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

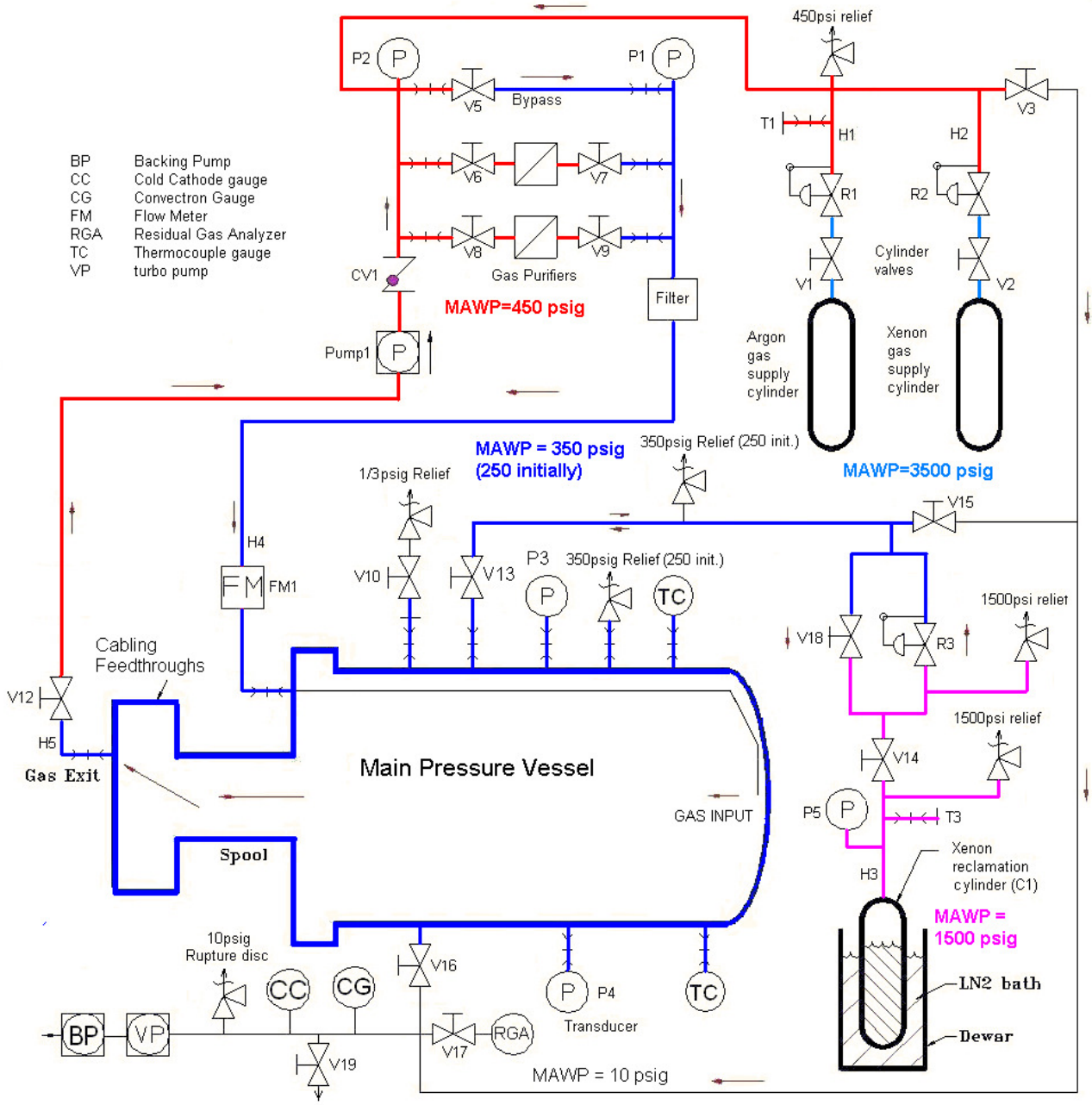

Fig. 15. Gas system (same as fig. 5)

~~Operation~~ **Description**:

This TPC (Time Projection Chamber) gas system is designed to circulate ~~purified~~ Xenon gas, through the pressure vessel and a purifier system at various pressures up to 300psig MOP (225 psig MOP initially with Ceramtec SHV-20 feedthroughs installed). It also includes a cryogenic Xenon reclamation section, as described previously. The AHD will initially specify only an 250psig MAWP (225psig MOP) with these feedthroughs, then it will be updated to the higher pressure MAWP (= 350 psig) only when these feedthroughs are replaced with higher pressure rated feedthroughs.

