alarm level 2
- Verify input 2-2 (“recirculation pressure”) is OFF and circulation pressure LED is RED
- Close VVM-44 (purification bypass) to isolate relief valve from pressure gauge.
- Open VVPC-7, VVPC-2, VVPC-3, VVPC-5
- Close VVPC-9
- Set compressor to Manual and output to 27%
- Set helium low-flow rotameter to 10 l/min
- Start compressor — *you have only 30 seconds before the system will go into alarm.*
- Monitor pressure on exhaust manifold pressure gauge (B636-05 front) and record pressure at which relief valve RV-C releases: (1.6 bar) _____
- Select rest mode.
- Open VVM-44

- Verify input 2-2 (“recirculation pressure OK”) is ON.
Circulation Pressure _____ Pressure on exhaust manifold gauge: _____
- Above two pressure readings are consistent. Initial _____
- Select VME mode
- Open VVPC-7, VVPC-2, VVPC-3, VVPC-5
- Close VVPC-9
- Set “mix circ” mass flow controller to 3 lt/min.
- Start compressor (required to get alarm).
- Monitor “circulation pressure” until pressure increases above alarm 1 and system goes into alarm.
Verify input 2-2 (“recirculation pressure OK”) is OFF and corresponding indicator LED on gas rack is RED.
- Select Rest Mode to reset alarm.
- Close helium low-flow rotameter
- Reset controller to automatic
- Set “mix circ” mass flow controller to zero.

- All relief valves released at pressures < 3 bar (45 psi), or the gas system is incapable of delivering gas at this pressure. Initials: _____

Test Switch Inputs to Nanoautomate

- Select RUN mode with manual switch and verify that nano input 1-13 flashes.
- Select Rest mode with manual switch and verify that nano input 1-12 flashes.
- Select VME mode and verify that nano input 1-11 flashes.
- Select Rest mode
- Turn off 110V power for DPMs using breaker D6 on back of B636-02; verify input 2-12 goes OFF and corresponding indicator LED on rack B636-04 is RED.
- Turn on 110V power for DPMs; verify input 2-12 goes ON.
- Reset alarm

Flow and Temperature Alarms

- Verify Rest mode light is on.
- Verify input 2-5 (“recirc flow OK”) is OFF and Circulation Flow indicator LED on gas rack is RED.
- Verify input 2-6 (“fresh gas flow OK”) is OFF and corresponding indicator LED on rack B636-02 is RED.
- Verify input 3-12 (“gain chamber flow OK”) is OFF.

- Current bulkhead flows: Front: _____ Rear: _____

- SLOWLY decrease front bulkhead gas flow. Flow at which input 2-11 (“Bulkhead flows OK”) goes OFF and corresponding LED on gas rack goes RED (note that alarm has 30 sec delay): _____
- Return front bulkhead flow to previous value.
- Reset alarm.
- SLOWLY decrease rear bulkhead gas flow. Flow at which input 2-11 (“Bulkhead flows OK”) goes OFF and corresponding LED on gas rack goes RED: _____
- Return rear bulkhead flow to previous value.
- Reset alarm.

- Pack crushed ice in plastic bag on isobutane temperature sensor TEMP-1. Temperature at which input 2-4 (“isobutane temperature OK”) goes OFF and “Temperature” LED on rack B636-02 goes RED: _____
- Reset alarm

Gas Sensor Alarms

Note that the General Monitors model 2100 isobutane sensors now in use do not require regular calibration.

- Verify that Teledyne Analytical trace O2 sensor mounted on the circulation line has been tested within the last 6 months.
- Range setting at 25% and alarm setting at 4% of full scale (0-40)

Other Pressure Alarms

Pressure alarms are tested by directly varying the gas pressures.

Compressed Air input

- Record current setting of compressed air pressure at Regulator panel (higher pressure regulator): _____
Gauge behind rack B636-05: _____
- Above two pressure readings are consistent. Initial _____
- Close inlet near gauge at back of rack and push button on bottom to vent line.
- Verify 2-9 “compressed air OK” goes OFF and corresponding LED goes red.
- Open inlet valve.
- Reset alarm.

Chamber and Inlet Pressure

Compare three pressure readings to test meters. Increase pressure to get alarm; vent to decrease pressure.

Chamber over-pressure

- Chamber pressure (top): _____ (bottom) _____ Input DCH pressure: _____
- Above three pressure readings are consistent. Initial _____
- Alarm levels on DPMs for chamber pressure (from bubbler tests):
Top: Alarm 1 _____ Alarm 2 _____ Bottom: Alarm 1 _____ Alarm 2 _____
- Alarm levels are identical for two DPMs.
- Select VME mode
- Open VVPC-7, VVPC-2, VVPC-3, VVPC-4 to allow helium flow into (but not out of) chamber.
- Adjust helium low-flow rotameter to 10 l/min.
- Monitor “chamber pressure” until pressure increases above alarm 1 and system goes into alarm. Verify input 2-3 (“chamber pressure OK”) is OFF and “input pressure” LED on gas rack is RED.
- Open VVM-41 slightly until pressure drops to 3.5 mbar – 4.5 mbar.
- Select Rest mode to reset alarm.

