8. Gas System (in detail) (Tom Miller, designer)

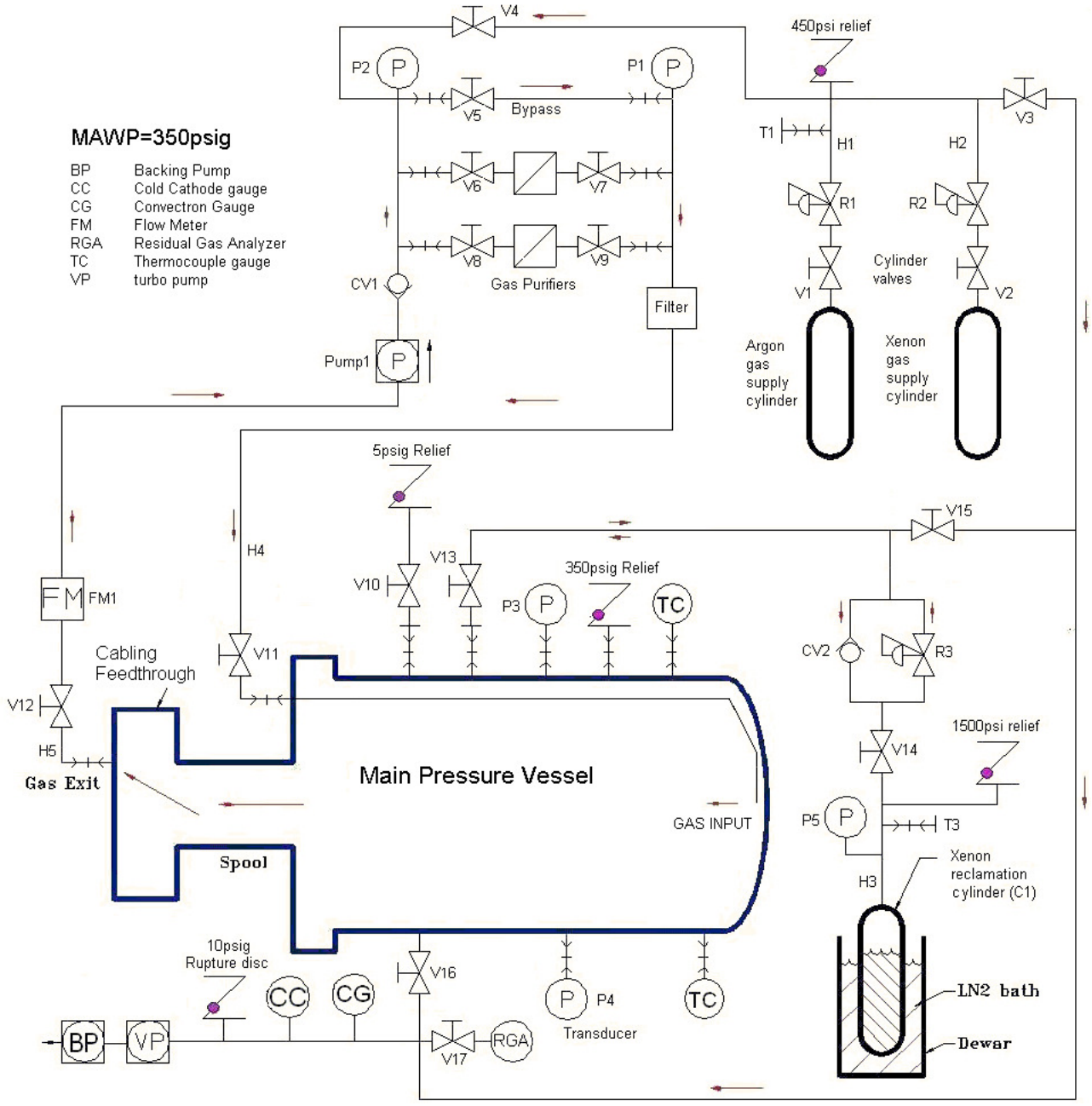

Fig. 15. Gas system (same as fig. 5)

Operation:

This TPC (Time Projection Chamber) gas system is designed to circulate purified Xenon gas at pressures up to 300psig MOP (225 psig MOP) initially with Ceramtec SHV-20 feedthroughs installed). The AHD will initially specify only an 250psig MAWP (225psig MOP) with these feedthroughs, then it will be updated to the higher pressure MAWP only when these feedthroughs are replaced with higher pressure rated feedthroughs.

In operation, the procedures are sequential, unless otherwise indicated. There are steps inserted for checking valve status, **Valves** listed in **bold red** are **closed**; Valves listed in nonbold green are open.

