Relief Valve Test Panel: Pressure Test

T. Schaus, 6/22/92

As noted in the ASME Boiler and Pressure Vessel Code (section VIII, U-1(c)), 'Vessels having an inside diameter, width, height, or cross section diagonal not exceeding 6 in. .... are not considered to be within the scope [of the pressure vessel division].' All of the pressurized equipment in the Relief Valve Test Panel has an inside diameter of 6 inches or less, including the two volume chambers, and therefore falls under the Fermilab ES&H 'Pressure Piping Systems' standard (chapter 5031.1). Following this standard, 'All pressure piping systems shall be pressure tested as described per Fermilab ES&H manual chapter 5034.' Thus, the Relief Valve Test Panel will be tested in this manner. Although hydrostatic testing is safer, a pneumatic test will be performed since the system is not easily dried.

A Pressure Testing Permit was thus obtained (copy at rear) and the system reviewed by the division/section safety officer. The system is divided into a low pressure (0-100 psig) section, a high pressure (0-500/0-2000 psig) section, and a section between the source bottle and the three regulators. Each shall be tested separately as per ASME section VIII, UG-100. This requires a test pressure at least equal to '1.25 times the maximum allowable working pressure .... multiplied by the lowest ratio .... of the stress value S ....' Refer to drawing # MD-194470, 'Piping, Valve & Instrument List' (located in rear), and the testing procedure outlined below.

A. <u>Pre-regulator Section Test</u>

1. Close the manual valve on the source bottle if it is in place.
2. Relieve all pressure in the braided flex line:
   i. Close MV-104 and 105.
   ii. Open MV-103 and, if applicable, the manual valve on the end of the vent line (outside the portakamp).
   iii. Opening RV-127 as much as necessary to relieve the pressure.
3. Close RV-125, 126, and 127 to isolate the high and low pressure sections.
4. Cap relief valve SV-128.
5. Remove the source bottle from the system by detaching the flex line at the bottle.
6. As diagrammed in Fig. 1, attach the testing apparatus to the braided flex line.
7. During most of the test, all personnel shall leave the room but may stand as close as outside the next door. Following UG-100:
   i. Determine the test pressure:
      Test Press. = 1.25(MAWP)(S)
      = 1.25(2300)(1) = 2875 psig
   ii. Close vent MV-204 on the testing apparatus.
   iii. Turn on the compressor and let ~~it run momentarily.~~ 5 MIN
   iv. Using regulator RV-201, gradually increase the test pressure until one half of the test pressure is reached:
      0.5(T.P.) = 0.5(2875) = 1438 psig
   v. The pressure should now be increased by steps of one tenth of the test pressure until the test pressure is reached:
      0.1(T.P.) = 0.1(2875) = 288 psig
   vi. The test pressure shall be held for five minutes. The pressure will then be reduced to four fifths of the test pressure (through RV-201), at which time personnel may again enter the room.
      0.8(T.P.) = 0.8(2875) = 2300 psig
   vii. At the reduced pressure, leak test all seams, welds, and connections with soapy water (Snoop).

Also vent 114

viii. If a leak is suspected, reduce the pressure to one half of the current pressure while the leak is pinpointed, and depressurize all lines before repairs are attempted.
ix. When the inspection is complete, shut off the compressor and close the regulator, thereby slowly relieving the pressure. If necessary, use MV-204 to speed the release of air.
x. Refer to the Fermilab ES&H manual chapter 5034TA p. 1-2 and ASME UG-100 for further guidelines.