Inlet over-pressure

- Close VVM-38 and VVM-40 in rack 10 to isolate chamber.
- Alarm level on West DPMs for “input DCH”: Alarm 1 _____
- Select VME mode
- Open VVPC-7, VVPC-2, VVPC-3, VVPC-4
- Monitor “input DCH” until pressure increases above alarm 1 and system goes into alarm. Verify input 2-10 (“inlet pressure OK”) is OFF and corresponding indicator LED on gas rack is RED.
- Close helium rotameter.
- Open VVM-39 (make sure VVM-40 really is closed).
- Open and close VVM-41 to release inlet pressure.
- Close VVM-39
- Reset alarm

Chamber under-pressure – Helium security line

- Open VVM-38 and VVM-40 (chamber inlet and outlet).
- Open VVM-41 (exhaust) slightly to allow chamber pressure to slowly decrease.
- Monitor “chamber pressure” until pressure decreases below alarm 2 and system goes into alarm. Verify input 2-3 (“chamber pressure OK”) is OFF and corresponding indicator LED on gas rack is RED.
- Close VVM-41
- Continue to monitor pressure and helium security-line rotameter. Chamber pressure at which security line flow becomes 1 lt./min: _____
- Wait until security line flow decreases to ≤ 0.5 lt./min. Chamber pressure: _____

- Select Rest mode to reset alarm.
- If necessary, adjust security line regulators and repeat.

Verify Alarm Response

- The nanoautomate programming is certified in a separate procedure. This step verifies that the correct hardware responses occur as a result of an alarm.
- Reset SIAMS 0, 2, 3, 4 in the electronics house and any tripped gas hut SIAMS
- Clear annunciator alarms in the control room and the electronics house.
- HV is enabled (interlock light on HV supply is OFF).
- LV is ON.

Alarm mode 1 – trip LV and HV; annunciator alarm

- Turn off front N₂ bulkhead flow.
- Verify alarm mode 1 on nanoautomate: Output 2–3 flashing; 3–9 ON; all others OFF.
- LED is flashing on gas panel.
- Gain chamber HV is disabled.
- “DCh gas alarm” Annunciator Alarm is lit in control room.
- “DCh gas alarm” Annunciator Alarm is lit in electronics house.
- Electronics hut SIAM 0 is tripped (HV disabled)
- Electronics hut SIAM 4 is tripped (LV disabled)
- LV supply is at 0.
- CAEN SY527 HV supply is disabled (interlock red light is ON).
- VVPC–1 and VVPC–9 open (EPICS panel)
- VVPC–2, 3, 4, 5, 6, 7 and 8 are closed (EPICS panel)
- Set front flow to previous value; wait until input 2–11 is ON
- Select Rest mode to reset alarm.
- Reset electronics house SIAMs.
- Reset annunciator alarms in control room and electronics house.

Alarm mode 2 – trip HV but not LV; annunciator alarm

- Turn off power to DPMs using breaker D6 on back of electronics rack.
- Verify alarm mode 2 on nanoautomate: output 2–3 flashing. 3–5 and 3–9 ON; all others OFF.
- LED is flashing on gas panel
- Gain chamber HV is disabled.
- “DCh gas alarm” Annunciator Alarm is lit in control room.

- "DCh gas alarm" Annunciator Alarm is lit in electronics house.
- Electronics hut SIAM 0 is tripped (HV disabled).
- Electronics hut SIAM 4 is NOT tripped.
- Turn 110V DPM power back on.
- Select Rest mode to reset alarms
- Reset HV SIAM 0.
- Reset annunciator alarms in control room and electronics house.

Alarm mode 3 – trip HV without annunciator alarm

- Test-trip Gas Hut SIAM 3 (DCH interlocks).
- Verify input 3–6 goes OFF.
- Verify alarm mode 3 on nanoautomate: output 2–3 flashing, 3–5, 3–6 and 3–9 ON, all others OFF.
- LED is flashing on gas panel
- Gain chamber HV is disabled.
- Electronics hut SIAM 0 is tripped (HV disabled).
- Electronics hut SIAM 4 is NOT tripped.
- "CEN GAS" annunciator alarm is lit in electronics house.
- "CEN GAS" annunciator alarm is lit in control room.
- DCh gas system annunciator alarm is OFF.
- Reset alarm by selecting REST mode.
- Reset SIAM 0
- Reset Gas Hut SIAM 9
- Reset annunciator alarms in control room and electronics house.

Reset System to Rest Mode

- Use "Initial Check — Rest Mode" checklist to reset gas system to default state. Attach.
- Inform Shift supervisor and anyone else in control room and electronics hut that sensor testing is completed. Remove signs.

- All sensors and alarms performed as expected in all parts of this test.

Signature: _____ Date: _____

- Additional Comments and Notes: