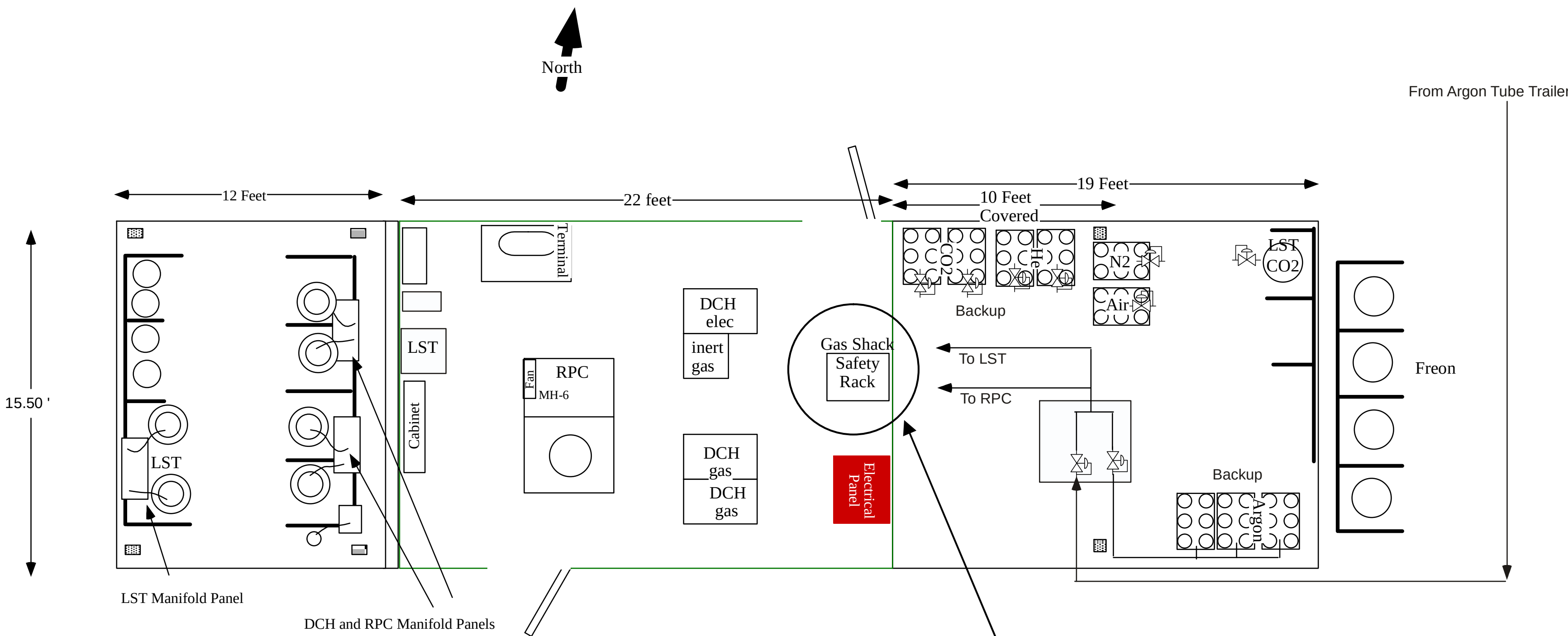
The LST gas mixing system

Oct 4, 2004

R. Messner

The Gas Shack

Plan view of the gas shack (Building 636)



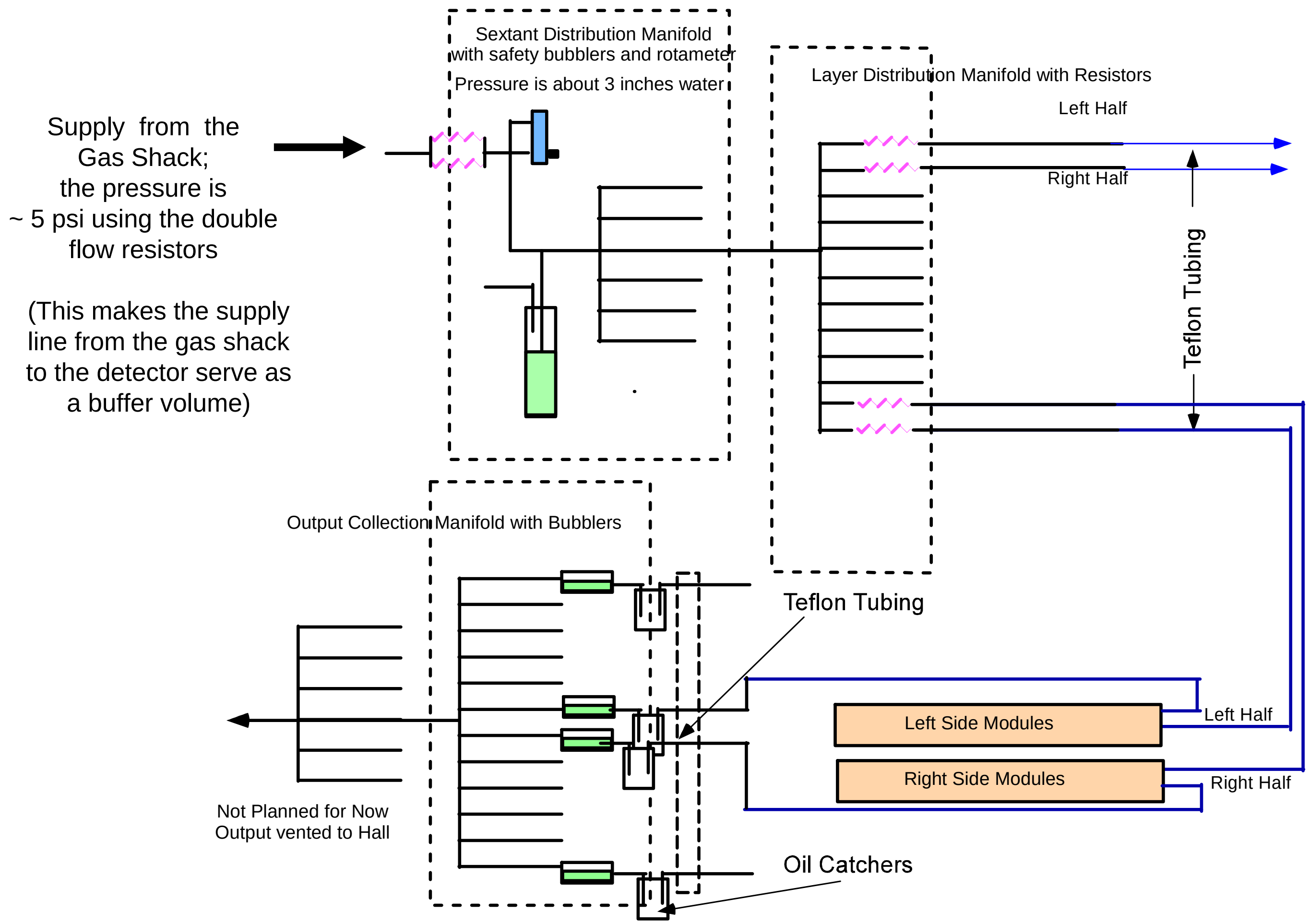
The gas shack safety system controls gases entering the shack using shutoff valves in the gas lines outside of the shack

The LST gas mixing and distribution system

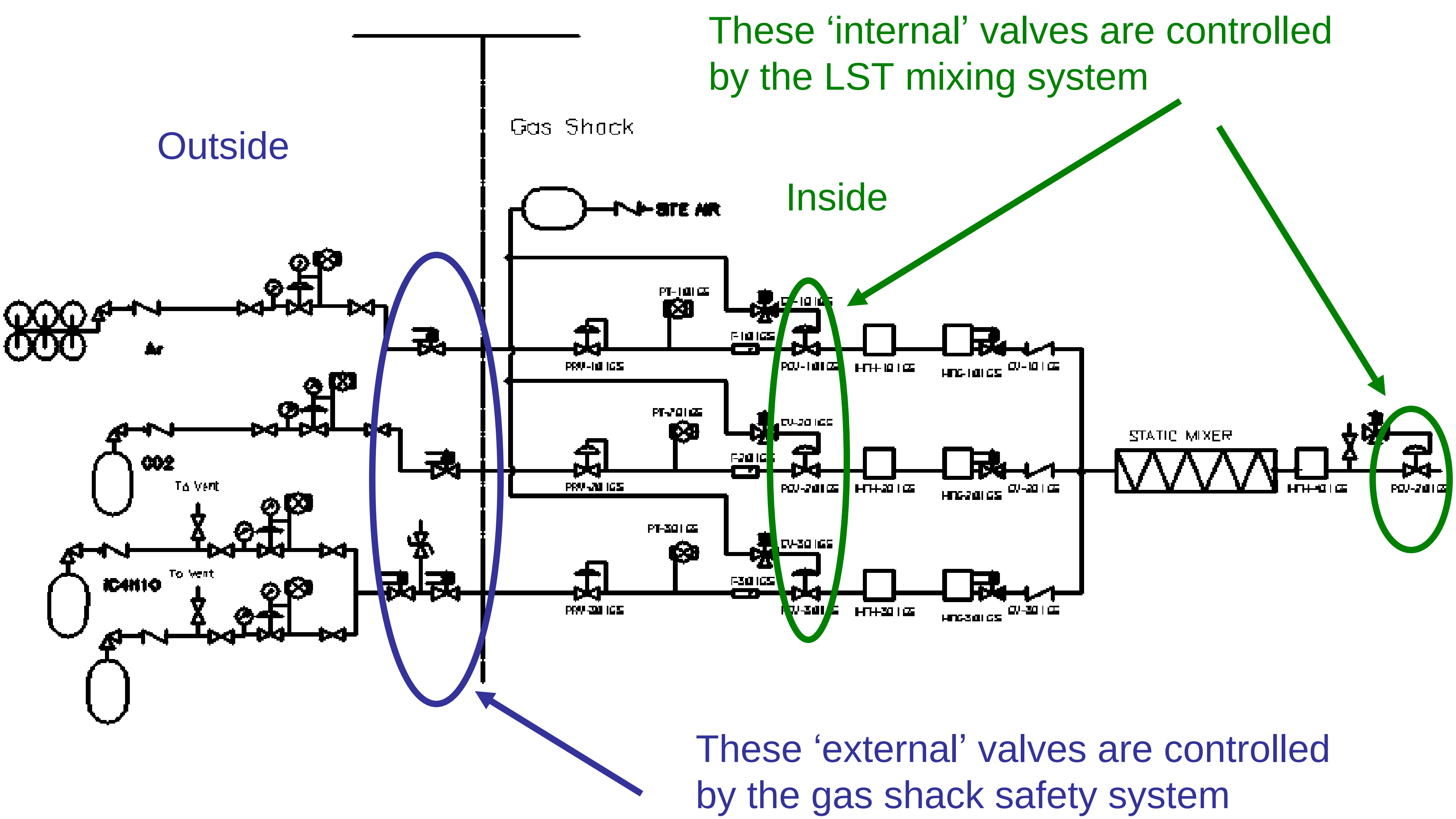
- How it is put together

- How to maintain it

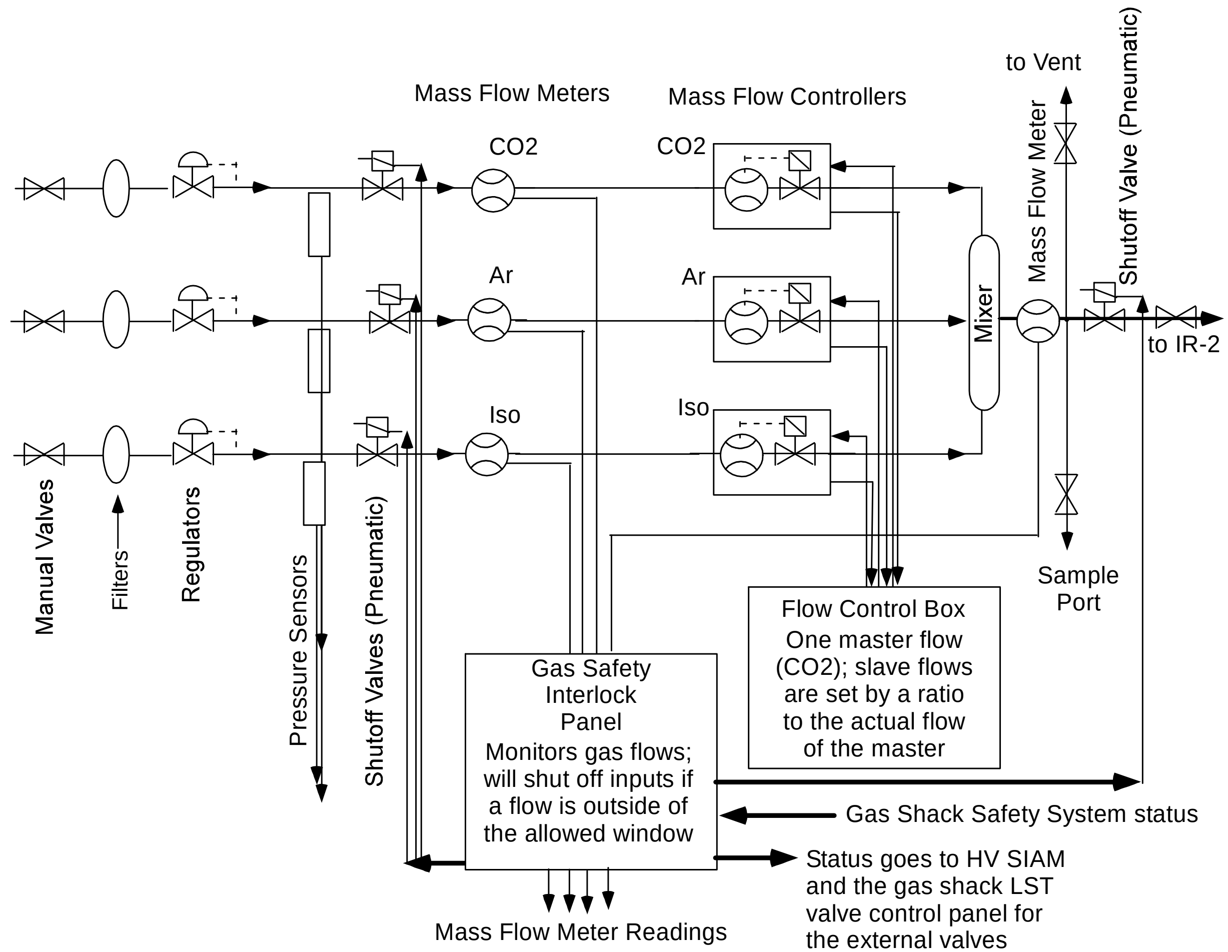
Overview of the LST distribution system



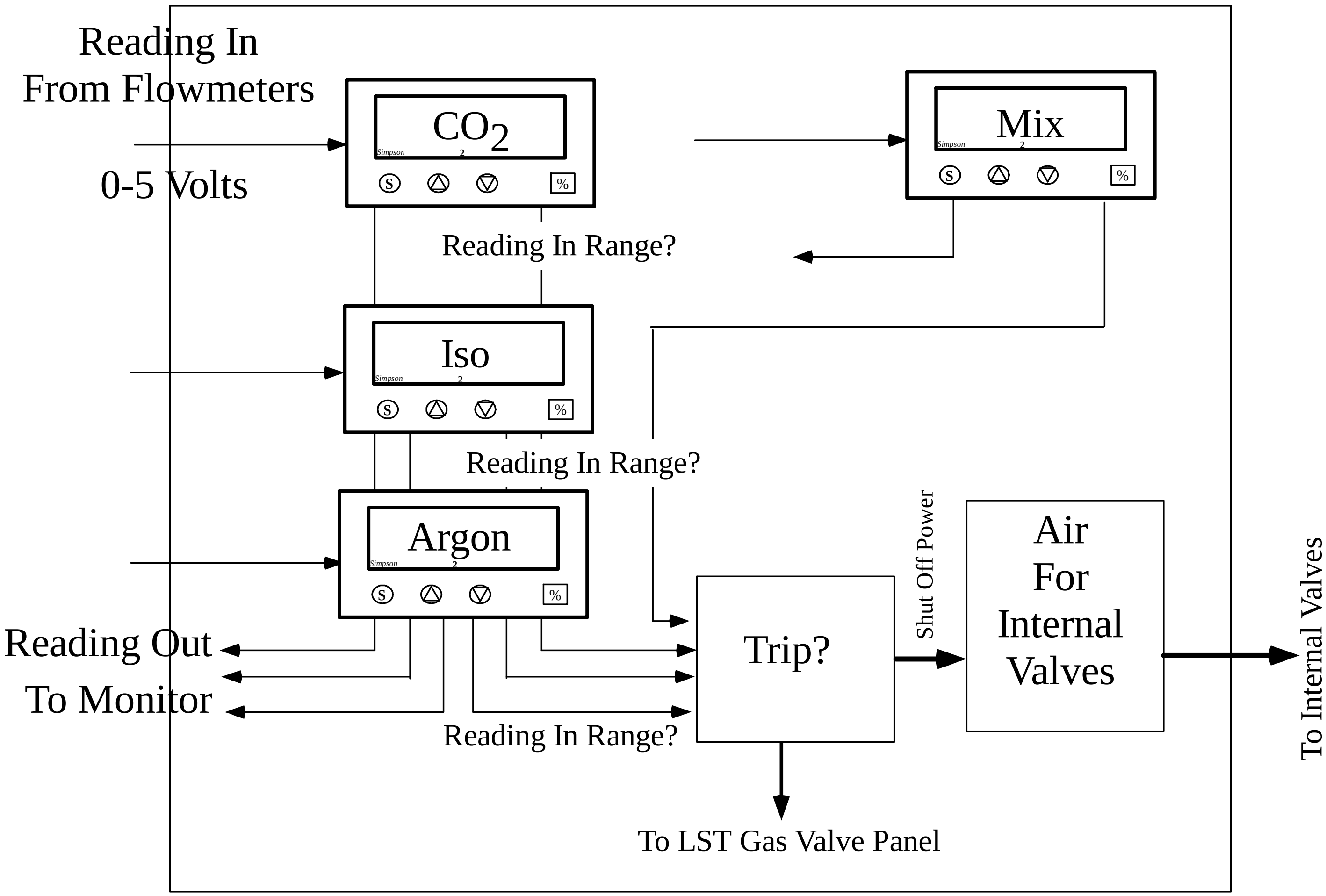
Overview of the LST gas supply and mixing system at the gas shack



The LST Gas Mixing System Functionality, concentrating on what is in the rack



General Outline of the Safety Interlock Panel's Function



Where components are located and how to respond to problems

Please note:

- There are <u>**two**</u> systems here which can shut off the LST gas flow; this can cause some confusion

- The Gas Shack safety system – monitors the situation in the gas shack as a whole
  - The gas shack ventilation prevents a release of gas(es) in the shack from producing an asphyxiating or flammable atmosphere in the gas shack itself
  - Gas flows into the shack are stopped if the ventilation system fails (or if a leak of flammable gas is detected)
    - We are required to do this
  - Controls its own set of shutoff valves on the <u>outside of the gas shack</u>
  - Always shuts off <u>all three</u> LST gases; never one at a time
  - Uses its own panel that resides in the LST mixing rack; this is connected to the main gas shack safety control rack

- The LST Gas Safety Interlock Box – monitors the flows that produce our gas mix
  - Protects against the production of a flammable gas mix that is then sent to the IR
    - We are required to do this also
  - Also protects the integrity of the gas mix in regard to the chambers' performance and safety
  - Controls its set of shutoff valves <u>in the mixing rack</u>
  - Always shuts off <u>all three</u> LST gases <u>and</u> the gas going to IR-2; never one at a time

- The two can be separated logically; *<u>operationally</u> we have decided to close all of the exterior valves if the LST Interlock Box trips*
  - We did this primarily as an extra precaution for the integrity of the mix

LST gas mixing rack (B636-07) – summary

LST Gas Safety Interlock Box:
Mass Flow Meters (MFM) and Monitoring
Internal Valve Control

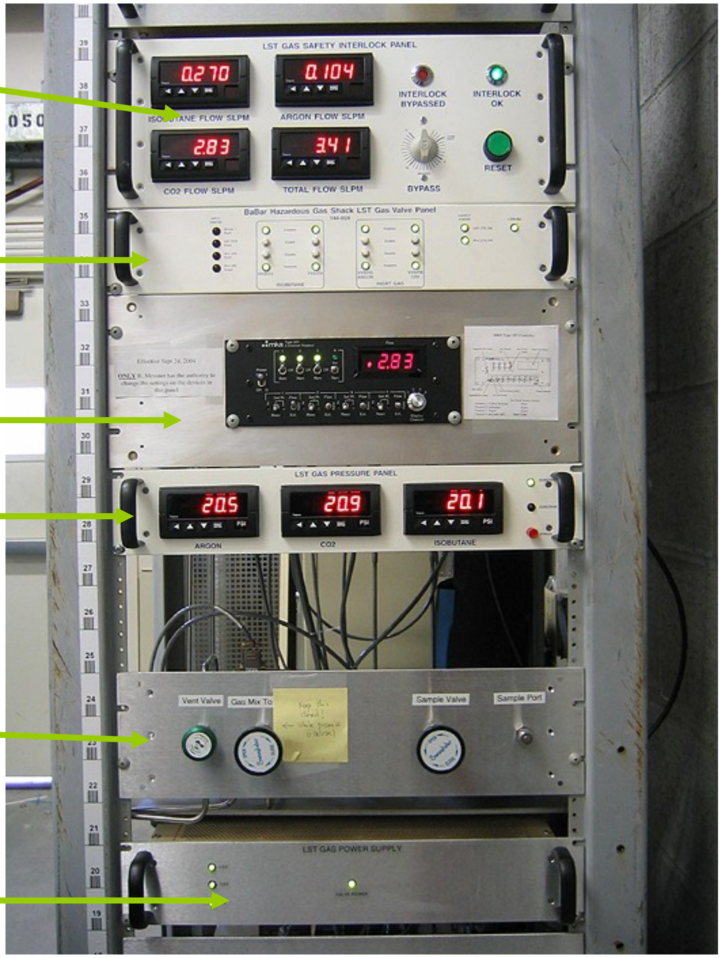
Gas Shack LST Gas Valve Panel
External Valve Controls and Status

Mass Flow Controllers (MFC)

Pressures

Manual Valves

Power Supply for the Flow Meters and Internal Valves



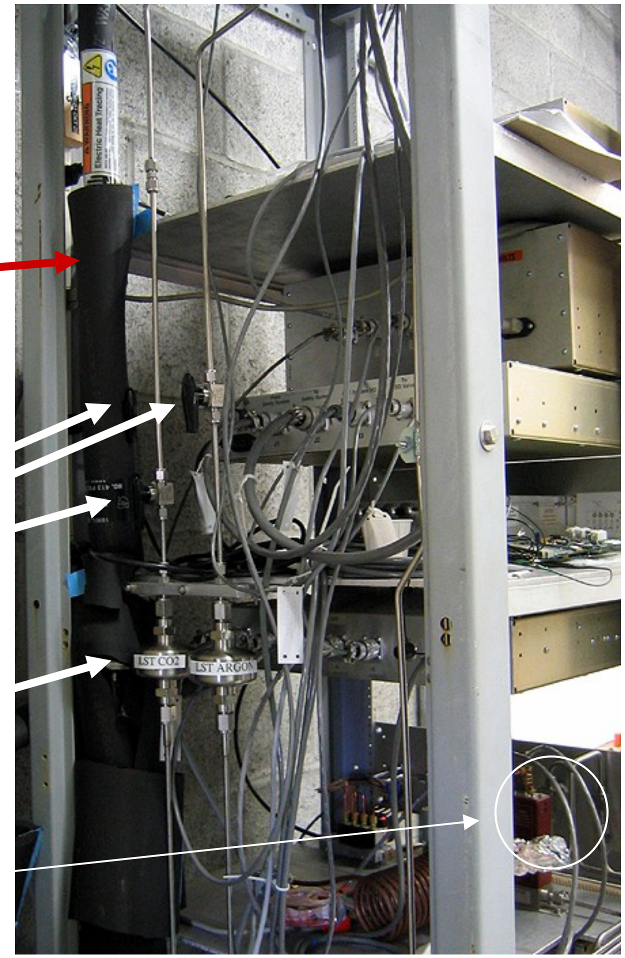
Rear/Side View of (B636-07)

The isobutane line is insulated and kept warm by heater tapes

FYI: there are three manual shutoff valves here for the gas coming into the mixing rack

These are filters

The mass flow mixers and mass flow controllers have small green LEDs on their top; they are easy to spot. When on, this says they have power and are running okay



LST gas mixing rack (B636-07) – explanation of the front view

LST Gas Safety Interlock Box – this monitors the mass flow meters; the readings you see are in liters per minute.
This will shut down the LST gas system if any of the flows are out of range; it closes the <u>internal</u> valves.
The green button is a reset button

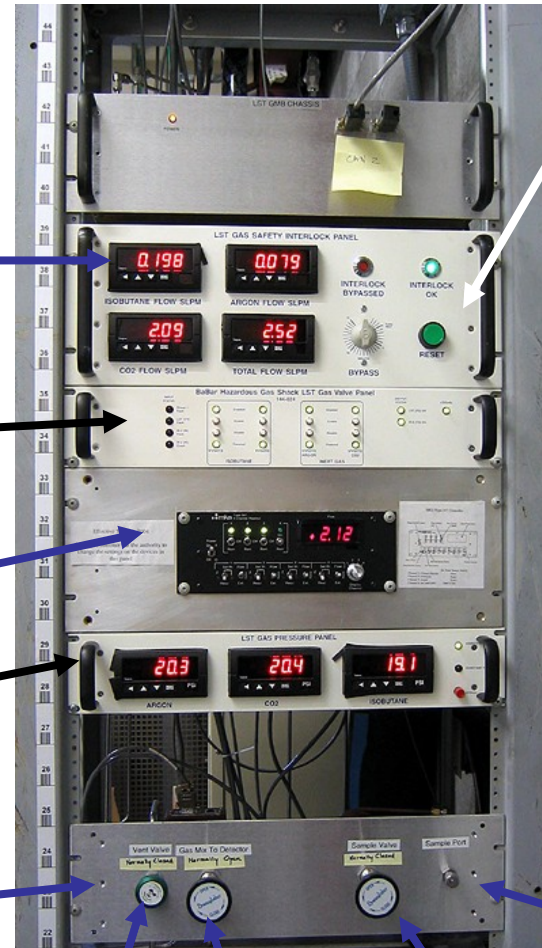
<u>Exterior</u> gas valve power control panel; this is connected to the Gas Shack safety rack. It closes the <u>external</u> valves.

Flow control box – the mass flow controllers are set here

Gas pressure monitor panel
It also monitors a pressure sensitive switch looking at the isobutane which can turn off the system (on the right); there is an override

Manual gas output valves

The power supply for the flow meters and internal valves is below the manual valve panel



RESET

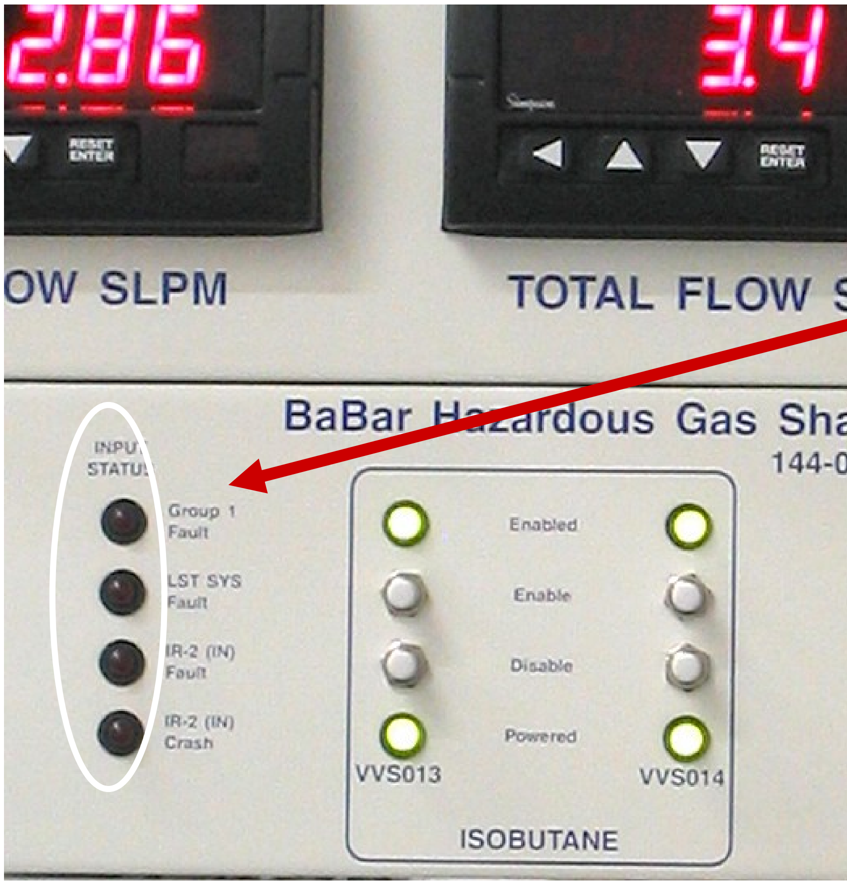
Sample Port (normally capped)

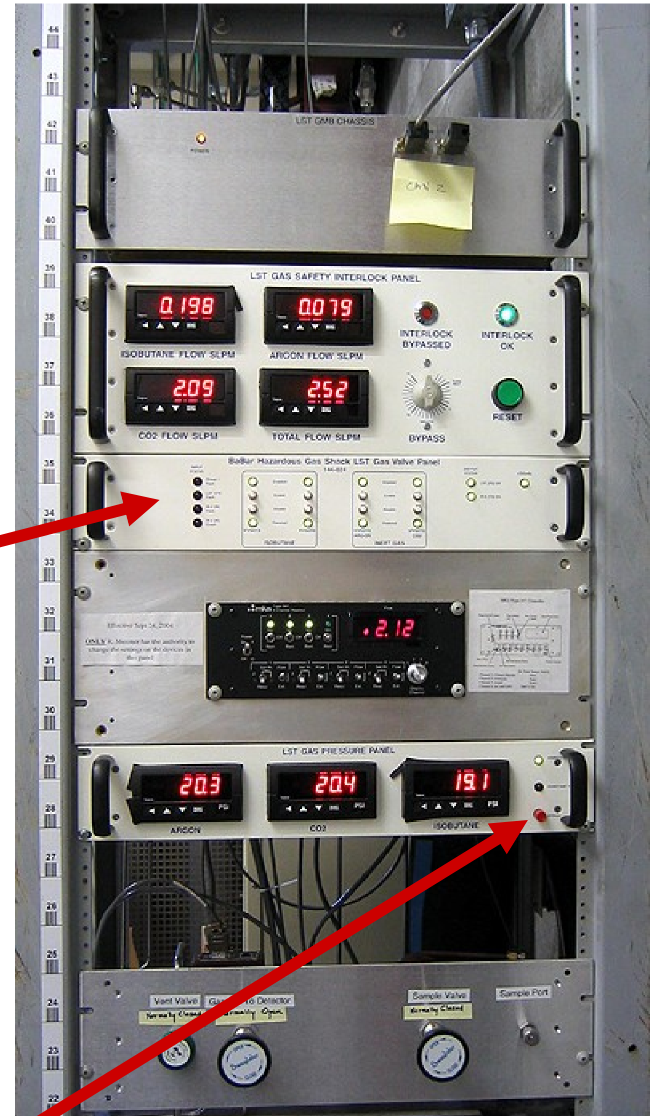
Manual Vent valve
(normally closed)

Manual valve to
IR-2
(normally open)

Sample valve
(normally closed)

The LST gas shack valve control panel summarizes the status of the shutoff valves; it will tell you whether the gas shack or the LST gas mixing system initiated the fault.





