proj: **NEXT-100 XENON TPC**
Energy Plane, Tooling
title: **Pressure Safety Note, Pressure Test Chamber**

revision history:
A - no revision, initial release

Prepared by:_____
Responsible Designer - Derek Shuman

Reviewed by:_____
EH&S Pressure Safety Subject Matter Expert - Scott Robinson

Approved by:_____
Engineering Division Director - Kem Robinson or Designee (Ken Chow)

This is an Engineering Safety Note for a small pressure vessel to be used for gas pressure testing prototype photomultiplier tube (PMT) enclosures for the NEXT-100 Xenon Time Projection Chamber (TPC). The PMT enclosures operate under external xenon gas pressure of 15 bara. It may also be used for other, similar purposes, such as to test gas permeation into various materials.

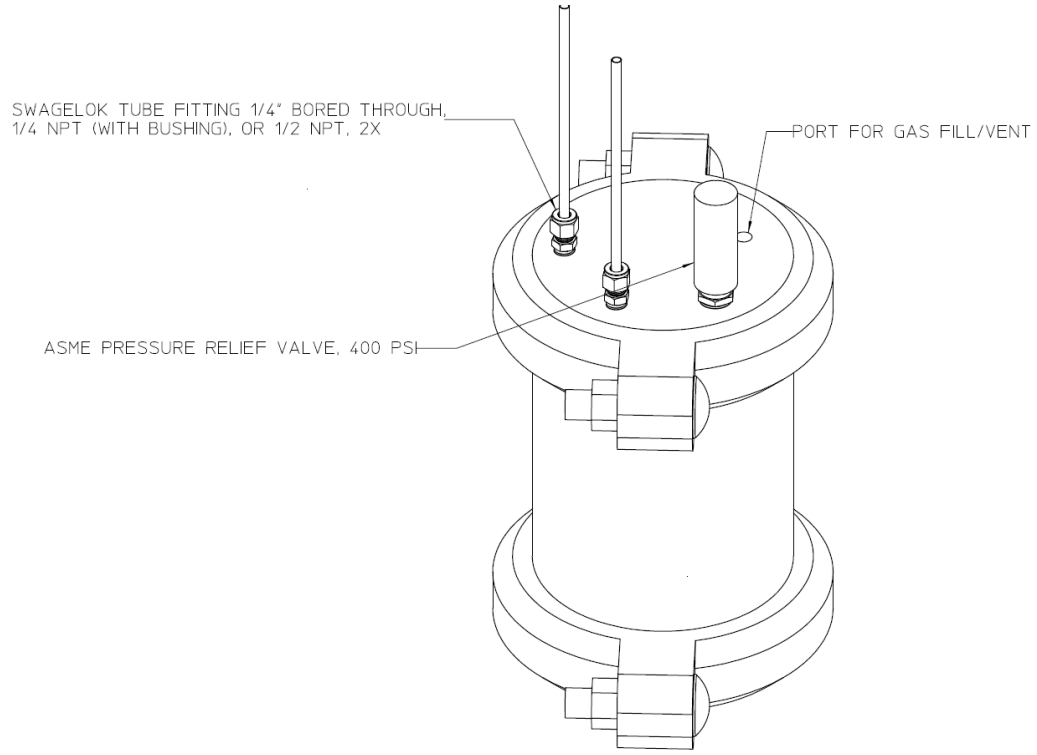
The pressure vessel is of a simple construction, using Victaulic grooved pipe couplers with a section of 6" IPS schedule 40 pipe, 9 inch long, and two 1 inch thick caps. This results in a much lighter and easier assembling vessel than a similar one with ANSI flanges. One cap, the lid, is drilled and tapped for several 1/4" NPT fittings to allow pressurization/vent, pressure relief and two service tubes from the PMT enclosure inside the vessel to be brought out.

The vessel will likely be used no more than 2 dozen times.

MAWP= 400 psig

The following LBNL drawings show the assembly and parts:

26K597 PMT Test Chamber
26K586 Nipple, Victaulic
26K588 Cap, Flat



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1. Background

NEXT is a collaboration between LBNL and other institutions to build a detector to observe neutrinoless double beta decay. The NEXT-100 TPC will contain 100 kg of enriched xenon gas at up to 15 bara pressure. The PMTs used inside this gas volume cannot withstand this pressure, so an enclosure has been designed to protect it.

