Detroit
Edison
2000 Second Avenue
Detroit, Michigan 48226
(313) 237-8000

July 29, 1981
EF2 - 54,193

Mr. L. L. Kintner
Division of Project Management
Office of Nuclear Regulation
U. S. Nuclear Regulatory Commission
Washington, D. C. 20555

Dear Mr. Kintner:

Reference: Enrico Fermi Atomic Power Plant, Unit 2
NRC Docket No. 50-341

Subject: 10CFR50, Appendix G & H
Information Transmittal

Please find attached five (5) copies of information requested in Questions 121.16 through 121.27. The information addresses the ferritic materials used in pressure retaining components of the RCPB within General Electric's scope of supply as well as additional information concerning the materials surveillance program.

This is essentially the same as that Emery Expressed to your attention on July 24, 1981, with the following exceptions:

1. The response to Appendix H questions has been reorganized.

2. A response to Questions 121.24 f and g is included

3. The response to Questions 121.26 is given in the response to Question 121.24c which now provides a statement that the program will be updated to include a total of 108 Charpy V-notch specimens.

Sincerely,

W. F. Colbert
Technical Director
Fermi 2 Project

B001
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1/1

WFC/AAS:jl
Attachments

cc: Mr. B. Little

Fermi 2 Reactor Vessel
Beltline Plate and Weld
Information

1. Available Charpy V-notch and drop-weight NDT toughness data are presented in Tables 1, 2 and 4 for Fermi 2 beltline plates and welds. Table 2 gives supplementary transverse Charpy results which were determined for one of the Fermi 2 surveillance plates. Table 3 shows a typical Test Certificate for a Fermi 2 beltline plate.

2. The beltline layout is shown in Figure 1. This gives plate heat numbers and locations, as well as weld seam locations and identifications.

3. Copper and phosphorous values, to estimate the effects of radiation on toughness, are presented in Table 5. It can be seen in Table 5 that the analysis for Cu and P was not done for the final weld wire/flux combination weld deposit for one set of longitudinal weld seams.

4. Estimated starting (unirradiated) RT_{NDT} values are given in Table 5. They are estimated by using the data in Tables 1 and 4 in accordance with GE procedure Y1006A006 which meets the intent of ASME Code paragraph NB-2300. This procedure is explained in paragraph 5.2.4.2.2 (Attachment A) of the Fermi 2 FSAR, Amendment 23. The data base for this procedure is further clarified in response to Zimmer (ZPS-1) Q 121.15.

   For the Fermi 2 beltline plates, longitudinal Charpy V-notch transition curve data are available (Table 1). Thus, the 50 ft-lb transition temperature can be determined by interpolation of these values, and by adding 30°F to the result to correct for orientation effects. These Charpy transition temperatures can then be used with the corresponding NDT data (Table 1) to determine RT_{NDT} in accordance with ASME NB-2300.

   For the beltline welds all Charpy values (Table 4) are in excess of 50 ft-lb at +10°F, except for one value of 47 ft-lb. The 50 ft-lb transition temperature was taken as +10°F for those welds exceeding 50 ft-lb. The 50 ft-lb temperature for the weld with the 47 ft-lb value was estimated as +16°F by adding the correction factor of 2°F/ft-lb (Y1006A006). Since NDT data are not available for these welds, an assumption of -50°F for NDT was made. Justification for this assumption is given in Item 7. This NDT value was used with the Charpy transition temperatures to determine RT_{NDT} in accordance with ASME NB-2300.

5. Estimated end-of-life (EOL) RT_{NDT} values (for ¼ thickness location from the vessel inside diameter) are given in Table 5. These values are slightly lower than those previously reported in Amendment 23 of the FSAR, because of a correction to the predicted fluence. The estimations are in accordance with NRC Regulatory Guide 1.99 Rev. 1. Where Cu and P content analyses were not available for the

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deposited wire/flux combination, the maximum RT_{NDT} shift (ΔRT_{NDT}) is conservatively assumed in accordance with Reg. Gude 1.99 Rev. 1.

6. Charpy V-notch upper shelf toughness was not a requirement when the Fermi 2 vessel was manufactured. Thus, such data is not available for the Fermi 2 beltline welds, but is available for the plates as shown in Tables 1 and 2.

   A very conservative assumption of 65% factor on longitudinal upper shelf can be applied to the results of Table 1 in order to estimate transverse orientation upper shelf. (Table 2 shows that a higher factor may be justified.) The factor of 65% (from MTEB 5-2) would result in a longitudinal requirement of 115 ft-lb in order to meet the 10CFR50 Appendix G value of 75 ft-lb upper shelf. This value is met by all plates in Table 1 except C4564-1, which very narrowly misses. However, since the Cu content of this plate is only 0.09% (Table 5) a reduction of upper shelf of only 10% at EOL is conservatively predicted by Reg. Guide 1.99 Rev. 1. Combining these 2 conservative factors of 65% and 10% results in an initial longitudinal upper shelf value of only 85 ft-lb to meet the goal of 50 ft-lb transverse upper shelf at EOL. This value of 85 ft-lb, as calculated in the following equation, is exceeded by plate C4564-1.

   $$50 = .65(L) - (.10)\,[.65\,(L)]$$

   (where L is the longitudinal upper shelf value at start of life)

   As seen in Table 4, upper shelf toughness values are not available for Fermi 2 welds. However, all Charpy results at the test temperature of +10°F are in excess of 75 ft-lb except for one weld material (Heat 12008/Lot 3833). It is expected that further testing at higher temperatures would have revealed an upper shelf in excess of 75 ft-lb for this material also. Evidence in this respect is presented in Tables 6 through 15 which show weld procedures and upper shelf toughness results for similar submerged arc weld materials. All upper shelf (~ 100% shear results in Tables 12 through 15) are in excess of 75 ft-lb. These welds are considered to be representative of the Fermi 2 weld in question (seams 2-307 A, B, C) since the welding processes (generally tandem wire submerged arc for the bulk of the weld), post weld heat treatment, and weld materials are similar (as shown in Tables 8 through 11). Particular attention should be given to the LaSalle 1 results, since these welds were made by the same vendor (Combustion Engineering) and with the exact same weld procedure (Tables 8 and 9) as for the Fermi 2 weld. The LaSalle 1 surveillance program weld material 1P3571/3958 in Table 12 gave values less than 75 ft-lb at +10°F, but further testing at +200°F revealed an upper shelf of 110 ft-lb.

7. Drop-weight NDT values for the Fermi 2 weld materials were not determined by testing. However, evidence for a conservative assumption of -50°F is found in Table 12, based on the LaSalle 1 result. All values of NDT are -50°F or lower. Further results in this respect are also shown in Tables 13, 14 and 15 (CBIN welds) and verify NDT

values of -50°F and lower, except for one case. This case (1P6484/0156 for Laguna Verde 2) is considered to be non-representative of Fermi 2, because of the relatively low Charpy test value (17 ft-lb) at +10 and 0°F for this material.

8. The RT_{NDT} values for weld heat affected zones (HAZ) are assumed the same as for the base material. Weld procedure qualification test requirements for HAZ toughness indicate this assumption is valid. This is also supported by the following technical publications, which conclude that the HAZ toughness for these materials is actually superior to that of the base material: (a) T. U. Marston and W. Server, "Assessment of Weld Heat-Affected Zones in a Reactor Vessel Material" Journal of Engineering Materials and Technology, July 1978, Vol. 100, page 267, (b) D. A. Canonico, "Significance of Reheat Cracks to the Integrity of Pressure Vessels for Light-Water Reactors," Supplement to the Welding Journal, May 1979, page 137-S.

9. Refer to Fermi 2 FSAR Table 5.2-9, Amendment 23 for justifications regarding toughness testing calibration and qualification of testing personnel.

10. Weld material toughness test coupons were made with the exact same weld filler metal and procedure as in the actual vessel weld. However, these weld deposits were not necessarily made on the exact same heat of base plate as in the vessel. Base plate of the same specification was employed for this purpose. This small difference in base plate would not effect the testing of the weld metal since the Charpy specimen would be in the weld metal. Toughness testing of the exact base plates in the vessel was done separately.

11. Cross-Reference of paragraphs for resolution of open items:

EF-2 Question	This Submittal	10CFR Part 50 Appendix G
121.16(b)	8	I.B
121.17	7	III.A
121.18	1-6	III.C.1, IV.B
121.19	10	III.C.2
121.22	6	IV.B
--	9	III.B.4

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FERMI 2 REACTOR VESSEL

NON-BELTLINE INFORMATION

1. Limiting RT_{NDT} values which affect vessel testing and operation are shown in the FSAR (paragraphs shown on Attachment A). A sentence has been added in paragraph 5.2.4.2.2 of Attachment A to further clarify that these are the RT_{NDT} values for the limiting vessel locations and materials that affect testing and operating limits. The other materials in the vessel, which meet specific toughness requirements, do not affect the pressure-temperature curves.

2. The estimation procedures for these RT_{NDT} values are in accordance with GE procedure Y1006A006, and are also explained in paragraph 5.2.4.2.2 of the FSAR. As with the beltline, the data base for this procedure is further clarified in response to Zimmer (ZPS-1) Q121.15. A more specific explanation follows:

   a) Non-beltline Plates - Both longitudinal Charpy values over the full temperature range and NDT values are available. RT_{NDT} was evaluated the same as for the beltline plates. The limiting plate (highest RT_{NDT}) is in the bottom head (Heat No. C4504-2) with an NDT of +10°F and lowest Charpy values of 40 ft-lb. at +40°F and 76 ft-lb at +110°F. Linear interpolation estimates the longitudinal 50 ft-lb. temperature as +60°F. Adding 30°F for orientation correction and subtracting 60°F (NB-2300) gives an RT_{NDT} of +30°F.

   b) Vessel and head closure flange materials had NDT values of +10°F (or possibly lower - no break at +20°F) and lowest Charpy values of 95 ft-lb. at +40°F and 167 ft-lb. at +40°F. The correction of 30°F was added to +40°F for orientation and 60°F was subtracted to give an RT_{NDT} of +10°F.

   c) Feedwater nozzles had a maximum specified NDT value of +40°F, and Quality Assurance records show no deviations in this respect. The lowest Charpy value for these forgings is 38 ft-lb. at +10°F. Adding 2°F/ft-lb. gives an estimated 50 ft-lb. temperature of +34°F. Adding 30°F for orientation and subtracting 60°F (NB-2300) gives an RT_{NDT} of +4°F, as determined by Charpy. Thus, the RT_{NDT} is set equal to the NDT value of +40°F.

   d) Closure Studs - The lowest Charpy values at +10°F are 50 ft-lb. and 33 mils lateral expansion. Thus, in accordance with NB-2300 the lowest service temperature is +10°F.

e) Non-beltline Welds - The purchase specification required Charpy tests at +10°F or drop-weight NDT of +10°F or lower. Quality Assurance records show no deviations in this respect. Charpy requirements at +10°F were for 30 ft-lb. average with no single value less than 25 ft-lb. Assuming 25 ft-lb. at +10°F as the limiting case, and adding 2°F/ft-lb. gives an estimated 50 ft-lb. temperature of +60°F. Subtracting 60°F (NB-2300) gives an RT_{NDT} of 0°F. Data presented in support of the beltline welds indicate NDT values much below 0°F. Thus, the RT_{NDT} value is taken as 0°F.

3. Refer also to paragraphs 7 through 10 of the Beltline section of this submittal, since they also apply to non-beltline materials and testing.

4. Cross-reference of paragraphs for resolution of open items:

EF-2 Question	This Submittal	10CFR Part 50 Appendix G
121.16 (a)	2.e	I.B
121.16 (b)	3	I.B
121.17	2	III.A
121.18	1, 2	IV.A.1
121.21	2.d	IV.A.3
	3	III.B.4

FERMI 2 MAIN STEAM

PIPING AND FERRITIC VALVES

(MSIV AND SRV)

1. The Fermi 2 main steam piping was procured to the USAS B31.7, Class I, 1969 Code, which did not require toughness testing. However, data are supplied in Tables 16 through 21 to show that the Fermi 2 NSSS supply steam pipe materials would possess adequate toughness. This is concluded from available toughness information for Fermi 2 in Tables 16, 17, and 18, and from the fact that similar materials (as shown in Tables 19, 20, and 21) have data showing adequate toughness per more current 10CFR50 Appendix G Main Steam Pipe requirements.

   No toughness results are available for the 26" pipe. However, the material is pipe fabricated from A516 Grade 70 plate which is a tough carbon steel melted to fine-grain practice for low temperature service. Charpy V-notch data for this material in Tables 17 and 19 verify this toughness. Furthermore, Charpy keyhole data are available at -50°F for the Fermi 2 26" elbows fabricated from A516 Grade 70. A Charpy transition curve shift of about 60°F increase should give an estimation of Charpy V-notch results for these elbows (Reference: W. S. Pellini, ASTM Spec. Tech. Publ. 158 page 222, 1954). Thus, they should have adequate toughness at about +10° [illegible] even better toughness at the more current test temperature of [illegible] Table 19). This transition temperature shift and argument also should apply to the sweepolet Charpy keyhole results in Table 16.

