Argon Test Cell (ATC) Cryostat Engineering Note

3740.512-EN-243

February, 1990
K. Dixon

PRESSURE VESSEL ENGINEERING NOTE
PER MANDATORY STANDARD SD37

Prepared by: Kelly Dixon
Preparation date: 10 Nov 89

1 Description and Identification

Fill in the label information below:

This vessel conforms to engineering standard SD37
Vessel Title Argon Test Cell Cryostat
Vessel Number RD4010
Vessel Drawing Number 3740.512-ME-194027
Maximum Allowable
Working Pressure (MAWP) W/FV 65 PSI
Working Temperature Range -320 °F 100 °F
Contents Liquid argon
Designer/Manufacturer Bottom vessel: Minnesota Valley Engineering, Top vessel: FNAL
Test Pressure (if tested at Fermi) Acceptance
Date: 81 PSI, Hydraulic Pneumatic X
Accepted as conforming to standard by
John A. Pacheco 8 JAN 90
of Division/Section Research Division
NOTE: Any subsequent changes in contents, pressures, temperatures, valving, etc., which affect the safety of this vessel shall require another review and test.

Obtain from
← Division/Section
Safety Officer

Actual signature
required in this
← space

Reviewed by: Richard P. Storch Date: 1/8/90

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

Date: _____

Lab Property Number(s): 67793 (bottom vessel)
Lab Location Code: DAB-AH (obtain from Safety Officer)
Purpose of Vessel(s): Liquid argon container for electronegativity measurements
Vessel Capacity/Size: 1.7 ft³ Diameter: 10.625 in. Length: 33 1/2 in.
Normal Operating Pressure (OP) 3 PSIG
MAWP-OP = 62 PSI

Is the above enough to provide relief cracking pressure tolerance plus system uncertainty tolerance per M-9.

As an option, provide a photo of the entire vessel in the Appendix.

List the numbers of all pertinent drawings and the location of the originals.
(Append copies).

<u>Drawing #</u>	<u>Location of Original</u>
3740.000-ME-193913	Wilson Hall, 11th Floor
3740.000-MB-193921	" " , " "
3740.000-MB-193922	" " , " "
3740.000-MB-193923	" " , " "
3740.000-MD-193924	

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 if photo is not clear of if copies are unreadable.

Bottom Vessel

Copy data here:

National Board No.

Minnesota Valley Engineering

H-1 Dewar W B Flange

MAWP at full vacuum 65 psi

at 100°F

Minimum design metal

temp -320°F at 65 psi

Service: LN₂ at -320°F

Serial No. 222

Year built 1989

On the sketch below, circle all applicable sections of the ASME code per Section VIII, Division I. List the results of all calculations. (Insert copies of calculations in the appendix).

Summary of ASME Code

Item	Reference ASME Code Section
Shell, Int. Pressure	UG-27
Shell, Ext. Pressure	UG-28
Flat Head	UG-34
Opening in Head	UG-39
Flange	App. Y
Bolts	App. Y

If this vessel is exceptional or had exceptional parts, list their details under 5.6. Yes ☐ No ☒

CALCULATION RESULT (Required thickness or stress level vs. actual thickness or calculated stress level)

$t = 0.159"$ vs. $t = 0.165"$
$P = 217 \text{ psi}$ vs. 15 psi
$t = 0.470"$ vs. $t = 0.500"$
$A = 0.940 \text{ in}^2$ vs. $A = 1.15 \text{ in}^2$
$S_R = 7 \text{ ksi}$ vs. $S_f = 15 \text{ ksi}$ *
$\sigma_b = 17.1 \text{ ksi}$ vs. $S_b = 20 \text{ ksi}$

* Worst case

- 3 System Venting. Provide the system schematic in the Appendix, if the vessel safety is system sensitive.

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

Yes _____ No X

If "Yes", the system must conform to M-5. Provide an explanation on the appended schematic. (An isolatable vessel, not conforming to M-5 violates the Standard.)

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

Yes X No _____ Actual setting 65 PSI
(A no response violates the Standard.)

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 violate the Standard.)

List of reliefs and settings:

<u>Manufacturer</u>	<u>Relief</u>	<u>Setting</u>	<u>Flow Rate</u>	<u>Size</u>
<u>Anderson Greenwood, Inc.</u>	<u>#83568-6</u>	<u>65 psig</u>	<u>142 scfm air</u>	<u>3/4" x 1"</u>
_____	_____	_____	_____	_____
_____	_____	_____	_____	_____
_____	_____	_____	_____	_____
_____	_____	_____	_____	_____
_____	_____	_____	_____	_____

Is the relief device an ASME stamped device? Yes X No _____

- 4 Operating Procedure

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

Yes _____ No X If "Yes", please append.

- 5 Welding Information

Has the vessel been fabricated in a Fermilab shop? Yes X No X ^{Top} ^{Bottom}

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

- 6 Exceptional, Existing, Used, and Non-Manned 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 in free form below.

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ATC Piping Schematic

K. Dixon
10 Nov 89

A 1.2

FORM U-2 MANUFACTURER'S PARTIAL DATA REPORT
A part of a Pressure Vessel Fabricated by One Manufacturer for Another Manufacturer
As Required by the Provisions of the ASME Code Rules, Section VIII, Division 1

1. Manufactured and certified by MINNESOTA VALLEY ENGINEERING, 407 7th ST, NW; NEW PRAGUE, MN 56071
(Name and address of manufacturer)

2. Manufactured for _____
(Name and address of purchaser)

3. Location of installation _____
(Name and address)

4. Type VERT H-1 DEWAR 222 C-30971 NA 1989
(Name of vessel) (Design series No. or Part) (Code) (Drawing No.) (Part No.) (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 1989
(Year)

NANALOW TEMP SVC UHA 51ASME CodeCase Code No.Special service per UG-120(a)

6. (a) Drawing prepared by MINNESOTA VALLEY ENG. (b) Description of part inspected BOTTOM HEAD - SHELL TOP FLANGE

7. Post weld heat treatment: Temp. NA °F Time NA

Items 8-13 incl. to be completed for single wall vessels, jackets of jacketed vessels, or shells of heat exchangers

8. Shell: SA240 T304 .075 0 10.625" 1' 3"
Mat. (Spec. No., Grade) (Nom. Thk. (in.)) (Corr. Allow. (in.)) (O.D. (in.)) (Length (Overall (ft. & in.))

9. Seams: WLD. DBL. BUTT NONE 70 NA NA WLD. SGL. BUTT NONE 1
Long. (Weld. Dis. Sph. Lmb. Butt) R.T. (Spot or Full) EL (in) R.T. Temp. (°F) Type (Weld. Dis. Sph. Lmb. Butt) R.T. (Spot, Partial, or Full) No. of Courses

10. Heads: (a) Mat. SA240 T304

(b) Mat.

(Spec. No., Grade)(Spec. No., Grade)

	Location (No. Bottom, Side)	Minimum Thickness	Corrosion Allowance	Corros. Radius	Reinforce Radius	Stiffness Factor	Corros. Area Amps	Manufactured Radius	Flat Diameter	Side to Pressure (Convex or Concave)
(a)	<u>BOTTOM</u>	<u>.0625</u>	<u>0</u>	<u>NA</u>	<u>NA</u>	<u>2:1</u>	<u>NA</u>	<u>NA</u>	<u>NA</u>	<u>CONCAVE</u>
(b)										

If removable, bolts used (describe other fastenings) BOLTS NOT INCLUDED

(Mat., Spec. No., Gt. Size, No.)

11. Type of Jacket _____ Proof Test _____

12. Jacket Closure _____ If bolt, give dimensions _____
(Describe as spot & weld, etc. incl.)

13. MAWP _____ psi at max. temp. _____ °F Min. temp. (when less than -20°F) _____ °F

Hydra. pneu., or comb. test press.

Items 14 and 15 to be completed for tube sections

14. Tubesheets: _____
Stationary Mat. (Spec. No., Gt.) (O.D. (in.)) (Subject to pressure) (Nom. Thk. (in.)) (Corr. Allow. (in.)) (Allow. (Hydro. Stress))

Flaring Mat. (Spec. No., Gt.)(O.D. (in.))(Nom. Thk. (in.))(Corr. Allow. (in.))Allow.

15. Tubes: _____
Mat. (Spec. No., Gt.) (O.D. (in.)) (Nom. Thk. (in. or Gauge)) (No.) (Type (Straight or U))

Items 16-18 incl. to be completed for inner chambers of jacketed vessels or channels of heat exchangers

16. Shell: _____
Mat. (Spec. No., Gt.) (Nom. Thk. (in.)) (Corr. Allow. (in.)) (O.D. (in.)) (Length (Overall (ft. & in.))

17. Seams: _____
Long. (Weld. Dis. Sph. Lmb. Butt) R.T. (Spot or Full) EL (in) R.T. Temp. (°F) Type (Weld. Dis. Sph. Lmb. Butt) R.T. (Spot, Partial, or Full) No. of Courses

18. Heads: (a) Mat. _____ (b) Mat. _____
(Spec. No., Grade) (Spec. No., Grade)

	Location (No. Bottom, Side)	Minimum Thickness	Corrosion Allowance	Corros. Radius	Reinforce Radius	Stiffness Factor	Corros. Area Amps	Manufactured Radius	Flat Diameter	Side to Pressure (Convex or Concave)
(a)										
(b)										

If removable, bolts used (describe other fastenings) _____

(Mat., Spec. No., Gt. Size, No.)

Form U-2 (Back)

19. MAWP 65 psi at max. temp. 100 °F. Min. temp. (when less than -20°F) -320 °F.
Hydro. pneu. or comb. test press. 130 psi.

Items below to be completed for all vessels where applicable

23. Nozzles, Inspection and Safety Valve Openings:

[illegible]

21. Support: Shirt _____ Lugs _____ Legs _____ Other _____ Attached _____
(Type or tag) (Mat.) (Mat.) (Comment) (Where and how)

22. Remarks: PART - INCLUDES BOTTOM HEAD, SHELL AND TOP FLANGE. WELDED
CONSTRUCTION. ALL MATERIAL SA240 T304. DOES NOT INCLUDE CLOSING
COVER OR BOLTS.