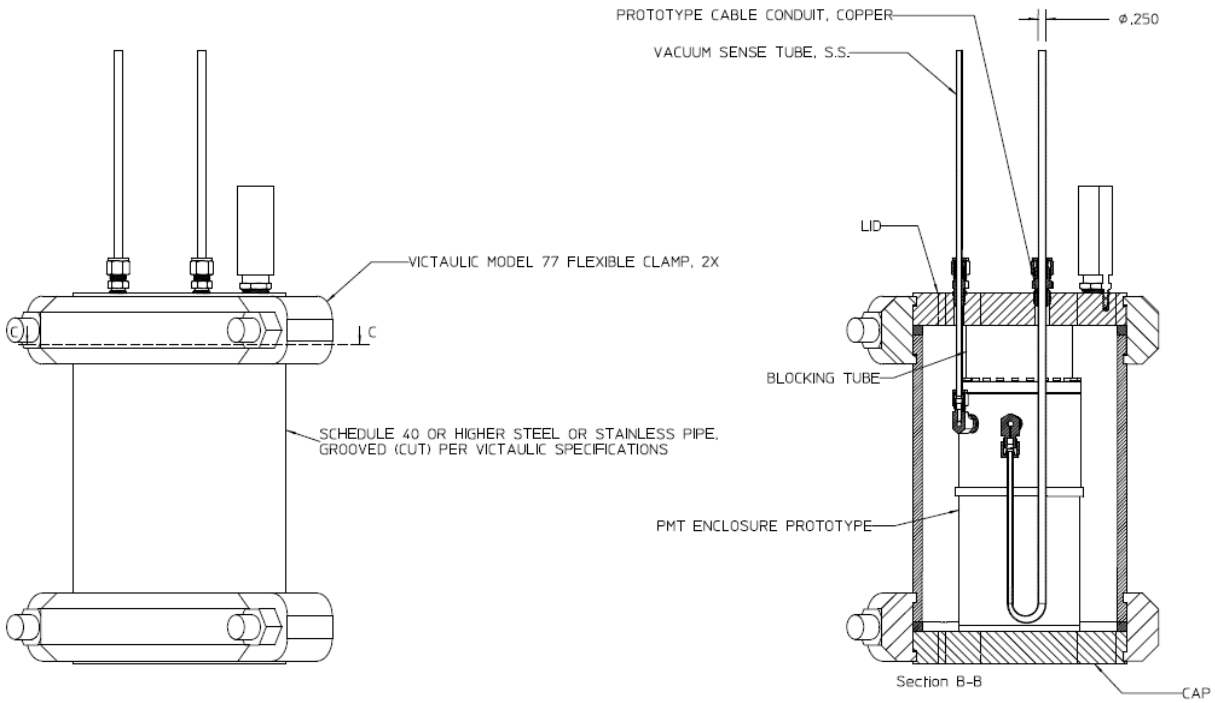
Although not the subject of this Note, this PMT enclosure is designed in accordance with ASME PV code sec VIII div. 1, and sees external pressure only. It is fabricated from OFE (C10100) copper for high radiopurity, and is heavily built to provide shielding from background gamma rays. The enclosure incorporates a single crystal sapphire window for the PMT to view light produced in the xenon gas; this is the critical strength component of the enclosure due to its brittle failure mode. There will be a total of 60 of these windows inside the TPC, and they have been designed using the methodology of the Weibull distribution, in combination with linear elastic fracture mechanics to provide a quantitative estimate of reliability. These windows will be pressure tested hydrostatically in a separate test chamber (described in a separate note) before using.

This pressure test chamber is for the purpose of demonstrating proper PMT operation under high pressure conditions. We are primarily interested in measuring Xenon permeation through O-ring seals, and the achievable vacuum inside the enclosure under actual external pressure, using different conduit tubing diameters. We want to verify the collapse resistance of the different tubing diameters (after bending to shape). We plan to use an aluminum alloy substitute "window" here for most tests to avoid any brittle fracture possibility. We may run a pressure test with a pre-tested sapphire window installed; we will first do this without a PMT inside the enclosure, and with a high flow filter or muffler installed on the outside tubing (open to atmosphere) so as to capture any fragments of sapphire should it fracture.

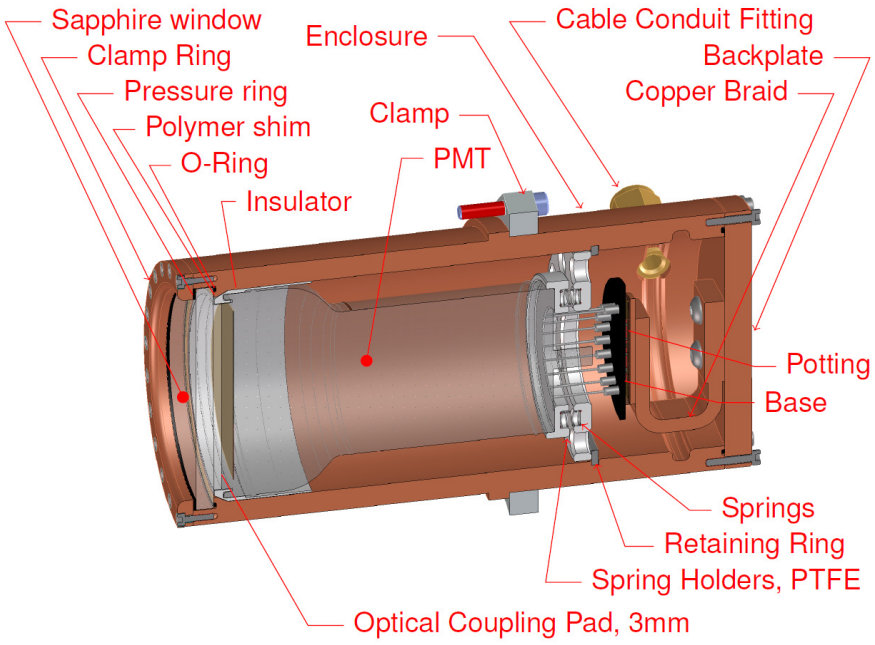
The maximum pressure to be applied to the enclosure, for testing is 1.6 x 15 bara = 360 psia; therefore we set 350 psig as the MOP for the test vessel described below.