1. Complete system pump-down

a. Close V1, V2 and V10. Open R1 and R2 one turn each.
b. Open V4, V5, V11, V13-V16. DO NOT open V6-V9.
c. **V1 V2 V3** V4 V5 **V6 V7 V8 V9 V10** V11 **V12** V13 V14 V15 V16 **V17**
d. Turn on the backing pump and convectron gauge controller
e. When the convectron gauge reads < 1e-2 torr, turn on the turbo pump and cold cathode gauge controller. Open V3 and V12.
f. When the cold cathode gauge reads < 5e-5 torr, open V17 and turn on the RGA.
g. If the system pressure and RGA scan are acceptable, turn off the RGA. If not, continue to pump until the pressure improves to an acceptable level.
h. Close V3, V4, V13-V17. Back off R1 and R2.
i. Turn off pumps and controllers.
j. **V1 V2 V3 V4** V5 **V6 V7 V8 V9 V10** V11 V12 **V13 V14 V15 V16 V17**
k. Proceed to step 3.

2. System pump-down with xenon in the Xenon reclamation cylinder

a. Close V1, V2 and V10. Open R1 and R2 one turn each.
b. Open V4, V5, V11-V13, V16. DO NOT open V6-V9.
c. **V1 V2 V3** V4 V5 **V6 V7 V8 V9 V10** V11 **V12** V13 **V14 V15** V16 **V17**
d. Turn on the backing pump and convectron gauge controller
e. When the convectron gauge reads < 1e-2 torr, turn on the turbo pump and cold cathode gauge controller. Open V3.
f. When the cold cathode gauge reads < 5e-5 torr, open V17 and turn on the RGA.
g. If the system pressure and RGA scan are acceptable, turn off the RGA.
h. Close V3, V4, V13, V16 and V17. Back off R1 and R2.
i. Turn off pumps and controllers.
j. **V1 V2 V3 V4** V5 **V6 V7 V8 V9 V10** V11 V12 **V13 V14 V15 V16 V17**
k. Proceed to step 3.

3. Argon purge

a. **V1 V2 V3 V4** V5 **V6 V7 V8 V9 V10** V11 V12 **V13 V14 V15 V16 V17**
b. Back off R1. Open V1
c. Set R1 to 20psig
d. Open V4.
e. Wait for P3 to read > 5 psi. Open V10 1/4 turn. Argon will bleed out the 5psig relief.
f. Wait 5 minutes, then close V10.
g. Start pump1
h. Once P3 reads 20psi, close V1 and V4. Back off R1.
i. Continue pumping for desired interval.
j. Turn off pump1.
k. Open V10 to vent argon.
l. When P3 reads < 6psi, close V10, V12.
m. **V1 V2 V3 V4** V5 **V6 V7 V8 V9 V10** V11 **V12 V13 V14 V15 V16 V17**
n. Proceed to step 4

4. Post-purge pump-down

a. **V1 V2 V3 V4** V5 **V6 V7 V8 V9 V10** V11 **V12 V13 V14 V15 V16 V17**
b. Check that P3 reads < 6psi. Open V10 to relieve pressure. Close V10 when done.
c. Open V4 and crank down R1 1 turn.
d. Start the backing pump and convectron gauge controller
e. Slowly open V16.
f. When the convectron gauge reads < 1e-2 torr, turn on the turbo pump and cold cathode gauge controller.
g. When the cold cathode gauge reads < 5e-5 torr, open V17 and turn on the RGA.
h. Close V4 and back off R1.
i. If the system pressure and RGA scan are acceptable, turn off the RGA, close V16 and V17.

j. Turn off pumps and controllers.
k. **V1 V2 V3 V4** V5 **V6 V7 V8 V9 V10** V11 **V12 V13 V14 V15 V16 V17**
l. If the partial pressures are not acceptable, repeat procedure from step 3.
m. If the Xenon reclamation cylinder is filled, proceed to step 6.

5. Xenon reclamation cylinder fill procedure
a. **V1 V2 V3 V4** V5 **V6 V7 V8 V9 V10** V11 **V12 V13 V14 V15 V16 V17**
b. Back off R2. Open V2 and V12.
c. Open V13 and V14. Check that V10 is closed.
d. Set R2 to 200psig
e. Carefully open V4
f. Once P3 reads 200psig, close V4
g. Read the gas temperature at the TC. When T > 15 deg C, continue
h. Set R2 to 300psig (225psig initial)
i. Open V4
j. Once P3 reads 300psig (225psig initial), close V2 and back off R2.
k. Chill C1 with LN until P4 bases out.
l. Close V4 and V14.
m. Open V2. Set R2 to 50psig
n. Open V4
o. Once P3 reads 50 psig, close V2, V4 and back off R2.
p. Open V14.
q. Continue to chill C1 with LN until P4 bases out.
r. Close V13 and V14. Stop chilling C1.
s. **V1 V2 V3 V4** V5 **V6 V7 V8 V9 V10** V11 V12 **V13 V14 V15 V16 V17**
t. Proceed to step 6