An LST system trip will occur if the isobutane line has too low a pressure; this should be rare. If a trip happens, the green LED goes off and the red LED lights up on the LST Gas Pressure Panel. When this is a problem, the small red button is an override so the line can be charged up with isobutane.

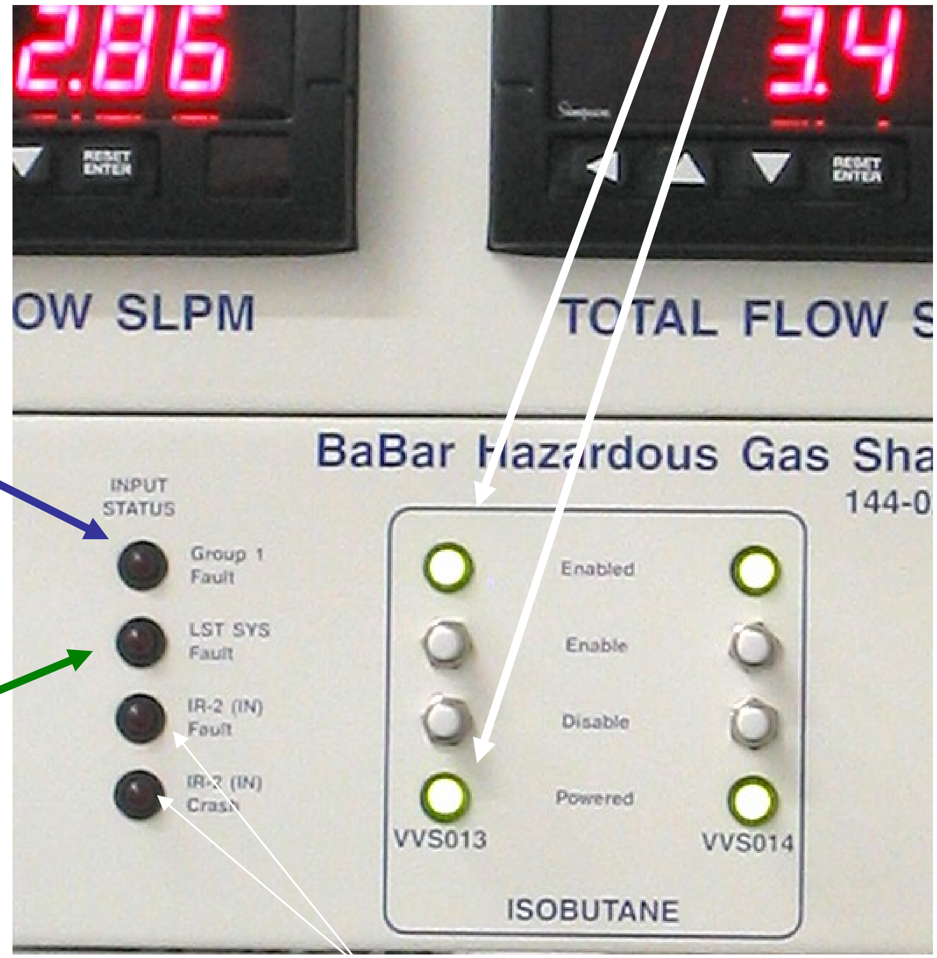
Initial diagnosis of a problem … start with the valve control panel

A **Group 1 Fault** means that the gas shack safety system has shut the <u>exterior</u> valves. Because a gas supply will run low, this also causes the LST safety interlock panel to trip and close the <u>interior</u> valves; this shows up as an LST SYS Fault.

A gas shack problem needs to be fixed first; then you can reset the LST SYS Fault via the green reset button on the LST Valve Control Panel.

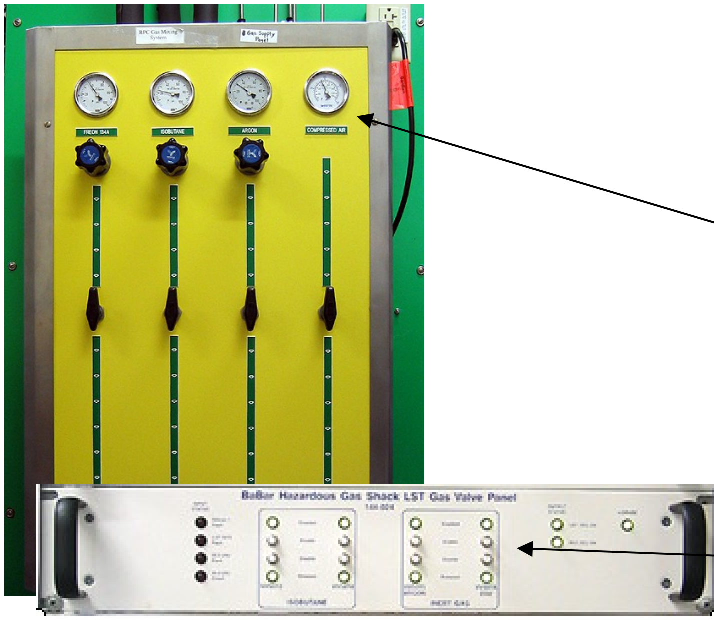
If there is only an **LST SYS Fault**, then a failure in the gas mixing system (the LST Safety Interlock Panel) has caused the trip; either the mix has drifted off, or there is too low a pressure in a supply line, etc.

LEDs display the status of the exterior valves; the valves need to be both enabled and powered to be open



These are signals from IR-2 telling the gas shack to shut down; not used

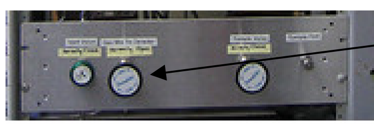
How to Restore the LST Gas System after a power outage



1) The gas shack safety system will shut off all isobutane and inert gases going into the shack in the event of a power outage. After the power has been restored, the safety system needs to be reset. There are instructions on the door of the safety system rack (and on the wall next to the safety system rack.)

2) Check to see if there is instrument air available. We share it with the RPC system. Look at the compressed air pressure gauge on the RPC gas rack. (see picture) If that is more than 50 psi, we should be okay; otherwise the house air must be off, and our backup supply has bled away (call the cryotechs for help, x5160)

3) Press the four white ‘enable’ buttons on the LST Gas Valve Panel (144-024); the top green LEDs should turn on, indicating that the valves are ‘enabled’



4) Close the manual valve to IR-2, open the manual vent valve

5) Press and **hold down** the green reset button on the LST Gas Safety Interlock Panel until the flows are restored and the ‘**LST SYS Fault’** light goes out in the LST Gas Valve Panel below

6) Open the manual valve to IR-2, then close the manual vent valve. Reset the SIAMs that have tripped

7) If there are any more problems, go to ‘How to Restore the LST System after a Trip’

How to Restore the LST System after a trip

1) Record the gas pressures for later reference; and record the status (on or off) of all of the red LEDs on the Gas Shack LST Valve Control Panel and the LST Gas Pressure Panel
2) If there is a gas shack safety system fault (Group 1 Fault), that must be cleared. Attend to that first. The red **'Group 1 Fault'** LED needs to turn off ; all green 'enabled' LEDs should be lit on the Gas Shack LST Valve Control Panel
3) If there was a gas shack problem, this has caused the LST safety system to trip; press and **hold down** the green reset button on the LST Gas Safety Interlock Panel until the flows are restored and the '**LST SYS Fault'** light goes out. When flows are restored go to the **LAST** instruction. Otherwise, read further
4) If there is an LST gas mixing system fault by itself, there has been a problem with the flows; check the gas supplies, fix any problems. (Checks are given below)
5) The pressures for all three gases read by the LST Gas Pressure Panel should be between 18 and 21 psi, otherwise problems can result; the instrument air supply is checked via the compressed air gauge on the yellow RPC panel (see what to do after a power outage)
6) If the isobutane pressure has gotten too low (below 8 psi or so), the red bypass button on the LST Gas Pressure Panel might need to be pressed to let the pressure build up; the panel's red LED should go off, the green LED should turn on
7) Then: close the manual valve to IR-2, open the vent valve
8) Press the green reset button on the LST Gas Safety Interlock Panel until all the flows resume at the normal rate. This should take less than 10-20 seconds if the gas supplies are truly okay
9) Gas flow rates should be restored and stable
10) Open the manual valve to IR-2, close the manual vent valve
11) Do this **LAST:** Reset the SIAMs that have tripped (there will be slides to follow that show you how.) You need to do this to enable the Alarm Handler to catch new trips

A closer picture of the LST mixing crate

1) Press all 4 of the 'enable' buttons if the green 'enabled' LEDs are not lit

2) See if the Group 1 fault is **lit**

4) If there is no Group 1 fault, but the system has tripped, you might have run out of gas. Check the pressures to find out which gas supply is the culprit and fix that. Shut off the flow to IR2, and open the manual valve to vent the gas; then push and hold RESET. If flows restore to normal, open the valve to IR2 and close the vent.

3) If the Group 1 fault is lit, fix the gas shack problem; then push and **hold** RESET until the LST SYS Fault goes out.

These all have to be green for the external valves to be open

5) If the gas supplies are okay, and the LST mixing system still trips, then compare the Mass Flow Meter (MFM) flow values with the Mass Flow Controller (MFC) values. Turn this knob to look at the MFC values one by one to compare with the MFM values. The chart tells you what gas each channel controls.

If the MFM and MFC flow values differ by more than the last digit, something is wrong; you could have liquid isobutane in the lines. Consider calling an expert.

What can cause an LST system fault by itself (i.e., when there is no gas shack problem)

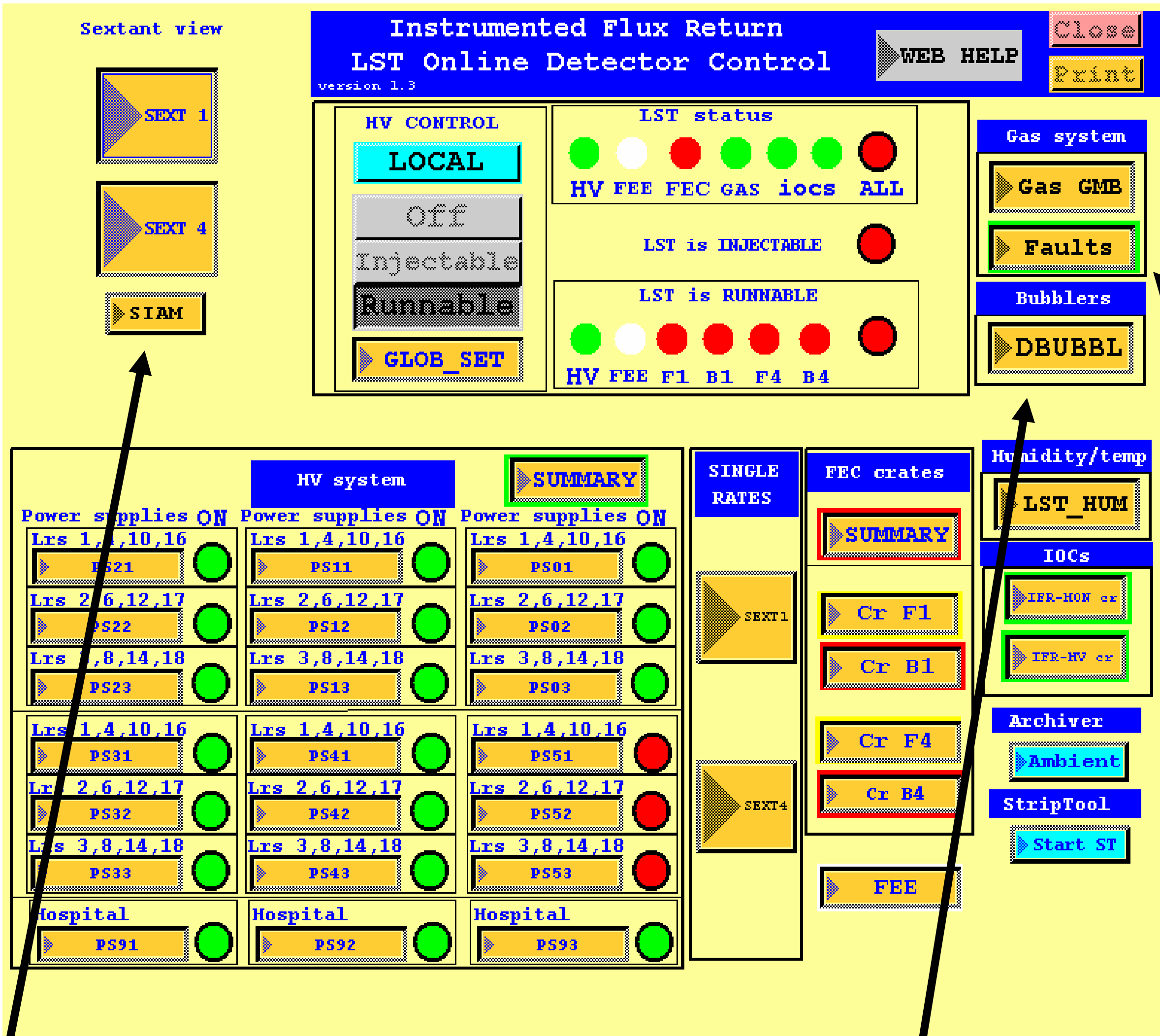
- A gas supply has been shut off, or a gas supply is at too low a pressure
  - A manual valve has been closed; an external valve has been accidentally disabled
  - Insufficient pressure (not enough heating) on the isobutane (look at the pressures at the manifold and in the rack)
  - A supply of gas has run out (look at the pressures along the relevant gas lines) – this includes instrument air
  - A primary supply of gas has run out and the backup system was set at too low a pressure
  - The vent valve for the isobutane supply tank could have been left slightly open; gas will escape through the vent, the system will run off the backup isobutane tank until that runs out

- A power glitch (reset the external valves if needed and reset the LST safety interlock panel)
  - The mass flow controllers and mass flow mixers need at least a couple of minutes to reinitialize after power is back

- There is liquid isobutane in the lines leading to the mass flow meters and controllers
  - Close the manual valve sending gas to IR-2; open the manual vent valve
  - Turn the Bypass timer switch on the LST Gas Safety Interlock Panel (it will beep away); push the green reset button
  - Compare the mass flow meter readings with the mass flow controller readings for the isobutane (the mass flow meter reading will tend to be very erratic if there is liquid)
  - If there is liquid, close the manual isobutane valve in the back of the mixer rack
  - Bleed off the liquid isobutane until the isobutane pressure is less than 15 psi
  - Beware of the low pressure isobutane trip; if tripped, you have to use its bypass button
  - Open the manual isobutane valve
  - See if the flows stabilize
  - You may need to lower the input isobutane pressures so you don't get excessive cooling across regulators
  - Let the system run for about five minutes; if it is stable, close the vent valve, open the valve to IR-2
  - The bypass timer will time out on its own
  - Liquid in the lines can knock out a meter or a controller; monitor things carefully; call an expert

- Other
  - A comparison of the total flow meter with the other flow meters may help to isolate an inaccurate read back, discriminate between a bad flow meter or a bad flow controller

Resetting SIAMs: software control is available on two panels you can access via EPICs



This panel displays the gas flows and pressures

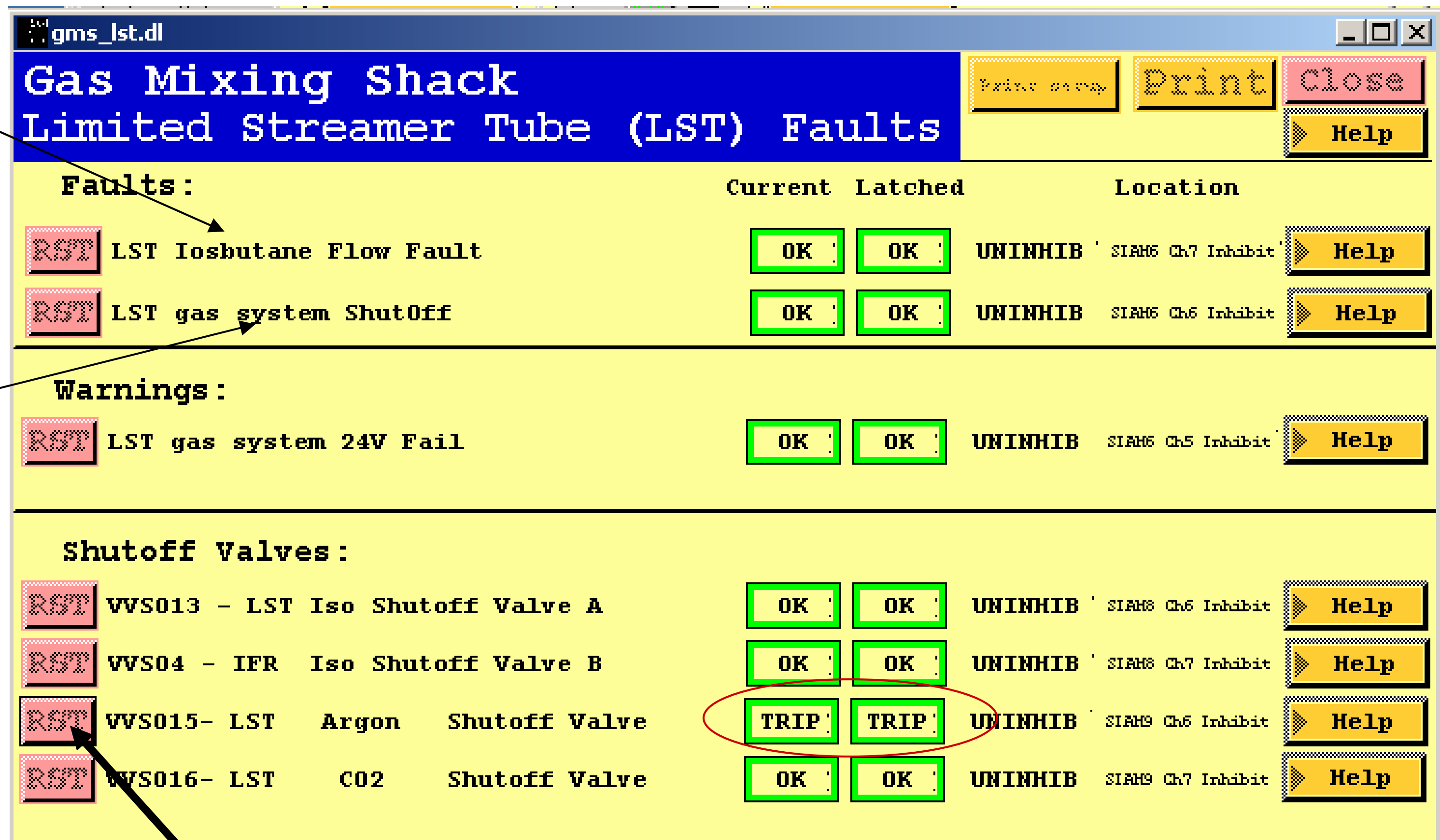
(2) This panel gives a list of the status of the external LST gas valves; the gas shack safety signal to the LST system; a 24 volt supply; and the isobutane pressure monitor – reset the ones that were tripped!

(1) The status of the LST mixing system is channel 0 on this SIAM – reset this!

(3) DBUBBL shows the bubbler values for all channels

Resetting SIAMs: the mixing shack LST Fault panel

Low pressure

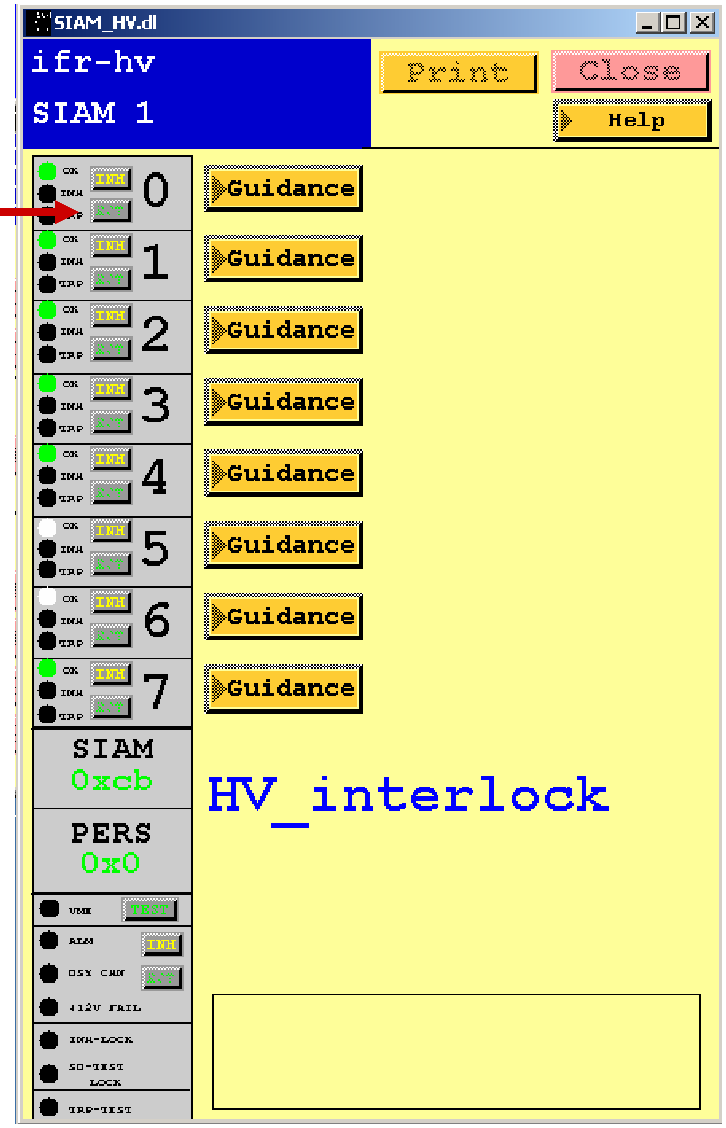


When 'tripped', says that the Gas Shack has closed the external LST valves

Click on these to reset the channels after the problem is fixed; this will be when the 'Current' state reads OK, but the 'Latched' state reads TRIP. You must clear these to re-enable the Alarm Handler

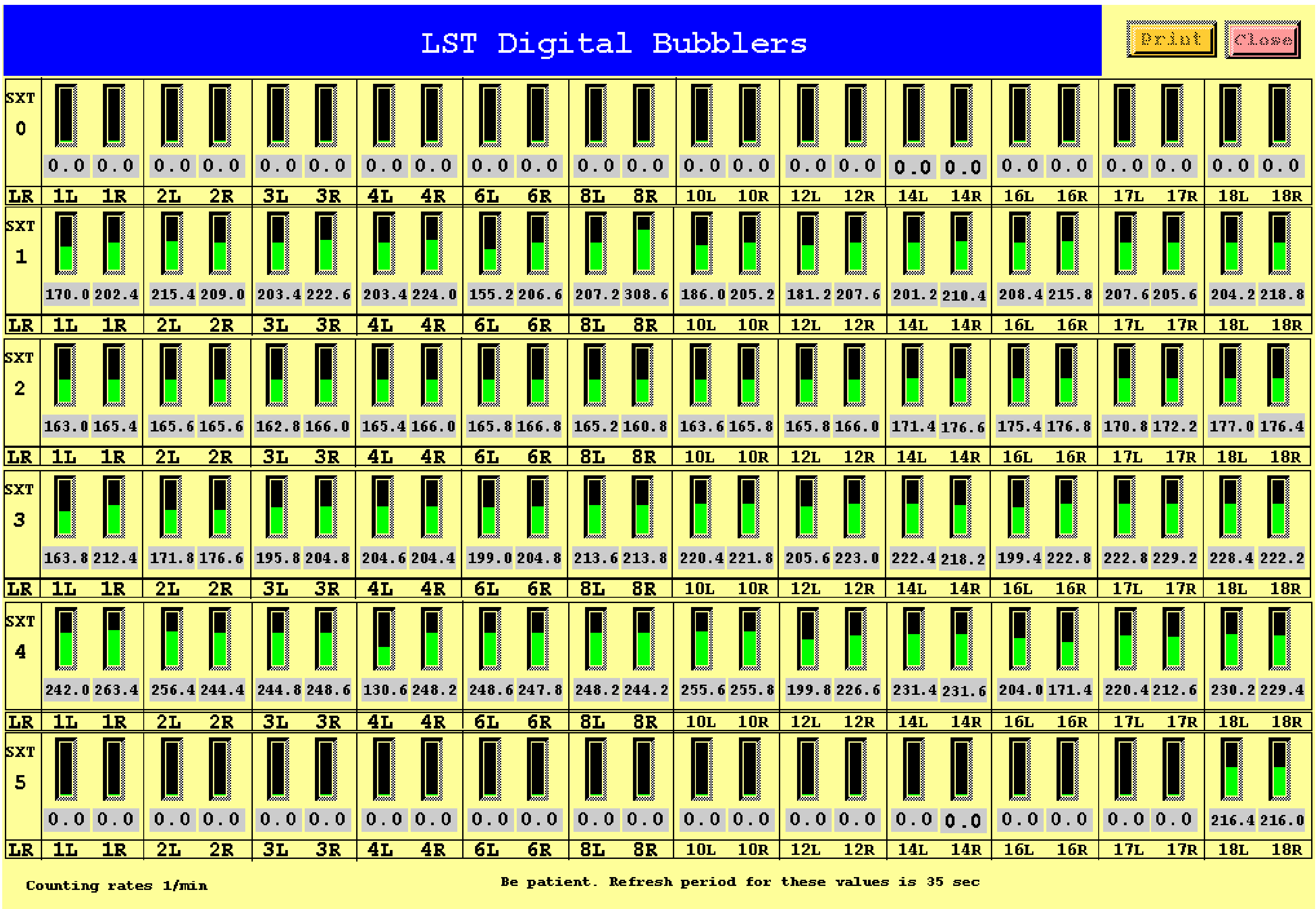
Resetting SIAMs: the LST SIAM (the physical SIAM is located in the electronics hut)

Click on this reset button to clear the trip; you need to reset all tripped channels in order to re-enable the Alarm Handler.



The output bubbler panel (DBUBBL)

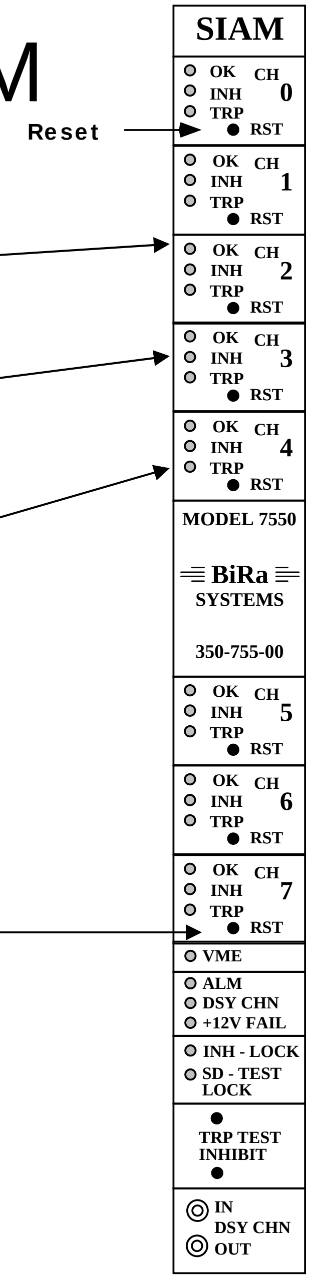
The long run of piping between the gas shack and IR-2 means that there is a buffer volume between the two. The gas can flow for 10-20 minutes after the system shuts off. Below is a picture while sextants 0 and 5 were being installed; you can see layer 18 of sextant five under fast flush.



A Drawing of a ‘Real’ SIAM

There are several items per channel

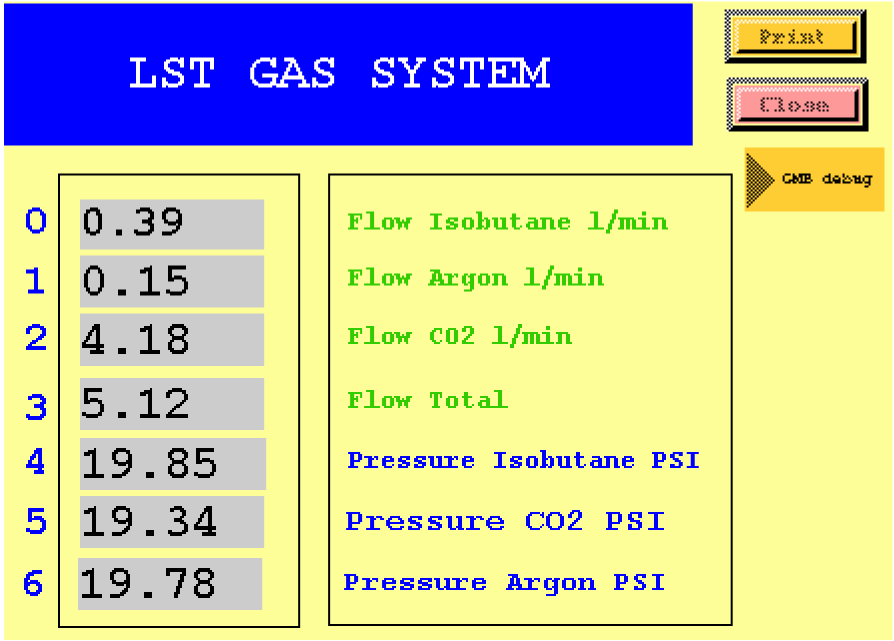
1. OK light (green); if on, the input is okay <u>at this specific time</u>
2. The inhibit indicator ‘INH’ (orange); if lit, this channel is not being used to create an alarm
3. The trip light ‘TRP’ (red); the input has tripped, either now <u>or</u> in the past. The input might be okay now, but a trip is latched until cleared. You need to clear this by pressing the …
4. Reset buttons (one for each channel.) There are plastic ‘toothpicks’ inside the safety rack to access them.



