

configuration, along with the gas system test at a test pressure of $1.25 \times \text{MAWP} = 438 \text{ psig}$ (313 initial), as described below:

9.6 Final assembled system pressure check

Completed gas system, including pressure vessel, shall be pneumatically tested 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. 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 on 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, at a minimum.

Test as follows:

1. Procure:
 - a. Gas cylinder 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% accuracy. Gauge maximum scale pressure should not be less than $1.2 \times$ or more than $4 \times$ 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 set to 438 psig (313 initial), 563 psig, and 1875 psig (using calibrated gauge), to fit exhaust ports of 350 psig (250 initial), 450 psig, and 1500 psig relief valves.
 - 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. Survey for, and remove any hazardous material (such as radioactive sources, flammable liquids, glassware, etc.) from line of sight to test area. Have fire extinguishers on hand. 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 psig (313 initial), 563 psig, and 1875 psig relief valves into exhaust ports of 350 psig (250 initial), 450 psig, and 1500 psig relief valves, respectively.
4. Check that gas system is fully depressurized (open V4 if closed).
5. 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).
6. Test 1500 psig MAWP subsystem as follows:
 7. Close V13, V15. Open V14. 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 $< 1 \times 10^{-2}$ torr, close V15, and turn off backing pump and convectron gauge controller. Close V15.
 10. Check that V14 is open. Check that ~~V3~~, V13 are 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, however this should not be regarded as accurate since 1500 psig relief valve could leak during test.
 14. Remove 1875 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.
17. ~~We start by testing~~ Test 450 psig MAWP subsystem as follows:
18. Open V4, then check that entire system is depressurized.
19. Close valves V1-V9, V11, V12, V15, V16, V17. Back off R1, R2.
20. Remove T1 plug and install hose end.
21. Start the backing pump and convectron gauge controller, Slowly open V3. When the convectron gauge reads $< 1 \times 10^{-2}$ torr, close V3, and turn off backing pump and convectron gauge controller.
22. Check that installed test gauge, GT, and regulator, RT, are for 563 psig test pressure.
23. Open valves V4-V9. Close valve V3. Check valves V11, V12, V16, V17 are closed.
24. Back off RT handle fully.
25. Open test gas cyl. valve 1-2 turns.
26. 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, however this should not be regarded as accurate since 450 psig relief valve could leak during test.
27. Remove 563 psig relief valve from exhaust port of 450 psig relief valve.
28. 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.
29. Proceed directly to test main pressure vessel as follows:
30. Open valves V11, V12, V13. Leave V4-V5 open. Close valves V6-V9, V10, V14, V15. Leave valves V3, V16, V17 closed.
31. Back off RT knob fully.
32. Open test gas cyl. valve 1-2 turns.
33. 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, however this should not be regarded as accurate, since 350 (250 initial) psig relief valve could leak during test.
34. Remove 438 (313 initial) psig relief valve from exhaust port of 350 (250 initial) psig relief valve.
35. 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.
36. Remove hose from T1, replace plug.
37. Start the backing pump and convectron gauge controller, Slowly open V3. When the convectron gauge reads $< 1 \times 10^{-2}$ 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.

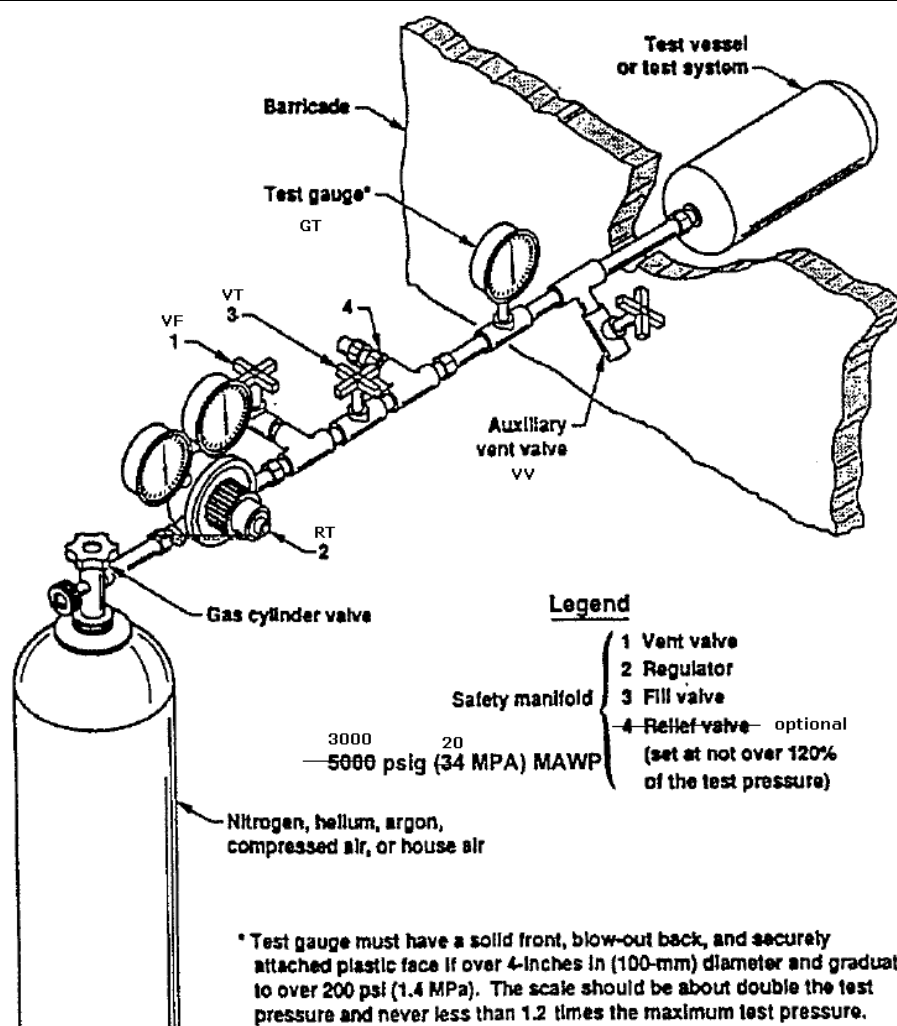


Fig. 17 Pressure Test Set up (Pneumatic, in-situ)

Leak Detection Methods for Pressure Leaks (not Vacuum):

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

Main Pressure Vessel Pressure Tests (LLNL).....	35
Main Pressure Vessel Design Safety Note MESN-99-020-OA (LLNL).....	47
Gas Delivery System and Reclamation Cylinder Safety Note MESN99-38--OA (LLNL).....	186
LLNL Note (END92-072-OA) on use of CF flanges for pressure Applications.....	249
ANL Note on Tightening of CF flanges for Pressure Use.....	264
Pressure Test Report for Spool.....	272
to be added->Pressure Test Reports for Vac. Valve, Spool, Octagon, Source Tube, Gas System	