LIQUID NITROGEN SUBCOOLER
PRESSURE VESSEL
ENGINEERING NOTE

D-ZERO ENGINEERING NOTE # 3823.115 EN-466

Author: Russ Rucinski, PPD/ETT/DØ
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Approved:
PPD/ETT/D-Zero Mechanical Group leader

PER CHAPTER 5031

Prepared by: ANDREW KUWAZAKI
Preparation date: 1/31/97

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

This vessel conforms to Fermilab ES&H Manual
Chapter 5031

Vessel Title LIQUID NITROGEN SUBCOOLER

Vessel Number PPD-10050

Division/Section

Vessel Drawing Number 3823.115-ME-317304

Maximum Allowable

Working Pressure (MAWP) 150 PSIG

Working Temperature Range -320 °F 100 °F

Contents LIQUID NITROGEN

Designer/Manufacturer MINNESOTA VALLEY

ENGINEERING

Test Pressure (if tested at Fermi) Acceptance
Date: _____

____ PSI, Hydraulic _____ Pneumatic _____

Accepted as conforming to standard by

of Division/Section Particle Physics Date: 4/22/97

Obtain from Safety Officer

Document per Chapter
5034 of the Fermilab
ES&H Manual

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: [Signature] Date: 4/2/97

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): N/A

Lab Location Code: 325 (obtain from safety officer)

Purpose of Vessel(s): LIQUID NITROGEN CONTAINER FOR UPGRADE

Vessel Capacity/Size: 1.3 ft.³ Diameter: 13" Length: 16"

Normal Operating Pressure (OP) 1.5 PSIG*

MAWP-OP = 48.5 PSIG

* THE NORMAL OPERATING PRESSURE OF THIS DEWAR IS EXPECTED TO BE LESS THAN 1.5 PSIG. THIS VESSEL IS OPEN TO ATMOSPHERIC PRESSURE THRU A NON-ISOLATABLE VENT LINE. THE BACKPRESSURE IN THE VENT LINE WAS CALCULATED TO BE LESS THAN 1.5 PSIG AT MAXIMUM ANTICIPATED FLOW RATES.

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

Drawing #

Location of Original

3823.115-ME-317304

DØ MAIN BUILDING - HIGH BAY

2. Design Verification

BOTTOM

TOP

Does the vessel(s) have a U stamp? Yes X No X. 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:

Minnesota Valley Engineering

J-1 Dewar W/B Flange

MAWP at Full Vacuum 65 psi

at 100°F

Min. Design Metal Temp: -320°F

at 65 psi

Serial No. 496

Year Built: 1995

Tare Weight: 74 lbs.

Provide ASME design calculations in an appendix. On the sketch below, circle all applicable sections of the ASME code per Section VIII, Division I. (Only for non-coded vessels)

Summary of ASME Code

Item	Reference ASME Code Section	CALCULATION RESULT (Required thickness or stress level vs. actual thickness calculated stress level)
FLAT HEAD	UG - 34	$t_{REQ} = .571''$ vs $t_{ACT} = .75''$
REINFORCEMENT AREA	UG - 39	$A_{REQ} = .473 \text{ in}^2$ vs $A_{ACT} = .4815 \text{ in}^2$
		vs
		vs
		vs

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 ☒

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 ☒ No ☐ Actual setting 50 PSI

(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 ☒ 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:

<u>Manufacturer</u>	<u>Model #</u>	<u>Set Pressure</u>	<u>Flow Rate</u>	<u>Size</u>
ANDERSON, GREENWOOD & CO.	81MS44-4	50 PSIG	51 SCFM, AIR	1/2" NPT IN & OUTLET
ANDERSON, GREENWOOD & CO.	81MS44-4	50 PSIG	51 SCFM, AIR	1/2" NPT IN & OUTLET
_____	_____	_____	_____	_____
_____	_____	_____	_____	_____
_____	_____	_____	_____	_____
_____	_____	_____	_____	_____

Does the primary relief device follow UG-129? Yes ☒ 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 ☒ (If "Yes", it must be appended)

5. Welding Information

TOP (FERMI) BOTTOM

Has the vessel been fabricated in a non-code shop? Yes ☒ No ☒

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. Exceptional, Existing, Used and Unmanned Area Vessels

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.