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. 8377 expires JAN. 15 1992
Date July 7, 1989 Co. name MINNESOTA VALLEY ENG. Signed [Signature]

CERTIFICATE OF SHOP INSPECTION

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 MINNESOTA and employed by H.S.B.I. & I. CO.

of HARTFORD have inspected the pressure vessel described in this Manufacturer's Partial Data Report on 7-7
19 89 and state that, to the best of my knowledge and belief, the Manufacturer has constructed this part in accordance with the ASME Boiler
 and Pressure Vessel Code, Section VIII, Division 1. By signing this certificate neither the Inspector nor his employer makes any warranty, expressed or
 implied, concerning the part described in this Manufacturer's Partial 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. 8841 M/S 9-20

Date 8-8-84 Signed John A. Duggess Commission ND 10804 14N01234
(Not) Board, State, Province and No. 1

Fermilab

EXHIBIT B
Pressure Testing Permit*

Date: 11-22-89

A1.5

Type of Test: ☐ Hydrostatic ☒ Pneumatic

Test Pressure: 81 psig Maximum Allowable Working Pressure: 65 psig

Items to be Tested: LIQ. ARGON PURITY TEST CELL - D-0

Location of Test: ER- CONCRETE HOOP Date and Time: 11/22/89 1300

Hazards Involved: High Pressure & rupture

Safety Precautions Taken: Good No personnel access above 50% of test pressure

Special Conditions or Requirements: Contact H. Casbolt page 613 for witness

Test Coordinator: Dick Appligato AD-Cyros Dept/Date: 11-22-89

Division/Section Safety Officer: H. Casbolt Dept/Date: 11/22/89

Division/Section Head: [Signature] Dept/Date: 11/22/89

Results: Tested satisfactory at 81 psig

Witness: [Signature]
(Safety Officer or Designee)

Dept/Date: Accelerator Safety
11/22/89

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

TABLE UHA-23 P. 390

MAX. ALLOWABLE STRESS VALUES IN TENSION FOR HIGH ALLOY ST

ASTM
STAINLESS PIPE, TYPE 304 UNS # S30400, A-312
WELDED CONSTRUCTION
MARKED ON PIPE: "T-304HT. 271744 BMI ASTM A-312 SW-42M. WELD 10" SCH. 10
SPECIFIED MINIMUM YIELD = 30 KSI

SPECIFIED MINIMUM TENSILE = 75 KSI

MAX. ALLOWABLE STRESS = 16.0 KSI (-20 TO 100°F)

UG-16 GENERAL DESIGN

$$t_{min} = 1/16"$$

FERILAB ENGINEERING STD. SD-37B

$$\text{MAXIMUM ALLOW. STRESS} = (.80)(16.0 \text{ ksi}) = 12.8 \text{ ksi}$$

UG-23 MAX. ALLOWABLE STRESS VALUES

LONGITUDINAL COMPRESSION OF THE VESSEL IS NEGLIGIBLE.

UG-25 CORROSION.

REFERS TO UHA-6 FOR HIGH ALLOY MAT'L'S.

UHA-6 CONDITIONS OF SERVICE

THE VESSEL WILL NOT BE SUBJECT TO A CORROSIVE ENVIRONMENT. IT WILL CONTAIN ARGON GAS WHICH IS CHEMICALLY INERT. THE OUTSIDE ATMOSPHERE IS NOT SEVERE. THE VESSEL WILL BE USED INDOORS OUT OF THE WEATHER.

UG-22 LOADINGS

a) INTERNAL PRESSURE — DESIGN PRESSURE = 65 psig

b) WEIGHT OF VESSEL

CONSERVATIVE ESTIMATES

TOP PLATE — 1" x 10.4" O.D.	≈ 24 lbs
PIPE — 10" PIPE x 18" LG.	≈ 28 lbs
COND. COILS — 1/2" PIPE x 9 FT	≈ 5 lbs
DET. & SUPPORTS	≈ 10 lbs
SIGHT GLASSES	≈ 10 lbs
FLANGE PORTS	≈ 20 lbs
MISCELL.	≈ 20 lbs

ESTIMATED ≈ 120 lbs

1/16/89

R. RUKINSKI

UPPER SHELL
ANALYSIS

REVISED 9/13/89

12.2

UG-27 THICKNESS OF SHELLS UNDER INTERNAL PRESSURE

2) CYLINDRICAL SHELL

1) CIRCUMFENTIAL STRESS.

RESTRICTIONS: $t \stackrel{?}{\leq} \frac{1}{2}$ INSIDE RADIUS = $\frac{1}{2} 5.2" = 2.6"$ O.K.

$$P \stackrel{?}{\leq} .385 SE = .385 (12.8 \text{ ksi})(.45) = 2218 \text{ psi} \quad \text{O.K.}$$

$$t_{MW} = \frac{PR}{SE - .6P} = \frac{(65 \text{ psi})(5.21 \text{ in})}{(12.8 \text{ ksi})(.45) - .6(65 \text{ psi})}$$

12,800

$$t_{MW} = \frac{339 \text{ lb/in}}{5721 \text{ lb/in}^2} = .059 \text{ in.}$$

NOTE: A JOINT
EFFICIENCY OF
.45 WAS THE
MINIMUM EFF.
LISTED IN TABLE
UW-12 AND
WAS CHOSEN TO
BE CONSERVATIVE

FOR A $t = .165 \text{ in.}$ (10" SCH. 10 PIPE)

$$MAWP = \frac{SEt}{R + .6t} = \frac{(12.8 \text{ ksi})(.45)(.165 \text{ in})}{5.21 \text{ in} + .6(.165 \text{ in})} = 179 \text{ psi}$$

2) LONGITUDINAL STRESS

RESTRICTIONS: $t \stackrel{?}{\leq} \frac{1}{2}$ INSIDE RADIUS O.K.

$$P \stackrel{?}{\leq} 1.25 SE = \dots \quad \text{O.K.}$$

$$t_{MW} = \frac{PR}{2SE + .4P} = \frac{(65 \text{ psi})(5.21 \text{ in})}{2(12.8 \text{ ksi})(.45) + (.4)(65 \text{ psi})} = .029 \text{ in.}$$

FOR A $t = .165 \text{ in.}$

$$MAWP = \frac{2SEt}{R - .4t} = \frac{2(12.8 \text{ ksi})(.45)(.165 \text{ in.})}{5.21 \text{ in} - .4(.165 \text{ in})} = 370 \text{ psi}$$

UG-28 THICKNESS OF SHELLS UNDER EXTERNAL PRESSURE

MUST DESIGN THE SHELL TO WITHSTAND A FULL VACUUM. $\Rightarrow P = 15 \text{ psia}$

c) CYLINDRICAL SHELLS

RESTRICTION: $D_o/t \geq 10 \Rightarrow D_o/t = \frac{10.75 \text{ in}}{.165 \text{ in}} = 65 > 10 \text{ o.k.}$

STEP 1: $D_o/t = 65.2$

$L/D_o = \frac{18 \text{ in}}{10.75 \text{ in}} = 1.7$

STEP 2-3: CONSULTING APPENDIX 5, FIG. 5-UGO-28.0

$A = .0015$

STEP 4-5: CONSULTING APPENDIX 5, FIG. 5-UHA-28.1

$B = 10,600$

STEP 6: $P_a = \frac{4B}{3(D_o/t)} = \frac{4(10,600)}{3(65.2)} = 217 \text{ psi}$

WHERE P_a = ALLOWABLE EXTERNAL WORKING PRESSURE

STEP 7: SKIP

STEP 8: COMPARISON OF P_a & P = EXTERNAL DESIGN PRESSURE

$P = 15 \text{ psi} < P_a = 217$

UG-34 UNSTAYED FLAT HEADS AND COVERS

TYPE TO BE CONSIDERED IS (c) OF FIG. UG-34

$C = .33$
 $C_{\min} = .20$

MINIMUM REQ'D THICKNESS:

$t = d \sqrt{CP/SE}$

WHERE:

C = A FACTOR

m = REQ'D THICKNESS OF SHELL

ACTUAL THICKNESS OF SHELL

P = DESIGN PRESSURE

S = MAX ALLOW. STRESS

E = JOINT EFFICIENCY

d = DIA. OF SPAN

VALUES

$m = \frac{.0625 \text{ in}}{.165 \text{ in}} = .379$

$C = .33(.379) = .125 \Rightarrow C_{\min} = .2$

$d = 10.42 \text{ in}$ $P = 20 \text{ psi}$ $S = 12.8 \text{ ksi}$ $E = .70$

2/2/89 REVISED 8/30
R. RUCINSKI

UPPER SHELL ANALYSIS

REVISED 9/13/89

A2.4

HEAD DESIGN

MATERIAL:

FINAL STOCK # 1550-6030

304 STN. STL. PLATE, HOT ROLLED,
ANNEALED & PICKLED.

PROBABLY (90% SURE) FROM RYERSON,
RYERSON & CENTRAL STEEL MEET ASTM A240

FROM UHA-23 pg. 390 $S = 18.8 \text{ ksi}$

$10\frac{3}{4}" \text{ O.D.}$

SMALL
OPENINGS

4" DIA. HOLE

UG-34 UNSTAYED FLAT HEADS & COVERS

SKETCH (W)
Fig. UG-34

THE REQUIRED THICKNESS

$$t = d \sqrt{CP/SE} \quad (1)$$

$$C = .33 \text{ if } t_s > 1.25 t_r$$

$$t_s = .165 > 1.25(.0625) = .0781 \text{ REQ'D MET}$$

$$P = 65 \text{ psi}$$

$$S = .8(18,800) = 15,000 \text{ psi} \quad (304 \text{ S.S. PLATE, SEE ABOVE})$$

$$E = .70 \quad d = 10.375 \text{ in.}$$

$$t = 10.375 \text{ in.} \sqrt{.33(65 \text{ psi}) / .70(15,000 \text{ psi})}$$

$$t_{\text{REQ.}} = .469 \text{ in.}$$

$$t_{\text{ACTUAL}} = \frac{1}{2}" > t_{\text{REQ'D}} = .47"$$

See A2.20-21 for reinforcement calculation.

WELD FOR HEAD ATTACHMENT

PER FIG. UW-13.2 SKETCH d

WELD ELECTRODE E308

SCALE: 1 SQUARE = 1/16

UG-36 - OPENINGS IN PRESSURE VESSELS

- c) 3a) HOLES LESS THAN 2 IN. PIPE SIZE IN HEADS 3/8" THICK DON'T REQUIRE REINFORCEMENT. THEREFORE THE PIPE CONNECTION FOR THE LEVEL SENSOR DOESN'T NEED TO BE ANALYZED, ALSO THE 1" NPT FOR THE VIEW LAMP IS O.K.

UG-39 REINFORCEMENT REQUIRED FOR OPENINGS IN FLAT HEADS

- b) CROSS SECTIONAL AREA OF REINFORCEMENT REQ'D = A

$$A = .5 d t \quad d = 4.0 \text{ in.} \quad t = .47 \text{ in. (FROM UG-34)}$$

$$A = .5(4.0 \text{ in.})(.47 \text{ in.}) = .94 \text{ in}^2$$

- d) ALTERNATIVE, SEE IF HEAD IS THICK ENOUGH TO NOT REQUIRE REINFORCEMENT.

