LHe STORAGE DEWAR

PRESSURE VESSEL & VACUUM VESSEL

ENGINEERING NOTE

D-ZERO ENGINEERING NOTE # 3823.115 EN-465

Author: Russ Rucinski, PPD/ETT/DØ
April 24, 1997

Approved: ______________
PPD/ETT/D-Zero Mechanical Group leader

PRESSURE VESSEL ENGINERING NOTE
PER CHAPTER 5031

Prepared by: TODD LEICHT & RUSS RUCINSKI
Preparation date: 8/26/96

1. Description and Identification
Fill in the label information below:

This vessel conforms to Fermilab ES&H Manual Chapter 5031

Vessel Title DØ LHe DEWAR INNER VESSEL

Vessel Number RD10036 — Obtain from Safety Officer

Division/Section RD/D-ZERO

Vessel Drawing Number CMSH-3000 (MFR. NUMBER)

Maximum Allowable Working Pressures (MAWP):
Internal Pressure 90 PSIA
External Pressure 15 PSIA

Working Temperature Range -452 oF 100 oF

Contents LIQUID HELIUM

Designer/Manufacturer CRYOFAB

Test Pressure (if tested at Fermi) Acceptance Date: N/A — Document per Chapter 5034 of the Fermilab ES&H Manual

_______PSI, Hydraulic_______ Pneumatic _________

Accepted as conforming to standard by

of Division/Section Particle Physics Date: 4/22/97 — Actual signature required

NOTE: Any subsequent changes in contents, pressures, temperatures, valving, etc., which affect the safety of this vessel shall require another review.

Reviewed by: _______________ Date: 3/27/97

Director's signature (or designee) if the vessel is for manned areas but doesn't conform to the requirements of the chapter.

_______________ Date: _______________

Amendment No.: Reviewed by: Date:

Lab Property Number(s): NONE

Lab Location Code: D.A.B. (obtain from safety officer)

Purpose of Vessel(s): LIQUID HELIUM STORAGE FOR SOLENOID AND VLPC CRYOGENIC SYSTEMS UPGRADE.

Vessel Capacity/Size: 3,300 L GROSS Diameter: 68" Length: 68"

Normal Operating Pressure (OP) 12 PSIG + INS. VACUUM = 27 PSID

MAWP-OP = 90-27 = 63 PSI

List the numbers of all pertinent drawings and the location of the originals.

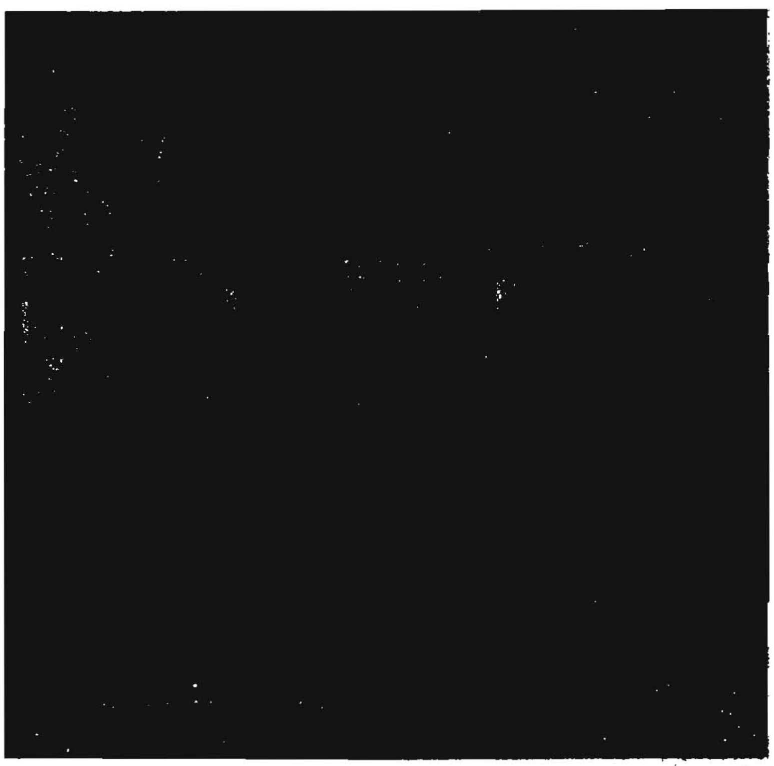
Drawing #	Location of Original
CMSH - 3000	MFR. DRAWING, ATTACHED
3823.115-ME-317223 SHT. 3	DØ He REFRIGERATOR FLOW SCHEMATIC, D.A.B.
3823.115-MD-317641	TOP FLANGE ASSEMBLY, D.A.B.
3823.115-MD-317635	TOP FLANGE WELDMENT, D.A.B.
3823.115-MC-317636	TOP FLANGE - 3000L DEWAR, D.A.B.

2. Design Verification

Does the vessel(s) have a U stamp? Yes X No_____. If "Yes", fill out data below and skip page 3; if "No", fill out page 3 and skip this page.

Staple photo of U stamp plate below.

Copy "U" label details to the side



Copy data here:

NAT'L BD.: 108

CERTIFIED BY: WESTFIELD SHEET METAL WORKS INC.

MAWP: 90 PSI @ 100°F

MIN. DESIGN TEMP: -452°F @ 90 PSI

SERIAL NO.: 6668

YEAR BUILT: 1996

WSM "THE SYMBOL OF QUALITY..."

261 MONROE AVE.

KENILWORTH, NJ 07033

3. System Venting Verification Provide the system schematic in the Appendix.

Is it possible to isolate the relief valves by a valve from the vessel?

Yes___ No_X_

If "Yes", the system must conform to code rules. Provide an explanation on the appended schematic. (An isolatable vessel, not conforming to code rule is non-compliant under this chapter.)

Is the relief cracking pressure set at or below the M.A.W.P.?

Yes _X_ No_____ Actual setting _75_ PSIG

(A "No" response violates this chapter.)

Is the pressure drop of the relief system at maximum anticipated flow such that vessel pressure never rises above the following? (UG 125)

Yes_X_ No_____ 110% of MAWP (one relief)
116% of MAWP (multiple reliefs)
121% of MAWP (unexpected heat source)

Provide test or calculational proof in the Appendix.
(Non-conforming pressure rises is non-compliant under this Chapter.)

List of reliefs and settings:

Manufacturer	Model #	Set Pressure	Flow Rate	Size
FIKE METAL PRODUCTS	CPV	75	3211 scfm air	2" DIA.
ANDERSON GREENWOOD	815I216-G	48	508 scfm AIR	1½" x 2"

Does the primary relief device follow UG-129? Yes_X_ No_____
(A "No" response is non-compliant under this chapter)

4. Operating Procedure

Is an operating procedure necessary for the safe operation of this vessel?

Yes_____ No_X_ (If "Yes", it must be appended)

5. Welding Information

Has the vessel been fabricated in a non-code shop? Yes_____ No_X_

If "Yes", append a copy of the welding shop statement of welder qualification (Procedure Qualification Record, PQR) which references the Welding Procedure Specification (WPS) used to weld this vessel.

6. <u>Exceptional, Existing, Used and Unmanned Area Vessels</u>

Is this vessel or any part thereof in the above categories?
Yes_____ No_X_

If "Yes", follow the Engineering Note requirements for documentation and append to Note.

LHe Dewar Relief Summary

Cases (See Appendix C)	**Capacity Requirement***
1.) Loss of vacuum.	198 scfm Air
2.) Loss of vacuumw/ air condensation	343 scfm Air
3.) Fire.	1327 scfm Air
4.) Operator error	308 scfm Air

Relief Capacities (See Appendix D)

2" Fike Rupture disc, Burst Press. = 75 psig	3211 scfm Air
AGCO relief valve, Set Press.= 48 psig	508 scfm Air

Inlet Pressure Drop Calcs. (See Appendix D)

At maximum flow (Fire case), the pressure drop of inlet piping = 3.6 psi

* 1/14/97 Revision: Capacities were 204, 340, and 1426 for cases 1,2,3.
1/30/97 Revision: Capacities were 207, 360, and 1420 for cases 1,2,3.
3/21/97 Revision: Fike rupture disc capacity was 3898 scfm.

R. Rucinski 1/14/97
Todd Leicht

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FOR APPENDICES

SUBJECT: ASME CODE CALC'S, 3,000 L HELIUM STORAGE DEWAR FOR DØ REFRIGERATOR

NAME: TODD M. LEICHT

DATE: 8/26/96 | REVISION DATE:

APPENDIX A

PER UG-34 : UNSTAYED FLAT HEADS & COVERS

Minimum req'd thickness given by :

$$t = d\sqrt{CP/SE + 1.9\, W h_G / SE d^3} \qquad \text{(EQ. 1)}$$

where t is calculated for operating conditions and gasket seating. Use whichever is greater.

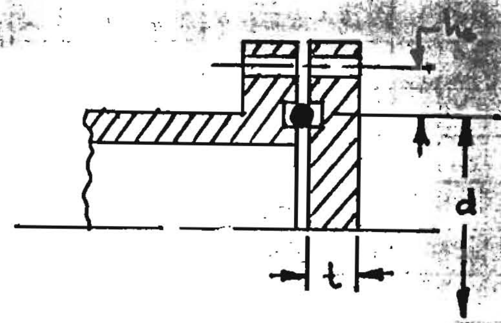
DEWAR LID DIMENSIONS :

$d = 8.125"$

$h_G = (9.5" - 8.125")/2$

$h_G = 0.6875"$

$t = ?$



NOTE : If the cover plate is grooved for the gasket as shown in the figure above, the net thickness under the groove shall be not less than :

$$d\sqrt{(1.9) W h_G / S d^3}$$

Define variables in thickness EQ. 1 :

- t = Min. req'd thickness (in)
- d = diameter (in) = 8.125"
- C = factor = 0.3
- P = internal design pressure (psi) = 75.3 psig

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NAME: TODD M. LEICHT

DATE: 8/26/96 | REVISION DATE:

S = max. stress in tension (psi) = 16,700 psi — SA-240 304L SS, see Table 1A, Sect. II Part D, line #32

E = joint efficiency = 1.0

W = total bolt load (lb) = ?

h_G = gasket moment arm = .6875"

CALCULATE BOLT LOAD, W ⇒ (Sect. VIII, Div. 1, App. 2)

2-5(e) Flange Design Bolt Load:

$$W\Big|_{\substack{\text{operating}\\\text{conditions}}} = W_{m1}$$

$$W\Big|_{\substack{\text{gasket}\\\text{seating}}} = \frac{(A_m + A_b)\,S_a}{2}$$

Case (1) Operating Conditions:

$$W_{m1} = H + H_p = .785\,G^2P + (2b \times 3.14\,GmP) \qquad \text{(EQ. 2)}$$

where,

H = hydrostatic end force (lb) = $.785\,G^2P$

H_p = total joint-contact surface compression load (lb) = $2b \times 3.14\,G^2Pm$

G = diameter at gasket load reaction (in) = 8.125"

$$b_o = \frac{w}{8} = \frac{.125"}{8} = .015625"$$

P = internal design pressure (psi) = 75.3 psig

b = effective gasket seating width (in) = .015625"

$b = b_o$ when $b_o \le 1/4$ in.

m = gasket factor = 0

substituting ...

$$W_{M1} = (.785)(8.125'')^2(75.3\ \text{psig}) + \left(2(.015625'') \times 3.14\,(8.125'')\ \cancel{m}^{0}\,P\right)$$

$$W_{M1} = \underline{3{,}902\ \text{lb}}$$

Case (2) Gasket Seating:

$$W = \frac{(A_m + A_b)S_a}{2} \qquad \text{(EQ. 3)}$$

where,

A_m = req'd x-sectional area of bolts (in²) = greater of A_{m1} or A_{m2}

$$A_{m1} = \frac{W_{m1}}{S_b} = \frac{3{,}902\ \text{lb}}{18.8\ \text{ksi}} = .2076\ \text{in}^2$$

$$A_{m2} = \frac{\cancel{W_{m2}}^{0}}{S_a} = 0$$

$\boxed{\text{NOTE:}}$ $S_a = S_b = 18.8$ ksi @ 100 °F per Table 3, Sect. II, Part D

$$\therefore A_m = .2076\ \text{in}^2$$

A_b = x-sectional of bolts using root dia. (in²) = .334 in²
see Table 8.2.2, Mark's Handbook for M.E.'s, 3/4" UNC screws

S_a = 18.8 ksi

substituting ...
$$W = \frac{(.2076\ \text{in}^2 + .334\ \text{in}^2)(18.8\ \text{ksi})}{2} = \underline{5{,}091\ \text{lb}}$$

$\therefore$ Max. bolt load is due to Case (2) Gasket Seating.

$$W \approx 5{,}100\ \text{lb}$$

FERMILAB ENGINEERING NOTE	SECTION RD/DØ-MECH.	PROJECT 3823	SERIAL-CATEGORY 115	PAGE A4

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	DATE 8/26/96	REVISION DATE

Finally, substitute into EQ. 1 to calculate minimum req'd top flange thickness.

$$t = (8.125'')\sqrt{\frac{(.3)(75.3\ psig)}{(1)(16{,}700\ psi)} + (1.9)\frac{(5{,}100\ lb)(.6875'')}{(1)(16{,}700\ psi)(8.125'')^3}}$$

$$\underline{t = 0.372\ in}$$

FERMILAB ENGINEERING NOTE	SECTION: RD/DØ	PROJECT	SERIAL-CATEGORY	PAGE: A5
SUBJECT: ASME CODE CALCS : ATTACHED PIPING.		NAME: RUSS RUCINSKI		
		DATE: 9-16-96	REVISION DATE	

<u>DEWAR NECK;</u> 6" OD. × (.072") WALL × 36" LONG.

SE = 16.0 ksi LINE 20, TABLE 1A, ASME, SECTION II pg. 98 304 STN. STL.

NOTE; INCLUDES 0.85 WELD EFFICIENCY

UG-27 THICKNESS, INT. PRESS.

C,1) CIRCUMFERENTIAL STRESS

$$t = \frac{PR}{SE - 0.6P} = \frac{(90\text{ psi})(2.93\text{ in.})}{16{,}000 - 0.6(90)}$$

$$t_{REQ'D} = 0.017\text{ in.}$$

C,2) LONGITUDINAL

$$t = \frac{PR}{2SE + 0.4P} = .008\text{ in.}$$

$$t_{ACTUAL} = .072" \gg t_{REQ'D}.$$

[illegible]

<u>NECK EXTENSION</u>; $6\frac{3}{4}$" OD × .105" THK × 12" LG.

SE = 16.0 ksi (SEE ABOVE)

$$t = \frac{PR}{SE - 0.6P} = \frac{(75)(3.27\text{ in.})}{16{,}000 - 0.6(75)} = .015\text{ in.}$$

$$t_{ACTUAL} = .105" \gg t_{REQ'D}.$$

<u>OSCILLATION CHAMBER</u>

ASME CODE DOESN'T APPLY. PER PHONE CONVERSATION WITH TAM TU, CRYOFAB ON 9-20-96, OSCILLATION CHAMBER IS DESIGNED FOR PRESSURES UP TO 150 PSIG.

APPENDIX B: Dewar Top Flange Reinforcement

PURPOSE

To calculate the reinforcement area for the openings in the 3,000 L helium dewar flat head per ASME Section VIII Division 1 Part UG, and compare it with the required area. The area available for reinforcement is determined assuming there are no reinforcing elements added (see Fig. UG-37.1).