B. Low Pressure Test

1. Close the manual valve on the source bottle. Relieve all pressure in the system by opening valves MV-110, MV-111, and MV-112. Also, open regulator RV-125 fully in order to vent the braided flex line. If a temporary valve has been installed on the vent line (outside the portakamp), open it.
2. Close both high pressure regulators RV-126 and 127 and MV-103 in order to isolate the high pressure system.
3. If this step wasn't done previously, attach a manual valve to the venting pipe outside the portakamp. Close this valve.
4. Cap relief valves SV-122 and 123.
5. Cap the relief valve test opening in volume chamber B (located on top of the volume chamber).
6. Close valves MV-107, 108, 109, and 114.
7. Open valve MV-113. Valves MV-110, 111, and 112 should still be open, as should regulator RV-125 so as not to restrict the test pressure (RV-125 is actually a 0-750 psig regulator, not 0-100 psig, so the open regulator will not alter the pressure).
8. Connect the testing apparatus (see Fig. 1) to the braided flex line.
9. During most of the test, all personnel shall leave the room but may stand as close as outside the next door. Following UG-100:
   i. Determine the test pressure:
      Test Press. = 1.25(MAWP)(S)
      = 1.25(103)(1) = 129 psig
   ii. Close vent MV-304 on the testing apparatus.
   iii. Turn on the compressor and ~~let it run~~ momentarily.
   iv. Using regulator RV-301, gradually increase the pressure to one half of the test pressure:
      0.5(T.P.) = 0.5(129) = 65 psig
   v. The pressure should now be increased by steps of one tenth of the test pressure until the test pressure is reached:
      0.1(T.P.) = 0.1(129) = 13 psig
   vi. The test pressure shall be held for five minutes. The pressure will then be reduced to four fifths of the test pressure (through RV-301), at which time personnel may again enter the room.
      0.8(T.P.) = 0.8(129) = 103 psig
   vii. At the reduced pressure, leak test all seams, welds, and connections of fittings with soapy water (Snoop).
   viii. If a leak is suspected, reduce the pressure to one half of the current pressure while the leak is pinpointed, and depressurize all lines before repairs are attempted.
   ix. When the inspection is complete, shut off the compressor and close the regulator, thereby slowly relieving the pressure. If necessary, use MV-304 to speed the release of air.
   x. Refer to the Fermilab ES&H manual chapter 5034TA p. 1-2 and ASME UG-100 for further guidelines.

B. High Pressure Test

1. Close the manual valve on the source bottle. Relieve all pressure in the system by opening valves MV-103, 104, 105, and 106, along with regulator RV-127 (just enough to relieve the pressure in the braided flex line). If a manual valve was installed on the vent line outside the portakamp, open it.
2. If this step wasn't done previously, attach a manual valve to the venting pipe on the end outside the portakamp. Close this valve.
4. Remove the 0-500 psig gauge (PI-116) and cap the line. The pressure in this test will run over 500 psig and may damage this gauge otherwise.
5. Remove the high pressure regulators RV-126 and 127 and cap the output lines on both regulators. Removal is necessary because the test pressure will exceed the maximum output pressures of both regulators.
6. Cap relief valves SV-121 and 124.
8. Cap the relief valve test opening in volume chamber A (located on top of the volume chamber).
9. Check to make sure MV-103, 104, 105, and 106 are still open.
11. Connect the test apparatus to MV-115 and open MV-115.
12. During most of the test, all personnel shall leave the room but may stand as close as outside the next door. Following UG-100:
    i. Determine the test pressure:
        Test Press. = 1.25(MAWP)(S)
        = 1.25(1950)(1) = 2438 psig
    ii. Close vent MV-404 on the testing apparatus.
    iii. Turn on the compressor and let it run momentarily.
    iv. Using regulator RV-401, gradually increase the test pressure until one half of the test pressure is reached:
        0.5(T.P.) = 0.5(2438) = 1219 psig
    v. The pressure should now be increased by steps of one tenth of the test pressure until the test pressure is reached:
        0.1(T.P.) = 0.1(2438) = 244 psig
    vi. The test pressure shall be held for five minutes. The pressure will then be reduced to four fifths of the test pressure (through RV-401), at which time personnel may again enter the room.
        0.8(T.P.) = 0.8(2438) = 1950 psig
    vii. At the reduced pressure, leak test all seams, welds, and connections with soapy water (Snoop).
    viii. If a leak is suspected, reduce the pressure to one half of the current pressure while the leak is pinpointed, and depressurize all lines before repairs are attempted.
    ix. When the inspection is complete, shut off the compressor and close the regulator, thereby slowly relieving the pressure. If necessary, use MV-404 to speed the release of air.
    x. Refer to the Fermilab ES&H manual chapter 5034TA p. 1-2 and ASME UG-100 for further guidelines.