The alarm output is the ‘OR’ of all the inputs

The Daisy chain is the ‘OR’ of multiple SIAMs

Gas Flows


LST GAS SYSTEM
Print
Close
GMB debug
0 0.39
1 0.15
2 4.18
3 5.12
4 19.85
5 19.34
6 19.78
Flow Isobutane l/min
Flow Argon l/min
Flow CO2 l/min
Flow Total
Pressure Isobutane PSI
Pressure CO2 PSI
Pressure Argon PSI

Gas Shack SIAM contents (1)

SIAMs 1-4 contain information on the status of the ventilation, the gas shack HADs, a gas shack smoke detector, and DCH monitors

SIAM 1	
0	MH1 - Air Intake
1	MH2 - Air Supply
2	MH3 - Air Return
3	MH4 - Air Exhaust
4	
5	
6	
7	Smoke Det

SIAM 2	
0	HAD 1
1	HAD 2
2	HAD 3
3	HAD 4
4	HAD 5
5	HAD 6
6	HAD 7
7	HAD 8

SIAM 3	
0	DCHiso VLow
1	DCH Ret Low
2	DCH Sply Low
3	DCH Sply Hi
4	HAD 9 - front bulkhead vent
5	HAD 10 - rear bulkhead vent
6	HAD 11 - rack 10 top
7	HAD 12 - rack 10 bottom

SIAM 4	
0	MH6 - RPC Rack Ventilation
1	DCH Sys Problem
2	IR-2 (in)
3	IR-2 Crash
4	
5	
6	
7	

Gas Shack SIAM contents (2)

SIAM 5	
0	RPC: Input Pressure Fault
1	RPC: Input Flow Fault
2	RPC: Mixing Tank Pressure High
3	RPC: Mixed Gas Output Flow Fault
4	RPC: Ext Mixed Gas Output Interlock
5	RPC iso Vlow
6	
7	

SIAM 6, channel 5 shows the status of the 24V supply for the external valves

SIAM 6	
0	RPC: Ext Fill Interlock
1	RPC: Fill Operation Fault
2	
3	24V Supply OK
4	HAD 6-8 Bypass (tank change)
5	LST 24V Supply OK
6	LST System SO
7	LST Isobutane Vlow Fault

SIAM 6, channel 6 will indicate when the gas shack is sending a signal that closes the LST external valves

SIAM 7	
0	RPC: Isobutane low
1	DCH: Isobutane low
2	RPC: Argon low
3	RPC: Freon low
4	DCH: Helium low
5	DCH: Nitrogen low
6	Compressed Air low
7	DCH: CO2 low

SIAM 8	
0	DCH isobutane - VVS01
1	DCH isobutane - VVS02
2	RPC isobutane - VVS03
3	RPC isobutane - VVS04
4	Span Gas - VVS05
5	Span Gas - VVS06
6	LST Isobutane – VVS013
7	LST Isobutane – VVS014

SIAM 9	
0	RPC Argon - VVS07
1	DCH Nitrogen - VVS08
2	DCH Helium - VVS09
3	RPC Freon - VVS010
4	DCH CO2 - VVS011
5	VVS012
6	LST Argon – VVS015
7	LST CO2 – VVS016

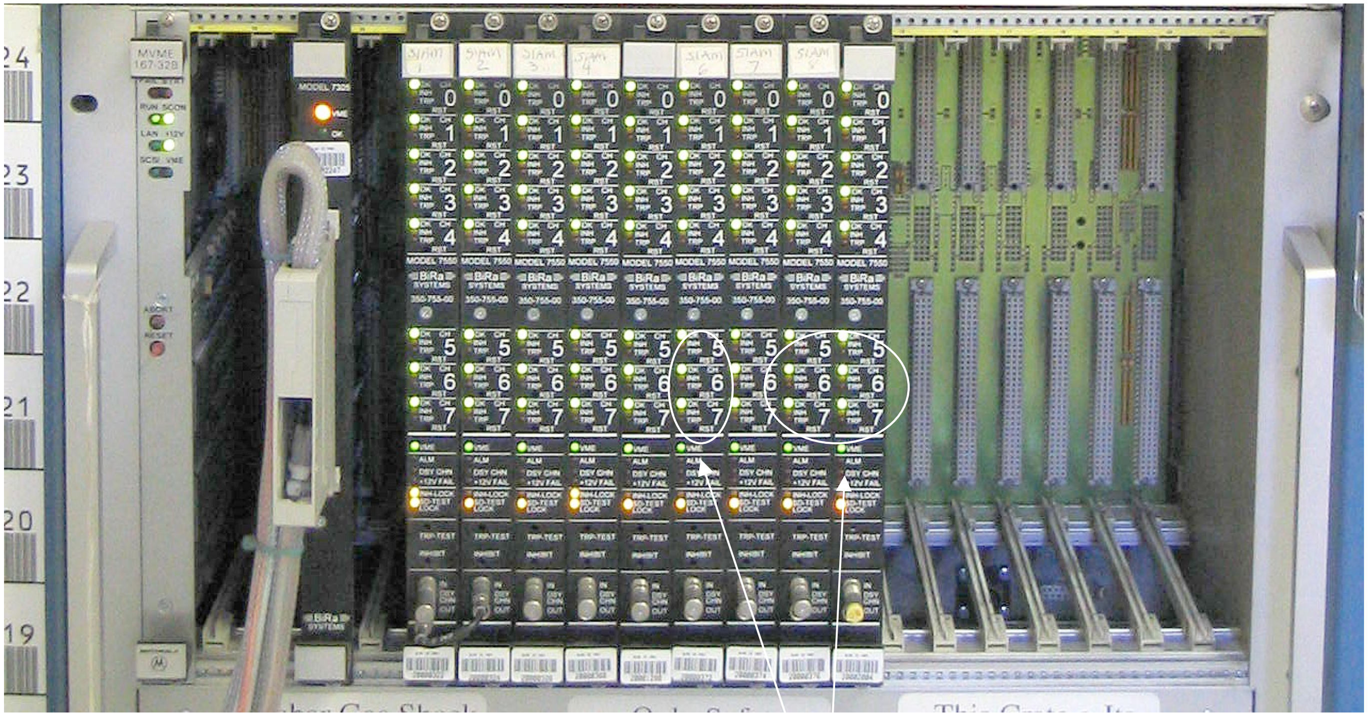
SIAMS 8 and 9 show the status of the LST external valves

SIAM 6, channel 7 indicates if there is low isobutane pressure that has shut off the LST system

Picture of the SIAMs in the gas shack VME crate

(Rack B636-03)

SIAM: 1 2 3 4 5 6 7 8 9



This is where you look to reset the LST SIAMs manually

The power for the LST isobutane heater tapes originates on the south wall of the shack

There are two controls. One heats the line outside; the other heats the line inside of the shack.

Notes on the MKS Type 247 Controller; these are FYIO. <u>Don't</u> touch the controls!

- I really mean this; don't change any settings
- You risk sending flammable gas down into the detector if you make a mistake
- Experts, and only experts, are empowered to change the gas mix; and that only after following a written procedure
- BTW, FYIO = For Your Information Only

There is a procedure that is required before there is any change of the LST gas flows; and appropriate individuals must be informed (ES&H Bulletin 70)

11/8/2004

LST gas system

Gas Mixture Authorization for a mixture containing

______________ **% Isobutane**

______________ **% Argon**

And

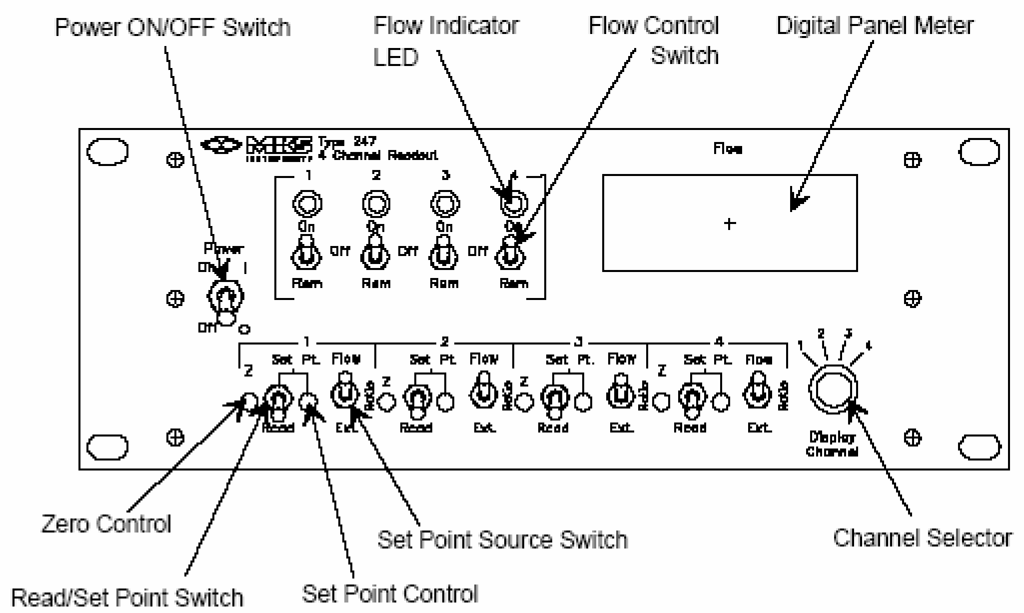
______________ **% Carbon Dioxide**

Signatures: ___________________________ LST system manager

___________________________ LST gas system expert

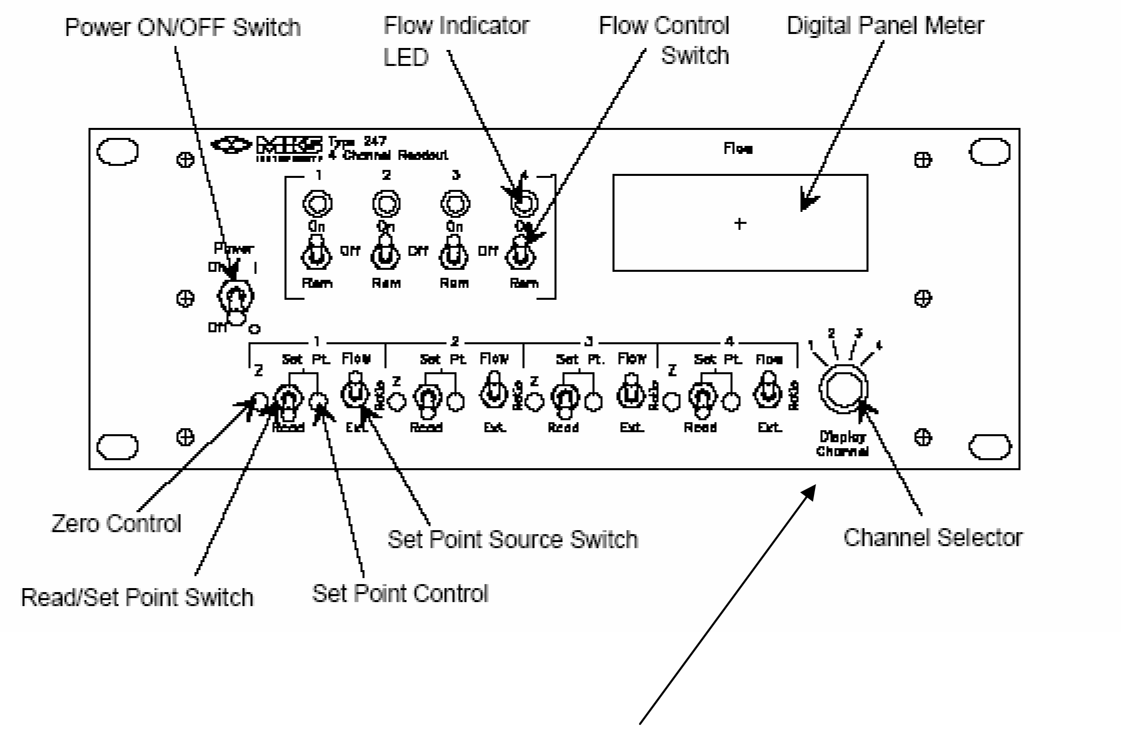
___________________________ Date

MKS Type 247 Controller



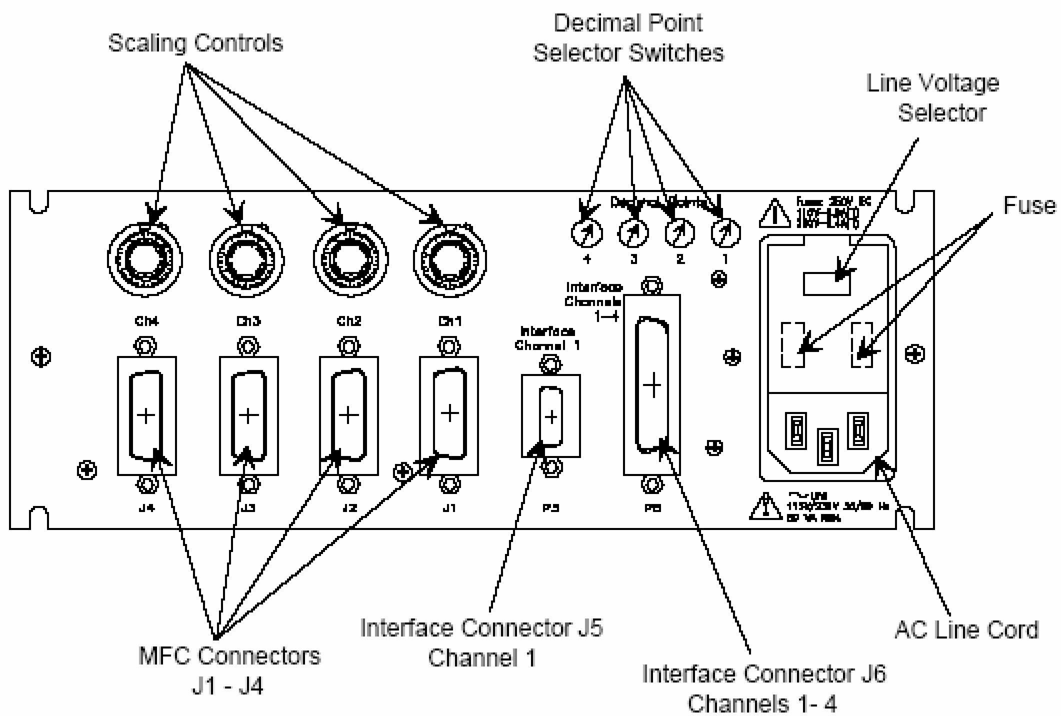
	Set Point Source Switch
Channel 1: Carbon Dioxide	Flow
Channel 2: Isobutane	Ratio
Channel 3: Argon	Ratio
Channel 4: not used (off)	Don’t Care

MKS Type 247 Controller



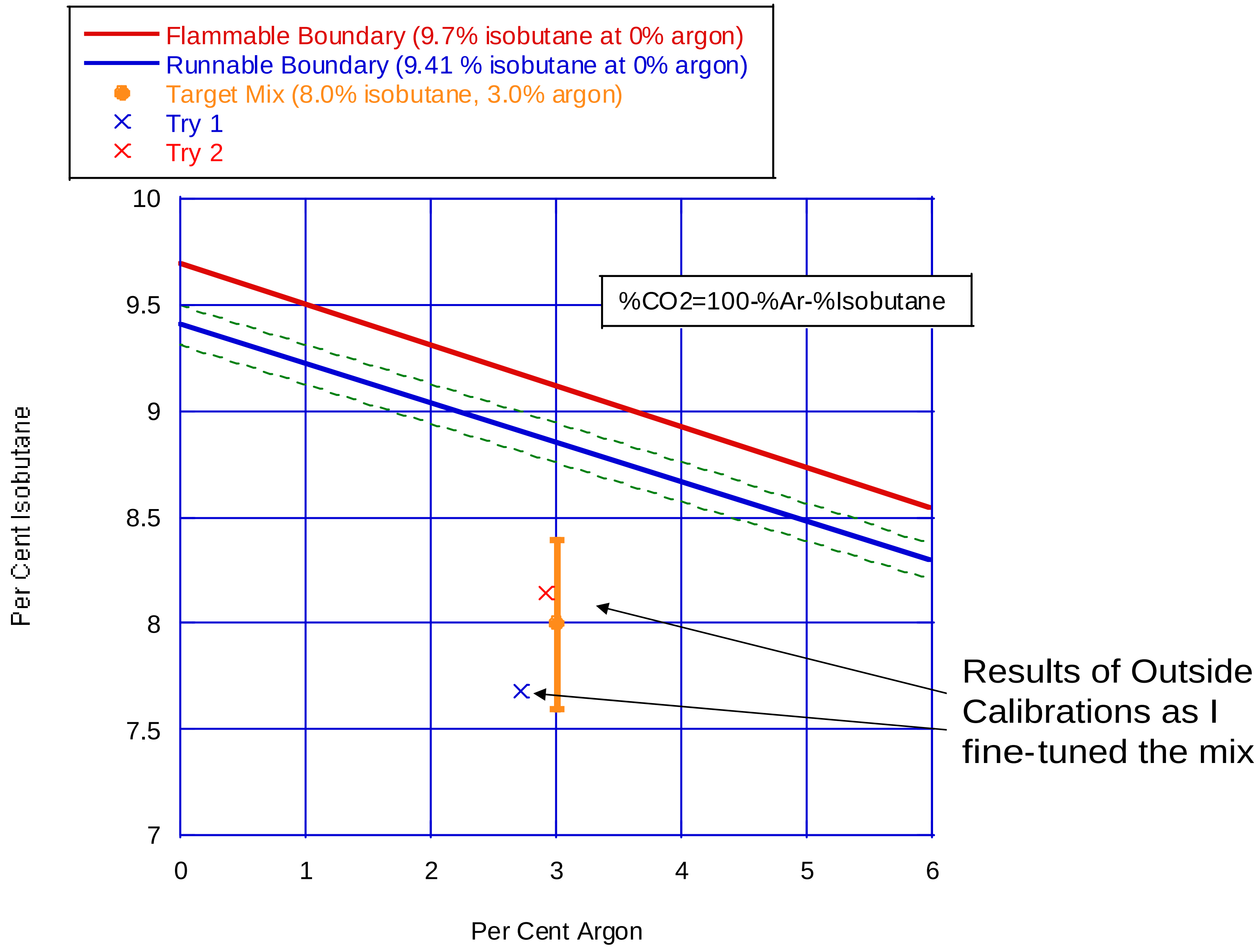
You can turn the channel selector switch to look at the read back values for each of the individual gas flows as measured by the mass flow controllers; these should be very close to the values read by the mass flow meters

MKS Type 247 Controller Rear Panel



	Scaling Controls
Channel 1: Carbon Dioxide	74
Channel 2: Isobutane	100
Channel 3: Argon	50
Channel 4: not used (off)	Don’t Care

Where we are running the system now



LST gas supplies

LST checklist – standard readings (Part 1) while we have 2/6 sextants installed

LST Isobutane Supply Panel

Tank 1 Weight	(> 50 lbs)	
Tank 1 Supply Pressure	(>30 psi)	
Tank 1 Temperature	(> 80 deg F)	
Tank 2 Weight	(> 15 lbs)	
Tank 2 Supply Pressure	(>30 psi)	
Tank 2 Temperature	(> 80 deg F)	
Manifold Pressure	(~28 psi)	

Inert Gas Pad

CO_2 Supply: Fill Gauge	(> 1/4 full)	
CO_2 Supply: Output pressure	(~40 psi)	
Compressed Air Cylinder	(>500 psi)	
Argon Six Pack #1	(>750 psi)	
Argon Six Pack #2	(>750 psi)	
Argon Six Pack #3	(>750 psi)	
Argon Trailer Supply Pressure	(>200 psi!)	

LST checklist – standard readings (Part 2) while we have 2/6 sextants installed

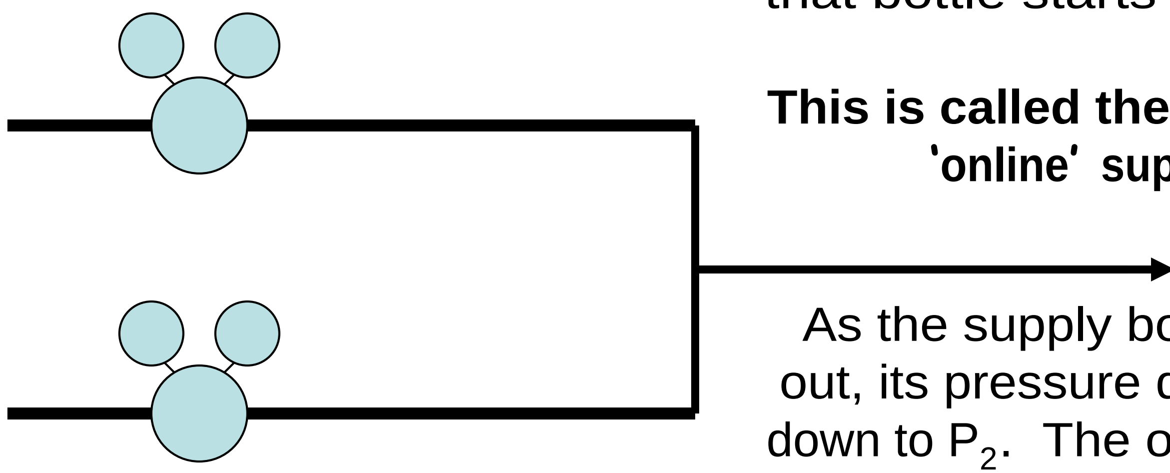
LST Gas Mixer Rack (B636-07)

LST Gas Safety Interlock Panel		
Isobutane Flow	(.200+-.01)	
Argon Flow	(.078+-.01)	
CO_2 Flow	(2.10+-0.1)	
Total Flow	(2.52+-0.1)	
LST Gas Pressure Panel		
Argon	(> 18 psi)	
CO_2	(> 18 psi)	
Isobutane	(> 18 psi)	

Gas Supplies -
Idea behind using two supplies, one as a backup

Regulator 1 – output pressure set at $\mathbf{P_1}$

Bottle 1



Bottle 2

Regulator 2 – output pressure set at $\mathbf{P_2 < P_1}$

Note that the output pressure gauge on Regulator 2 will read the pressure $\mathbf{P_1}$ until the first bottle starts to run out

The output comes from Bottle 1 at pressure P_1 until that bottle starts to run out

This is called the supply or 'online' supply

As the supply bottle runs out, its pressure decreases down to P_2. The output then comes from Bottle 2 at pressure P_2 until Bottle 1 is replaced

This is called the standby or backup supply

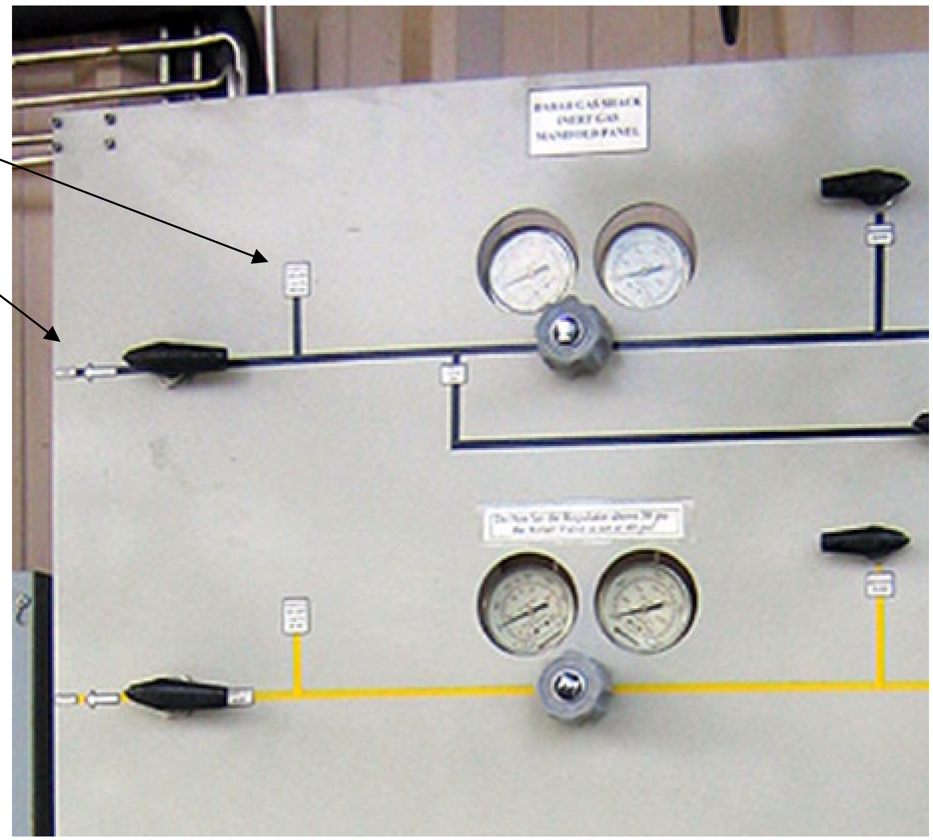
Inert Gas - Pressure relief valves

The gas lines for the inert gases have an orifice plus a pressure relief valve before going into the shack.

The combination limits the amount of each inert gas that can get into the shack. The argon and freon pressure relief is done on the RPC inert gas manifold.

One problem that can happen is that someone adjusts a regulator to a pressure above the pressure relief valve, and vents (wastes) gas and we run out.

There are caution signs about this and labels.



The CO_2 supply

The CO2 supply is a dewar that gets filled by a delivery truck, usually after midnight

Temporary supply until the real dewar arrived

CO_2 supply

The dewar contains 750 pounds of CO_2 when full (about 20 days worth at one volume change per day for the entire barrel.)

We will develop a regular delivery schedule; once a month now, once every two weeks later. The deliveries are usually made late at night or first thing in the morning

There is a fill level indicator on top

CO_2 supply

The connection for the delivery truck to use to fill the dewar is inside the box

One day we found that our main delivery line had been shut off; hence the sign on the side of the bottle

CO_2 supply

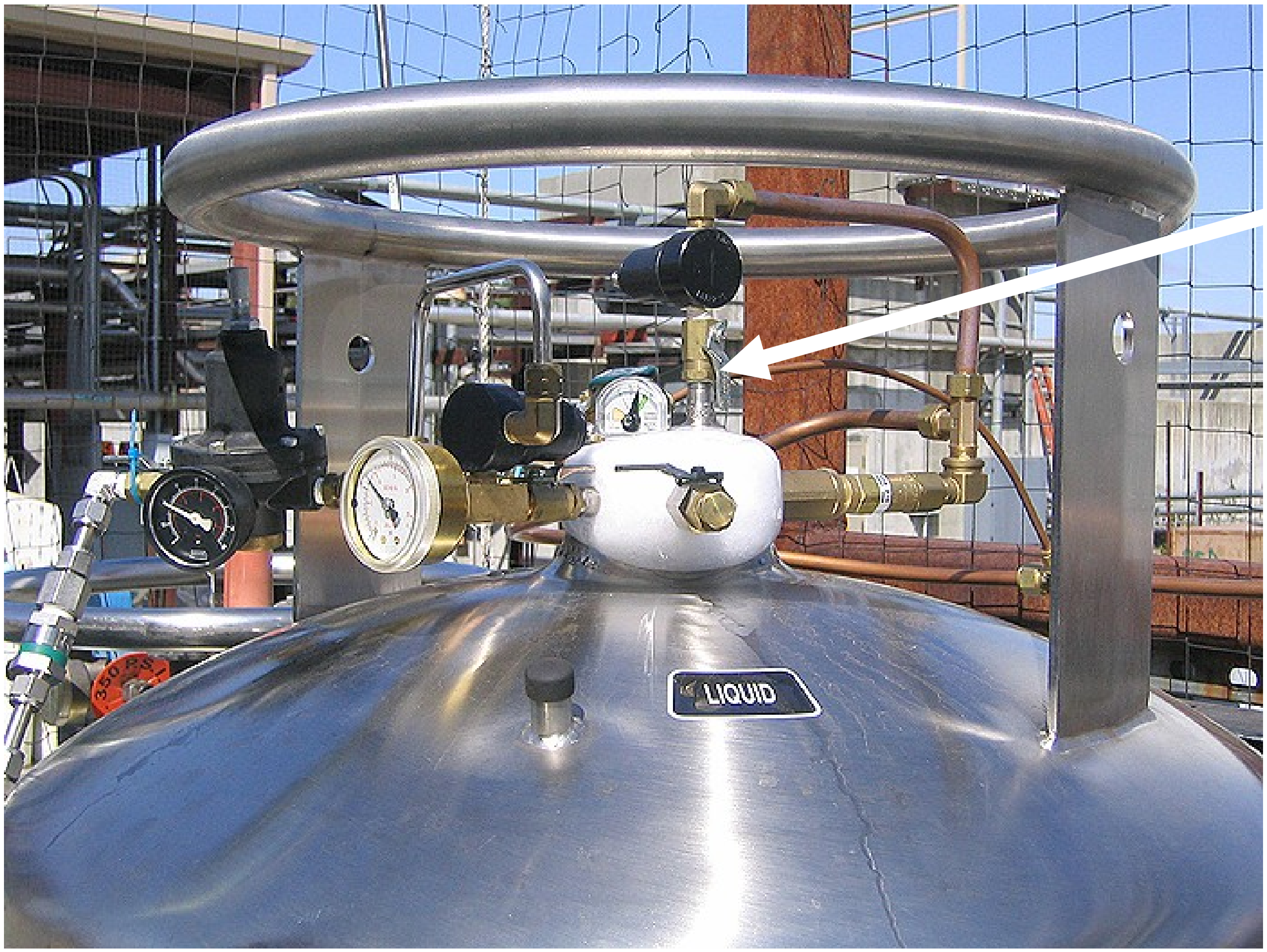
This gauge measures the pressure of the gas going to the LST gas mixer panel