MATERIAL PROPERTIES

Vessel Top Head: 18Cr-8Ni, SA-240 304L Plate

$S_v := 16700$ psi, maximum allowable stress

Nozzle Neck: 18Cr-8Ni, SA-312 TP304L Welded Pipe

$S_n := 14200$ psi, maximum allowable stress

VARIABLE DEFINITIONS

$c := 0$		in., corrosion allowance
$d := 1.9 - 2 \cdot 0.145$		in., finished diameter of opening
$E_1 := 1.0$		joint efficiency
$F := 1.0$		stress correction factor
$f_{r1} := \frac{S_n}{S_v}$	$f_{r1} = 0.85$	strength reduction factor
$f_{r2} := \frac{S_n}{S_v}$	$f_{r2} = 0.85$	strength reduction factor
$t := 0.75$		in., nominal thickness of top head
$t_n := 0.145$		in., nominal nozzle wall thickness
$t_r := 0.372$		in., required thickness of top head
$t_{rn} := 0.02$		in., required thickness of nozzle wall

$leg_u := 0.125$ in., outward nozzle weld leg length

$leg_i := 0$ in., inward nozzle weld leg length

REQUIRED REINFORCEMENT AREA

Per UG-39(b)(2) the required reinforcement for each opening in a pair of openings, when the spacing between them is $1.25d_{avg} < p < 2d_{avg}$ is calculated below. The reinforcement for each opening shall be summed together, and then distrubuted such that 50% of the sum is located between the openings.

$$A_{required} := 0.5 \cdot d \cdot t_r + t_r \cdot t_n \cdot (1 - f_{r1})$$

$$A_{required} = 0.308 \quad in^2$$

AVAILABLE REINFORECEMENT AREA

The area available for reinforcing a single opening shall be the sum of A_1, A_2, A_3, A_{41}, and A_{43} calculated below.

$$A_{1a} := d \cdot (E_1 \cdot t - F \cdot t_r) - 2 \cdot t_n \cdot (E_1 \cdot t - F \cdot t_r) \cdot (1 - f_{r1})$$

$$A_{1b} := 2 \cdot (t + t_n) \cdot (E_1 \cdot t - F \cdot t_r) - 2 \cdot t_n \cdot (E_1 \cdot t - F \cdot t_r) \cdot (1 - f_{r1})$$

$$A_1 := if(A_{1a} > A_{1b}, A_{1a}, A_{1b})$$

$A_1 = 0.66$ in^2, area available in shell

$$A_{2a} := 5 \cdot (t_n - t_{rn}) \cdot f_{r2} \cdot t$$

$$A_{2b} := 5 \cdot (t_n - t_{rn}) \cdot f_{r2} \cdot t_n$$

$$A_2 := if(A_{2a} < A_{2b}, A_{2a}, A_{2b})$$

$A_2 = 0.077$ in^2, area available in nozzle projecting outward

$h := 0$ in., usable extension of the inner nozzle for reinforcement

$$A_3 := 2\cdot(t_n - c)\cdot f_{r2}\cdot h$$

$A_3 = 0$ in², area available in nozzle projecting inward

$A_{41} := leg_u^2\cdot f_{r2}$ $A_{41} = 0.013$ in², area available in outward weld

$A_{43} := leg_i^2\cdot f_{r2}$ $A_{43} = 0$ in², area available in inward weld

$$A_{available} := A_1 + A_2 + A_3 + A_{41} + A_{43}$$

$A_{available} = 0.751$ in², area available for reinforcement

SUMMARY

There is sufficient reinforcement area available in the dewar top flange, provided that the limits of reinforcement do not overlap significantly.

$A_{required} = 0.308$ in²

$A_{available} = 0.751$ in²

Appendix C: Required Relief Capacity for the 3,000 L LHe Dewar Inner Vessel

PURPOSE

To determine the required relief capacity of the inner vessel of the 3,000 L LHe dewar for the failure conditions of loss of vacuum, fire, and operator error per CGA S-1.3, 1995 [1].

GENERAL ASSUMPTIONS

1. That there is no flow into the inner vessel from the He supply line. This is assured because the check valve, CV-2515-H, would prevent flow from entering should the dewar pressure become elevated.

2. The inner vessel is insulated with 2 inches of superinsulation.

DEWAR PARAMETERS

Gross Capacity	869 gal (3,300 L)
Net Capacity	790 gal (3,000 L)
Inner Vessel MAWP	90 psia (620.6 kPa)
Operating Pressure	26.5 psia (182.7 kPa)

FLOW RATING PRESSURES

Paragraph 4.3.3 of CGA S-1.3 states that the flow rating pressure under loss of insulating vacuum shall be 110% of the inner vessel MAWP, and for fire condition shall be 121% of the inner vessel MAWP.

Loss of Vacuum: $P_{f.r.} = (1.10)(90 \text{ psia}) = 99.0 \text{ psia } (682.6 \text{ kPa})$

Fire Condition: $P_{f.r.} = (1.21)(90 \text{ psia}) = 108.9 \text{ psia } (750.9 \text{ kPa})$

CALCULATIONS

<u>Loss of insulating vacuum</u>

The minimum required capacity of the primary relief device in scfm of air is given in paragraph 5.2.2 of CGA S-1.3 as:

$$Q_a = \frac{(590-T)}{4(1660-T)} FG_i UA \qquad \text{(eqn. A-1)}$$

where, T = temperature per CGA par. 5.1.3, degrees Rankine
F = correction factor
G_i = gas factor for insulated containers
U = Overall heat transfer coefficient, Btu/hr-ft^2-°F
A = mean surface area of insulation, square feet

Per paragraph 5.1.3, the temperature to use in equation A-1 is the temperature at which the function $\dfrac{\sqrt{v}}{v\left[\dfrac{\partial h}{\partial v}\right]_p}$ is a maximum. This function can be obtained by using HePak computerized helium tables. At 99 psia, this function is a maximum value at 7.907 K (14.2 °R). Per Note 3 of Table 1 in CGA S-1.3, the gas factor, G_i, for super critical helium is to be determined as in Appendix 6A of *Technology of Liquid Helium* [2].

$$G_i = \frac{0.097(1200-t)}{L'}\sqrt{ZT} \qquad \text{(eqn. A-2)}$$

where, t = -445.8 °F (7.907 K)
L' = 13.07 Btu/lb efflux (From HePak)
T = 14.2 °R (7.907 K)
Z = 0.645 compressibility factor (From HePak)

Substituting into eqn. A-2:

$$G_i = \frac{0.097(1200+445.8)}{13.07}\sqrt{(0.645)(14.2)} = 37.02$$

The overall heat transfer coefficient, U, is that of the insulating material of the container when saturated with gaseous helium or air at atmospheric pressure and 100 °F, whichever is greater. From Table A-4 in *Fundamentals of Heat and Mass Transfer* [5], k_{He} = 0.14654 W/m-K (0.0847 Btu/hr-ft-°F).

$$U = \frac{k_{He}}{t_{insulation}} = \frac{0.0847\ \text{Btu/hr}\cdot\text{ft}\cdot{}^\circ\text{F}}{0.1667\ \text{ft}} = 0.5082\ \text{Btu/hr}\cdot\text{ft}^2\cdot{}^\circ\text{F}$$

The surface area of a cylindrical container with 2:1 semielliptical heads is given in paragraph 5.1.2 of CGA S-1.3 as:

$$A = (\text{overall length} + 0.19 \text{ outside diameter}) \times (\text{outside diameter}) \times \pi$$

$$A = (68 \text{ in} + 0.19\,(68 \text{ in})) \times (68 \text{ in}) \times \pi = 120.05 \text{ ft}^2$$

Finally, F = 1.0 since the upstream piping is less than 2 feet long. Sustituting into eqn. A-1:

$$Q_a \bigg|_{\substack{\textit{loss of}\\ \text{vacuum}}} = \frac{(590 - 14.2)}{4(1660 - 14.2)}(1.0)(37.02)(0.5082)(120.05) = 198 \text{ scfm air}$$

Loss of vacuum, air conduction with condensation

Depending upon the insulation thickness, the heat load on the inner vessel due to air conduction with condensation on the insulation could be greater than the heat load under fire conditions. This is assuming a rupture in the vacuum vessel.

$$q_{total}\ [\text{Btu/hr}] = q_{conduction} + q_{condensation} \qquad \text{(eqn. A-3)}$$

From Figure C-2 with A = 120.05 ft^2 and assuming worst case 1" super insulation, the heat flux due to air condensation is $q_{condensation}$ = 55,000 Btu/hr.

$$q_{conduction} = UA(100 - t)$$

$$U = \frac{k_{air}}{t_{insulation}} = \frac{0.0157 \text{ Btu/hr} \cdot \text{ft} \cdot {}^\circ\text{F}}{0.1667 \text{ ft}} = 0.0942 \text{ Btu/hr} \cdot \text{ft}^2 \cdot {}^\circ\text{F}$$

$$q_{conduction} = (0.0942)(120.05)(100 + 445.8) = 6{,}172 \text{ Btu/hr}$$

$$q_{total} = 6{,}172 \text{ Btu/hr} + 55{,}000 \text{ Btu/hr} = 61{,}172 \text{ Btu/hr}$$

The following equation for the minimum required relief capacity in scfm of air is presented in Appendix 6A in *Technology of Liquid Helium.*

$$Q_a = \frac{18.3 \cdot q_{total}}{378 \cdot L}\sqrt{\frac{ZT}{4.00}}$$

$$Q_a \bigg|_{\substack{\textit{air} \text{ conduction}\\ + \text{ condensation}}} = \frac{(18.3)(61{,}172)}{(378)(13.07)}\sqrt{\frac{(0.645)(14.2)}{4.00}} = 343 \text{ scfm air}$$

Fire condition

The minimum required capacity of the primary and secondary relief devices in scfm of air is given in paragraph 5.3.3 of CGA S-1.3 as:

$$Q_a = FG_i UA^{0.82} \qquad \text{(eqn. A-4)}$$

where, F = correction factor
G_i = gas factor for insulated containers
U = Overall heat transfer coefficient, Btu/hr-ft^2-K
A = mean surface area of insulation, square feet

The temperature at which to evaluate this equation is per par 5.1.3, where the function $\dfrac{\sqrt{v}}{v\left[\dfrac{\partial h}{\partial v}\right]_p}$ is a maximum. This function can be obtained by using HePak computerized helium tables. At 108.9 psia, this function is a maximum value at 8.18 K (14.7 °R).
Per Note 3 of Table 1 in CGA S-1.3, the gas factor for super critical helium is to be determined as in Appendix 6A of *Technology of Liquid Helium*.

$$G_i = \frac{0.097(1200 - t)}{L'}\sqrt{ZT} \qquad \text{(eqn. A-5)}$$

where, t = -445.3 °F (8.18 K)
L' = 13.93 Btu/lb efflux (from HePak)
T = 14.7 R (8.18 K)
Z = 0.662 compressibility factor (from HePak)

Substituting into eqn. A-5:

$$G_i = \frac{0.097(1200 + 445.3)}{13.93}\sqrt{(0.662)(14.7)} = 35.79$$

The overall heat transfer coefficient, U, is that of the insulating material of the container when saturated with gaseous helium or air at atmospheric pressure and the mean temperature, whichever is greater. From Table C-1, the thermal conductivity of helium at the mean temperature between 1200 °F and saturation is k_{He} = 0.121838 Btu/hr-ft^2-°F.

$$U = \frac{k_{He}}{t_{insulation}} = \frac{0.121838 \;\; \text{Btu/hr}\cdot\text{ft}\cdot{}^\circ\text{F}}{0.1667 \text{ ft}} = 0.731 \;\; \text{Btu/hr}\cdot\text{ft}^2\cdot{}^\circ\text{F}$$

Finally, F = 1.0 since the upstream piping is less than 2 feet long. Substituting into eqn. A-4:

$$Q_a\Big|_{fire} = (1.0)(35.79)(0.731)(120.05)^{0.82} = 1327 \text{ scfm air}$$

Operator error failure mode

This failure occurs when the dewar is full of liquid helium (3,000 L) and with the refrigerator at 300 K. The compressor is turned on and 300 K He gas flows into the dewar with D0BEVXJT 100% open and the wet engine at maximum speed (300 RPM). The analysis is identical to that presented in CDF Coil Design Note #79 [7]. Therefore, the detailed calculations have been omitted here, and only the minimum required capacity is reported.

$$Q_a\Big|_{\substack{operator\\error}} = 308 \text{ scfm air}$$

SUMMARY

Hazard Condition	Required Capacity, Q_a
loss of insulating vacuum	198 scfm air
air conduction + condensation	343 scfm air
fire	1327 scfm air
operator error	308 scfm air

REFERENCES

1. CGA S-1.3, *Pressure Relief Device Standards-Part 3-Stationary Storage Containers for Compressed Gases*, Compressed Gas Association, Inc., Arlington, VA, 1995

2. NBS Monograph 111, *Technology of Liquid Helium*, U.S. Government Printing Office, Washington, D.C., 1968

3. NIST Tech. Note 1334, T*hermophysical Properties of Helium-4 from 0.8 to 1500 K with Pressures to 2000 MPa*, U.S. Government Printing Office, Washington, D.C., 1989

4. J. Howell, R. Buckius, *Fundamentals of Engineering Thermodynamics*, McGraw-Hill, Inc., New York, 1992

5. F. Incropera, D. DeWitt, *Fundamentals of Heat and Mass Transfer*, John Wiley and Sons, New York, 1990

6. R. Rucinski, *Specification for 3,000 Liter Liquid Helium Storage Dewar*, Fermi National Accelerator Laboratory, Batavia. IL. Sept. 1995

7. R. Fast, CDF Coil Design Note #79, *Effect of Operator Error Failure Mode on Safety of CDF LHe Storage Dewar*, Fermi National Accelerator Laboratory, Batavia, IL, Dec. 1984

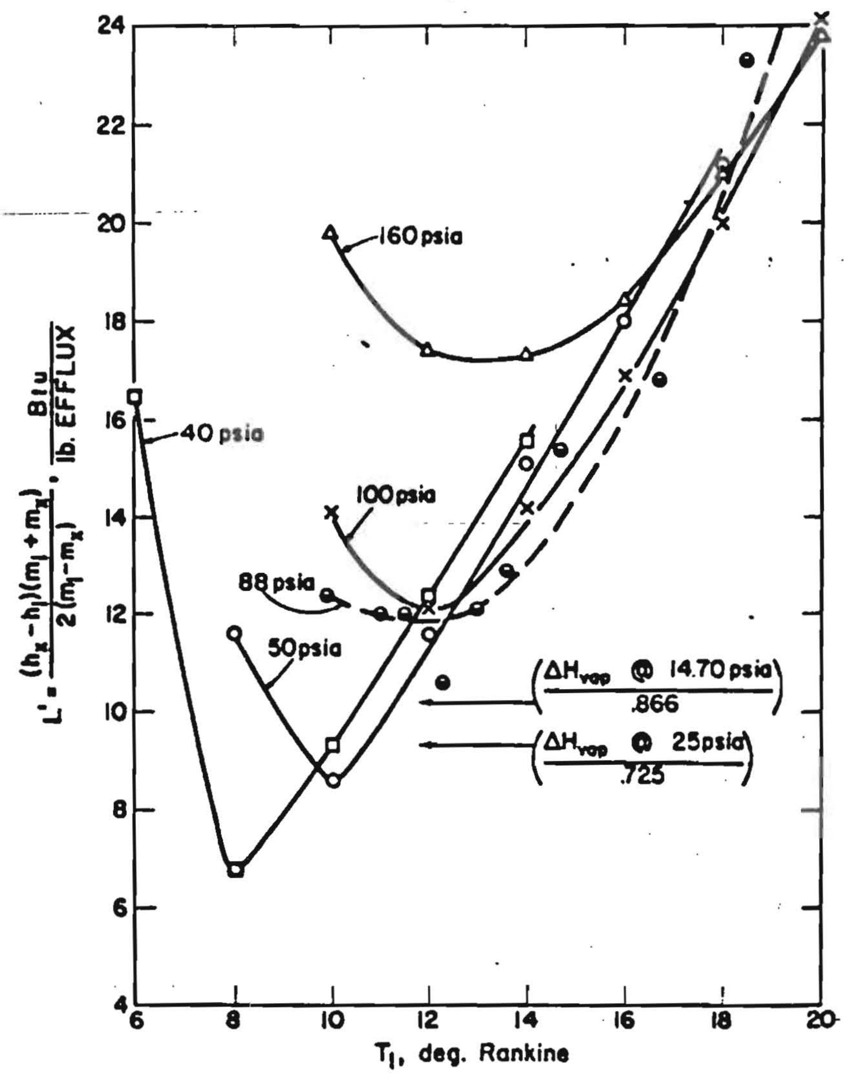


FIGURE 6A-2. *Heat absorbed per pound efflux for a helium container relieving above the critical pressure.*

Relief pressures of 40, 50, 88, 100, and 160 psia are indicated.