- (1) USE 2C IN EQ. 1 OF UG-34

$$t_{\text{REQ'D}} = d \sqrt{ZCP/SE} = 10.375 \text{ in.} \sqrt{\frac{2(.33)(65)}{.70(15,000)}}$$

$$t_{\text{REQ'D}} = .663 \text{ in.}$$

$$t_{\text{ACTUAL}} = 1/2 \text{ in.} < t_{\text{REQ'D}} = .663 \text{ in.}$$

⇒ REINFORCEMENT REQUIRED

1/17/89 R. RUCINSKI

UPPER SHELL
ANALYSIS

REVISED 9/15/89

A2.6

UG-36 OPENINGS IN PRESSURE VESSELS

1/19/89 R. RUCINSKI

ANALYSIS

REVISED 9/15/89

A2.0

Y-6.1 THE ANALYSIS OF A CLASS 1 ASSEMBLY [CATEG. 3]

EQ. 5c

$$F' = 0$$

• FLANGE MOMENT DUE TO FLANGE-HUB INTERACTION

$$M_s = \frac{J_p F' M_p}{t^3 + J_s F'} \quad (7)$$

$$M_s = 0 \quad (F' = 0)$$

• SLOPE OF FLANGE AT INSIDE DIAMETER TIMES E

$$E\theta_B = \frac{5.46}{\pi t^3} (J_s M_s + J_p M_p) \quad (8)$$

$$E\theta_B = \frac{5.46}{\pi (.4375 \text{ in})^3} [J_s M_s + J_p M_p]$$

$$E\theta_B = 20.754 J_p M_p$$

$$J_p = \frac{1}{8} \left[\frac{h_D}{\beta} + \frac{h_C}{\alpha} \right] + \pi r_B = \frac{1}{(10.75 \text{ in})} \left[\frac{\frac{13-10.75}{2} \text{ in}}{\frac{13+10.75}{2(10.75)}} + \frac{.5 \text{ in}}{\frac{14+13}{2(10.75)}} \right] + \pi r_B$$

$$J_p = .13177 + \pi r_B$$

1/19/89

R. RUCINSKI

UPPER SHELL
ANALYSIS

REVISED 9/15/89

A2.9

- CONTACT FORCE BETWEEN FLANGES AT h_c

$$H_c = (M_p + M_s^{10}) / h_c \quad (9)$$

$$H_c = [7433 \text{ in-lb}] / (.5 \text{ in.}) = 14,866 \text{ lb.}$$

- BOLT LOAD AT OPERATING CONDITIONS

$$W_{m1} = H + H_g + H_c \quad (10)$$

$$W_{m1} = (.785)(11.5 \text{ in})^2 (65 \text{ lb/in}^2) + 0 + 14,866$$

$$W_{m1} = 21,5614 \text{ lb}$$

- OPERATING BOLT STRESS

$$\sigma_b = W_{m1} / A_b \quad (11)$$

Check Flange Stresses Using 24 Bolts w/ Contact outside B.C.

 AD
 27 Sept 89

$$J_P = 0.132 + \pi r_B$$

$$r_B = \frac{1}{n} \left(\frac{4}{\sqrt{1 - AR^2}} \tan^{-1} \sqrt{\frac{1 + AR}{1 - AR}} - \pi - 2AR \right)$$

$$\overline{AR} = \frac{nD}{\pi C} = 2 \times (.12855) = 0.257$$

$$r_B = \frac{1}{24} \left(\frac{4}{\sqrt{1 - (0.257)^2}} \tan^{-1} \sqrt{\frac{1.257}{0.743}} - \pi - 0.514 \right)$$

$$r_B = 0.00554$$

$$J_P = 0.149$$

$$E \theta_B = 21500 \frac{0.149}{0.139} = 23,000 = 20.7 \text{ T.M.P.} = (20.7)(0.149)(743) = 23,000 \text{ ✓}$$

$$S_R = \frac{6(M_P + M_S)}{t^2(\pi C - nD)} = \frac{6(7400)}{(0.4375)^2 [\pi(13) - 24(.3125)]}$$

$$S_R = 6960 \text{ psi}$$

$$S_T = \frac{t E \theta_B}{B_1} = 875 \frac{23000}{21500} = 936 \text{ psi}$$

$$S_H = 0$$

$$= (.139)(23,000) = 3200 \text{ ✓}$$

Check Bolt Stresses using 24 BoltsKD
27 Sep 89

$$W_{M1} = 21,600 \text{ lb}$$

Use $5/16'' - 18 \text{ UNC Class 2B}$, $\sigma_a = 0.8(25,000) = 20,000 \text{ psi}$

$$A_b = (.0524)(24) = 1.26 \text{ in}^2$$

$$\sigma_b = \frac{21600}{1.26} = 17100 \text{ psi}$$

$17,100 < 20,000$, bolts OK if we use
 $24 - 5/16'' \phi$.

Y-7, Allowable Flange Design Stresses

type: Class 1, category 3 ass'y

a) $\sigma_b < S_b$ $S_b = 0.8 \times 25 \text{ ksi} = 20 \text{ ksi}$
 $17.1 < 20 \text{ ksi}$ O.K.

c) $S_R < S_f$ $S_f = 0.8 \times 18.8 \text{ ksi} = 15 \text{ ksi}$
 $7.0 < 15 \text{ ksi}$ O.K.

d) $S_T < S_f$
 $0.9 < 15 \text{ ksi}$ O.K.

e) $\frac{S_H + S_R}{2} < S_f$
 $3.5 < 15 \text{ ksi}$ O.K.

and

$$\frac{S_H + S_T}{2} < S_f$$

$0.5 < 15 \text{ ksi}$ O.K.

parts b & f do not apply.

$\therefore$ Flange, bolt stresses O.K.

APPENDIX 2

FIG. 2-4 (3a)

FIGURE - WELD DETAIL BOTTOM FLANGE, FOR DRAFTER

FERMILAB

ENGINEERING NOTE

SECTION

RD/CRYO

PROJECT

NWA

SERIAL-CATEGORY

PAGE

A212

SUBJECT

ATTACHMENTS TO VESSEL HEAD

NAME

RUSS RUCINSKI

DATE

3/21/89

REVISION DATE

VIEW PORT & LEVEL PROBE TUBES TO HEAD:

LIGHT SOURCE, 1" - 200X COUPLING TO HEAD

NOTE THESE WELDS ARE ACCEPTABLE PER ASME B&PV
CODE VIII DIV. 1, PART UW.

REFERENCE FIG. UW-16.1 SKETCHES b & (Y-2)

1/23/89

R. BYKINSKI

CONFLAT FLANGE
ANALYSIS

A2.13

VARIAN **conflat flanges**

APPENDIX Y - FLAT FACE FLANGES W/ METAL TO METAL CONTACT OUTSIDE OF THE BOLT CIRCLE.

Y-5.1 - CLASSIFICATION OF FLANGE ASSY

CLASS 3 TYPE FLANGE. A BLIND FLANGE WITH A CENTRALLY LOCATED OPENING WILL MATE WITH THE ABOVE.

Y-5.2 - CATEGORY OF FLANGE

LOOSE TYPE - CATEGORY 3 FLANGE

FROM TABLE Y-6.1 APPLICABLE FORMULAS ARE:

(1)-(4), (6A), (17)-(31), (32C), (33C), (34C), (35)-(38)

1/23/89

R. RUCINSKI

CONFLAT FLANGE
ANALYSIS

REVISED 9/15/89

A2.14

Y.6.3 FLANGE ANALYSIS - CLASS 3 ASS'Y

SOLVING EQUATIONS IN ORDER;

$$C_1 = \text{FACTOR} = -(.748 - 1.567 J_s \log \frac{A}{B_1}) \div (1 + 1.3 J_s) \quad (1)$$

$$J_s = \frac{1}{B_1} \left[\frac{2h_o}{a} + \frac{h_c}{a} \right] + \pi r_b \quad B_1 = 1.51'' \quad h_o = \frac{C-B}{2} = \frac{2.312 - 1.51}{2} = .401''$$

$$B = \frac{C+B}{2B} = \frac{2.312 + 1.51}{2(1.51)} = 1.266 \quad h_c = .219''$$

$$a = \frac{A+C}{2B_1} = \frac{2.75 + 2.312}{2(1.51)} = 1.676 \quad r_b = \frac{.08}{6} = .0133 \quad (\text{Fig. Y-3.1})$$

$$\overline{AR} = \frac{\pi D}{\pi C} = \frac{6(.265)}{\pi(2.312)} = .2189$$

$$J_s = \frac{1}{1.51} \left[\frac{2(.401 w)}{1.266} + \frac{.219 w}{1.676} \right] + \pi(.0133) = .54795$$

$$C_1 = -(.748 - 1.567(.54795) \log \frac{2.75}{1.51}) \div [1 + 1.3(.54795)]$$

$$= -.725645 \div 1.712335 = \boxed{-.4238} = C_1$$

$$C_2 = \text{FACTOR} = \left[\frac{\pi}{32} (P B_1^3) - 1.3 J_p M_p \right] \div [1 + 1.3 J_s] \quad (2)$$

$$P = 65 \text{ psi} \quad B_1 = 1.51 \quad J_s = .54795$$

$$M_p = H_o h_o + H_T h_T + H_G h_G \quad J_p = \frac{1}{B_1} \left[\frac{h_o}{B} + \frac{h_c}{a} \right] + \pi r_b$$

$$H_o = .785 B^2 P = .785 (1.51)^2 (65) = 116$$

$$h_o = .401 w$$

$$H_T = H - H_o \quad H = .785 G^2 P = .785 (1.625 w)^2 (65 \frac{lb}{w}) = 135 lb$$

$$H_T = 135 - 116 = 19$$

$$h_T = .3435 w \quad H_G = 0$$

$$M_p = (116)(.401) + (19)(.3435) + 0 = 53$$

$$J_p = \frac{1}{1.51} \left[\frac{.401}{1.266} + \frac{.219}{1.676} \right] + \pi(.0133) = .338$$

$$C_2 = \left[\frac{\pi}{32} (65 (1.51)^3) - 1.3 (.338)(53) \right] \div [1 + 1.3(.54795)]$$

$$\boxed{C_2 = -.7694}$$

1/23/89

CONFLAT FLANGE
ANALYSIS

REVISED 9/15/89

A2.75

$$C_3 = \text{FACTOR} = -(1.575 - 1.206 J_2 \log \frac{A}{B}) \cdot \left(\delta_5 + \frac{t^3}{F_1} \right) \quad (3)$$

$$F_1 = 0 \Rightarrow$$

$$C_3 = 0 \quad (3)$$

$$C_4 = 0 \quad (4)$$

$$F_2 = 0 \quad (6c)$$

• RIGID BODY ROTATION OF FLANGES - TIMES E^*

$$E_I^* \phi_{rbI} = \frac{X(C_4 - C_2)}{1.206 \log(A/B) - XC_3 - (1-X)C_1} \quad (17)$$

$$X = \text{FACTOR} = \frac{E_I^*}{E_I^* + E_{II}^*}$$

$$E_I^* = \text{FACTOR} = E_I t_I^3 \quad E_I = E_{II} = 28.3 \times 10^6 \text{ psi} \quad (\text{TABLE UF-27})$$

$$E_I^* = (28.3 \times 10^6 \text{ psi})(.5 \text{ in})^3 = 3,537,500 \text{ in-lb}$$

$$E_{II}^* = E_{II} t_{II}^3 = E_I^* = 3,537,500 \text{ in-lb}$$

$$X = \frac{1}{2} = .5$$

$$E_I^* \phi_{rbI} = \frac{.5(+.7694)}{1.206 \log \frac{2.75}{1.51} - .5(6) - (1-.5)(-.4238)} = \frac{.3847}{.31399 + .2119}$$

$$E_I^* \phi_{rbI} = .7315$$

$$E_{II}^* \phi_{rbII} = -E_I^* \phi_{rbI} \left(\frac{E_{II}^*}{E_I^*} \right) \quad (18)$$

$$E_{II}^* \phi_{rbII} = -.7315$$

• TOTAL FLANGE MOMENT AT DIA: B.