Should be ~> 40 psi

Measures the Internal pressure of CO_2 gas
Typically runs > 100 psi

These valves must be open

CO_2 supply

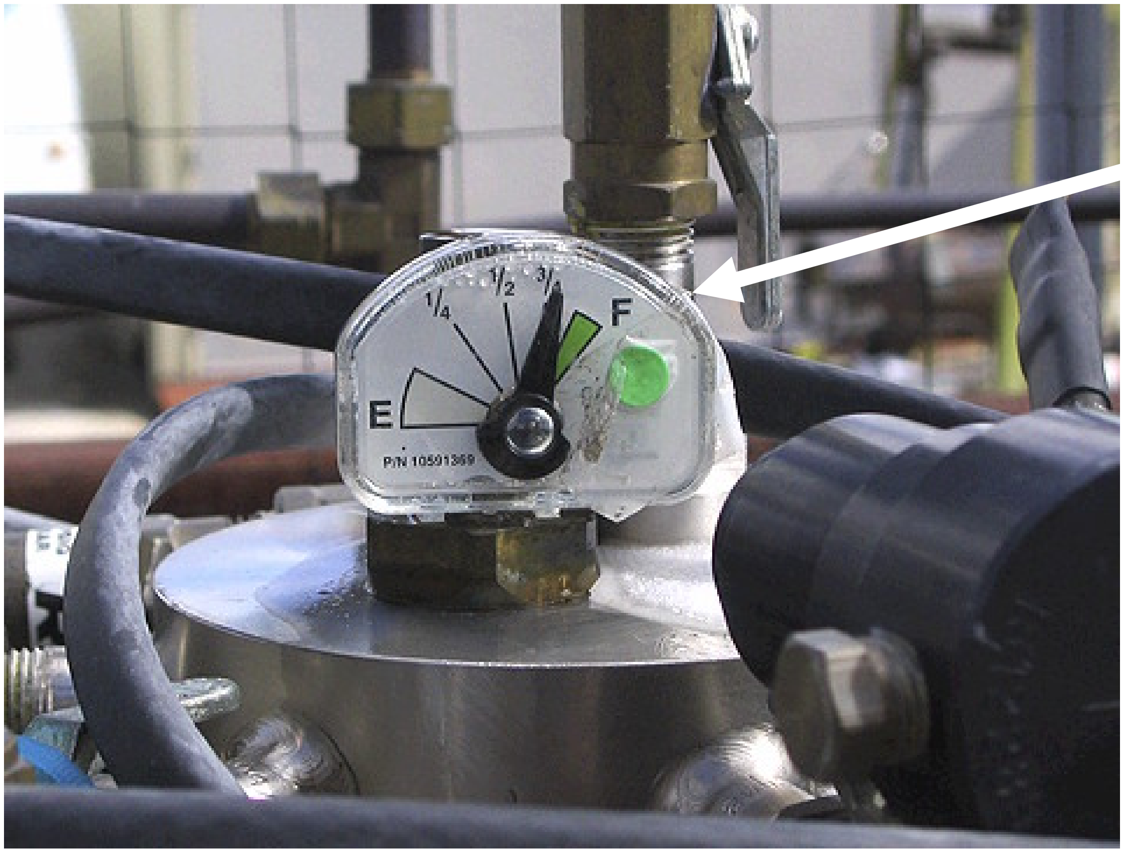


Fill level indicator

It is pretty much like a car's gas gauge, in that the level doesn't go down evenly; we've made a coarse calibration

If it reads ¼ of a tank or less, call Mike Racine or Tom Weber; we want to have it filled fairly soon! (There is still a week's supply)

CO_2 supply: close-up



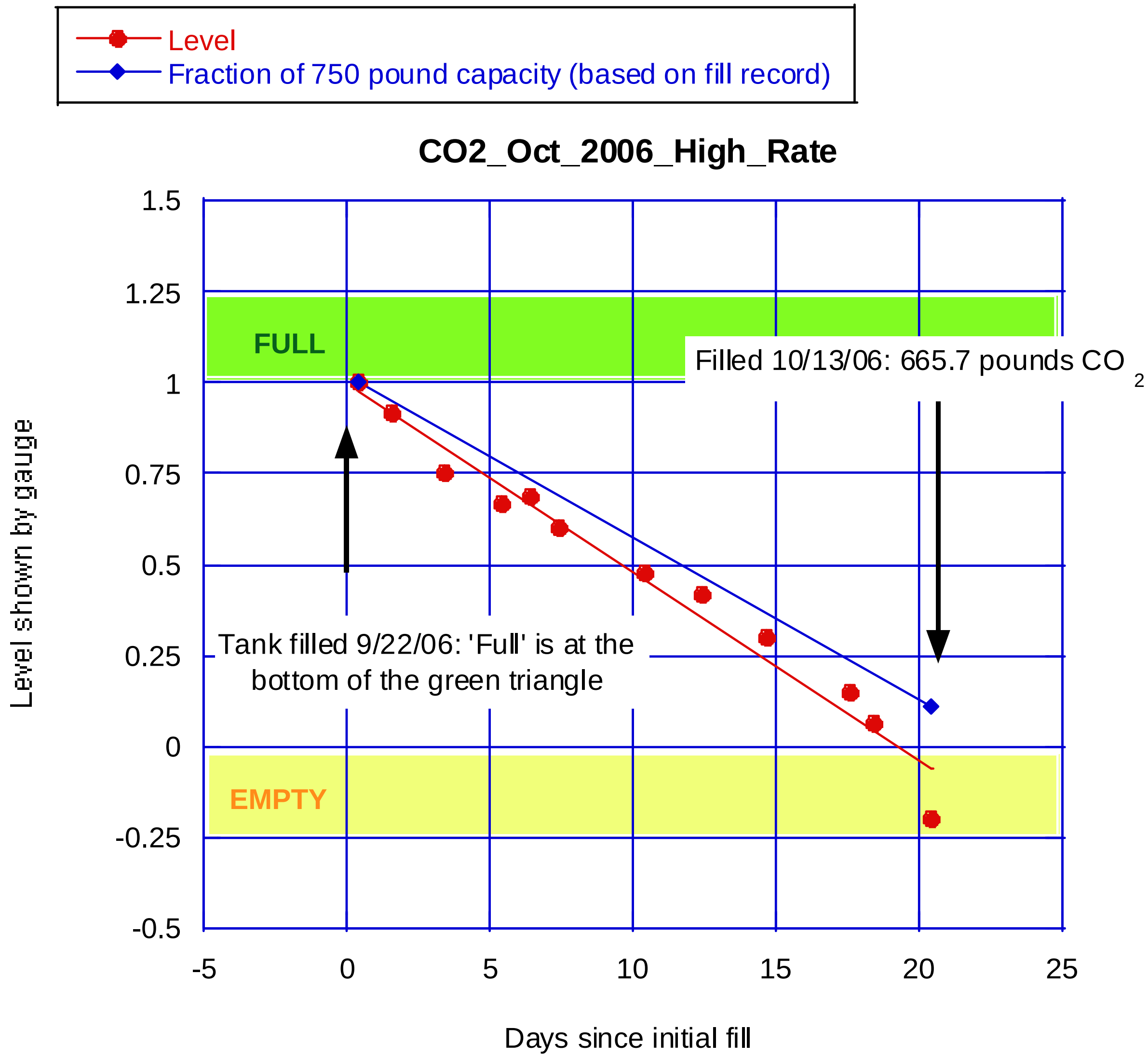
Fill level indicator

It is pretty much like a car's gas gauge; we've made a coarse calibration

If it reads ¼ of a tank or less, call Mike Racine or Tom Weber; we should be certain to have it filled soon! (There is still 5 days supply)

Poor man's calibration of the CO_2 fill gauge (constant daily consumption)

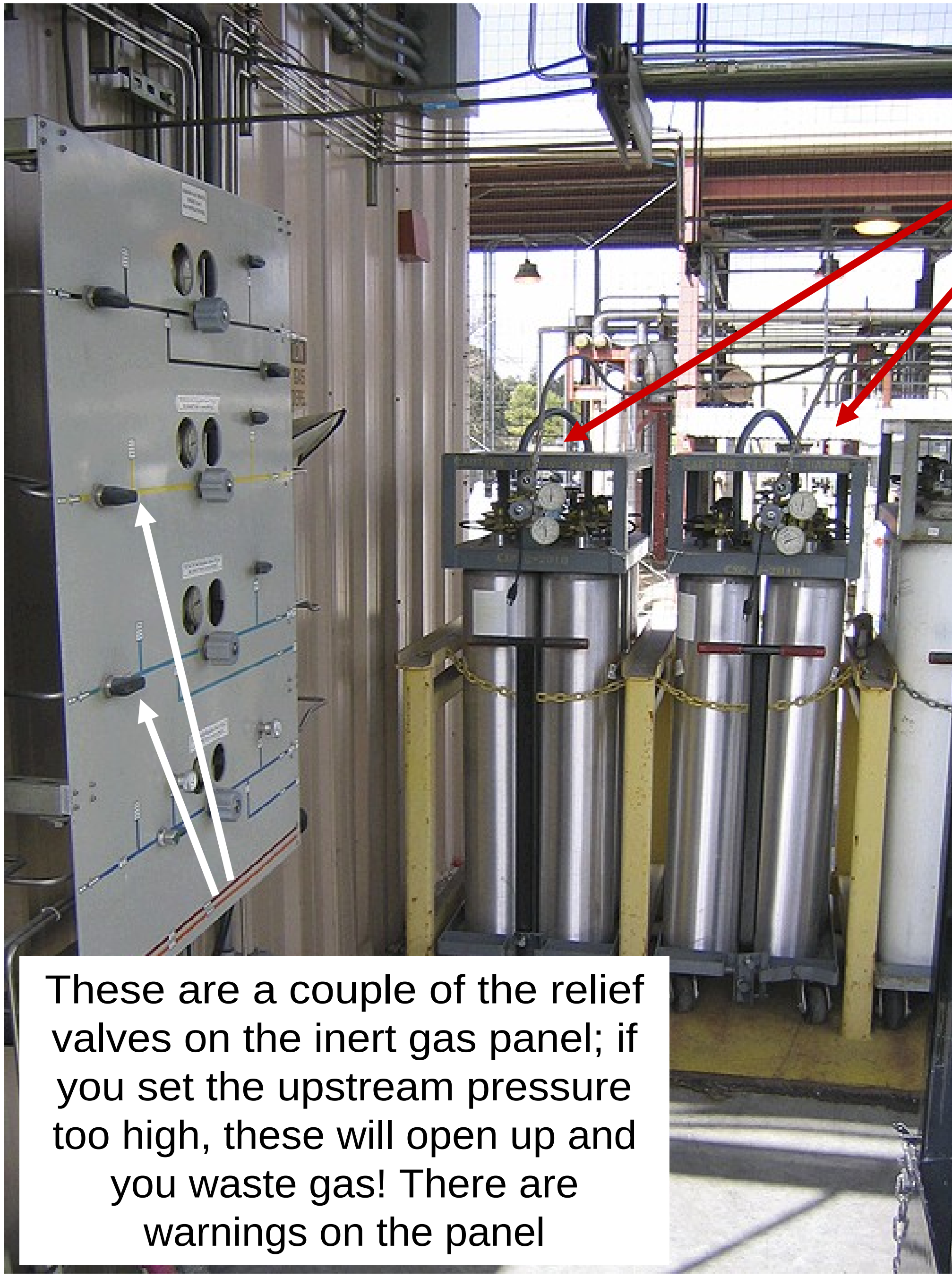
The CO_2 dewar capacity is supposed to be 750 pounds; we use 32 pounds per day, which says that a dewar lasts about 21 days



CO_2 backup

- Two six-packs have been hooked up
- We keep one six pack shut off; the second is ready to go and should last a week
- Just the same, we want to watch the contents of the primary CO_2 dewar to make certain it is filled in a timely manner; we really **don't** want to use the backup CO_2 if at all possible (it's hard to get them refilled or even to know how much is left after they have been in use)
- If the dewar's CO_2 level is at the ¼ full point, that should last us 5-6 days, enough to cover a holiday and a couple of missed phone calls.
- We are scheduled for regular fills every 14 days

CO_2 backup



These are a couple of the relief valves on the inert gas panel; if you set the upstream pressure too high, these will open up and you waste gas! There are warnings on the panel

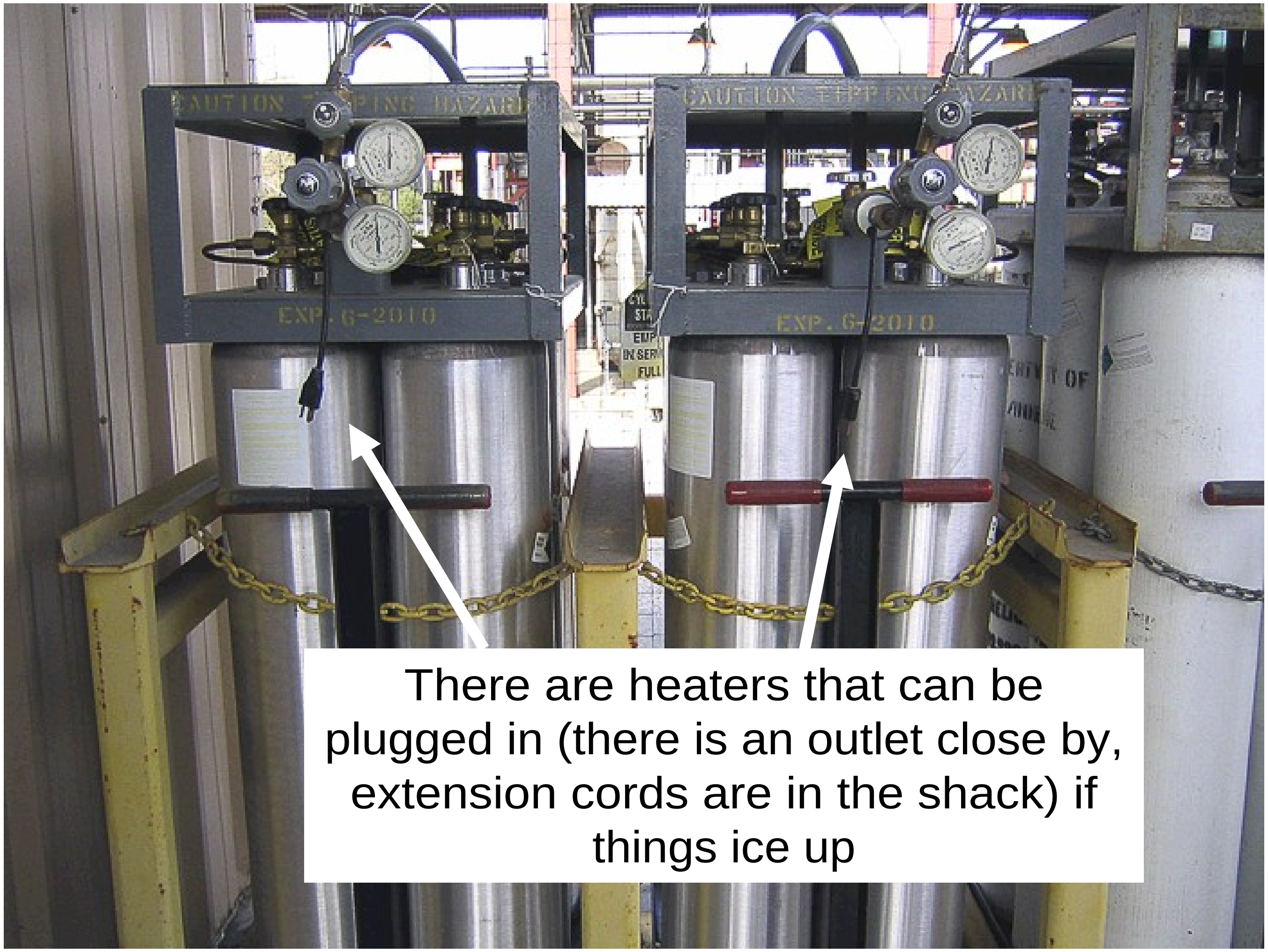
Two six-packs have been hooked up, but the one on the left in this picture is normally valved off

There are heaters that can be plugged in (there is an outlet close by) if the lines start to ice up

The gauge on the primary CO_2 dewar gives us warning before we run low there; there is no gauge or warning on the six packs. The CO_2 is normally a solid in the tanks

One important caution: there are relief valves on all of the inert gas input lines to keep the pressure below a maximum. Don't let any pressure for the CO_2 supply get above that, or we run out of gas quickly!

CO_2 backup


CAUTION TIPPING HAZARD
EXP. 6-2010
CAUTION TIPPING HAZARD
EXP. 6-2010
There are heaters that can be plugged in (there is an outlet close by, extension cords are in the shack) if things ice up

The LST isobutane supply

Called the
Cylinder Valve

Thermometer

Heating
Blankets

Should read
85 < T <120 degrees F

Explosion-proof outlets

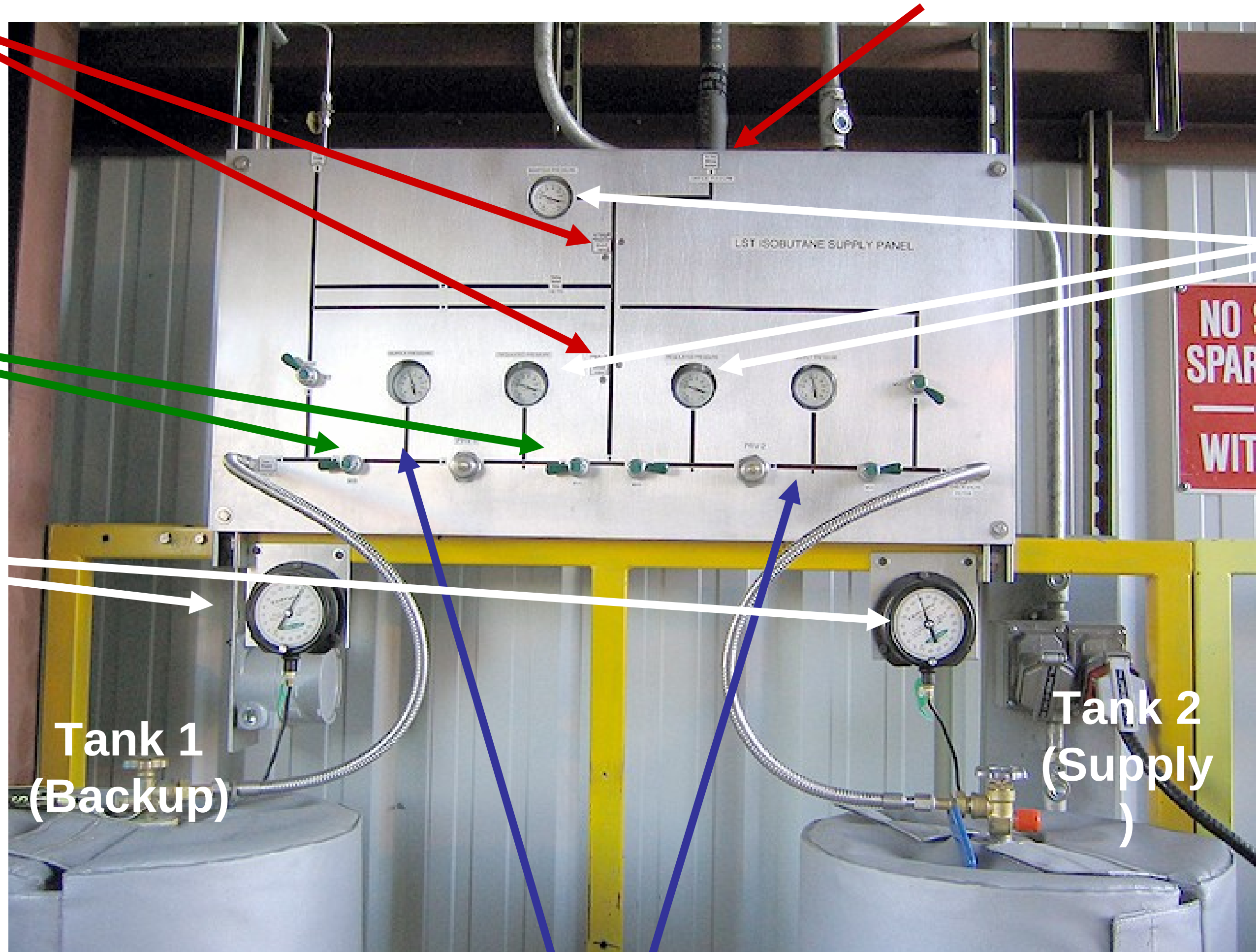
The LST Isobutane manifold panel

Gas Shack safety system shutoff valves

Manual Shutoff valves
(six in all)

Weight scales

An orifice limits the isobutane flow



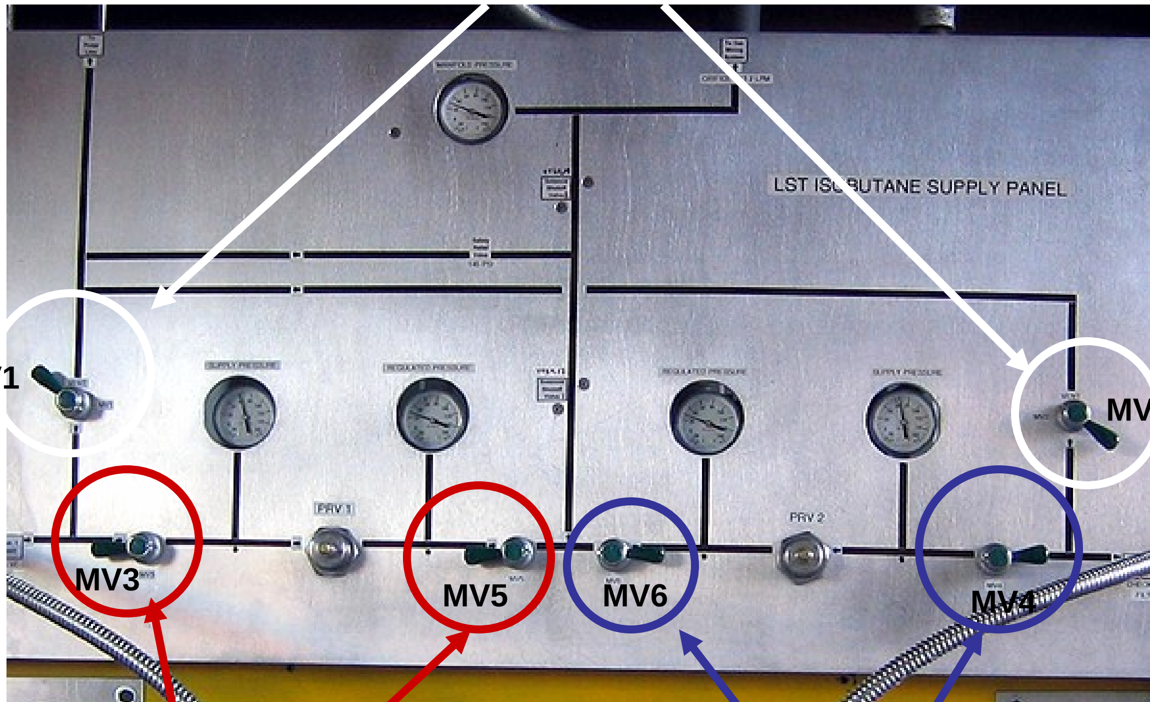
Pressure gauges; normally all three read the same

The pressure should be 28 psi

These supply pressure gauges look at the pressure in the tanks; the pressure should be >= 35 psi, depending on the isobutane temperature; this depends on the outside temperature, the blanket temperature, and how much isobutane is left. (As we run out of liquid, the pressure will drop, as the evaporation of the isobutane provides self-cooling.)

Normal status of the manual valves on the LST isobutane manifold panel

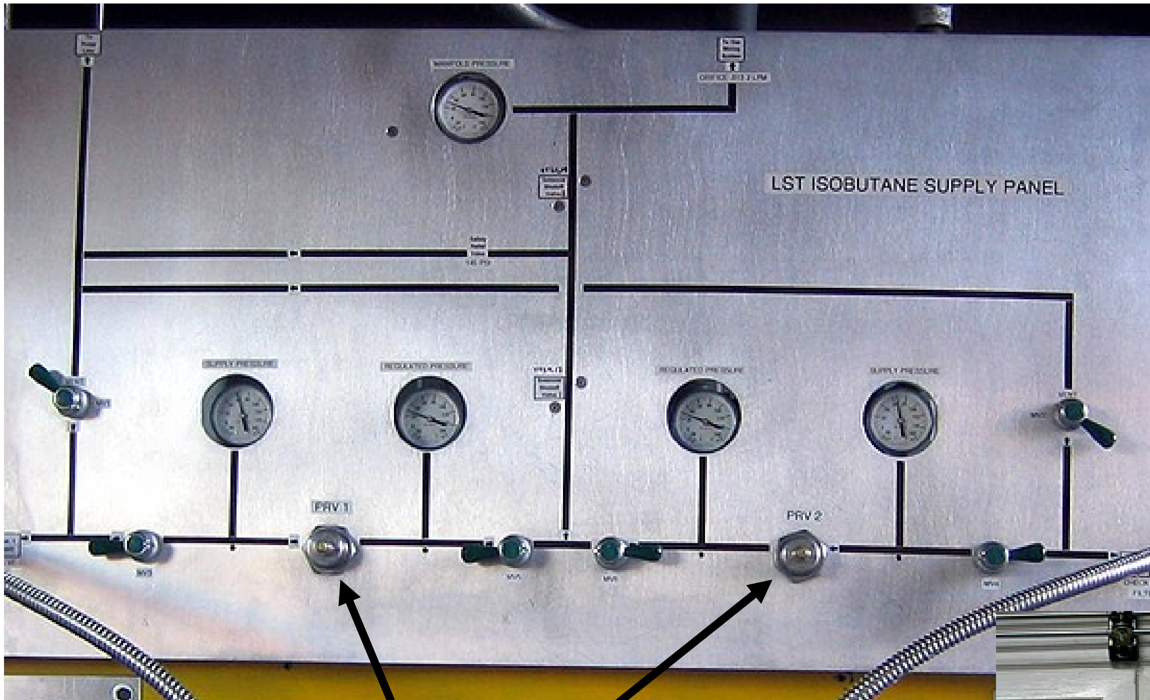
Normally **closed**; they are used to vent isobutane when open



Normally **open**; these are for the reserve tank

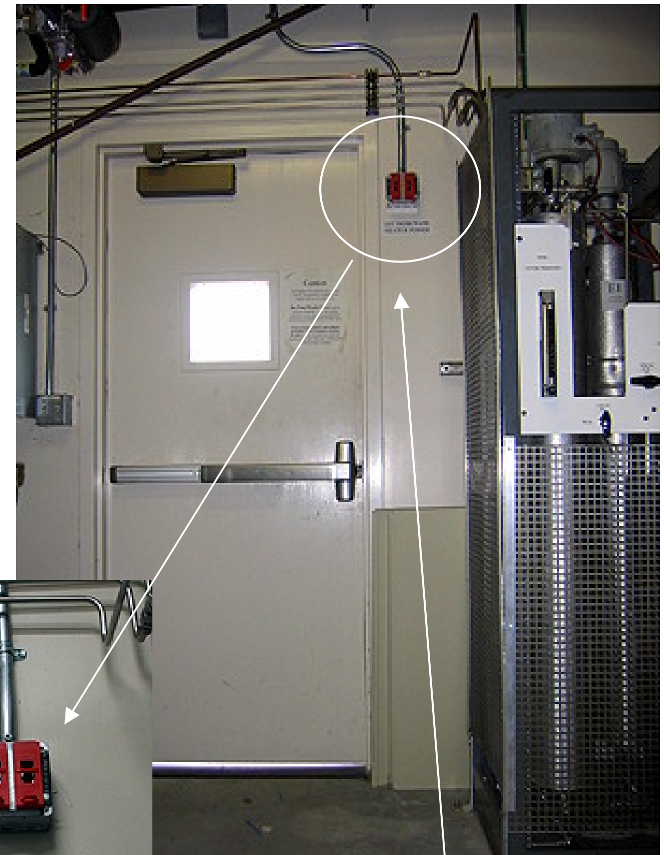
Normally **open**; these are for the main supply tank

The regulators on the LST Isobutane manifold panel are heated



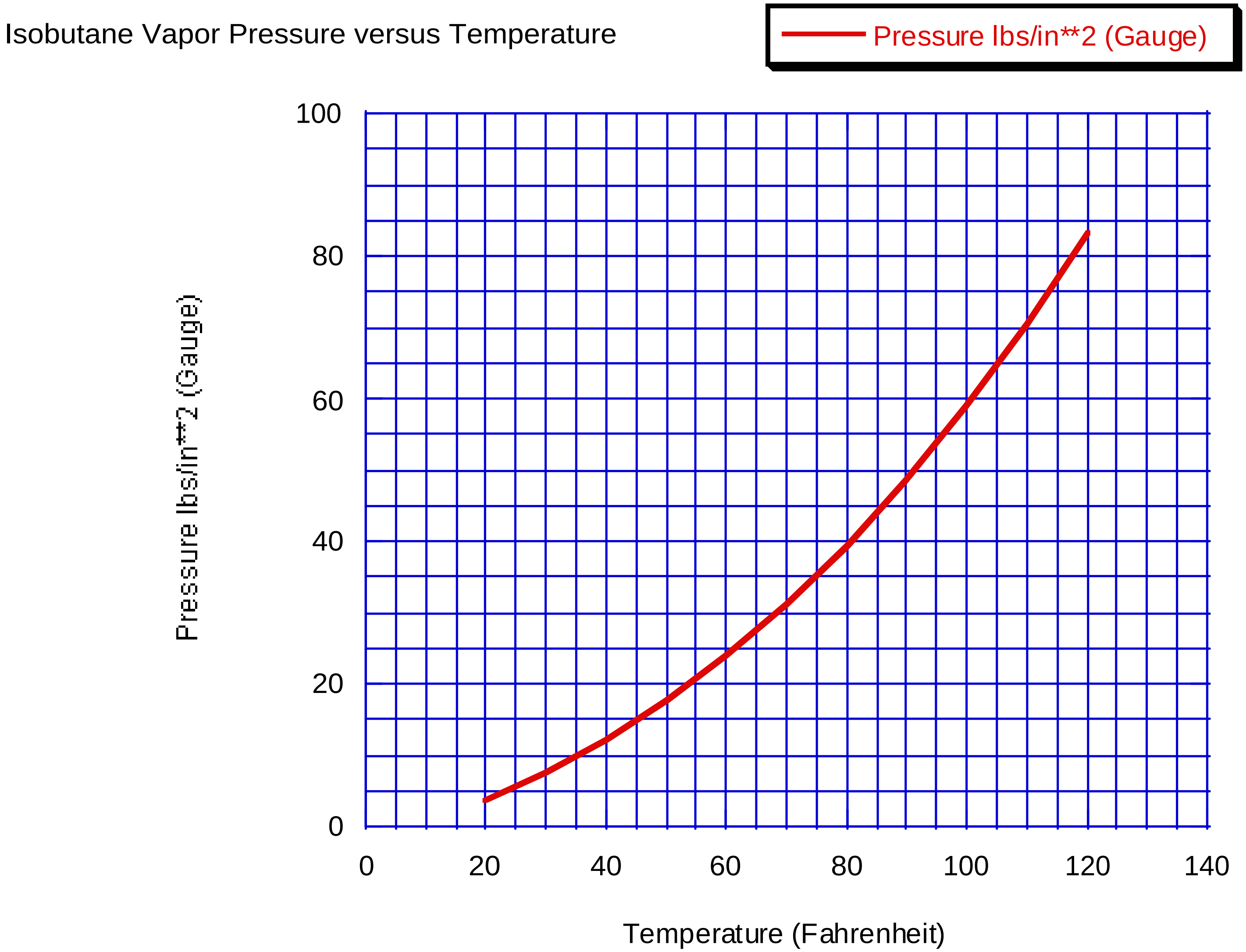
These are heated regulators

The left one is set to 24 psi, the right one is set to 28 psi; the gauge readings can swing about 1-2 psi over a day

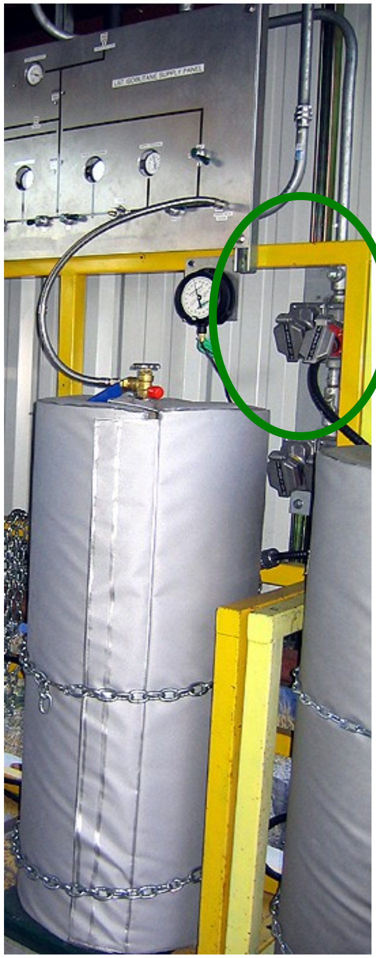


These are the power switches; they should be locked on

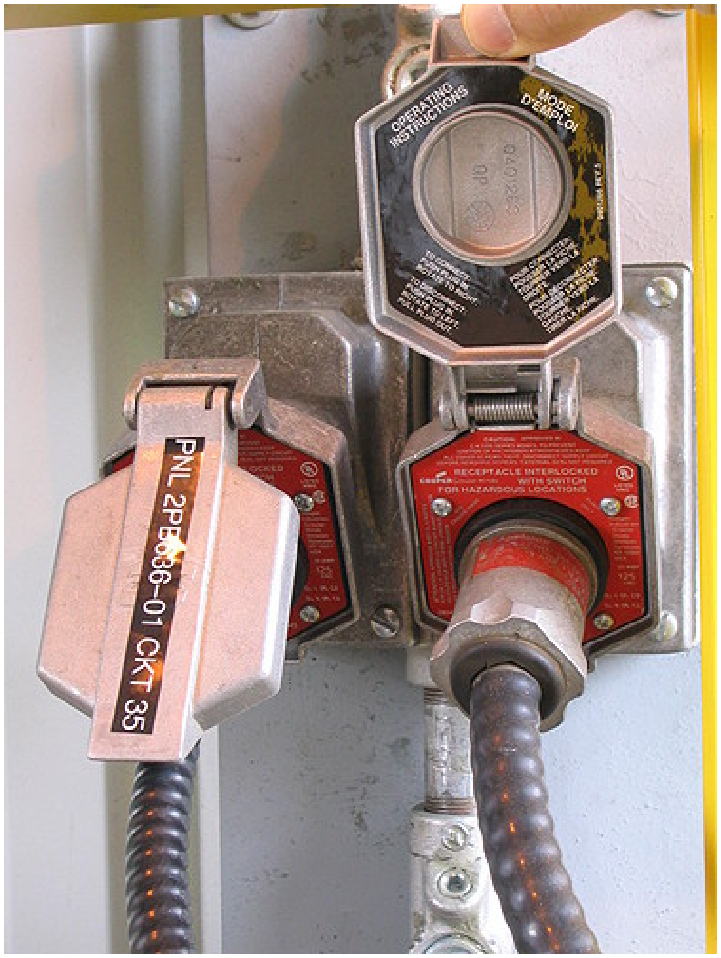
We heat the isobutane in the tanks to maintain a sufficiently high vapor pressure; this is done using heater blankets



Electric Heater Blankets for the Isobutane



The explosion-proof plugs are a bit tricky; you need to insert them into the outlet, then rotate the plug clockwise a little bit in order to make electrical contact.