6. Chamber fill from Xenon reclamation cylinder
a. **V1 V2 V3 V4** V5 **V6 V7 V8 V9 V10** V11 V12 **V13 V14 V15 V16 V17**
b. Close V11
b. Back off R3. Open V14
c. If P5 < 300psig (225psig initial) at any point in step 6, turn on heat to C1
d. Once P5 > 300psig (225psig initial), set R3 to 200psig(150psig initial)
e. Close V4.
f. Open V13
g. Open V6, V8
h. When P3 reads 200psig, close V13
i. Check the temperature at the TC. When T > 15 deg C, Continue
j. Set R3 to 300psig(225psig initial)
k. Open V13
l. When P3= 300psig (225psig initial), close V13 and V14
m. Close V5, V6, V8. Back off R3.
n. TPC is ready to operate
o. **V1 V2 V3 V4 V5 V6 V7 V8 V9 V10 V11** V12 **V13 V14 V15 V16 V17**

7. TPC operation
a. **V1 V2 V3 V4 V5 V6 V7 V8 V9 V10 V11** V12 **V13 V14 V15 V16 V17**
b. Open V6,V7 or V8,V9 and V11
d. Start pump1
e. Monitor total flow with FM1. Adjust pump controller as required
f. Log flow and pressure at P4, if desired
g. **V1 V2 V3 V4 V5** V6 V7 **V8 V9 V10** V11 V12 **V13 V14 V15 V16 V17** (V8,V9 may be open instead of V6,V7)

8. TPC shutdown

a. **V1 V2 V3 V4 V5** V6 V7 **V8 V9 V10** V11 V12 **V13 V14 V15 V16 V17** (V8,V9 may be open instead of V6,V7)
b. Stop pump1
c. Close V6-V9, as required.
d. Stop data logger
e. **V1 V2 V3 V4 V5 V6 V7 V8 V9 V10** V11 V12 **V13 V14 V15 V16 V17**

9. Cryogenic Xenon reclamation from TPC
a. **V1 V2 V3 V4 V5 V6 V7 V8 V9 V10** V11 V12 **V13 V14 V15 V16 V17**
b. Open V5, V13, V14. Close V12
c. Chill C1 with LN.
d. Once P4 bases out, close V13.
e. Close V14.
f. **V1 V2 V3 V4** V5 **V6 V7 V8 V9 V10** V11 **V12 V13 V14 V15 V16 V17**

10. Let-up to Argon
a. **V1 V2 V3 V4** V5 **V6 V7 V8 V9 V10** V11 **V12 V13 V14 V15 V16 V17**
b. Back off R1. Open V1
c. Set R1 to 15psig
c. Open V4
d. When P3 > 0psig, close V1. Back off R1.
f. Open V10.
g. Once the 5psi relief is closed, close V10, V11
h. Proceed with disassembly of TPC. Leave 1 main flange bolt loosely in place until any residual pressure is vented.
i. **V1 V2 V3 V4** V5 **V6 V7 V8 V9 V10 V11 V12 V13 V14 V15 V16 V17**

11. Replacement of Argon gas supply cylinder
a. **V1 V2 V3 V4** V5 **V6 V7 V8 V9 V10 V11 V12 V13 V14 V15 V16 V17**
b. Make certain V1 is closed. Back off R1.
c. Disconnect R1 from Ar cylinder.
d. Connect new Ar cylinder to R1.
e. Crank down R1 1 turn.
f. Open V3
g. Start backing pump and convectron gauge
h. When the convectron gauge reads < 1e-2 torr, turn on the turbo pump and cold cathode gauge controller.
g. When the cold cathode gauge reads < 5e-5 torr, close V3 and turn off pumps.
h. Back off R1.
i. **V1 V2 V3 V4** V5 **V6 V7 V8 V9 V10 V11 V12 V13 V14 V15 V16 V17**

12. Replacement of Xenon gas supply cylinder
a. **V1 V2 V3 V4** V5 **V6 V7 V8 V9 V10 V11 V12 V13 V14 V15 V16 V17**
b. Make certain V2 is closed. Back off R1.
c. Disconnect R2 from Xe cylinder.
d. Connect new Xe cylinder to R1.
e. Crank down R2 1 turn.
f. Open V3
g. Start backing pump and convectron gauge
h. When the convectron gauge reads < 1e-2 torr, turn on the turbo pump and cold cathode gauge controller.
g. When the cold cathode gauge reads < 5e-5 torr, close V3 and turn off pumps.
h. Back off R2.
i. **V1 V2 V3 V4** V5 **V6 V7 V8 V9 V10 V11 V12 V13 V14 V15 V16 V17**