SUBJECT

LN₂ SUBCOOLER TOP LID THICKNESS CALC

NAME

ANDREW KUWAZAKI

DATE

1/28/97

REVISION DATE

PURPOSE: FOLLOW ASME CODE TO DETERMINE REQ'D THICKNESS OF LN₂ SUBCOOLER FLAT HEAD.

SUBJECT TO: UG-34.(c).(2) "UNSTAYED FLAT HEADS & COVERS"

OUR CONFIGURATION IS SIMILAR TO SKETCH UG-34.(j) WHERE,

$$h_g = 15/16" = 0.9375"$$

$$d = 14 1/8" = 14.125"$$

$$t = ?$$

FIGURE 1: LN₂ SUBCOOLER FLAT HEAD DIMENSIONS.

SOLUTION:

$$\text{EQN. (2) APPLIES} \Rightarrow t = d \sqrt{CP/SE + (1.9)Wh_g / SE d^2}$$

$$C = 0.3$$

$$P = 50 \text{ PSIG}$$

, DESIGN PRESSURE

$$S = 18,800 \text{ PSI}$$

, MAX. ALLOWABLE TENSILE STRESS (304 SS. PLATE)

$$S = 0.8 \times 18,800$$

$$S = 15,040 \text{ PSI}$$

, MAX. ALLOW. TENSIL STRESS PER FERMILAB

$$E = 1.0$$

, JOINT EFFICIENCY

$$W = 15,180 \text{ LBS}$$

, TOTAL BOLT LOAD

FROM MANDATORY APPENDIX 2

* EQN. (2) REQUIRES t BE CALCULATED FOR BOTH OPERATING & GASKET SEATING.

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LN₂ SUBCOOLER TOP LID THICKNESS CALC.

NAME

TODD LEIGHT

DATE

5/18/95

REVISION DATE

I WILL FOLLOW SECTION VIII, DIV. 1, APPENDIX 2 TO DETERMINE BOLT LOAD W .

2-1 SCOPE : "PROPER ALLOWANCE SHALL BE MADE IF CONNECTIONS ARE SUBJECT TO EXTERNAL LOADS OTHER THAN EXTERNAL PRESSURE."

THIS WOULD INCLUDE THE ADDITIONAL TENSILE STRESS ON THE BOLTS DUE TO THE METHOD OF SUPPORT OF THE SUBCOOLER.

FIGURE 2: METHOD OF LN₂ SUBCOOLER SUPPORT

2-4 CIRCULAR FLANGE TYPES :

THE DESIGN CONFORMS TO 2-4(b) "INTEGRAL TYPE FLANGES"

2-5(e) FLANGE DESIGN BOLT LOAD W :

CASE ① : OPERATING CONDITIONS

$$W = W_{M1}$$

(EQN #3)

CASE ② : GASKET SEATING

$$W = \frac{(A_n + A_b) S_a}{2}$$

(EQN #4)

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LN₂ SUBCOOLER TOP LID THICKNESS CALC.

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1/28/97

CASE ①:

ACCORDING TO 2-5 (C.3) THE USE OF SELF-ENERGIZING GASKETS (O-RINGS) DEMANDS THAT THE REQUIRED BOLT LOAD W_{M1} SHALL RESIST THE HYDROSTATIC END FORCE H EXERTED BY THE MAMP. ON THE AREA BOUNDED BY THE OUTSIDE DIA OF THE GASKET. $H_p = 0$, UNLESS AXIAL LOADS ARE GENERATED BY CONFIGURATION.

$$W = W_{M1} = H = (.785) G^2 P$$

$$W = W_{M1} = (.785)(14.125 \text{ in})^2 (50 \text{ psi}) = 7,830 \text{ lb}$$

BUT THE BOLTS MUST ALSO CARRY THE WEIGHT OF THE VESSEL AND ITS CONTENTS (LN₂). LET'S DETERMINE MAXIMUM WEIGHT AND ASSUME LN₂ IS FILLED TO THE BOTTOM OF THE INSULATION.