That clockwise twist is important; it helps to twist the plug counter-clockwise two or three full turns, then insert the plug, and twist clockwise. That way the cable wants to twist even more in the clockwise direction, and maintains contact.

Check the plug if the blanket seems too cold.

The weight scale for the isobutane tanks

The isobutane in the tank is a liquid which vaporizes to provide the gas we use. We need to weigh the tank to find out how much isobutane is left, since the vapor pressure is a function of the temperature, not how much liquid is in the tank.

One looks at how much weight the tank has lost relative to the weight of the tank and its isobutane at the beginning. We get about 110-115 lbs of isobutane in a tank. Each new tank has a label that tells how much isobutane it contains and the tare weight, which is the weight of the cylinder.

Once a new tank is mounted, with the heating blanket on and the hose attached, set the scale to read the weight of the isobutane alone by using the adjustment knob. Record the position of the adjustment knob – i.e., what weight is read just above center of the brass gear – so you can tell if someone else has played with the scale. That happens.

Here a new cylinder and the blankets weigh about 210 pounds. The reading will be reset to 110 pounds, the weight of the isobutane in the tank. Change tanks when the remaining isobutane gets to 15 – 20 pounds (or else we will have trouble maintaining pressure.)

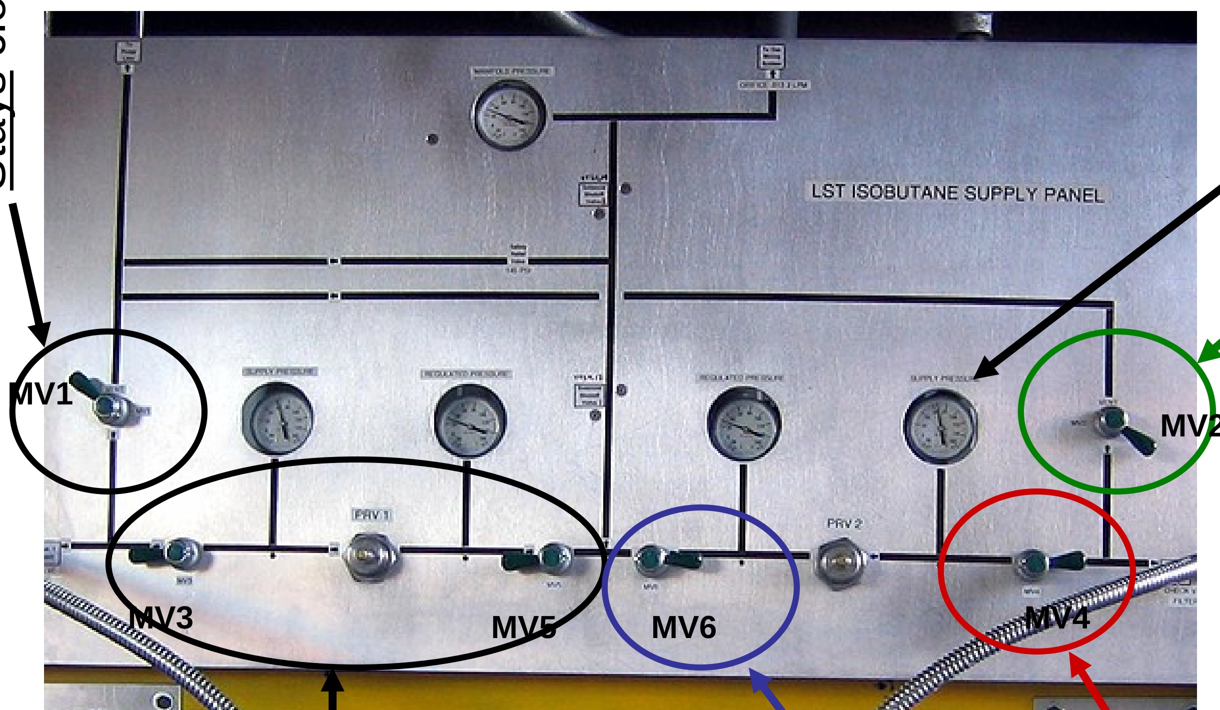
Adjustment Knob

Preparing to change an isobutane bottle

The system is set up to run off tank 2 (on the right) while using tank 1 (on the left) as a backup. This way tank 2 is the one that normally gets used up, and is the only one that regularly will need to be replaced

Stays closed

Tank 2 Supply Pressure



MV2: This will be opened for a short time to vent a new bottle just after it is attached; be certain to close it afterward

Let the system run off the backup supply during the switch; keep these valves open

MV4: Closing this will completely isolate the tank that will be changed out

MV6: You have to close this so you can use the supply pressure gauge with Tank 2 isolated

Steps to change an LST isobutane bottle (1)

1. NOTIFY the pilot/shift leader (Ext 5255) that you are changing an LST isobutane cylinder and ask them to enter it in the electronic logbook. Also tell the LST operations manager at 353-1272 (or page him/her at 650-846-9940.) You should be changing the old, 'empty' cylinder in the Tank 2 location. The new cylinder must be an IFR isobutane cylinder. **DO NOT use a DCH isobutane cylinder**. If you don't know the difference, stop here; get expert help.
2. RECORD the weight of the old Tank 2 cylinder (blanket on/hose connected) using the weight scale <u>and</u> record the location of the adjustment knob, as a check; we want the weight of the isobutane left in the tank.
3. REMOVE the thermometer from the old Tank 2 cylinder.
4. CLOSE the primary supply valve (MV6) on the manifold to isolate the Tank 2 line.
5. CLOSE the cylinder valve on the old Tank 2 cylinder.
6. OPEN the Tank 2 purge valve (MV2) on the manifold and wait until the supply pressure lowers to 0 psig to get rid of any liquid isobutane (this should only take a few minutes. If it takes significantly longer, the purge orifice is probably plugged and must be removed from the manifold, cleaned and replaced).
7. CLOSE MV4 to isolate Tank 2 from the manifold completely.
8. REMOVE the manifold Tank 2 supply hose from the old isobutane cylinder using the brass crescent wrench (The wrench should be in the storage cabinet inside the gas shack. If the hose is still pressurized, close it and let it purge a little longer).

Steps to change an isobutane bottle (2)

9. CLOSE the Tank 2 purge valve (MV2).
10. UNCHAIN and REMOVE the old cylinder with the blanket on.
11.ADJUST the weight scale to zero (if necessary).
12. REMOVE the heating blanket from the old cylinder. Tear the bottle status label on the old cylinder to leave it with the 'EMPTY' designation. Place the blanket on the new cylinder.
13. PUT the new cylinder onto the TANK 2 scale with the blanket on and plugged in. Point the opening of the tank valve toward the east.
14. CENTER the cylinder on the scale (if the scale reading is not within +/- 5 lbs of the listed weight of the gas (generally ~116 lbs) + the tare weight of the cylinder (generally ~70 lbs) + 20 lbs (for the blanket), re-adjust the position of the cylinder on the scale until it does). Remove the valve cover (transport cap) and the plug (outlet plug), and store them on the south-west wall with the others.
15. CONNECT the manifold Tank 2 supply hose to the new cylinder; tighten securely using the brass crescent wrench.
16. REPLACE the thermometer under the heating blanket.
17. CHAIN the new cylinder; make certain nothing can get hung up or caught that could disturb the weight measurement.
18. ADJUST the dial of the weight scale so that it is set at the net weight of the isobutane in the new tank as specified on the tank's label.

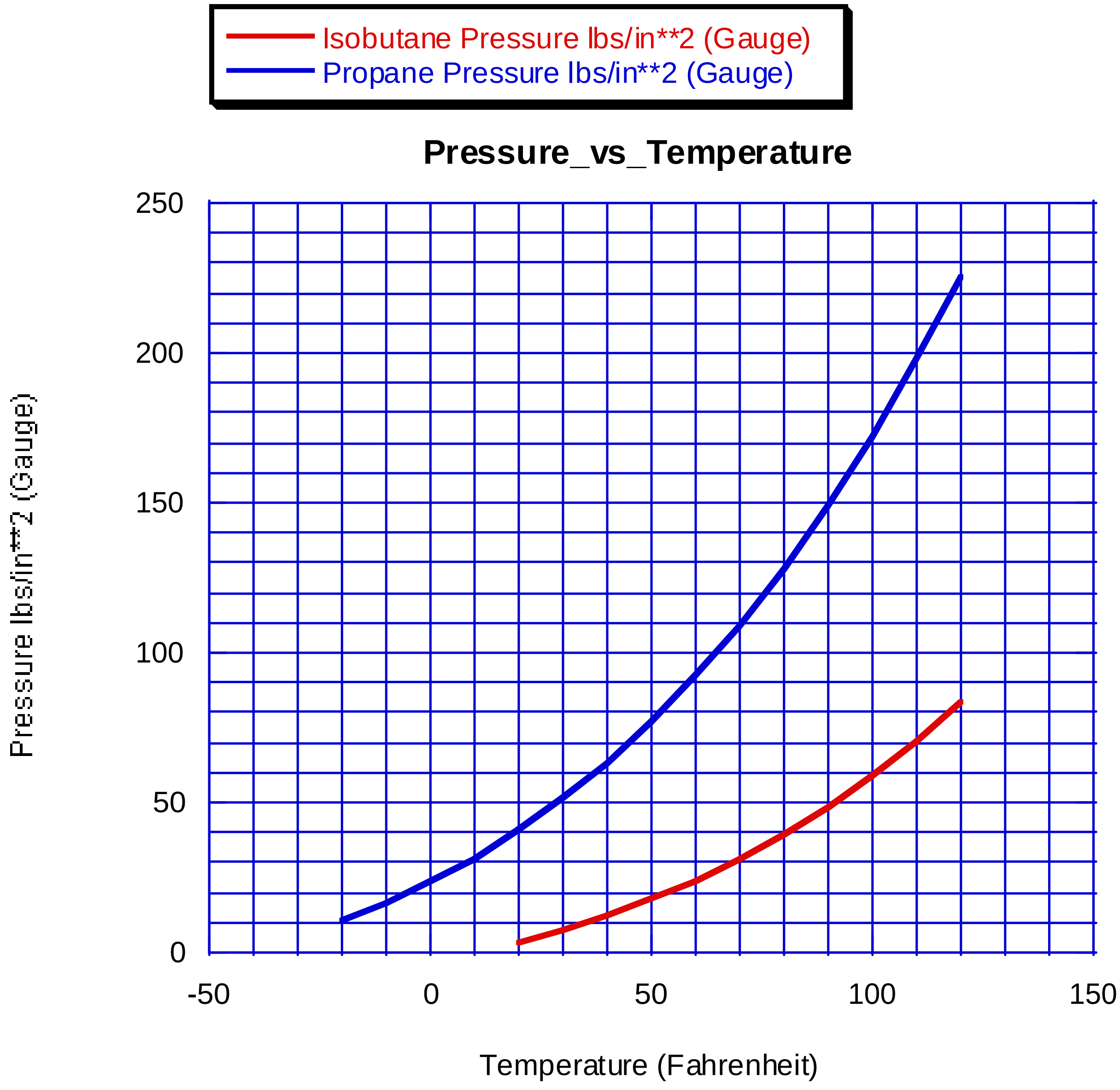
Steps to change an isobutane bottle (3)

19. RECORD the weight of isobutane and the position of the weight scale adjustment knob (i.e., record the weight reading just above the brass gear of the adjustment knob.) Write this information on the new bottle's status label for easy reference.
20. OPEN the cylinder valve on the new Tank 2 cylinder of isobutane.
21. OPEN the Tank 2 purge valve (MV2) on the manifold and vent the supply line for at least two minutes, preferably five.
22. CHECK for leaks on the hose connection using SNOOP while the system is purging.
23. CLOSE the Tank 2 purge valve (MV2).
24. OPEN valve MV4; check that the Tank 2 supply pressure is ~= 30-40 psi. (If the pressure is much lower than that, see if that correlates with a low temperature for the new cylinder; if that is the case, continue with step 24. The system will run on the backup until the new cylinder is warmed further. If the pressure is greater than 70-80 psi, the tank could contain a significant amount of propane. (See the plot of propane vapor pressure.) In this case, call for expert help; prepare to warm another cylinder while running on the Tank 1 backup supply; and stop here.)
25. OPEN the primary Tank 2 supply valve (MV6.)

Steps to change an isobutane bottle (4)

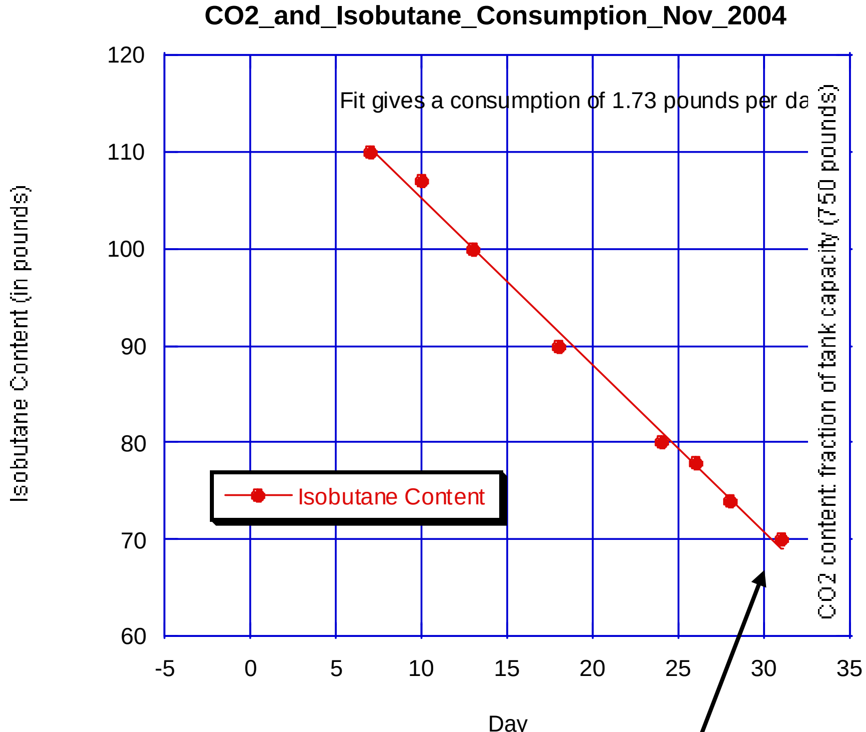
26. PUT a spare cylinder of IFR isobutane in the spare warming blanket. **DO NOT use a DCH isobutane cylinder.**
27. NOTIFY the pilot/shift leader (Ext 5255) you are finished.
28. NOTIFY Kirk Stoddard via email (stoddard@slac.stanford.edu) of the weight of the old cylinder and the location of the adjustment knob, and the weight of the new cylinder and the new location of the adjustment knob (from steps 2 and 19 above).
29. NOTIFY Mike Racine to order additional isobutane if there is only one spare cylinder (which should be in the spare warming blanket).
30. RETURN the brass crescent wrench to the cabinet.
31. Store the old isobutane cylinder in the rack just north of the gas shack, by the IR-2 cooling water support pad. Make certain to insert an outlet plug and place a transport cap (if used) on the used bottle.

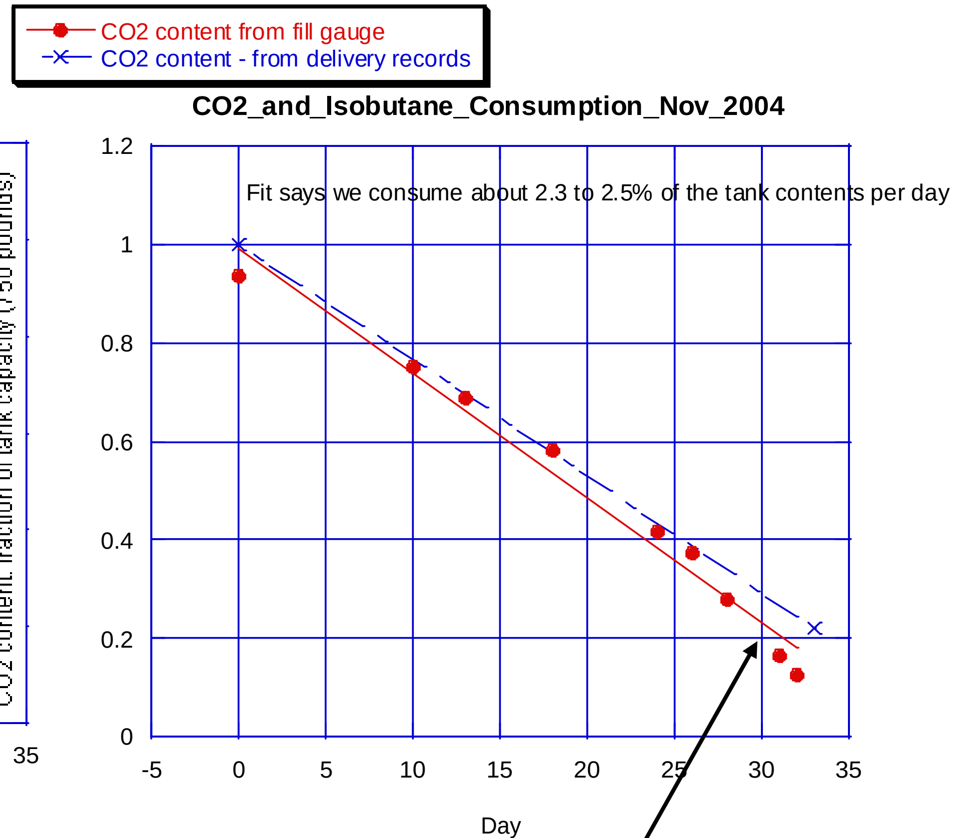
Vapor Pressures for Propane and Isobutane



Propane has a much higher vapor pressure than isobutane

Isobutane and CO_2 consumption November, 2004





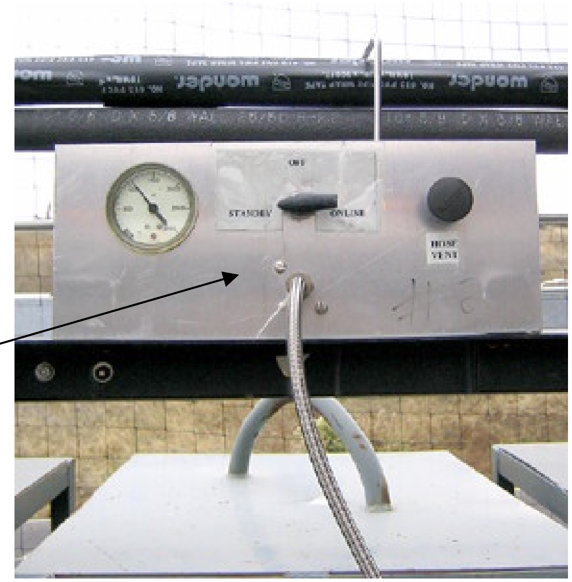
We can go all the way down to 15-20 pounds of isobutane

This is as low as we want to go

The Main Argon Supply is a Tube Trailer

The Argon Tube Trailer; three-four tubes are used at a time

The standby argon is a set of six-packs



The pressure of each six pack is shown; the lever for one six pack should point to STANDBY

A line from the six-packs goes to the argon standby regulator

(A second line from the six-packs also goes to the argon online regulator; when the argon trailer is being filled, the six-packs become the main supply)

Another view of the backup argon supply

Pressures should be >= 1000 psi

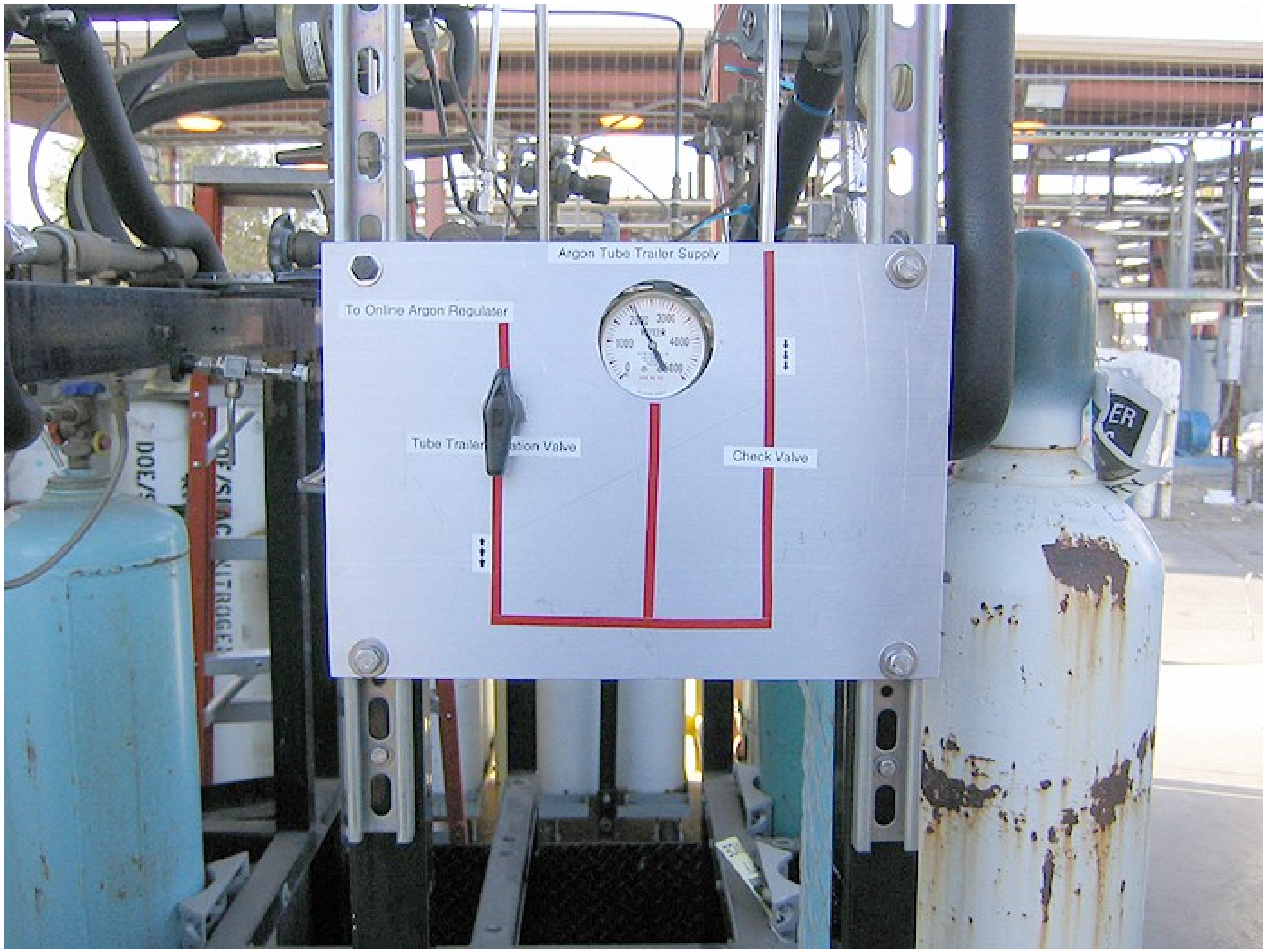
The RPC uses the majority of the argon.

They can consume two to three six packs in a week when we run off the six-packs.

At least 1 of 3 should be set to **STANDBY**

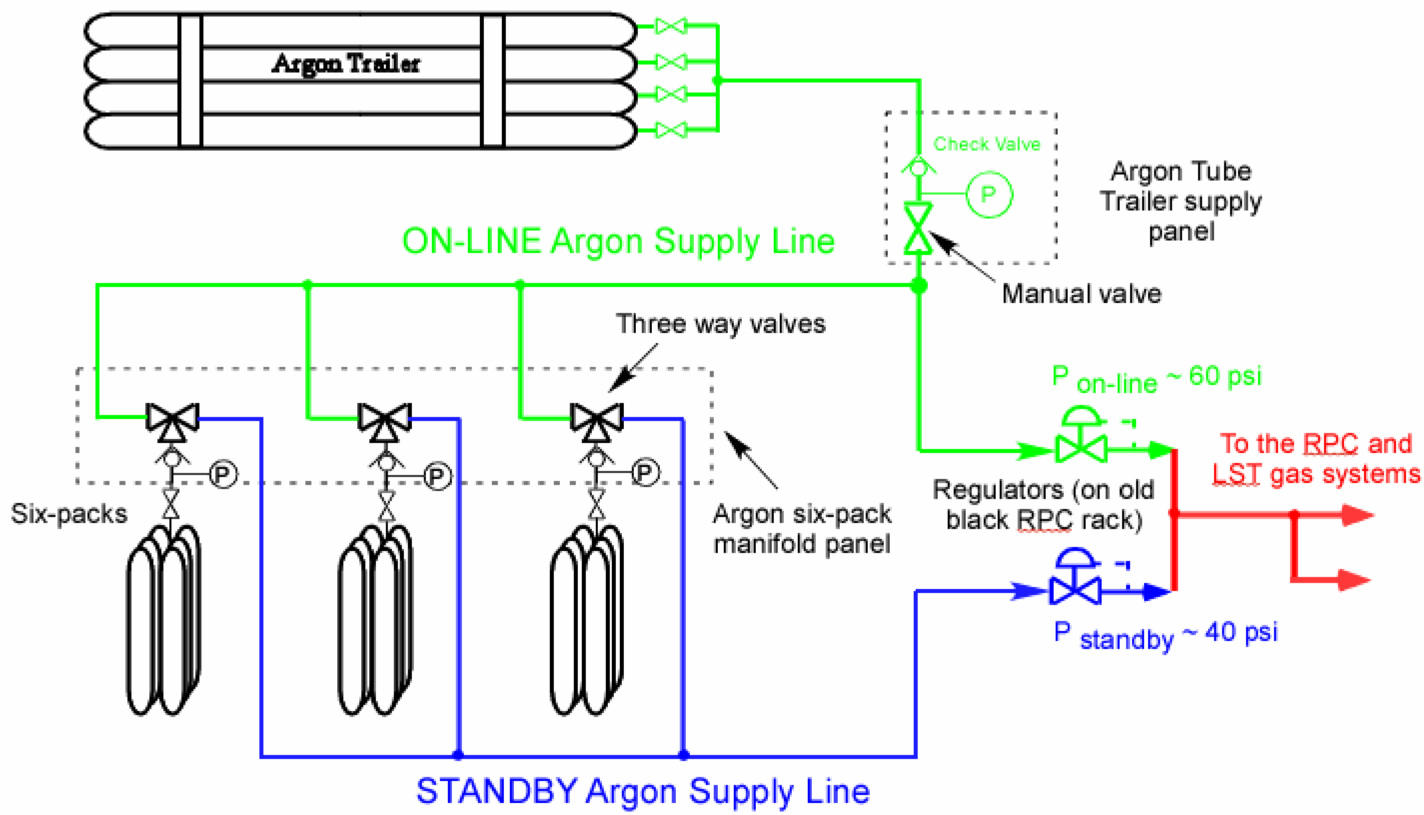
One six pack should be set to OFF to serve as a reserve

The Argon tube trailer feed to the argon manifold – it goes to the supply or ‘online’ regulator



An overview of the argon trailer and the six- packs

Note that when the argon trailer is in use, none of the six-packs is in the online position (or else we consume the backup)



When the Argon Trailer is in use, we should have one (or two) full six-packs on STANDBY, and two (or one) full six-packs OFF

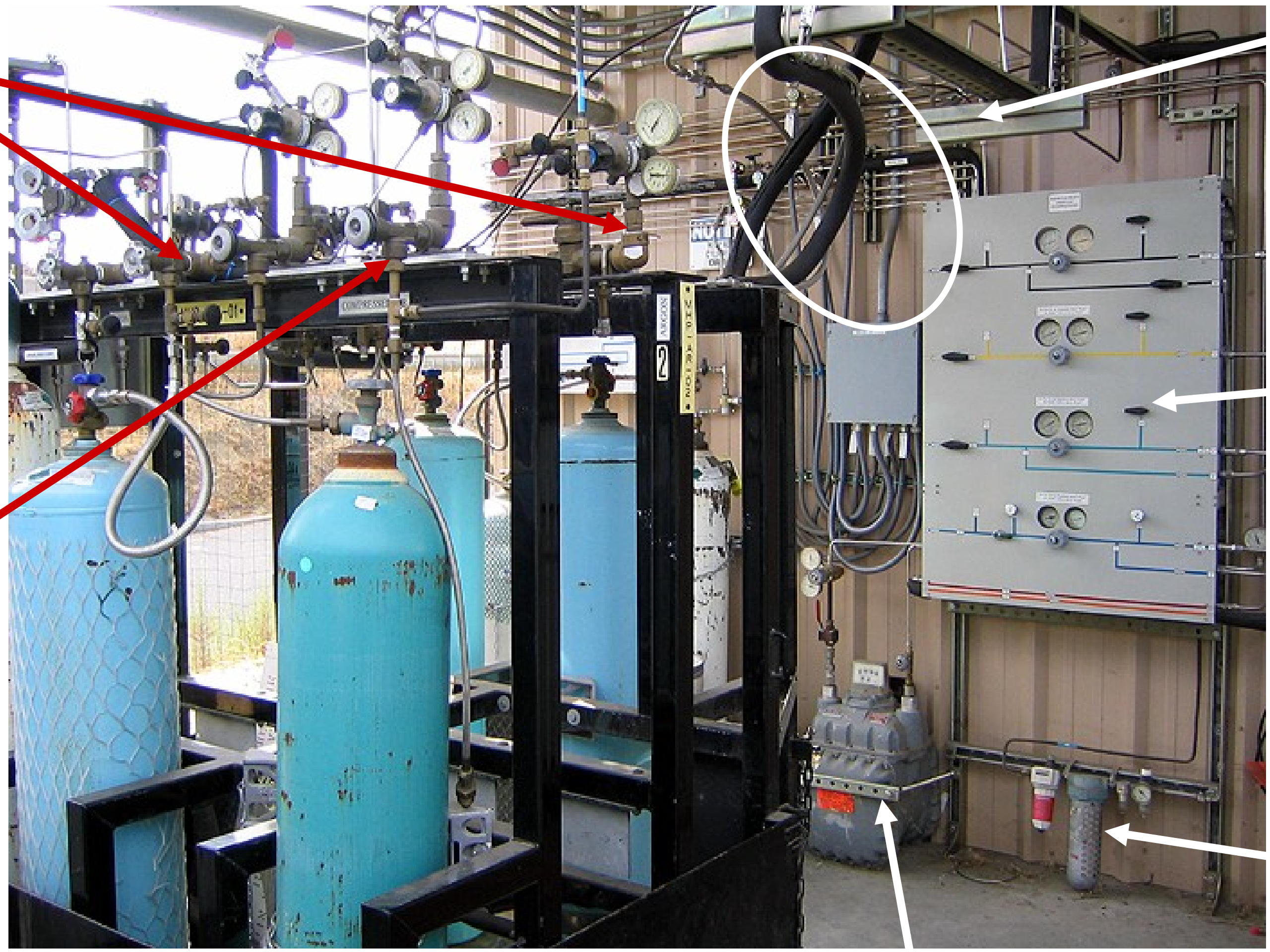
When we are running off of the Argon Trailer, none of the six-packs should be in the on-line position - or else we will consume the backup supply!