Relief Valve Capacity

There are no operating conditions whereby a sudden pressure rise can occur, such as a sudden release of energy leading to rapid gas heating, or loss of insulating vacuum. We consider some extraordinary circumstances:

Pressure Rise under Gas Cylinder Regulator Failure

This is probably the most credible mechanism for accidental overpressure (someone accidently screws a regulator all the way in, then opens a valve downstream) Regulators are Matheson Dual Stage High Purity Stainless Steel, model 3810 :

maximum flow rate (@2500 psi N2 inlet pressure)

$Q_{reg} := 300SCFH \qquad Q_{reg} = 5\ SCFM$

Pressure Relief valve is a Swagelok R4. From relief valve catalog ms-01-141.pdf, flow curves are:

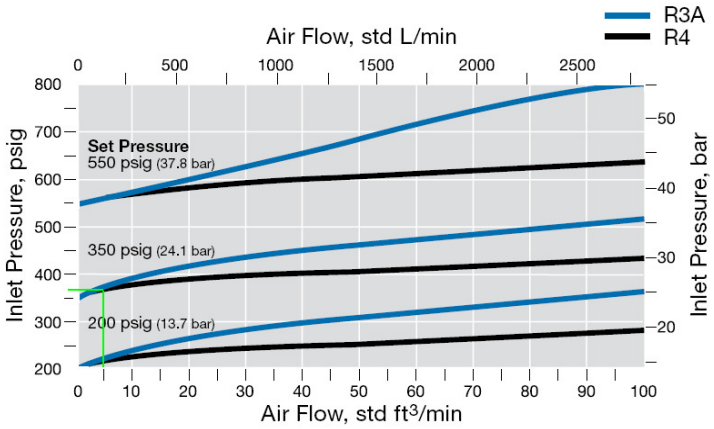

Fig 16. Pressure Relief Pressure Drop

For a set pressure of 350 psig, and a flow rate Q_{reg}, we find (green lines) an inlet pressure of:

$P_{inlet} := 370psi$ ASME Boiler and Pressure Vessel Code, Section VIII subsection UG-125 Overpressure Protection subsection (c) calls for (in this case) a maximum of 10% vessel overpressure under relief condition.

$\frac{P_{inlet}}{350psi} - 1 = 5.7\%$ OK

TPC Gas System parts list

ID	MFR.	Part Number	Note/Product Description	Pressure rating (psig)
	Swagelok			
V3-V4, V10-V15,V17		SS-8BG-V47-VD	1/2" valve Female VCR	1000
" (mixed)		SS-8BG-VCR-VD	1/2" valve Male VCR	1000
		SS-CHVCR8-1/3	1/2" VCR check valve 1/3 psi opening	6000
		SS-R4M8F8-SC11	Relief valve .25 orifice	6000
		SS-4R3A5	Relief valve .14 orifice	6000
		177-R3A-K1-A	350-750 psi spring kit for line 6	-
		177-R3A-K1-A	0-350 psi spring kit for line 6	-
		177-13K-R4-A	0-350 psi spring kit for line 5	-
		SS-FM4RM4RF4-12	1/4" VCR hose M/F fittings 12" lg	3100
		SS-4-VCR-7-8VCRF-SC11	1/2" to 1/4" VCR reducing adapter	14300
		SS-8-WVCR-6-DF-SC11	1/2" VCR close coupling	5800
		SS-8-VCR-T-SC11	1/2" VCR Tee	10900
		Ni--8-VCR-2-SC11	- 1/2" Ag plated Ni VCR gasket	-
		Ni-4-VCR-2-SC11	- 1/4" Ag plated Ni VCR gasket	-
		SS-8-VCR-CP-SC11	1/2" VCR cap	-
		SS-8-VCR-P-SC11	1/2" VCR plug	-
		SS-8-VCR-9-SC11	1/2" VCR elbow	10900
		SS-4-VCR-2-4-SC11	1/4" VCR elbow	14300
Filter		SS-6TF2-15-SC11	15 micron TF type filter 3/8 MPT	3000
		SS-8-VCR-7-6-SC11	3/8 NPT to 1/2" VCR female connector	5300
		SS-8-VCR-7-8-SC11	1/2 NPT to 1/2" VCR female connector	4900
		SS-4-VCR-1-4-SC11	1/4 NPT to 1/4" VCR male connector	8000
		SS-8-VCR-4-SC11	1/2" VCR Male tube nut	-
		SS-8-VCR-1-SC11	1/2" VCR female tube nut	-
		SS-4-VCR-4-SC11	1/4" VCR Male tube nut	-
		SS-4-VCR-1-SC11	1/4" VCR female tube nut	-
		SS-8-VCR-3-SC11	1/2" VCR socket weld	3000
		SS-6-VCR-3-SC11	1/2" VCR socket weld 3/8 tube	8200
		SS-FM4RF4RF4-36	1/4" VCR hose F fittings 36" lg	3100
		SS-FM4RM4RF4-48	1/4" VCR hose M/F fittings 48" lg	3100
		SS-FM4RF4RF4-24H	1/4" VCR hose F fittings 24" lg	3100
		SS-6-RB-4-SC11	3/8 NPT to 1/4 NPT reducing bushing	3000
		6LV-8-VCR-3S-4TB7	1/2 VCR to 1/4" tube reducing gland	5100
		-	3/8 OD x .035W 316SST Tubing	2936
		-	1/4 OD x .035W 316SST Tubing	4375
		SS-8-VCR-CS	1/2" VCR cross	10900
		SS-4-WVCR-1-4	1/4 NPT male to 1/4 VCR female	10200
		SS-4-VCR-T	1/4" VCR tee	14300
		SS-4-VCR-CS	1/4" VCR cross	14300
		SS-DSV51	1/4" VCR diaphragm valve	2500
		SS-4-WVCR-7-4	1/4" fem VCR to 1/4 fem NPT	6600
		SS-8-VCR-3-4TSW	1/2 VCR to 1/4" tube reducing gland	13600
		SS-4-VCR-3	1/4 VCR socket weld gland	5500
		SS-8-VCR-6-DM-4	Double male VCR reducing union 1/2 to 1/4	10900
		SS-4-VCR-7-4	1/4 male VCR to 1/4" NPT female	6600
		SS-4-VCR-1-00032	1/4 male VCR to 9/16-18 adapter	14300
		SS-8-VCR-1-01081	1/2 male VCR to 9/16-18 adapter	15000
		SS-4-VCR-3-4TA	1/4 swage to 1/4 VCR gland	10200
P1,P2		4066K418	0-600 psig dry gauge	600
P3		4005K48	0-400 psig dry gauge	400
P5		3852K24	0-2000 psig dry gauge	2000
	Acme Cryogenics (for LLNL orig.)			
C1		C1	Xenon condensation cylinder	3000