$$U_{\text{SAT. LIQ.}} = 1.237 \frac{\text{cc}}{\text{g}}$$

ESTIMATE LN₂ VOLUME:

$$V = \frac{\pi}{4} D^2 h$$

$$V = \frac{\pi}{4} (13'')^2 (16'') \approx 1.3 \text{ ft}^3$$

$$F_{\text{LN}_2} = \frac{V}{U}$$

$$F_{\text{LN}_2} = (1.3 \text{ ft}^3) \left(\frac{62.43 \frac{\text{lb}}{\text{ft}^3}}{1 \frac{\text{g}}{\text{cc}}} \right) \left(\frac{1}{1.237 \frac{\text{cc}}{\text{g}}} \right) = 66 \text{ lb}$$

$$\text{ESTIMATE } F_{\text{DEWAR}} \approx 100 \text{ lb}$$

$$\text{THEN, } F_{\text{TOTAL}} = F_{\text{LN}_2} + F_{\text{DEWAR}} = 166 \text{ lb}$$

LET'S SAY $F_{\text{TOTAL}} = 200 \text{ lb}$ TO BE CONSERVATIVE.

$$\text{FINALLY, } W = W_{M1} + F_{\text{TOTAL}} = \boxed{8,030 \text{ lb}}$$

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CASE ② : $W = \frac{(A_m + A_b) S_a}{2}$

(see 2-5 (c.3.6))

$A_m = \text{GREATER OF } A_{m1} = W_{m1}/S_b \text{ OR } A_{m2} = W_{m2}/S_a$

THEN, $A_{m1} = (8030 \text{ lb}) / (24 \text{ ksi})$

* ASSUME $S_a = S_b = 0.8(30 \text{ ksi})$

$A_{m1} = 0.3346 \text{ in}^2$

$S_a = S_b = 24 \text{ ksi}$

$A_b = (.0775 \text{ in}^2)(12) = .93 \text{ in}^2$ { FROM TABLE 8.2.2 IN "MARK'S STANDARD HANDBOOK FOR ME'S". (FOR 1/8" UNC SCREWS.) }

FINALLY, $W = \frac{(.3346 \text{ in}^2 + 0.93 \text{ in}^2)(24 \text{ ksi})}{2}$

$W = 15,180 \text{ lb}$

∴ THE MAX. BOLT LOAD IS DUE TO GASKET SEATING (CASE 2) AND IS $W = 15,180 \text{ lb}$.

WE CAN NOW FIND t_r , REQUIRED PLATE THICKNESS :

USING EQN #2 ON PAGE 1,

$t_r = (14.125") \sqrt{\frac{(.3)(50 \text{ psi})}{(15.04 \text{ ksi})(1.0)} + \frac{(1.9)(15.18 \text{ kips})(.9375")}{(15.04 \text{ ksi})(1.0)(14.125")^3}}$

$t_r = 0.571 \text{ in}$

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NOW LET'S CONSIDER THE NECESSARY REINFORCEMENT DUE TO THE MANY OPENINGS IN THE FLAT HEAD. SEE APPENDIX "B" FOR DETAILS.

UG-39 REINFORCEMENT REQ'D FOR OPENINGS IN FLAT HEADS

UG-39(b.2) FOR MULTIPLE OPENINGS CAN BE REINFORCED WHEN SPACING BETWEEN ANY PAIR IS $\geq 2(D_{avg})$ OF THE PAIR.

AS IN UG-39(b.2)

UG-39(b.1) REQUIRES: $A = 0.5 d t =$ X-SECTIONAL AREA OF REINFORCEMENT

$$A_{1\frac{1}{2}} = (0.5)(1.682 \text{ in})(.571 \text{ in})$$

$$A_{2"} = (.5)(2.245 \text{ in})(.571 \text{ in})$$

$$A_{1\frac{1}{2}} = 0.480 \text{ in}^2$$

$$A_{2"} = 0.641 \text{ in}^2$$

UG-40 LIMITS OF REINFORCEMENT:

(b) USE THE LARGER OF: d OR $R_n + t_n + t$
FROM FIG. UG-37.1. SEE APPENDIX B.

$$d_{1\frac{1}{2}} = 1.682 \text{ in}, \quad R_n + t_n + t = (.0841) + (.109) + (.75) = 0.943 \text{ in}$$

$$d_{2"} = 2.245 \text{ in}, \quad R_n + t_n + t = (1.123) + (.065) + (.75) = 1.938 \text{ in}$$