Upon completion of this test, a report on our findings will be written. Reports "Relief Valve Sizing," "Pressure Test," and "Pressure test results" will be filed in the ES&H Section Pressure Vessel Master File (MS 119) and a copy kept by the RD/Cryo division.

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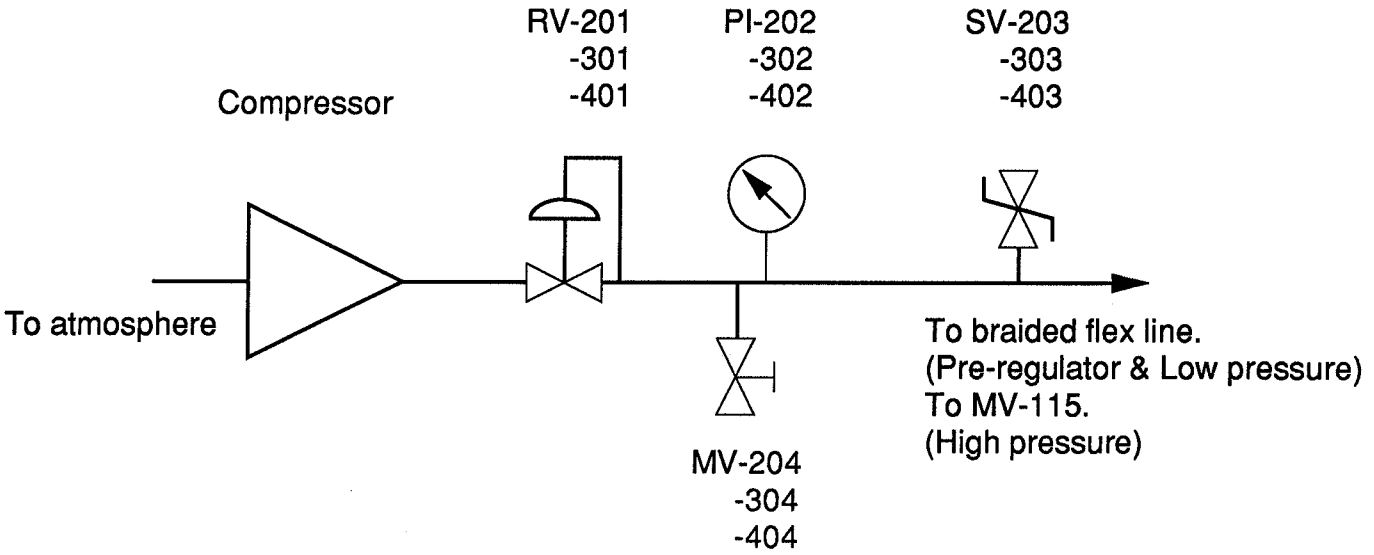

Fig. 1 TEST APPARATUS

SYSTEM	RV	PI	SV	MV
Pre-regulator	201	202	203	204
	(0-3000 psig)	(0-4500 psig)	(C.P. = 3000 psig)	(MAWP > 3000 psig)
Low Pressure	301	302	303	304
	(0-3000 psig)	(0-200 psig)	(C.P. = ~~140~~ 150 psig)	(MAWP > 200 psig)
High Pressure	401	402	403	404
	(0-3000 psig)	(0-4500 psig)	(C.P. = 2475 psig)	(MAWP > 2500 psig)

T.P.