When the Argon Trailer is being filled, we run off of the six-packs. We should have one six-pack on ON-LINE, one full six-pack on STANDBY, and one full six-pack OFF

The RPC (and the LST argon) inert gas manifolds;
the instrument air for the LST and RPC is also part of this plumbing

Argon and Freon manifolds with their supply and backup regulators are here

RPC Instrument air; house air plus a bottle backup



Inert Gas shutoff valves (on the wall of the shack)

Inert Gas Panel

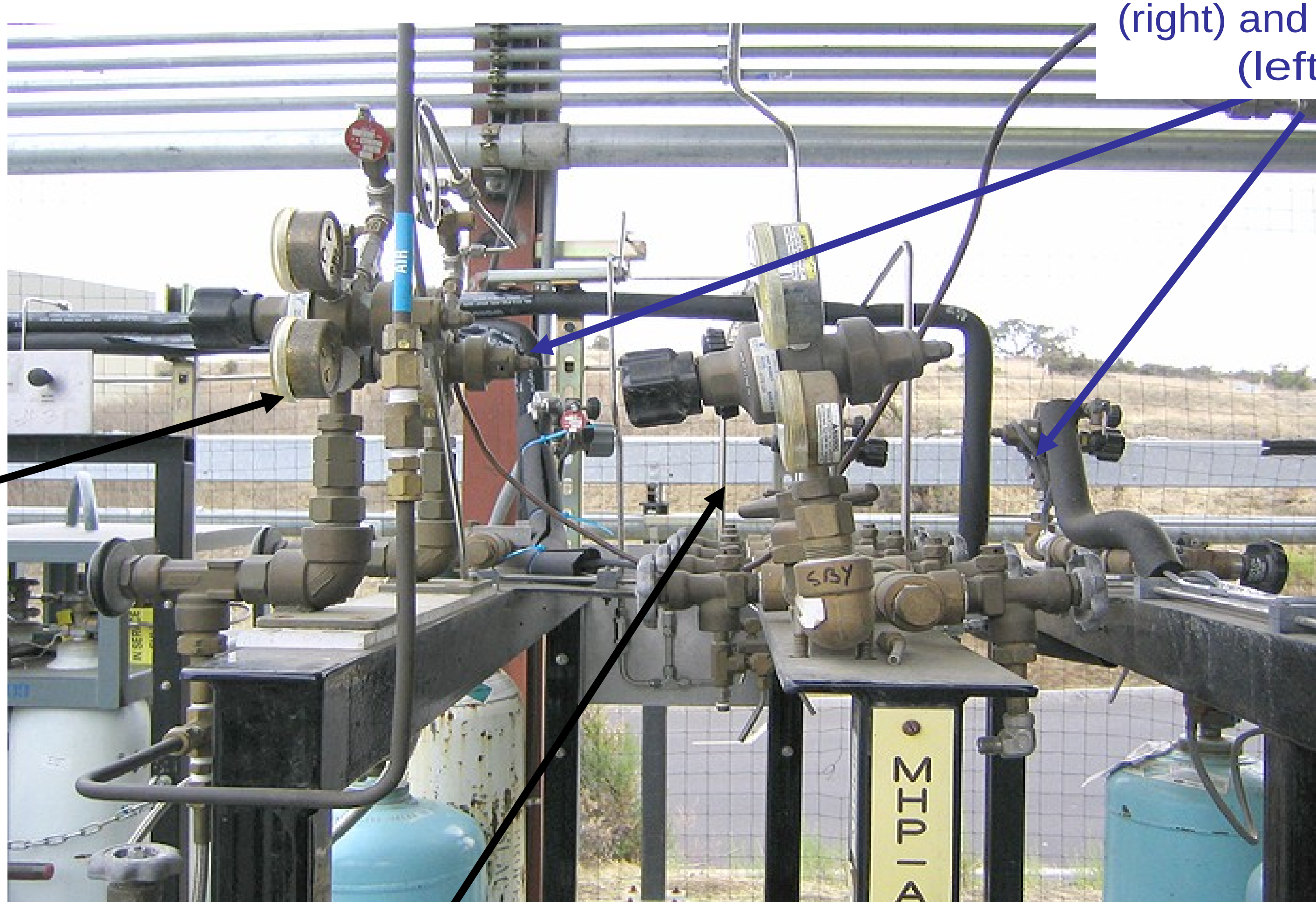
Filter for the house air supply to the DCH

Helium consumption meter

A side view of the manifolds on the old RPC rack

RPC Freon regulators: supply (right) and backup (left)

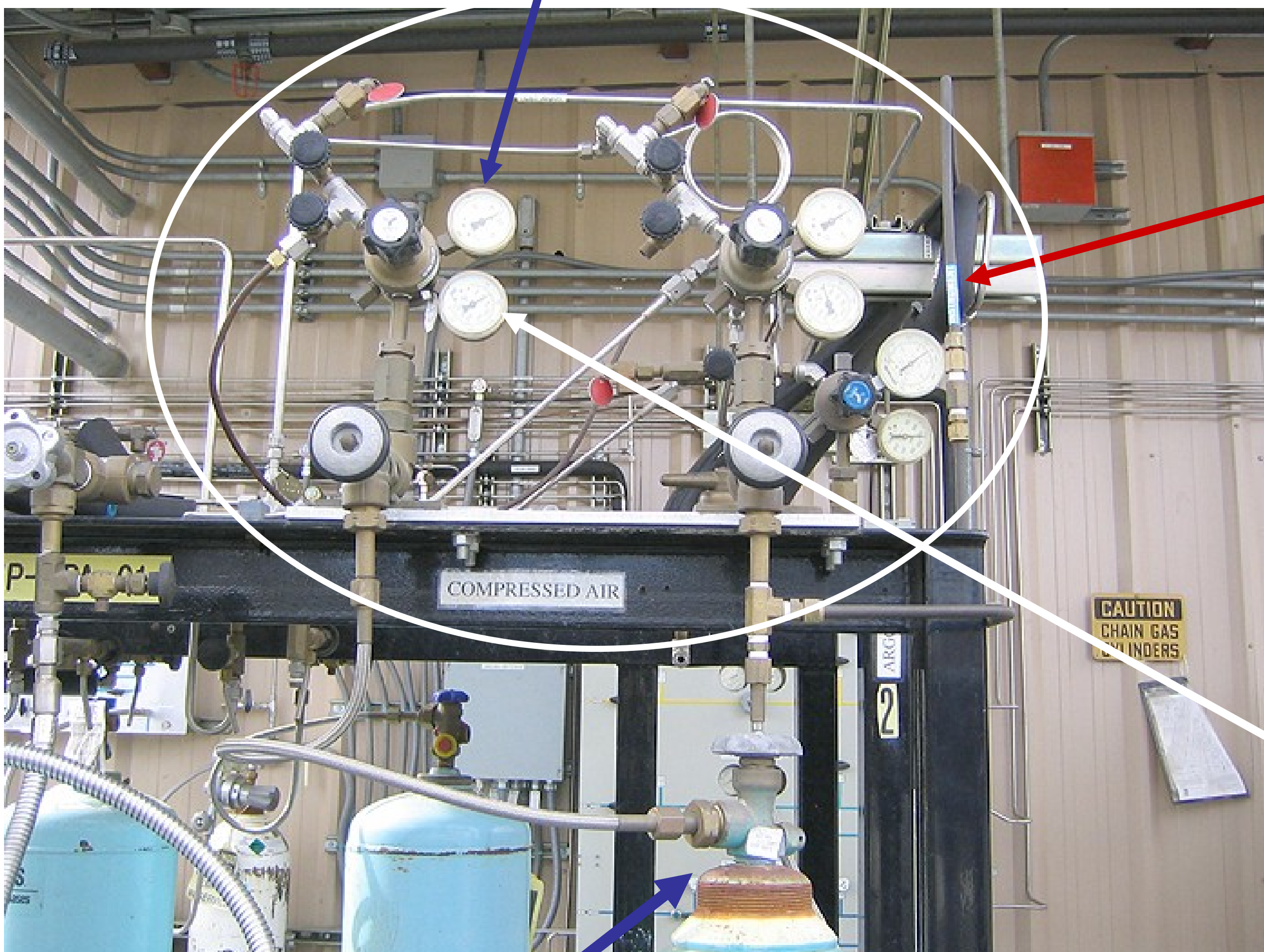
Instrument air; this also has two regulators. One controls the House Air to the RPC system



There are two argon regulators here (one is hidden) for the supply and the backup

The Manifold for the RPC (and LST) Instrument Air – a closer look

The pressure of the air going inside can be read off this gauge. The air comes from the house air supply, or if that fails, the bottle backup

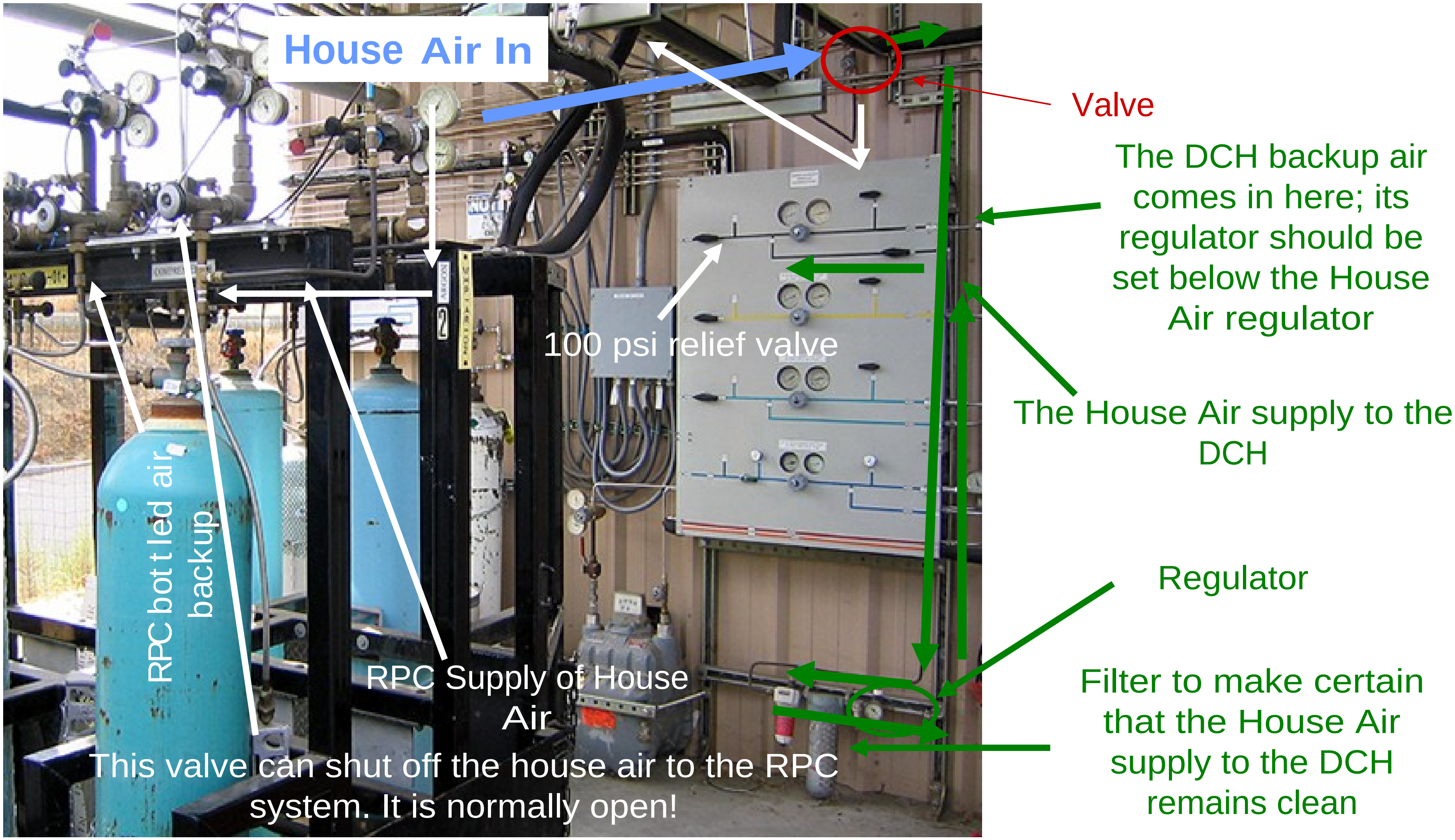


This copper tubing supplies the feed of house air to the rack

The amount of reserve backup air can be read off this gauge

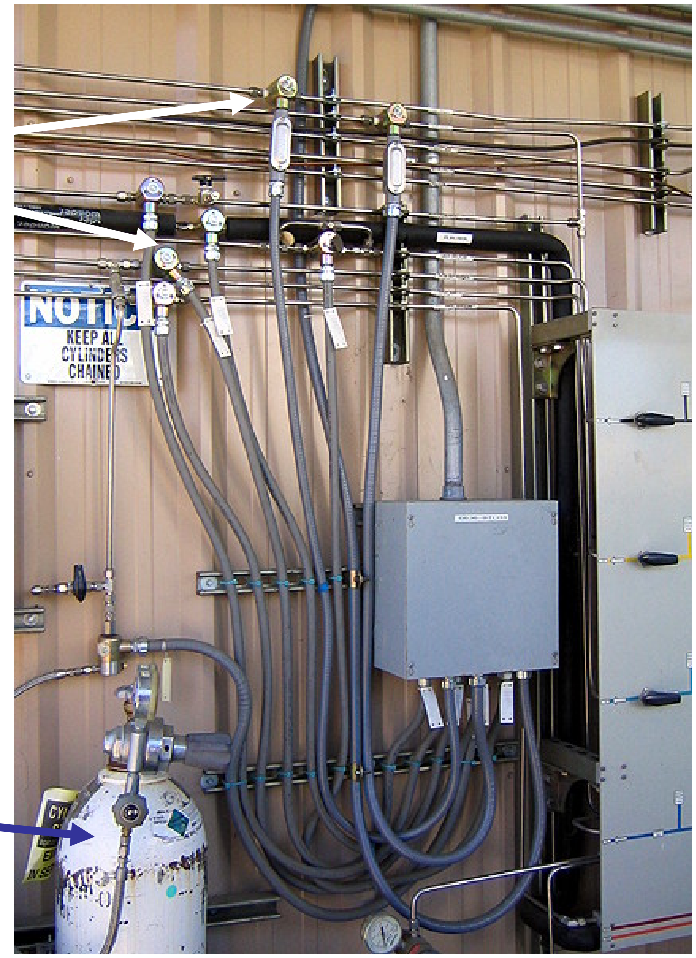
This is the backup bottle for the instrument air; it is there in case the supply of house air fails, or someone cuts into the line, etc.

The **House Air** comes in along the east gas shack wall and is split into two copper lines, one going to the DCH and one going to the RPC (and LST) gas systems. There is a valve in the line going to the RPC gas system right after the split.



The Inert Gas Shutoff Valves

Inert Gas shutoff valves (these are ‘normally closed’ valves; they have to be <u>held</u> open. The power required is enough that they get warm)



Backup nitrogen bottle for the DCH bulkhead flush

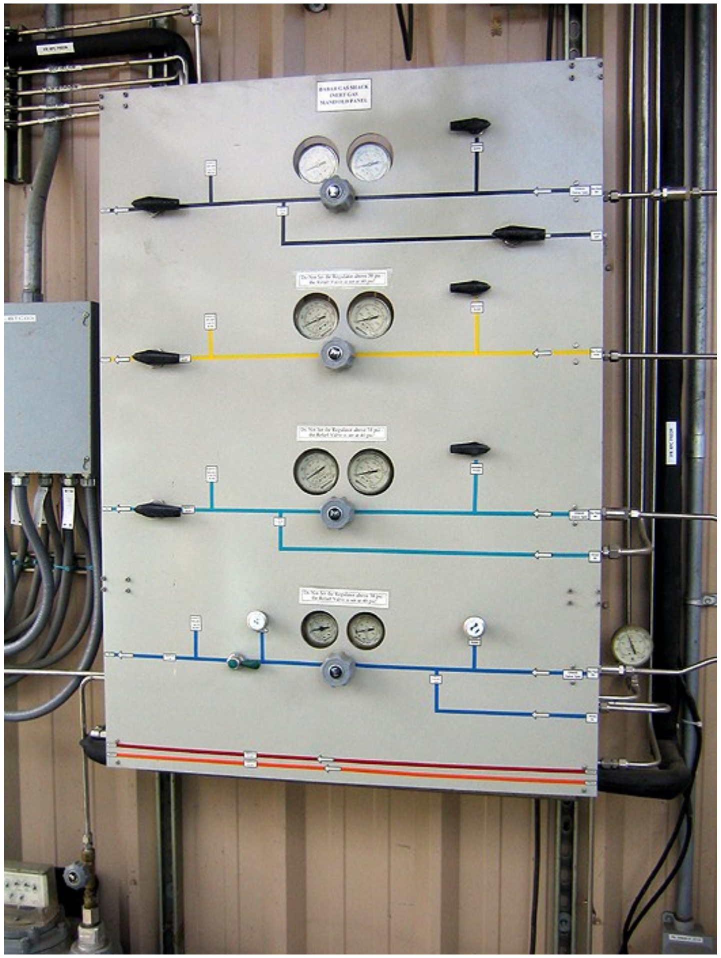
The Inert Gas Panel

The lines for the inert gases have an orifice plus a pressure relief valve before going into the shack.

The combination limits the amount of each inert gas that can get into the shack. The argon and freon pressure relief is done on the RPC inert gas manifold.

One problem that can happen is that someone adjusts a regulator to a pressure above the pressure relief valve, and vents (wastes) gas and we run out.

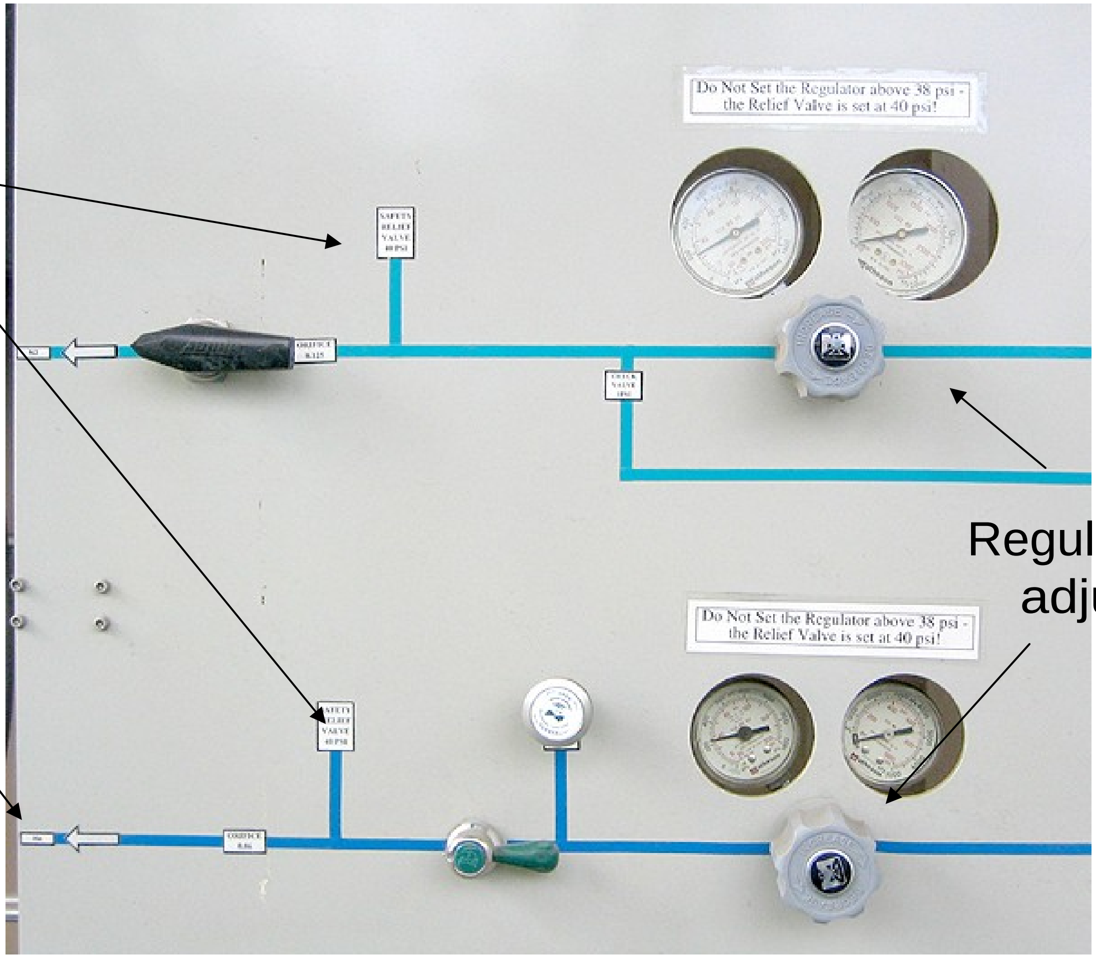
There are caution signs about this and labels.



A closer look at two inert gas lines

Labels indicating the pressure relief valves

orifices



Regulators; don't adjust them

The Gas Shack and its safety system

The BaBar Gas Shack

Cooling and Heating Unit

Ventilation Exhaust Stack

Inert Gas Storage

Ventilation Ducts: Supply

Isobutane storage area

Ventilation Status Display

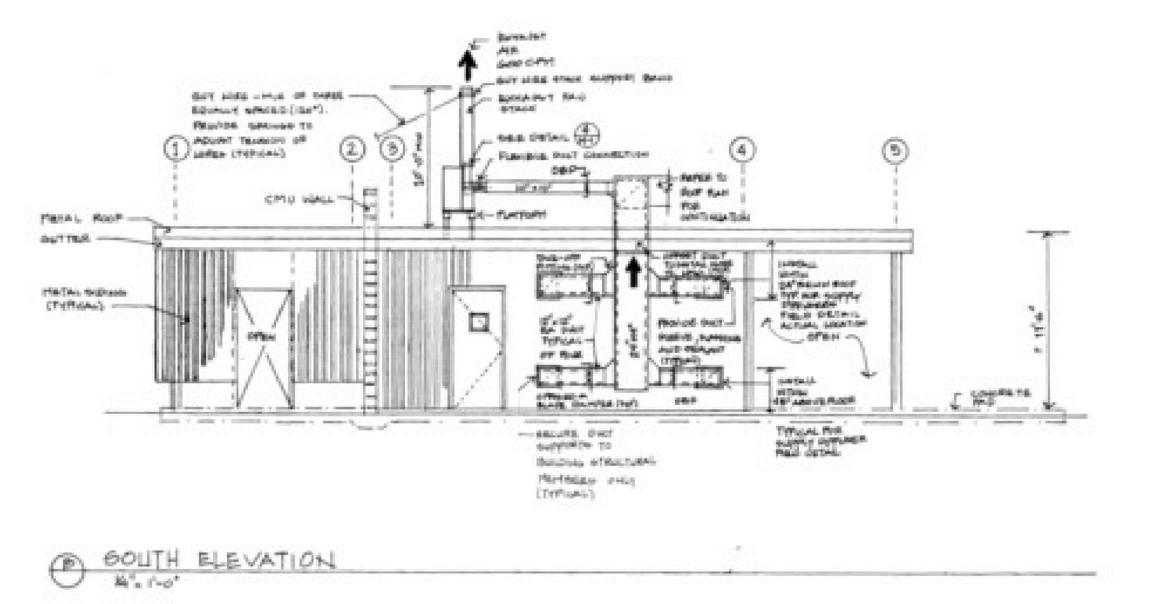
The ventilation is the primary safety device in the gas shack

The fresh air that is pulled into the shack by the ventilation guarantees that there is a dilution (via fresh air input) of any potential leak of gas in the interior of the shack to levels well below those dictated by safety concerns.

This relies upon

1) Fresh air input
2) Circulation
3) Exhaust

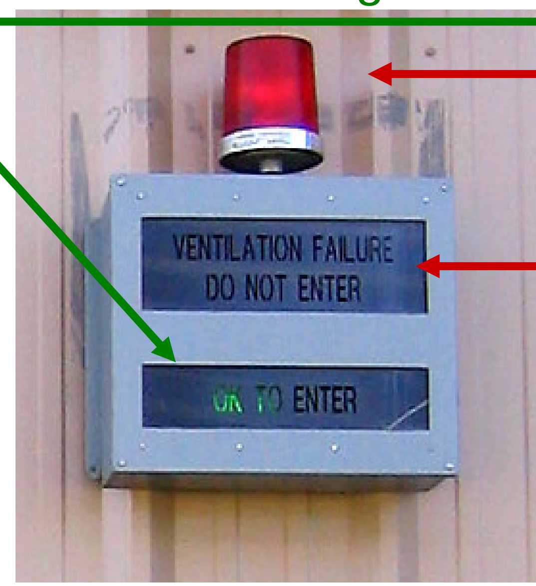
All three components are monitored in the Gas Shack Safety rack



If the ventilation fails, we shut off all of the gas supplies into the shack

Gas Shack: North Entrance

Check the green 'OK to enter' sign; it should be lit when the ventilation system is functioning properly – You want a **positive** indication that the ventilation is working!



Be Aware:
Lights <u>can</u> burn out!

1. If there is a ventilation problem, the green 'OK TO ENTER' sign goes off;
2. The red 'VENTILATION FAILURE DO NOT ENTER' sign goes on;
3. The red warning light on top turns on and rotates.

Gas Shack: South Entrance

The South Entrance is set up the same way. It has an ‘OK TO ENTER’ sign and a “VENTILATION FAILURE’ sign.

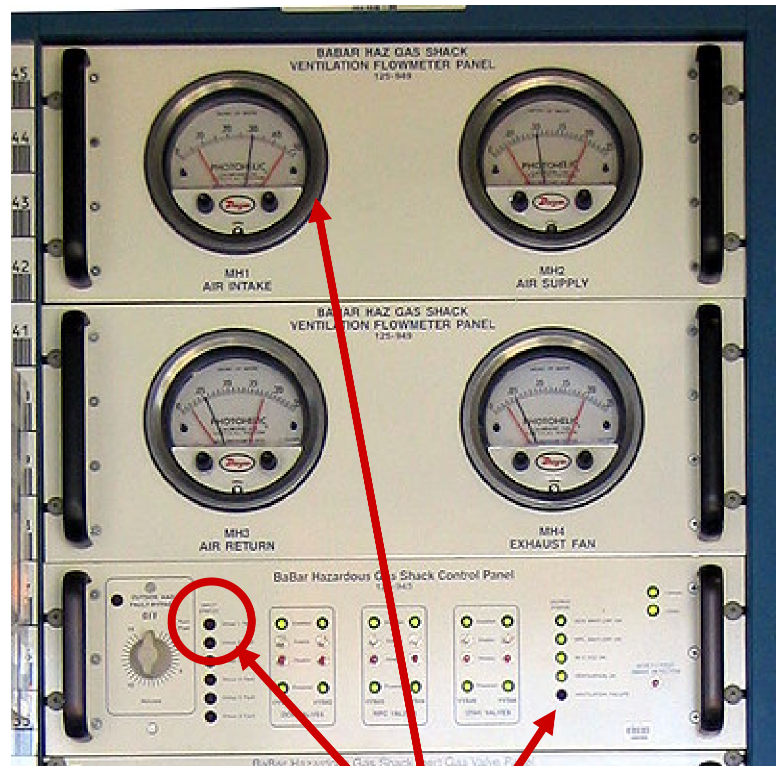
If you suspect that a light has burnt out, check the other entrance before making any conclusions.

Remember that the rotating red light on top is also an indicator of a ventilation problem if it is lit and/or if it is rotating.