(c) USE THE SMALLER OF: $2.5t$ OR $2.5t_n$

$$2.5(t) = 2.5(.75") = 1.875 \text{ in}, \quad 2.5(t_n) = 2.5(.109") = 0.273 \text{ in} \quad 1\frac{1}{2}" \text{ SCH. 40}$$

$$2.5(t_n) = 2.5(.065") = 0.163 \text{ in} \quad 2" \text{ SCH. 40}$$

(d) DETERMINE METAL WITHIN LIMITS OF REINFORCEMENT THAT MAY BE CONSIDERED TO HAVE REINFORCING VALUE.

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$$A_1 = \text{LARGER OF } \begin{cases} (E_t t - F t_r) d \\ 2(E_t t - F t_r)(t + t_n) \end{cases}$$

$$(E_t t - F t_r) d = (1(.75") - 1(.571"))(1.682") = 0.301 \text{ in}^2$$

$$2(E_t t - F t_r)(t + t_n) = (2)[1(.75") - 1(.571")](.75" + .109") = 0.308 \text{ in}^2$$

$$\underline{A_1 = 0.308 \text{ in}^2}$$

$$A_2 = \text{SMALLER OF } \begin{cases} (t_n - t_{rn}) 5t \\ (t_n - t_{rn}) 5t_n \end{cases}$$

* WE NEED TO FIND t_{rn} , THE REQUIRED VACUUM JACKET THICKNESS TO WITHSTAND 14.7 PSIA EXTERNAL PRESSURE. I WILL FOLLOW UG-28 "THICKNESS OF SHELLS AND TUBES UNDER EXTERNAL PRESSURE."

UG-28 (C.1) - CYLINDERS WITH $D_o/t > 10$:

ASSUME $t = .02 \text{ in}$

$$\text{THEN, } D_o/t = 1.9"/.02" = 95$$

ASSUME $L/D_o > 50$, SO ENTER FIG. 5-UGO-28.0 AT $L/D_o = 50$.

FROM FIGURE 5-UGO-28.0 : $A = .00012$

FROM FIGURE 5-UHA-28.1 : $B = 1,700 \text{ psi}$ WHEN $T = 100^\circ\text{F}$

$$P_a = \frac{4B}{3(D_o/t)} = \frac{4(1,700 \text{ psi})}{3(1.9"/.02")} = 23.9 \text{ psi}$$

$\therefore t_{rn} = .02"$ GIVES ALMOST A FACTOR OF SAFETY = 2.

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$$\text{THEN, } A_2 = (.109" - .02") (5) (.75") = 0.338 \text{ in}^2$$

$$A_2 = (.109" - .02") (5) (.109") = .0485 \text{ in}^2$$

$$\underline{A_2 = 0.0485 \text{ in}^2}$$

ALSO ASSUME 1/4" FILLET WELDS ON OUTSIDE & INSIDE OF HEAD.

$$\text{THEN, } A_{41} = A_{43} = (\text{leg})^2 f_{r2} = (.25")^2 (1) = .0625 \text{ in}^2$$

?

$$A_1 + A_2 + A_{41} + A_{43} \geq A$$

$$(.308 \text{ in}^2) + (.0485 \text{ in}^2) + 2(.0625 \text{ in}^2) \geq A$$

?

$$0.4815 \text{ in}^2 > 0.473 \text{ in}^2$$

$$(A_{\text{ACTUAL}} > A_{\text{REQ'D}})$$

- ∴ THERE IS ENOUGH REINFORCEMENT AREA FOR THE 1 1/2" SCH 10 V.J.'S WITH 1/4" FILLET WELDS ON BOTH SIDES. SEE APPENDIX "C" FOR CALC'S ON REINFORCING THE 2" V.J. FOR THE GN₂ VENT.

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LN₂ SUBCOOLER TOP LID THICKNESS CALC.

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WELDMENT OF VACUUM JACKETS TO FLAT HEAD :

UW-16(d) : NECK ATTACHED BY FILLET OR PARTIAL PENETRATION
GROOVE WELDS.