$$M_{SI} = C_3(E_I^* \phi_{rbI}) + C_4 \quad (19)$$

$$M_{SI} = 0$$

$$M_{SII} = C_1(E_{II}^* \phi_{rbII}) + C_2 \quad (20)$$

$$M_{SII} = -.4238(-.7315) + -.7694$$

$$M_{SII} = -.459 \text{ in-lb}$$

1/24/89

R. RUCANWSKI

CONFLAT FLANGE
ANALYSIS

REVISED 9/15/89

A2.16

- UNBALANCED FLANGE MOMENT AT DIA. B_I

$$M_{UI} = 1.206 E_I^* \phi_{rBI} \log A/B_I \quad (21)$$

$$M_{UI} = 1.206 (.7315) \log \frac{2.75}{1.51}$$

$$M_{UI} = .23 \text{ in-lb}$$

$$M_{UII} = 1.206 E_{II}^* \phi_{rBI} \log A/B_I \quad (22)$$

$$M_{UII} = -.23 \text{ in-lb}$$

- BALANCED FLANGE MOMENT AT DIA. B_I

$$M_{bI} = M_{sI} - M_{UI} \quad (23)$$

$$M_{bI} = 0 - .23 \text{ in-lb} = -.23 \text{ in-lb}$$

$$M_{bII} = M_{sII} - M_{UII} \quad (24)$$

$$M_{bII} = -.459 - (-.23) = -.23 \text{ in-lb}$$

- SLOPE OF FLANGE AT DIA. B TIMES E

$$E_I \phi_{BI} = \frac{5.46}{\pi t_I^3} (J_S M_{bI} + J_P M_P) + E_I^* \phi_{rBI} / E_I^3 \quad (25)$$

$$E_I \phi_{BI} = \frac{5.46}{\pi (.50)^3} [.54795 (-.23) + .338 (53)] + .7315 / (.5)^3$$

$$E_I \phi_{BI} = 253$$

$$E_{II} \phi_{BII} = \frac{-1.337 (M_{sII} - \pi P B_I^3 / 32)}{t_{II}^3} \quad (26)$$

$$E_{II} \phi_{BII} = \frac{-1.337 [-.459 \text{ in-lb} - \pi (65 \text{ psi}) (.5 \text{ in})^3 / 32]}{(.50 \text{ in})^3}$$

$$E_{II} \phi_{BII} = 235$$

- CONTACT FORCES BETWEEN FLANGES AT h_c

$$H_c = (M_P + M_{bI}) / h_c \quad (27)$$

$$H_c = (53 \text{ in-lb} + -.23 \text{ in-lb}) / .219 \text{ in.}$$

$$H_c = 241 \text{ lb}$$

• BOLT LOAD AT OPERATING CONDITIONS

$$W_{m1} = H + H_G + H_C \quad (28)$$

$$W_{m1} = 135 \text{ lb} + 0 + 241 \text{ lb}$$

$$W_{m1} = 376 \text{ lb}$$

• OPERATING BOLT STRESS

$$\sigma_b = W_{m1} / A_b \quad (29)$$

BOLTS WILL BE $1/4''$ -28 UNF CLASS 2B AISI 304

$$A_b = 6 \times (.0364 \text{ in}^2) = .2184 \text{ in}^2$$

$$\sigma_b = 376 \text{ lb} / .2184 \text{ in}^2 = 1722 \text{ psi}$$

• DESIGN PRESTRESS IN BOLTS

$$S_i = \sigma_b - \frac{1.159 h_c^2 (M_p + M_{bz})}{2(1-x) a t_i^3 l_{et} B_i} \quad (30)$$

$$l = t_i + t_{ii} + \frac{1}{2} d = .5 + .5 + \frac{4}{16} h_o g \cdot \frac{1}{2} = 1.0 \text{ in.}$$

$$S_i = 1722 \text{ psi} - \frac{1.159 (.219 \text{ in})^2 (53 + -.23)}{2(1-.5)(1.676)(.5)^3(1.0)(1.0)(1.51)}$$

$$S_i = 1713 \text{ psi}$$

• RADIAL STRESS IN FLANGE I AT BOLT CIRCLE

$$S_{RI} = \frac{6(M_p + M_{sz})}{t_i^3 (\pi C - n D)} \quad (31)$$

$$S_{RI} = \frac{6(53 + 0)}{.5^3 (\pi(2.312) - 6(.265))}$$

$$S_{RI} = 224 \text{ psi}$$

- RADIAL STRESS IN FLANGE I AT INSIDE DIAMETER

$$S_{RI} = 0 \quad (32c)$$

- TANGENTIAL STRESS IN FLANGE I AT INSIDE DIAMETER

$$S_{TI} = \frac{t_I E_I \theta_{BI}}{B_I} \quad (33c)$$

$$S_{TI} = \frac{(0.5 \text{ in.}) 253}{1.51 \text{ in.}} = 84 \text{ psi} = S_{TI}$$

- LONGITUDINAL HUB STRESS IN FLANGE I

$$S_{HI} = 0 \quad (34c)$$

- RADIAL STRESS IN FLANGE II AT BOLT CIRCLE

$$S_{RII} = \frac{6(M_p + M_{SII})}{t_{II}^2 (\pi C - nD)} \quad (35)$$

$$S_{RII} = \frac{6(53 + 46)}{(1.5)^2 (\pi (2.312) - 6(.265))} = 222 \text{ psi} = S_{RII}$$

- RADIAL STRESS IN FLANGE II AT DIAMETER B_I

$$S_{RI} = \frac{6 M_{SII}}{\pi B_I t_{II}^2} \quad (36)$$

$$S_{RI} = \frac{6(-.459 \text{ in. lb})}{\pi (1.51 \text{ in.}) (0.5 \text{ in.})^2} = -2.3 \text{ psi} = S_{RI}$$

- TANGENTIAL STRESS IN FLANGE II AT DIA. B_I

$$S_{TII} = \frac{t_{II} E_{II} \theta_{BII}}{B_I} - \frac{1.8 M_{SII}}{\pi B_I t_{II}^2} \quad (37)$$

$$S_{TII} = \frac{(1.5 \text{ in.}) (235 \text{ psi})}{1.51 \text{ in.}} - \frac{1.8(-.459 \text{ in. lb})}{\pi (1.51 \text{ in.}) (1.5 \text{ in.})^2}$$

$$S_{TII} = 78.5 \text{ psi}$$

• RADIAL AND TANGENTIAL STRESS AT CENTER OF FLANGE II

$$S_{RII} = S_{TII} = \frac{0.3094 P B_i^2}{t_{II}^2} - \frac{6 M_{SI}}{\pi B_i t_{II}^2} \quad (38)$$

$$S_{RII} = S_{TII} = \frac{0.3094 (65 \frac{\text{lb}}{\text{in}^2}) (1.51 \text{ in})^2}{(.5 \text{ in})^2} - \frac{6 (-.46 \text{ in-lb})}{\pi (1.51 \text{ in}) (.5 \text{ in})^2}$$

$$S_{RII} = S_{TII} = 186 \text{ psi}$$

Y-7 ALLOWABLE FLANGE DESIGN STRESSES

$$S_b = \text{ALLOW. BOLT STRESS} = 25,000 \text{ psi}$$

$$S_f = \text{ALLOW DESIGN STRESS} = 18,800 \text{ psi} \times .8 = 15,000 \text{ psi}$$

$$a) \sigma_b < S_b \Rightarrow \sigma_b = 1722 \text{ psi} < 25,000 \text{ psi} = S_b \quad \text{STRESS O.K.}$$

$$b) S_H < S_f \Rightarrow S_H = 0 \quad \text{STRESS O.K.}$$

$$c) S_R < S_f \Rightarrow S_{R \text{ MAX}} = 222 \text{ psi} < 15,000 \text{ psi} = S_f \quad \text{STRESS O.K.}$$

$$d) S_T < S_f \Rightarrow S_{T \text{ MAX}} = 84 \text{ psi} < 15,000 \text{ psi} = S_f \quad \text{STRESS O.K.}$$

$$e) (S_H + S_R) / 2 < S_f \Rightarrow \frac{S_H + S_R}{2} = \frac{0 + 222}{2} \text{ psi} < 15,000 \text{ psi} = S_f \quad \text{STRESS O.K.}$$

AND:

$$\frac{S_H + S_T}{2} < S_f \Rightarrow \frac{S_H + S_T}{2} = \frac{0 + 84}{2} \text{ psi} < 15,000 \text{ psi} = S_f \quad \text{STRESS O.K.}$$

$$f) S_{RII} = S_{TII} < S_f \xrightarrow{\text{REF}} \text{(EQ. 38)} 186 \text{ psi} < 15,000 \text{ psi} = S_f \quad \text{STRESS O.K.}$$

CONCLUSION ALL STRESS VALUES FOR THE CONFLAT FLANGE ARE WAY BELOW ALLOWABLE STRESS VALUES. CONFLAT FLANGE IS O.K. FOR POSITIVE PRESSURE ABOVE 65 PSI.

BECAUSE THE MAGNITUDES OF THE STRESSES ARE SO SMALL I CONCLUDE THAT THE 1.33" O.D. CONFLAT WILL ALSO BE GOOD FOR POSITIVE PRESSURES ABOVE 65 PSI.