FIGURE C-1: HEAT ABSORBED PER POUND EFFLUX, FROM TECHNOLOGY OF LIQUID HELIUM

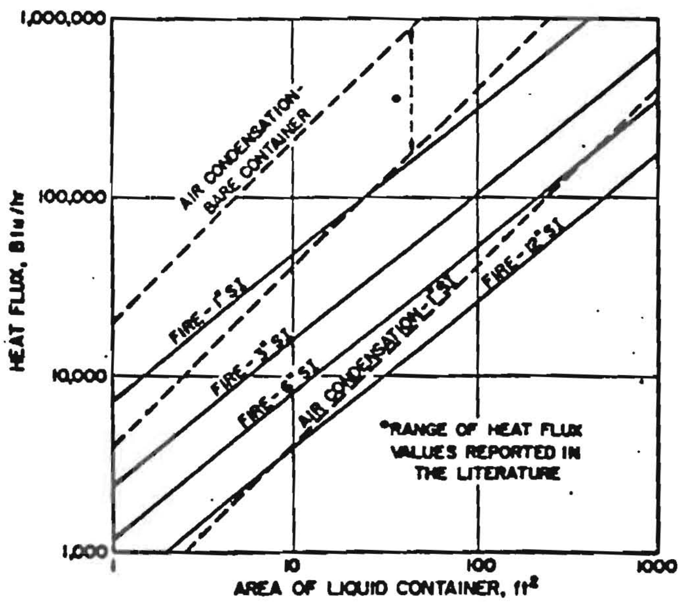


FIGURE 6.3. *Estimated total heat flux versus area for air condensation and fire conditions in multilayer (SI) insulated liquid helium containers.*

FIGURE C-2: HEAT FLUX vs. AREA, FROM TECHNOLOGY OF LIQUID HELIUM

Table 3
Thermal conductivity for refrigerated (cryogenic fluids) at the mean temperature between saturation and 1200 °F (649 °C) at 14.7 psia (101.325 kPa abs.)

FLUID	BTU/(hr.FT.°F)	kJ/(hr.m.°C)
Air (-130 °F to 1200 °F)	0.024573	0.153069
Argon	0.015812	0.098495
Carbon Dioxide	0.022819	0.142143
Carbon Monoxide	0.022342	0.139171
Helium	0.121838	0.758945
Hydrogen	0.1254	0.781133
Methane	0.043032	0.268052
Neon	0.03882	0.241815
Nitrogen	0.023236	0.14474
Oxygen	0.025041	0.155984

TABLE C-1 : THERMAL CONDUCTIVITY OF He FROM CGA STANDARDS

APPENDIX D

PER CONVERSATION WITH R.RUCINSKI & K.KREMPETZ ON 5/23/96 THE RELIEVING STRATEGY FOR THE 3,000 L HELIUM STORAGE DEWAR IS AS FOLLOWS:

1) PRIMARY RELIEF: (RD1) IS A 2" RUPTURE DISK SET @ 75 PSIG. THIS DEVICE HANDLES ALL FAILURE CONDITIONS, INCLUDING FIRE.

2) SECONDARY RELIEF: (RV2) IS A 2" ANDERSON - GREENWOOD RELIEF VALVE SET @ PSIG. IT IS INTENDED TO OPEN @ 70% OF THE PRIMARY RELIEF DEVICE'S (RD1) SET PRESSURE SO AS TO PREVENT ANY UNNECESSARY WEAKENING OF THE RUPTURE DISK.

CAPACITY OF RD1:

FOLLOWING FIKE TECHNICAL BULLETIN TB 8102, "RUPTURE DISK SIZING."

IS FLOW SONIC OR SUBSONIC?

$$\frac{P_e}{P_o} \leq \left(\frac{2}{k+1}\right)^{k/k-1} \quad \text{FOR SONIC FLOW}$$

P_e = 14.7 psia

P_o = 89.7 psia (MAWP)

k = 1.66 FOR HELIUM

$$\frac{14.7}{89.7} \overset{?}{\leq} \left(\frac{2}{1.66+1}\right)^{1.66/1.66-1}$$

$$.164 \leq .488 \quad \therefore \text{ FLOW IS SONIC!}$$

FERMILAB
ENGINEERING NOTE

SECTION	PROJECT	SERIAL-CATEGORY	PAGE
RD/DØ-MECH.	3823	115	D2

SUBJECT	NAME
CAPACITY OF INSTALLED RELIEFS; 3000 L He DEWAR FOR DØ REFRIGERATOR	TODD LEICHT
DATE: 8/27/96	REVISION DATE: 3-21-97 RAR

FOR SONIC FLOW, GIVEN Q_a IN SCFM OF AIR, THE REQUIRED ORIFICE AREA IS:

$$a = \frac{Q_a}{11.4\ P_o}$$

INSTALLED RD1 IS A FIKE 2" CPV RUPTURE DISK. NEEDS VACUUM SUPPORT FOR PUMP & PURGES.

$$a = \frac{\pi}{4}D^2 = \frac{\pi}{4}(2")^2 = 3.14\ in^2$$

THEN,

$$Q_a = (11.4)(3.14\ in^2)(89.7\ psi)$$

$$\boxed{Q_a = 3211\ \text{SCFM AIR}}$$

CAPACITY OF RV2:

INSTALLED RELIEF IS AN ANDERSON GREENWOOD 1½" x 2" RELIEF, MODEL 81S1216-G WITH SET PRESSURE = 48 PSIG.

STAMPED CAPACITY ON THE ASME NAMEPLATE IS

$\boxed{\text{508 SCFM AIR}}$ @ 110% SET PRESSURE

THIS IS CONSISTENT WITH THE CAPACITY CHARTS IN THE AGCO CATALOG.

FERMILAB ENGINEERING NOTE	SECTION RD/DØ	PROJECT LHe DEWAR	SERIAL-CATEGORY 3823.115	PAGE D3
SUBJECT RELIEF PIPING PRESSURE DROP		NAME RUSS RUCINSKI	DATE 11-11-96	REVISION DATE

- I WILL CALCULATE THE PRESSURE DROP IN THE RELIEF SYSTEM INLET PIPING AT THE MAXIMUM REQUIRED RELIEF CAPACITY.

$$Q_{a_{MAX}} = Q_{a_{FIRE}} = 1426 \text{ scfm AIR}$$

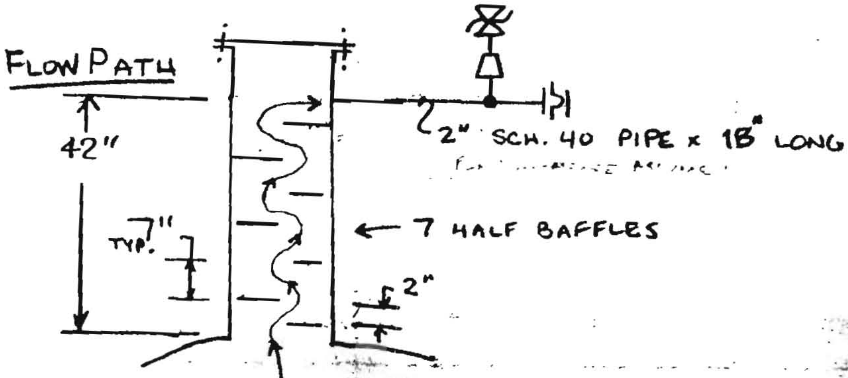
CONVERTING THIS TO A MASS FLOW RATE OF HELIUM @ 75 psig, 6.9 K :

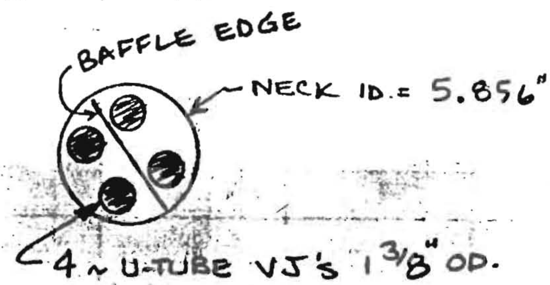
$$Q_a = \frac{13.1\, W C_a}{60\, C}\left(\frac{Z T M_a}{M Z_a T_a}\right)^{1/2}$$ EQN 6A-1 "TECHNOLOGY OF LIQUID HELIUM" NBS MONOGRAPH 111

$$W = \frac{Q_a\, 60 c}{13.1\, C_a}\left(\frac{M Z_a T_a}{Z T M_a}\right)^{1/2}$$ REF. CALCS. PG. C5 FOR Z, T

$$W = \frac{(1426 \text{ scfm air})\, 60\, (378)}{13.1\,(356)}\left[\frac{4.0\,(1.0)\,(520°R)}{0.67\,(12.45°R)\, 28.97}\right]^{1/2}$$

$$\underline{W = 20{,}346 \text{ lbm/hr}}$$ HELIUM @ 75 psig & 12°R





CROSS SECTION W/ U-TUBES

HYDRAULIC DIAMETER OF NECK:

$$D_{HYD} = \frac{4A_x}{\text{WETTED PERIMETER}}$$

$$D_{HYD} = \frac{4\left[\frac{\pi(5.856)^2}{4} - 4\,\frac{\pi(1.375)^2}{4}\right]}{\pi(5.856) + 4\,\pi(1.375)} \approx 2.354 \text{ IN.}$$

BAFFLES CAN BE MODELED AS SUDDEN CONTRACTIONS TO $\frac{1}{2} D_{HYD}$.

$$K_{BAFFLE} = 0.5\left(1 - \left[\frac{1/2\, D_{HYD}}{D_{HYD}}\right]^2\right)$$ EQN- 2-10 CRANE TECH. PAPER #410

$$K_{BAFFLE} = .375$$

FERMILAB ENGINEERING NOTE	SECTION RD/DØ	PROJECT LHe DEWAR	SERIAL-CATEGORY 3823.115	PAGE D4

SUBJECT	NAME	REVISION DATE
RELIEF PIPING PRESSURE DROP.	RUSS RUCINSKI	
	DATE 11-11-96	

REYNOLDS # FOR FLOW

$$Re = 6.31 \frac{W}{d\mu} = 6.31 \frac{(20{,}346 \frac{lbm}{hr})}{(2.354\,in.)(2.74\times10^{-6}\,Pa\text{-}s)(\frac{1000\,cp}{1\,Pa\text{-}s})}$$

$Re = 2.0\times10^{7}$ COMPLETE TURBULENCE $f_T = 0.019$

OTHER "FITTINGS"

~~ELBOW INTO 2" PIPE, $K = 60 f_T = 1.14$~~

TEE THRU RUN, $K = 20 f_T = .38$

$$\Sigma K = (.375)(7\ \text{BAFFLES}) + 1.14 + .38 = 4.145$$

$$L = K\frac{D}{f} = 4.145 \cdot \frac{(2.354/12\ ft)}{.019} = 42.8\ ft.$$

ASSUME TO BE = $D_{HYDRAULIC}$ FOR GAS

$$L_{TOTAL} = 42.8\ ft. + \frac{42" + 18"}{12} = 47.8\ ft.$$

$$\Delta P = 3.36\times10^{-6} \frac{f L W^2}{\rho d^5} = 3.36\times10^{-6} \frac{(.019)(47.8\,ft)(20{,}346\frac{lbm}{hr})^2}{(4.8103\frac{lb}{ft^3})(2.354\,in)^5}$$

$\Delta P = \underline{3.63\ psi}$

TO PUT THIS IN TANGIBLE TERMS OF A RELIEVING CASE;

1. PRESSURE RISES UNTIL RELIEF VALVE POPS. FULL RELIEF CAP. @ 75 psig INLET PRESSURE = 508 scfm AIR $\times \frac{75\ psig + 14.7}{1.1(48\ psig) + 14.7}$
   = 675 scfm AIR

   $$\Delta P\ @\ \text{FULL RELIEF FLOW} = (3.63\,psi)\left[\frac{675\,scfm}{1426}\right]^2 = 0.81\ psi$$

2. He DEWAR IS @ 75.81 psi WHEN RUPTURE DISC BLOWS. THE RELIEVING FLOW RATE THEN INCREASES TO THE COMBINED RUPTURE DISC & RELIEF CAPACITY. THE He DEWAR PRESSURE DROPS FROM IT'S MAXIMUM PRESSURE $= \frac{75.81 + 14.7}{75 + 14.7} = 101\%$ MAWP

Post-it® Fax Note 7672

To Russ
Company FERMILAB
Location
Fax # 630-840-8481
Telephone #
Comments

No. of Pages 1
Today's Date 8-23-96
Time
From TAM TU
Company CRYOFAB, INC.
Location
Dept. Charge
Fax # 908-686-9538
Telephone # 908-686-3636
Original Disposition ☐ Destroy ☐ Return ☐ Call for pickup

HERE'S THE COPY OF THE U-1 FORM FOR THE 3000 LITER HELIUM DEWAR. PLEASE CALL ME, IF YOU NEED A COPY MAILED TO YOU.
RGDS, Tam Tu

FORM U-1A MANUFACTURER'S DATA REPORT FOR PRESSURE VESSELS
(Alternative Form for Single Chamber, Completely Shop-Fabricated Vessels Only)
As Required by the Provisions of the ASME Code Rules, Section VIII, Division 1

1. Manufactured and certified by Westfield Sheet Metal Works, Inc. 261 Monroe Ave. Kenilworth NJ 07033 (Name and address of manufacturer)

2. Manufactured for Cryofab Inc. 540 Michigan Avenue Kenilworth, NJ 07033 (Name and address of purchaser)

3. Location of Installation Fermilab Batavia, Illinois 60510 (Name and address)

4. Type Vert. (Horiz. or vert., tank) 6668 (Mfg's serial No.) --- (CRN) B-1467 (Drawing No.) 108 (Nat'l. Bd. No.) 1996 (Year built)

5. The chemical and physical properties of all parts meet the requirements of material specifications of the ASME BOILER AND PRESSURE VESSEL CODE. The design, construction, and workmanship conform to ASME Rules, Section VIII, Division 1 1993 (Year)
to W1995 (Addenda (Date)) --- (Code Case No.) --- (Special Service per UG-120(d))

6. Shell: SA240-304 (Matl. (Spec. No., Grade)) 1/4" (Nom. Thk. (in.)) 0 (Corr. Allow. (in.)) 5'-8" OD (Diam. I.D. (ft. & in.)) 2'-6-3/4" (Length (overall) (ft. & in.))

7. Seams: DBL (Long. (Welded, Dbl., Sngl., Lap, Butt)) --- (R.T. (Spot or Full)) 70% (Eff. (%)) --- (H.T. Temp. (°F)) --- (Time (hr)) DBL & SNGL with backing (Girth (Welded, Dbl., Sngl., Lap, Butt)) --- (R.T. (Spot, Partial, or Full)) 1 (No. of Courses)

8. Heads: (a) Matl. SA240-304 (Spec. No., Grade) (b) Matl. SA240-304 (Spec. No., Grade)

	Location (Top, Bottom, Ends)	Minimum Thickness	Corrosion Allowance	Crown Radius	Knuckle Radius	Elliptical Ratio	Conical Apex Angle	Hemispherical Radius	Flat Diameter	Side to Pressure (Convex or Concave)
(a)	Top		0	--	--	2:1	--	--	--	Concave
(b)	Bottom		0	--	--	2:1	--	--	--	Concave

If removable, bolts used (describe other fastenings) --- (Matl., Spec. No., Gr., Size, No.)

9. MAWP 90 psi at max. temp. 100 °F
Min. design metal temp. -452 °F at 90 psi. Hydro., pneu., or comb. test pressure 135 psi.