2. Assembly and Operation

The pressure vessel is simply a section of 6 inch schedule 40 stainless steel pipe, grooved on each end for Victaulic grooved pipe couplers (type 77, flexible). The ends are capped with stainless steel lids machined from plate. Below is the assembly drawing showing the PMT enclosure mounted inside the pressure vessel:



The PMT enclosure prototype module, (with cable conduit and vacuum sense tubes assembled) is shown in the following figure:

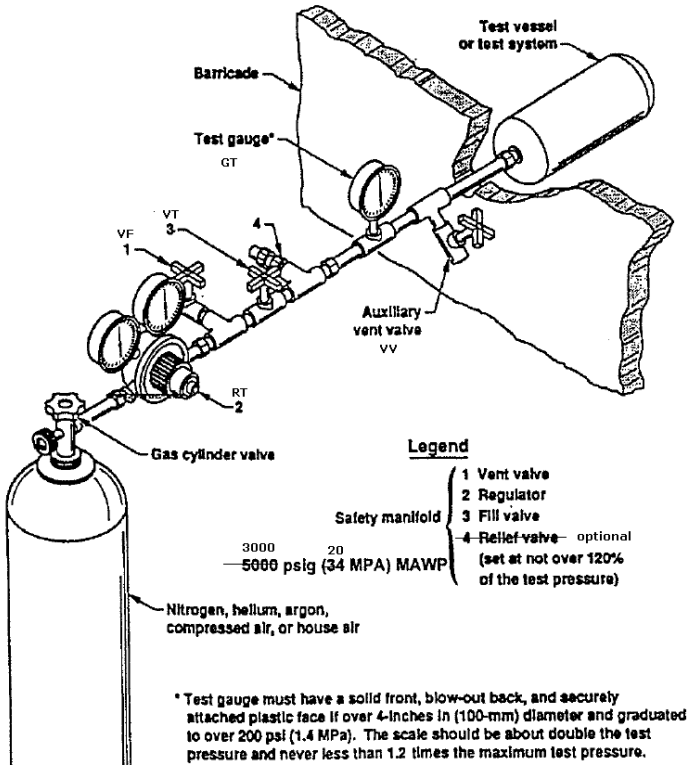


The lid is placed over the tubes and the top clamp assembled. The through-bored Swagelok tube fittings have plastic ferrules to avoid tube deformation that would disallow lid removal without cutting the tube.

The space between the vessel and the enclosure will then be pressurized with inert gas, thus applying an external pressure to the PMT enclosure. During this time, a vacuum will be applied through the cable conduit tube, and the vacuum inside the PMT enclosure will be measured with a vacuum gauge connected to the vacuum sense tube. In further testing, the PMT will be assembled inside the enclosure, with

electrical signals brought out through the cable conduit/vacuum tube; allowing the PMT operation to be verified. The PMT operates at a modestly high voltage 1.5 kV and we are concerned about flashover on the pins and resistor base inside the enclosure, so gas permeation through O-rings while under external pressure is something we want to quantify before operating the PMT.

Gas pressure for enclosure testing will be provided with the gas test rig pictured below, which was used for pressure testing the HP Xenon TPC (Eng. Note 10506)



3. Maximum operating and allowable Pressures:

For the gas permeation tests, the maximum operating pressure need only be 15 bara (14 barg), however we would like to verify a minimum safety factor on the enclosure, including the sapphire window (though it will be pretested separately in a hydrostatic tester) of 1.6 against collapse or 24 bara (23barg):

$MOP := 350psi \quad MOP = 23.816\,bar$

ASME certified pressure relief valves are available in 400 psi (closest size)

$MAWP := 400psi$

Check, is MAWP > 110% MOP? (per PUB3000 recommendations)

$MAWP > 1.1MOP = 1$ (1=true, 0=false)

All components except the pipe, lid and cap, are manufacturer rated for working pressures higher than MAWP above. The lid and cap are designed and made here at LBNL.

4. Hazards:

Stored Energy (formula from PUB3000):

$$U := \frac{P_h \cdot V_h}{\gamma - 1}\left[1 - \left(\frac{P_l}{P_h}\right)^{\frac{\gamma-1}{\gamma}}\right]$$

$\gamma := 1.667$ monatomic gas

$P_h := MAWP$ $P_l := 1\,bar$

Pipe is a 6" schedule 40 IPS (6.625" OD x .28" thk) welded 304 stainless steel. It is likely ASME SA-312 (general purpose austenitic stainless welded and seamless pipe), though provenance is unknown. Length inside is 9 inch. Volume, empty, is:

$$V_h := \frac{\pi}{4} 6in^2 \cdot 9in \qquad V_h = 42.412\,in^3$$

$$U := \frac{P_h \cdot V_h}{\gamma - 1}\left[1 - \left(\frac{P_l}{P_h}\right)^{\frac{\gamma-1}{\gamma}}\right] \qquad U = 2.108\,kJ$$

PUB3000 classifies pressure vessel with less than 75 kJ stored energy as low hazard, which this vessel is. However the pressure is higher than 150 psi and is gas pressure, so we treat as high hazard.