   Note that the material and pipe suppliers in Table 19 are the same as for the Fermi 2 26" pipe (Table 16).

2. Fermi 2 Safety Relief Valves (SRV) are in compliance with 10CFR50 Appendix G since they are exempted by the ASME Code from toughness testing because of their 6-inch size.

3. Fermi 2 Main Steam Isolation Valves (MSIV) were exempt from toughness testing at the time of purchase. They do not see significant pressures at temperatures below that of steam.

   Typical information is given in Table 22 for Fermi 2 MSIV's. Toughness data on similar materials for MSIV's on other projects, where toughness testing was done, is attached on Tables 23 and 24. In fact, Table 23 gives A216 WCB base metal, weld metal, and HAZ toughness results from the Weld Procedure Qualification used for Fermi 2. In some cases (Table 24), the materials and valves vendor are the same as for Fermi 2. These data demonstrate the capability of the Fermi 2 MSIV materials to meet current toughness requirements.

Further evidence of toughness for SA-105 forgings (MSIV bonnet, or cover, material) can be found in the July 1978 issue of Metal Progress, pages 35-39. This article shows Charpy V-notch toughness in excess of 25 mils at +40°F and NDT values no greater than -10°F for SA-105 material normalized at 1565°F for 4 hr. and air cooled after forging.

4. Cross-reference of paragraphs for resolution of open items:

EF-2 Question	This Submittal	10CFR Part 50 Appendix G
121.20	1, 2, 3	IV.A.3

Compliance With Appendix H, 10 CFR Part 50

Question 121.23

Response:

A sketch of the beltline of the reactor vessel showing the location of all of the beltline plates and welds is shown in Figure 1. The azimuth angle giving the location of the capsules is given in the response to Question 121-24(c).

Question 121.24

Response:

The weld material has a Cu content of 0.32 wt. % (Table 5) and is very close to being the limiting material in the vessel beltline. (It may actually be limiting since the Cu for the limiting material in seams 2-307 is not known, but is probably lower than 0.32.) The plate materials are very close to being the limiting beltline plates (only 8 to 10°F lower EOL RT_{NDT} than the limiting plate).

The surveillance specimens were not taken from alongside the ASME NE-2300 specimens. This is not considered critical since they are just as representative of the material in the vessel as the NB-2300 specimens. This requirement has been dropped from the current proposed revision (Nov. 1980).

(a&b) Fermi 2 surveillance specimen plate and weld materials are identified, with properties and predicted radiation effects, in Tables 1 through 5. The weld procedure is given in Tables 6 and 7 and represents weld seam 15-308.

(c) The actual specimens in each capsule are the following:

	Tensile	Present Program Charpy V-notch
Capsule 1 (Azimuth 300°)	2 BM Long 2 WM 2 HAZ	8 BM, Long 8 WM 8 HAZ
Capsule 2 (Azimuth 120°)	3 BM Long 3 WM 2 HAZ	8 BM, Long 8 WM 8 HAZ
Capsule 3 (Azimuth 30°)	3 BM Long 2 WM 3 HAZ	12 BM, Trans. 12 WM 12 HAZ

The specimens indicated above are as the program is presently constituted. Capsules 1 and 2 will be updated to include 12 each of Charpy V-notch specimens of base metal (longitudinal), weld metal and heat-affected zone.

(d) Location given in response to Question 121.24(c).

The attachment method of the capsules is in accordance with GE Drawing 922D218. The assembly is attached to mounting brackets (upper and lower) and a bolt at approximately the center of the assembly can be adjusted to secure the holder firmly against the top and bottom brackets.

(e) The lead factor is the ratio of the flux greater than 1 MeV at the surveillance sample, divided by the flux greater than 1 MeV at the point of greatest flux in the vessel. For Fermi 2 this value is 1.4. This lead factor has arbitrarily been reduced by a factor of 2 in order to improve the probability that vessel fluxes estimated from surveillance data will be underestimated. The lead factor then becomes 0.7.

<u>Note</u>

The lead factor is the relationship between the measured flux/fluence at the surveillance sample and the peak flux/fluence at 1/4 depth into the vessel wall. This relationship has two variations. One variation is the radial variation from a position inside the reactor pressure vessel wall to a radial position at 1/4 thickness of the vessel wall. The second variation is the variation of the flux as a function of angle from a position adjacent to the surveillance sample to the position of the peak flux.

The peak fluence at 1/4 t was calculated using a one-dimensional program and applying a peaking factor to adjust for the maximum point in the angular direction. In addition to the peaking factor, a safety factor is applied to the analysis to insure that the calculated peak is a maximum. Attached is an updated sheet for Table 4.3-2 for the FSAR Chapter 4 that provides the current 251-764 neutron fluence calculations including the data at 1/4 t in the vessel.

Not all of the analysis required is available to define the fluence at the surveillance sample. The radial value can be selected from the one-dimensional analysis. However, the angular variation from the surveillance sample at 30° to the peak is not well defined.

(f) The materials surveillance capsules will be loaded prior to fuel loading.

(g) The material surveillance program assumes a 40-year life and 80% capacity factor, thus the capsules withdrawal will be:

	Withdrawal
Capsule #1	8 full-power years
Capsule #2	24 full-power years
Capsule #3	Standby

Due to uncertainty in capacity factor, the calendar withdrawal schedule cannot be stated with any confidence.

Question 121.25

Response:

See response to Question 121.24.

Question 121.26

Response:

See response to Question 121.24(c)

Question 121.27

Response:

Each capsule also includes a Fe, Ni, and Cu flux wire. A separate neutron dosimeter is attached at Azimuth 30° and contains 3 Cu and 3 Fe flux wires, at Capsule 3.

AAS/br
7/29/81

Table 1

FERMI 2, BELTLINE PLATE TOUGHNESS DATA
(SA-533 GRADE B, CLASS 1 - LUKENS)

CHARPY V-NOTCH TOUGHNESS

	Plate Heat No.	Dropweight NDT	Orientation (L or T)	Charpy Temp	Energy (ft-lbs)	Lat. Expansion Mils	% Shear
Lower Intermediate Shell	C4564-1	$-20^{o}F$	L	$-80^{o}F$	11, 10	7, 7	0, 0
				$-40^{o}F$	30, 36, 23	21, 26 17	10, 10, 10
				$+10^{o}F$	60, 45, 59	44, 32, 42	25, 15, 25
				$+40^{o}F$	86, 74, 63	59, 52, 45	40, 30, 30
				$+110^{o}F$	104, 95	70, 72	95, 90
				$+160^{o}F$	113, 116	85, 83	100, 100
	B8614-1 (Also in surveillance program)	$-20^{o}F$	L	$-80^{o}F$	5, 10	5, 7	0, 0
				$-40^{o}F$	43, 25, 27	32, 20, 21	5, 5, 5
				$+10^{o}F$	62, 64, 56	41, 45, 40	20, 25, 20
				$+40^{o}F$	86, 75, 70	62, 54, 50	40, 35, 30
				$+110^{o}F$	112, 110	81, 79	95, 90
				$+160^{o}F$	125, 135	86, 90	100, 100
	C4574-2 (Also in surveillance program)	$-30^{o}F$	L	$-80^{o}F$	8, 16	6, 13	0, 0
				$-40^{o}F$	34, 32, 27	25, 24, 20	10, 10, 5
				$+10^{o}F$	48, 49, 60	36, 37, 43	15, 15, 20
				$+40^{o}F$	76, 63, 69	56, 47, 51	30, 20, 25
				$+110^{o}F$	98, 103	72, 76	95, 95
				$+160^{o}F$	12[illegible], 119	85, 82	100, 100

Table 1 (Continued)

FERMI 2, BELTLINE PLATE TOUGHNESS DATA

	Plate Heat No.	Dropweight NDT	Orientation (L or T)	Charpy Temp	Energy (ft-lbs)	Lat. Expansion Mils	% Shear
Lower Intermediate Shell	C4568-2	-30°F	L	-80°F	10, 18	5, 13	0, 0
				-40°F	30, 38, 30	22, 27, 23	5, 5, 5
				+10°F	46, 67, 63	37, 54, 47	15, 30, 25
				+40°F	76, 85, 61	58, 61, 45	40, 50, 35
				+110°F	106, 102	75, 72	95, 95
				+160°F	116, 122	89, 87	100, 100
Lower Shell	C4540-2	-10°F	L	-80°F	7, 9	6, 8	0, 0
				-40°F	30, 44, 30	23, 34, 25	5, 10, 5
				+10°F	64, 76, 74	49, 58, 56	30, 30, 30
				+40°F	87, 84, 97	69, 63, 72	40, 40, 50
				+110°F	115, 119	85, 84	85, 85
				+160°F	144, 146	90, 92	100, 100
	C4560-1	-10°F	L	-80°F	14, 11	12, 8	0, 0
				-40°F	59, 53, 38	45, 41, 30	20, 20, 15
				+10°F	85, 79, 99	62, 60, 72	30, 30, 35
				+40°F	90, 121, 109	69, 78, 74	50, 65, 60
				+110°F	160, 144	88, 88	100, 90
				+160°F	158, 153	90, 88	100, 100
	C4554-1	-10°F	L	-80°F	13, 25	8, 18	0, 1
				-40°F	35, 40, 42	27, 30, 32	20, 20, 20
				+10°F	59, 65, 68	45, 49, 51	30, 30, 30
				+40°F	79, 77, 87	59, 61, 64	35, 35, 35
				+110°F	131, 118	88, 89	100, 90
				+160°F	137, 127	90, 87	100, 100

METALLURGY LABORATORY

CHARPY IMPACT TEST DATA

Table 2
TRANSVERSE RESULTS
(SURVEILLANCE PLATE)

Requestor: John Copeland

Responsible Engineer:

Charge No.: P7830

Date: 5/18/79

DRF No.:

EWA No.: EA302-01

Material Condition: SA533B plate HT # C4574-2

Specimen Identification	Bath Medium	Test Temperature °F	Energy Absorbed Ft-Lb	Lateral Expansion Mils	Remarks % Shear
63 B	MeOH	-20°	22.0	17.5	1 %
63 U	"	10°	32.0	22.5	5 %
63 L	"	10°	35.0	27.5	5 %
63 J	"	40°	50.0	35.5	10 %
63 P	"	40°	52.5	41.5	10 %
63 D	AIR	65°	64.0	47.0	30 %
63 A	"	65°	55.0	42.5	30 %
63 M	H_2O	102°	75.0	60.5	50 %
63 C	"	119°	108	75.0	100 %
63 Y	"	119°	88	66.0	85 %
63 T	"	201°	112.5	83.5	100 %
63 E	"	202°	108.5	79.0	100 %

TINUS Olsen Model 74 Calibrated per TP-509.0294

date last calibrated - 7/26/78

Centered per 2.1.7.2 Rev-0 Temp Control - Calibrated thermocouple

Test Procedure No. CMSS 2.1.7.2 Rev 0

Specimen Size 1 cm x 1 cm

S/N Tester 110073

Specimen Orientation TRANSVERSE

Calibration File No. 509-1

S/N Laterial Expansion gage 16602

Performed by [signature]

Level 3

Table 3

FERMI 2 TYPICAL BELTLINE PLATE (SURVEILLANCE PLATE C4574-2)

LUKENS STEEL COMPANY

COATESVILLE, PA. 19320

TEST CERTIFICATE

PURCHASER: 10 Combustion Engr Inc.
Chattanooga Div.
Mr. Jack Michael, Purch Dept

MILL ORDER NO	CUSTOMER P.O.	
25720-2	48-37377	NB 62958 FJ 7208

DATE: 7-9-68 FILE NO. 1771

CONSIGNEE: V-70711 Nuclear V-70063

SPECIFICATIONS

Combustion Spec P3F12(C) 9/25/67 (SA-533-65 Gr. B Class 1) ASME Sec 3 Class A FBX 80000 Req.# 2557

O.K. O.K.

CHEMICAL ANALYSIS

MELT NO	C	Mn	P	S	Cu	Si	Ni	Cr	Mo	V	Ti	Al	B		
C4578	23	1.33	010	015		24	51		56					F.O.P.	V.I.P. Steel
Slab 1	20	1.35	012	015		24	53		57						
C4568	23	1.32	011	016		24	61		56					" " "	" " " "
Slab 2	20	1.29	012	016		23	60		54						
C4574	22	1.36	013	016		24	55		54					" " "	" " " "
Slab 2	22	1.34	014	016		25	55		52						

PHYSICAL PROPERTIES

MELT NO	SLAB NO	Y.P. PSI	T.S. PSI	% Elong in 2"	% R.A.	BHN	IMPACTS		DESCRIPTION
C4578	1	728	960 / 939	22	G-3704-2				1-291-7/16 x 139-1/2 x 7-3/8"
C4568	2	766	969 / 985	24	G-3705-3				1-231-5/16 x 172-3/4 x 7-3/8"
C4574	2	693	925 / 917	24	G-3705-2				1- "
					2667				

Tests heated 1550-1650°F. held 4 hrs max and programcooled per C.E. cooling rate for 7-3/8" Gauge plate. Then tempered 1200-1300°F. held 4 hrs max and air cooled.