10. Nozzles, inspection and safety valve openings:

Purpose (Inlet, Outlet, Drain)	No.	Diam. or Size	Type	Matl.	Nom. Thk.	Reinforcement Matl.	How Attached	Location
Inlet	1	6" Ø	Nozzle	SA312-304	5/16	SA240-304	Welded	Top
Outlet	1	3/4" Ø	Cpl'g	SA182-304	3000#	Not Required	Welded	Top

Supports: Skirt ____ (Yes or no) Lugs ____ (No.) Legs ____ (No.) Other ____ (Describe) Attached ____ (Where and how)

12. Remarks: Manufacturer's Partial Data Reports properly identified and signed by Commissioned Inspectors have been furnished for the following items of the report: Hydro tested in vertical position, safety valve located elsewhere in system per UG-125. (Name of part, item number, Mfg's name and identifying stamp)

Impact tested as per UHA-51(a).

CERTIFICATE OF SHOP COMPLIANCE

We certify that the statements made in this report are correct and that all details of design, material, construction, and workmanship of this vessel conform to the ASME Code for Pressure Vessels, Section VIII, Division 1. "U" Certificate of Authorization No. 15,598 expires Feb. 5, 19 98.

Date ______ Co. name Westfield Sheet Metal Works, Inc. Signed [signature] (Representative) William F. Nicolson

CERTIFICATE OF SHOP INSPECTION

Vessel constructed by Westfield Sheet Metal Works, Inc at 261 Monroe Ave. Kenilworth, NJ 07033.

I, the undersigned, holding a valid commission issued by the National Board of Boiler and Pressure Vessel Inspectors and/or the State or Province of New Jersey and employed by Hartford Steam Boiler I&I Co. have inspected the component described in this Manufacturer's Data Report on 4-4, 19 96, and state that, to the best of my knowledge and belief, the Manufacturer has constructed this pressure vessel in accordance with ASME Code, Section VIII, Division 1. By signing this certificate neither the Inspector nor his employer makes any warranty, expressed or implied, concerning the pressure vessel described in this Manufacturer's Data Report. Furthermore, neither the Inspector nor his employer shall be liable in any manner for any personal injury or property damage or a loss of any kind arising from or connected with this inspection.

Date 4-4 Signed [signature] (Authorized Inspector) Commissions NB 11422-17 (Nat'l Board (incl. endorsements), State, Prov. and No.)

This Form (E00117) may be obtained from the ASME Order Dept., 22 Law Drive, Box 2300, Fairfield, NJ 07007-23

TEST DOCUMENTATION
CODE STAMPED RELIEF VALVES

This procedure would be used for relief valves returned from a vendor to check the accuracy and quality of the vendor's work. It would also be used to check code stamped valves for the 6 year test. Valves that pass this test can be put in service if the original seal from a vendor is still in place and not broken.

All valves should be bubble tight at 90% of set pressure while increasing pressure, lift within the code requirement, and reset bubble tight. Reset pressure as a percent of set pressure would vary, depending on the blowdown setting.

The valve should be connected to the appropriate test chamber with adapters as required being careful not to choke the valve with fittings smaller than the valve inlet.

Date - 10-31-1996

Vessel number (from silver sticker) - RD10036

Physical location and valve number - A0 SV2502-H

Manufacturer - Anderson Greenwood

Model number - 81S1216-G

Serial number - 86/02167

Valve size - 1½" x 2"

Seal intact - yes

Set pressure - 48 psig

Bubble tight at 90% set pressure - @43.2 psig - yes

Valve lift within +/- 2 psig for settings 70 psig and below or within 3% for higher settings? Tolerances defined by UG- 134(d) (1)

Test 1 - 49.5 psig Test 2 - 49.3 psig Test 3 - 49.3 psig

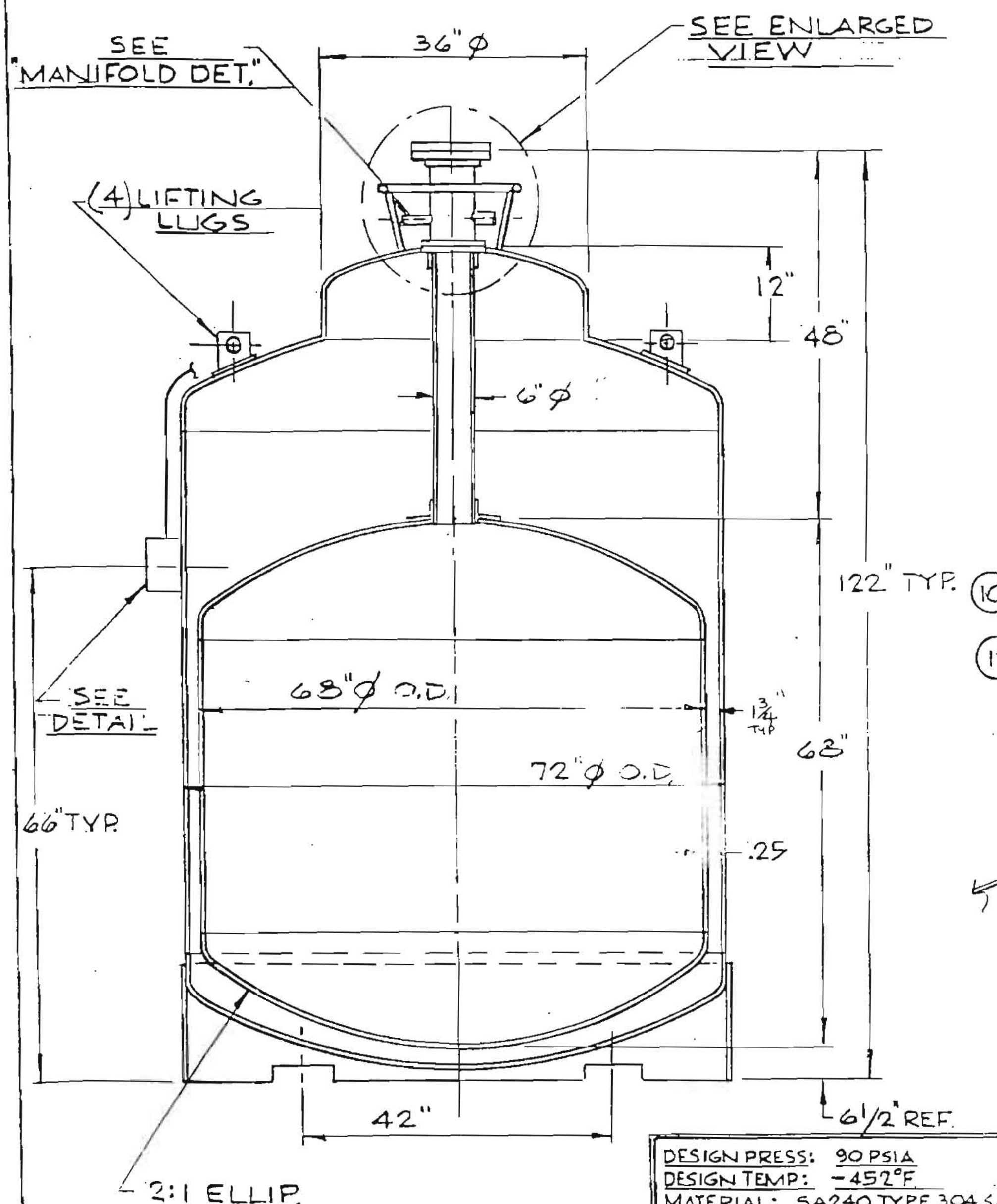
Bubble tight at reset - @43.2 psig - OK

If valve passed test attach a brass tag to valve with "TESTED", set pressure, date, and tester's initials.

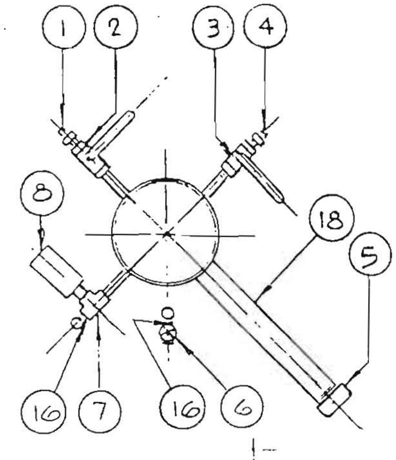
Signed [signature]

Date 10-31-1996

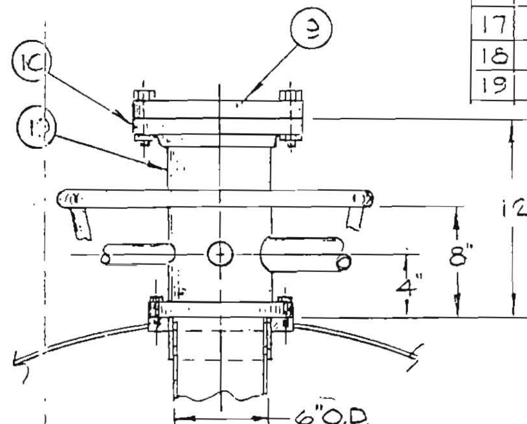
JMD
4-96



DESIGN PRESS: 90 PSIA
DESIGN TEMP: −452°F
MATERIAL: SA240 TYPE 304 S/S
ALL DIMENSIONS IN INCHES

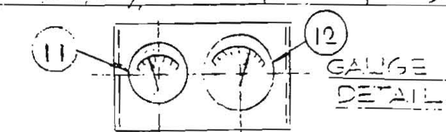


MANIFOLD DETAIL

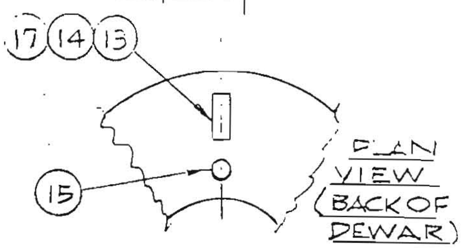


ENLARGED VIEW

PARTS LIST			
NO.	REQ	DESCRIPTION	MAT'L
1	1	HEX. NIPPLE, 1/2"NPT	BRASS
2	1	BALL VALVE, 1/2"NPT	S/S
3	1	BALL VALVE, 1/4"NPT	BRONZE
4	1	RELIEF VALVE, 1/4"NPT, 1/2 PSIG	BRASS
5	1	PIPE CAP, 2"NPT	S/S
6	1	NEEDLE VALVE, 1/8"NPT	
7	1	TEE, 1/4"NPT	BRASS
8	1	OSCILLATION CHAMBER	304 S/S
9	1	BLIND FLG, 150# STD.	S/S
10	1	LAP JOINT FLG, 150# STD	S/S
11	1	COMPOUND GAUGE 30HG-0-100PSIG	S/S
12	1	LIQUID LEVEL GAUGE	S/S
13	1	CVI SEAL-OFF VALVE, V-1046-31	
14	1	GAUGE TUBE, DV-6R	
15	1	CRYOFAB SEAL-OFF VALVE, S-[illegible]	
16	2	FITTING, 1/8" TUBE×1/4"NPT	
17	1	COVER	S/S
18	1	PIPE, 2" SCH.40, 12" LG	304 S/S
19	1	TUBE, 6 3/4" O.D. × 105" THK.	304 S/S



GAUGE DETAIL



PLAN VIEW (BACK OF DEWAR)

