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AUTH.NAME AUTHOR AFFILIATION
BOUCHEY,G.D. Washington Public Power Supply System
RECIP.NAME RECIPIENT AFFILIATION
SCHWENCER,A. Office of Nuclear Reactor Regulation, Director

SUBJECT: Forwards evaluation of containment pressure boundary matl compliance w/GDC 51.Evaluation justifies revising NRC lowest svc metal temp values.

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Washington Public Power Supply System

P.O. Box 968 3000 George Washington Way Richland, Washington 99352 (509) 372-5000

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Docket No. 50-397

Director
Office of Nuclear Reactor Regulation
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555

Attention: Mr. A. Schwencer, Chief

Subject: NUCLEAR PROJECT NO. 2
GENERAL DESIGN CRITERION 51, CLARIFICATION

Reference: G02-82-551, G.D. Bouchey (SS) to A. Schwencer (NRC), Same Subject, dated June 21, 1982

The referenced letter provided the results of a Supply System evaluation for fracture toughness of containment pressure boundary components with respect to GDC 51. The evaluation developed Lowest Service Metal Temperature (LSMT) values for the most limiting pressure boundary components. Subsequently, the NRC informally provided more conservative LSMT values to replace those developed by the Supply System.

The Supply System has reviewed the LSMT values developed by the NRC and feels that further analysis (attached) justifies revising the NRC LSMT values.

To summarize, the attached analysis provides for:

- Actual material properties of the material used at WNP-2 to develop the technical basis for the evaluation. The NRC analysis utilized a metallurgical characterization based on fabrication and thermal history to establish a technical basis for the NRC evaluation and did not consider actual material properties.

- Yield stress, stress levels, and a through thickness flaw were used in the attached analysis. The NRC analysis did not consider specific stress levels or flaws of any type.

In conclusion. the attached analysis provides LSMT values from a more specific analysis than that provided by the NRC. These values represent actual LSMT values for WNP-2 and should be used in evaluating WNP-2 compliance to GDC 51.

B001

At your convenience the Supply System is prepared to meet with your staff, on site or at your offices, to discuss the attached analysis. If desired a site tour can be provided to review the installation of the components analyzed.

Very truly yours,

G. D. Bouchey
Manager, Nuclear Safety and Regulatory Programs

PLP/jca
Attachment

cc: R Auluck - NRC
WS Chin - BPA
J Halapatz - NRC
A Toth - NRC Site

ATTACHMENT

EVALUATION OF WNP-2 CONTAINMENT PRESSURE BOUNDARY MATERIALS - GDC-51

The CMTR's which were previously provided to the NRC were for the limiting materials used in the fabrication of the containment pressure boundary. These CMTR's were used to provide actual data needed to perform this evaluation. The data used was material type, component thickness, test temperature, yield strength (Code min.) and Charpy impact test data.

This current evaluation takes into account actual material properties, component thickness, flaw size (through thickness) loading rate and stress levels to develop a temperature above the nil ductility temperature (NDT) to provide crack arrest.

In comparison, the general analysis used estimated NDT temperatures from a statistical distribution of toughness properties for a particular material type and also a temperature correction factor was added to compensate for component thickness. This type of analysis is used to prevent brittle failure in components where impact test data is not available or required by Code.

This current evaluation reflects more realistically the material properties of WNP-2's containment pressure boundary and the materials's ability to withstand lower service temperatures than those determined by the general analysis.

The procedure used in calculating the LSMT was developed by using the information available in the following references:

- NUREG/CR-1815 UCRL-53013 RT
  "Recommendations for Protecting Against Failure by Brittle Fracture in Ferritic Steel Shipping Containers up to Four Inches Thick"
  August, 1981
  W. R. Holman, R. T. Langland

- "Manual of Engineering Procedures for Fracture-Safe Design"
  Association of American Railroads, Chicago, IL, AAR Report R 451
  November, 1980
  W. S. Pellini

This evaluation is conservative due to the assumption of dymanic loading conditions (loading occurs in a period < 1 second) developing total stresses equal to the yield strength of the material.

All data accumulated or developed during this evaluation is provided in Table 1.

Procedure

Impact data was compiled for all the limiting materials used in the fabrication of WNP-2 containment. The Charpy values (CVN) for each material used were then averaged. The dynamic stress intensity factor K_{Id} was then calculated using the following equation:

$$K_{Id}^2 = 5(CVN)E$$

$$E = 30 \times 10^6 \text{ psi}$$

This condition was performed for each component.