Tests stress relieved 1125-1175°F. held 40 hrs and furnace cooled within a rate of 4 hrs min to 600°F.
Plates furnished in as rolled temper.

We hereby certify the above figures are correct as contained in the records of the company.

SUPERVISOR TESTING: [illegible]

13

Table 3 (continued)

G. E. St. Cin

COMBUSTION ENGINEERING, INC.

METALLURGICAL RESEARCH AND DEVELOPMENT DEPT

MATERIALS CERTIFICATION REPORT

MATERIAL SPECIFICATION P3F12(c) CONTRACT NO. 2667

VENDOR Lukens Steel Company JOB NO. V-70637-002

HEAT NO. C 4574-2 CODE NO. G-3705-2

MATERIAL DESCRIPTION 231-5/16" x 172-3/4" x 7-3/8" Lower Intermediate Shell

MILL CHEMICAL ANALYSIS

TYPE	C	Mn	P	S	Si	Ni	Cr	Mo	Cb	Cu	
	.22	1.34	.014	.015	.26	.55		.52			

MECHANICAL TESTS

TEST NO.	GAUGE	TEST TEMPERATURE °F	YIELD STRENGTH, KSI	ULTIMATE TENSILE STRENGTH, KSI	ELONG. IN 2"%	REDUCTION OF AREA %
VLT-A	.505	RT	71.6	95.0	25.0	70.0
VLT-B	.505	RT	71.6	94.0	25.0	54.[illegible]

IMPACT AND/OR FRACTURE TESTS

TYPE	TEMP °F	VALUES Ft/Lbs	%Shear	Mils Lat. Exp.	TEMP °F	VALUES Drop Weights	NDT
Charpy V Notch	-80	8.0	0	6			
	-80	16.0	0	13	-40	1-F	
	-40	34.0	10	25	-30	1-F	-30°F
	-40	32.0	10	24	-20	2-NF	
	-40	27.0	5	20	0	1-NF	
	+10	48.0	15	36			
	+10	49.0	15	37			
	+10	50.0	20	43			
	+40	76.0	30	56			
	+40	63.0	20	47			
	+40	69.0	25	51			
	+110	98.0	95	72			
	+110	103.0	95	76			
	+160	121.0	100	85			
	+160	119.0	100	82			

ADDITIONAL DATA INCLUDING HEAT TREATMENT:

(a) 1550-1650°F 4 hours water quenched.

(b) 1225° ± 25°F 4 hours.

(c) 1150°F ± 25°F 40 hours furnace cooled to 600°F.

The CVN impact specimens were taken parallel to the major rolling direction of the plate at the 1/4T level, and were notched perpendicular to the plate surface.

The tensile specimens were taken in accordance with ASTM A-20-68.
The above tests were witnessed by G. E. Representative, S. G. Hall.

Form E-[illegible]

cc: P. Webb (2)✓
J. Brasfield
T. B. Burton
T. M. Cullen
R. E. Lorentz, Jr.

We hereby certify that the foregoing [illegible] is a [illegible] copy of the data furnished us by the producing mill, or data resulting from tests performed in the Combustion [illegible] Laboratory.

COMBUSTION [illegible] ENGINEERING, INC.

BY S. R. Lewis

DATE May 19, 1969

Table 4

FERMI 2 BELTLINE WELD TOUGHNESS DATA, POST WELD 1150°F FOR 40 HR. TYPICAL, SUBMERGED ARC WELDING - B-4 MODIFIED WIRE WITH LINDE FLUX

					Charpy Toughness			
Weld Seam	Type	Heat #	Lot # or Flux #	Drop-Weight NDT °F	Charpy Temp °F	Charpy Energy ft-lbs	Lat. Expansion Mils	% Shear
2-307 A, B, C	B-4 Mod.	13253	3833 (Linde 1092)	NA	+10	79, 79, 82	NA	NA
		12008	3833 (Linde 1092)	NA	+10	62, 47, 62	NA	NA
15-308 A, B, C, D	B-4 Mod.	*33A277	*3878 (Linde 124)	NA	+10	83, 94, 87	NA	NA
1-313	B-4 Mod.	10137	3999 (Linde 0091)	NA	+10	101, 108, 107	NA	NA

NA = Not Available

*This material is also in the surveillance program.

Table 5

FERMI 2

BELTLINE RADIATION ΔRT_{NDT} & EOL (END-OF-LIFE) RT_{NDT}

Peak EOL Fluence = 1.1×10^{18} n/cm^2 (¼T wall)

A. Plates - Beltline

HEAT NO.	WT. % Cu	WT. % P	Y1006A006 START RT_{NDT} (°F)	REG. GUIDE 1.99 EXTRAP. ΔRT_{NDT} (°F)	EOL RT_{NDT} (°F)	
C4564-1	.09	.010	-12	20	8	
B8614-1*	.12	.011	-20	32	12	
C4574-2*	.10	.014	-16	30	14	
C4568-2	.12	.012	-12	33	21	
C4540-2	.08	.010	-10	17	7	
C4560-1	.11	.010	-10	27	17	
C4554-1	.12	.011	-10	32	22	Limiting Plate

B. Welds - Beltline

SEAM	HEAT/LOT	WT. % Cu	WT. % P	Y1006A006 START RT_{NDT}(°F)	REG. GUIDE 1.99 EXTRAP. ΔRT_{NDT}(°F)	EOL RT_{NDT} (°F)	
2-307A,B,C	13253/3833	(.07	.013)**	-50	(110)**	60	
	12008/3833	.13	.010)	-44	110)	66	Limiting Weld
15-308A,B,C,D	33A277/3878*	.32	.016	-50	106	56	
1-313	10137/3999	.23	.016	-50	76	26	

* This material is also in the surveillance program.

** Bare wire analysis only; as deposited wire/flux combination analysis not done. Therefore, maximum ΔRT_{NDT} is assumed.

Table 6

BELTLINE WELD PROCEDURE FOR FERMI 2 SURVEILLANCE PROGRAM

COMBUSTION ENGINEERING, INC.
NUCLEAR QUALITY ENGINEERING
SURVEILLANCE PROGRAM TEST REPORT

Customer: General Electric Company — Contract: 2667

Material: SA-533 Gr. B, Cl. 1 — Job No.: V-70711

Dwg. No.: E-232-902 — Seam No.: 15-308

Detail Weld Procedure No.: SAA-4-0 — TK.: 7-3/8"

Code No.: G-3705-1 and G-3705-2

Filler Metal (Type, Ht. and Size): S4, 33A277, 1/8"

Flux (Type and Lot): Linde 124 Lot # 3878

Post Weld Heat Treatment: Temp. 1150°F ± 25° — Hours: 40-3/4

Weld Dept. or Shop: Nuclear Shop

Welders Symbols: WP - YY - MU - TV - TN

Non-Destructive Tests

MT: M&P 2.4.2.4(d) Add. 1(a), 3(a)

PT:

RT: M&P 2.4.1.3(b) Add. 1(a), 2(a), 4(a)

UT:

We certify that the statements in this Report are correct as contained in the Records of the company.

COMBUSTION ENGINEERING, INC.

By: C. E. White

Date: 5/8/72

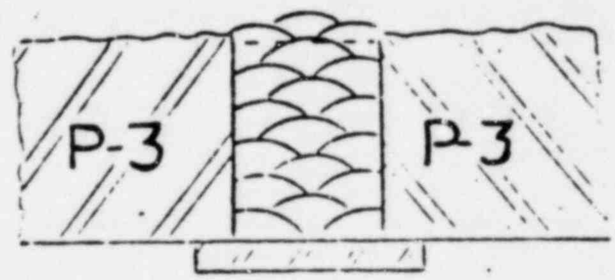
Table 7
DETAIL WELD PROCEDURE FOR FERMI 2 SURVEILLANCE PROGRAM

COMBUSTION ENGINEERING, INC.
NUCLEAR COMPONENTS DEPARTMENT
CHATTANOOGA, TENNESSEE

CONTRACT NO.:
DRAWING NO.:
WELD NO.:
REFERENCES: M&P 6.1.1.2(c),
M&P 4.3.8.5(b)
SAA-33-29
QSAA-11A(1), QMA-11A(1)F4
Non-destructive Testing:

P.T.
M.T.
R.T.
U.T.

DETAIL WELDING PROCEDURE
NO.: SAA-4 Rev. 0
DATE:



WELDING CONDITIONS:

Electrode Type & Size	1/8"Ø Mil. B-4
Filler Metal Type & Size	
Flux Type & Size	Linde 124, 20 X 150
*Welding Current & Polarity	550 AC
*Arc Voltage	33
*Travel Speed (in/min.)	12-13
Shield Gas Type & Flow	
Gas Cup Size	
Gas Cup to Work Distance	
Other	

*± 10% of Value or Range

WELDING POSITION: Flat (Vertical Progression)

Preheat: 250 °F. Hold [illegible]. Until P.W.H.T.
Interpass: 500 °F.

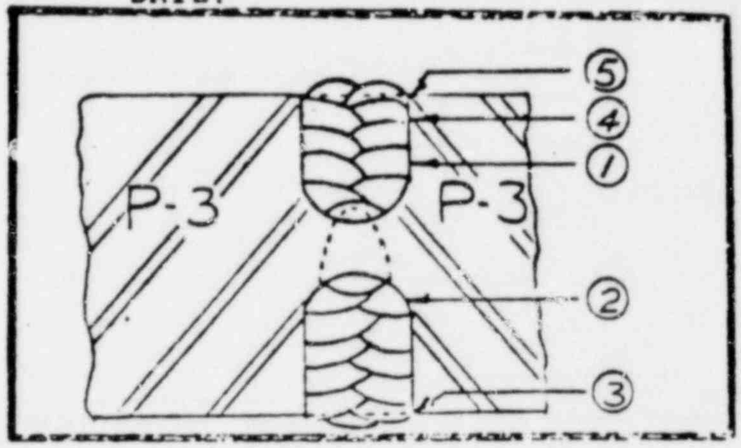
Post-weld heat treatment: 1150 °± 25 °F hold one hour/inch thickness of weld
Intermediate P.W.H.T. 1100 °+ 50 °F, hold 15 minutes

Table 8
DETAIL WELD PROCEDURE FOR FERMI 2 BELTLINE SEAMS 2-307A,B,C

COMBUSTION ENGINEERING, INC.
NUCLEAR COMPONENTS DEPARTMENT
CHATTANOOGA, TENNESSEE

CONTRACT NO.:
DRAWING NO.:
WELD NO.:
REFERENCES: M&P 6.1.1.2(c), M&P 4.3.8.5(b), SAA-33-27

DETAIL WELDING PROCEDURE
NO.: TSAA-2(A) Rev. 0
DATE:



Non-Destructive Testing:

P.T.
M.T.
R.T.
U.T.

WELDING CONDITIONS:

Electrode Type & Size — See attached sheet.

Filler Metal Type & Size

Flux Type & Size

•Welding Current & Polarity

•Arc Voltage

•Travel Speed (in/min.)

Shield Gas Type & Flow

Gas Cup Size

Gas Cup to Work Distance

Other

•± 10% of Value or Range

WELDING POSITIONS: Flat

Preheat: 250 °F. Hold [illegible] Until P.W.H.T.
Interpass: 500 °F.

Post-weld heat treatment: 1150 °± 25 °F hold one hour/inch thickness of weld.
Intermediate P.W.H.T. 1100 °+ 50 °F, hold 15 minutes.