Improper Assembly

The Victaulic couplers are very straightforward to assemble, however, if the coupling lips are not fully seated into the grooves on the pipe, the assembly will not hold much pressure, and the lid of cap will pop off with high velocity when pressurizing. The two clamps will not come together when bolting, so this is the necessary condition to check for; **THERE SHOULD BE NO SIGNIFICANT GAP BETWEEN THE TWO SEMICIRCULAR CLAMPS WHEN FULLY BOLTED UP**. The clamps should be bolted up as tight as possible with a large wrench, however this is primarily to avoid any possibility of nuts coming loose between pressure cycling; pressure capacity is not dependent on bolt torque, once snug. The gaskets should be installed on the pipe with either Victaulic water soluble grease or with a vacuum grease. Grease the sealing surfaces and OD on the gasket; grease the inside surfaces on the clamps where they contact the gasket. Several types of couplers are feasible, type 07 (rigid) type 77(flexible) or type 05 (standard); we use type 77 here. See chart below. Type 741 couplers must not be used.

Sapphire window fracture

The enclosure will be tested initially with an aluminum window, so all parts are ductile. Eventually, once the prototype sapphire windows on the PMT enclosure are hydrostatically tested, they may be installed on the PMT enclosure and pressurized with gas in this vessel. The first time this is done, the conduit tube should be left open to air (not connected to a vacuum pump) and a standard air exhaust filter installed to catch any fragments. The sense line should be plugged.

5. Pressure Test Procedure

Vessel is to be assembled as in the drawing above, without the enclosure inside, but with a copper tubing loop simulating both the bent cable conduit and sense lines. This tube loop is left open to air on the exterior. Use plastic ferrules on tube. A certified pressure gauge is to be installed on one of the remaining lid ports and a hydrostatic water pump and vent valve connected to the remaining port on a tee, the vent valve being for air bleed-off.

The hydrostatic pump being used (in bldg. 78-103) has its own pressure regulator which has been set to 600 psi; if tested subsequently with a different pump, a pressure relief valve of 600 psig shall be installed on the lid. Vessel shall be filled slowly with water with vent valve open until air is purged. Raise test pressure to 600 psi. Vessel shall be held at pressure for 5 minutes to verify that leakage is negligible. Slight leakage around seals or threads is tolerable, as most testing of enclosures will be fairly short duration.

After successful testing, engrave, etch, or otherwise permanently label the following information on the pipe, lid and cap:

MAWP = 400 psi

Safety Note = 10688A

6. Pipe and Coupler Calculations

Maximum allowable stress, from **2009b ASME PV code sec II, part D - table 1A**,

$S := 17000psi \qquad E := 1 \qquad R_{pipe} := 3.03in \qquad t_{pipe} := .28in$

From **UG-27** pressure rating would be:

$$P_{pipe\_max} := \frac{S \cdot E \cdot t_{pipe}}{R_{pipe} + 0.6 t_{pipe}} \qquad P_{pipe\_max} = 1.488 \times 10^{3}\ psi$$

However, pressure rating is conjunction with the Victaulic type 77 flanges is given in Victaulic publication # 17.09 "Pressure Ratings and End Loads for Victaulic Ductile Iron Grooved couplings on stainless steel pipe" :

Style 07 Zero-Flex Rigid Coupling

Style 77 Flexible Coupling

Style 75 Standard Coupling

Style 741 Vic-Flange® Adapter

Pipe Size		Pipe Inches/millimeters			Style 07 Maximum		Style 77 Maximum		Style 75 Maximum		Style 741 Maximum	
Nominal Dia. In./mm	Actual Out. Dia. In./mm	Wall Thickness	Sched. #	R = Roll C = Cut	Work. Press.* PSI/kPa	End Load* Lbs./N	Work. Press.* PSI/kPa	End Load* Lbs./N	Work. Press.* PSI/kPa	End Load* Lbs./N	Work. Press.* PSI/kPa	End Load* Lbs./N
165,1 mm	6.500 165,1	0.280 7,11	–	C	700 4825	23230 103375	750 5175	24900 110805	450 3100	14930 66440	250 1725	8300 36935
		0.280 7,11	–	R	450 3100	14930 66440	500 3450	14930 66440	300 2065	9955 44300	150 1034	4975 22140
		0.134 3,40	–	R	200 1375	6635 29525	200 1375	6635 29525	125 862	4150 18470	125 862	4150 18470
		0.109 2,77	–	R	125 862	4150 18470	125 862	4150 18470	75 517	2490 11080	75 517	2490 11080
6 150	6.625 168,3	0.280 7,11	40S	C	700 4825	24130 107380	750 5175	25850 115030	450 3100	15525 69085	250 1725	8625 38380
		0.280 7,11	40S	R	450 3100	15515 69040	500 3450	17235 76695	300 2065	10340 46015	150 1034	5170 23005
		0.134 3,40	10S	R	200 1375	6895 30685	200 1375	6895 30685	125 862	4310 19180	125 862	4310 19180
		0.109 2,77	5S	R	125 862	4310 19180	125 862	4310 19180	75 517	2585 11505	75 517	2585 11505