After obtaining the K_{Id} values, each value was compared to the K_{Id} Design-reference curve (Figure 1) to determine the NDT temperature relative to the test temperature of the impact specimens. This reference curve is the lower bound K_{Id} values for low and intermediate strength steels. (Figure 2 provides a comparison of the K_{Id} reference curve to the ASME Code K_{IR} curve.)

NDT temperature was then determined by adding the difference between the NDT on the reference curve and the location of the calculated K_{Id} value from the specimen test temperature for each component.

The plain strain limit (L) and yield-criterion (YC) were then calculated using the following equations:

$$\text{L Value} \quad K_{Id} = \left(\frac{B\,(\sigma_{yd})^2}{2.5} \right)^{1/2}$$

$$\text{YC Value} \quad K_{Id} = \left(B\,(\sigma_{yd})^2 \right)^{1/2}$$

B = thickness in inches
σ_{yd} = σ_{ys} + 20 ksi (equation from AAR R-451)
σ_{ys} = Code Min. Yield Strength

These values were then referenced to the K_{Id} reference curve to determine the NDT+T value for both the L and YC value. These temperatures were plotted on a graph as the abscissa and stress levels as the ordinate (Figures 3-5). The stress levels are in increments of the yield stress level and L corresponds to 0.2 X yield stress level. A straight line was drawn between the two points corresponding to the L and YC values. This line forms an arrest-transition curve. The curve indicates the transition in stress required for propagation of through-thickness cracks. The area to the right of the line indicates that fracture propagation of a through-thickness crack is not possible. The minimum temperature above NDT required to provide fracture arrest of through-thickness cracks upon yield stress loading was then added to the NDT temperature previously determined from the K_{Id} reference curve to determine LSMT.

The Main Steam Isolation Valves LSMT were determined by the original analysis, which used the material information provided in NUREG-0577 and the temperature correction factor from Summer 1977 Addenda of the ASME Code. The reason for the use of this analysis method was that impact test data was not available for the valves (see Section 5.2.3.3.1 of WNP-2 FSAR).

Conclusion

This evaluation provides a more realistic LSMT for the limiting materials used in the containment pressure boundary at WNP-2 than the general analysis previously submitted to the NRC.

The LSMT determined by this analysis eliminates the probability of brittle fracture and the potential for rapidly propagating cracks during all conditions specified in GDC-51. The limiting condition effecting WNP-2 will be hydrostatic testing at which time the test temperature will not be lower than LSMT.