Table 8 continued

DETAIL WELDING PROCEDURE
No.: TSAA-2(A) Rev.0
Sheet: 2 of 2

WELDING SEQUENCE	TRAVEL	AMPS*	VOLTS*
*1st Pass - O.D. 3/16"Ø Mil.B4 Mod.	13 IPM	700 AC	31
NOTE: Use copper backing bar		Single Arc	
1st Increment - O.D. 3/16"Ø Mil.B4 Mod.	13 IPM	650 AC Single Arc	31
(1) O.D. to 1½" Level 3/16"Ø Mil. B4 Mod.	13 IPM	650 AC Single Arc	31
(2) I.D. to 1" Level 3/16"Ø Mil. B4 Mod.	22 IPM	600/550 AC Tandem Arc	31
(3) *Remainder - I.D. 3/16"Ø Mil. B4 Mod.	22 IPM	600/550 AC Tandem Arc	31
(4) O.D. to 3" Level 3/16"Ø Mil. B4 Mod.	22 IPM	600/550 AC Tandem Arc	31
(5) *Remainder O.D. 3/16"Ø Mil. B4 Mod.	22 IPM	600/550 AC Tandem Arc	31
Backweld if required			
1/4"Ø E-8018 C-3 (Flat Only)		325-375 DC-RP	25
or			
3/16"Ø E-8018 C-3		210-260 DC-RP	25

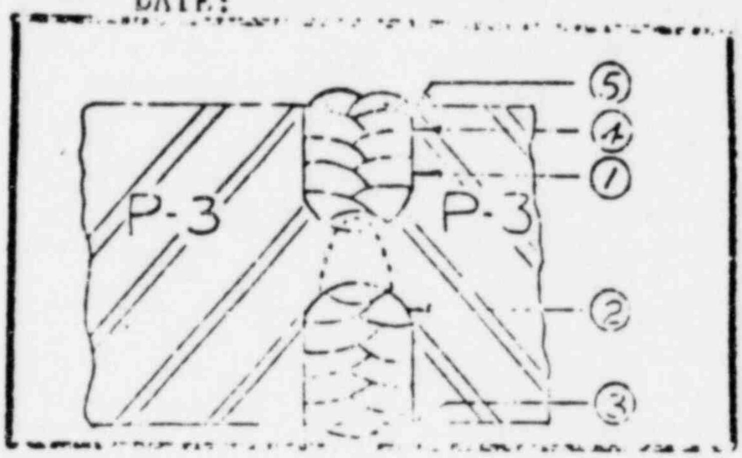
*Flux Linde 1092 65 x 200

Table 9
DETAIL WELD PROCEDURE FOR LA SALLE 1 SURVEILLANCE PROGRAM

COMBUSTION ENGINEERING, INC.
NUCLEAR COMPONENTS DEPARTMENT
Chattanooga, Tennessee

CONTRACT NO.:
DRAWING NO.:
WELD NO.:
REFERENCES: M&P 6.1.1.2(c), M&P 4.3.8.5(b), SAA-33-27 QSAA-11A(3), QMA-11A(1)F4

DETAIL WELDING PROCEDURE
NO.: TSAA-2(A) Rev. 1
DATE:



Non-Destructive Testing:

P.T.
M.T.
R.T.
U.T.

WELDING CONDITIONS:

Electrode Type & Size — See attached sheet.

Filler Metal Type & Size

Flux Type & Size

*Welding Current & Polarity

*Arc Voltage

*Travel Speed (in/min.)

Shield Gas Type & Flow

Gas Cup Size

Gas Cup to Work Distance

Other

*± 10% of Value or Range

WELDING POSITIONS: Flat

Preheat: 250 °F. Hold [illegible] Until P.W.H.T.
Interpass: 500 °F.

Post-weld heat treatment: 1150 °± 25 °F hold one hour/inch thickness of weld.
Intermediate P.W.H.T. 1100 °+ 50 °F, hold 15 minutes.

Table 9 continued

DETAIL WELDING PROCEDURE
No.: TSAA-2(A) Rev. 1
Sheet: 2 of 2

WELDING SEQUENCE	TRAVEL	AMPS*	VOLTS*
*1st Pass - O.D. 3/16"Ø Mil.B4 Mod.	13 IPM	550 AC Single Arc	31
1st Increment - O.D. 3/16"Ø Mil.B4 Mod.	13 IPM	650 AC Single Arc	31
(1) O.D. to 1½" Level 3/16"Ø Mil. B4 Mod.	13 IPM	650 AC Single Arc	31
(2) I.D. to 1" Level 3/16"Ø Mil. B4 Mod.	22 IPM	600/550 AC Tandem Arc	31
(3) *Remainder - I.D. 3/16"Ø Mil. B4 Mod.	22 IPM	600/550 AC Tandem Arc	31
(4) O.D. to 3" Level 3/16"Ø Mil. B4 Mod.	22 IPM	600/550 AC Tandem Arc	31
(5) *Remainder O.D. 3/16"Ø Mil. B4 Mod.	22 IPM	600/550 AC Tandem Arc	31
Root or Backweld 1/4"Ø E-8018 C-3 (Flat Only)		325-375 DC-RP	25
or 3/16"Ø E-8018 C-3		210-260 DC-RP	25

*Flux Linde 1092 65 x 200

Table 10
DETAIL WELD PROCEDURE FOR LAGUNA VERDE 2 SURVEILLANCE PROGRAM

CBI

CBI NUCLEAR COMPANY
CHICAGO BRIDGE & IRON CO.

WELD PROCEDURE SPECIFICATION
Low Alloy SMA & SA Grooves & buildup

CUSTOMER General Electric Company
PRODUCT NUCLEAR VESSELS (Class 1)
DESCRIPTION Shielded Metal Arc and Submerged Arc Welding of ASME P120 Subgroup 1 Material

PROCEDURE NUMBER [illegible]
PAGE NO. 1 OF 3
DATE 2-17-69
REVISION NO. [illegible] (7-23-74) [illegible]

REFERENCE SPECIFICATIONS
General WPS 800 Latest Revision
General WPS 820 Latest Revision

PROCEDURE QUALIFICATION

NO.	POSITION	THICKNESS RANGE
1890 (SMA)	V	3/16" to 8"
1891 (SMA)	H	3/16" to 8"
1892 (SMA)	OH, F	3/16" to 8"
1893 (SA-1)	F	3/16" to 8"
2200 (SA-2)	F	3/16" to 8"

POST HEAT TREATMENT –
Procedure qualified with 50 hrs. at 1150°F +25°/-50°F.
Postweld heat treatment of the weldment shall be in accordance with a CB&I approved procedure.

BASE METAL –
ASME SA-533 Gr B Class 1 or
SA-508 Class 2
ASME Group No. P123 Subgroup I

FILLER METAL – ASME
Shielded Metal Arc
Specification – SFA-5.5
Classification – E8018-G
Analysis – A3 (except Ni 0.50 tol.25)
Usability – F4
Trade Name – Alloy Rods E8018NM
Submerged Arc
See Adjacent Column.

ELECTRICAL CHARACTERISTICS –
See Adjacent Column.

SHIELDING GAS – None

BACKUP GAS – None

FLUX – Linde 124

CUSTOMER APPROVAL

PREHEAT REQUIREMENTS:

Minimum preheat of 300°F shall be applied uniformly to the full thickness of the weld joint and adjacent base material for a minimum distance of "T" or "6", whichever is least, where "T" is the material thickness.

Maintain 300°F min. preheat temp. until start of postweld heat treatment except for longitudinal and circumferential shell and head seams, preheat may be dropped to 250°F min. 8 hours after completion of welding. All runoff tabs and flux dams must be removed prior to dropping preheat below 300°F.

INTERPASS TEMPERATURE REQUIREMENTS:

The interpass temperature shall not exceed 500°F maximum.

FILLER METAL:
Submerged Arc
Specification – N.A.
Classification – N.A.
Analysis – A3 (except Ni 0.50 to 1.25)
Usability – F6
Trade Name – CBI 1NMM (1% Nickel) or equal

ELECTRICAL CHARACTERISTICS:

SMA – DCRP

Submerged Arc
Tandem Wire
Lead Wire – DCRP
Trail Wire – AC
Single Wire – DCRP

00[illegible]

[illegible]

Table 11
DETAIL WELD PROCEDURE FOR ZIMMER 1 & LA SALLE 2 SURVEILLANCE PROGRAM

CB&I

CONTRACT NO.	BY	DATE
69-5571	PCJ	10/5/71

SPECIFICATION
Low Alloy SMA & SA Grooves & Buildup

CUSTOMER General Electric Company
PRODUCT NUCLEAR VESSELS (Class A)
DESCRIPTION Shielded Metal Arc and Submerged Arc Welding of ASME P12B Subgroup 1 Material

PROCEDURE NUMBER WPS 323-2F6
PAGE NO 1 OF 1
DATE 2-17-69
REVISION NO 4 (9-21-70) RF

REFERENCE SPECIFICATIONS
General WPS 800 Latest Revision
General WPS 820 Latest Revision

PROCEDURE QUALIFICATION

NO	POSITION	THICKNESS RANGE
963 (TW)	F (Sub Arc) F,V,H (SMA)	4 1/2" to 9.9"
1261 (TW)	F (Sub Arc) F,V (SMA)	2 3/4" to 8"

POST HEAT TREATMENT –
Procedure qualified with 50 hrs. at 1150°F +25°/-50°F.

Post weld heat treatment of the weldment shall be in accordance with a CB&I approved procedure.

BASE METAL –
ASME SA-533 Gr B Class 1 or
SA-508 Class 2
ASME Group No. P12B Subgroup 1

FILLER METAL – ASME
See Adjacent Column

ELECTRICAL CHARACTERISTICS –
See Adjacent Column

SHIELDING GAS – None

BACKUP GAS – None

FLUX – Linde 124

PREHEAT REQUIREMENTS:

Minimum preheat of 300°F shall be applied uniformly to the full thickness of the weld joint and adjacent base material for a minimum distance of "T" or 6", whichever is least, where "T" is the material thickness.

Maintain preheat temperature until start of post weld heat treatment.

INTERPASS TEMPERATURE REQUIREMENTS

The interpass temperature shall not exceed 500°F maximum.

FILLER METAL:

Submerged Arc
Specification - N.A.
Classification - N.A.
Analysis - A3 (except Ni 0.50 to 1.25)
Usability - F6
Trade Name - Adcom 1NMM (1% Nickel or equal

Shielded Metal Arc
Specification - SA-316
Classification - E8018-G
Analysis - A3 (except Ni 0.50 to 1.25)
Usability - F4
Trade Name - Alloy Rods E8018NM

ELECTRICAL CHARACTERISTICS:

SMA - DCRP

Submerged Arc
Tandem Wire
Lead Wire - DCRP
Trail Wire - AC
Single Wire - DCRP

VPF # 2812-93-2

Table 12

MILB-4 ELECTRODE, LINDE 1092 FLUX
SUBMERGED ARC
VESSEL WELD TOUGHNESS DATA

(LaSalle 1 - Combustion Engineering)

Heat No./ Lot No.	NDT (°F)	Charpy Temp (°F)	Single or Tandem Wire (S or T)	Energy (ft-lbs)	Lateral Expansion (mils)	% Shear
21935/3889		+10		97, 90, 83	NA	NA
12008/3889		+10		97, 90, 83	NA	NA
30544/3947		+10		82, 66, 80 92, 91, 92	NA	NA
12008/3947		+10		92, 91, 92	NA	NA
305424/3889		+10		82, 87, 92	NA	NA
1P3571/3958*		+10	S T	40, 46, 46 79, 68, 64	NA	NA
		+200	T	111,110,109	77,78,79.5	99, 99, 99
4P6519/0145	-60	+10		106,109,116	NA	NA
4P6519/0842	-80	+10		110, 79,126	NA	80, 70, 90
4P6519/0653	-60	0 +60 +212		88, 94, 96 121,121,120 125,133,133	NA NA NA	60, 70, 70 100,100,100 100,100,100
10137/3999		+10		101,108,107	NA	NA
6324637/3499		+10		101,108,103	NA	NA
5P5622/0831	-80	+10		108,112,109	NA	NA
2P5755/0831	-70	+10		109,104,114	NA	NA
6329637/3458		+10		103, 65, 88	NA	NA
51874/3458		+10		89, 64, 87	NA	NA

NA = Not Available
*This material (T) is in LaSalle 1 & Shoreham surveillance program.