	Pump Works Inc.			
P1		PW2070	Positive displacement pump	1400
	SAES Pure Gas inc.			
		HP190	inert gas purifier	1000
		MC50	inert gas purifier	1000
V5-V9			valves supplied w/ above purifiers	1000
	Carten			
V16		HF2000	2" straight thru valve	350
	Matheson			
R1-R3		3818-580	15-350 psi regulator with G type inlet	3500
	Omega			
FM1, FM2		FMA1818	flowmeter 5slpm	500
P		MMG500V10P3C0T3A6	500 psig pressure transducer	500
TC		EI1202105/TC-K-NPT-U-72/3"	Pipe plug TC probe	2500
	Ceramtec			
		18088-01-CF	SHV-20 Coaxial feedthrough, 1.33" CF flange	250
		8880-02-CF	SHV-5 Coaxial Feedthrough, 1.33" CF flange	1400
		18898-01-CF	Multipin feedthrough 2.75" CF flange, 32 pin	375

9. Test Procedures

9.1 Pressure Vessel and 350 MOP Head

These components have been tested at LLNL to higher pressures than used here. No retesting is needed, as there are no corrosive gasses or other materials used, and the vessel and lid have not been modified. Any minor modifications, such as rewelding a VCR fitting to the Vessel will require a retest. MESN-99-020-OA does not specify any retesting requirement. Since no cryogens are used, the vessel and head may be retested using a hydrostatic test in accordance with ASME Boiler and Pressure Vessel Code Section VIII, subsection UG-99 Standard Hydrostatic Test. Test pressure is 1.5x MAWP= 525 psig. Nevertheless, this component will be further tested, in its installed configuration, along with the gas system test at a test pressure of 1.25x MAWP = 438psig (313 initial).

9.2 Spool

This component will be hydrostatically tested by the manufacturer in accordance with ASME Boiler and Pressure Vessel Code Section VIII, subsection UG-99 Standard Hydrostatic Test, and tagged by the manufacturer, and may be used as received. Nevertheless, this component will be further tested, in its installed configuration, along with the gas system test at a test pressure of 1.25x MAWP = 438psig (313 initial).

9.3 Octagon

This component is not rated for pressure by the manufacturer, though the manufacturer does supply pressure rating recommendations. It shall be tested by either a certified pressure installer here at LBNL, or by an independent testing lab. It shall be tested using a hydrostatic test in accordance with ASME Boiler and Pressure Vessel Code Section VIII, subsection UG-99 Standard Hydrostatic Test. Test pressure is 1.5x MAWP= 525 psig. Nevertheless, this component will be further tested, in its installed configuration, along with the gas system test at a test pressure of 1.25x MAWP = 438psig (313 initial).