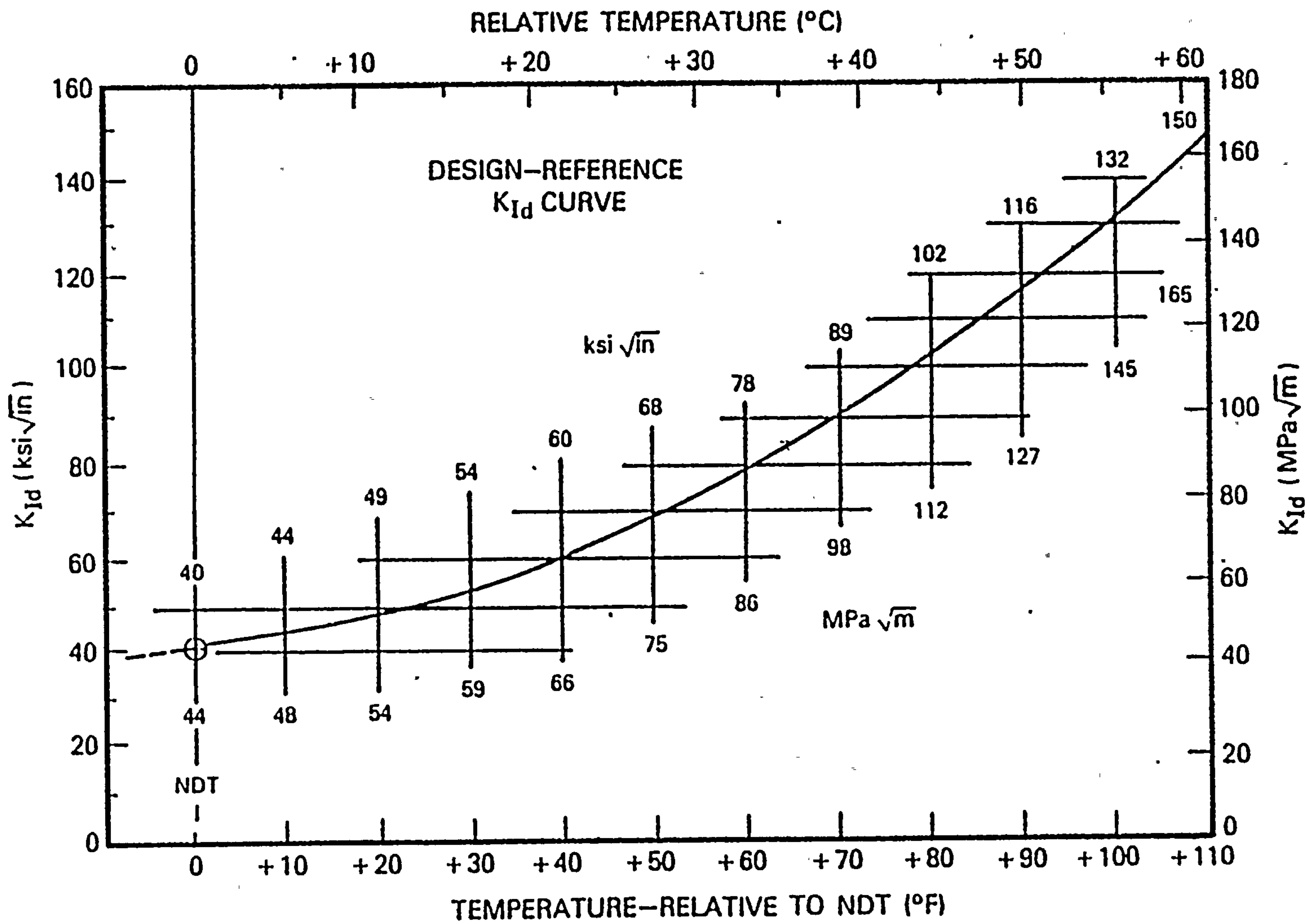

FIGURE 1 DESIGN-REFERENCE K_{Id} CURVE.