Be Aware:
Lights <u>can</u> burn out!

Gas Shack: Inside

If there is a ventilation problem, the red warning light on top of the gas shack safety rack lights up and rotates.



1. The red 'Group 1 Fault' LED will light up;
2. One or more of the ventilation monitors will have dropped below the limit switches;
3. The red 'Ventilation Failure' LED will light up.

When the ventilation fails:

- If you are outside, don't go into the shack (even though the gas lines going into the shack are shut off); we prefer that experts only go inside
  - E.g., DCH, RPC, LST experts
- If you are inside, leave the shack; on top of the gas shack safety rack there is a red warning light which will turn on and rotate when there is a problem with the ventilation. The sign on its base says:
  - Ventilation Failure if light is on and/or the beacon is rotating; leave immediately and obtain portable Oxygen Deficiency Monitor (ODM) before re-entry
- Someone from HVAC will have to be called to restore the ventilation system
  - Sometimes fan belts break or slip off
  - Rain has gotten inside the air circulation control panel; we've sealed that up, but it can happen again
- A power failure will stop the ventilation system (and turn off all the warning lights); therefore treat power failures as being equivalent to a ventilation failure
- <u>After</u> power is restored, the ventilation system will come back on again
  - You need to restore the valves, the VME crate, the gas mixing systems, etc.; however the <u>ventilation</u> system (and the safety system in general) should be running again
  - Note: the status lights will show that the ventilation system is up and running after the power is restored, so you don't have to do any guesswork

Front view of the Gas Shack Safety Rack

You will see the safety rack in front of you just as you walk into the gas shack; there are logic charts on the wall to the left

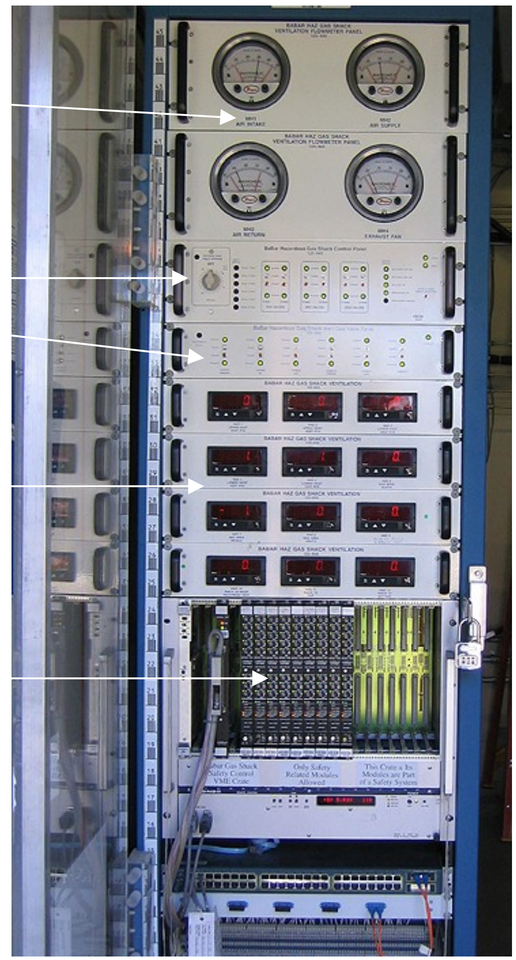
The safety rack was placed so you can look in through the window on the front door and see the it. That way you can diagnose the problem from the outside if something has gone wrong

Ventilation Monitors

Valve Status Panels

Hazardous Atmosphere Detectors (HADS)

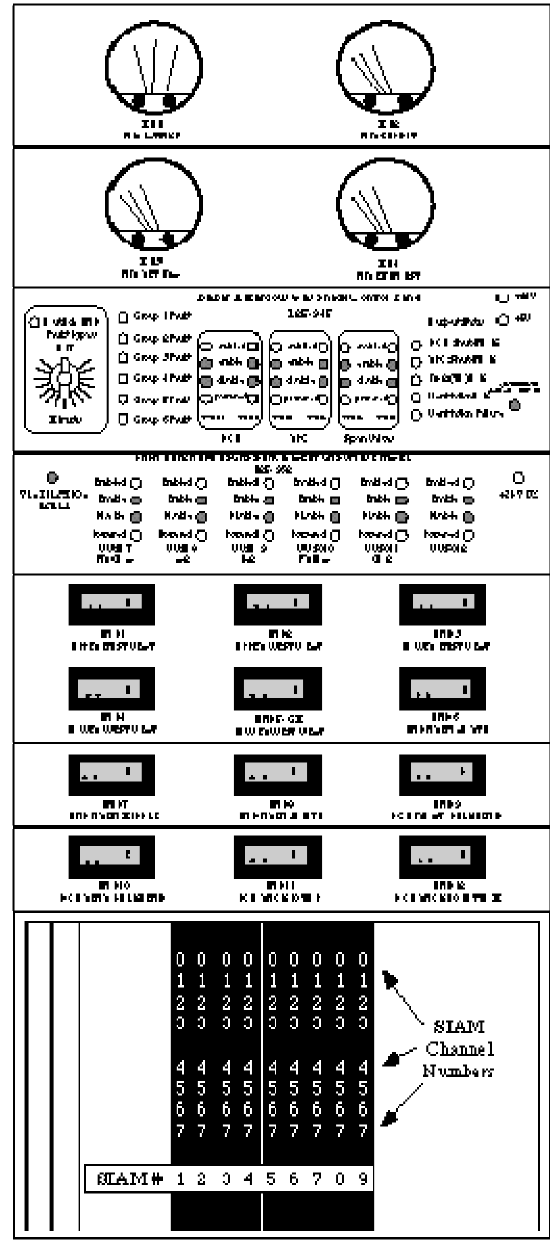
SIAMs



Front view of the Gas Shack Safety Rack

A note on the scale of the readings for the HAD monitors:

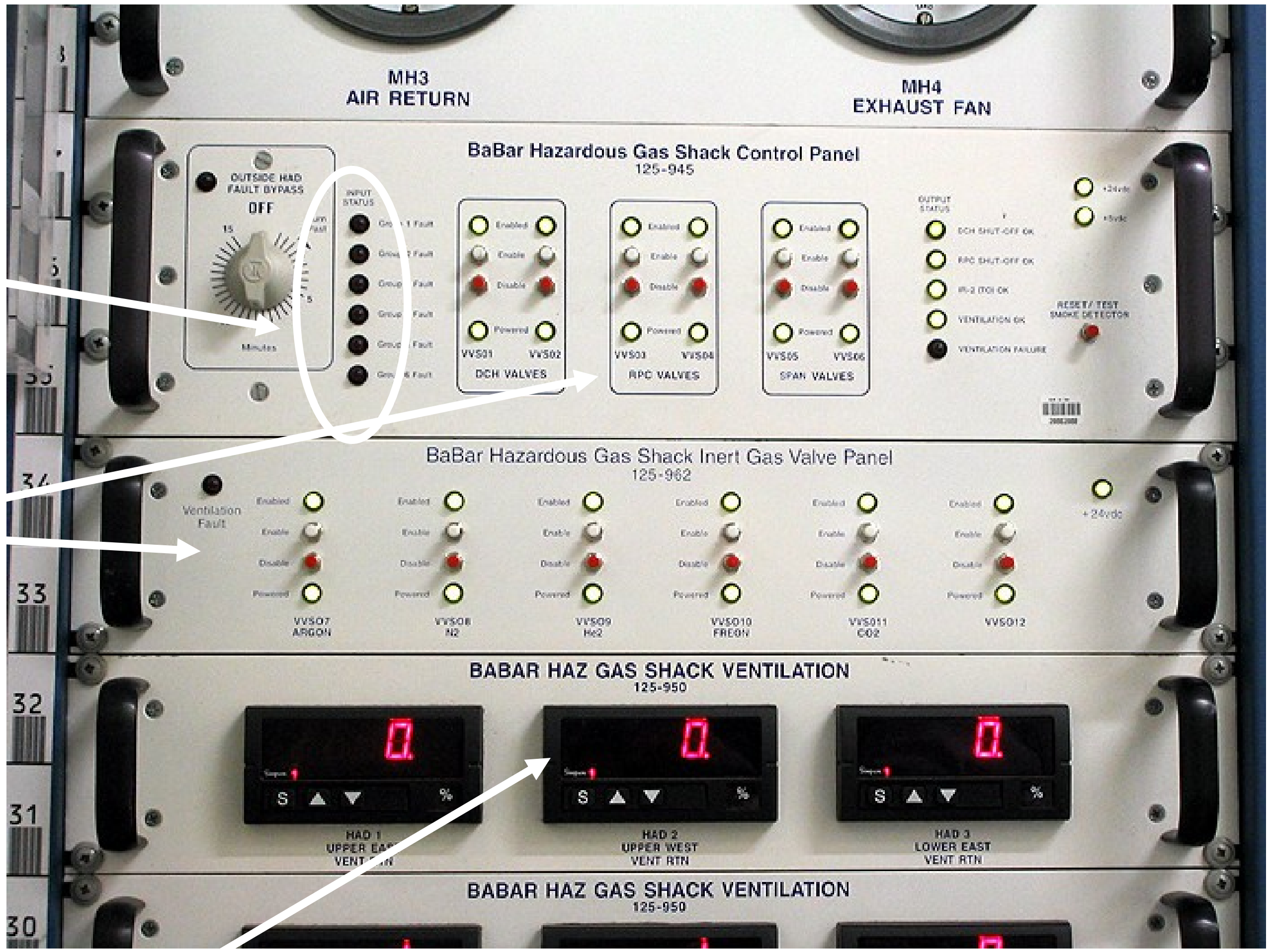
Their readings are in per cent of the lower flammable limit (LEL). In other words, a reading of 10. on the display means that you have gotten to 10% of the lower flammable limit. That is the point at which the isobutane supplies are shut off.



The Gas Shack Control Panel gives a summary of the source(s) of a fault

LEDs will tell you what tripped; the labels refer to the acronyms from the logic chart (Group 1 Fault, etc.)

Each valve has both an 'enable' and a 'disable' button and a 'powered' status light. DCH and RPC valves are controlled here.



In spite of the panel name, these monitor the HADs; the units are % LEL

The Gas Shack safety rack looks at a number of inputs; the average shifter only needs to know about the ventilation and the HAD monitors

			Isobutane Shutoff Values										System Alerts			
Sensor/Indicator		Light	DCH-A	DCH-B	RPC-A	RPC-B	LST-A	LST-B	SPAN-A	SPAN-B	Iso Gas	LST Iso Gas	DCH	RPC	LST	
			VVSO_1	VVSO_2	VVSO_3	VVSO_4	VVSO_11	VVSO_12	VVSO_5	VVSO_6	Exhaust valve	2 new valves	DCH_SO	RPC_SO	LST_SO	(io) IR-2
Photohelic MH1		Red	close	close	close	close	close	close	close	close	close	close	low	low	low	low
Photohelic MH2		Red	close	close	close	close	close	close	close	close	close	close	low	low	low	low
Photohelic MH3		Red	close	close	close	close	close	close	close	close	close	close	low	low	low	low
Photohelic MH4		Red	close	close	close	close	close	close	close	close	close	close	low	low	low	low
~~Photohelic MH5 (DCH)~~ '		NA	close	close	NA	NA	NA	NA	close	close	NA	NA	low	NA	NA	low
Photohelic MH6 (RPC)		NA	NA	NA	close	close	NA	NA	close	close	NA	NA	NA	low	NA	low
HAD1		NA	close	close	close	close	close	close	close	close	NA	close	low	low	low	low
HAD2		NA	close	close	close	close	close	close	close	close	NA	close	low	low	low	low
HAD3		NA	close	close	close	close	close	close	close	close	NA	close	low	low	low	low
HAD4		NA	close	close	close	close	close	close	close	close	NA	close	low	low	low	low
HAD5		NA	close	close	close	close	close	close	close	close	NA	close	low	low	low	low
HAD6		NA	close	close	close	close	close	close	close	close	NA	close	low	low	low	low
HAD7		NA	close	close	close	close	close	close	close	close	NA	close	low	low	low	low
HAD8		NA	close	close	close	close	close	close	close	close	NA	close	low	low	low	low
Fire (MXL)		NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Smoke/Heat		NA	close	close	close	close	close	close	close	close	NA	close	low	low	low	low
DCH iso VLow		NA	close	close	NA	NA	NA	NA	close	close	NA	NA	low	NA	NA	low
RPC iso VLow		NA	NA	NA	close	close	NA	NA	close	close	NA	NA	NA	NA	NA	low
LST Mixer Problem		NA	NA	NA	NA	NA	close	close	NA	NA	NA	close	NA	NA	low	NA
~~DCH return Low~~ '		NA	close	close	NA	NA	NA	NA	close	close	NA	NA	low	NA	NA	low
~~DCH supply Low~~ '		NA	close	close	NA	NA	NA	NA	close	close	NA	NA	low	NA	NA	low
~~DCH supply high~~ '		NA	close	close	NA	NA	NA	NA	close	close	NA	NA	low	NA	NA	low
~~DCH_System_Problem~~		NA	close	close	NA	NA	NA	NA	close	close	NA	NA	NA	NA	NA	low
RPC_System_Problem		NA	NA	NA	close	close	NA	NA	close	close	NA	NA	NA	NA	NA	low
IR-2 (incoming)		NA	close	close	close	close	NA	NA	close	close	NA	NA	low	low	NA	NA
IR-2_CRASH_BUTTON		NA	close	close	close	close	NA	NA	close	close	NA	NA	low	low	NA	NA

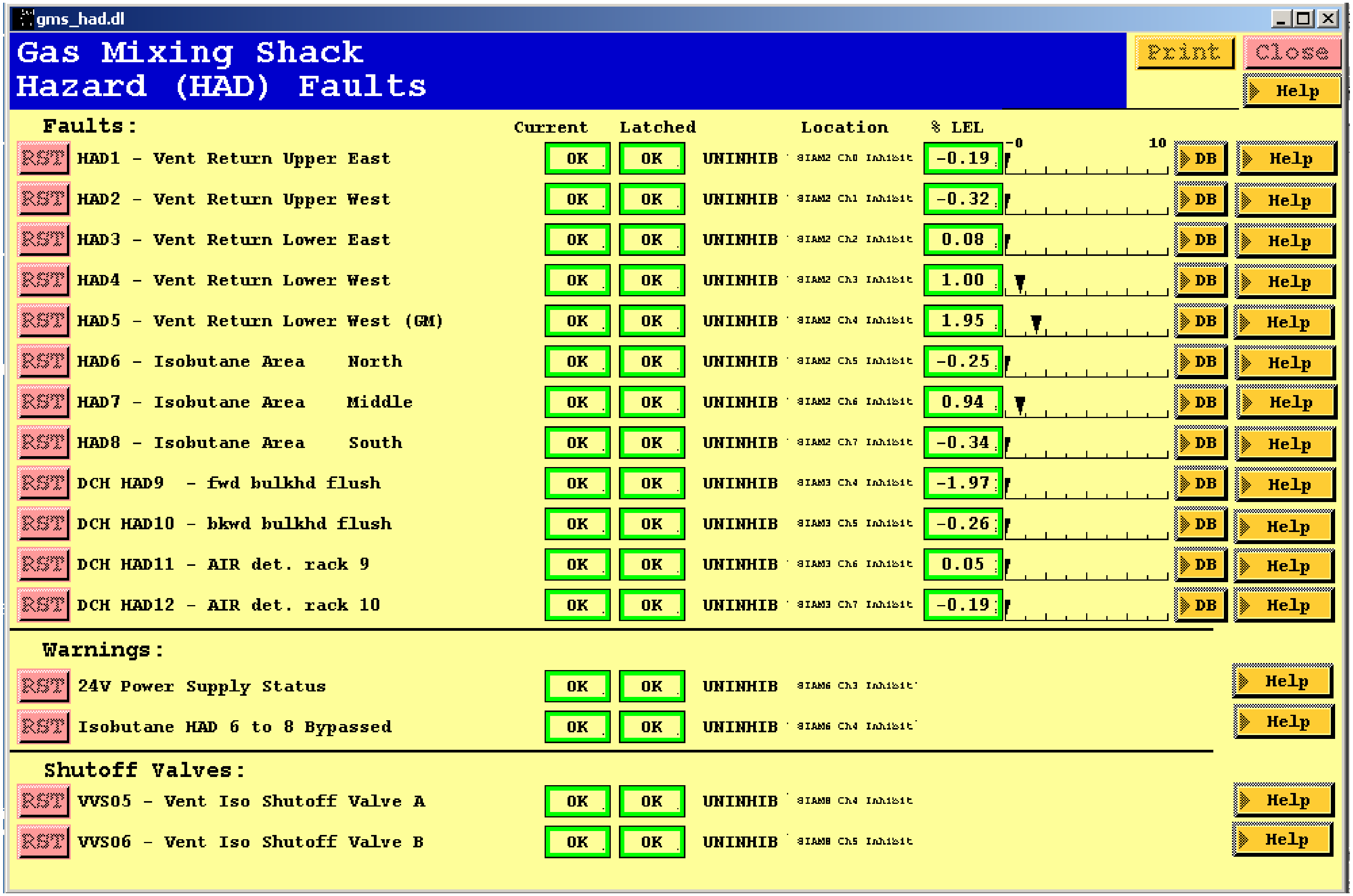
This refers to the warning lights at the entrances and on top of the rack

If there is a HAD alarm:
(HAD = Hazardous Atmosphere Detector)

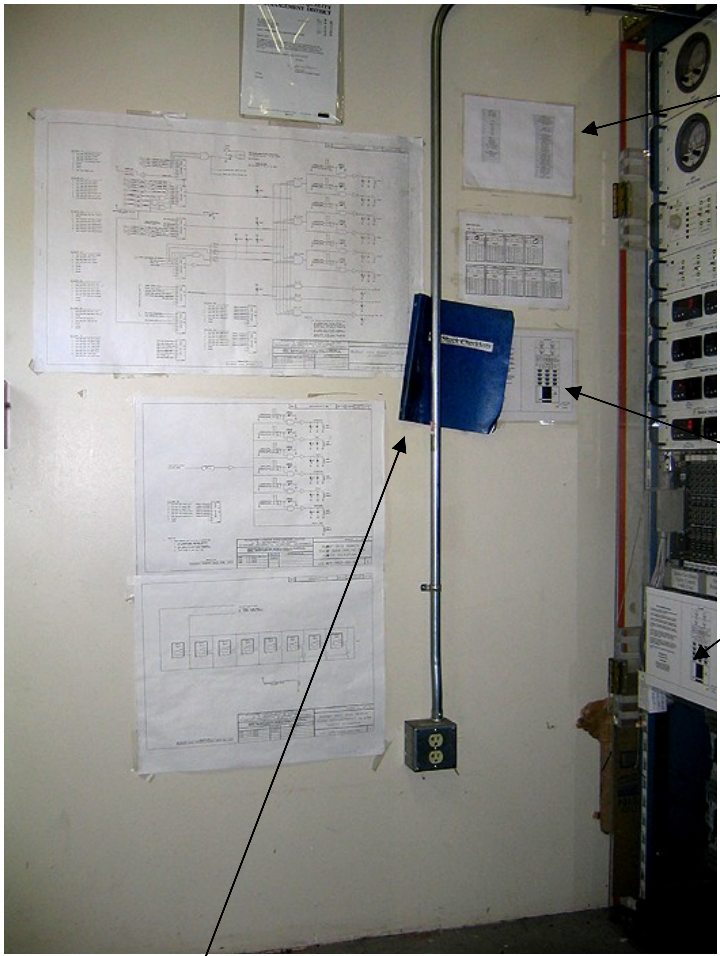
- The fire department is called
- All of the isobutane lines going into the shack are shut off at the supply manifolds
- There are HAD sensors inside the gas shack and also in the isobutane storage area; try to find out the location of the ones that caused the alarm before going to the shack
- The HAD sensors alarm at a level which is 10% of the lower flammable limit; the sensor displays available on the consoles (see next slide) will tell you what concentration they are reading
- So long as the ventilation system is running, any flammable gas that might be inside the shack will be swept away
- If you approach the gas shack, look towards the isobutane storage area for any evidence of a (cold) cloud of released isobutane. The concern here is that a connection or a hose between an isobutane tank and a supply panel might have come loose. This would trip an outside HAD sensor. Stay away if you see anything that looks like a cloud
- Once the shutoff valves are closed, the last remaining source of isobutane would be the bottles themselves; however let experts close the valves on the isobutane bottles
- If there is any significant spill of isobutane, the only thing that can be done is to stay at a safe distance and to wait for the isobutane to disperse

EPICs HAD display

Main -> CEN -> GMS -> HADs   Note that the units are % LEL



There is documentation on the inside wall next to the safety rack



What SIAM channels are what

Logic Diagrams

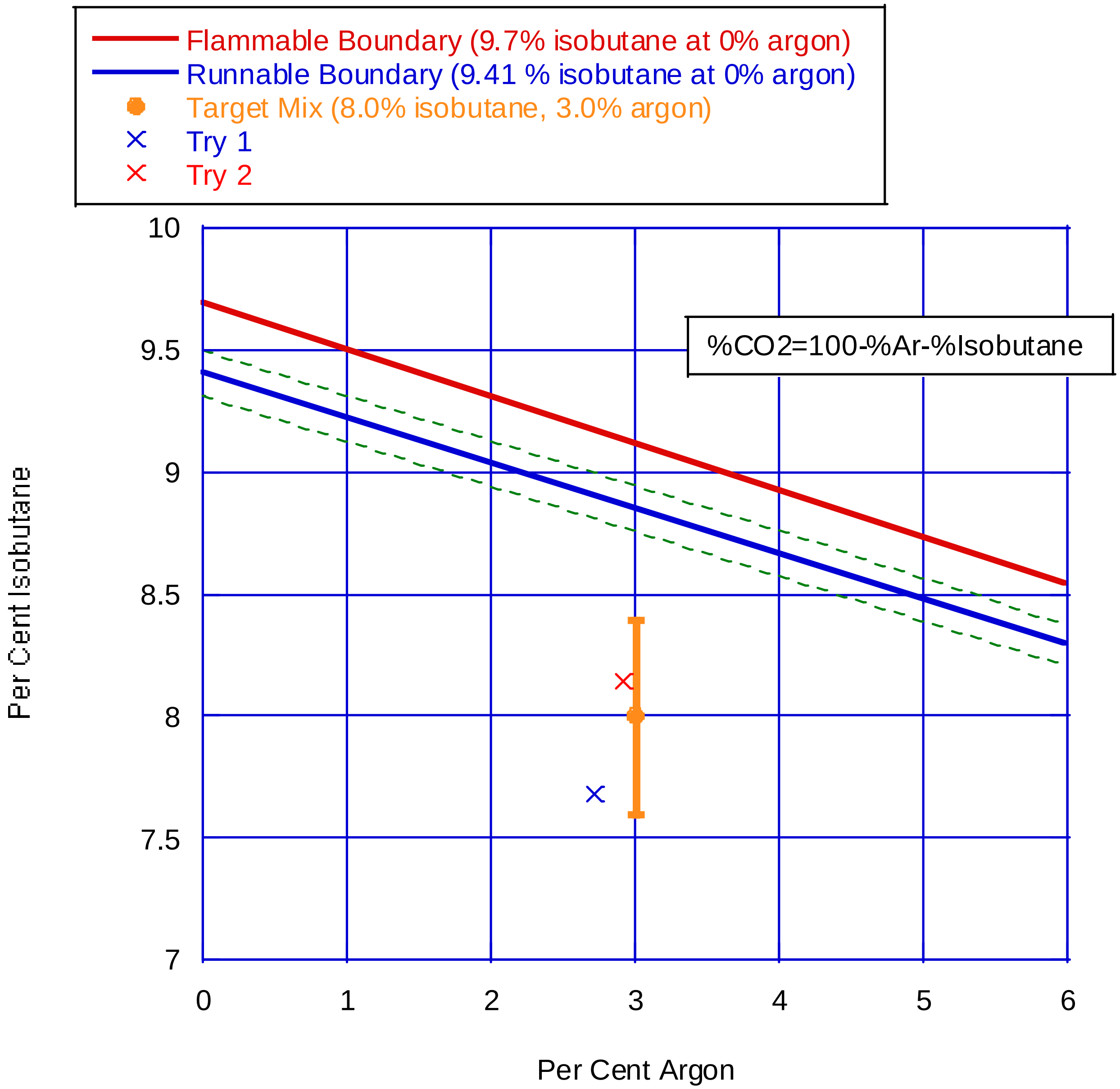
How to recover from a power outage

History of the ventilation monitor readings

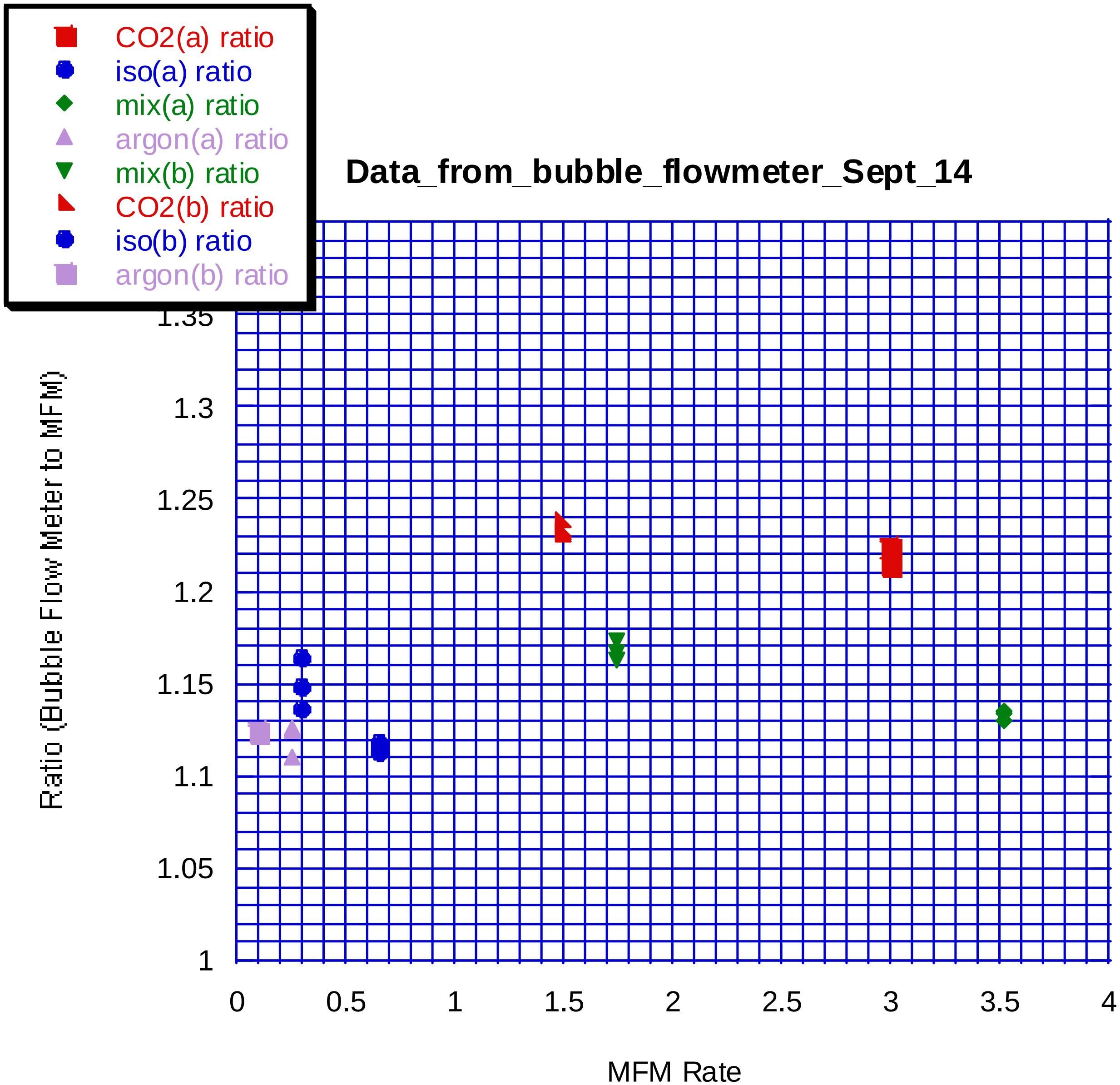
Measures of how well the LST system works

- Calibration
- Cross checks with a bubble flow meter
- Time histories of the gas flows
- Internal Pressure stability

The bottom line (this employs an outside analysis of the gas mix)