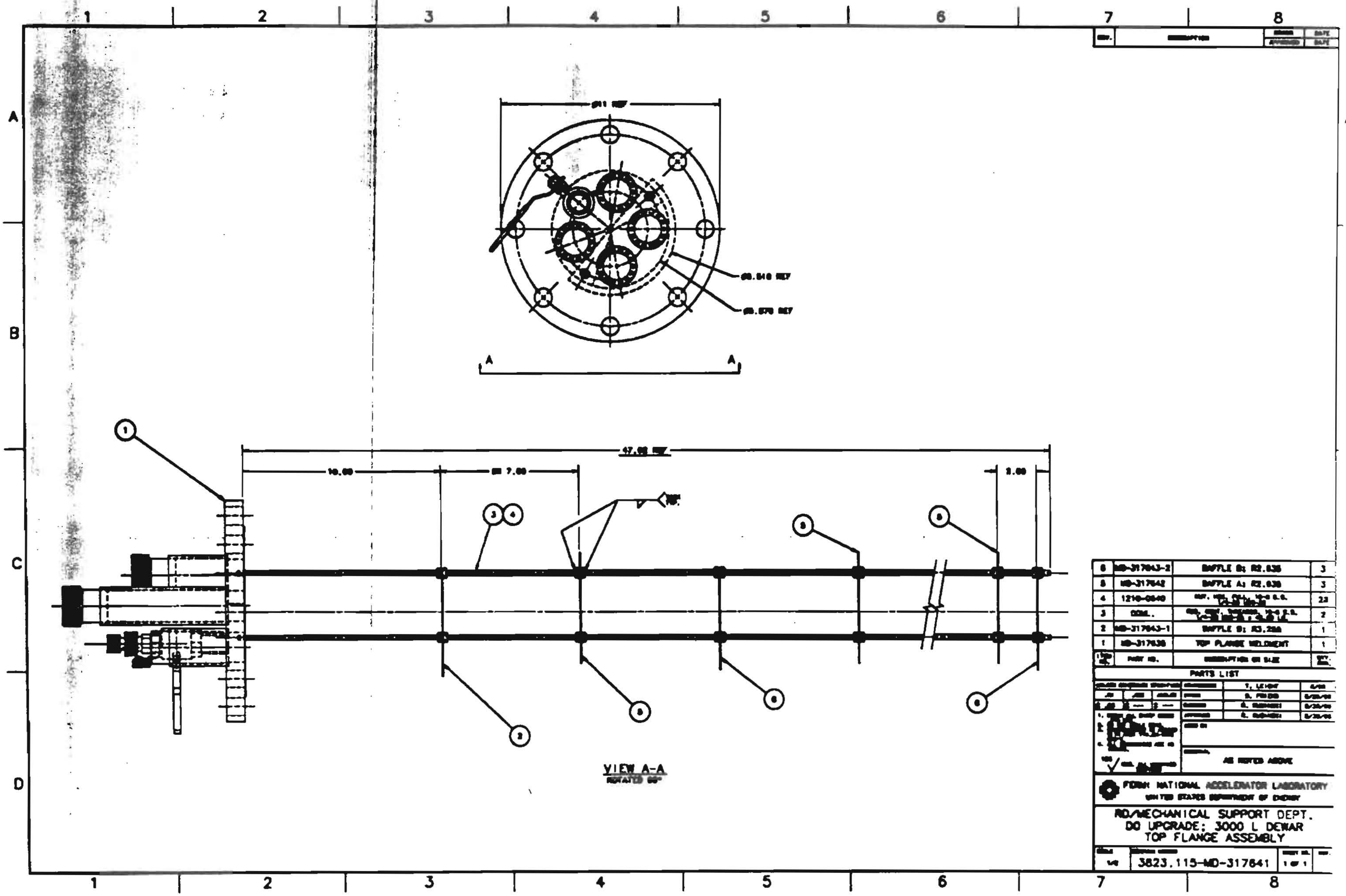
ISSUE	DATE	BY	REVISION

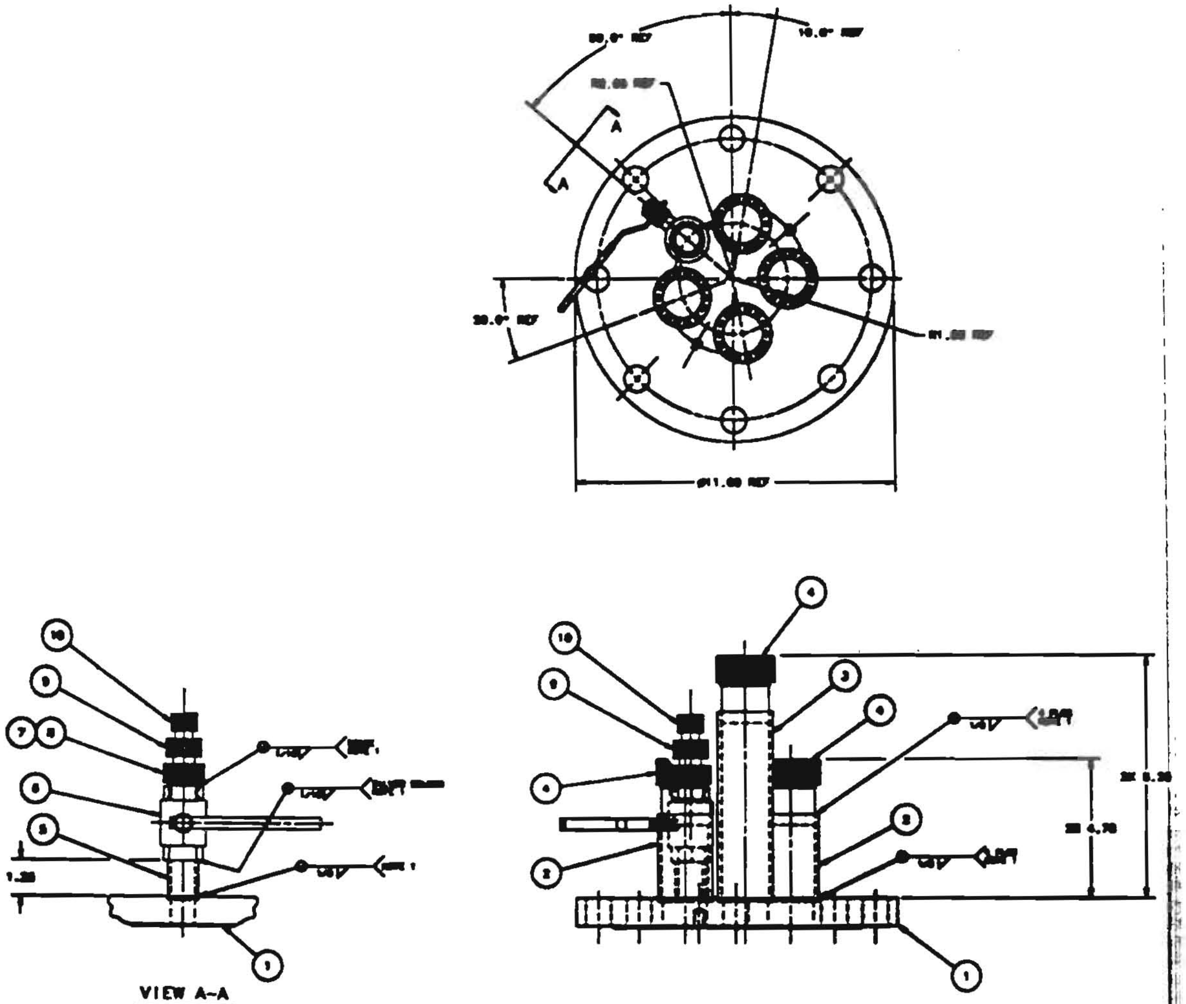
REVISIONS

CRYOFAB
KENILWORTH, N.J 07033

MULTISHIELDED LIQUID HELIUM STORAGE DEWAR, 3000 LITER CAPACITY

MADE	CHECKED	SCALE	CERTIFIED	DRAWING NO.	REV.
EWB 4/11/96		NTS	G.G. 4/16/96	CMSH-3000	-


VIEW A-A
47.00 REF
10.00
7.00
2.00
A
A
MD-317643-2
BAFFLE B: R2.835
MD-317642
BAFFLE A: R2.835
1210-0640
COML.
MD-317643-1
BAFFLE B: R3.250
MD-317636
TOP FLANGE WELDMENT
PART NO.
DESCRIPTION OR SIZE
PARTS LIST
T. LEIGHT
AS NOTED ABOVE
FERMI NATIONAL ACCELERATOR LABORATORY
UNITED STATES DEPARTMENT OF ENERGY
RD/MECHANICAL SUPPORT DEPT.
DO UPGRADE: 3000 L DEWAR
TOP FLANGE ASSEMBLY
3823.115-MD-317641
1 OF 1



NOTE:

1. VACUUM TEST ... NO LEAK SHALL BE DETECTABLE ON THE MOST SENSITIVE SCALE OF A HELIUM LEAK DETECTOR WITH A MINIMUM SENSITIVITY OF 10-9 ATM CC/SEC.

10	EXIST.	[illegible]	1
9	EXIST.	[illegible]	1
8	EXIST.	[illegible]	1
7	[illegible]	[illegible]	1
6	[illegible]	[illegible]	1
5	[illegible]	[illegible]	1
4	[illegible]	[illegible]	4
3	[illegible]	EXTENSION PIPE; 1-1/2 I.P.S.	2
2	[illegible]	EXTENSION PIPE; 1-1/2 I.P.S.	2
1	[illegible]	TOP [illegible] FLANGE	1
[illegible]	PART NO.	DESCRIPTION OR SIZE	[illegible]

PARTS LIST

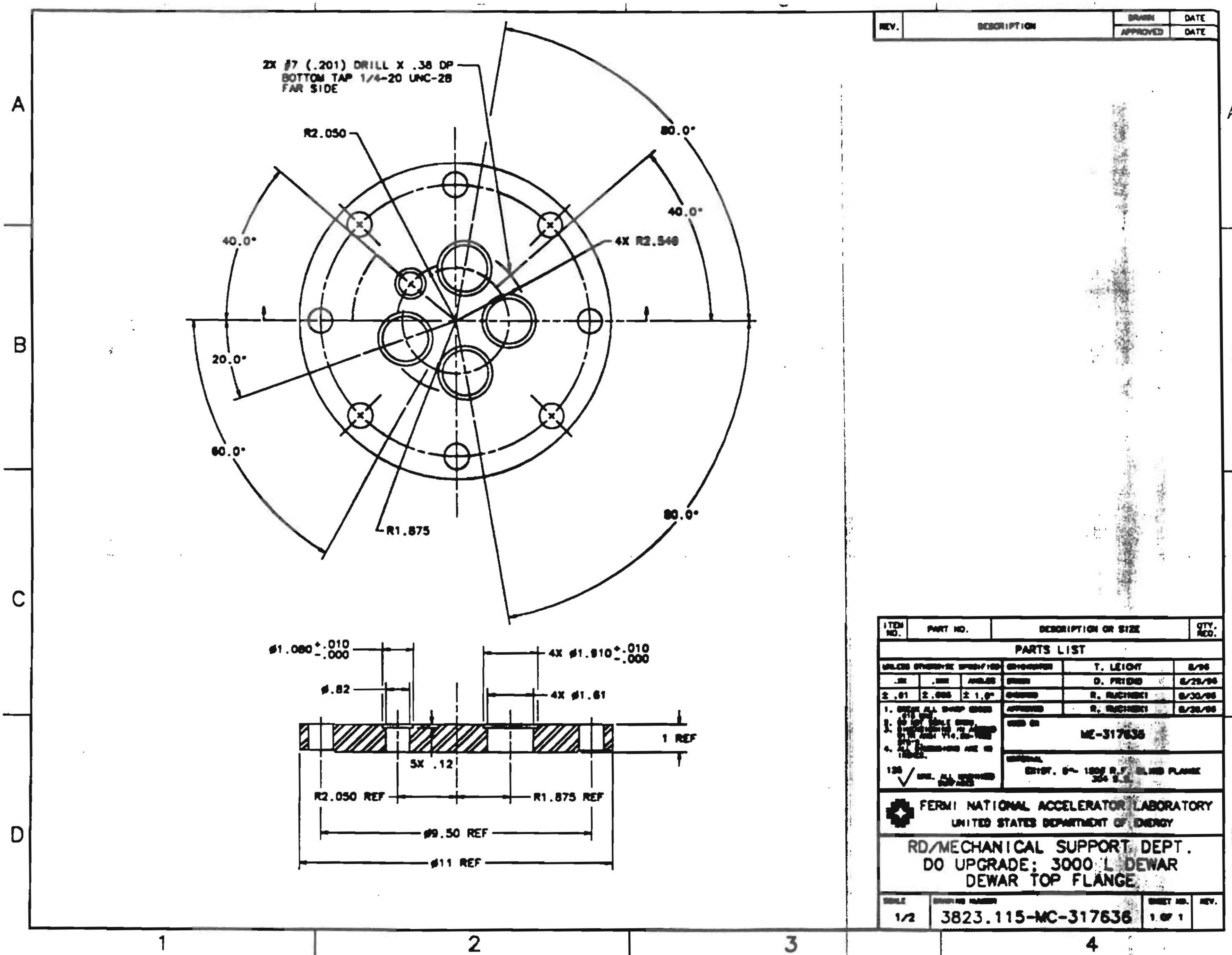
AS NOTED ABOVE

FERMI NATIONAL ACCELERATOR LABORATORY
UNITED STATES DEPARTMENT OF ENERGY

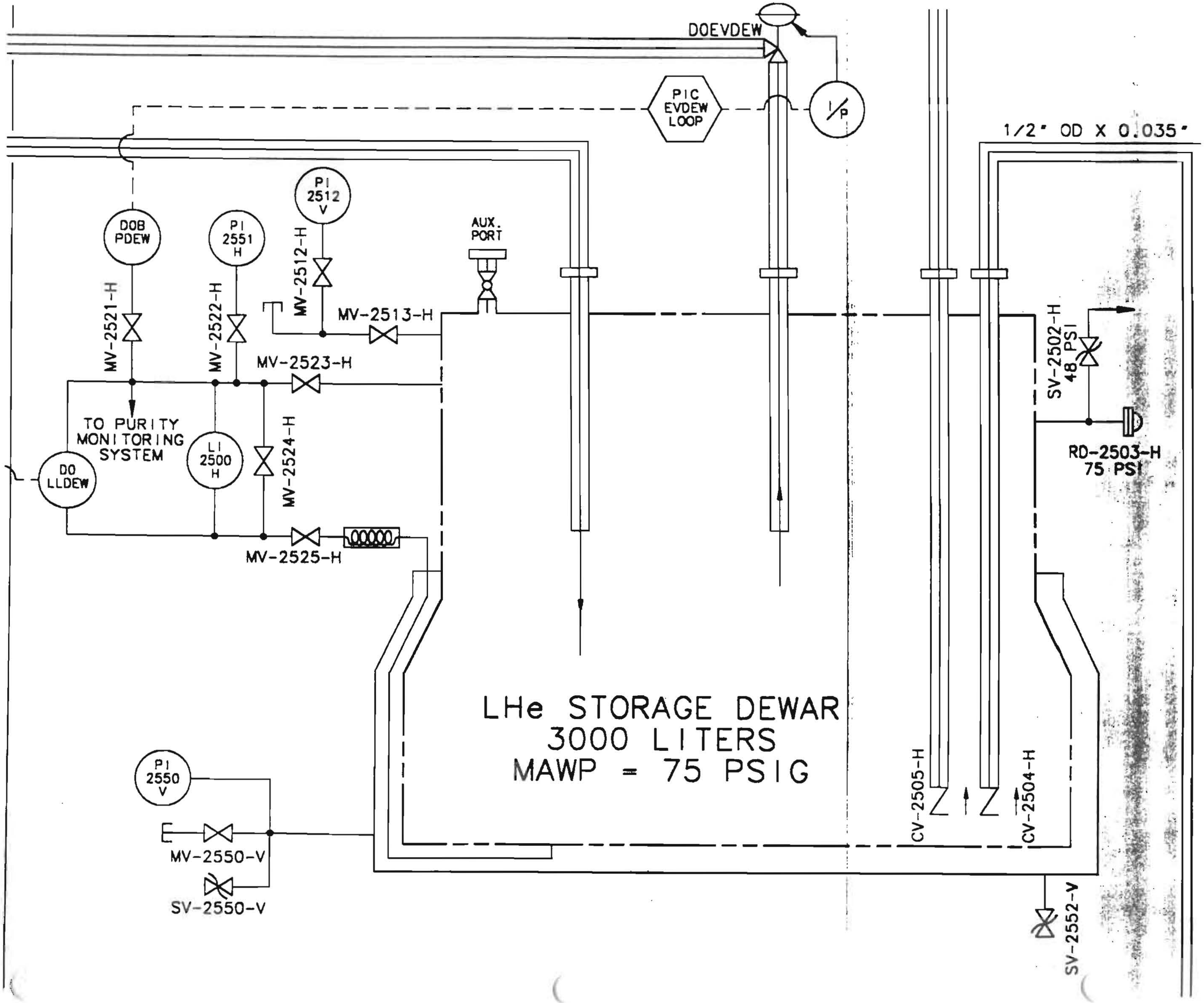
RD/MECHANICAL SUPPORT DEPT.
D0 UPGRADE: 3000 L DEWAR
TOP FLANGE WELDMENT

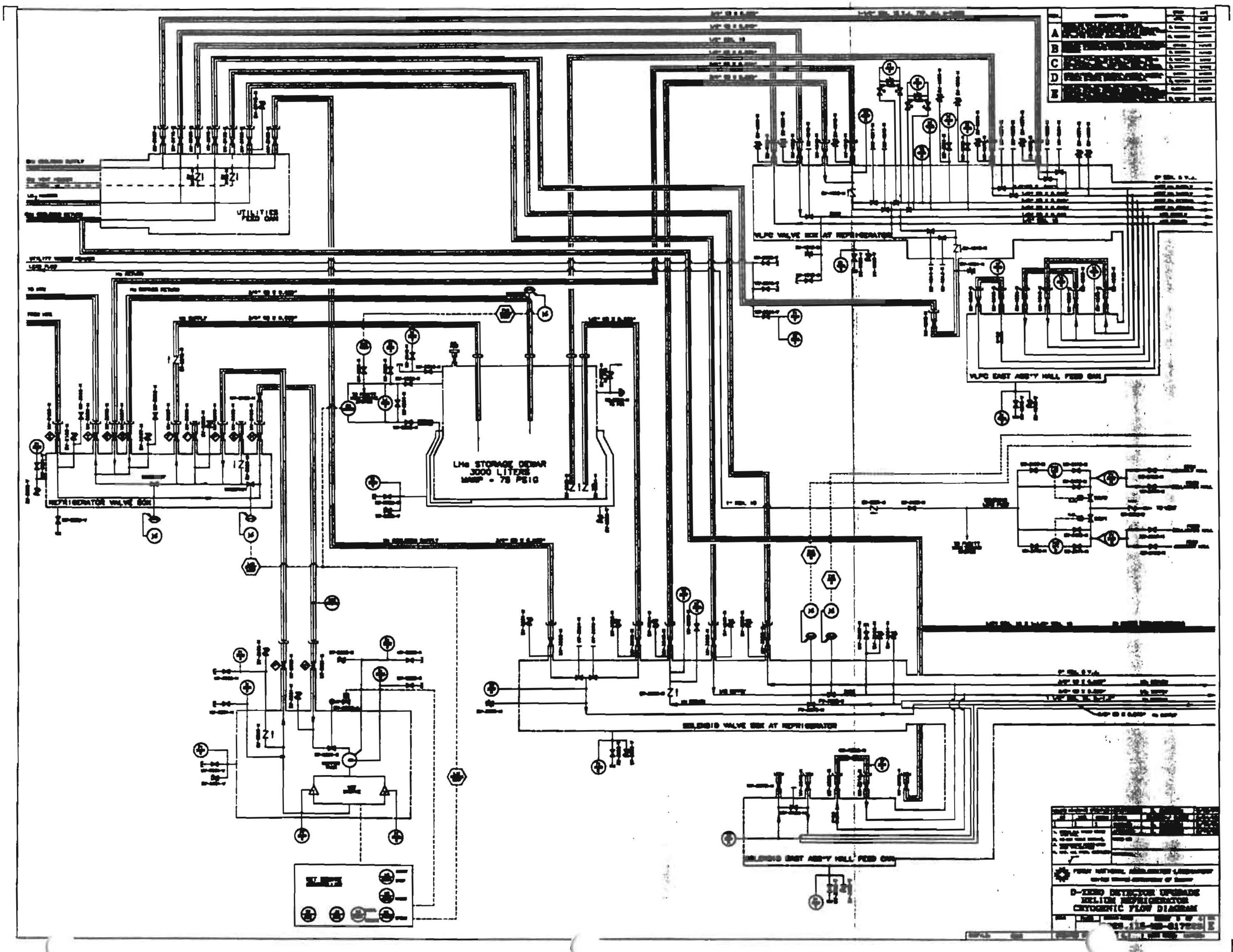
3823.118-MD-317835

1 OF 1



REV.
DESCRIPTION
DATE
DATE
2X #7 (.201) DRILL X .38 DP
BOTTOM TAP 1/4-20 UNC-2B
FAR SIDE
R2.050
80.0°
40.0°
40.0°
4X R2.546
20.0°
60.0°
80.0°
R1.875
ø1.080 +.010 -.000
4X ø1.910 +.010 -.000
ø.82
4X ø1.61
1 REF
5X .12
R2.050 REF
R1.875 REF
ø9.50 REF
ø11 REF
ITEM NO.
PART NO.
DESCRIPTION OR SIZE
QTY. REQ.
PARTS LIST
T. LEICHT
D. FRIEND
R. RUCINSKI
R. RUCINSKI
± .01
ME-317636
FERMI NATIONAL ACCELERATOR LABORATORY
UNITED STATES DEPARTMENT OF ENERGY
RD/MECHANICAL SUPPORT DEPT.
DO UPGRADE: 3000 L DEWAR
DEWAR TOP FLANGE
1/2
3823.115-MC-317636