822194-2A

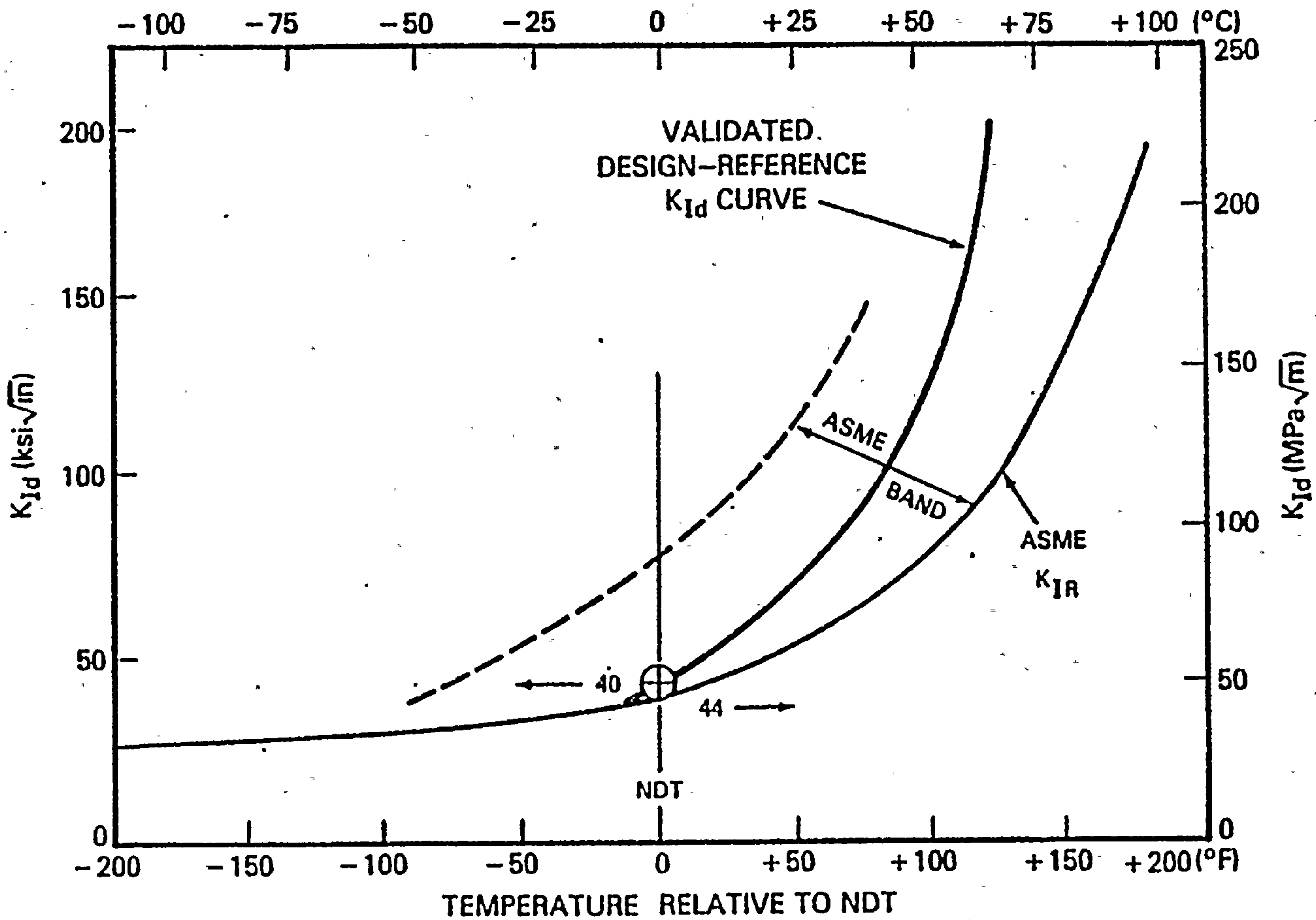

FIGURE 2 RELATION OF THE DESIGN-REFERENCE K_{Id} CURVE TO THE ASME CODE K_{IR} CURVE.