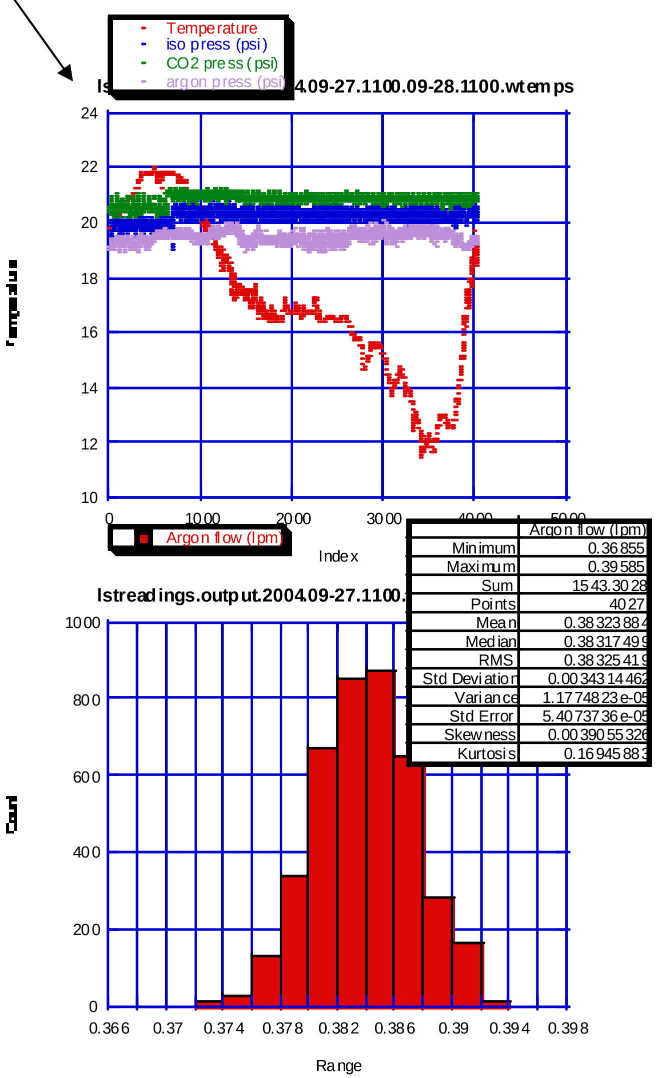
Mass Flow Meter Cross checks

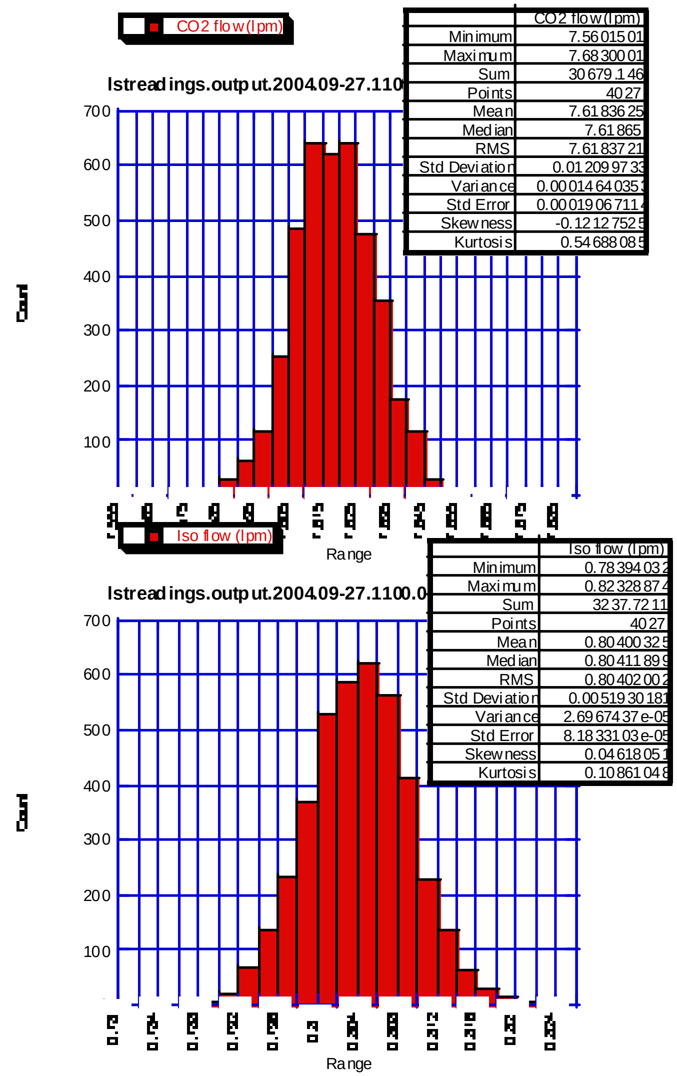


What we see

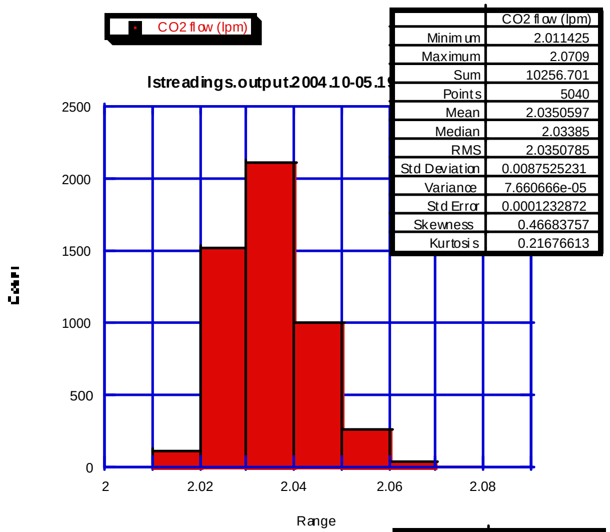
Pressures and Temperature versus Time

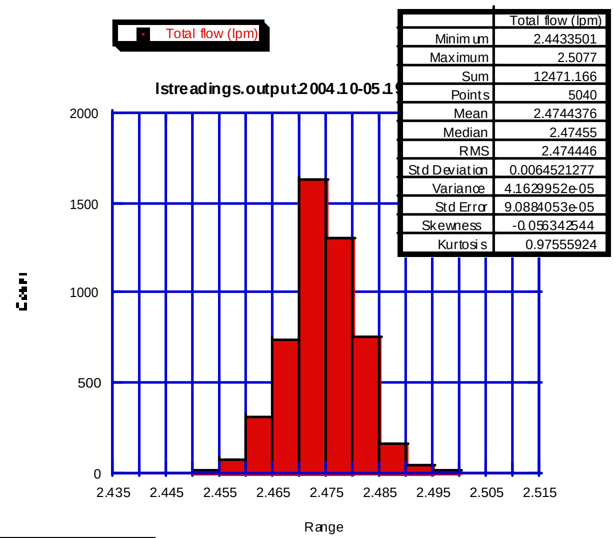
Distribution of Flow Readings

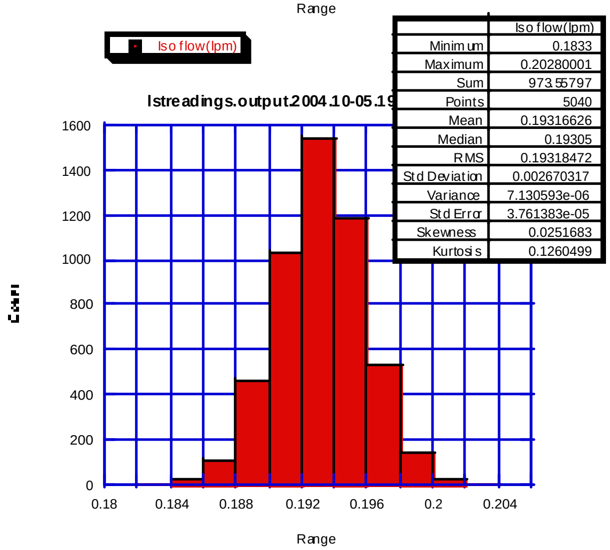


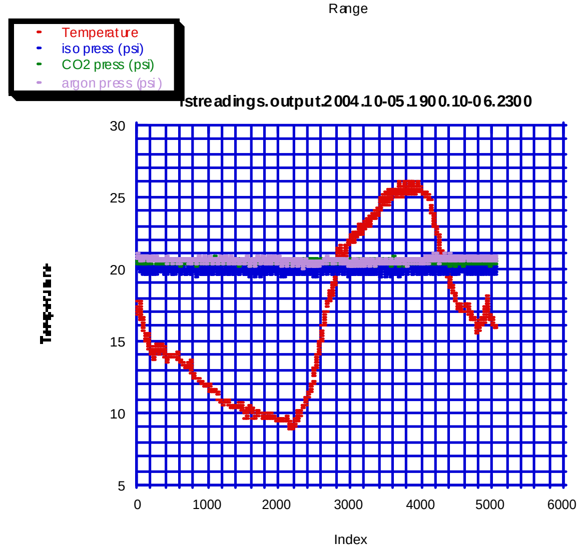


More recent flows









The RPC Mixing System

- Worthwhile if more people know how to reset the RPC system
- The RPC system will trip on very brief abnormalities, giving rise to intermittent faults; need to record the conditions when this happens
- Frequently need to use the ambient database to analyze problems

RPC checklist – standard readings (Part 1)

RPC Isobutane Supply Panel

Tank 1 Weight	(> 15 lbs)	
Tank 1 Supply Pressure (PRV111)	(>30 psi)	
Tank 1 Temperature	(> 80 deg F)	
Tank 2 Weight	(> 50 lbs)	
Tank 2 Supply Pressure (PRV112)	(>30 psi)	
Tank 2 Temperature	(> 80 deg F)	
Manifold Pressure	(~34 psi)	

Inert Gas Pad

Freon Regulated Pressure	(> 25 psi)	
Freon Online Tank has Liquid & a warm Belly Band Heater		
Freon Standby Tank has Liquid & a warm Belly Band Heater		
Helium Gas Usage Meter		

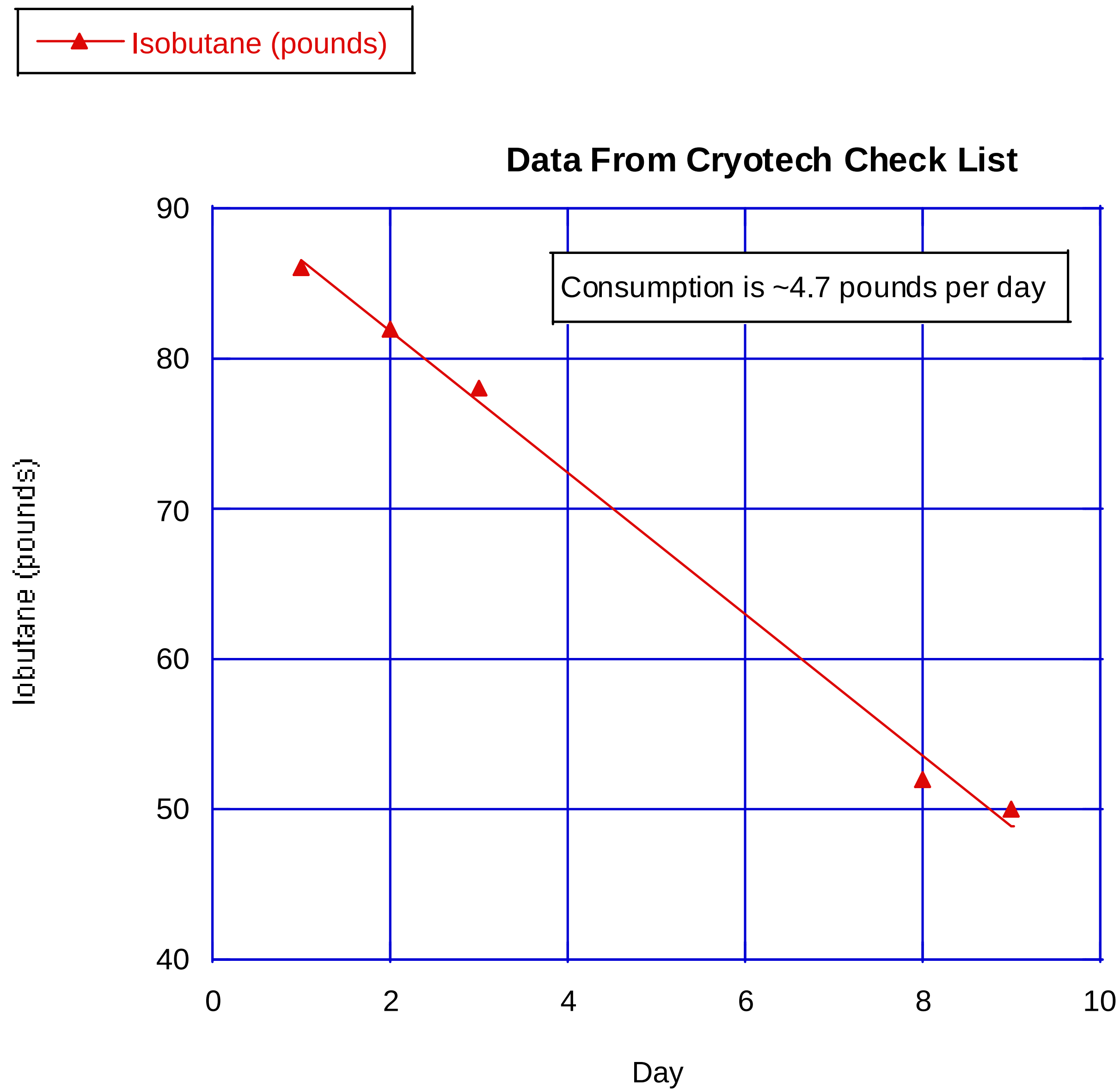
RPC checklist – standard readings (Part 2)

RPC Gas Mixer Rack (B636-01)

(The gas mixer cycles between standby and mixing gas; the flows and pressures will differ between the two cases)

PT 1 Pressure Cycle Sensor	(1500-1600)
Enable Button (green light)	ON
Interlock Status Lights	ALL OFF
Flow Controller - Gas 2	(0 or 3.6 +-.1)
Flow Controller - Gas 3	(0 or 2.7+-.1)
Flow Controller - Gas 4	(0 or 9.1+-.1)
Flow Monitor - Gas 2	(0 or 3.6 +-.1)
Flow Monitor - Gas 3	(0 or 2.9+-.1)
Flow Monitor - Gas 4	(0 or 8.7+-.1)
Input Pressure - Gas 2	(20-40 psi)
Input Pressure - Gas 3	(20-40 psi)
Input Pressure - Gas 4	(30-50 psi)
Mixed Gas Flow Monitor (Gas 5)	> 10
Mixed Pressure Monitor (Gas 5)	> 4.5

RPC isobutane consumption Nov 2004



RPC gas mixing station – side view

Note: there is a ventilation sensor here, called MH6; it checks whether the fan in the RPC rack is running. If the fan stops (or someone blocks the sensor) it will <u>shut off</u> the RPC isobutane.

Interior inputs for the three RPC gases, plus instrument air to operate the valves, with their regulators.

The freon and isobutane lines are heated and insulated.

The power for the RPC isobutane heater tapes originates on the south wall of the shack

RPC gas mixing station – front view

Illuminated green enable (start) and red disable (stop) buttons.

Red reset buttons for the various RPC system faults. Red LEDs above the reset buttons tell you what has tripped.

Pressure and flow readings.

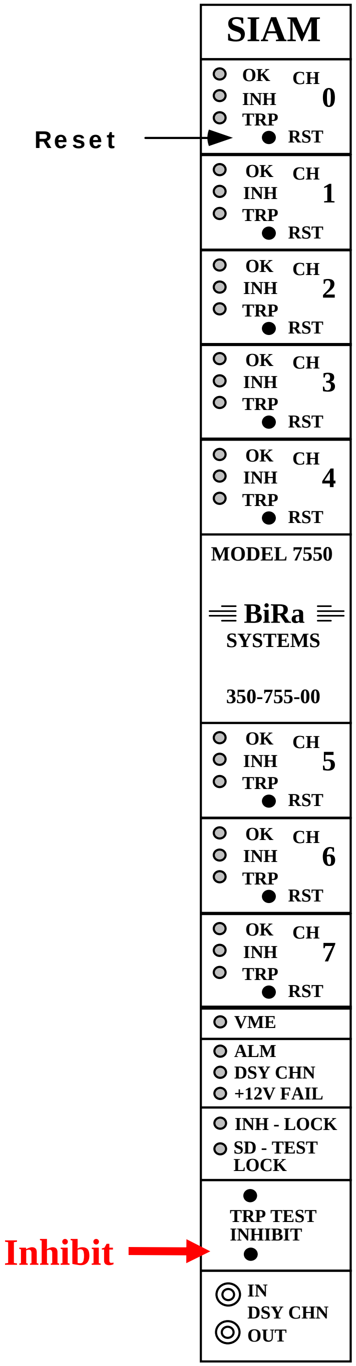
To reset a trip:

1) Push disable
2) Use the red reset buttons to reset the faults
3) Reset the SIAMs in the safety rack
4) Push enable

Resetting the RPC rack; a closer look

To reset a trip:

1. Push disable
2. Use the red reset buttons to reset the faults
3. Reset the SIAMs in the safety rack (next page)
4. Push enable



The RPC rack is B636-01. To reset a trip:

1. Push disable
2. Use the red reset buttons to reset the faults
3. Reset the SIAMs in the safety rack
4. Push enable

<u>If these steps don't work</u>, check that the ventilation system and the HAD system are up and running, and that only the internal RPC system trips are stopping the RPC gas flow.

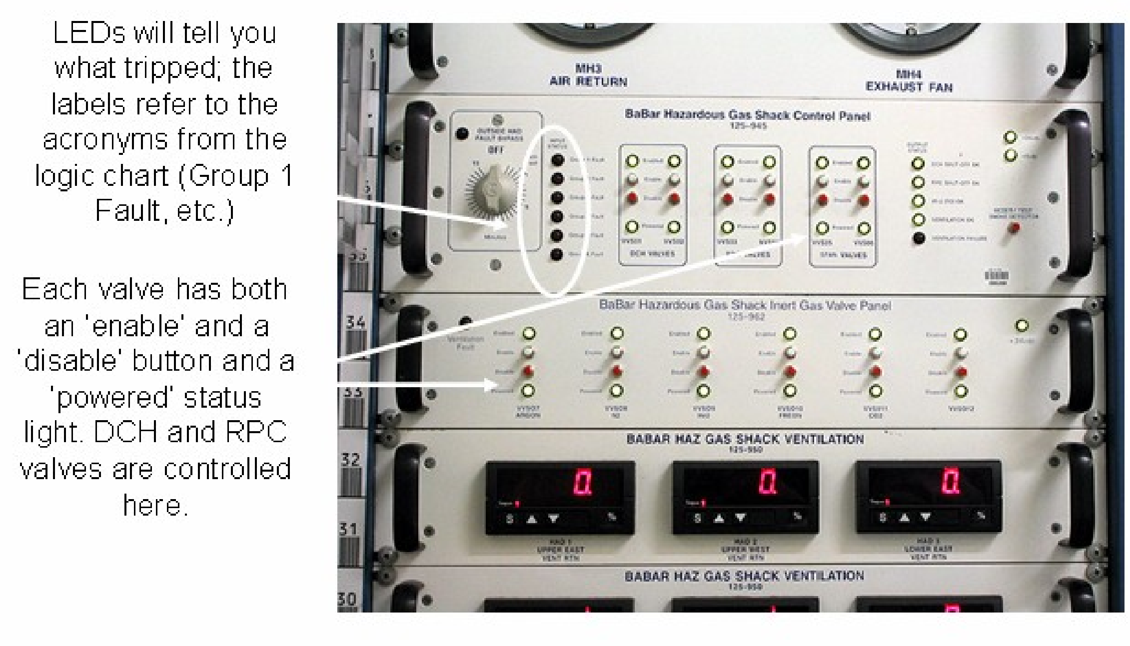
To verify this, check rack B636-03; when <u>only</u> SIAM 5 from SIAMS 1-5 has red TRP lights on, you can be certain that it is an internal RPC trip. All of the valves controlled by Panels125-945 and 125-962 should be enabled and powered except for the RPC isobutane. The RPC isobutane valves should both be enabled. Panel 125-945 should show only a Group 5 fault (RPC system).

If channel 5 of SIAM 5 is tripped, it will need to be put into bypass. To do this, push the SIAM 5 inhibit button at the bottom and the channel 5 RST button at the same time. The orange INH light should turn on. Once the isobutane flow is enabled, the input should revert to normal.

A 'MIXED GAS OUTPUT FLOW FAULT' could require the key for the 'OUTPUT FLOW OVERRIDE' to be turned horizontally before it can be cleared. This can happen if, for example, only the isobutane has been shut off as occurs when there is a HAD alarm. Return the key to the vertical position when done.

The system will have about a minute or two to start a fill. The system may trip at the end of this period because pressures and flows have not reached equilibrium. If so, repeat the process. Clear any inhibited channels when done.

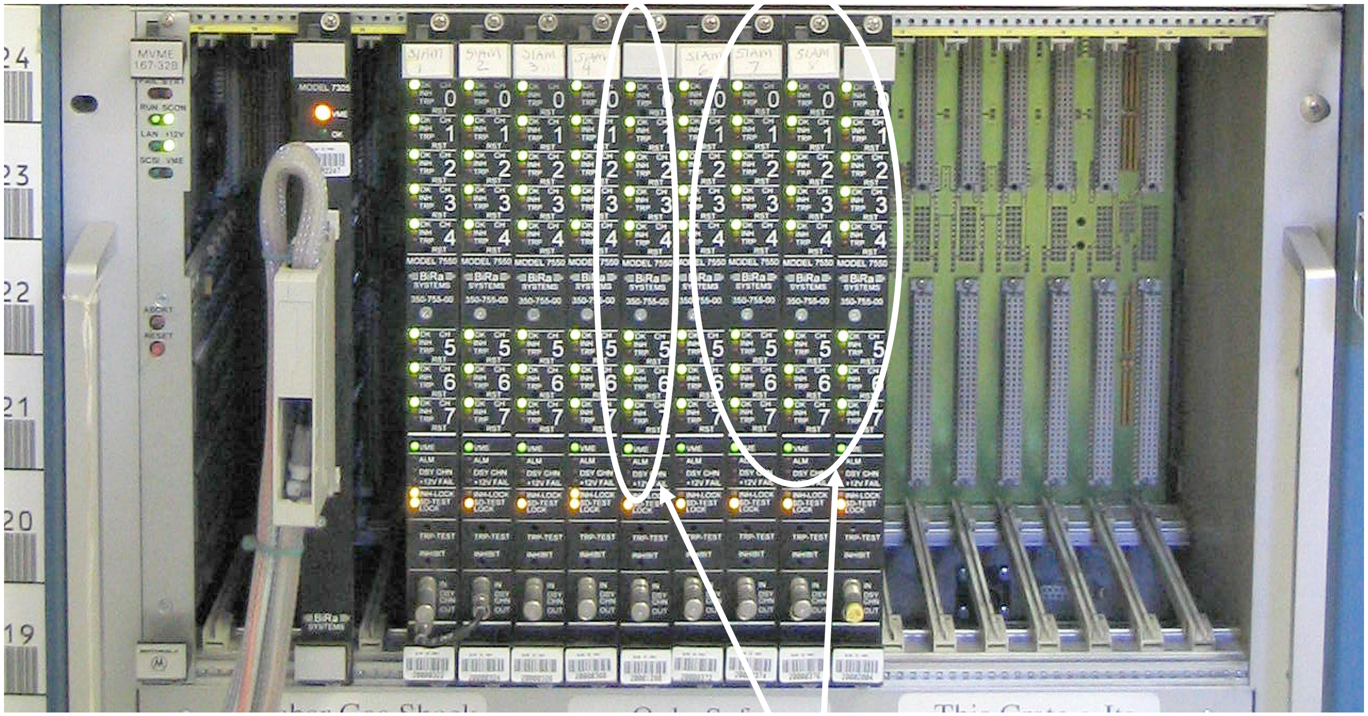
Below we show a picture of a portion of the gas shack safety rack, B636-03, concentrating on Panels125-945 and 125-962. All the valves in the panels should be ENABLED. The LEDs on the left side of Panel 125-945 will show the conditions causing the gas supplies to be shut down. After the ventilation and the HAD systems are restored, Panel 125-945 should show only a Group 5 fault (RPC system) under normal conditions.



The last RPC device that could trip off the system is the sensor monitoring the ventilation fan for the RPC mixing rack itself. The sensor makes certain that there is enough ventilation going into the rack to prevent a buildup of isobutane inside the rack were there to be a leak there. The signal from this sensor goes to channel 0 of SIAM 4; Panel 125-945 will show a Group 3 Fault. If the fan fails, one needs to remove the back door to the RPC mixing system to provide rack ventilation and to call an expert to physically bypass the sensor until the fan can be repaired.

Picture of the SIAMs in the gas shack VME crate

SIAM: 1 2 3 4 5 6 7 8 9



This is where you look to clear the RPC SIAMs manually; SIAM 5 will shut off the RPC isobutane

Gas Shack SIAM contents (1)

SIAMs 1-4 contain information on the status of the ventilation, the gas shack HADs, a gas shack smoke detector, and DCH monitors

SIAM 4, channel 0 monitors the ventilation in the RPC rack; it will shut off the RPC isobutane if the fans fail

SIAM 1	
0	MH1 - Air Intake
1	MH2 - Air Supply
2	MH3 - Air Return
3	MH4 - Air Exhaust
4	
5	
6	
7	Smoke Det

SIAM 2	
0	HAD 1
1	HAD 2
2	HAD 3
3	HAD 4
4	HAD 5
5	HAD 6
6	HAD 7
7	HAD 8

SIAM 3	
0	DCH iso VLow
1	DCH Ret Low
2	DCH Sply Low
3	DCH Sply Hi
4	HAD 9 - front bulkhead vent
5	HAD 10 - rear bulkhead vent
6	HAD 11 - rack 10 top
7	HAD 12 - rack 10 bottom

SIAM 4	
0	MH6 - RPC Rack Ventilation
1	DCH Sys Problem
2	IR-2 (in)
3	IR-2 Crash
4	
5	
6	
7	

Gas Shack SIAM contents (2)

SIAM 5	
0	RPC: Input Pressure Fault
1	RPC: Input Flow Fault
2	RPC: Mixing Tank Pressure High
3	RPC: Mixed Gas Output Flow Fault
4	RPC: Ext Mixed Gas Output Interlock
5	RPC iso Vlow
6	
7	

These will shut off the RPC isobutane

Channels 0-4 come from the gas mixing system

Channel 5 monitors a pressure switch in the RPC isobutane supply line

SIAM 6	
0	RPC: Ext Fill Interlock
1	RPC: Fill Operation Fault
2	
3	24 V Supply OK
4	HAD 6-8 Bypass (tank change)
5	LST 24 V Supply OK
6	LST System SO
7	LST Isobutane Vlow Fault

SIAM 7	
0	RPC: Isobutane low
1	DCH: Isobutane low
2	RPC: Argon low
3	RPC: Freon low
4	DCH: Helium low
5	DCH: Nitrogen low
6	Compressed Air low
7	DCH: CO2 low

Status Indicators

SIAM 8	
0	DCH isobutane - VVSO1
1	DCH isobutane - VVSO2
2	RPC isobutane - VVSO3
3	RPC isobutane - VVSO4
4	Span Gas - VVSO5
5	Span Gas - VVSO6
6	LST Isobutane – VVSO13
7	LST Isobutane – VVSO14

SIAM 9	
0	RPC Argon - VVSO7
1	DCH Nitrogen - VVSO8
2	DCH Helium - VVSO9
3	RPC Freon - VVSO10
4	DCH CO2 - VVSO11
5	VVSO12
6	LST Argon – VVSO15
7	LST CO2 – VVSO16

RPC mixer during a fill – closer look

Green enable and red disable buttons.

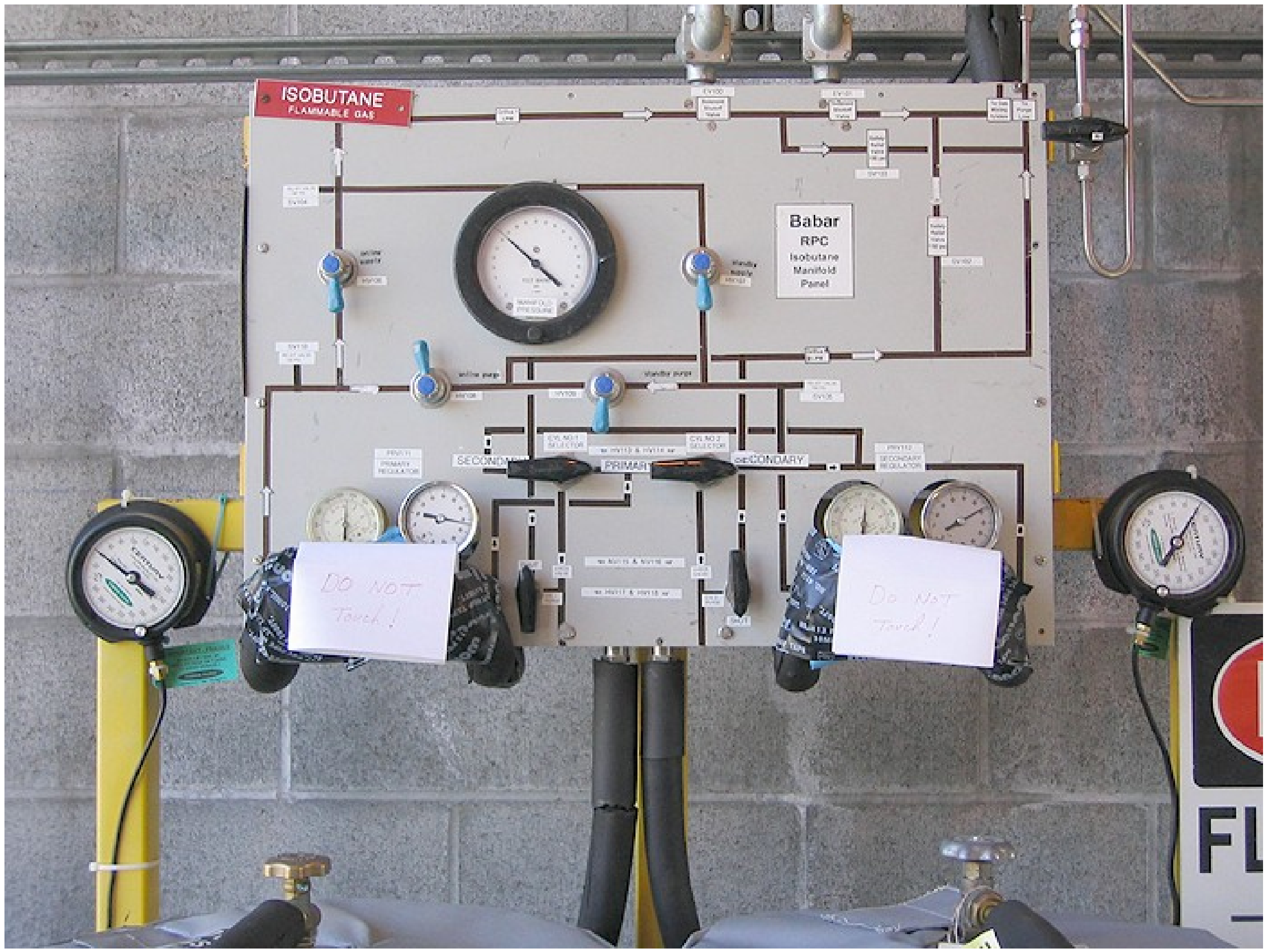
Red reset buttons for various system faults.

Pressure and flow readings. (One channel is a spare.)

The values you see here <u>should be the standards</u>.

RPC (and DCH on the right) side of the isobutane storage area

RPC isobutane manifold panel



RPC Freon supply - tank farm

These panels switch the tanks between online, standby, and off

The orange belly band heaters warm up the tanks and keep the pressure of the evaporating freon high enough for our needs

RPC Freon supply – the tank farm

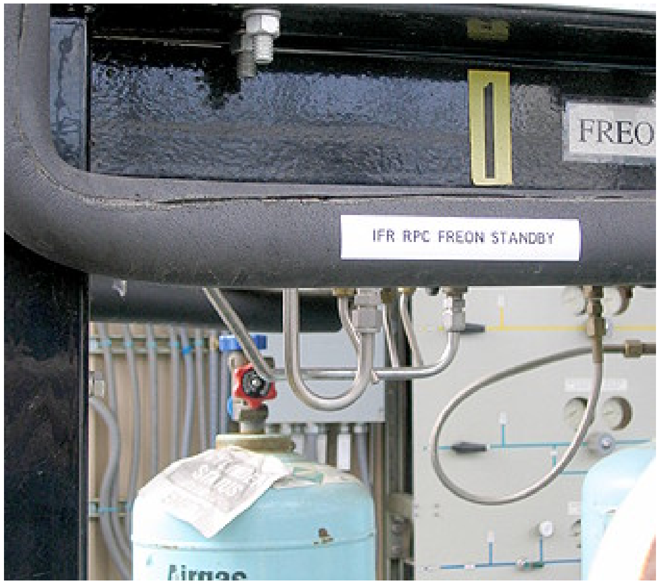
Tank status

The tanks have belly band heaters; the pressure coming out of the tanks can be read on the gauges

RPC Freon supply – the tank farm is plumbed into the old RPC gas rack

Supply

Standby



Inert Gas Area