9.4 Source Insertion Tube

This component will be hydrostatically tested by the manufacturer in accordance with ASME Boiler and Pressure Vessel Code Section VIII, subsection UG-99 Standard Hydrostatic Test, and tagged by the manufacturer, and may be used as received. Nevertheless, this component will be further tested, in its installed configuration, along with the gas system test at a test pressure of 1.25x MAWP = 438psig (313 initial).

9.5 Gas system

All other attachments, fittings and components are pressure rated by the manufacturer as in the above table and may be used as installed up to MAWP. Nevertheless, this system will be tested, in its installed

configuration, along with the gas system test at a test pressure of 1.25x MAWP = 438psig (313 initial), as described below:

9.6 Final assembled system pressure check

Completed gas system, including pressure vessel, shall be pneumatically tested to 125% MAWP in place using a remote test system comprising a gas cyl., regulator, gauge, test valve, and vent valve. There are three sections of the complete gas system having different MAWP's; therefore the test is in three parts. Test pressures for the 3 sections are (125%MAWP):

a. 438 psig (313 initial) for the pressure vessel,
b. 563 psig for the gas purifier and supply section, and
c. 1875 psig for the cryogenic reclamation section.

The test shall be repeated for each section that is modified. The test system and operator shall be located a minimum of 8 ft. from the main pressure vessel, with no line of sight to system (behind a barrier; this can be a room wall or the existing wall of cabinets and workbenches presently in 70A-2263). Testing is to be performed by a Certified Pressure Installer, and witnessed by the M.E. Dept. Designee for Pressure Safety, at a minimum.

Prepare for test as follows:

1. Procure:

a. Two full gas cylinders of clean Ar, N2, CO2, or dry air with supply pressure above 2000 psig.

b. Calibrated test gauge(s) for reading 438 psig (313 initial), 563 psig, and 1875 psig to within 3% accuracy. Gauge maximum scale pressure should not be less that 1.2x or more than 4x the test pressure. Electronic gauges (calibrated) are permissible, and are not subject to the above range limitations.

c. Regulator(s), to provide above pressures in (b) to fit cyl. in (a).

d. 10 ft. long high pressure clean gas service (e.g. McMaster P/N 5665K34 2-3 ea) or PTFE lined high pressure chemical hose (e.g McMaster P/N 5830K21, or similar), 2000 psig rated (min.), and fittings to connect to gas system at T1, T3.

e. Pressure relief valves that fit exhaust ports of existing relief valves set to a minimum of 5% over test pressure 460 psig (329 initial), 591 psig, and 1968 psig (using calibrated gauge), to fit exhaust ports of 350 psig (250 initial), 450 psig, and 1500 psig relief valves. These pressure relief valves should not be set higher than 40% of test pressure.

f. Test pressure isolation valve, and fill vent valve, rated for test gas maximum pressure.

g. Test pressure release vent valve on Tee, both rated for test gas maximum pressure.

2. Assemble remote gas cylinder, regulator(RT), test gauge(GT) for 563 psig test pressure, test isolation valve(TV), vent valve(VV), fill vent valve (VF) as shown in fig. 17 below, and locate around corner from experiment, out of line sight, and behind wall of cabinets, or wall. Note that the pressure relief valve shown in fig. 17 is optional, since test feed ports T1 and T3 cannot be isolated from the system pressure relief valves.

3. Install 460 psig (329 initial), 591 psig, and 1968 psig relief valves into exhaust ports of 350 psig (250initial), 450 psig, and 1500 psig relief valves, respectively.

4. Survey for, and remove any hazardous material (such as radioactive sources, flammable liquids, glassware, etc.) from line of sight to test area. Also remove as many other valuable or potentially hazardous materials such as glassware, dewars, electronic equipment as practical. Have fire extinguishers on hand.

5. Check that gas system is fully depressurized. Open V4 if closed, to connect T1 with P2 and open V14 if closed, to read pressure all the way to V13.

6. Barricade test area to prevent personnel ingress, notify building manager of impending test. Clear area of all people except for pressure test operator and witness(es).

Test 1500 psig MAWP subsystem (first) as follows (can be skipped if not needed for section retest):

7. Close V13, V15, if open. Open V14, if closed. Screw in handle of R3 all the way. Check that C1 is fully depressurized.

8. Unplug T3 and install test hose. Open VT, screw in RT; keep VV, test gas cyl valve closed.

9. Start the backing pump and convectron gauge controller, Slowly open V15. When the convectron gauge reads < 1e-2 torr, close V15, and turn off backing pump and convectron gauge controller. Close V15.

