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 (MAWP=350 psig/250 psig initially) ,
b. 563 psig for the gas purifier and supply section (MAWP=450 psig), and
c. 1875 psig for the cryogenic reclamation section (MAWP=1500 psig).

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. 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.

Prepare for test as follows (initial each step)**:**

1. Procure:

a. Two full gas cylinders, size 200 SCFM or more of clean Ar, N2, CO2, or dry air with supply pressure 2200 psig min.

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. 30-35 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 (1.05x T.P. = 460 psig (329 initial), 591 psig, and 1968 psig), 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 33% of test pressure. See step 3 below for explanation.

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 1875 psig test pressure, test isolation valve(TV), vent valve(VV), and 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 (see step 3 below for more explanation), 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. Note that this is permissible only because the system pressure relief vaves used, (Swagelok R3, R4 high pressure) are designed to be insensitive to back pressure; other types of pressure relief valves can be sensitive to back pressure and must be plugged while a separate test pressure relief valve installed as shown on fig. 17 (not optional).

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 and V18 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, V18 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 handle; 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. Close V18. Back off R3 handle fully. Check that V14 is open. Check that V13 is closed. Leave V15 closed.

11. Back off RT handle fully.

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

13. Screw in RT handle slowly, in steps in steps of 33% MAWP (500 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 (stepwise, as above) until 1500 psig reads on test gauge. Watch GT closely while increasing pressure to note when 1500 psig relief valves open; pressure should drop slightly for each one. If this is not observed, 1500 psig relief valve(s) may be leaking, or not opening properly, and step 15 below must be performed. 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.

14. Remove 1968 psig relief valves from exhaust ports of 1500 psig relief valves.

15.(not necessary if both P.R valve openings observed in step 13). 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. Check that entire system is depressurized.

18. Close valves V1-V9, 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 V6, V8 Check that valves V3, V5, V7,V9, 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 33% MAWP (150 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 (stepwise, as above) until 450 psi reads on GT. Watch GT closely while increasing pressure to note when 450 psig relief valve opens; pressure should drop slightly. If this is not observed, 450 psig relief valve may be leaking, or not opening properly, and step 27 below must be performed. 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.

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

27. (not necessary if P.R valve opening observed in step 25). 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 V5, V12, V13. Close valves V6, V8, V10, V14, V15, V18. Leave valves V3, V16, V17 closed. Back off R3 handle fully.

29. Back off RT handle fully.

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

31. Screw in test regulator slowly, in steps of 33% MAWP (115 psi, 85 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 (stepwise, as above) until 350 psig (250 initial) reads on GT. Watch GT closely while increasing pressure to note when 350 (250 initial) psig relief valves open; pressure should drop slightly for each one. If this is not observed, 350 psig (250 initial) relief valve(s) may be leaking or not opening properly, and steps 33-35 below must be performed. 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 P3, if removed.

32. Remove 460 psig (329 initial) psig relief valve from exhaust port of 350 (250 initial) psig relief valve located between V13 and V15.

33. (not necessary if both P.R valve openings observed in step 31). Close VV, and progressively repressurize system until 350 (250 initial) psig relief valve located between V13 and V15 exhausts, but not past 380 (275 initial) psig. Depressurize and vent pressure. Adjust relief valve if needed and repeat test.

34. Close V13, and remove 460 psig (329 initial) psig relief valve from exhaust port of 350 (250 initial) psig relief valve located on main pressure vessel.

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

36. Remove hose from T1, replace plug.

37. 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.

38. 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.

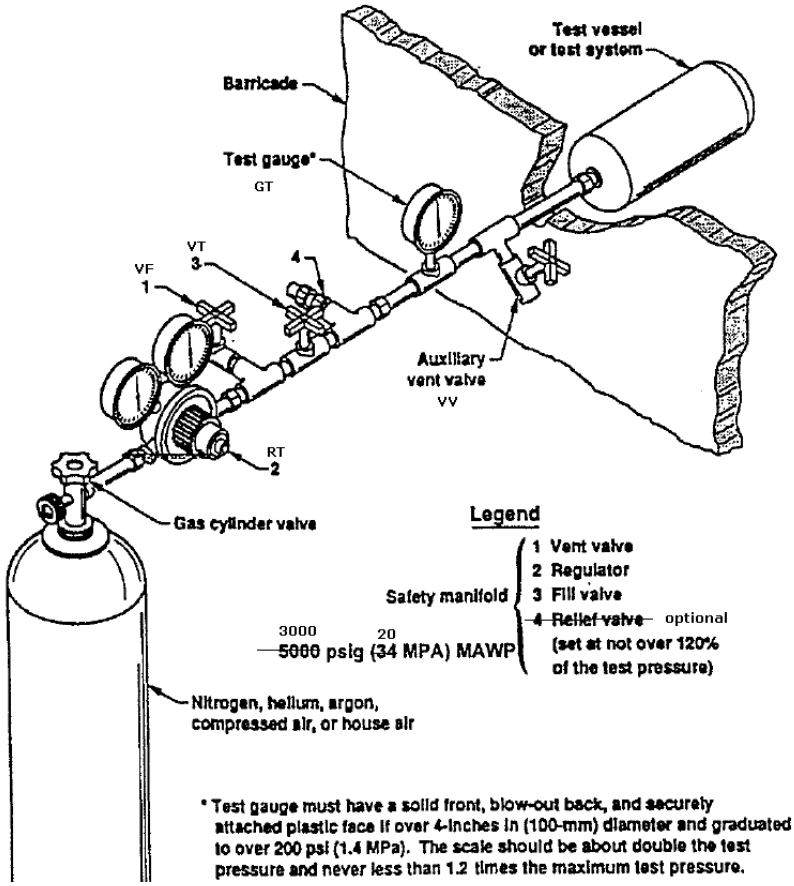

Fig. 17 Pressure Test Set up (Pneumatic, in-situ)

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.

5. LACO Technologies Gas Check 3000 (P/N LHHLD-G3), leak detector - PREFERABLE, which can sniff for a variety of different gasses based on differential thermal conductivity (to air).

10. Appendix