Therefore:

$Pmax\_SSpipe\_Vic77 := 750psi$ pipe has a cut groove

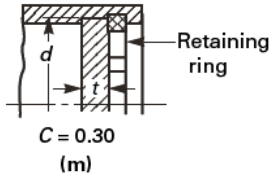
This publication also states that a one time only overpressure of 1.5x the max. working pressure is acceptable for a field test. We will not exceed the working pressure for the hydraulic pressure test

7. Lid and Cap Calculations

From **UG-34 Unstayed Flat Heads and Covers**

diameter: $d := 6.625in$

attachment factor: $C := 0.3$ from fig. UG-34:



$P := MAWP$ $P = 27.218\,bar$

material : steel SA-283 carbon steel or better (plate is SA-240 304L stainless steel (UNS30403)

$S_{283} := 15700psi$ $S_{304} := 16700psi$ from table 1A ASME PV code, sec. II, part D

$E = 1$ (weld efficiency) from Table UW12

$S_{plate} := S_{283}$

Minimum head thickness is then:

$$t := d \cdot \sqrt{\frac{C \cdot P}{S_{plate} \cdot E}} \qquad t = 0.579\,in \qquad (1)$$

$t_h := 1.0 \cdot in$ $t_h > t = 1$

This completes the calculation for the (bottom) cap. The (top) lid is identical thickness and has four 1/4-NPT tapped holes in it:

UG-39 Reinforcement Required for Openings in Flat heads

UG-39(a) General, rules in this section are exempted for openings that do not exceed size and spacing limits of UG-36(c)(3)

UG-36 (c) (3) Strength and Design of finished Openings:

(3) Openings in vessels not subject to rapid fluctuations in pressure do not require reinforcement other than that inherent in the construction under the following conditions: <--no rapid fluctuations

(a) welded, brazed, and flued connections meeting the applicable rules and with a finished opening not larger than:

$3\frac{1}{2}$ in. (89 mm) diameter — in vessel shells or heads with a required minimum thickness of $\frac{3}{8}$ in. (10 mm) or less; <-- not applicable
$2\frac{3}{8}$ in. (60 mm) diameter — in vessel shells or heads over a required minimum thickness of $\frac{3}{8}$ in. (10 mm);

(b) threaded, studded, or expanded connections in which the hole cut in the shell or head is not greater than $2\frac{3}{8}$ in. (60 mm) diameter; <--holes <60mm dia

(c) no two isolated unreinforced openings, in accordance with (a) or (b) above, shall have their centers closer to each other than the sum of their diameters; <-- check this below

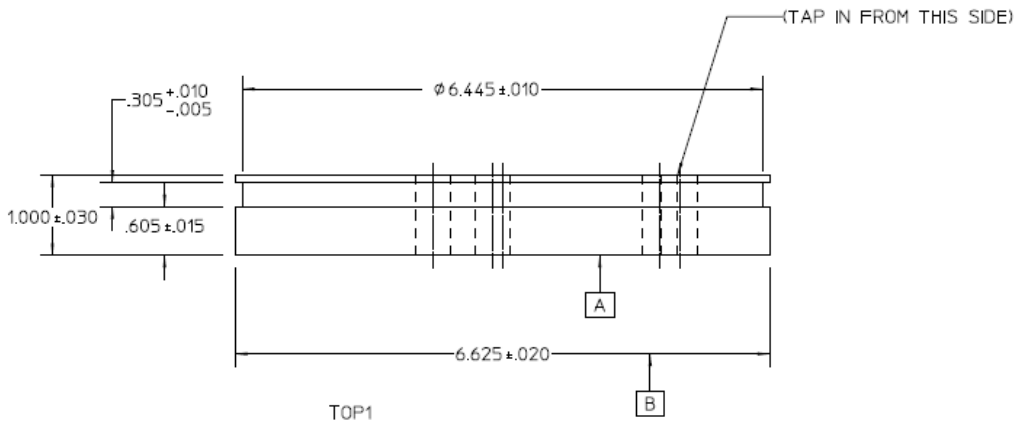
(d) no two unreinforced openings, in a cluster of three or more unreinforced openings in accordance with (a) or (b) above, shall have their centers closer to each other than the following: for cylindrical or conical shells, <-- check this below