DOEVDEW
PIC EVDEW LOOP
I/P
1/2" OD X 0.035"
PI 2512 V
DOB PDEW
PI 2551 H
AUX. PORT
MV-2512-H
MV-2513-H
MV-2521-H
MV-2522-H
MV-2523-H
SV-2502-H 48 PSI
TO PURITY MONITORING SYSTEM
DO LLDEW
LI 2500 H
MV-2524-H
RD-2503-H 75 PSI
MV-2525-H
LHe STORAGE DEWAR
3000 LITERS
MAWP = 75 PSIG
PI 2550 V
MV-2550-V
SV-2550-V
CV-2505-H
CV-2504-H
SV-2552-V


UTILITIES FEED CAN
REFRIGERATOR VALVE BOX
LHe STORAGE DEWAR
3000 LITERS
MAWP - 75 PSIG
VLPC VALVE BOX AT REFRIGERATOR
VLPC EAST ASS'Y HALL FEED CAN
SOLENOID VALVE BOX AT REFRIGERATOR
SOLENOID EAST ASS'Y HALL FEED CAN
D-ZERO DETECTOR UPGRADE
HELIUM REFRIGERATOR
CRYOGENIC FLOW DIAGRAM

SPECIFICATION FOR

3,000 LITER

LIQUID HELIUM STORAGE DEWAR

D-ZERO EXPERIMENT - 823

D-ZERO ASSEMBLY BUILDING

FERMILAB, ILLINOIS

Written by: Russ Rucinski
RD/DØ Mechanical
September 21, 1995

1.0 Scope

1.1 This specification defines the requirements for a liquid helium storage dewar to be installed inside the D-Zero assembly building, Fermilab, Illinois.

2.0 Dewar Description

2.1 Process Flow diagram	Drg. # 3823.115-MA-317450
2.2 Configuration:	Vertical, Vacuum Insulated
2.3 Diameter:	6.0 feet nominal outside diameter
2.4 Capacity:	
2.4.1 Gross Capacity	869 gallons (3,300 liters)
2.4.2 Net Capacity	790 gallons (3,000 liters)

3.0 Dewar Design Requirements

3.1 Design Pressure:

3.1.1 Inner Vessel

Maximum Allowable Working Pressure is 75 psig internal pressure with full vacuum externally. (This is 90 psi design pressure.)

3.1.2 Inner Vessel

Full vacuum internally with outer vacuum vessel at atmospheric pressure

3.2 Design Temperature: - 452 Degrees Fahrenheit

3.3 Normal Operating parameters:

3.3.1 Application: Liquid Helium buffer volume

3.3.2 Contents: 790 gallons liquid Helium

3.3.3 Normal Operating Pressure: 26.5 psia

3.4 Maximum Boil-off rate: 0.5 % per day

3.5 Handling Provisions: The dewar shall have lifting lugs and fork lift provisions for moving empty dewar at installation.

3.6 Temperature depression: When in normal operation, no outside area of the vacuum vessel, neck, or access port shall have a temperature more than 10 degrees Fahrenheit below ambient when warmed solely by free convection of ambient air.

3.7 Delivered Condition: The inside surfaces of the pressure vessel, piping, tubing, and inside surfaces of the vacuum vessel shall be clean. No oil, grease, dirt, soil, scale, residue or other form of surface contaminant shall be present.

4.0 Dewar Design Criteria

4.1 The dewar shall consist of an all welded stainless steel inner helium reservoir enclosed by an all welded stainless steel vacuum jacket.

4.2 Multi layer superinsulation shall be installed between the inner and outer vessel in the high vacuum space.

4.3 The use of liquid nitrogen cooled radiation shield(s), helium gas vapor cooled radiation shield(s), or any other multi shielding technique may be used to meet the maximum boil-off rate requirement.

4.4 The inner vessel shall be built and stamped in accordance with the ASME pressure vessel code, Section VIII for the Maximum Allowable Working Pressure in 3.1 above, and design temperature in 3.2 above, and shall be registered with the national board.

4.5 The outer vessel (vacuum jacket) shall be designed for full vacuum internally with a safety factor not less than two. (Minimum collapse pressure of 30 psi.)

5.0 Piping

5.1 All piping shall be of weldable AISI 300 series stainless steel, and shall be formed from continuous lengths of pipe or tubing to the maximum extent practical. All joints within the vacuum space shall be welded.

5.2 Threaded connections at gages shall be made up with an epoxy type thread sealant.

5.3 Neck: A 6" pipe size vertical neck shall connect the inner vessel to a room temperature access port. The outer vessel vacuum jacket shall extend up the neck a minimum of 36". In addition, the uninsulated portion of the neck shall be a minimum of 12"

5.4 Access Port: The room temperature access port shall consist of a 6" pipe size flange, AISI 300 series stainless steel, with o-ring groove, welded to the top of the neck and a 6" pipe size blind flange, AISI 300 series stainless steel, bolted on for closure. A standard size o-ring shall make the port leak tight. Provide one extra o-ring as a spare.

5.5 Relief Port: A 2" stainless steel pipe with 2" NPT thread and pipe cap shall extend from the side of the vertical neck. The pipe shall extend approximately 12" from the neck.

5.6 Pump out port: A 1/2" stainless steel pipe with stainless steel ball valve shall be provided.

5.7 Liquid level gage: The dewar shall be provided with a differential pressure liquid level gage, connected between the top and bottom gage lines. Two shut-off valves and a by-pass valve shall be provided. An oscillation damper shall be provided if necessary. A liquid inventory versus gage indication chart shall be provided.

5.8 Pressure gage: The dewar shall be provided with a 100 psig pressure gage attached to the top gage line. The gage shall be rated to withstand vacuum service.

5.9 Additional gage ports: Two additional capped gage ports (as shown on the Process Flow diagram, Drg. # 3823.115-MA-317450) shall be connected to the top and bottom gage lines.

5.10 Vacuum vessel relief port: The outer vessel shall be protected by a relief device having a discharge area of at least 1.8 square inches and opening at a pressure not more than the lesser of the internal design of the outer vessel (as calculated by the ASME code) or 15 psig.

5.11 Vacuum vessel pump out port: In addition to 5.10 above, a vacuum seal off valve with 1/8" FNPT connection, CVI incorporated model V-1046-31 shall be provided. The vendor is CVI incorporated, P.O. Box 2138, Columbus, Ohio, 43216, phone: (614)-876-7381, fax: (614)-876-5648.

5.12 Vacuum vessel Vacuum Gage: A battery operated vacuum gauge tube, Teledyne Hastings-Raydist model DV-6R shall be installed in the 1/8" FNPT hole of 4.10 above. The vendor is Teledyne Brown Engineering Hastings Instruments, P.O. Box 1436, Hampton, Virginia, 23661-0436, phone: (804)-723-6531, fax: (804)-723-3925.

6.0 Testing and documentation

[In addition to testing required by the ASME code]

6.1 The dewar and piping described in 4.0 above shall be helium mass-spectrometer leak tested for vacuum tightness of the inner and outer vessels. No leak shall be detectable on the most sensitive scale of a helium leak detector with a minimum sensitivity of 10^{-9} atm. cc/sec.

6.2 The manufacturer shall furnish to the buyer the code form, U-1 for the inner pressure vessel.

6.3 The ASME Pressure vessel code nameplate or duplicate is to be readily visible.

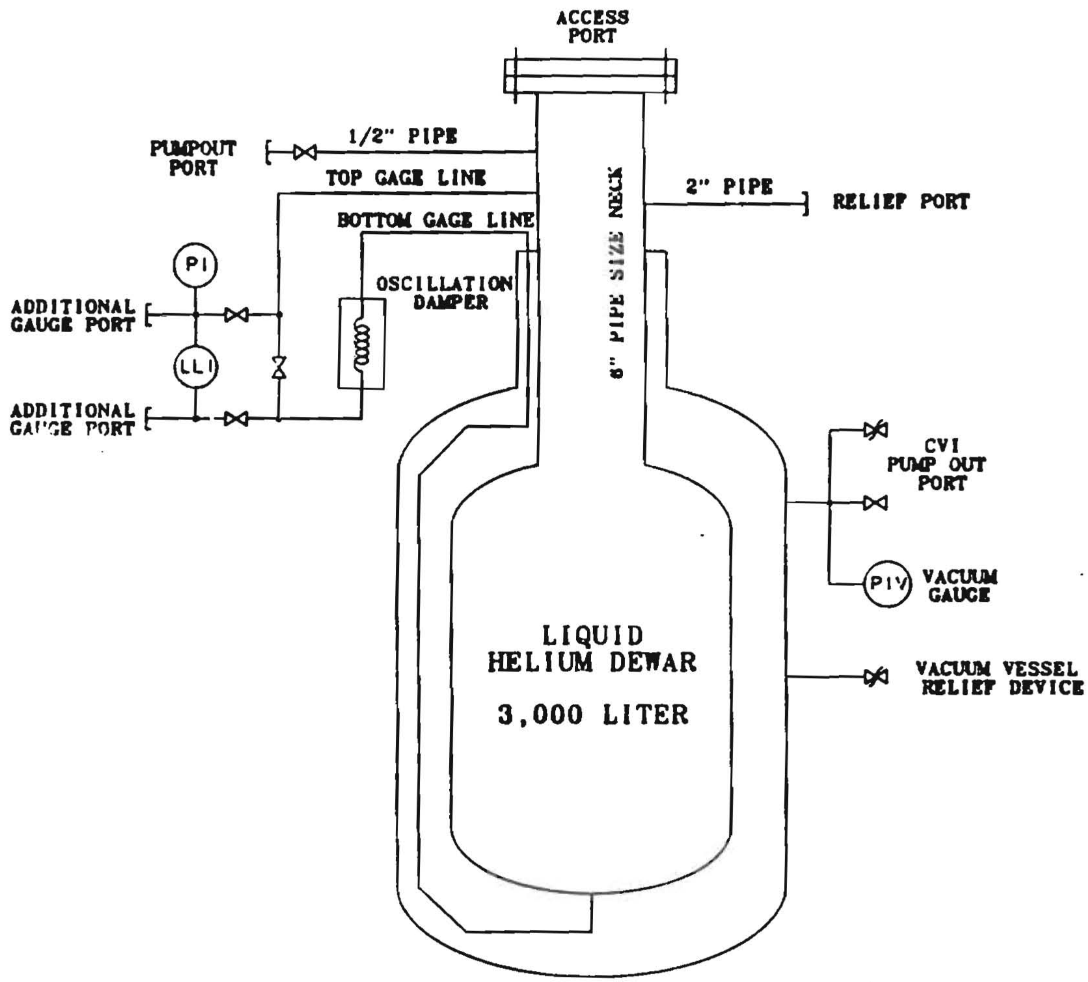
6.4 The manufacturer shall furnish the buyer with an assembly drawing of the dewar which shows overall dimensions and basic construction information.

7.0 Warranty

7.1 General: Manufacturer to warrant material and workmanship for a period of not less than one year from the date of delivery to Fermilab, Batavia, IL.

7.2 Vacuum: The vacuum vessel pressure must be less than 10^{-3} Torr when delivered to Fermilab. When cold and isolated, the vacuum vessel must be capable of not exceeding 10^{-3} Torr for a period of six months.

REV.	DESCRIPTION	DRAWN / APPD.	DATE / DATE



ITEM	PART NO.	DESCRIPTION OR SIZE	QTY.
PARTS LIST			

UNLESS OTHERWISE SPECIFIED					
FRACTION ±	DECIMAL ±	ANGLES ±	ORIGINATOR	R. RUCINSKI	9/18/95
			DRAWN	A. KUWAZAKI	9/18/95
			CHECKED	R. RUCINSKI	9/19/95
			APPROVED	K. KREMPETZ	9/20/95

1. BREAK ALL SHARP EDGES 1/64 MAX.
2. DO NOT SCALE DRAWING.
3. DIMENSIONS BASED UPON ANSI Y14.5M-1982
4. MAX. ALL MACH. SURFACES

USED ON

MATERIAL

FERMI NATIONAL ACCELERATOR LABORATORY
UNITED STATES DEPARTMENT OF ENERGY

D-ZERO DETECTOR LIQUID HELIUM DEWAR FLOW DIAGRAM

SCALE	FILMED	DRAWING NUMBER	REV.
N.T.S.		3823.115-MA-317450	

CADFILE: XDCS | CREATED WITH I-DEAS 4.1 | USER NAME: R. RUCINSKI

Plotted Thu Sep 21 14:40:40 CDT 1995 by maleski

[redacted]

Vacuum Vessel Engineering Note
(per Fermilab ES&H Manual Chapter 5033)

[CONTACT: RUSS RUCINSKI]

Prepared By TODD M. LEICHT Date 8/23/96 Div/Sec RD/DØ-MECH.

Reviewed By Date 3/27/97 Div/Sec BD/Cryogenics

Div/Sec Head Date 4/22/97 Div/Sec Particle Physics

~~* THIS VACUUM VESSEL HAS A VOLUME LESS THAN 35 ft³ AND IS THEREFORE EXEMPTED FROM FESHM 5033. ACTUAL VOL = 31.2 ft³.~~

1. Identification and Verification of Compliance

Fill in the Fermilab Engineering Conformance Label information below:

This vessel conforms to Fermilab ES&H Manual Chapter 5033

Vessel Title DØ UPGRADE - 3,000 L He DEWAR VACUUM VESSEL

Vessel Number RDV-10036

Vessel Drawing Number CMSH - 3000

Internal MAWP > 2 psig

External MAWP 30 PSI

Working Temperature Range -20 °F 120 °F

Designer/Manufacturer CRYOFAB

Date of Manufacture SPRING 1996

Acceptance Date

Director's signature (or designee) if vessel is for manned area and requires an exception to the provisions of this chapter.

Amendment No.: Reviewed By: Date:

Laboratory location code DAB

Laboratory property number NONE

Purpose of vessel INSULATING VESSEL FOR 3,000 L He DEWAR

List all pertinent drawings

Drawing No.:	Location of Original:
3823.115-ME-317223 SHT. 3	FLOW SCHEMATIC
CMSH-3000	MFR. DWG.

2. Design Verification

Provide design calculations in the Note Appendix. PURCHASED VESSEL. SEE ATTACHED PERFORMANCE SPECIFICATION.

3. System Venting Verification

Can this vessel be pressurized either internally or externally? [ ] Yes [X] No
If yes, to what pressure? __________

List all reliefs and settings. Provide a schematic of the relief system components and appropriate calculations or test results to prove that the vessel will not be subjected to pressures greater than 110% beyond the maximum allowable internal or external pressure.

Manufacturer	Relief	Pressure Setting	Flow Rate	Size
CRYOLAB, SV7-88-5W1	POP-OFF	2 psig	A= 1.0 IN²	1" NOMINAL
CVI INC., V-1046-31	POP-OFF	≈ 2 psig	A= .8 IN²	1" NOMINAL

4. Operating Procedure Section

Is an operating procedure necessary for the safe operation of this vessel?