10. Check that V14 is open. Check that V13 is closed. Leave V15 closed.

11. Back off test gas cyl. regulator knob fully.

12. Open test gas cyl. valve 1-2 turns.

13. Screw in test regulator slowly, in steps in steps of 20% MAWP (300 psi), each time closing VT, and watching GT to see that stable pressures are achieved. Watch GT for 5 minutes minimum, each time. If leaks occur, back off pressure to 300 psig (20% MAWP) max. and inspect to find leak. See note on possible methods below fig. 17. Once found, back off RT fully, open VV to depressurize fully, and fix leak. If no leaks occur, continue increasing pressure until 1500 psig reads on test gauge. Record pressures on system gauges. Increase pressure to 1875 psig. Hold for 5 minutes, if stable then back off RT, close test gas cyl. valve and release system pressure; otherwise depressurize and fix leak as above. Note that it may be possible to tell when 1500 psig relief valve opens (GT needle will jump to a lower pressure), however this should not be regarded as accurate since 1500 psig relief valve could leak during test.

14. Remove 1968 psig relief valve from exhaust port of 1500 psig relief valve.

15. Close VV, and progressively repressurize system until relief valve exhausts, but not past 1600 psig. Depressurize and vent pressure. Adjust 1500 psig relief valve if needed and repeat this step.

16. Remove hose from T3, replace plug. Proceed to purge system as described in Gas System Operation.

Test 450 psig MAWP subsystem (next) as follows (skip steps 22-27 if not needed for section retest):

17. Open V4, if closed, then check that entire system is depressurized.

18. Close valves V1-V9, V11, V12, V15, V16, V17. Back off R1, R2.

19. Remove T1 plug and install hose end.

20. Start the backing pump and convectron gauge controller, Slowly open V3. When the convectron gauge reads < 1e-2 torr, close V3, and turn off backing pump and convectron gauge controller.

21. Check that installed test gauge, GT, and regulator, RT, are for 563 psig test pressure.

22. Open valves V4-V9. Check that valves V3, V11, V12, V15, V16, V17 are closed.

23. Back off RT handle fully.

24. Open test gas cyl. valve 1-2 turns.

25. Screw in RT handle slowly, in steps of 20% MAWP (90 psi), each time closing VT, and watching GT to see that stable pressures are achieved. Watch GT for 5 minutes minimum, each time. If leaks occur, back off pressure to 90 psig (20% MAWP) max. and inspect to find leak. See note on possible methods below fig. 17. Once found, back off RT fully, open test vent valve VV to depressurize fully, and fix leak. If no leaks occur, continue increasing pressure until 450 psi reads on GT. Record pressures on system gauges. Increase pressure to 563 psig. Hold for 5 minutes, if pressure is stable, then back off regulator fully, close test gas cyl. valve, and release system pressure through VV; otherwise depressurize and fix leak as above. Note that it may be possible to tell when 450 psig relief valve opens (GT needle will jump to a lower pressure), however this should not be regarded as accurate since 450 psig relief valve could leak during test.

26. Remove 591 psig relief valve from exhaust port of 450 psig relief valve.

27. Close VV, and progressively repressurize system until 450 psig relief valve exhausts, but not past 475 psig. Depressurize and vent pressure. Adjust relief valve if needed then repeat this step.

Test main pressure vessel (directly following 450 psig MAWP subsystem) as follows:

28. Open valves V11, V12, V13. Leave V4-V5 open. Close valves V6-V9, V10, V14, V15. Leave valves V3, V16, V17 closed.

29. Back off RT knob fully.

30. Open test gas cyl. valve 1-2 turns.

31. Screw in test regulator slowly, in steps of 20% MAWP (70 psi, 50 psi initial), each time closing VT, and watching GT, to see that stable pressures are achieved. Watch GT for 5 minutes minimum, each time. If leaks occur, back off pressure to 50 psig (20% MAWP) max. and inspect to find leak. See note on possible methods below fig. 17. Once found, back off RT fully, open VV to depressurize fully, and fix leak. If no leaks occur, continue increasing pressure until 350 psig (250 initial) reads on GT. Record pressures on system gauges. If gas system pressure gauge (P3) cannot read higher than 438 (313 initial) psi, then hold for 5 minutes, then back off regulator, close test gas cyl. valve, and release system pressure. Remove P3, plug and

repressurize to 438 psig (313 initial) as above. Hold for 5 minutes, if stable, then back off regulator, close test gas cyl. valve and release system pressure; otherwise depressurize and fix leak as above. Replace gas system gauge, if removed. Note that it may be possible to tell when 350 (250 initial) psig relief valve opens (GT needle will jump to a lower pressure), however this should not be regarded as accurate, since 350 (250 initial) psig relief valve could leak during test.

32. Remove 460 psig (329 initial) psig relief valve from exhaust port of 350 (250 initial) psig relief valve.

33. Close VV, and progressively repressurize system until 350 (250 initial) psig relief valve exhausts, but not past 380 (275 initial) psig. Depressurize and vent pressure. Adjust relief valve if needed and repeat test.