Table 13

INMM ELECTRODE (TRADE NAME - RACO)
LINDE 124 FLUX, SUBMERGED ARC
POST WELD 1150°F for 50 HR TYPICAL

Plant C (Laguna Verde 2 - CBIN)

Heat No./ Flux No.	NDT (°F)	Charpy Temp (°F)	Single or Tandem Wire (S or T)	Energy (ft-lbs)	Lateral Expansion (mils)	% Shear
5P7397/0156	-50	-70		25, 21	18, 15	5, 5
		-50		42, 27, 19	33, 25, 20	10, 15, 10
		+10		64, 67, 55	53, 53, 52	30, 35, 40
		+10		64, 70	53, 54	40, 45
		+40		91, 84, 85	78, 68, 79	85, 90, 95
		+212		103, 92, 94	59, 66, 59	100,100,100
3P4966/0342	-80	-80		51, 27, 9	45, 25, 12	5, 5, 5
		-20		71, 66, 54	57, 57, 45	30, 25, 20
		+10		85, 84, 71	68, 72, 61	70, 80, 65
		+10		83, 76	67, 64	65, 55
		+40		87, 91	71, 60	75, 80
		+70		100,101, 97	82, 89, 71	90, 95, 90
		+212		108,111,108	66, 84, 86	100,100,100
4P7465/0751	-60	-80		27, 14	21, 12	5, 0
		-70		48, 43, 26	42, 36, 22	15, 15, 5
		0		63, 57, 68	54, 45, 63	30, 25, 35
		+10		56, 58, 90	62, 62, 86	30, 25, 45
		+10		87, 55	83, 42	40, 30
		+40		67, 97	71, 90	45, 50
		+212		118,102,112	88, 71, 72	100,100,100
1P6484/0156	-20	-80		5, 8	6, 11	5, 5
		-60		22, 16, 12	23, 13, 10	10, 10, 10
		0		17, 36, 30	20, 27, 28	25, 20, 25
		+10		30, 38, 17,	25, 38, 12,	15, 15, 15,
				34, 38	28, 30	15, 20
		+30		34, 46, 42	29, 37, 45	25, 50, 35
		+40		72, 60, 72	54, 47, 49	50, 45, 50
		+212		93, 81, 83	65, 66, 69	100,100,100
5P5657/0931	-60	-80		39, 39	27, 37	5, 5
		-60		19, 20, 32	18, 22, 28	10, 10, 10
		0		51, 55, 58	50, 50, 63	30, 30, 55
		+10		69, 69, 66	61, 65, 59	50, 50, 40
		+10		62, 57	60, 63	60, 40
		+40		77, 66	73, 72	70, 80
		+212		88, 91, 85	86, 75, 83	100,100,100

Table 14

INMM ELECTRODE (TRADE NAME - TECHALLOY)
LINDE 124 FLUX, SUBMERGED ARC
POST WELD 1150°F FOR 50 HRS TYPICAL

Plant A (Zimmer RPV, CBIN)

Heat No./ Flux Lot	NDT (°F)	Charpy Temp (°F)	Single or Tandem Wire (S or T)	Energy (ft-lbs)	Expansion (mils)	% Shear
KS203/0171	-80	-130	S	7, 6	7, 7	5, 5
		-80		34, 18, 22	32, 16, 21	40, 35, 40
		-20		68, 70, 62	61, 57, 56	80, 70, 75
		+10		75, 72	64, 64	90, 90
		+40		94, 82	81, 71	100, 95
		+212		94, 92, 86	76, 80, 80	100, 100, 100
		-130	T	7, 5	6, 5	5, 5
		-100		25, 16	24, 19	10, 10
		-80		24, 22, 25	21, 19, 25	25, 20, 30
		-20		48, 49, 54	44, 42, 46	45, 45, 60
		-10		59, 54, 54	48, 49, 46	60, 45, 60
		+10		78, 67	65, 56	95, 80
		+40		80, 79	68, 68	95, 95
		+212		86, 89, 87	87, 86, 85	100, 100, 100

Table 15

1NMM ELECTRODE (TRADE NAME - RACO)
LINDE 124 FLUX, SUBMERGED ARC
POST WELD 1150°F FOR 50 HR TYPICAL

Plant B (La Salle 2 RPV, CBIN)

Heat No./ Flux Lot	NDT (°F)	Charpy Temp. (°F)	Single or Tandem Wire (S or T)	Energy (ft-lbs)	Lateral Expansion (mils)	% Shear
5P7397/ 0342	-70	-70	T	22, 16, 36	22, 18, 28	5, 5, 5
		-10		58, 68, 61	54, 50, 47	25, 20, 20
		+10		76, 73, 75	60, 65 60	30, 45, 50
		+10		75, 69	58, 56	35, 35
		+40		91, 84	75, 63	80, 85
		+70		79, 75, 77	73, 63, 74	90, 95, 95
		+212		84, 81, 87	69, 67, 75	100, 100, 100
		-70	S	20, 34, 24	16, 32, 22	5, 5, 5
		-10		54, 50, 59	47, 47, 53	25, 20, 20
		+10		65, 59, 69	60, 56, 65	30, 25, 75
		+10		70, 75	56 61	45, 55
		+40		71, 78	65, 68	75, 90
		+70		92, 101, 94	82, 65, 69	95, 95, 100
		+212		100, 95, 96	88, 58, 82	100, 100, 100

Table 16

FERMI 2 REACTOR COOLANT PRESSURE BOUNDARY NSSS SUPPLY MAIN STEAM PIPE DATA

Mfr.	Material Supplier	Material	Component	O.D. Size	Min. Wall	Heat No.	Lot No.	Wt. % C	Wt. % Mn	Wt. % P	Wt. % S	Wt. % Si	TS ksi	YS ksi	Grain Size	Charpy Data* ft-lb
NABCO	Lukens	A155 Class 1 Grade KCF70 (from A516-69 Gr. 70)	Pipe	26"	1.088"	B2875	---	.21	.99	.009	.021	.24	77.5	47	7-8	NA
		(Pipe stress relieved 1175°F, 2-1/2 hr.)														
Taylor Forge	Bethlehem	A420 WPL1-W (from SA-516 Gr. 70)	Elbows	26"	1.140"	ECNU 802B10449	---	.22	1.07	.016	.026	.26	76.4	48.4	Fine Grain	40-29-27
			Elbows	26"	1.140"	ECPY 802C05829	---	.22	1.01	.009	.025	.25	78.2	53.7		38-33-39
			Elbows	26"	0.950"	ECNT 801B08420	---	.22	1.11	.009	.020	.24	75.4	50.4		21-56-42
			Elbows	26"	1.140"	ECPV 802C09120	---	.23	1.04	.017	.030	.25	77.2	52.8		45-41-32
			Elbows	26"	0.950"	ECNW 802C05820	---	.22	1.01	.009	.025	.25	73.2	51.6		50-40-54
	Crucible	A350 Gr. LF1	Expander Flange	6"x8"	Sch.160	EMMY 3108903	---	.26	.83	.006	.025	.21	74.0	46.5	7	33-15-16
		(Materials normalized 1650°F, welds stress relieved 1175°F)														
Bonney Forge	Sharon	A350 Gr. LF1	Sweepolets	26"x8"	1.088"	219839	Q1Q57/ 307M	.26	.80	.010	.010	.22	83.3	56.1	Fine Grain	26-25-32
						218543	Q1Q20/ 693J&694J	.29	.81	.010	.021	.23	84.5	56.3		13-16-17
						218306	Q1Q10/ 695J	.29	.74	.010	.013	[illegible]	85.0	56.9		19-20-19
				26"x6"	1.088"	210608	G772	.24	.69	.009	.012	.23	75.3	49.4		23-23-23
	Bethlehem	SA-105 Gr. 2	Socket/ Weld	26"x2"	0.950"	662C499	F873	.30	.75	.010	.023	.22	88.4	57.6		>15 (Spec.)
		(Materials normalized 1650°F, weld stress relieved 1175°F)														

*Charpy Keyhole at -50°F

NA = Not Available

CERTIFICATE OF TESTS   P.O. Box [illegible], Houston, Texas 77001   0-13447-10

THS [illegible]	630-1193-HO		ATSF 73459	06/28/71	7086823	06/29/71	jb	28

DESCRIPTION	HEAT OR PLATE NO	NO PCS	YIELD PSI	TENSILE PSI	% ELONG 8"	% REDUCT	BEND TEST	HOMO TEST	BHN	IMPACT ORIEN	TEMP	1	2	3	AVG
PLATES FOR PRESSURE VESSELS NORMALIZED ASTM A516 GR 70 PLUS S1 ADDITIONAL TENSION TEST TO A593 CVN L OF 15 FT/LBS AT MINUS 50 DEG F	GE 205-AD210 SPOOL NO. 5, 9, 10, 15														
HEAT 84232 1/4 X 96 X 480"	P43345	1	55700 55700	73900 73600	25.0 27.0		OK			L	-50°F	27	29	29	28
THE ABOVE PLATES AND TEST SPECIMENS WERE NORMALIZED AT 1650°F FOR A PERIOD OF 13 MINUTES															
											CHARPY			V	FULL
HEAT 50905 3/4 X 96 X 480"	P44138	1	[illegible] [illegible]	76100 [illegible]	25.0 24.[illegible]		OK			L	-50°F	23	25	29	26
THE ABOVE PLATES AND TEST SPECIMENS WERE NORMALIZED AT 1650°F FOR A PERIOD OF 1[illegible] MINUTES															
HEAT 60267 3/4 X 96 X 480"	P44137	1	53600 53100	74400 73500	25.5 28.5		OK			L	-50°F	24	25	26	25
THE ABOVE PLATES AND TEST SPECIMENS WERE NORMALIZED AT 1650°F FOR A PERIOD OF 15 MINUTES															
HEAT 70161 2 X 96 X 240"	P43868	2	[illegible] 45900	71100 71600	29.5 29.0		OK			L	-50°F	17	22	28	22
THE ABOVE PLATES AND TEST SPECIMENS WERE NORMALIZED AT 1650°F FOR A PERIOD OF 40 MINUTES															

HEAT	C	Mn	P	S	Si	Cr	Ni	Mo	Cu		V			A	N	G.S.
84232	.20	1.00	.010	.020	.19											9
50905	.20	1.11	.010	.023	.27											8
60267	.21	[illegible]	.010	[illegible]	.24											8
70161	.21	1.01	.010	.022	.20											8

[signature] 11-?-71

DUQUESNE METALS & SUPPLY CO
POST OFFICE BOX 1730
HOUSTON, TEXAS 77001

Table 17
FERMI2
MAIN STEAM NSSS
PROTECTIVE PIPE CAPS

THE CHEMICAL AND PHYSICAL OR MECHANICAL TEST REPORTED HEREWITH ARE CORRECT AS CONTAINED IN THE RECORDS OF THE CORPORATION

METALLURGICAL DEPT

THIS CERTIFIED TEST REPORT HAS BEEN DELIVERED TO A CONSIGNEE OF MATERIAL PURCHASED FROM ARMCO STEEL CORPORATION. TO AVOID THE POSSIBILITY OF ITS MISUSE ON THE REDELIVERY OF THIS REPORT TO A THIRD PARTY IT MUST BE RECERTIFIED BY AND UNDER

Table 18

FERMI 2 MAIN STEAM NSSS PIPE WELD FILLER METAL

1. AWS A5.1, E7018 - Meets charpy v-notch minimum requirment of 20ft-lb. at -20 °F.
2. AWS A5.17, EH14 - RACO 123/402B0451 heat no. used for elbows reports charpy v-notch values at -50 °F of 47-46-45 ft-lb.
3. AWS A5.18, E70S2- Charpy v-notch minimum requirement of 20 ft-lb. at -20 °F.

Table 19

TVA #17 MAIN STEAM PIPE TOUGHNESS
(SA-516 Gr. 70, LUKENS/NABCO)

NATIONAL ANNEALING BOX CO.

WASHINGTON, PENNA.

MATERIAL RECORD

INSPECTION

F-18691-A

CODE CP 408

APPROVED
AP&E
QC DEPT.
DATE 4/22/77
SIGNED [illegible]

[illegible] 4/25/77

PURCHASER Associated Piping & Eng. Corp.

TYPE EQUIPMENT ASME SA 155-C.1. ASME Sect III Cl 1 Mat'l ASME SA 516 Gr 70 ASME Sect III Winter '74

YEAR BUILT 1977 (50-1467-7)

DWG. NO. NA-2311-4 Rev I

SERIAL NO. 1467-1 [illegible]

PUR. ORDER NO. 42114-4

INSPECTED BY [illegible]

LABORATORY TEST REPORT

PART NO	MANUFACTURER OF MATERIAL	MELT, SLAB SERIAL NO.	Slab or Test No.	C.	MN	P.	S.	SIL.					ULT. STRGHT.	EL. LIMIT	ELONG.	BEND	FRACTURE
1467-1	Lukens 58384	C 6220	3A	.23	1.07	.005	.014	.26					78100	49400	29	OK	
-1-	PM Check	Lukens 58386	7-11877	.24	1.11	.007	.016	.23									
[illegible]													81,500	(Tests)		OK	
1467-2	Lukens 58384	C 6220	4B	.23	1.07	.005	.014	.26					77200	65600	26	OK	
-2	PM Check	Lukens 58386	7-11877	.24	1.11	.007	.016	.23									
[illegible]													81,500	(Tests)		OK	

[illegible] Rel 5/20/77

[illegible] Test 77-1

[illegible] 1150° F [illegible] Test 77-3

[illegible] Tested [illegible] PSIG [illegible]

[illegible] of each lot of pipe

Charpy Impact Test of each lot of pipe as req. of mat'l

[illegible] Ft. lbs. 70-68-72 — MLE .065 .064 .066 % Shear 70%

[illegible] weld - 30°F Ft. lbs. 48-35-30 — MLE .043 .032 .038 % Shear 30%

Base metal + 60°F Ft. lbs. 70-68-68 — MLE .062 .066 .063 % Shear 70%

ABOVE DATA CERTIFIED CORRECT BY MANUFACTURER [illegible] BY [illegible] DATE 4-15-77