822194-1A

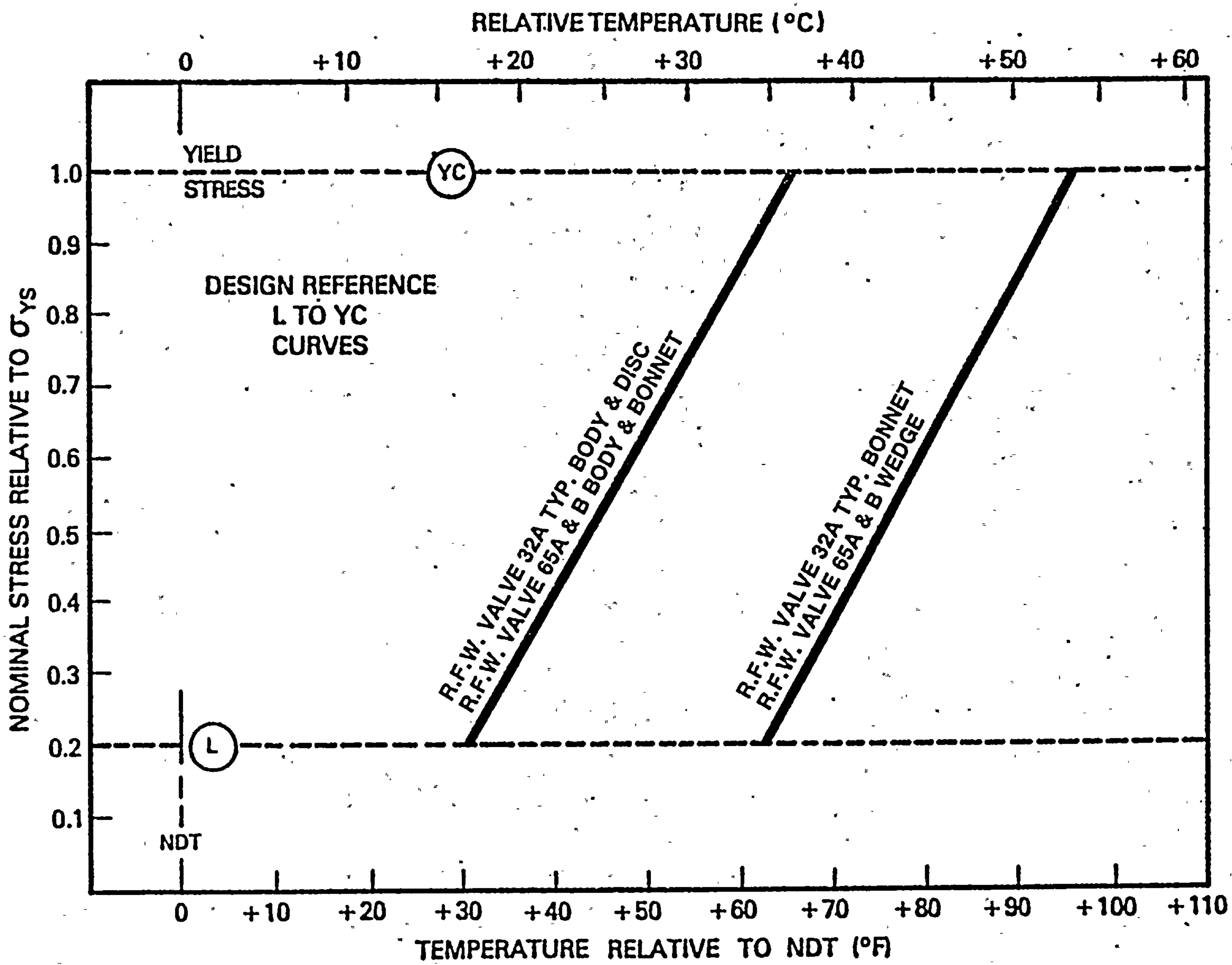

FIGURE 3

822194-4A

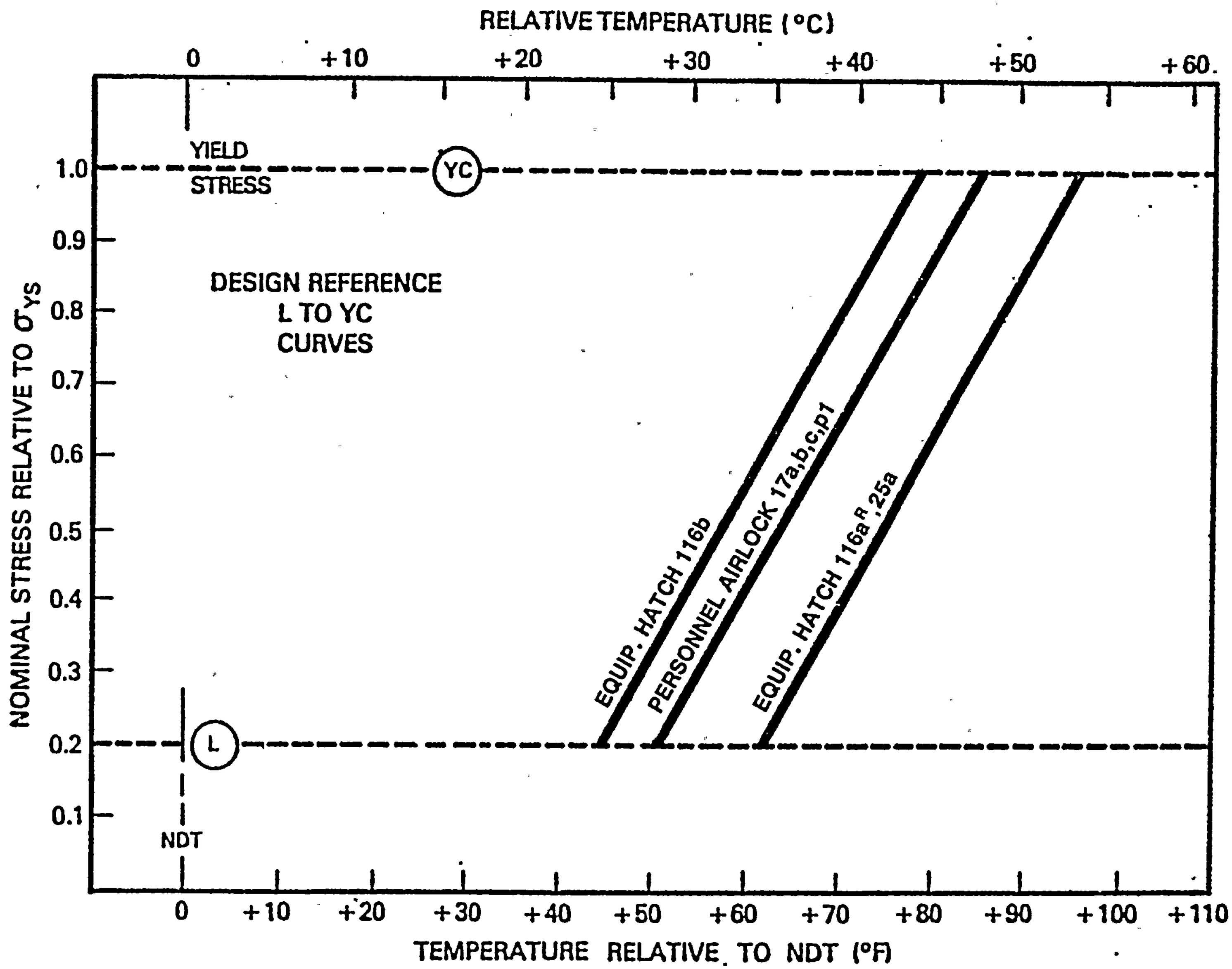

FIGURE 4

822194-5A

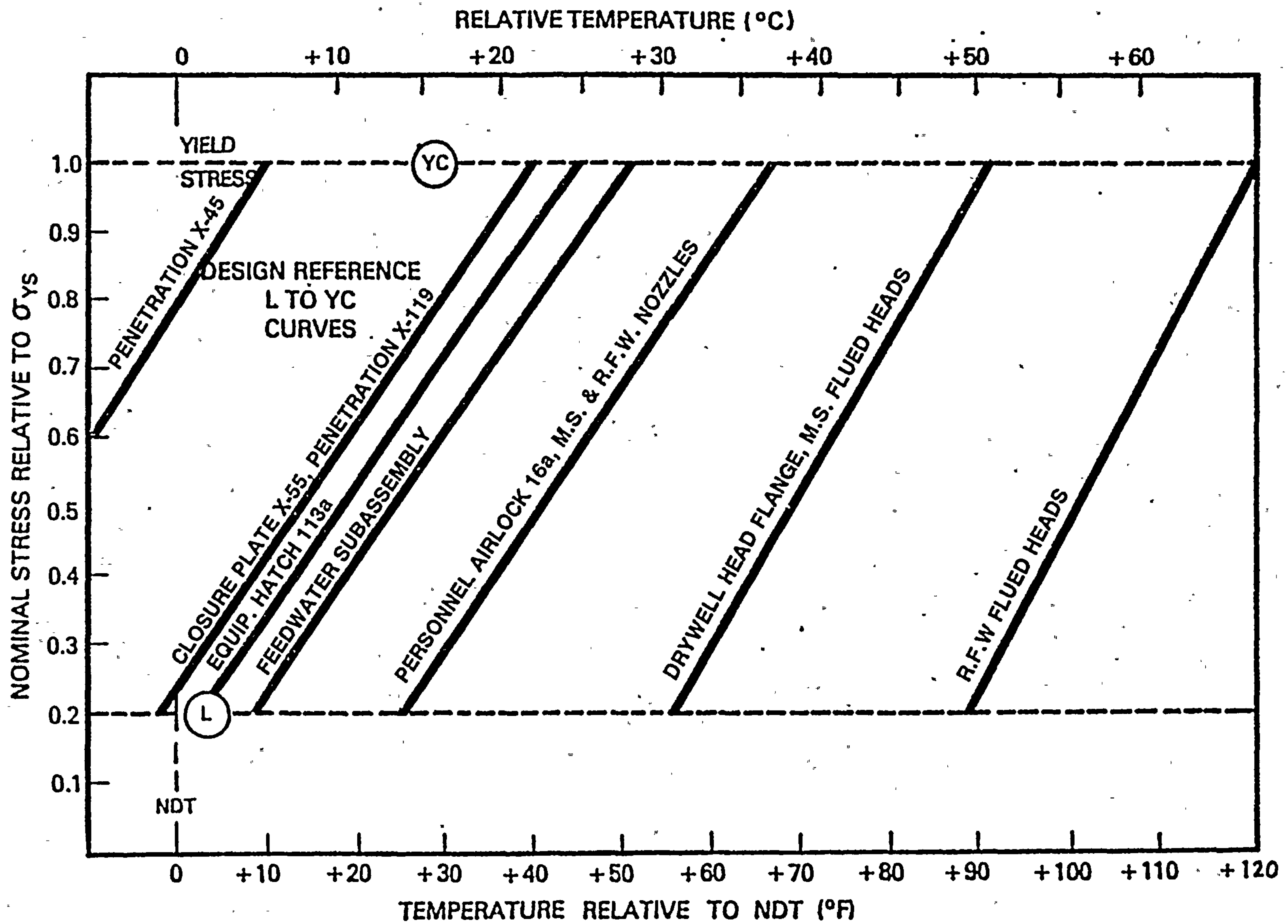

FIGURE 5

822194-3A

TABLE I

Component	Material	Thickness	Tensile Code Min.	Yield Code Min.	Test Temp.	Charpy Ft. lb.	Mil. Lat. expansion	% Shear	Calculated K_{Id}	NDT-from Calculated K_{Id}	L	YC	NDT + T at YC	LSMT
Feedwater Valve 65A-body	SA-352 LCB-70 Normalized	2.4"	65-95 ksi	35 ksi	−28°F	32,24,26 27.3 Ave.	NA	NA	64.0	−73°F	53.8	85.2	65°F	−8°F
Feedwater Valve 65B-body	SA-352 LCB-70 Normalized	2.4"	65-95 ksi	35 ksi	−28°F	24,24,25 24.3 Ave.	NA	NA	60.4	−68°F	53.8	85.2	65°F	−3°F
Feedwater Valves 65A&B-Wedge	SA-352 LCB-70 Normalized, Tempered	5.125"	65-95 ksi	36 ksi	−28°F	34,32,32 32.6 Ave.	NA	NA	69.9	−78°F	80.2	126.7	95°	17°F
Feedwater Valves 65A&B Bonnet	SA-350 LF2-74 Quenched & Tempered	2.4"	70-95 ksi	36 ksi	−28°F	18,24,21 21. Ave.	58,50,52	NA	56.1	−63°F	54.8	86.7	65°F	2°F
Feedwater Valve 32A-Typ-Body	SA-216 WCB Norm., Quench & Temp	2.28"	70-95 ksi	36 ksi	−20°F	68,54,53 58.3 Ave.	54,45,45	85,80,80	93.5	−50°F	53.4	84.5	65°F	15°F