FIGURE 4: COPY OF SKETCH UW-16(d)

REQ'D $\left\{ \begin{array}{l} t_1 + t_2 \geq 1/4 t_{min} \\ t_1 \text{ OR } t_2 \text{ NOT LESS THAN} \\ \text{SMALLER OF } 1/4 \text{ in OR} \\ 0.7 t_{min} \end{array} \right.$

$$t_{min} = 0.109 \text{ in}$$

$$(1.25) t_{min} = 0.13625 \text{ in}$$

$$(0.7) t_{min} = 0.0763 \text{ in}$$

∴ CHOOSE $1/4$ " FILLET WELD, ALL AROUND
ON BOTH SIDES.

Fig. L-7

SECTION VIII — DIVISION 1

1983 Edition

Without Reinforcing Element

	$A = d t_r F + 2 t_n t_r (1 - f_{r1})$	Area required
	$A_1 = \begin{cases} d(E_1 t - F t_r) - 2 t_n (E_1 t - F t_r) (1 - f_{r1}) \\ 2(t + t_n)(E_1 t - F t_r) - 2 t_n (E_1 t - F t_r) (1 - f_{r1}) \end{cases}$	Area available in shell; use larger value
	$A_2 = \begin{cases} 5(t_n - t_m) f_{r1} t \\ 5(t_n - t_m) f_{r1} t_n \end{cases}$	Area available in nozzle projecting outward; use smaller value
	$A_3 = 2(t_n - c) f_{r1} h$	Area available in inward nozzle
	$A_{41} = \text{outward nozzle weld} = (\text{leg})^2 f_{r1}$	Area available in outward weld
	$A_{43} = \text{inward nozzle weld} = (\text{leg})^2 f_{r1}$	Area available in inward weld
If $A_1 + A_2 + A_3 + A_{41} + A_{43} \geq A$		Opening is adequately reinforced
If $A_1 + A_2 + A_3 + A_{41} + A_{43} < A$		Opening is not adequately reinforced so reinforcing elements must be added and/or thicknesses must be increased

With Reinforcing Element Added

A	= same as A , above	Area required
A_1	= same as A_1 , above	Area available
A_2	$\begin{cases} 5(t_n - t_m) f_{r1} t \\ 2(t_n - t_m) (2.5 t_n + t_e) f_{r1} \end{cases}$	Area available in nozzle projecting outward; use smaller area
A_3	= same as A_3 , above	Area available in inward nozzle
	$A_{41} = \text{outward nozzle weld} = (\text{leg})^2 f_{r1}$	Area available in outward weld
	$A_{42} = \text{outer element weld} = (\text{leg})^2 f_{r3}$	Area available in outer weld
	$A_{43} = \text{inward nozzle weld} = (\text{leg})^2 f_{r1}$	Area available in inward weld
	$A_5 = (D_p - d - 2 t_n) t_e f_{r3}$	Area available in element
If $A_1 + A_2 + A_3 + A_{41} + A_{42} + A_{43} + A_5 \geq A$		Opening is adequately reinforced

FIG. L-7 EXAMPLE OF A REINFORCED OPENING
(This Figure Illustrates a Common Nozzle Configuration and Is Not Intended to Prohibit Other Configurations Permitted by the Code.)

SUBJECT

FLOW CAPACITY: OVERPRESSURE CONDITION

NAME

ANDREW KUWAZAKI

DATE

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THE RELIEF VALVES CHOSEN ARE TWO AGCO SAFETY-RELIEF VALVES, 81MS44-4, WITH 1/2" NOMINAL PIPE THREADS FOR BOTH THE INLET AND OUTLET. THE SET PRESSURE IS 50 PSIG.

CALCULATING THE FLOW CAPACITY USING THE AGCO CAPACITY CHARTS AT 110% OVERPRESSURE AND A 50 PSIG SET PRESSURE:

INTERPOLATING FOR A SUPPLY PRESSURE OF 50 PSIG:

S.P (PSIG)	FLOW CAPACITY (SCFM AIR)	
40	43	
50	?	$\Rightarrow Q_a = 51$ SCFM AIR
60	59	