2875 psig

129 psig

2438 psig

LESS THAN 110% TEST PRESSURE

Piping, Valve, and Instrumentation List

TAG NO.		DESCRIPTION	MFG.	CAT. #	MAWP	NOTES
CV	101	CHECK VALVE	CIRCLE SEAL	25TB-4PP-.15	3000 PSI	FROM VENT TO OUTSIDE
CV	102	CHECK VALVE	CIRCLE SEAL	25TB-4PP-.15	3000 PSI	FROM VENT TO OUTSIDE
MV	103	BALL VALVE	WHITEY	SS-45F8	2500 PSI	0-500/0-2000 VOL. CHAMBER VENT
MV	104	BALL VALVE	WHITEY	SS-45F8	2500 PSI	0-500 REGULATOR ISOLATION
MV	105	BALL VALVE	WHITEY	SS-45F8	2500 PSI	0-500 REGULATOR ISOLATION
MV	106	BALL VALVE	WHITEY	SS-45F8	2500 PSI	0-2000 REGULATOR ISOLATION
MV	107	BALL VALVE	WHITEY	SS-45F8	2500 PSI	LOW PRESSURE AUX. TEST
MV	108	BALL VALVE	WHITEY	SS-45F8	2500 PSI	VACUUM DEAD WEIGHT TEST
MV	109	BALL VALVE	WHITEY	SS-45F8	2500 PSI	MANIFOLD VACUUM
MV	110	BALL VALVE	WHITEY	SS-45F8	2500 PSI	DEAD WEIGHT TEST
MV	111	BALL VALVE	WHITEY	SS-45F8	2500 PSI	0-100 VOLUME CHAMBER FILL
MV	112	BALL VALVE	WHITEY	SS-45F8	2500 PSI	0-100 VOLUME CHAMBER VENT
MV	113	BALL VALVE	WHITEY	SS-45F8	2500 PSI	MANIFOLD INLET
MV	114	BALL VALVE	WHITEY	SS-44F6	2500 PSI	0-100 VOLUME CHAMBER VENT
MV	115	GLOBE VALVE	CIRCLE SEAL	MV-30T1-04P	3000 PSI	0-500/0-2000 VOLUME CHAMBER VENT
PI	116	0-500 GAUGE	HEISE	...	500 PSI	0-500 PRESSURE INDICATOR
PI	117	0-3000 GAUGE	HEISE	...	3000 PSI	0-2000 PRESSURE INDICATOR
PI	118	0-130 GAUGE	HEISE	...	130 PSI	0-100 PRESSURE INDICATOR
PI	119	0-30"HG GAUGE	ASHCROFT	...	30 IN. HG	VACUUM PRESSURE INDICATOR
PI	120	0-3000 GAUGE	HELICOID	...	3000 PSI	SUPPLY BOTTLE PRESSURE INDICATOR
SV	121	RELIEF VALVE	CIRCLE SEAL	5159-4MP	2500 PSI	C.P. = 450 PSI, MAX FLOW = 450 SCFM
SV	122	RELIEF VALVE	CIRCLE SEAL	5159-4MP	2500 PSI	C.P. = 103 PSI, MAX FLOW = 100 SCFM
SV	123	RELIEF VALVE	CIRCLE SEAL	5159-4MP	2500 PSI	C.P. = 110 PSI, MAX FLOW = 100 SCFM
SV	124	RELIEF VALVE	AND./GRNWD.	81MS44-4	4000	C.P. = 1950 PSI, MAX FLOW =
SV	128	RELIEF VALVE	CIRCLE SEAL	5159-4MP	2500 PSI	C.P. = 2300 PSI, MAX FLOW = 300 SCFM
RV	125	REGULATOR	GROVE	15LG	3000 PSI	0-750 PSI RANGE, 0-100 PSI CALIBRATION
RV	126	REGULATOR	GROVE	15L	3000 PSI	0-750 PSI RANGE, 0-500 PSI CALIBRATION
RV	127	REGULATOR	FAIRCHILD	8225-2000	6500 PSI	0-2000 PSI RANGE, 0-2000 PSI CALIBRATION
...	...	1/2" TUBING	...	...	3975 PSI	
...	...	3/8" TUBING	...	...	3768 PSI	
...	...	VOL CHAMBER	...	...	2500 PSI	VOL. = 396 CU. IN. = 1.71 GAL., 0-500/0-2000 CAL.
...	...	VOL CHAMBER	...	...	103 PSI	VOL. = 1260 CU. IN. = 5.458 GAL., 0-100 CALIBRATION
...	...	FLEX LINE	UNION CARB.	SG6451	3000 PSI	FROM AIR BOTTLE TO PANEL, BRAIDED