Feedwater Valve 32A Typ-Disc	SA-352 LCB Normalize & Tempered	2.28"	65-95 ksi	35 ksi	+35°F	35,35,34 34.6 Ave.	39,41,39	45,45,45	72.1	−15°F	52.5	83.0	65°F	50°F
Feedwater Valve 32A Typ-Bonnet	SA-516 Gr.70 Normalized	4.93"	70-90 ksi	38 ksi	+28°F	82,81,78 80.3 Ave.	69,72,68	70,70,70	109.7	−57°F	81.4	128.7	95°F	38°F
Equipment Hatch Pc. Mk 116aR	SA-537 Gr. B Quenched & Tempered	2.5"	80-100 ksi	60 ksi	−30°F	30,25,42 32.3 Ave.	21,18,28	33,32,28	69.6	−80°F	80.0	126.5	95°F	15°F
Equipment Hatch Pc. Mk. 116b	SA-516 Gr. 70 Quenched & Tempered	3.0"	70-90 ksi	38 ksi	−25°F	45,51,50 48.6 Ave.	29,32,33	47,47,43	85.4	−90°F	63.5	100.5	78°F	−12°F
Equipment Hatch Pc. Mk. 113a	SA-516 Gr. 70 Normalized	1.25"	70-90 ksi	38 ksi	−30°F	28,24, 21 24.3 Ave.	19,16,14	33,23,33	60.4	−70°F	41.0	64.8	45°F	−25°F
Personnel Airlock Pc. Mk. 17a,b,c,pl	SA-516 Gr. 70 Quenched & Tempered	3.5"	70-90 ksi	38 ksi	−25°F	28,34,40 34 Ave.	22,24,34	47,37,47	71.4	−75°F	68.6	108.5	85°F	10°F
Personnel Airlock Pc Mk. 169	SA-516 Gr. 70 Normalized	2"	70-90 ksi	38 ksi	−30°F	25,31,27 27.6 Ave.	32,31,29	33,33,30	64.3	−75°F	51.8	82.0	65°F	−10°F
Personnel Airlock Pc. Mk. 25a	SA-537 Gr. B Quenched & Tempered	2.5"	80-100 ksi	60 ksi	−30°F	28,28,35 30.3 Ave.	21,19,25	47,47,47	67.4	−80°F	80.0	126.5	95°F	15°F