$$(1 + 1.5 \cos \theta)(d_1 + d_2);$$

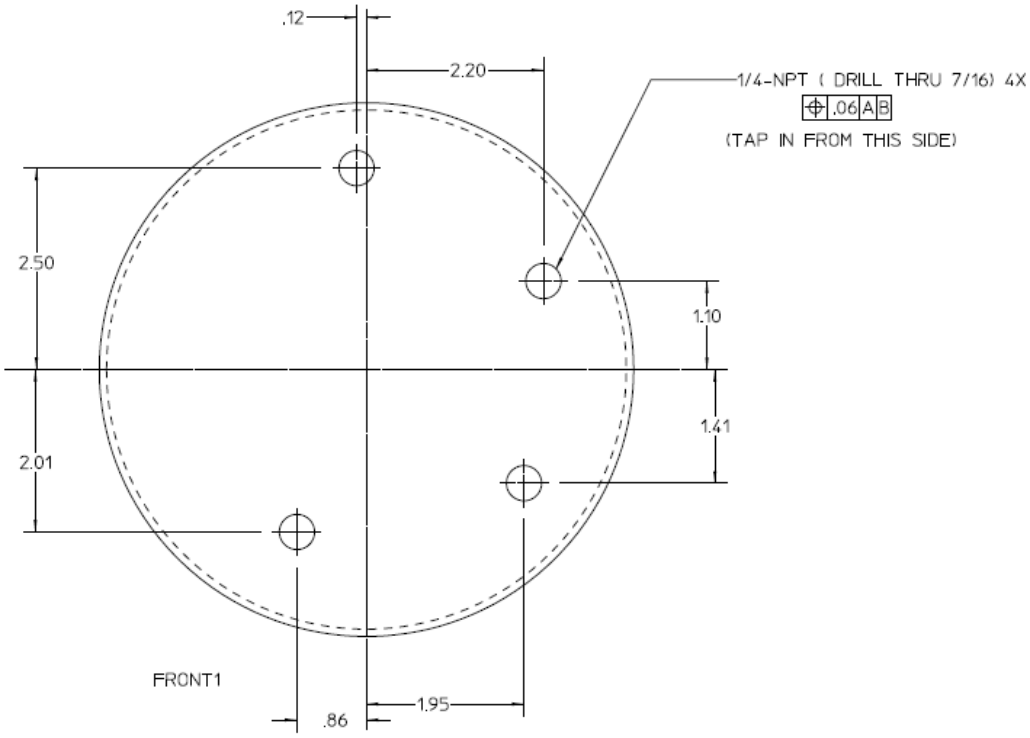
for doubly curved shells and formed or flat heads,

$$2.5(d_1 + d_2)$$

Lid drawing is shown below (excerpted):



STEEL, PER ONE OF THE FOLLOWING, WITH MATERIAL CERTIFICATION:
1. ASTM(ASME) SA-285, ANY GRADE (HIGHEST PREFERRED) UNS K01700
2. ASTM(ASME) SA-283, ANY GRADE (HIGHEST PREFERRED)
3. ASTM(ASME) SA-36 (A-36) UNS K02600
4. ASTM(ASME) SA-240, SA-240M (304, 316 S.S.)



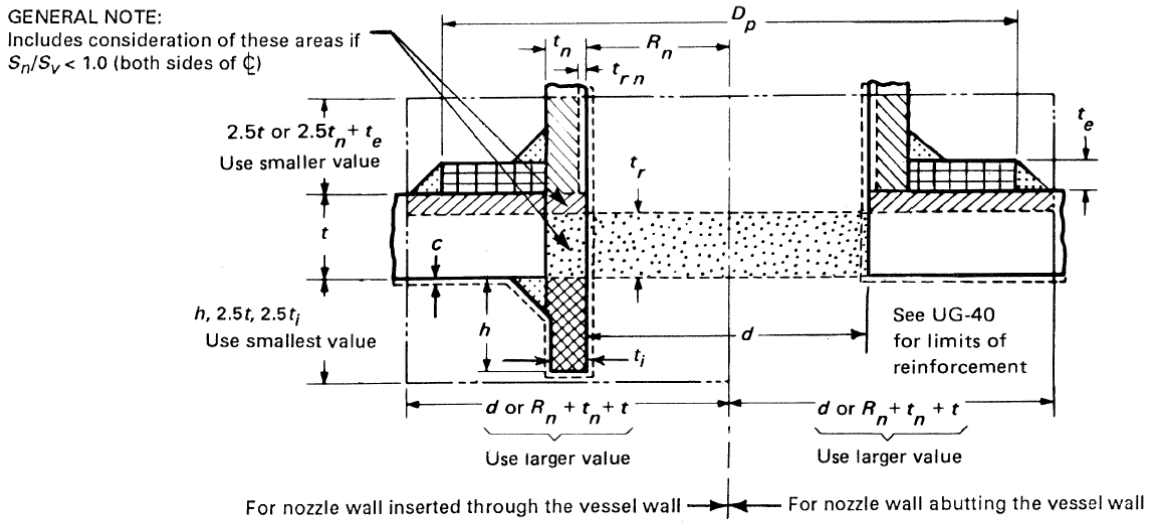
holes do not form clusters so (d) is not applicable; closest hole spacing is

$d_s := 2.5in$ These are 1/4NPT holes $d_o := .44in$

Reinforcement is not needed, and in fact, 1/2-NPT holes could be used, where d=.73 in

Nevertheless we calculate here:

