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). ~~This test will be done with pressure vessel set to an MAWP of 350 psig (250 initial).~~ Testing is to be performed by a Certified Pressure Installer, and witnessed by the ~~Responsible Designer~~ 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 ~~5~~ 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 ~~438~~ 460 psig (~~313~~ 329 initial), ~~563~~ 591 psig, and ~~1875~~ 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 ~~438~~ 460 psig (~~313~~ 329 initial), ~~563~~ 591 psig, and ~~1875~~ 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 ~~1875~~ 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 ~~563~~ 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 ~~438~~ 460 ~~psig~~ (~~313~~ 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.

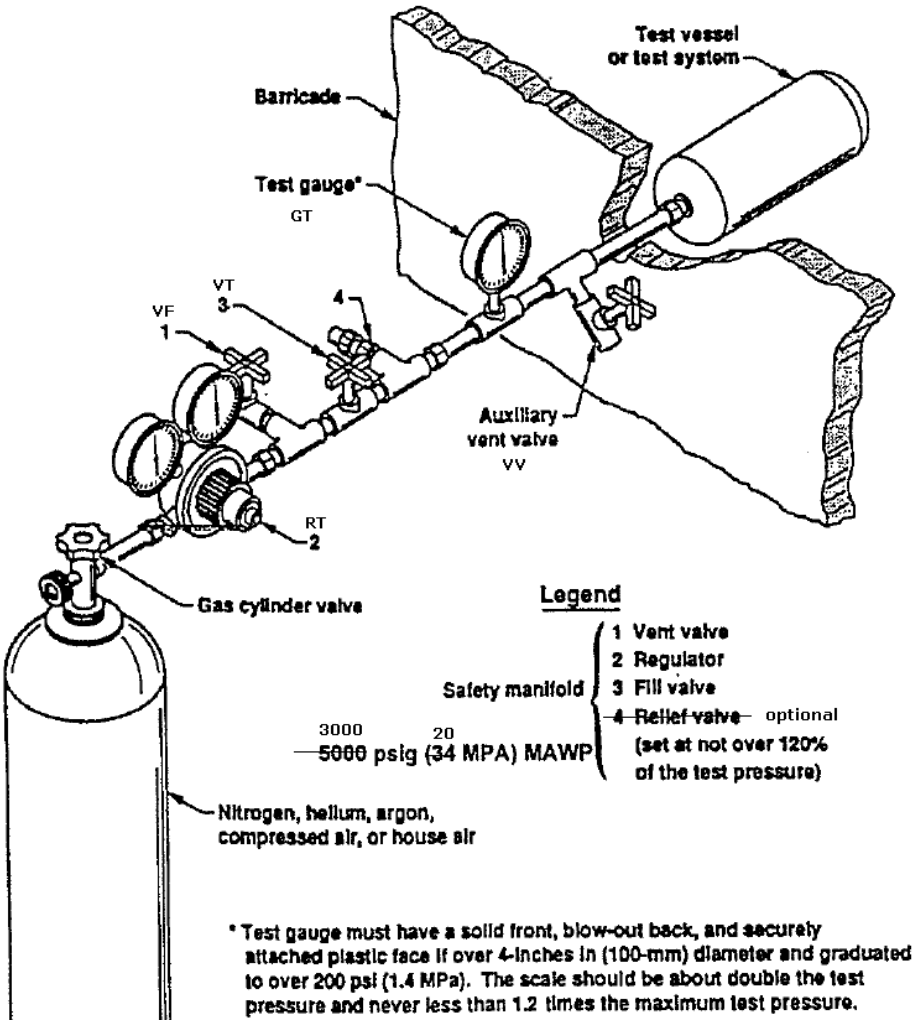

Fig. 17 Pressure Test Set up (Pneumatic, in-situ)

Leak Detection Methods for Pressure Leaks (not Vacuum):

Leak checking may be performed at full MAWP after successful pressure testing. Prior to tersting 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