Yes________ No___X____(If "Yes", it must be appended)

Is a testing procedure necessary for the safe acceptance testing (proof testing) of this vessel?
[ ] Yes [X] No

If yes, the written procedure must be approved by the Division Head prior to testing and supplied with this Engineering Note.

5. <u>Welding Information</u>

Has the vessel been fabricated in a Fermilab shop? [ ] Yes [X] No

If "Yes," append a copy of the welding shop statement of welder qualification.

6. <u>Exceptional, Existing, Used and Non-Manned Area Vessels</u>

Is this vessel or any part thereof in the above categories?
Yes______ No__X__

If "yes" follow the Engineering Note requirements for documentation and append to note.

FERMILAB
ENGINEERING NOTE

SECTION	PROJECT	SERIAL-CATEGORY	PAGE
RD / DØ	REFRIGERATOR	3823.115	1

SUBJECT	NAME		
VACUUM VESSEL RELIEF REQ'MT	RUSS RUCINSKI		
	DATE 9-16-96	REVISION DATE 1-14-97	

CGA S-1.3 (1995), PAR. 4.4.2

$$A_{REQ'D} = .00024 \ \frac{IN^2}{lb} \text{ WATER CAPACITY.}$$

$$M_{WATER} = 3300 \ \underset{MAX.}{LITERS} \times .2641794 \ \frac{gal}{L} \times 8.337 \ \frac{lb}{gal} = 7268 \text{ lbs.}$$

$$A_{REQ'D} = \underline{1.74 \text{ IN}^2}$$

$$A_{NOMINAL} = 1.8 \text{ IN}^2 > A_{REQ'D}$$

ACTUAL AREA MAY BE SOMEWHAT REDUCED DEPENDING ON LIFT OF POPPET FOR CRYOLAB RELIEF. CVI IS MODIFIED TO ALLOW FULL VENTING AREA. SEE PAGES 2 & 3 AND CATALOG CUTS TOWARD END OF THIS NOTE.

NOTE THAT THE SPECIFICATION REQ'D THE MANUFACTURER TO PROVIDE AT LEAST 1.8 IN^2 OF RELIEVING AREA IN ADDITION TO THE CVI PUMP OUT. CRYOFAB DID NOT MEET THIS SPECIFICATION. THE RESULT OF THIS MISTAKE IS VERY LITTLE EXTRA AREA.

FERMILAB ENGINEERING NOTE	SECTION: PP/ETT DØ	PROJECT: LHe DEWAR	SERIAL-CATEGORY: 3323.115	PAGE: 2
SUBJECT: VACUUM RELIEF AREAS		NAME: RUSS RUCINSKI	DATE: 1-15-97	REVISION DATE:

- CRYOLAB SV7; THRU PORT "C" = 1.13 IN

$$A_{MIN.} = \frac{\pi d^2}{4} = 1.00 \text{ IN}^2$$

AMOUNT OF LIFT REQ'D TO GET THIS AREA BETWEEN POPPET & SEAT

$$A_{SIDE} = A_{THROAT}$$

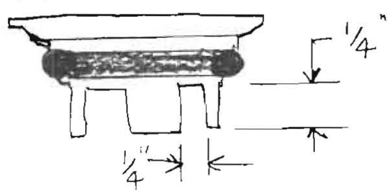
$$\pi d (LIFT) = \frac{\pi d^2}{4}$$

$$LIFT = \frac{d}{4} = \frac{1.13}{4} = 0.283 \text{ IN.}$$ ← REASONABLE AND POSSIBLE.

- CVI V-1046-31; THRU HOLE "A" = 1.00 IN.

$$A = 0.79 \text{ IN}^2$$

NOTCHES IN POPPET:



$$A = 4 \text{ NOTCHES} \times (.25 \text{ IN})(.25 \text{ IN})$$

$$A = 0.25 \text{ IN}^2$$ FULL LIFT ≈ 1/4"

I COULD MACHINE OFF MATERIAL THAT FORMS NOTCHES THEN AREA $= \pi D L = \pi (1.0)(0.25) = 0.79 \text{ IN}^2$.

SIDE HOLES IN BODY: 4 HOLES = 1/2 DIA. POPPET LIFTS TO 1/2 DIA.

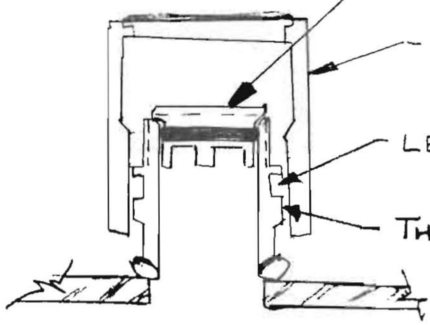
$$A_{HOLES} = 4 \text{ HOLES} \times \frac{\pi (0.5 \text{ IN})^2}{4} \times \frac{1}{2} \text{ HOLE OPEN}$$

$$A_{HOLES} = 0.393 \text{ IN}^2$$

⇒ SOLUTION: I WILL REMOVE THE SPRING AND CARRIER AND MAKE THE CVI A LIFT OFF PLATE SO TO SPEAK. VACUUM PUMPING WILL BE DONE THRU SV7 RELIEF PORT.

FERMILAB ENGINEERING NOTE	SECTION PP/ETT DØ	PROJECT LHe DEWAR	SERIAL-CATEGORY 3823.115	PAGE 3

SUBJECT	NAME	
VACUUM RELIEF AREAS	RUSS RUCINSKI	
	DATE 1-15-97	REVISION DATE 1-31-97



SKETCH OF MODIFIED CVI PORT

SPECIFICATION FOR

3,000 LITER

LIQUID HELIUM STORAGE DEWAR

D-ZERO EXPERIMENT - 823

D-ZERO ASSEMBLY BUILDING

FERMILAB, ILLINOIS

Written by: Russ Rucinski
RD/DØ Mechanical
September 21, 1995

1.0 Scope

1.1 This specification defines the requirements for a liquid helium storage dewar to be installed inside the D-Zero assembly building, Fermilab, Illinois.

2.0 Dewar Description

2.1 Process Flow diagram	Drg. # 3823.115-MA-317450
2.2 Configuration:	Vertical, Vacuum Insulated
2.3 Diameter:	6.0 feet nominal outside diameter
2.4 Capacity:	
2.4.1 Gross Capacity	869 gallons (3,300 liters)
2.4.2 Net Capacity	790 gallons (3,000 liters)

3.0 Dewar Design Requirements

3.1 Design Pressure:

3.1.1 Inner Vessel

Maximum Allowable Working Pressure is 75 psig internal pressure with full vacuum externally. (This is 90 psi design pressure.)

3.1.2 Inner Vessel

Full vacuum internally with outer vacuum vessel at atmospheric pressure

3.2 Design Temperature: - 452 Degrees Fahrenheit

3.3 Normal Operating parameters:

3.3.1 Application: Liquid Helium buffer volume

3.3.2 Contents: 790 gallons liquid Helium

3.3.3 Normal Operating Pressure: 26.5 psia

3.4 Maximum Boil-off rate: 0.5 % per day

3.5 Handling Provisions: The dewar shall have lifting lugs and fork lift provisions for moving empty dewar at installation.

3.6 Temperature depression: When in normal operation, no outside area of the vacuum vessel, neck, or access port shall have a temperature more than 10 degrees Fahrenheit below ambient when warmed solely by free convection of ambient air.

3.7 Delivered Condition: The inside surfaces of the pressure vessel, piping, tubing, and inside surfaces of the vacuum vessel shall be clean. No oil, grease, dirt, soil, scale, residue or other form of surface contaminant shall be present.

4.0 Dewar Design Criteria

4.1 The dewar shall consist of an all welded stainless steel inner helium reservoir enclosed by an all welded stainless steel vacuum jacket.

4.2 Multi layer superinsulation shall be installed between the inner and outer vessel in the high vacuum space.

4.3 The use of liquid nitrogen cooled radiation shield(s), helium gas vapor cooled radiation shield(s), or any other multi shielding technique may be used to meet the maximum boil-off rate requirement.

4.4 The inner vessel shall be built and stamped in accordance with the ASME pressure vessel code, Section VIII for the Maximum Allowable Working Pressure in 3.1 above, and design temperature in 3.2 above, and shall be registered with the national board.

4.5 The outer vessel (vacuum jacket) shall be designed for full vacuum internally with a safety factor not less than two. (Minimum collapse pressure of 30 psi.)

5.0 Piping

5.1 All piping shall be of weldable AISI 300 series stainless steel, and shall be formed from continuous lengths of pipe or tubing to the maximum extent practical. All joints within the vacuum space shall be welded.

5.2 Threaded connections at gages shall be made up with an epoxy type thread sealant.

5.3 Neck: A 6" pipe size vertical neck shall connect the inner vessel to a room temperature access port. The outer vessel vacuum jacket shall extend up the neck a minimum of 36". In addition, the uninsulated portion of the neck shall be a minimum of 12"

5.4 Access Port: The room temperature access port shall consist of a 6" pipe size flange, AISI 300 series stainless steel, with o-ring groove, welded to the top of the neck and a 6" pipe size blind flange, AISI 300 series stainless steel, bolted on for closure. A standard size o-ring shall make the port leak tight. Provide one extra o-ring as a spare.

5.5 Relief Port: A 2" stainless steel pipe with 2" NPT thread and pipe cap shall extend from the side of the vertical neck. The pipe shall extend approximately 12" from the neck.

5.6 Pump out port: A 1/2" stainless steel pipe with stainless steel ball valve shall be provided.

5.7 Liquid level gage: The dewar shall be provided with a differential pressure liquid level gage, connected between the top and bottom gage lines. Two shut-off valves and a by-pass valve shall be provided. An oscillation damper shall be provided if necessary. A liquid inventory versus gage indication chart shall be provided.

5.8 Pressure gage: The dewar shall be provided with a 100 psig pressure gage attached to the top gage line. The gage shall be rated to withstand vacuum service.

5.9 Additional gage ports: Two additional capped gage ports (as shown on the Process Flow diagram, Drg. # 3823.115-MA-317450) shall be connected to the top and bottom gage lines.

5.10 Vacuum vessel relief port: The outer vessel shall be protected by a relief device having a discharge area of at least 1.8 square inches and opening at a pressure not more than the lesser of the internal design of the outer vessel (as calculated by the ASME code) or 15 psig.

5.11 Vacuum vessel pump out port: In addition to 5.10 above, a vacuum seal off valve with 1/8" FNPT connection, CVI incorporated model V-1046-31 shall be provided. The vendor is CVI incorporated, P.O. Box 2138, Columbus, Ohio, 43216, phone: (614)-876-7381, fax: (614)-876-5648.

5.12 Vacuum vessel Vacuum Gage: A battery operated vacuum gauge tube, Teledyne Hastings-Raydist model DV-6R shall be installed in the 1/8" FNPT hole of 4.10 above. The vendor is Teledyne Brown Engineering Hastings Instruments, P.O. Box 1436, Hampton, Virginia, 23661-0436, phone: (804)-723-6531, fax: (804)-723-3925.

6.0 Testing and documentation

[In addition to testing required by the ASME code]

6.1 The dewar and piping described in 4.0 above shall be helium mass-spectrometer leak tested for vacuum tightness of the inner and outer vessels. No leak shall be detectable on the most sensitive scale of a helium leak detector with a minimum sensitivity of 10^{-9} atm. cc/sec.

6.2 The manufacturer shall furnish to the buyer the code form, U-1 for the inner pressure vessel.

6.3 The ASME Pressure vessel code nameplate or duplicate is to be readily visible.

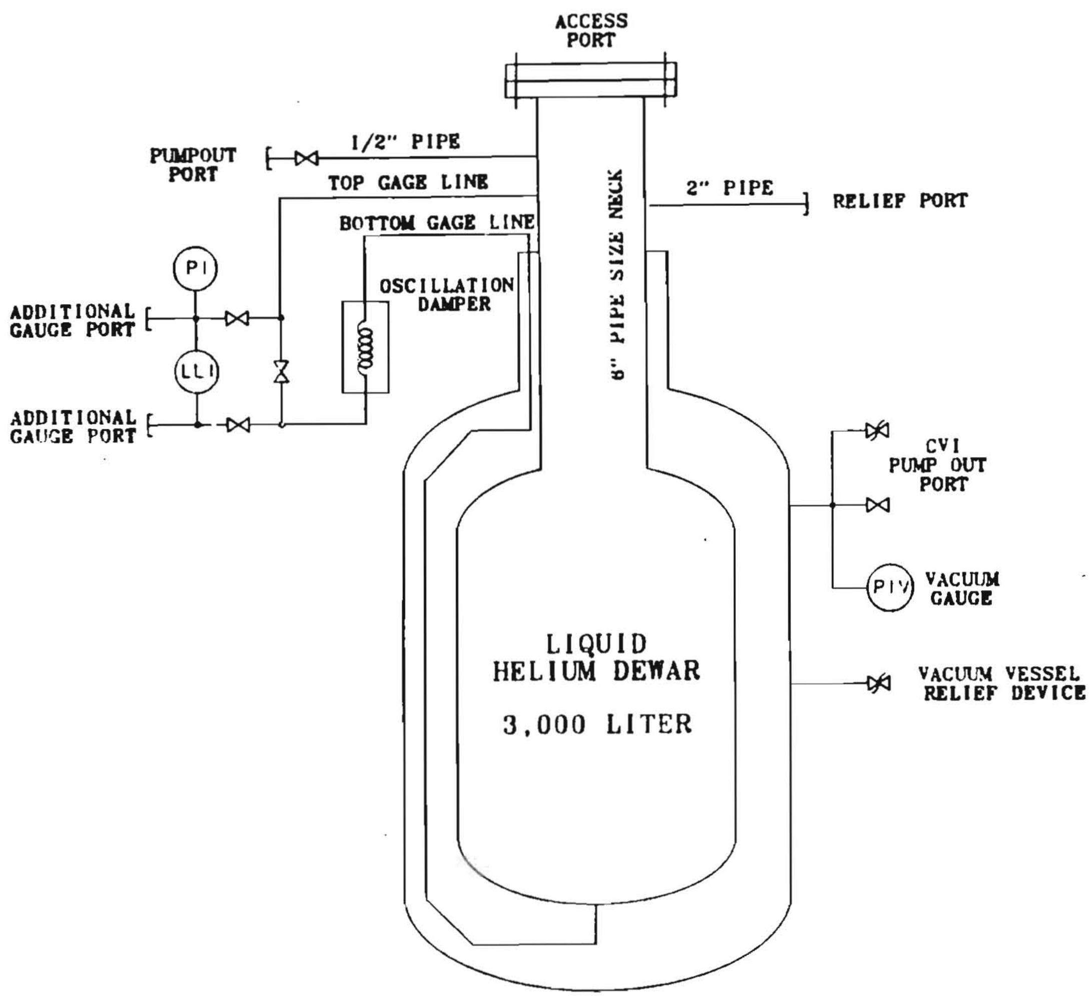
6.4 The manufacturer shall furnish the buyer with an assembly drawing of the dewar which shows overall dimensions and basic construction information.

7.0 <u>Warranty</u>

7.1 General: Manufacturer to warrant material and workmanship for a period of not less than one year from the date of delivery to Fermilab, Batavia, IL.

7.2 Vacuum: The vacuum vessel pressure must be less than 10^{-3} Torr when delivered to Fermilab. When cold and isolated, the vacuum vessel must be capable of not exceeding 10^{-3} Torr for a period of six months.

REV.	DESCRIPTION	DRAWN / APPD.	DATE / DATE



ITEM	PART NO.	DESCRIPTION OR SIZE	QTY.