FERMILAB
ENGINEERING NOTE

SECTION
RD/CRYO

PROJECT
ATC

SERIAL-CATEGORY

PAGE
A2.20

SUBJECT

NOZZLE NECK THICKNESS UG-45

NAME

RUSS RUCINSKI

DATE

9/15/89

REVISION DATE

WALL THICKNESS REQ'D IS LARGER OF 1a, 2a, & 2b

- 1) THICKNESS PER UG-22 - REQ'D FOR INTERNAL OR EXTERNAL PRESSURE
INT. PRESSURE

$$t_{min} = \frac{PR}{SE - .6P} = \frac{(65 \text{ psi})(2)}{(12,800)(.45) - .6(65)} = .023 \text{ in.}$$

$$t_{min} = \frac{PR}{2SE + .4P} = \frac{65(2)}{2(12,800)(.45) + .4(65)} = .011 \text{ in.}$$

EXT. PRESSURE

$$D_o/t = \frac{4}{.065} = 62 > 10$$

$$L/D = \frac{2.25}{4} = .5625$$

$$A = .0055$$

APPENDIX 5
FIG. 5-UGO-28.0

$$B = 13,300 \text{ APPENDIX 5, FIG. 5-UHA-28.1}$$

$$P_a = \frac{4B}{3(D_o/t)} = \frac{4(13,300)}{3(62)} = 286 \text{ psi} >> P_{design} = 65 \text{ psi}$$

$$\text{TO DETERMINE REQ'D } t \quad \frac{3 \cdot P_{design} \cdot D_o}{4B} = \frac{3(65)(4)}{4(13,300)} = .015 \text{ in.}$$

FROM PART 1a): $t_r = .023 \text{ in.}$

2a, b) SMALLEST OF FOLLOWING

$$\left. \begin{array}{l} \text{a) THICKNESS REQ'D FOR PRESSURE, } t = .023 \\ \text{MINIMUM THICKNESS PER UG-16, } t = .0625 \end{array} \right\} .0625 \text{ in.}$$

$$\left. \begin{array}{l} \text{b) THICKNESS REQ'D FOR INT. PRESSURE, } t = .015 \\ \text{MIN. THICKNESS PER UG-16, } t = .0625 \end{array} \right\} .0625 \text{ in.}$$

→ LARGEST OF OF 1a, 2a, & 2b IS $.0625 \text{ in.} = t_{rn}$

SUBJECT

REINFORCEMENT OF 4 IN. HOLE

NAME

RUSS RUCINSKI

DATE

9/15/89

REVISION DATE

FROM UG-39b, REINFORCEMENT AREA REQ'D, $A = .94 \text{ in}^2$
 REFERENCE UG-37 FOR DETERMINATION OF REINFORCEMENT AREA

$$A_1 = \text{LARGER OF } \begin{cases} 1) d(E_1 t - F t_r) - 2 t_n (E_1 t - F t_r) (1 - F_{r1}) \\ 2) 2(t + t_n)(E_1 t - F t_r) - 2 t_n (E_1 t - F t_r) (1 - F_{r1}) \end{cases}$$

{SEE FIGURE UG-37.1}

$$d = 4.0 \text{ in.} \quad E_1 = 1 \quad t = 1/2" \quad F = 1 \quad t_r = .47 \text{ in.} \quad t_n = .065" \\ F_{r1} = 1.0 \quad t_{rn} = .0625"$$

$$d(E_1 t - F t_r) = 4.0(1(.5) - (1)(.47)) = .12$$

$$2(t + t_n)(E_1 t - F t_r) = 2(.5 + .065)(1(.5) - 1(.47)) = .034$$

EXPRESSION 1. IS LARGER FROM COMPARISON

$$1) A_1 = .12 - 2(.065)(1(.5) - (1)(.47)(1 - 1)) = \underline{\underline{.12 \text{ in}^2}}$$

$$A_2 = \text{SMALLER OF } \begin{cases} 1. 5(t_n - t_{rn}) F_{r2} t \\ 2. 2(t_n - t_{rn})(2.5 t_n + t_c) F_{r2} \end{cases}$$

$$1) 5(.065 - .0625)(1)(.5) = .00625"$$

$$2) 2(.065 - .0625)(2.5(.065) + 0)1 = .0008" > \underline{\underline{.0008}}$$

$$A_3 = 0$$

A_5 - WHAT WE NEED TO ADD

$$A_5 = (D_p - d - 2 t_n) t_c F_{r4} \quad F_{r4} = 1.0$$

FROM PHYSICAL CONSTRAINTS, $D_p = 5.5 \text{ in.}$ $d = 4.0$

TRY $t_c = .5 \text{ in.}$

$$A_5 = (5.5 - 4 - 2(.065))(.5 \text{ in.})(1) = .685$$

$$\sum_{i=1}^5 A_i = .12 + .685 = .805 < A \therefore \text{MORE REINFORCEMENT NEEDED}$$

TRY $t_c = .75 \text{ in.}$

$$\rightarrow A_5 = (5.5 - 4 - 2(.065))(.75 \text{ in.})(1) = 1.0275$$

$$\sum A_i = .12 + .0008 + 1.0275 = 1.15 \text{ in}^2 > A = .94 \text{ in}^2$$

9/15/89

TITLE NOZZLE REINFORCEMENT RING

3740.000
USED ON: ME193913

MATERIAL: 304 STN. STL.
FINAL STOCK # 1550-1540

→ ONE REQUIRED ←

Fermilab

Cryogenics Department--MS 219

Wilson Hall 11th Floor--Ext. 2888

October 6, 1989

TO: Andrew Szymulanski, Independent Safety Reviewer
FROM: Russ Rucinski²
SUBJECT: Addendum to Pressure Vessel Engineering Note for LAr Purity Vessel,
Vessel No. RD-1102

Two signal feedthru nozzles require modification due to an installation fit up problem. The modification is sketched and described on the attached sheet. The modification is designed per ASME code rules and will be performed by a qualified welder. This cover sheet and the attached sheet will become an addendum to the design calculations in the engineering note after your approval.

APPROVAL

The signal feedthru port modification sketched and described on the attached sheet is acceptable.

Signature

Oct. 6. 89
Date

SUBJECT

SIGNAL FEEDTHRU PORT MODIFICATION

NAME

RUSS RUCINSKI

DATE

10-5-89

REVISION DATE

THE ABOVE MODIFICATION IS NECESSARY TO ALLOW FIT-UP OF THE "SIGNAL FEEDTHRU SHELL". THIS SHELL HAS AN O.D. OF 1.4" WHEREAS THE ORIGINAL TUBE ONLY HAD AN I.D. OF 1.37". THE SIGNAL FEEDTHRU SHELL IS BEING SUPPLIED BY J. BLAZEY.

SECTION UW - WELDING REQUIREMENTS

PER FIG. UW-3 THE FLANGE TO TUBE WELD IS A CATEGORY C WELD
" " " TUBE TO TUBE WELD IS A CATEGORY B WELD
PERMISSIBLE WELDS ARE LISTED IN TABLE UW-12

THE TUBE TO TUBE WELD IS A TYPE 6 WELD WITH A WELD EFFICIENCY OF .45. THE WELD SIZE AND OVERLAP IS PER FIG. UW-13.1. MINIMUM WELD SIZE = $1.3 t_s = .08"$. AND THE MINIMUM OVERLAP IS 1".

THE TUBE TO FLANGE WELD IS A TYPE 3 WELD AND IS SIZED PER FIG. UW-13.2. MINIMUM WELD SIZE = $.7(t_s) = .045"$ OR $1.4 t_r = 1.4 (.018) = .025"$

Determine Reg'd Relief Flow for ATC Cryostat

Assumed worst cases:

1. Fire condition per CGA 51.3
2. Max available purge flow
3. Max flow thru "test" line

Case #1

This vessel is similar to RD 1102, purity test cell at NWA. Calculations done by R. Rucinski for that vessel apply since wetted area and fluid used is the same.

$$Q_a = 15.6 \text{ scfm air}$$

Case #2

The current plan is to use regulated bottle gas (N_2 or Ar) to backfill during pump & purge operations and to warm the cryostat contents.

Typically, flow through standard bottle regulators is quite low ($< 20 \text{ scfm}$) for the delivery range of 0-50 psi. However, if a larger range is used, this flowrate can increase. After perusing through an assortment of vendor catalogues, I've found a maximum flow rate of 53 scfm for std. regulators.

Even though there are no plans to go outside of the 0-50 psig range, I will use 53 scfm as a worst case purge flow. This also neglects any flow reduction due to the tubing.

$$Q_a = 53 \text{ scfm air}$$

Case #3

Source of this flow vendor trailer or argon storage dewar. Both will operate below set pressure of relief, 65 psig.

Therefore, no flow is req'd at relieving pressure for this particular case.

KD
10 Nov 89

∴ Will use 53 scfm as req'd flow

Relief valve chosen is an Anderson Greenwood #83568-6 set at 65 psig. Flow rating for this valve is 142 scfm air.

CASE 3 FIRE IN BUILDING

THE AREA TO BE USED IN CALCULATION OF
THE FLOW CAPACITY WILL BE THE AREA
OF THE VENTED SURFACE.

FROM CGA PUBLICATION 2-1.3

PAR. 5.3.6.3 APPLIES

ALSO EQ. 5.3.5 $Q_a = G_1 U A^{0.32}$

Q_a = FLOW CAPACITY IN FT^3/MIN FREE A.R.

$G_1 = 10.2$ FROM TABLE 1

$D = 11.125 \text{ in.}$

$H = 12.3125 \text{ in.}$ MAXIMUM NORMAL
VENTED AREA

$$A = \pi \left(\frac{12.3125}{12} \right) \left(\frac{11.125}{12} \right) + \pi \left(\frac{11.125}{12} \right)^2 \frac{1}{4} = 3.8152 \text{ FT}^2$$

$$U = \frac{K}{L} = \frac{.0231 \frac{\text{BTU}}{\text{hr-ft}^2 \cdot ^\circ\text{F}}}{\left(\frac{12.3125 - 10.625}{2} - .09 - .0625 \right) \frac{1 \text{ ft}}{12 \text{ in.}}}$$

$$U = .401 \frac{\text{BTU}}{\text{hr-ft}^2 \cdot ^\circ\text{F}}$$

$$Q_a = (10.2) (.401 \frac{\text{BTU}}{\text{hr-ft}^2 \cdot ^\circ\text{F}}) (3.8152 \text{ FT}^2)$$

$$Q_a = 15.6 \text{ FT}^3/\text{MIN.}$$

FROM AGCO $A = \frac{V \sqrt{14.7 Z}}{6.32 \text{ PSF}}$

$$P_1 = 1.21(20) + 14.3$$

$$= 38.5 \text{ PSF}$$

$$A = \frac{15.6 \sqrt{29(520)}}{6.32(38.5)(.315)(33.5)}$$

$$A = .02711 \text{ IN}^2$$

Model 8

Brass Two-Stage Regulators

DESCRIPTION

These brass two-stage regulators combine proven design with economical construction to provide a reliable, long lasting regulator at an affordable price. The two-stage design permits steady gas delivery pressure at high or low flows throughout the discharge of virtually an entire supply gas cylinder. These popular regulators can be found in just about any laboratory — worldwide.

Two-Stage

APPLICATIONS

The Model 8 regulator is the ideal general purpose laboratory regulator for the control of the following grades of non-corrosive gases

- Prepurified
- High Purity
- Extra Dry
- Technical
- C.P. (non-liquefied hydrocarbon gases).

These regulators maintain desired delivery pressure accurately and simplify gas analytical work by eliminating the need to compensate for drifting gas pressure. In addition to laboratory applications, the Model 8 regulator is widely used for general plant, pilot plants, and maintenance shops for use in controlling gas pressure for instrument calibrations.

When equipped with flowmeters as shown on page 117, gas flow rate as well as pressure can be set and easily monitored.

DESIGN FEATURES

- Porous metal filter on inlet... Protects internal parts and extends useful life of regulator.
- Pre-set safety device... Prevents excessive pressure build-up in regulator first stage.
- Stainless steel ball in adjusting screw end... Allows easy and accurate setting of delivery pressure.
- Brass body/neoprene rubber construction... Excellent performance at affordable cost.

MATERIALS OF CONSTRUCTION

Body:	Brass
Diaphragm:	1st stage: 302 Stainless steel 2nd stage: Neoprene
Seat:	1st stage: Nylon 2nd stage: Neoprene

SPECIFICATIONS

Maximum inlet pressure: 3600 psi (24,840 kPa)
Operating temperature: -20° to 140°F (-30 to 60°C)
Maximum flow of air through regulator equipped with outlet valve at inlet pressure 2000 psi.