Drywell Head flange	SA-516 Gr. 70 Normalized	4"	70-90 ksi	38 ksi	−30°F	32,38,16 28.6 Ave.	42,43,41	NA	65.5	−75°F	73.3	116.0	90°F	15°F
Main Steam Flued Head	SA-105 Gr. II	4.5"	70 ksi	36 ksi	0°F	50,35,50 45 Ave.	40,33,40	20,30,30	82.1	−65°F	75.1	118.0	90°F	25°F
Feedwater Flued Head 17A	SA-350 Gr. LF2 Quenched & Tempered	10"	70-95 ksi	36 ksi	−30°F	43,32,42,51,54,61 47.3 Ave.	43,36,44,51,56,65	27,22,25,35,25,30	84.2	−95°F	112	177	120°F	25°F
Feedwater Flued Head 17B	SA-350 Gr. LF2 Quenched & Tempered	10"	70-95 ksi	36 ksi	−30°F	34 67,56,52,53,46 57.6 Ave.	51,65,63,62,57,67	25,25,27,26,25,27	93	−100°F	112	177	120°F	20°F
Main Steam Nozzles	SA-155 KCF 70 Normalized	2"	70-90 ksi	38 ksi	−30°F	37,34,42 37.6 Ave.	50,50,50	36,35,30	75.1	−85°F	51.8	82.0	65°F	−20°F
Feedwater Nozzles	SA-155 KCF70 Normalized	2"	70-90 ksi	38 ksi	−30°F	29,32,30 30.3 Ave.	26,28,26	10,10,10	67.4	−80°F	51.8	82.0	65°F	−15°F
Penetration X-55 closure plate	SA-516 Gr. 70 Normalized	1"	70-90 ksi	38 ksi	−30°F	20,37,24 27.0 Ave.	22,32,23	42,45,31	63.6	−75°F	36.6	58.0	40°F	−35°F