The gas system can be divided into 5 subsections, each having different MAWPs:

1.Gas supply subsystem MAWP =3500 psig (or gas cyl burst disk pressure)

2.Vacuum subsystem MAWP= 10 psig.

3.Pressure vessel and purifier downstream subsection,MAWP as above

4.Purifier upstream subsection; this MAWP is set 100 psi higher than the pressure vessel since Pump1 can deliver 130 psi maximum differential pressure if downstream flow is blocked; we desire not to vent Xenon gas should this occur (pump operated erroneously with [V3+V5+(V6 or V7)+(V8 or V9)] all closed.

5. Reclamation subsystem, MAWP =1500 psig

Operations

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. Note that there is no V4 or V11 ; these valves were present in an earlier draft configuration and have been removed. Valves have not been renumbered to avoid confusion.

1. Complete system pump-down

a. Close V1, V2 and V10. Open R1, ~~and~~ R2, and R3 one turn each.
b. Open V5, V13-V16, V18. DO NOT open V6-V9.
c. **V1 V2 ~~V3~~** V5 **V6 V7 V8 V9 V10 ~~V11~~ V12** V13 V14 V15 V16 **V17 V18 V19**
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, V13-~~V17~~V18. Back off R1 ~~and~~ R2, and R3.
i. Turn off pumps and controllers.
j. **V1 V2 V3**- V5 **V6 V7 V8 V9 V10** V12 **V13 V14 V15 V16 V17 V18 V19**
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, and R3 one turn each.
b. Open V5, V12-V13, V16, V18. DO NOT open V6-V9.
c. **V1 V2 V3 ~~V4~~** V5 **V6 V7 V8 V9 V10 ~~V11~~ V12** V13 **V14 V15** V16 **V17** V18 **V19**
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, V13, V16 and V17. Back off R1 and R2.
i. Turn off pumps and controllers.
j. **V1 V2 V3** V5 **V6 V7 V8 V9 V10** V12 **V13 V14 V15 V16 V17 V18 V19**
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 V18 V19**
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 V12 V13 V14 V15 V16 V17 V18 V19**
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 V18 V19**
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 V18 V19**
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 V18 V19**
b. Back off R2. Open V2 and V12.
c. Open V13, V14, and V18. Check that V10 is closed. Check that V5 is open.
d. Slowly 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 to next step.
h. Slowly 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. Slowly set R2 to 50 psig.
~~n. Open V4~~ Check P5 is based out.
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 and V18. Stop chilling C1.
s. **V1 V2 V3 ~~V4~~** V5 **V6 V7 V8 V9 V10** ~~V11~~ V12 **V13 V14 V15 V16 V17 V18 V19**
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 V18 V19**
~~b. Close V11~~
b. Back off R3. Check that V18 is closed. 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); turn off C1 heat.
~~e. Close V4.~~
f. Open V13.
g. Open ~~V6, V8~~ V5.
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~~** V5 **V6 V7 V8 V9 V10** ~~V11~~ V12 **V13 V14 V15 V16 V17 V18 V19**

7. TPC operation

a. **V1 V2 V3** ~~**V4 V5**~~ V5 **V6 V7 V8 V9 V10** ~~V11~~ V12 **V13 V14 V15 V16 V17 V18 V19**

~~b. Open V6,V7 or V8,V9 and V11~~

d. Start pump1; set to desired flow rate

b. Open V6,V7 or V8,V9 ~~and V11~~ as needed to control flow and purification (usually close V5 but may be left open)

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 V18 V19** (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 V18 V19**(V8,V9 may be open instead of V6,V7)

b. Stop pump1

c. Close V6-V9, ~~as required..~~Open V5.

d. Stop data logger.