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Table 20

SUSQUEHANNA I A106 GR. B
MAIN STEAM NSSS SUPPLY TOUGHNESS DATA

Pipe Size	Sch.	Thickness	Mfgr	Heat	C	Mn	P	S	Si	TS K	YS K	Charpy Data Ft-Lbs.			Charpy Data Mils Lat. Exp.			°F
23.5 ID		1.013	Cameron	4410	0.24	1.03	0.011	0.015	0.26	78.9	53.6	116	122	105	77	79	71	70
23.5 ID		1.013	Cameron	4410	0.24	1.03	0.011	0.015	0.26	78.9	53.6	115	115	120	81	77	82	70
23.5 ID		1.013	Cameron	4411	0.24	1.01	0.020	0.024	0.23	79.6	54.9	94	98	94	69	72	72	70
23.5 ID		1.013	Cameron	4411	0.24	1.01	0.020	0.024	0.23	79.6	54.9	93	97	92	68	72	72	70
8"	160	0.906	Phoenix	21342	0.26	0.92	0.012	0.027	0.23	80	40	32	45	40	39	48	46	70
26" Reducer		1.013	Tube Turns	S9351	0.26	0.97	0.020	0.035	0.23	80.9	56.3	165	164	210	99	91	100	70
26" Weld Ell		1.013	Tube Turns	S9087	0.25	0.85	0.007	0.024	0.18	76.6	42.1	158	139	142	91	88	83	70
26" Weld Ell		1.013	Tube Turns	S2155	0.23	0.87	0.008	0.020	0.17	67.9	40.8	33	42.5	52.0	45	40	32	70
26" Weld Ell		1.013	Tube Turns	S9923	0.27	0.92	0.020	0.028	0.21	82	55.6	54	68	67	59	69	62	70
26" Weld Ell		1.013	Tube Turns	S9925	0.30	0.92	0.020	0.020	0.20	80.9	45.5	59	50	65	62	43	57	70
26" Weld Ell		1.013	Tube Turns	S9924	0.26	0.99	0.026	0.018	0.25	81.9	50.6	60	57	59	54	52	52	70
26 Weld Ell		1.013	Tube Turns	S8249	0.24	0.95	0.009	0.025	0.16	77.5	38.4	69	64	[illegible]	73	55	62	70
26" Tee		1.013	Tube Turns	S8843	0.27	[illegible]	0.015	0.024	0.23	79	61.5	44	52	44	26	25	33	70

Table 21

ZIMMER 1 A106 GR. B
MAIN STEAM NSSS SUPPLY TOUGHNESS DATA

Pipe Size	Sch.	Thickness	Mfgr	Heat	C	Mn	P	S	Si	F TS	F YS	Charpy Data Ft-Lbs.			Charpy Data Mils Lat. Exp.			°F
24"		0.945	USS	L41121	0.24	0.91	0.013	0.019	0.18	75	41	74	90	118	64	76	80	70
24"		0.945	USS	N51188	0.25	0.93	0.014	0.021	0.16	73	40	40	62	60	50	58	55	70
24"		0.945	USS	L51114	0.25	0.95	0.018	0.023	0.20	73	42	44	48	50	44	42	42	70
24		0.945	USS	N51118	0.24	0.95	0.016	0.023	0.16	75	42	33	32	32	34	36	34	70
24		0.945	USS	N51123	0.23	0.92	0.015	0.024	0.22	73	40	62	75	70	65	66	64	70
FITTINGS A234 (A106B)																		
24 LR Ell (Elbows)		0.945	Tube Turns	L41822	0.23	0.93	0.010	0.022	0.17	70	40	43	50	54	61	55	58	70
24 LR Ell		0.945	Tube Turns	L22473	0.25	0.93	0.005	0.021	0.16	76	41	61	56	56	47	55	49	70
24 LR Ell		0.945	Tube Turns	L41821	0.25	0.98	0.011	0.025	0.19	73	44	75	75	83	69	66	61	70
24 LR Ell		0.945	Tube Turns	L60344	0.25	0.95	0.013	0.016	0.22	76	58	96	103	105	74	79	75	70

Table 22

Project	Fermi 2
Valve	MSIV
Component	Cover
Applicable Code	1968 Pump & Valve Code (ASME)
Valve Vendor	Atwood & Morril Co.
Material Vendor	Cann & Saul Steel Co.

Material Specification	ASTM A105 Grade 2
Heat No.	219222 (Typical)

	C	Mn	Si	P	S	Al	
Chemical Composition (Wt. %)	.30	.68	.19	.009	.014	NA	(Typical)

Grain Size (ASTM No.)	NA
Heat Treatment	1650 ^{O}F (12 hr.) Air Cool

Charpy V - Notch Impact Toughness

Test Temperature:	NA
Ft-lb.	NA
Mils	NA
% Shear	NA

NA - Not Available

Table 22

Project	Fermi 2
Valve	MSIV
Component	Body
Applicable Code	1968 Pump & Valve Code (ASME)
Valve Vendor	Atwood & Morrill Co.,
Material Vendor	Quaker Alloy Casting Co.

Material Specification: ASTM A216 WCB

Heat No.: F7080 (Typical)

	C	Mn	Si	P	S	Al
Chemical Composition (Wt. %)	0.27	0.79	0.39	0.019	0.012	NA (Typical)

Grain Size (ASTM No.): NA

Heat Treatment:
1700 °F (4 hr. 30 min.) Air Cool
+1320/1340°F (4 hr. 10 min.) Air Cool
+1245/1260°F (4 hr. 20 min.) Air Cool
+1100/1160°F (3 hr.) Air Cool
+1150°F (4 hr. 15 min.) Air Cool
+1150°F (3 hr. 10 min.) Air Cool

Charpy V - Notch Impact Toughness

Test Temperature:

Ft-lb.
Mils
% Shear
} NA

Weld Filler Metal: AWS A5.1-69 Type E7018
Tested by charpy v-notch at -20 °F to meet the requirement of at least 20 ft-lb.

NA - Not Available

RECOMMENDED FORM Q-1 MANUFACTURER'S RECORD OF WELDING PROCEDURE QUALIFICATION TESTS

Specification No. QAP-L9, Rev. D, Mod. Date 10-26-71

Welding Process Shielded Arc Manual or Machine Manual

Material Specification A216 WCB to A216 WCB of P-No. 1 to P-No. 1

Thickness (if pipe, diameter and wall thickness) 4 Inches

Thickness Range this test qualifies 3/16 Inch to 8 Inches

Filler Metal Group No. F- 4

Weld Metal Analysis No. A- 1

Describe Filler Metal if not included in Table Q-11.2 or QN-11.2

For oxyacetylene welding—State if Filler Metal is silicon or aluminum killed

FLUX OR ATMOSPHERE

Flux Trade Name or Composition

Inert Gas Composition

Trade Name Flow Rate

Is Backing Strip used? Yes

Preheat Temperature Range 60°F Minimum

Interpass Temperature Range 600°F Maximum

Postheat Treatment 1100°F Minimum Air Cool

WELDING PROCEDURE

Single or Multiple Pass Multiple

Single or Multiple Arc Single

Position of Groove Vertical - Upward (See Pars. & Figs. Q-2 & Q-3, or QN-2 & QN-3)
(Flat, horizontal, vertical, or overhead; if vertical, state whether upward or downward)

FOR INFORMATION ONLY

Filler Wire—Diameter 1/8" - 5/32" - 3/16" - 1/4"

Trade Name Atom Arc 7018

Type of Backing Carbon Steel

Forehand or Backhand Forehand

WELDING TECHNIQUES

Joint Dimensions Accord with 1971 ASME Code

amps * volts * inches per min.

Current Direct Polarity Reverse

REDUCED SECTION TENSILE TEST (Figs. Q-6 and QN-6)

Specimen No.	Dimensions Width	Dimensions Thickness	Area	Ultimate Total Load, lb.	Ultimate Unit Stress, psi	Character of Failure and Location
SEE PAGE 2 FOR TENSILE RESULTS						
SEE PAGE 2 FOR TENSILE RESULTS						

GUIDED BEND TESTS (Figs. Q-7.1, Q-7.2, QN-7.1, QN-7.2, QN-7.3)

Type and Figure No.	Result	Type and Figure No.	Result
Q-7.1	Satisfactory	Q-7.1	Satisfactory
Q-7.1	Satisfactory	Q-7.1	Satisfactory

Results of Filletweld Tests, Fig. Q-8(c)

Welder's Name Earl Zellers Clock No. 275 Stamp No. EZ

Who by virtue of these tests meets welder performance requirements.

Test Conducted by Quaker Alloy Casting Co. Laboratory—Test No. EZ 62071

per Mark Landis

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

Signed QUAKER ALLOY, CASTING CO.
(Manufacturer)

Date 10-26-71 By John [signature] Jr.

(Detail of record of tests are illustrative only and may be modified to conform to the type and number of tests required by the Code. Recommended Form Q-1 is available for purchase at ASME Headquarters.)

NOTE: Any essential variables in addition to those above shall be recorded.

Re-typed March 20, 1973

*See Paragraph 11.5 of QAP-L9

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Table 23

FERMI 2 MSIV BODY WELD PROCEDURE QUALIFICATION TOUGHNESS RESULTS

QAP-49, D, Mod.
Manual Shielded Arc

Table 23

Specimen No.	Diameter	Area	Ultimate Total Load Lb.	Ultimate Unit Stress, psi	Location of Failure
1	.505	.2	15100	75500	Weld Metal
2	.505	.2	15000	75000	Weld Metal
3	.505	.2	14900	74500	Weld Metal
4	.505	.2	15200	76000	Weld Metal
5	.505	.2	14800	74000	Weld Metal
6	.505	.2	15100	75500	Weld Metal
7	.505	.2	14900	74500	Weld Metal
8	.505	.2	14800	74000	Weld Metal

Charpy Impact
"V" Notch @ Minus 20°F

Base Metal -

Foot pounds	34-31-34
Lateral Expansion	24-21-22
Percent Ductile-Fracture	20-20-20

Weld Metal -

Foot pounds	60-72-80
Lateral Expansion	40-52-66
Percent Ductile Fracture	40-40-50

Heat Affected Zone

Foot pounds	51-45-57
Lateral Expansion	23-21-28
Percent Ductile Fracture	40-40-40

Non-Destructive Examination of Completed Weld

1. Radiographic Examination - Acceptable
2. Magnetic Particle Examination - Acceptable
3. Visual Examination - Acceptable

John Juppenlatz, Jr.
Quaker Alloy Casting Co.

3-20-73

Table 24

Project	Clinton 1
Valve	MSIV
Component	Body
Applicable Code	ASME Sect. III, 1974
Valve Vendor	Atwood & Morrill Co.
Material Vendor	Quaker Alley Casting Co.

Material Specification	ASME SA216 Grade WCB					
Heat No.	F7516					
	C	Mn	Si	P	S	Al
Chemical Composition (Wt. %)	0.25	0.78	0.53	0.018	0.013	NA
Grain Size (ASTM No.)	NA					

Heat Treatment: 1690/1710°F (6 hr. 5 min) Air Cool
+ Temper 1350/1360°F (6 hrs) Air Cool
+ Post Weld 1200°F (6 hr, 5 min) Air Cool

Charpy V - Notch Impact Toughness

Test Temperature:	+60°F
Ft-lb.	30,24,34
Mils	37,27,33
% Shear	40,40,40

NA - Not Available

TABLE 24

Project Clinton 1

Valve MSIV

Component Cover (Bonnet)

Applicable Code ASME Sect. III, 1974

Valve Vendor Atwood & Morrill Co.,
Material Vendor Cann & Saul Steel Co.

Material Specification ASME SA105 QT

Heat No. 214934

	C	Mn	Si	P	S	Al
Chemical Composition (Wt. %)	0.28	0.76	0.22	0.017	0.023	NA

Grain Size (ASTM No.) N/A

Heat Treatment 1600°F (12 hr) Quench, Water
+ 1175°F (12 hr) Furnance Cool

Charpy V - Notch Impact Toughness

Test Temperature: + 60°F

Ft-lb. 62,60,55

Mils 48,45,50

% Shear 30,30,30

NA - Not Available

Table 24

Project	Grand Gulf 1
Valve	MSIV
Component	Body
Applicable Code	ASME Sect. III, 1974
Valve Vendor	Atwood & Morrill, Co.,
Material Vendor	Quaker Alloy Casting Co.

Material Specification ASME SA216 Grade WCB

Heat No. F6406

	C	Mn	Si	P	S	Al
Chemical Composition (Wt. %)	0.23	0.89	0.53	0.019	0.012	NA

Grain Size (ASTM No.) NA

Heat Treatment 1680/1710°F (5 hrs, 30 min) Air Cool
+ Temper 1350°F (5 hr, 30 min) Air Cool
+ Post Weld 1200°F (6 hr) Air Cool

Charpy V - Notch Impact Toughness

Test Temperature:	+60°F
Ft-lb.	32,31,3[illegible]
Mils	33,32,31
% Shear	40,40,40

NA - Not Available

Table 24

Project	Grand Gulf 1
Valve	MSIV
Component	Cover (Bonnet)
Applicable Code	ASME Sect. III, 1974
Valve Vendor	Atwood & Morrill Co.,
Material Vendor	Cann & Saul Steel Co.