ALSO, THE PRESSURE AT THE VALVE INLET DURING FLOW IS PROPORTIONAL TO THE FLOW CAPACITY:

$$P_i \propto V$$

THEREFORE:

$$\begin{aligned} (40 + 14.7) \text{ PSIA} \times 1.10 &= 60.17 \text{ PSIA} \\ (50 + 14.7) \text{ PSIA} \times 1.10 &= 71.17 \text{ PSIA} \\ (60 + 14.7) \text{ PSIA} \times 1.10 &= 82.17 \text{ PSIA} \end{aligned}$$

$$\frac{60.17 \text{ PSIA}}{71.17 \text{ PSIA}} = \frac{43 \text{ SCFM AIR}}{51 \text{ SCFM AIR}}$$

$$0.845 \approx 0.843 \quad \text{O.K.}$$

THE FLOW CAPACITY, $Q_a = 51$ SCFM AIR

SUBJECT

FLOW CAPACITY FOR VACUUM LOSS

NAME

ANDREW KUWAZAKI

DATE

1/29/97

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CGA S-1.3 APPLIES
PARAGRAPH 5.2.2

$$Q_a = \frac{(130 - T)}{4(1200 - T)} F G_i U A$$

WHERE:

Q_a = FLOW CAPACITY [ft^3/min FREE AIR]

T = TEMPERATURE AT FLOWING CONDITIONS [$^{\circ}\text{F}$]

F = CORRECTION FACTOR FROM CGA S-1.3, 5.1.4

U = TOTAL THERMAL CONDUCTANCE = $\frac{K}{X}$ [$\text{BTU}/\text{hr} \cdot \text{ft}^2 \cdot ^{\circ}\text{F}$]

G_i = GAS FACTOR FROM TABLE 1 OF CGA S-1.3

A = OUTSIDE SURFACE AREA OF INNER VESSEL [ft^2]

PROPERTIES:

$$T = 77 \text{ K} = -320^{\circ}\text{F}$$

$$G_i = 10.2$$

$$\begin{aligned} A &= \pi D h + \underbrace{\frac{1}{2} (\pi D^2)}_{\text{HEMISPHERE}} \\ &= \pi (13") (20.75") + \frac{1}{2} \pi (13")^2 \\ &= 1113 \text{ in}^2 \\ &= 1113 \text{ in}^2 \left(\frac{1 \text{ ft}^2}{144 \text{ in}^2} \right) = 7.73 \text{ ft}^2 \end{aligned}$$

$$F = 1.0 \quad * \text{ ASSUME } P_i \approx P \text{ AND } v_i \approx v.$$

$$U = \frac{\text{THERMAL CONDUCTIVITY OF INSULATION}}{\text{THICKNESS OF INSULATION}}$$

$$\text{ASSUME INSULATION THICKNESS } X = 3/8 \text{ in} = 0.03125 \text{ ft}$$

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LOSS OF VACUUM CONTINUED

NAME

ANDREW KUWAZAKI

DATE

1/29/97

REVISION DATE

3/27/97

NITROGEN

$$\begin{aligned} @ P = 29.7 \text{ psia} : K &= 0.01757 \text{ W/m}\cdot\text{K} & \{ \text{N.B.S} \} \\ &= 0.01015 \text{ BTU/hr}\cdot\text{ft}\cdot^\circ\text{F} \end{aligned}$$

AIR

$$\begin{aligned} @ P = 1 \text{ ATM} : K &= 0.0171 \text{ W/m}\cdot\text{K} \\ &= 0.00988 \text{ BTU/hr}\cdot\text{ft}\cdot^\circ\text{F} \end{aligned}$$

USE K_{N_2} BECAUSE $K_{N_2} > K_{AIR}$.

THUS, THE FLOW CAPACITY IS:

$$Q_a = \frac{1.30 - (-320)}{4(1200 - (-320))} (1.0)(10.2) \left(\frac{0.01015}{(375/12)} \right) (7.73)$$

$$Q_a = 1.895 \text{ SCFM AIR}$$

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SUBJECT

FLOW CAPACITIES UNDER FIRE CONDITIONS

NAME

ANDREW KUNAZAKI

DATE

1/29/97

REVISION DATE

3/27/97

CGA S-1.3 APPLIES
PARAGRAPH 5.3.3

$$Q_a = F G_i U A^{0.82}$$

WHERE:

Q_a = FLOW CAPACITY [ft³/min FREE AIR]

G_i = 10.2 (CGA S-1.3 TABLE 1)