8L: 360 cfh (170 liters/min)
8: 800 cfh (375 liters/min)
8H: 1400 cfh (660 liters/min)
8-250: 3200 cfh (1500 liters/min) = 53 scfm

Interstage relief pressure: Model 8: 800-1200 psi
Model 8-250: 900-1300 psi

Inlet port in body: 1/2"-27
Outlet: 1/4" MNPT
Dimensions, overall: Model 8: 7 1/2" w x 7 1/2" h x 7" d
(19 x 19 x 18 cm)
Shipping weight: Model 8: 7 lb. (3.2 kg)

MODELS

Model	Delivery Pressure Range (psig)	Delivery Pressure Gauge (psig)	Cylinder Pressure Gauge (psig)
8L (Specify CGA)	2-15	0-30	0-3000
8 (Specify CGA)	4-50	0-100	0-3000
8H (Specify CGA)	10-100	0-200	0-3000
8-250 (Specify CGA)	20-250	0-100	0-3000

OPTIONS

Check Valve — Model 400V — (see page 185)
Cylinder Quick Coupler Inlet — (1/2" - 27) see page 189.
Swagelok Outlet Connection (Brass)
Preset (Specify pressure)
Ultrasonic Cleaning
Safe Venting Assembly

taken from:
Matheson Gas Products
catalogue.

Check Pressure Loss in Relief Valve Piping

KD
6 Feb 90

Assume: No pressure loss due to 1" outlet elbow
Incompressible flow
Argon flowing sonically through purge
regulator (ASME flow relationship for
relief valve applies)
Fully developed flow

Argon properties at 6 bar (1.1 x 65 psig):
 $\rho = 0.62 \text{ lbm/ft}^3$, $C = 1043 \text{ ft/s}$
 $\mu = 0.054 \text{ lbm/ft}\cdot\text{hr}$

Velocity, incompressibility check:

max req'd air flow is 53 scfm

$$Q_{\text{argon}} = 53 \sqrt{29/40} \left(\frac{377}{356} \right) = 48 \text{ scfm argon}$$

$$\bar{V} = \frac{Q}{A} =$$

$$A = \frac{\pi}{4} d^2 \quad d = \frac{.884}{12} = .074 \text{ ft}$$

$$\bar{V} = \frac{48}{\frac{\pi}{4} (.074)^2 60} = 186 \text{ ft/s}$$

$M \equiv$ mach no.

$$M = \frac{\bar{V}}{c} = \frac{186}{1043} = 0.2$$

$\therefore$ Since $0.2 < 0.3$, incompressible assumption OK

find friction factor:

$$R_d = \frac{\rho \bar{V} D}{\mu} = \frac{(0.62)(186)(0.074)}{(1.054)(1/3600)} = 5.7 \times 10^5$$

$$\epsilon/d = .002 \quad \text{for comm'l steel pipe}$$

$$\underline{f = .024} \quad \text{from Moody chart}$$

find Δp inlet:

$$\left(\frac{P_1}{\rho_1} + K \frac{\bar{V}_1^2}{2} + g z_1 \right) - \left(\frac{P_2}{\rho_2} + K_2 \frac{\bar{V}_2^2}{2} + g z_2 \right) = h_{eT}$$

$\alpha \approx 1$ for large Reynold's #s

$$V_1 \approx 0, \quad g\Delta z \approx 0, \quad \rho_1 \approx \rho_2 = \rho, \quad \bar{V}_2 = \bar{V}$$

$$\frac{\Delta p}{\rho} - \frac{\bar{V}^2}{2} = h_{LT}$$

$$h_{LT} = h_L + h_m$$

$$= f(l/d) \frac{\bar{V}^2}{2} + \sum K \frac{\bar{V}^2}{2}$$

$$\Delta p = \rho \frac{\bar{V}^2}{2} [f(l/d) + \sum K + 1]$$

$$\Delta p = \frac{\rho \bar{V}^2}{2g_c} [f(l/d) + \sum K + 1] \quad \text{english units}$$

$$\sum K = K \Big|_{\substack{\text{vessel} \\ \text{to} \\ 1.26'' \phi}} + K \Big|_{\substack{1.26'' \phi \\ \text{to} \\ 0.89'' \phi}} = 0.5 + 0.25 = 0.75$$

$K \Big|_{\substack{1.26'' \phi \\ \text{to} \\ 0.89'' \phi}}$ taken from Flow Measurement Engineering Handbook;
Miller, RW; New York; McGraw-Hill; 1983

$$l = l_{eq} = 2\frac{1}{2} \text{ ft} + 2\frac{1}{2} \text{ ft} = 0.33 \text{ ft}$$

above is conservative if we use smaller diameter when determining the pressure drop.

$$f(l/d) = 0.024 \left(\frac{0.33}{0.074} \right) = 0.11$$

$$\Delta p = \frac{0.62 (186)^2 (0.11 + 0.75 + 1.0)}{2 (32.2)}$$

$$\boxed{\Delta p = 619 \text{ lb/ft}^2 = 4.3 \text{ psi}}$$

Valve blowdown set at 10% of set pressure, or 6.5 psi

$\therefore$ Inlet pressure drop is acceptable at assumed largest flow. Valve will NOT chatter.

FERMILAB

ENGINEERING NOTE

SECTION

RD/CRYO

PROJECT

NWA

SERIAL-CATEGORY

PAGE

A4.1

SUBJECT

SD-37B ENGINEERING NOTE

NAME

RUSS RUCINSKI

DATE

3/22/89

REVISION DATE

WELDER QUALIFICATION AND WPS

WELDING IS TO BE DONE PER A WPS BY A WELDER
QUALIFIED TO THE PROCESS OF THE PROCEDURE
FOLLOWING CODE RULES.

QW-423.1 BASE MATERIAL USED FOR WELDER QUALIFICATION
MAY BE SUBSTITUTED FOR THE P-NUMBER MATERIAL
SPECIFIED IN THE WPS IN ACCORDANCE WITH THE
FOLLOWING:

BASE METAL FOR
WELDER QUALIFICATION

P-No. 1 THRU P-No. 11

QUALIFIED PRODUCTION
BASE METAL

P-No. 1 THRU P-No. 11

PAR. QW-423.1 ALLOWS WELDERS QUALIFIED ON MATERIAL WITH A
P-No. 1, QUALIFIED TO WELD 304 STN. STL. WHICH IS A
MATERIAL WITH P-No. 8.

THE WELDING PROCEDURE SPECIFICATION (WPS) TO BE
USED IN WELDING THIS VESSEL IS ~~X~~ FNI-WP-900.

WELDER QUALIFICATION TEST RECORD

Welder's Name William Gatfield #4609 Ident. No. 45 Date Sept. 27
Welding Process(es) GTAW Type MANUAL
Test in Accordance with WPS No. ES 155003
Material Spec. Spec/Grade No. SA53-B to Spec/Grade SA53-B
P No. P-1 to P No. P-1 Thick. .277 Dia. 6" DIA
Filler Metal Spec. No. AWS A5.18-79 Class. No. #65 F No.
Backing No
Position 6-G Weld Progression UPWARD
Gas Type ARGON Composition
Electrical Characteristics: Current DC Polarity STRAIGHT
Other Thickness range : up to .554

FOR INFORMATION ONLY

Filler Metal Diameter and Trade Name Linde 65
Submerged Arc Flux Trade Name N A
Gas Metal Arc Welding Shield Gas Trade Name N A

GUIDED BEND TEST RESULTS

Specimen No.	Type	Figure No.	Results
1	Face	QW 462.3a	Acceptable
2	Root	QW 462.3a	Acceptable
3	Face	QW 462.3a	Acceptable
4	Root	QW 462.3a	Acceptable

RADIOGRAPHIC TEST RESULTS
(FOR ALTERNATIVE QUALIFICATION BY RADIOGRAPHY)

Radiographic Results N/A
Test Conducted by IFR Engineering Test No. 008-01-13

We certify that the statements in this record are correct and that test welds were prepared, welded and tested in accordance with the requirements of Section IX of the ASME Code.

By: J. D. [Signature]Date: 9/27/1983

WELDER QUALIFICATION TEST RECORD

#4609

Welder's Name William Gatfield, Ident. No. 45 Date October 4
Welding Process(es) SMAW Type MANUAL
Test in Accordance with WPS No. ES-155000
Material Spec. Spec/Grade No. 6A 53A to Spec/Grade SA 53A
P. No. P-1 to P No. P-1 Thick. .277 Dia.
Filler Metal Spec. No. A5.1 Class. No. 6010-7018 F No.
Backing NA
Position 6-G Weld Progression Up
Gas Type NA Composition
Electrical Characteristics: Current DC Polarity Reversed
Other Thickness Range Qualified up to .554

FOR INFORMATION ONLY

Filler Metal Diameter and Trade Name (Lincoln) Root Fleet Weld 5P Rema
Submerged Arc Flux Trade Name Kimtron 7018
Gas Metal Arc Welding Shield Gas Trade Name

GUIDED BEND TEST RESULTS

Specimen No.	Type	Figure No.	Results
1	Face	QW 462.3a	Acceptable
2	Root	QW 462.3a	Acceptable
3	Face	QW 462.3a	Acceptable
4	Root	QW 462.3a	Acceptable

RADIOGRAPHIC TEST RESULTS
(FOR ALTERNATIVE QUALIFICATION BY RADIOGRAPHY)

Radiographic Results N/A
Test Conducted by IFR Engineering Test No. 008-01-13

We certify that the statements in this record are correct and that 1 test welds were prepared, welded and tested in accordance with the requirements of Section IX of the ASME Code.

By: *James Forster*Date: 10/4/83

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FERMI NATIONAL ACCELERATOR LABORATORY

PTS-8-350-5011
305-782-
A4.

WELD PROCEDURE NO.: FNI-WP-900

PROCEDURE TITLE: Gas Tungsten Arc Welding of Chromium-Nickel Steel
Materials. (P number 8, Group number 1)

PROCEDURE REVISION RECORD:

Revision	_____	Date	_____	Supporting PQR Nos.	_____
Revision	_____	Date	_____	Supporting PQR Nos.	_____
Revision	_____	Date	_____	Supporting PQR Nos.	_____
Revision	_____	Date	_____	Supporting PQR Nos.	_____

Prepared By: _____ Date _____

Approved By: _____ Date _____

A

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Weld Procedure No.: FNI-WP-900

SCOPE

This procedure covers the welding of Chromium Nickel Steel materials utilizing the Gas Tungsten Arc Welding process. (P number 8, Group number 1)

INDEX

Written Weld Procedure Specification - Manufacturer's or contractor's standards indicating the scope of the procedure, methods used to accomplish welding, materials and techniques used in production of welding, and those items which may or may not be changed with or without requalification of procedure. There may be more than one procedure qualification record required per weld procedure specification due to the change of one or more of the essential variables established in the succeeding paragraphs.