Fermilab

Date 4/19/92

EXHIBIT B

Pressure Testing Permit*

Type of Test: [ ] Hydrostatic [X] Pneumatic

Test Pressure: 129 psig Maximum Allowable Working Pressure: 103 psig

Items to be Tested 2 TESTS TO BE RUN: ONE EACH ON THE LOW (0-100 psig) & HIGH (0-500/0-2000 psig PRESSURE) SECTIONS OF THE RD/CRYO RELIEF VALVE TEST PANEL.

Location of Test LAB A, DOMOLECZNY'S OFFICE Date and Time _____

Hazards Involved BURSTING TUBING, ETC.

Safety Precautions Taken ALL PERSONNEL WILL STAND BEHIND PANEL, AWAY FROM PRESSURIZED TUBING. LONG PIECES OF TUBING & FLEX LINE WILL BE CHAINED DOWN AS NEEDED. SAFETY GLASSES, ETC.

Special Conditions or Requirements _____

Test Coordinator _____ Dept/Date _____

Division/Section Safety Officer _____ Dept/Date _____

Division/Section Head R. STANEK Dept/Date _____

Results _____

Witness _____ Dept/Date _____
(Safety Officer or Designee)

* Must be signed by division/section safety officer and division/section head prior to conducting test. It is the responsibility of the test coordinator to obtain signatures.

spection of the vessel required by (g) above be delayed until the temperature is reduced to 120°F or less.

CAUTION: A small liquid relief valve set to 1⅓ times the test pressure is recommended for the pressure test system, in case a vessel, while under test, is likely to be warmed up materially with personnel absent.

(i) Vents shall be provided at all high points of the vessel in the position in which it is to be tested to purge possible air pockets while the vessel is filling.

(j) Before applying pressure, the test equipment shall be examined to see that it is tight and that all low-pressure filling lines and other appurtenances that should not be subjected to the test pressure have been disconnected.

(k) The test pressure for enameled vessels shall be at least equal to, but need not exceed, the maximum allowable working pressure to be marked on the vessel.

(l) Vessels which are to be galvanized may be pressure-tested either before or after galvanizing.

(m) Homogeneously lead-lined vessels may be pressure tested before or after completion of all lead lining, including nozzles.

UG-100 PNEUMATIC TEST[34] (SEE UW-50)

A89 *(a)* Subject to the provisions of UG-99(a)(1) and (a)(2), a pneumatic test prescribed in this paragraph may be used in lieu of the standard hydrostatic test prescribed in UG-99 for vessels:

(1) that are so designed and/or supported that they cannot safely be filled with water;

(2) not readily dried, that are to be used in services where traces of the testing liquid cannot be tolerated and the parts of which have, where possible, been previously tested by hydrostatic pressure to the pressure required in UG-99.

A89 *(b)* Except for enameled vessels, for which the pneumatic test pressure shall be at least equal to, but need not exceed, the maximum allowable working pressure to be marked on the vessel, the pneumatic test pressure shall be at least equal to 1.25 times the maximum allowable working pressure to be stamped on the vessel multiplied by the lowest ratio (for the materials of which the vessel is constructed) of the stress value S for the test temperature of the vessel to the stress value S for the design temperature (see UG-21). In no case shall the pneumatic test pressure exceed 1.25 times the calculated test pressure as defined in 3-2.

(c) The metal temperature during pneumatic test shall be maintained at least 30°F above the minimum design metal temperature (see UG-20) to minimize the risk of brittle fracture.