PARTS LIST

UNLESS OTHERWISE SPECIFIED					
FRACTION	DECIMAL	ANGLES	ORIGINATOR	R. RUCINSKI	9/18/95
±	±	±	DRAWN	A. KUWAZAKI	9/13/95
			CHECKED	R. RUCINSKI	9/19/95
			APPROVED	K. KREMPETZ	9/20/95

1. BREAK ALL SHARP EDGES 1/64 MAX.
2. DO NOT SCALE DRAWING.
3. DIMENSIONS BASED UPON ANSI Y14.5M-1982
4. MAX. ALL MACH. SURFACES √

USED ON

MATERIAL

FERMI NATIONAL ACCELERATOR LABORATORY
UNITED STATES DEPARTMENT OF ENERGY

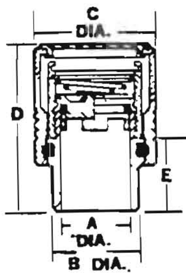
D-ZERO DETECTOR
LIQUID HELIUM DEWAR
FLOW DIAGRAM

SCALE	FILMED	DRAWING NUMBER	REV
N.T.S.		3823.115-MA-317450	

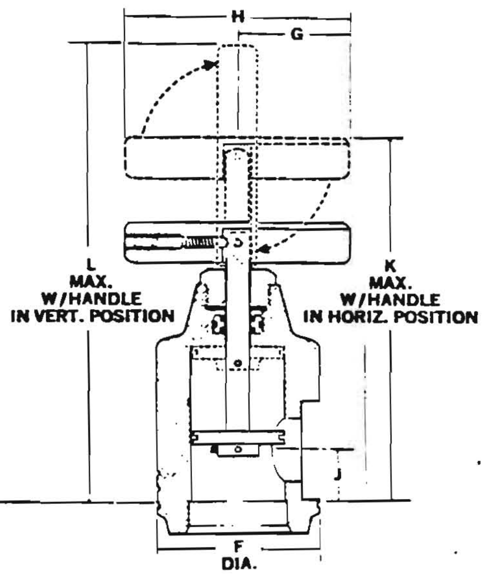
CADFILE: XDCS | CREATED WITH I-DEAS 4.1 | USER NAME: R. RUCINSKI

Thu Sep 21 14:40:40 CDT 1995 by mateski

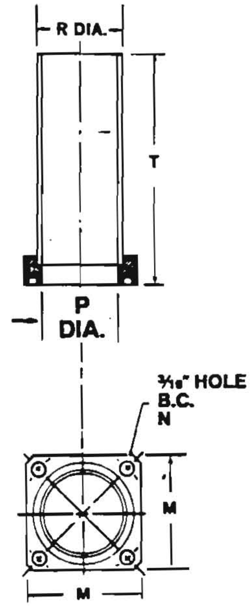
DIMENSIONAL DATA



VACUUM SEAL-OFF VALVES
V-1044, V-1046, V-1048



VACUUM SEAL-OFF VALVE OPERATORS
V-1045, V-1047, V-1049



PUMP OUT FLANGE
W/TUBE

Part No.		Dimensions (in Inches)												
Valves	Oper-ators	Size	A	B	C	D	E	F	G	H	J	K	L
V-1044		½"	½	21/32	1¼	2 5/16	1						
	V-1045	½"						2⅛	1⅝	3¼	¾	5¼	6⅜
V-1046		1"	1	1¼	1¾	2½	1⅛						
	V-1047	1"						2½	1 11/16	3⅜	13/16	5 11/16	7 1/16
V-1048		2"	2	2½	3	3 3/16	1⅜						
	V-1049	2"						4	2 13/16	5⅝	1⅜	9½	12

Part No.	Dimensions (in Inches)					
	Size	M	N	P	R	T
V-1053-5	½" & 1"	1½	1⅝	1	1⅛	3
V-1053-7	2"	2½	2¾	2	2⅛	3

HOW TO ORDER

Vacuum Seal-off Valve: V—XXXX —XX

Model No.

Basic Part No./Size
V-1044—½"
V-1046—1"
V-1048—2"

Options (V-1046 and V-1048 only)
—31 ⅛" F.N.P.T. connection in side of body for vacuum gage tube.
—41 Vacuum gage tube manifold isolation valve, and dust cover assembly.

Operator—Seal-off Valve: V—XXXX

Model No.

Basic Part No.
V-1045—½"
V-1047—1"
V-1049—2"

Pump-Out Flange: V—1053—X

Model No.

Basic Part No.
—5 ½", 1" Pump-out Flange w/Tube
—7 2" Pump-out Flange w/Tube

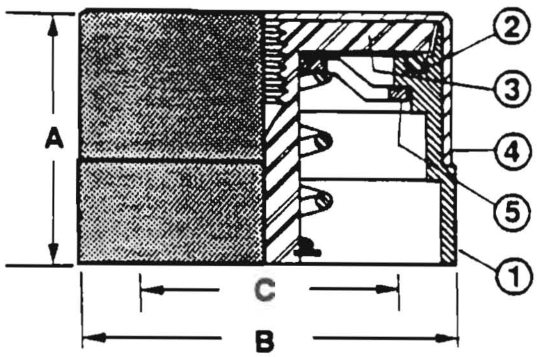
Example:

V-1046-31, V-1047, V-1053-5

a. 1 in. Vacuum Seal-off Valve with ⅛ in. FNPT connection.

b. Operator for 1 in. Vacuum Seal-off Valve.

c. Pump-Out Flange w/Tube for 1 in. Operator.



SV®7 SEAL-OFF VALVE
(PATENTED)

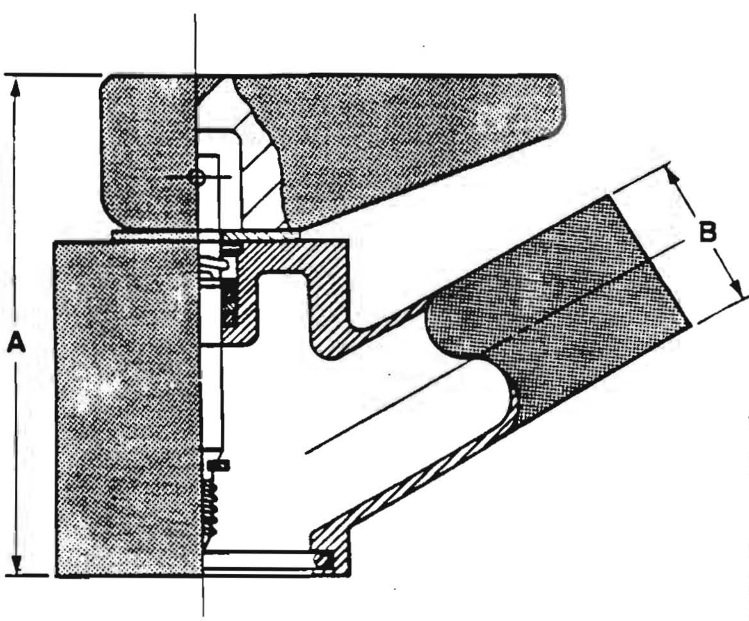
MATERIALS

Item	Part Name	Material (Specification)
1	Body	304 SS or 6061 Al
2	O-Ring	Viton-A (NAS 1593)
3	Poppet Assembly	18-8 SS (Mil-S-52043)
	Spring	302 SS (QQ-W-423B)
4	Cap	Plastic PVC (N.A.)
5	Retainer	304 SS (Mil-S-50243)

ITEM Vacuum Seal-Off Valve
SERVICE High vacuum and/or low pressure with all common gases
PRESSURE 1 x 10^{-8} torr up to 2 psig (higher spring setting on special order). Structural integrity: 1,000 psig min.
TEMPERATURE Plus 150°F. to minus 60°F.
LEAK RATE Less than 1 x 10^{-8} std. cc. GHe per second*
CONNECTIONS Weld standard, others available on special order
*Exclusive of permeability

SV®7 SEAL-OFF VALVE ORDERING INFORMATION

Size	304 SS Part No.	6061 Al Part No.	Valve Operator For SV®7 Valve	Seal-Off Valve Dimensions A	B	C
1"	SV7-88-5W1	SV7-88-1W1	VO7-88-5L1	1.13	1.63	1.13
2"	SV7-816-5W1	SV7-816-1W1	VO7-816-5L1	2.25	2.50	2.00
3"	SV7-824-5W1	SV7-824-1W1	VO7-824-5L1	3.12	3.12	2.75



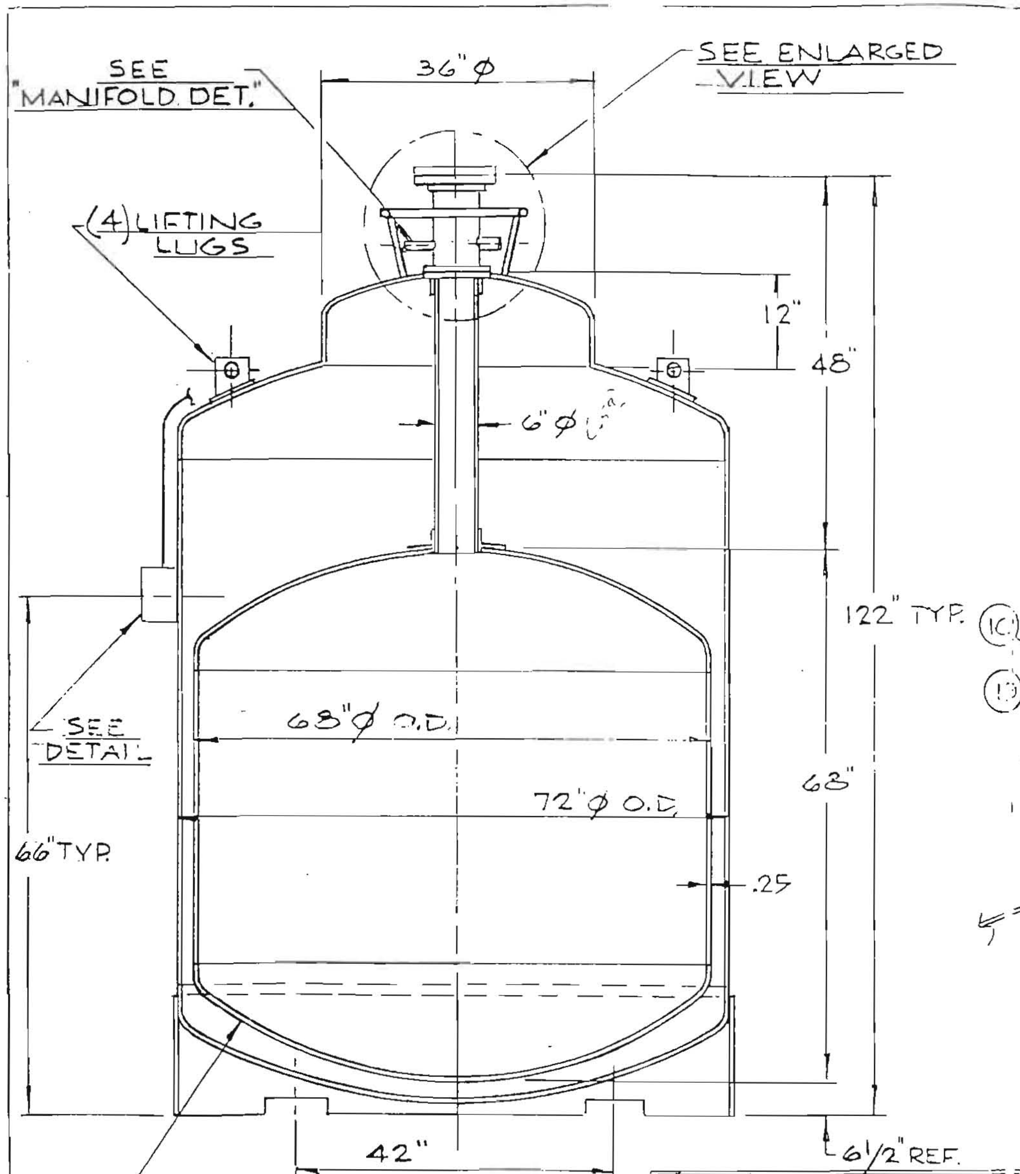
VO7 VALVE OPERATOR

VO7 VALVE OPERATOR ORDERING INFORMATION

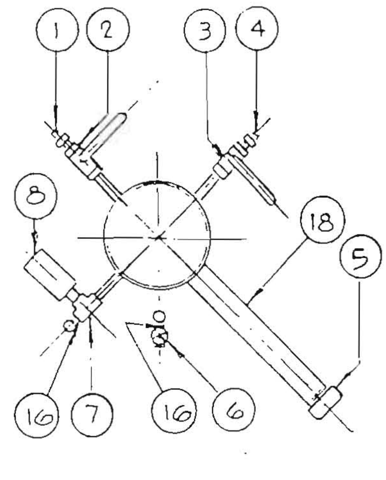
Size	Part Number	Dimensions A	B
1"	VO7-88-5L1	3.38	1.125
2"	VO7-816-5L1	5.0	2.25
3"	VO7-824-5L1	6.0	3.0

VO7 OPERATOR FOR SV®7 SERIES SEAL-OFF VALVE

The VO7 operator features a 30° pump-out connection and a proprietary vacuum-tight, O-ring-sealed quick coupling for seal-off valve connection. Full flow design assures maximum conductance for evacuation of equipment. Stainless is standard material..

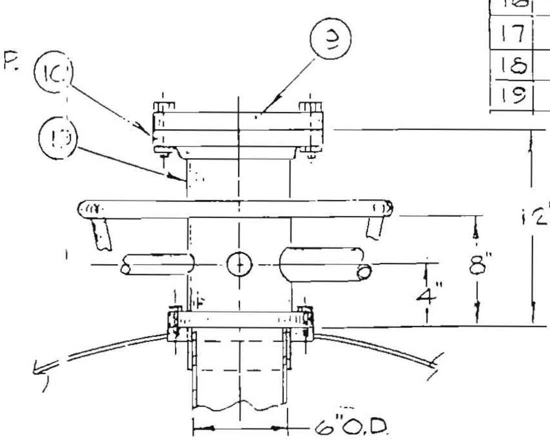


DESIGN PRESS: 90 PSIA
DESIGN TEMP: −452°F
MATERIAL: SA240 TYPE 304 S/S
ALL DIMENSIONS IN INCHES

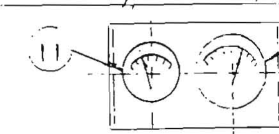


MANIFOLD DETAIL

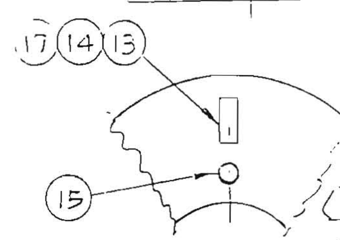
PARTS LIST			
NO.	REQ	DESCRIPTION	MAT'L
1	1	HEX. NIPPLE, 1/2" NPT	BRASS
2	1	BALL VALVE, 1/2" NPT	S/S
3	1	BALL VALVE, 1/4" NPT	BRONZE
4	1	RELIEF VALVE, 1/4" NPT 1/2 PSIG	BRASS
5	1	PIPE CAP, 2" NPT	S/S
6	1	NEEDLE VALVE, 1/8" NPT	
7	1	TEE, 1/4" NPT	BRASS
8	1	OSCILLATION CHAMBER	304 S/S
9	1	BLIND FLG. 150# STD	S/S
10	1	LAP JOINT FLG. 150# STD	S/S
11	1	COMPOUND GAUGE 30"HG-0-100 PSIG	S/S
12	1	LIQUID LEVEL GAUGE	S/S
13	1	CVI SEAL-OFF VALVE, V-1046-31	
14	1	GAUGE TUBE, DV-6R	
15	1	CRYOLAB SEAL-OFF VALVE, S/V	
16	2	FITTING, 1/8" TUBE × 1/4" NPT	
17	1	COVER	S/S
18	1	PIPE, 2" SCH. 40, 12" LG	304 S/S
19	1	TUBE 6 3/4" O.D. × .105" THK.	304 S/S



ENLARGED VIEW



GAUGE DETAIL



PLAN VIEW (BACK OF DEWAR)

ISSUE	DATE	BY	REVISION

REVISIONS

CRYOFAB
KENILWORTH, N.J. 07033

MULTISHIELDED LIQUID HELIUM STORAGE DEWAR, 3000 LITER CAPACITY

MADE	CHECKED	SCALE	CERTIFIED	DRAWING NO.	REV.
EWB 4/11/76		NTS	G.G. -/16/76	CMSH-3000	-