Weld Procedure Specification Form - Form QW-482

Procedure Qualification Record - Form QW-483

Independent Laboratory Test Reports

Manufacturer's Record of Welder or Welding Operator Qualification Tests - QW-484

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Weld Procedure No.: FNI-WP-900

ABBREVIATIONS

GTAW		Gas Tungsten Arc Welding
E.V.		Essential Variable
S.E.V.		Supplimentary Essential Variable
N.E.V.		Non-essential Variable
W.P.S.		Welding Procedure Specification
P.Q.R.		Procedure Qualification Record
ASME		American Society of Mechanical Engineers
AWS		American Welding Society

DEFINITIONS

Essential Variable - Essential variables are those in which a change as described in the specific variables, is considered to affect the mechanical properties of the weldment, and shall require requalification of the Weld Procedure Specification.

Supplimentary Essential Variable - Supplimentary essential variables are required for metals for which other sections of the code specify notch-toughness tests.

Non-essential Variables - Non-essential variables are those in which a change, as described in the specific variables, may be made in the Welding Procedure Specification without requalification.

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Weld Procedure No.: FNI-WP-900

1. WELDING PROCESS (E.V.)

Welding done in accordance with this procedure shall utilize manual Gas Tungsten Arc Welding Process. The Gas Tungsten Arc Welding shall be done using a non-consumable electrode of 2% Thoriated Tungsten (AWS A5.12, EWTH-2).

2. JOINTS (N.E.V.)

In any welding process, qualification of a single welded butt joint with or without consumable insert qualifies for fillet welds and single welded butt joints with backing strips.

3. BASE METAL (E.V.)

Base metal shall conform to those alloy steels listed in P-8, of QW 422 for P numbers, Section IX of the ASME Boiler & Pressure Vessel Code. This procedure is proposed to allow welding of plate or pipe with a range of thickness in accordance with the qualified welding procedure specifications.

4. FILLER METAL (E.V.)

This procedure may or may not utilize a consumable insert for the root pass in accordance with the qualified welding procedure specification (For the configuration of the consumable insert, see attached Drawing #1).

The supporting procedure qualification records shall show the type of insert to be used in the qualification. The materials of the consumable insert shall be compatible with the chemical composition of the base material and the corrosion resistance shall be at least that of the base material.

The filler metal shall conform to ASME filler metal specification SFA 5.9 for ferrous metal.

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5. POSITION (S.E.V.)

The welding shall be allowed in pipe positions: 1G flat, 2G horizontal, 5G multiple, and 6G multiple position; Plate positions: 1G flat, 2G horizontal, 3G vertical and 4G overhead. (See Sketch #2)

NOTE 1: *Qualification of all procedure weld test samples shall be made utilizing pipe materials in the 6G position and/or combination of 2G and 5G on a single weld test sample. This shall qualify test positions for all fillet welds and/or test positions for all groove welds on plate materials.*

NOTE 2: *Progression of each layover pass on all vertical welds shall be upward.*

6. PREHEAT AND INTERPASS TEMPERATURE (E.V.)

Metal temperature at the weld joint and immediate adjacent area shall be 60 deg. F prior to welding. No preheat is required, however, a maximum of 350 deg. F interpass temperature shall be maintained. The temperature of the weld deposit and surrounding material must fall below 300 deg. F before the next successive weld pass.

7. POST WELD HEAT TREATMENT (E.V.)

This weld procedure specification makes no allowance for post weld heat treatment. Therefore, any requirement for post weld heat shall result in establishing a new welding procedure specification and qualification of the same.

8. SHIELDING GAS FOR THE GTAW PROCESS (E.V.)

The shielding gas shall conform to the following nominal composition: Argon welding grade 99.9% pure. The minimum and maximum flow rates shall be as indicated in the weld procedure specification.

NOTE: *The rate of shielding gas flow specified in the procedure qualification record may not*

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be satisfactory in all applications unless the welding area of the weldment is properly and adequately protected from atmospheric disturbances.

9. ELECTRICAL CHARACTERISTICS (S.E.V.)

The current used for the GTAW process shall be direct current, straight polarity. The base material shall be on the positive side of the line.

10. JOINT WELDING PARAMETERS (N.E.V.)

Welding parameter ranges such as electrode and filler wire sizes, voltages and currents used for each electrode, filler wire, consumable insert rings, and/or backing rings shall be substantially as shown on the welding procedure specification and the supplementary parameter sheets.

11. TECHNIQUE (N.E.V.)

All welding shall be done utilizing the GTAW process with manual equipment. The tungsten electrode shall be 3/32 diameter tapered to a 30 degree conical. (Shown in Sketch #3) The travel speed shall be smooth and continuous using the stringer bead technique.

A.

Open Root:

Prior to initiating the arc, position the filler wire in the center of the joint. Initiate the arc on the bevel and move to the center of the joint, a slight oscillating motion may be necessary to assure fusion into both sides of the joint.

Travel shall be smooth and continuous with care being taken to maintain the proper arc length and electrode angle.

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When restarting, overlap the previously welded portion sufficiently to assure complete fusion of the tie in.

It may be necessary to prepare the starts and stops by grinding or other means so a smooth tie in can be accomplished.

B. Consumable Insert:

Initiate the arc on the bevel and move quickly to the center of the insert, hold until the motion of the puddle indicates the insert is breaking down. Travel shall be smooth and continuous with care being taken to maintain the proper arc length and electrode angle. When restarting overlap the previously welded portion sufficiently to assure that the entire insert is consumed.

C. Arc Termination:

When terminating the arc, taper off onto the bevel, increase arc length and travel speed in such a manner as to leave virtually no crater. A "foot pedal" control or automatic sloping device may also be used.

All stops shall be examined visually and any crater cracks or other defects shall be removed by grinding or other acceptable means prior to continuing welding operation.

D. Fill Pass Welding:

The second and subsequent weld passes for completion of the weld shall be done using the stringer bead technique. The width of the weld bead should not appreciably exceed the diameter of the gas cup orifice.

Caution - When welding the first layer over the root care should be exercised to prevent melting through or re-consuming of the root bead.

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E. Preparation of Base Material:

The edges or surfaces of parts to be joined by welding shall be prepared by mechanical means and/or grinding and shall leave the weld preparation with reasonably smooth surfaces. Interpass cleaning shall be done by brushing and/or grinding. Surfaces for welding shall be free of scale, rust, oil, grease and other deleterious contamination and from rain, snow and wind during welding. Welding shall not be performed on wet surfaces. The welding parameter sheets shall show the arrangements for parts to be welded with the spacing and details of the welding groove, if used, and shall be comprehensive and cover the full range of materials and base metal thickness to be welded.

12. APPEARANCE OF WELDING LAYERS (NE.V.)

The welding current and manner of depositing the weld metal shall be such that there shall be practically no undercutting of the side walls of the welding groove or the adjoining base material.

13. CLEANING (N.E.V.)

Any oxidation remaining on any bead of welding shall be removed prior to laying down the next successive bead of welding.

14. DEFECTS (N.E.V.)

Any oxidation, cracks, or blowholes that appear on the surface of any bead of welding shall be removed by chipping, grinding, or gouging before depositing the next successive bead of welding.

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15. JOINT ALIGNMENT (N.E.V.)

- A. Tack welds used to secure alignment of the consumable insert shall consist of fusing the insert to the machined end detail of the pipe joint using the GTAW process. If necessary, the welder is allowed to use the addition of filler wire to close the gap where the ends of the insert meet.
- B. Care shall be taken not to use an excess amount of current in tack welding the insert, so as to minimize oxidation and prevent cinderling of the insert ring.
- C. There shall be a sufficient amount of tacks spaced evenly around the diameter of pipe to insure a tight fit between the insert and the end detail of pipe. Tacks shall be held to a minimum of 1/8" and to a maximum of 3/16" in length. See attached Drawing #4.
- D. The tack welds are to become a part of the finished weld. They shall be visually examined and if necessary, their stopping and starting ends shall be properly prepared by grinding or other suitable means. Defective tack welds shall be removed and replaced properly.
- E. When the consumable insert is not used, the back side of the welding groove should be shielded with inert gas prior to commencing tack welding.
- F. The tack welds should be approximately 3/8" in length and of sufficient number and spacing to assure proper joint alignment during welding.
- G. All tack welding shall be done by qualified welders in accordance with Section IX of the ASME Boiler & Pressure Vessel Code.

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16. TEMPORARY ATTACHMENTS AND THEIR REMOVAL (N.E.V.)

- A. Temporary attachments are those attachments which are welded onto the component or parts of components during the process of installation but which are not incorporated into the final component (such as alignment lug or straps, tie straps, braces, preheat equipment, etc.).
- B. The material used under this procedure for temporary attachments shall conform to the specification of the materials found in Group P-8, or QW-422 of Section IX of the ASME Boiler & Pressure Vessel Code, and should be the same type of composition as the component base material.
- C. The welding materials used in the welding of temporary attachments shall be the same welding materials qualified in the welding procedure qualification record.
- D. All temporary attachments shall be welded in accordance with the qualified W.P.S. and welders shall be qualified as such.
- E. The immediate area around the temporary attachments shall be marked in a suitable manner so that after removal the area can be identified until after it has been examined by visual, magnetic particle or liquid penetrant method in accordance with requirements of the applicable section of the ASME Boiler & Pressure Vessel Code and/or the required method or methods as required by the specifications of the design specification.

17. THICKNESS OF WELD REINFORCEMENT FOR PIPING (N.E.V.)

For double welded butt joints, the limitation on the reinforcement given in Column 1 of the following tabulation shall apply separately to both inside and outside surfaces

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FNI-WP-900

of joints. For single welded butt joints, the reinforcement given in Column 2 shall apply to the inside surface and the reinforcement given in Column 1 shall apply to the outside surface. The reinforcement shall be determined from the higher or the abutting surfaces involved.

Material Nominal Thickness (Inches)	Maximum Reinforcement Thickness (Inches)	
	Column 1	Column 2
Up to 1/8, inc.	3/32	3/32
Over 1/8 to 3/16, inc.	1/8	3/32
Over 3/16 to 1/2, inc.	5/32	1/8
Over 1/2 to 1, inc.	3/16	5/32
Over 1 to 2, inc.	1/4	5/32
Over 2	The greater of 1/4" or 1/8 times the width of the weld in inches.	

18. SURFACE OF WELD REINFORCEMENT (N.E.V.)

The surface conditions of the finished weld shall be sufficiently free from coarse ripples, grooves, overlaps, and abrupt ridges and valleys. Where radiography and/or other non-destructive examination of the welds are required, the surface conditions of the finished weld shall be suitable for proper interpretation.

Undercuts shall not exceed 1/32" and shall not encroach on the required section thickness. Concavity on the root side of a single welded circumferential butt weld is permitted when the resulting thickness of the weld is at least equal to the thickness of the thinner member of the two sections being joined.

Internal root weld conditions are acceptable only when the density change as indicated in the radiograph is not abrupt. Elongated indications on the radiograph at either edge of such condition shall be unacceptable. If the surface of the weld required grinding to meet the above criteria, care shall be taken to avoid reducing the weld or base material below the required thickness.