F = 1.0

A = WETTED SURFACE AREA

$$A = \pi (12.75") (20") + \frac{1}{2} \pi (12.75")^2$$

$$A = 1056.5 \text{ in}^2$$

$$A = 1056.5 \text{ in}^2 \left(\frac{1 \text{ ft}^2}{144 \text{ in}^2} \right) = 7.34 \text{ ft}^2$$

U IS DETERMINED AT $T = 100^\circ\text{F} = 311 \text{ K}$

NITROGEN:
@ $P = 29.7 \text{ psia}$

$$K = 0.2652 \text{ W/m} \cdot \text{K}$$

$$= .0153 \text{ BTU/hr} \cdot \text{ft} \cdot ^\circ\text{F}$$

AIR:

$$K = .0271 \text{ W/m} \cdot \text{K}$$

@ $P = 1 \text{ atm}$

$$= .0157 \text{ BTU/hr} \cdot \text{ft} \cdot ^\circ\text{F}$$

USE K_{AIR} BECAUSE $K_{\text{AIR}} > K_{\text{N}_2}$.

$$U = \frac{.0157}{(.375/12)}$$

$$Q_a = (1.0)(10.2) \left(\frac{.0157}{(.375/12)} \right) (7.34)^{0.82}$$

$$Q_a = 26.27 \text{ SCFM AIR}$$

FERMILAB

ENGINEERING NOTE

SECTION

PPD-ETT

PROJECT

DD UPGRADE

SERIAL CATEGORY

3823.115

PAGE

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SUBJECT

PRESSURE RELIEF SUMMARY

NAME

ANDREW KUWAZAKI

DATE

1/30/97

REVISION DATE

NO OTHER RELIEVING CONDITIONS, OTHER THAN FIRE AND LOSS OF VACUUM, ARE NEEDED. THIS IS DUE TO THE FACT THAT THE LIQUID NITROGEN SUPPLY DEWAR NORMALLY OPERATES AT 35 PSIG, WHICH IS 15 PSIG BELOW THE MAXIMUM ALLOWABLE WORKING PRESSURE OF 50 PSIG.

NOTE: HELIUM REFRIGERATOR CRYOGENIC FLOW DIAGRAM DRAWINGS ARE PRESENTED NEXT.
ALSO, WELDER QUALIFICATION AND WELDING PROCEDURE SPECIFICATION HAS BEEN ATTACHED.

REV.	DESCRIPTION	DATE	BY
A	1. L&D DETAILED 8,000 GALLON	11/1/78	W. RICHMOND
B	2. L&D DETAILED 64,000 GALLON	11/1/78	W. RICHMOND
C	3. L&D DETAILED 278 PSIG	11/1/78	W. RICHMOND
D	4. L&D DETAILED 278 PSIG	11/1/78	W. RICHMOND

DESIGNED BY	W. RICHMOND	DATE	11/1/78
CHECKED BY	W. RICHMOND	DATE	11/1/78
APPROVED BY	W. RICHMOND	DATE	11/1/78
PROJECT NO.	3623.115-MX-317223	REV.	D
PROJECT NAME	D-ZERO DETECTOR UPGRADE	PROJECT NO.	3623.115-MX-317223
PROJECT LOCATION	FERMI NATIONAL ACCELERATOR LABORATORY	PROJECT NO.	3623.115-MX-317223
PROJECT DESCRIPTION	HELIUM REFRIGERATOR	PROJECT NO.	3623.115-MX-317223
PROJECT STATUS	CRYOGENIC FLOW DIAGRAM	PROJECT NO.	3623.115-MX-317223
PROJECT DATE	11/1/78	PROJECT NO.	3623.115-MX-317223
PROJECT BY	W. RICHMOND	PROJECT NO.	3623.115-MX-317223
PROJECT CHECKED BY	W. RICHMOND	PROJECT NO.	3623.115-MX-317223
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PROJECT APPROVED BY	W. RICHMOND	PROJECT NO.	3623.115-MX-317223

MOVES: 1. TIGHTEN BOLTS (ITEM 5) TO 11 LB-FT.
2. LEVEL FRAME (ITEM 3) SHOULD BE HELD
1/4" ABOVE THE BOTTOM OF THE BEAMS

[illegible]