e. **V1 V2 V3** ~~**V4**~~ V5 **V6 V7 V8 V9 V10** ~~V11~~ V12 **V13 V14 V15 V16 V17 V18 V19**

9. Cryogenic Xenon reclamation from TPC

a. **V1 V2 V3** ~~**V4 V5**~~ V5 **V6 V7 V8 V9 V10** ~~V11~~ V12 **V13 V14 V15 V16 V17 V18 V19**

b. Open ~~V5,~~ V13, V14, V18. ~~Close V12.~~ Check V5 and V12 are open. Check R3 is fully backed off.

c. Chill C1 with LN.

d. Once P4 bases out, operate Pump1 (to rattle piston valves, hopefully releasing gas trapped between Pump1 and CV1); check for pressure spike; allow to base out. ~~Close V13.~~

e. Close V13, V14, V18.

f. **V1 V2 V3** ~~**V4**~~ V5 **V6 V7 V8 V9 V10** ~~V11~~ V12 ~~**V12**~~ **V13 V14 V15 V16 V17 V18 V19**

10. Let-up TPC to Argon

a. **V1 V2 V3** ~~**V4**~~ V5 **V6 V7 V8 V9 V10** ~~V11~~ V12 ~~**V12**~~ **V13 V14 V15 V16 V17 V18 V19**

b. Back off R1. Open V1.

c. ~~Set~~ Slowly open R1 to ~~15~~ 2 psig.

~~e. Open V4.~~

d. When P3 >~~0~~ 2 psig, close V1. Back off R1 until desired purge gas flow is achieved.

f. Open V10. Leave open during service

~~g. Once the 5 1/3 psi relief is closed, close V10, V11~~

h. Proceed with service or disassembly of TPC. When removing lid, leave 1 main flange bolt loosely in place until lid is fully separated from vessel, and any residual pressure is vented.

i. **V1 V2 V3** ~~**V4**~~ V5 **V6 V7 V8 V9** ~~**V10**~~ V10 ~~**V11**~~ **V12 V13 V14 V15 V16 V17 V18 V19**

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 V18 V19**

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 V18 V19**

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 V18 V19**

~~b. Make certain V2 is closed. Back off R2.~~

b. Make certain V2 is closed. Back off R2.
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 V18 V19**

13. Reclamation of Xenon back into Xenon gas supply cylinder (at end of experiment, or to repair or reconfigure reclamation gas subsystem; assume entire system is filled with Xe and reclamation cyl. C1 is not isolatable)
a. **V1 V2 V3** V5 **V6 V7 V8 V9 V10** V12 **V13 V14 V15 V16 V17 V18 V19**
b. Back off R2. Open V2. Check that V5 and V12 are open.
c. Chill Xe supply cyl. with LN until P3, P4 and R2 high side bases out. Maintain LN temp.
d. Open V13, V18 , and V14. Wait until P3, P4 and R2 high side base out. Maintain LN temp.
e. Start Pump1 (to rattle piston valves, hopefully releasing gas trapped between Pump1 and CV1).
f. Close V2, V5, V12, V13, V18, V14. Plug high side of R2.
g. Back off and disconnect R2 from Xe cylinder.
h. **V1 V3 V5 V6 V7 V8 V9 V10 V12 V13 V14 V15 V16 V17 V18 V19**

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)

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

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

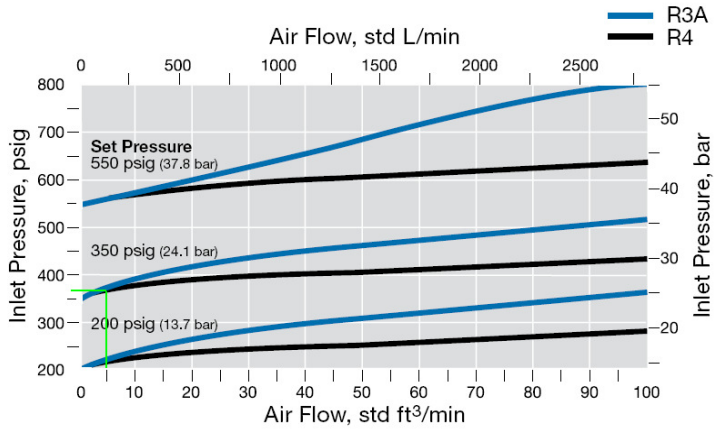

Fig 16. Pressure Relief Pressure Drop

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