34. Remove hose from T1, replace plug.

35. Start the backing pump and convectron gauge controller, Slowly open V3. When the convectron gauge reads < 1e-2 torr, close V3, and turn off backing pump and convectron gauge controller. Close V3.

36. Attach pressure test tags to pressure relief valves. These are found in Appendix D of PUB3000. File pressure test report (also in Appendix D) with Regulator Shop.

Leak checking may be performed at full MAWP after successful pressure testing. No tightening of flange bolts or other repair is allowable when under pressure.

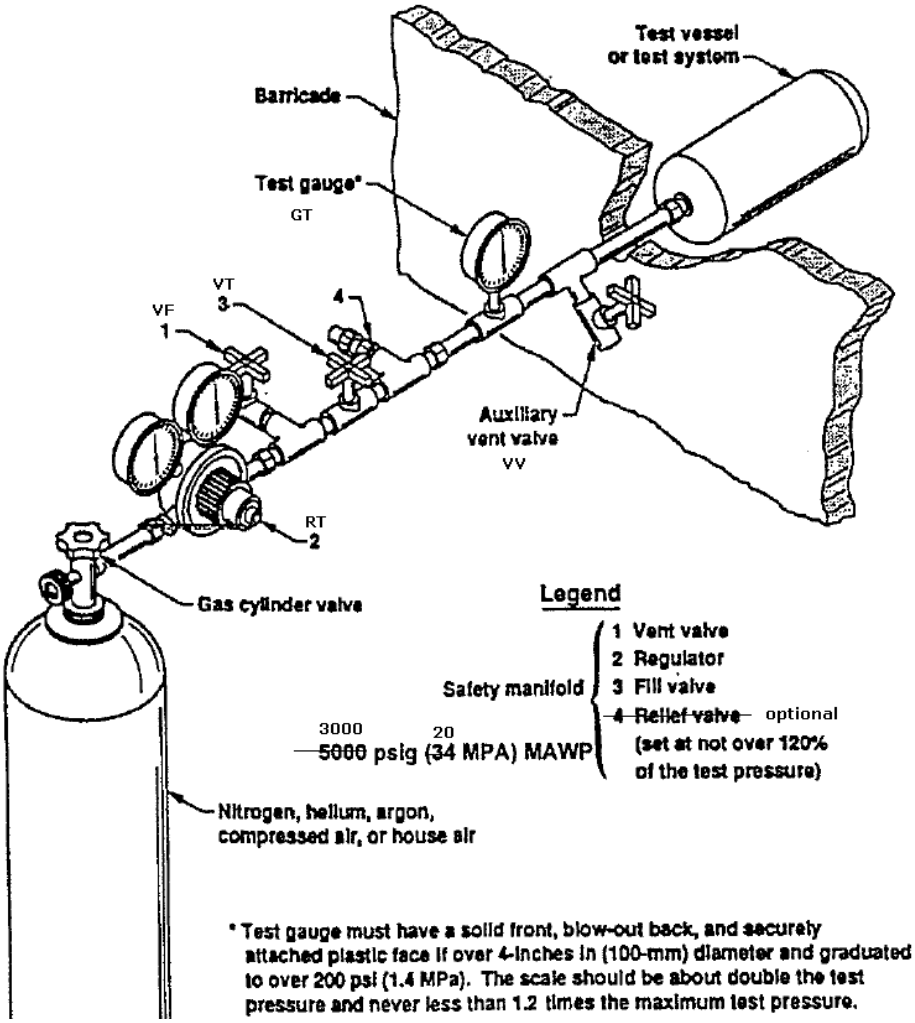

Fig. 17 Pressure Test Set up (Pneumatic, in-situ)

Leak Detection Methods for Pressure Leaks (not Vacuum):

Leak checking may be performed at full MAWP after successful pressure testing. Prior to pressure testing. leak checking may be performed up 20% MAWP

Methods (not conclusive):

1. SNOOP - this is essentially soapy water; NOT PREFERABLE, as it may be pulled into vacuum. If used, clean area throughly with DI water afterwards before pulling vacuum.

2. Helium Leak Testing (sniffer) - DO NOT USE, glass in PMT's are very permeable to He, which will then ruin them.

3. Hydrogen Leak Testing (sniffer) - PREFERABLE, uses 5% H2/95% N2 nonflammable mix test gas. Sniff as with He using appropriate equipment.

4. Gas Bag - PREFERABLE, Wrap plastic bag material very loosely around suspect joint and seal tightly; watch for inflation.

10. Appendix

to be added->Pressure Test Reports for Vac. Valve, Spool, Octagon, Source Tube, Gas System