FIG. UG-37.1 NOMENCLATURE AND FORMULAS FOR REINFORCED OPENINGS



We have no nozzle, weld or reinforcement, reinforcement area is only available as extra shell thickness

$d := d_o$ $t = 0.579\,in$ $t_h = 1\,in$ $t_n := 0in$ $f_{r1} := 1.0$

$d = 0.44\,in$

Area or reinforcement required **UG-39(b)(1)**, total:

$A := 0.5d \cdot t + t \cdot t_n \cdot (1 - f_{r1})$ $A = 0.127\,in^2$ t as defined in **UG-34**

UG-39 (b)(2) holes may be reinforced individually as above, as no two holes have a distance between their centers less than 2x their avg. diameter (2d=1inch < min. distance)

from **UG-40(b) Limits of Reinforcement**, limit parallel vessel wall, from hole axis:

$L_1 := \max(d, 0.5d + t_h)$ $L_1 = 1.22\,in$

We can see in the drawing above, that these limits will not overlap

from **UG-40(c) Limits of Reinforcement**, limit perpendicular to vessel wall:

$L_2 := \min(2.5t_h)$ $L_2 = 2.5\,in$

This is greater than the nominal plate thickness, so all excess plate material can be counted for reinforcement.

Area available for reinforcement, on each side of opening axis

$A_1 := L_1 \cdot (t_h - t)$ $A_1 = 0.513\,in^2$ t, t_h as defined in **UG-34**

Check:

$2A_1 > A = 1$

8. Cap and Lid material certs:

Outokumpu Stainless Plate, Inc.

OUTOKUMPU

Certificate of Analysis and Tests

OUR ORDER 0276973 - 01 HEAT & PIECE 852271-2A 08/23/11

SOLD TO: SHIP TO: UC 11202 11193 Derek Shuman

YOUR ORDER	DATE
796	7/22/11

ITEM DESCRIPTION

HEAT & PIECE 852271 - 2A
WEIGHT 7272
FINISH 1
GRADE 304LP / 304P UNS-S30403 / UNS-S30400
DIMENSIONS 1.000 X 101.000 X 243.000 EXACT

*** MFG IN NEW CASTLE, IN, USA
AMS 5511H WITH EXCEPTIONS
PLUS TEN 1304L PRODEC
ASTM A240-11A ASME SA240-10E
ASTM A262-02A
MIL-S-5059D WITH EXCEPTIONS
ASTM E112-96E2
ASTM A312-11 CHEM&MECH ONLY
NO SPECS REQUIRED ON INVOICE
QQ-S-763F COND A CHEM ONLY
NACE MR0175-2003/ISO 15156
NO WEEE RELEVANT SUBSTANCES
ASTM A262-02A PRACTICE A
PRODEC QUALITY

SPECIFICATIONS

FROM SLABS IMPORTED FROM BRITAIN
AMS 5513J WITH EXCEPTIONS
ASTM A276-10 CHM&MECH CON-A
ASTM A480-11A ASMESA480 10ED
ASTM A479-10A CHEM&MECH ONLY
OUTOKUMPU MACH TEST LP020
MEETS RQMTS UNS S30302 T302
QQ-S-766D AMENDIII EX.P4.5.2
LIST HEAT/PIECES ON INVOICE
ASTM A666-03 ANN COND ONLY
MEETS EU ELECTRICAL ROHS
DFAR 252.225-7014 & ALT 1
ASTM A262-02A PRACTICE E

PLATES & TEST PCS SOLUTION ANNEALED @ 1900 DEGREES FAHRENHEIT MINIMUM,
THEN WATER COOLED OR RAPIDLY COOLED BY AIR
FREE FROM MERCURY CONTAMINATION AT CURRENT DETECTION LIMITS
HOT ROLLED, ANNEALED & PICKLED (HRAP)

MECHANICAL & OTHER TESTS

HARDNESS HRBW	79
GRAIN SIZE	6
YIELD STRENGTH (PSI)	43013
TENSILE STRENGTH (PSI)	91950
BEND	OK
INTERGRANULAR CORROSION	OK
ELONGATION % IN 2"	54.7
REDUCTION OF AREA %	53.5

CMTR'S FURNISHED BY
CUSTOMER TCI ALUMINUM/NORTH
P.O.# 32991 S.O.# 6777
DESC. 24 x 24
QTY. 1pc

CHEMICAL COMPOSITION

CARBON	(C)	.016
MANGANESE	(MN)	1.38
PHOSPHORUS	(P)	.030
SULFUR	(S)	.021
SILICON	(SI)	.41
CHROMIUM	(CR)	18.36
NICKEL	(NI)	8.12
COBALT	(CO)	.15
COPPER	(CU)	.46
MOLY	(MO)	.38
NITROGEN	(N)	.07
COLUMBIUM	(CB)	.010
TITANIUM	(TI)	.009
ALUMINUM	(AL)	.005
TIN	(SN)	.016
TANTALUM	(TA)	.001

ISO 9001-2008
SAI Cert#CERT-0033834

WE HEREBY CERTIFY THAT THE MATERIAL HEREIN HAS BEEN MADE AND TESTED IN ACCORDANCE WITH THE LISTED SPECIFICATION(S) AND THAT THE RESULTS OF ALL TESTS ARE ACCEPTABLE.