(d) The pressure in the vessel shall be gradually increased to not more than one-half of the test pressure. Thereafter, the test pressure shall be increased in steps of approximately one-tenth of the test pressure until the required test pressure has been reached. Then the pressure shall be reduced to a value equal to four-fifths of the test pressure and held for a sufficient time to permit inspection of the vessel.

The visual inspection of the vessel at four-fifths of the required test pressure may be waived provided:

(1) a suitable gas leak test is applied;

(2) substitution of the gas leak test is by agreement reached between Manufacturer and Inspector;

(3) all welded seams which will be hidden by assembly be given a visual examination for workmanship prior to assembly;

(4) the vessel will not contain a "lethal" substance.

UG-101 PROOF TESTS TO ESTABLISH MAXIMUM ALLOWABLE WORKING PRESSURE

(a) General

(1) The maximum allowable working pressure for vessels or vessel parts for which the strength cannot be computed with a satisfactory assurance of accuracy (see U-2) shall be established in accordance with the requirements of this paragraph, using one of the test procedures applicable to the type of loading and to the material used in construction.

(2) Provision is made in these rules for two types of tests to determine the internal maximum allowable working pressure:

(a) tests based on yielding of the part to be tested. These tests are limited to materials with a ratio of minimum specified yield to minimum specified ultimate strength of 0.625 or less.

(b) tests based on bursting of the part.

(3) Safety of testing personnel should be given serious consideration when conducting proof tests, and particular care should be taken during bursting tests in (m) below.

[34] In some cases it is desirable to test vessels when partly filled with liquids. For such vessels a combined hydrostatic and pneumatic test may be used as an alternative to the pneumatic test of this paragraph, provided the liquid level is set so that the maximum stress including the stress produced by pneumatic pressure at any point in the vessel (usually near the bottom) or in the support attachments, does not exceed 1.5 times the allowable stress value of the material multiplied by the applicable joint efficiency. After setting the liquid level to meet this condition, the test is conducted as prescribed in (b) and (c) above.

Air or gas is hazardous when used as a testing medium. It is therefore recommended that special precautions be taken when air or gas is used for test purposes.

sel shall be established in accordance with the provisions of UG-101.

UG-20 DESIGN TEMPERATURE

A90 *(a) Maximum.* Except as required in UW-2(d)(3), the maximum temperature used in design shall be not less than the mean metal temperature (through the thickness) expected under operating conditions for the part considered (see 3-2). If necessary, the metal temperature shall be determined by computation or by measurement from equipment in service under equivalent operating conditions.

(b) Minimum. The minimum metal temperature used in design shall be the lowest expected in service except when lower temperatures are permitted by the rules of this Division (see UCS-66). The minimum mean metal temperature shall be determined by the principles described in (a) above. Consideration shall include the lowest operating temperature, operational upsets, autorefrigeration, atmospheric temperature, and any other sources of cooling [except as permitted in (f)(3) below].

(c) Design temperatures listed in excess of the maximum temperatures listed in the Tables of Subsection C are not permitted. In addition, design temperatures for vessels under external pressure shall not exceed the maximum temperatures given on the external pressure charts.

(d) The design of zones with different metal temperatures may be based on their determined temperatures.

(e) Suggested methods for obtaining the operating temperature of vessel walls in service are given in Appendix C.

(f) Impact testing per UG-84 is not mandatory for pressure vessel materials which satisfy all of the following.

A89 *(1)* The material shall be limited to P-No. 1, Gr. No. 1 or 2, and the thickness, as defined in UCS-66(a), shall not exceed that given in (a) or (b) below:

(a) ½ in. for materials listed in Curve A of Fig. UCS-66;

(b) 1 in. for materials listed in Curve B, C, or D of Fig. UCS-66.

(2) The completed vessel shall be hydrostatically tested per UG-99(b), (c), or (k).

(3) Design temperature is no warmer than 650°F nor colder than −20°F. Occasional operating temperatures colder than −20°F are acceptable when due to lower seasonal atmospheric temperature.