Material Specification SA-105 (QT)

Heat No. 632202

	C	Mn	Si	P	S	Al
Chemical Composition (Wt. %)	0.26	0.94	0.20	0.023	0.015	NA

Grain Size (ASTM No.) NA

Heat Treatment 1550°F (12 hr) quench in water
+ 1175°F (12 hr) furnace cool

Charpy V - Notch Impact Toughness:

Test Temperature:	+60°F
Ft-lb.	66,74,65
Mils	58,64,54
% Shear	20,20,20

NA - Not Available

Table 24

Project	Riverbend 1
Valve	MSIV
Component	Cover (Bonnet)
Applicable Code	ASME Sect. III, 1974
Valve Vendor	Atwood & Morrill Co.,
Material Vendor	Cann & Saul Steel Co.

Material Specification	ASME SA105 QT					
Heat No.	216149					
	C	Mn	Si	P	S	Al
Chemical Composition (Wt. %)	0.30	0.88	0.16	0.006	0.014	NA
Grain Size (ASTM No.)	NA					
Heat Treatment	1550°F (12 hr) Quench in water + 1225°F (12 hr) Furnance cool					

Charpy V- Notch Impact Toughness

Test Temperature:	+60°F
Ft-lb.	62,64,60
Mils	56,54,52
% Shear	20,20,20

NA - Not Available

Table 24

Project	Riverbend 1
Valve	MSIV
Component	Body
Applicable Code	ASME Sect. III, 1974
Valve Vendor	Atwood & Morrill Co.,
Material Vendor	Atwood & Morrill, Ltd.

Material Specification SA216 Grade WCB

Heat No. 35

	C	Mn	Si	P	S	Al
Chemical Composition (Wt. %)	0.24	0.82	0.46	0.022	0.013	NA

Grain Size (ASTM No.) NA

Heat Treatment 1650°F - 1800°F (8 hrs.) air cool to 400°F
+ temper 1150°/1250°F (8 hrs) air cool
+ post weld 1095°/1195°F (18 hrs) furnace cool to 800°F (100°F/hr) air cool

Charpy V - Notch Impact Toughness

Test Temperature: +60°F

Ft-lb. 31.5,37.5,39.5

Mils 33,41,40

% Shear 10,10,10

NA - Not Available

Table 24

Project	Laguna Verde 1
Valve	MSIV
Component	Body
Applicable Code	ASME Sect. III, 1971 with Summer 1973 Addenda
Valve Vendor Material Vendor	Rockwell International

Material Specification	SA216 Grade WCC					
Heat No.	1750262					
	C	Mn	Si	P	S	Al
Chemical Composition (Wt. %)	0.21	1.19	0.43	0.011	0.009	0.043
Grain Size (ASTM No.)	NA					
Heat Treatment	1700°F (10 hrs) normalize + 1225°F (7.5 hrs) Temp + 1100°F (6 hr) post weld					

Charpy V - Notch Impact Toughness

Test Temperature:	+40°F
Ft-lb.	29.0,33.0,35.0
Mils	25.0,26.0,30.0
% Shear	15,15,15

NA - Not Available

Table 24

Project	Laguna Verde 1
Valve	MSIV
Component	Bonnet
Applicable Code	ASME Sect. III, 1971 with Summer 1973 Addenda
Valve Vendor	Rockwell International
Material Vendor	Cann & Saul Steel Co.

Material Specification SA105 Grade NUC

Heat No. 211971

	C	Mn	Si	P	S	Al
Chemical Composition (Wt. %)	0.27	1.03	0.22	0.010	0.014	NA

Grain Size (ASTM No.) NA

Heat Treatment 1550°F (10 hr) Quench in water
+ 1175°F (10 hr) Furnace cool

Charpy V - Notch Impact Toughness

Test Temperature: +40°F

Ft-lb.	35,45,34	31,34,35	45,38,48
Mils	NA	NA	64,57,65
% Shear	30,40,30	30,30,30	15,15,15

Ft-lb	55,47,43	62,64,52	58,62,72	39,44,38	40,45,50
Mils	66,64,60	74,72,65	70,68,75	56,60,57	58,60,60
% Shear	20,15,15	20,20,20	20,20,20	15,15,15	20,20,20

NA - Not Available

Table 24

Project	TVA X20
Valve	MSIV
Component	Body
Applicable Code	ASME Sect. III, 1974 with Summer 1975 Addenda
Valve Vendor	Atwood & Morrill Co.,
Material Vendor	Quaker Alloy Casting Co.

Material Specification	ASME SA216 Grade WCB					
Heat No.	F3547					
	C	Mn	Si	P	S	Al
Chemical Composition (Wt. %)	0.23	0.88	0.38	0.016	0.015	NA
Grain Size (ASTM No.)	NA					

Heat Treatment: 1700°/1725°F (6 hr, 20 min) air cool
+ temper 1345°F (6 hr, 45 min) air cool
+ post weld 1200°/1225°F (6 hrs, 30 min) air cool

Charpy V - Notch Impact Toughness

Test Temperature:	+60°F
Ft-lb.	66,56,54
Mils	53,50,53
% Shear	40,40,40

NA - Not Available

Table 24

Project	TVA X 20
Valve	MSIV
Component	Cover (Bonnet)
Applicable Code	ASME Sect. III, 1974 with Summer 1975 Addenda
Valve Vendor	Atwood & Morrill Co.,
Material Vendor	Cann & Saul Steel Co.

Material Specification: ASME SA105

Heat No.: 217630

	C	Mn	Si	P	S	Al
Chemical Composition (Wt. %)	0.23	0.92	0.19	0.013	0.013	NA

Grain Size (ASTM No.): #9

Heat Treatment: 1650°F (6 hrs) air cool
+ 1550°F (6 hr, 30 min) water quench
+ Temper 1200°F (12 hr, 30 min)

Charpy V - Notch Impact Toughness

Test Temperature:	+60°F
Ft-lb.	90,89,77
Mils	71,67,59
% Shear	50,50,40

NA - Not Available

Table 24

Project	CNV
Valve	MSIV
Component	Body
Applicable Code	ASME Sect. III, 1971 with S73 Addenda
Valve Vendor	Rockwell International,
Material Vendor	Rockwell International

Material Specification	SA216 Grade WCC					
Heat No.	3760171					
	C	Mn	Si	P	S	Al
Chemical Composition (Wt. %)	0.17	1.09	0.50	0.008	0.011	0.060
Grain Size (ASTM No.)	NA					
Heat Treatment	1700°F (8 hours) Normalize					
	1275°F (8 hours) Temper					
	1100°F (6 hours) Post Weld					

Charpy V - Notch Impact Toughness

Test Temperature:	+40°F
Ft-lb.	35.0,38.0,29.0
Mils	32.0,36.0,29.0
% Shear	20,20,20

NA - Not Available

Table 24

Project	CNV
Valve	MSIV
Component	Bonnet
Applicable Code	ASME Sect. III, 1971 with S73 Addenda
Valve Vendor	Rockwell International,
Material Vendor	Cann & Saul Steel Co.

Material Specification	SA105					
Heat No.	214943					
	C	Mn	Si	P	S	Al
Chemical Composition (Wt. %)	0.35	0.78	0.25	0.014	0.023	NA
Grain Size (ASTM No.)	NA					
Heat Treatment	1550°F (10 hours) water quench					
	1175°F (10 hours) furnace cool					
	1100°F (10 hours) post weld					

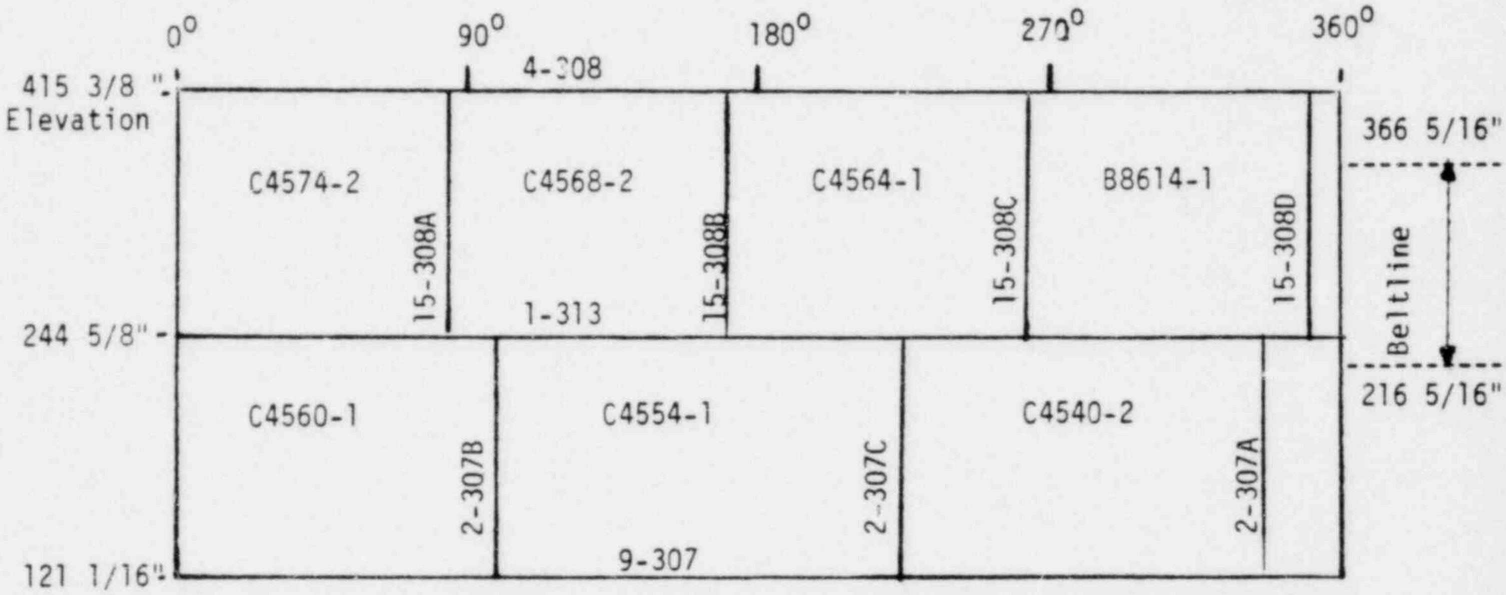
Charpy V - Notch Impact Toughness

Test Temperature:	+40°F	
Ft-lb.	25,25,29	28,30,34
Mils	36,34,34	36,37,35
% Shear	20,20,20	20,20,20

NA - Not Available

Figure 1

FERMI 2 BELTLINE PLATE AND WELD SEAM LOCATIONS



On the basis of the last paragraph on page 19013 of the July 17, 1973 Federal Register, the following subsection discusses what is considered to be an appropriate method of compliance.

5.2.4.2.1 Method of Compliance

The intent of the proposed special method of compliance with Appendix G for this vessel is to provide operating limitations on pressure and temperature based on fracture toughness. These operating limits assure that a margin of safety against a nonductile failure of this vessel is very nearly the same as that for a vessel built to the Summer 1972 Addenda.

The specific temperature limits for operation when the core is critical are based on a proposed modification to 10 CFR Part 50, Appendix G, Paragraph IV.A.2.c. The proposed modification and the justification for it are given in GE Licensing Topical Report NEDO-21778-A.

5.2.4.2.2 Method of Obtaining Operating Limits Based on Fracture Toughness

Operating limits that define minimum reactor-vessel metal temperatures versus reactor pressure during normal heatup, cooldown, inservice hydrostatic testing, and anticipated operational occurrences were established using the methods of Appendix G of Section III of the ASME Boiler and Pressure Vessel Code, 1971 Edition (Appendix G first appeared in the Summer 1972 Addenda). The results are shown in Figure 5.2-1. 23

Estimated RT_{NDT} values and temperature limits are given in this Section for the limiting locations in the reactor vessel.

All the vessel shell and head areas, remote from discontinuities, and the feedwater nozzles were evaluated, and the operating limit curves are based on the limiting location. The boltup limits for the flange and adjacent shell region are based on a minimum metal temperature of $RT_{NDT}+60^{\circ}F$. The maximum through-wall temperature gradient from continuous heating or cooling at $100^{\circ}F$ per hour was considered. The safety factors applied were as specified in Appendix G of the ASME Code and in GE Licensing Topical Report NEDO-21778-A.

For the purpose of setting these operating limits, the reference temperature, RT_{NDT}, is determined from the toughness test data taken in accordance with requirements of the ASME Code to which this vessel is designed and manufactured. This toughness test data, CVN and/or drop-weight NDTT, is analyzed to permit compliance with the intent of 10 CFR Part 50, Appendix G. Because not all toughness testing needed for strict compliance with Appendix G was required at the time of vessel procurement, some toughness results are not available. For example, longitudinal CVNs, instead of transverse CVNs, were tested for plate and forging materials. Also, at the time either CVN or NDT testing was permitted; therefore, in many cases for welds, it is expected that both tests were not performed as is currently required. To compensate for this absence of certain data, toughness property

correlations were derived for the vessel materials in order to operate upon the available data to give a conservative estimate of RT_{NDT}, in order to comply with the intent of Appendix G criteria.