Penetration X-119	SA-333 Gr. 6	1.219"	60 ksi	35 ksi	−50°F	60,34,38 44.0 Ave.	53,33,32	15,10,10	81.2	−110°F	38.4	60.7	40°F	−70°F
Penetration X-45	SA-333 Gr. 1	.844"	55 ksi	30 ksi	−50°F	90,98,70 86.0 Ave.	79,81,75	40,40,40	113.5	−140°F	29.0	45.9	10°F	−130°F
Feedwater Subassembly	SA-106 Gr. B Normalized	1.812"	48 ksi	30 ksi	32°F	55,47,46 49.3 Ave.	52,44,41	54,51,51	86.0	−28°F	42.5	67.3	50°F	22°F
Main Steam Valve 28A Typ-body	SA-216 WCB Norm., Quench & Temp	1.58"	70-95 ksi	36 ksi										60°F
Main Steam Valve 28A Typ-Bonnet	SA-105 Gr. II Normalized & Tempered	7.68"	70 ksi	36 ksi										65°F
Main Steam Valve 28A Typ-Disc	SA-182 Gr. F11 Normalized & Tempered	5.5"	70 ksi	40 ksi										25°F
Main Steam Valve 28A Typ-Sten	SA-182 Gr. F11	1.56"	70 ksi	40 ksi										25°F
Drywell Head Flange Bolts	SA-320 Gr. L43													NA
Drywell Head Flange Nuts	SA-194 Gr. 7													NA
M.S. and F.W. Bolts and Nuts	SA-193 Gr. B7 SA-1942 SA-194 Gr. 7													NA

USING INITIAL NUREG 0577 AND SUBSECTION NC ANALYSIS (Main Steam Valve 28A rows)

NUREG 0577
LEAST SUSCEPTIBLE TO BRITTLE FRACTURE (Drywell Head Flange Bolts, Nuts; M.S. and F.W. Bolts and Nuts)

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