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19. TREATMENT OF UNDERSIDE OF WELDING GROOVE (N.E.V.)

An internal purge shall be placed in such a manner to insure adequate atmospheric conditions using argon gas welding grade 99.9% pure.

The atmosphere in the purge chamber should contain less than 1% oxygen prior to commencing welding. This is accomplished by sealing off the chamber on both sides of the joint to be welded and displacing the air inside with a flow of argon gas. The flow rate and purging time should be such that a minimum of 6 volume changes will have taken place prior to welding.

CAUTION - *Excessively high flow rates can cause turbulence which could leave pockets of oxygen trapped in the chamber.*

The following is material suggested for use in constructing purge dams:

- A. Cardboard cut to fit inside diameter of the pipe, sealed with masking tape;
- B. Soluable paper and soluable tape;
- C. Inflatable canvas bags;
- D. Purge balloons;
- E. Inert gas chamber fixture as constructed by detailed drawing #5.
- F. Plexiglass disc's sealed with tape.

NOTE: *No material shall be used that is not approved for use in the particular system. When the weld joint area is not accessible for placement or removal of purge dam, it may become necessary to purge an entire line or system. This shall be done by blocking off the nearest openings to the weld joint. Where practical, the purge should be inletted below the weld joint and vented above. The internal argon purge shall be initiated prior to welding the root and maintained through a minimum of 3/16" fill.*

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Weld Procedure No.: FNI-WP-900

20. IDENTIFICATION OF JOINTS BY WELDER (N.E.V.)

The welder shall apply the identification mark assigned to him by the manufacturer or installer on or adjacent to all permanent welded joints made by him. As an alternative, the manufacturer or installer shall keep a record of permanent welded joints in a component and of the welders used in making each of the joints.

S U M M A R Y

This welding procedure is in accordance with, and meets the minimum requirements of, but is not limited to, the 1974 Edition, including Addenda thru Winter, 1975, of the following:

- A. Section II, Material Specification Parts A and C, Section III for Nuclear Power Plant Components, Classes I, II, III and MC Components.

Weld Procedure No.: FNI-WP-900

company

Fermi Nat'l Lab.

date

10-76

procedure qualification record

welding procedure specification

thickness range

position

FNI-WP-1A

FNI-WP-901

.083 to .560

All

joint design

Single Welded Vee Groove (open root)

remarks

Weld Procedure No.: FNI-WP-900

company Fermi Nat'l Lab.		date 10-76
welding procedure specification FNI-WP-901		supporting POR FNI-WP-1A
revisions		
welding process GTAW		types Manual
QW-402 JOINTS	groove design Single Welded Vee Groove other	backing Open Root
QW-403 BASE	P number range P-8 to P-8 other	thickness range 0.083" to 0.560
QW-404 FILLER	F number 6 A number 8 specification SFA 5.9 electrode size 3/32" flux composition N/A electrode flux composition N/A other	other other AWS number ER-3XX ER-308L filler size 3/32" particle size N/A consumable insert N/A
QW-405 POSITION	groove position All other	welding progression Uphill - All Vertical Passes
QW-406 PREHEAT	preheat temperature 600 Min. preheat maintenance	interpass temperature 3500F Max. other
QW-407 POSTHEAT	temperature N/A other	time range
QW-408 GAS	shielding gas Argon flow rate 20 CFH	percent composition 99.9% Welding Grade gas backing Argon Inert Gas
QW-409 ELECTRICAL	current Direct amperage range 45 to 115	polarity Straight voltage range 8-11
QW-410 TECHNIQUE	bead Stringer orifice or gas cup size 5/16" to 3/8" back gouging method N/A pass per side Multiple	oscillation Minimal initial and interpass cleaning Grinding and/or brushing contact tube to work distance N/A single or multiple electrodes Single

Weld Procedure No.: FNI-WP-900

company

date

-Fermi Nat'l Lab.

10-76

welding procedure specification

FNI-WP-901

Reinforcement of Welds

Thickness of Weld Reinforcement for Vessels, Pumps, and Valves. The surface of the reinforcement of all butt welded joints in vessels, pumps, and valves may be flush with the base material or may have uniform crowns. The height of reinforcement on each face of the weld shall not exceed the thickness in the following table.

Nominal Thickness in.	Maximum Reinforcement in.
Up to 1, incl.	$\frac{3}{32}$
Over 1 to 2, incl.	$\frac{1}{8}$
Over 2 to 3, incl.	$\frac{5}{32}$
Over 3 to 4, incl.	$\frac{7}{32}$
Over 4 to 5, incl.	$\frac{1}{4}$
Over 5	$\frac{5}{16}$

FILLET AND SOCKET WELD DIMENSIONS

(Not permitted for socket weld connections over 2 in. nominal diameter)

notes

Weld Procedure No.: FNI-WP-900

company

date

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10-76

welding procedure specification

FNI-WP-900

PEEPHOLE PLACEMENT FOR FLAT WASHER TYPE CONSUMABLE INSERT

NOTE: THERE SHALL NOT BE ANY PEEPHOLES BELOW CENTERLINE "A"

It may not be necessary to cut peepholes in all applications

notes

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remarks

Performance qualification in the 2G and 5G positions on a single sample or in the 6G position on a single sample.

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PREPARING D. C. ELECTRODES: .2% THORIATED TUNGSTEN

NEW ELECTRODE (BEFORE SHARPENING)

SHARPEN ELECTRODE ON GRINDER

2% ELECTRODE DIAMETER

GRIND OFF $\frac{1}{32}$ " FROM POINT

VIEW OF PROPERLY PREPARED TUNGSTEN. 30° CO

 $\frac{1}{32}$ D

notes

Care shall be taken to maintain properly prepared tungsten during the welding operation

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CONSUMABLE INSERT PLACEMENTS FOR ALL JOINT THICKNESSES

POSITIONS 1G-2G

POSITIONS 5G-6G

Eccentric Placement for 5G Fixed Position

When used for pipe in horizontal fixed-position, the Consumable Insert Ring is placed in the eccentric position.

This eccentric placement enables the ring to compensate for the downward sag of the molten weld metal. It also aids in obtaining a smooth, uniform root contour along the inside diameter of the joint.

Concentric Placement for 2G Fixed Position

When used for pipe in vertical fixed-position, the Consumable Insert Ring is placed in the concentric position.

notes

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TYPICAL INTERNAL PURGING DEVICE FOR PIPE

No material shall be used for purging devices that is not approved for use in the particular system. When the weld joint area is not accessible for placement or removal of purge dam, it may become necessary to purge an entire line or system. This shall be done by blocking off the nearest openings to the weld joint. Where practical, the purge should be inletted below the weld joint and vented above. The internal argon purge shall be initiated prior to welding the root and maintained through a minimum of 3/16" fill.

notes

QW-482 WELDING PROCEDURE SPECIFICATION (WPS)
See QW-201.1, Section IX, 1974 ASME Boiler and Pressure Vessel Code

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welding procedure specification	FNI-WP-902	supporting POR	FNI-WP-1B
revision			
welding process	GTAW	types	Manual
QW-402 JOINTS	groove design Single Welded Vee Groove	backing	Inert Gas
	other Consumable Weld Insert		
QW-403 BASE	P number range P8 to P8	thickness range	0.083" to 0.560"
	other		
QW-404 FILLER	F number 6	other	
	A number 8	other	
	specification SFA 5.9	AWS number	ER-308L, ER-3XX-X
	electrode size 3/32"	filler size	3/32"
	flux composition N/A	particle size	N/A
	electrode flux composition N/A	consumable insert	"K" Type
	other		
QW-405 POSITION	groove position All	welding progression	
	other		
QW-406 PREHEAT	preheat temperature	interpass temperature	350 deg. F. max.
	preheat maintenance	other	
QW-407 POSTHEAT	temperature N/A	time range	
	other		
QW-408 GAS	shielding gas Argon	percent composition	99.9%
	flow rate 20 CFH	gas backing	Argon
QW-409 ELECTRICAL	current Direct	polarity	Straight
	amperage range 60-115	voltage range	8-11
QW-410 TECHNIQUE	bead Stringer	oscillation	Minimal
	orifice or gas cup size 5/16" - 3/8"	initial and interpass cleaning	Grinding and/or Brushing
	back gouging method N/A	contact tube to work distance	N/A
	pass per side	single or multiple electrodes	Single
	Multiple		

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FNI-WP-902-

WELD END DETAILS FOR UTILIZING CONSUMABLE INSERT

notes

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position

A11

Single Welded Vee Groove (with consumable insert)

company

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date

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welding procedure specification

FNI-WP-902

Reinforcement of Welds

Thickness of Weld Reinforcement for Vessels, Pumps, and Valves. The surface of the reinforcement of all butt welded joints in vessels, pumps, and valves may be flush with the base material or may have uniform crowns. The height of reinforcement on each face of the weld shall not exceed the thickness in the following table.

Nominal Thickness in.	Maximum Reinforcement in.
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Over 2 to 3, incl.	$\frac{5}{32}$
Over 3 to 4, incl.	$\frac{7}{32}$
Over 4 to 5, incl.	$\frac{1}{4}$
Over 5	$\frac{5}{16}$

FILLET AND SOCKET WELD DIMENS

(Not permitted for socket weld connections over 2 in. nominal

notes

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thickness range

position

FNI-WP-1A & 1B

FNI-WP-903

0.250 to 0.560

A11

joint design

Single Welded Vee Groove (with backing) and all fillet welds

remarks

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welding procedure specification		supporting POR
FNI-WP-903		FNI-WP-1A & 1B
revisions		
welding process	GTAW	types
		Manual
QW-402 JOINTS	groove design	backing
	Single Welded Vee Groove	Backing Ring
	other	
	Fillet Welds	
QW-403 BASE	P number range	thickness range
	P8 to P8	.0250" to 0.560"
	other	
QW-404 FILLER	F number	other
	6	
	A number	other
	8	
	specification	AWS number
	SFA 5.9	ER-XX
	electrode size	filler size
	3/32"	3/32"
	flux composition	particle size
	N/A	N/A
	electrode flux composition	consumable insert
	N/A	N/A
	other	
QW-405 POSITION	groove position	welding progression
	All	
	other	
QW-406 PREHEAT	preheat temperature	interpass temperature
		350 deg. F Max.
	preheat maintenance	other
QW-407 POSTHEAT	temperature	time range
	N/A	
	other	
QW-408 GAS	shielding gas	percent composition
	Argon	99.9%
	flow rate	gas backing
	20 CFH	N/A
QW-409 ELECTRICAL	current	polarity
	Direct	Straight
	amperage range	voltage range
	85 - 115	9 - 11
QW-410 TECHNIQUE	bead	oscillation
	Stringer	Minimal
	orifice or gas cup size	initial and interpass cleaning
	5/16" - 3/8"	Grinding and/or Brushing
	back gouging method	contact tube to work distance
	Grinding	N/A
	pass per side	single or multiple electrodes
	Multiple	Single

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WELD JOINT DESCRIPTION AND BACKING RING PLACEMENT

notes