These toughness correlations vary, depending on the specific material analyzed. They were derived from the results of WRB Bulletin 217, "Properties of Heavy Section Nuclear Reactor Steels," and from toughness data from the Fermi 2 vessel and from other reactors. In the case of vessel plate material (SA-533, Grade B, Class 1), the predicted limiting toughness property is either NDT or transverse (CVN 50-ft-lb temperature minus 60°F). Longitudinal CVN transition curve results and NDT values are available for all Fermi 2 vessel plates. The transverse CVN 50-ft-lb transition temperature is estimated from longitudinal CVN data in the following manner. The lowest longitudinal CVN foot-pound value is adjusted to derive a longitudinal CVN 50-ft-lb transition temperature by adding 2 °F/ft-lb to the test temperature. If the actual data equal or exceed 50 ft-lb, the test temperature is used. If sufficient data are available, as in the case of Fermi 2, the 50-ft-lb temperature is derived by interpolation. Once the longitudinal 50-ft-lb temperature is derived, 30°F is added to account for orientation effects and to estimate the transverse CVN 50-ft-lb temperature minus 60°F, estimated in the preceding manner. Using this general approach, an initial RT_{NDT} of -10°F or lower was established for plates in the core beltline region of Fermi 2. 23

For forgings (SA-508 Class 2), the predicted limiting property is the same as for the vessel plates. Both CVN and NDT values are available for the vessel flange and closure head flanges for Fermi 2. Only CVN results at +10°F are available for feedwater-nozzle forgings. For the flange forgings, RT_{NDT} is estimated in the same way as for vessel plate, and an RT_{NDT} value of 10°F was obtained.

For the feedwater-nozzle forgings, a maximum 40°F-NDT value was required by the purchase specification and there were no deviations from this requirement. The CVN results indicate a maximum RT_{NDT} of ~~+12°F~~ +4°F. Therefore, an RT_{NDT} of 40°F was used for the feedwater nozzles.

For the vessel weld metal, the predicted limiting property is the CVN 50-ft-lb transition temperature minus 60°F, as the NDT values are -50°F or lower for these materials. This temperature is derived in the same way as for the vessel plate material, except that the 30°F addition for orientation effects is omitted since there is no principal working direction. When NDT values are available, they are also considered and the RT_{NDT} is taken as the higher of the NDT or the 50-ft-lb temperature minus 60°F. When the NDT is not available, the RT_{NDT} shall not be less than -50°F, because lower values are not supported by the correlation data. The limiting beltline RT_{NDT} for Fermi 2, established from CVN beltline weld metal values, was -44°F. No toughness data were

available for nonbeltline welds; however, the purchase specification required an average of 30 ft-lb and a minimum of 25 ft-lb at +10°F. Quality assurance records show no deviations from these requirements, which produce an RT_{NDT} value of 0°F for nonbeltline welds.

For vessel weld heat-affected zone (HAZ) material, the RT_{NDT} is assumed to be the same as for the base material, as ASME Code weld-procedure, qualification test requirements indicate this assumption is valid.

a 33 mil

Toughness test requirements for closure-bolting material in Fermi 2 were for 30 ft-lb at 60°F below the boltup temperature. Current ASME Code requirements are for 45 ft-lb and 25 mils lateral expansion (MLE) at the preload or lowest service temperature. The reactor-vessel closure studs have a minimum CVN impact energy of 50 ft-lb and a 2-mil lateral expansion at 10°F for Fermi 2. Therefore, since CVN values for Fermi 2 studs exceed current requirements at 10°F, the lowest service temperature is +10°F.

The effect of the main closure flange discontinuity was considered by adding 60°F to the RT_{NDT} to establish the minimum temperature for boltup and pressurization. The minimum boltup temperature of 71°F for Fermi 2, which is shown on Figure 5.2-1, is based on an initial RT_{NDT} of +11°F for the shell plate connected to the closure-flange forging. 23

The effect of the feedwater-nozzle discontinuities was considered by adjusting the results of a BWR/6 reactor discontinuity analysis to the Fermi 2 reactor. The adjustment was made by increasing the minimum temperatures required by the difference between the Fermi 2 and BWR/6 feedwater nozzle forging RT_{NDT}'s. The feedwater nozzle adjustment was based on an RT_{NDT} of 40°F.

5.2.4.2.3 Temperature Limits for Preoperational System Hydrostatic Tests and ISI Hydrostatic or Leak Pressure Tests

Based on 10 CFR Part 50, Appendix G, IV.A.2.d, which allows a reduced safety factor for tests prior to fuel loading, the preoperational system hydrostatic test at 1563 psig may be performed at a minimum temperature of 150°F, which is established by the feedwater nozzle.

The fracture toughness analysis for system pressure tests resulted in the curves labeled A shown in Figure 5.2-1. The curve labeled feedwater nozzle is based on an initial RT_{NDT} of 40°F. The beltline weld material is expected to be more limiting at end-of-service fluence levels, and this weld material has an initial RT_{NDT} of -44°F.

The predicted shift in the RT_{NDT} from Figure 5.2-2 (based on the neutron fluence at 1/4 of the vessel wall thickness) must be added to the beltline curve to account for the effect of fast neutrons.

5.2.4.2.4 Temperature Limits for Boltup

A minimum temperature of 10°F is required for the closure studs. A sufficient number of studs may be tensioned at 70°F to seal the closure flange O-rings for the purpose of raising reactor water level above the closure flanges in order to assist in warming them. The flanges and adjacent shell are required to be warmed to minimum temperatures of 71°F before they are stressed by the full intended bolt preload. The fully preloaded boltup limits are shown on Figure 5.2-1.

5.2.4.3 Operating Limits During Heatup, Cooldown, and Core Operation

23 The fracture toughness analysis was done for the normal heatup or cooldown rate of 100°F per hour. The temperature gradients and thermal stress effects corresponding to this rate were included. The results of the analyses are a set of operating limits for non-nuclear heatup or cooldown shown as curves labeled B on Figure 5.2-1. Curves labeled C on these figures apply whenever the core is critical. The basis for curves labeled C is described in GE BWR Licensing Topical Report NEDO-21778-A.

5.2.4.4 Surveillance Programs for the Reactor Pressure Vessel

A surveillance program will be carried out to monitor the neutron radiation effects on the RPV base metal, the weld HAZ metal, and the weld metal from a steel joint that simulates a welded joint in the RPV beltline. For the extent of compliance to 10 CFR Part 50, Appendix H, see Table 5.2-10.

5.2.4.4.1 Program Content

The program will consist of three baskets, each containing tensile and CVN specimens hermetically sealed in an inert gas environment in thinwall austenitic stainless steel capsules. The capsules are not buoyant and thus present no handling problems. The three baskets will be placed near core midplane adjacent to the RPV wall where the neutron flux and temperature will simulate that of the RPV wall. The three baskets contain test specimens made from the original RPV beltline material in accordance with the requirements of ASTM E185-66. In total, the program consists of 84 impact and 19 tensile specimens. In addition, there are 75 impact and 15 tensile baseline and spare specimens. The specimens will include the following:

a. Base metal impact, transverse and longitudinal
b. Weld metal impact
c. HAZ impact

d. Base metal te sile
e. Weld metal te sile
f. HAZ tensile

The following general statements apply to these specimens:

a. Base metal impac and tensile specimens are taken from the 1/4 T planes of the specimen plate.

b. HAZ impact and tensile specimens are all oriented parallel to the rolling direction.

c. Weld metal impact specimens are all transverse to the axis of the weld; tensile specimens are parallel. The fracture areas consist of all weld metal.

Details of the manufacture of these specimens are given in Reference 6.

The specimens were taken from two plates trimmed from the lower, intermediate shell section of the reactor vessel. The plate sections for the base material specimens were given a simulated stress relief for 40 hours at 1150°F to ensure that they represent the metallurgical condition of the lower, intermediate shell plates of the reactor vessel after final fabrication.

The plate sections for the weld and HAZ specimens were joined with a continuous central weld identical to the reactor vessel longitudinal weld. The welded plate was then given a simulated stress relief for 40 hours at 1150°F, similar to the base material plate. The weld was X-rayed to ensure quality; no repair to the weld was allowed by the specifications.

5.2.4.4.2 Withdrawal Schedule

The withdrawal schedule of the three sets of specimens in the reactor is planned as follows:

a. The first set will be withdrawn at 25 percent of the reactor service life.

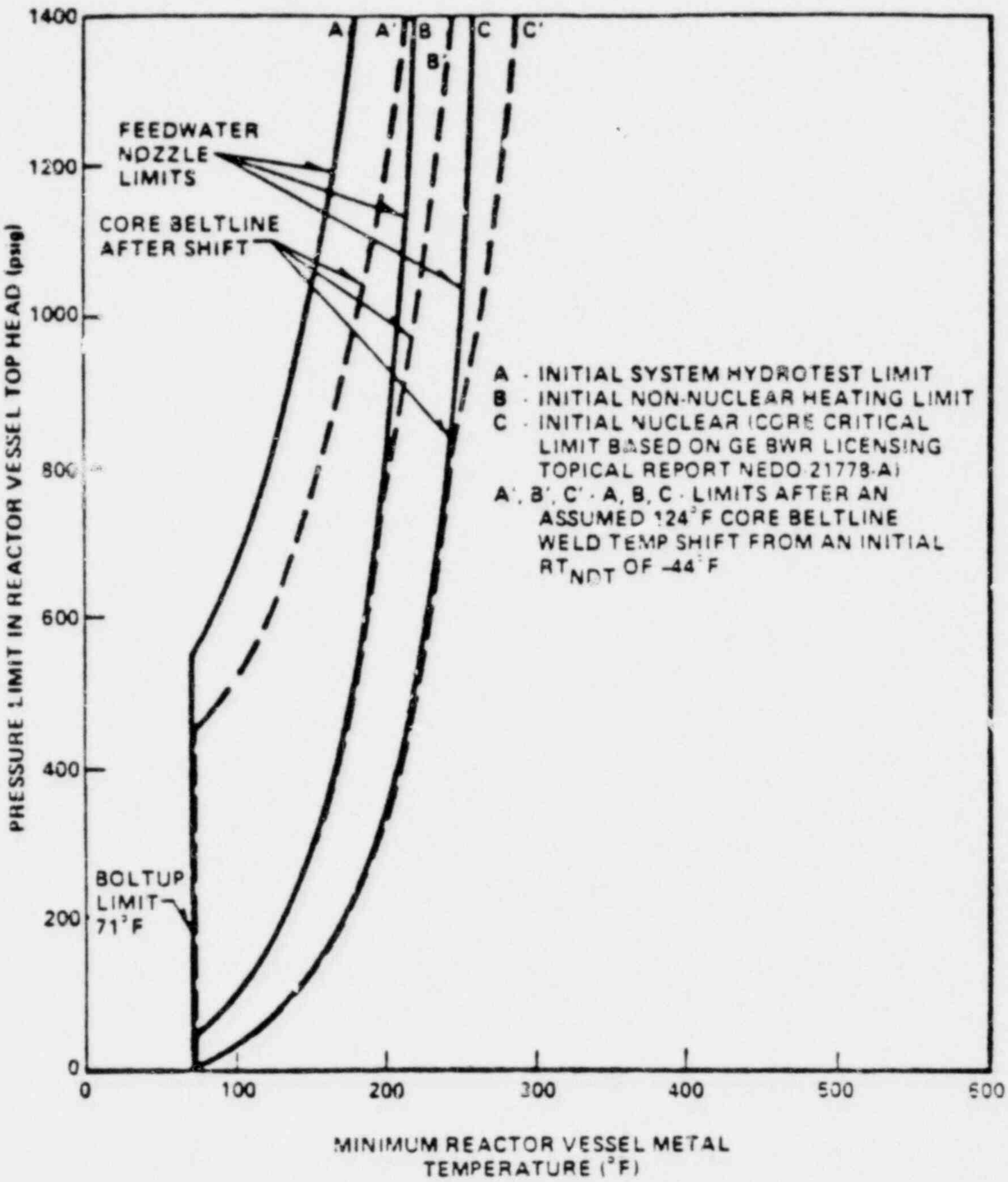
b. The second set will be withdrawn at 75 percent of the reactor service life.

c. The third set will be a standby.

5.2.4.5 Reactor Vessel Annealing

Inplace annealing of the reactor vessel because of radiation embrittlement is unnecessary because the predicted end-of-life value of adjusted reference temperature will not exceed 200°F (see 10 CFR Part 50, Appendix G, Paragraph IV.C).

ATTACHMENT A EF-2-FSAR



ENRICO FERMI ATOMIC POWER PLANT
UNIT 2
FINAL SAFETY ANALYSIS REPORT

FIGURE 5.2-1

MINIMUM TEMPERATURE REQUIRED VERSUS REACTOR PRESSURE