(4) The thermal or mechanical shock loadings are not a controlling design requirement. (See UG-22.)

(5) Cyclical loading is not a controlling design requirement. (See UG-22.)

UG-21 DESIGN PRESSURE[8] A90

Vessels covered by this Division of Section VIII shall be designed for at least the most severe condition of coincident pressure and temperature expected in normal operation. For this condition and for test conditions, the maximum difference in pressure between the inside and outside of a vessel, or between any two chambers of a combination unit, shall be considered [see UG-98, UG-99(e), and 3-2].

UG-22 LOADINGS

The loadings to be considered in designing a vessel shall include those from:

(a) internal or external design pressure (as defined in UG-21);

(b) weight of the vessel and normal contents under operating or test conditions (this includes additional pressure due to static head of liquids);

(c) superimposed static reactions from weight of attached equipment, such as motors, machinery, other vessels, piping, linings, and insulation;

(d) the attachment of:

(1) internals (see Appendix D);

(2) vessel supports, such as lugs, rings, skirts, saddles, and legs (see Appendix G);

(e) cyclic and dynamic reactions due to pressure or thermal variations, or from equipment mounted on a vessel, and mechanical loadings;

(f) wind, snow, and seismic reactions, where required;

(g) impact reactions such as those due to fluid shock;

(h) temperature gradients and differential thermal expansion.

UG-23 MAXIMUM ALLOWABLE STRESS VALUES[9]

(a) The maximum allowable stress value is the maximum unit stress permitted in a given material used in a vessel constructed under these rules. The maximum

[8]It is recommended that a suitable margin be provided above the pressure at which the vessel will be normally operated to allow for probable pressure surges in the vessel up to the setting of the pressure relieving devices (see UG-134).

[9]For the basis on which the tabulated stress values have been established, see Appendix P.

TECHNICAL APPENDIX TO PRESSURE VESSEL TESTING

Requirements for hydrostatic and pneumatic pressure vessel testing are as follows:

1. SAFETY PRECAUTIONS FOR PRESSURE TESTING

a) Hydrostatic testing is considerably safer than pneumatic testing and should be used whenever possible.

b) Testing should be done in an area set aside for the test with unnecessary persons kept away. This is especially important in pneumatic testing. All pressurized components shall be secured to prevent them from becoming missiles or whipping assemblies. Signs, lights, fences and barriers should be employed as needed to limit unauthorized access.

c) The vessel support system shall be evaluated to ensure that vessel buckling will not occur during the hydrostatic test. The floor loading conditions also should be evaluated so as to safely transfer the vessel's weight and contents to the floor slab and the supporting grade.

d) Prior to testing, the division/section safety officer or designee shall inspect the system to assure it conforms to the system layout drawing and that all appropriate safety precautions have been taken.

2. EQUIPMENT AND MATERIALS

a) The pressure test medium shall be inert. For hydrostatic testing, a nonhazardous liquid such as water shall be used at temperatures below 90°F and over 50°F to aid in avoiding condensation on the tank during the test. For pneumatic testing, an inert gas such as nitrogen or clean air (less than 50% RH) shall be used.

b) Pressure test gauges should be of the liquid filled type, and shall have a full scale range of 1.5 to 4.0 times the intended maximum test pressure and be calibrated prior to each use. The gauge is to be accurate to within 4%. The gauge shall be connected directly to the vessel and shall be visible to the operator throughout the duration of the test.

c) For hydrostatic tests, vents shall be provided at high points of the vessel in its test position to purge gas pockets during filling. A drain line with a valve capable of withstanding the test pressure shall be in place prior to filling the vessel. The manually operated valve shall be secured to a fitting at the lowest point of the vessel (flanged or threaded) and the drain line is to be connected to the outlet side of the valve.

d) The pressure source shall have a relief valve of proper capacity and a set cracking pressure not greater than 110% of the maximum test pressure or the test pressure