Outokumpu Stainless Plate, Inc.
O. Box 370
w Castle, Indiana 47362

JAMES DOUBMAN, QUALITY ASSURANCE MANAGER

The remainder of the vessel will consist of Swagelok tube fittings, stainless steel, in tube sizes

from 1/4 to 7/16. Swagelok pressure ratings are based on the size of the lowest rated end connection, which is 1/4-NPT. From Swagelok publication MS-01-140.pdf :

Pressure Ratings

Ratings are based on ASME Code for Pressure Piping B31.3, Process Piping, at ambient temperature.

NPT/ ISO Pipe Size	316 SS and Carbon Steel				Brass			
	Male		Female		Male		Female	
in.	psig	bar	psig	bar	psig	bar	psig	bar
1/16	11 000	760	6700	460	5500	380	3300	230
1/8	10 000	690	6500	440	5000	340	3200	220
1/4	8 000	550	6600	450	4000	270	3300	220
3/8	7 800	540	5300	360	3900	270	2600	180
1/2	7 700	530	4900	330	3800	260	2400	160
3/4	7 300	500	4600	320	3600	250	2300	160
1	5 300	370	4400	300	2600	180	2200	150
1 1/4	6 000	410	5000	350	3000	200	2500	170
1 1/2	5 000	340	4600	310	2500	170	2300	150
2	3 900	270	3900	270	1900	130	1900	130

9. Pressure Vessel Hydrostatic Test Report:

LAWRENCE BERKELEY NATIONAL LABORATORY

PRESSURE-TEST RECORD

Date: 3/9/2012

Location of vessel (or system): Build. 78 Rm. 103

Description: Pressure Vessel For Xenon TPC PMT Enclosure testing

LBL PRESSURE TESTED	
DWG. NO.	
SAFETY NOTE	
WORKING PRESS.	PSI
WORKING FLUID	
WORKING TEMP.	°F
REMA	
TEST NUMBER	
BY	D

Pressure Vessel ☒ Pressure System ☐ (check box)

"Pressure-Tested" Label attached ☐ TO BE ENGRAVED

TEST INFORMATION:

1. Test pressure 600 PSI Pa (kpsi)
2. Testing Fluid (oil, He, etc.) water
3. Test Temperature 75°F °C (°F)
4. Design Temperature 75°F °C (°F)
5. Safety Case
6. Responsible Designer Name: Derek Shuman
7. Responsible User Name: Derek Shuman

Dept. Mech Eng.

Divn: Engineering

8. Diameter measurements (for pressure-vessel tests only) N.A.

Location (marked) Before testing After testing Difference (+ or -)

Remarks: MARK Hvobschle 3/9/12

Test by:

M&O, Mech. Shop

CERTIFICATION:

The vessel identified above has been pressure tested and is approved for operation within these test conditions.

~~Certified~~ Witnessed by: Mar 9, 2012

Ken P. Chow

Pressure Test Gauge Certification

The Instrumentation Company
NOSHOK INCORPORATED

PRESSURE GAUGE CERTIFIED CALIBRATION RECORD

Traceable to NIST

Customer/Distributor:	User:
McMaster-Carr Supply Company	
9630 Norwalk Blvd	
Santa Fe Springs, CA 90670	

Purchase Order Number: FC-52079820	**Sales Order Number:** 230738
Calibration Due Date: ***Date gauge is to be recertified. This date is filled in by user based on installation date and user's QA program***	**Installation Date:** ***Date calibration cycle begins. Filled in by user when gauge is installed.***

Pressure Gauge Part Number: 25-300-800-psi, ¼" NPT Bottom Conn

Serial Number: N55390 **ASME Grade:** A

Lab Temperature: 70°F ± 7°F Lab Humidity: 20% to 70% R.H.

INCREASING PRESSURE			DECREASING PRESSURE		
CALIBRATION STANDARD	PRESSURE GAUGE	DEVIATION	CALIBRATION STANDARD	PRESSURE GAUGE	DEVIATION
0	0	0	600	610	10
200	200	0	400	410	10
400	400	0	200	210	10
600	600	0	0	0	0
800	790	10			

Certified Correct By: Brian Sokol

Verified By:

Calibration Date: 10-27-11

FOR NOSHOK INTERNAL USE ONLY
EQUIPMENT USED IN CALIBRATION

MANUFACTURER	MODEL	SERIAL NUMBER	CAL. DATE	DUE DATE
NOSHOK	60-800-1000-psi	N27621	10-05-11	01-05-12

Note: The aforementioned calibration standard is at least four times as accurate as the instrument being tested. **THE "DUE DATE" LISTED ABOVE APPLIES ONLY TO THE CALIBRATION STANDARD USED FOR THIS CERTIFICATION.**

NOSHOK, Inc. Corporate Headquarters
1010 West Bagley Road, Berea, OH 44017 | Phone: 440.243.0888 | Fax: 440.243.3472 | Email: noshok@noshok.com

MCSCPGCR1206
Rev.: 3

10. Markings on Vessel