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HOLYOKE WATER POWER COMPANY
NORTHEAST UTILITIES SERVICE COMPANY
NORTHEAST NUCLEAR ENERGY COMPANY

General Offices • Selden Street, Berlin, Connecticut

P.O. BOX 270
HARTFORD, CONNECTICUT 06141-0270
(203) 666-6911

June 8, 1984

Docket No. 50-423
B11216

Director of Nuclear Reactor Regulation
Attn: Mr. B. J. Youngblood, Chief
Licensing Branch No. 1
Division of Licensing
U. S. Nuclear Regulatory Commission
Washington, DC 20555

Dear Mr. Youngblood:

Millstone Nuclear Power Station, Unit No. 3
Request for Acceptance of a New Code Case and a Revised Code Case

Northeast Nuclear Energy Company had been resolving items identified as unresolved items by NRC Region I in URI 820805[1] and reviewed in URI 820810. NNECO requested the ASME Boiler and Pressure Vessel Code Committee to accept proposed Code Cases to resolve these items as follows:

Item 1

A revision was requested to Code Case N-249 to permit the use of AISI 4330V modified low alloy steel as ASTM A-668, Class M. Code Case N-249 has been revised by adding Note 44 accepting AISI 4330V modified low alloy steel to ASTM A-668, Class M. The ASME B&PV Main Committee approved this at the January 13, 1984, meeting. We await the published version of cc N-249-4.

Item 2

URI 820805 (see also 820810) is resolved by a technical report, The Effect of Carbon Content on the Need to Postweld Heat ASTM A-487, Class 10Q Material (Attachment 1) which was prepared and submitted for review. This report shows the acceptability of this material with carbon content up to 0.27 percent which has been weld repaired without postweld heat treatment. The ASME Subcommittee on Nuclear Power, SC III has approved the proposed Code Case (see attachments) on April 26, 1984; the ASME B&PV Main Committee also approved it, April 27, 1984, and subsequently assigned N-407 the Code Case Number.

Acknowledgement of your acceptance of these Code Cases (N-407 and N-249-4) will facillitate system hydro testing and our final in-service dates.

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(1) a. URI 820805 - Weld Repair Castings, ASTM A487-Class 10Q, without PWHT.
b. URI 820810 - Supplementary data for URI 820805.

B001
1/1

If you have any questions, please contact our licensing representative directly. If required, a meeting can be arranged to discuss these items.

Very truly yours,

NORTHEAST NUCLEAR ENERGY COMPANY

W. G. Counsil
Senior Vice President

By: C. F. Sears
Vice President

ATTACHMENT I

12179-J(B)-131

The Effect of Carbon Content on the Need to Postweld Heat Treated ASTM A 487 Class 10Q Material

Prepared for Northeast Utilities Service Co.
Millstone Nuclear Power Station, Unit 3

by

M. Banic, L. P. Earvolino and I. Sprung

Approved by ____________ Project Engineer ____________ Division Head

____________ Engineering Management

STONE & WEBSTER ENGINEERING CORPORATION

Boston, MA 02107

ACKNOWLEDGEMENTS

The authors wish to thank Messrs. R. M. Hanschka, M. Kupinski, and R. Lefebvre of Northeast Utilities Service Company and Messrs. S. Ibrahim and C. H. Hall of Stone & Webster Engineering Corporation (SWEC) for many helpful discussions during the experimental phase of the investigation and for their comments on the content of this report.

The authors also acknowledge the experimental assistance of Messrs. H. M. Aznoian, E. Watters, and R. Marquis of SWEC Materials Laboratory.

SUMMARY

Code Case N71-11, an adjunct of ASME III NF, mandates that ASTM A 487 Class 10Q castings must be postweld heat treated after any welding when the carbon content exceeds 0.23 percent, regardless of the material thickness. The purpose of the test program was to determine whether postweld heat treatment of this material containing up to 0.27 percent carbon should be mandatory.

Although postweld heat treatment has several effects on weldments, it was determined that the primary concern in this case is heat-affected zone toughness. Therefore, the study was programmed to evaluate heat-affected zone toughness of 0.23 percent and 0.27 percent carbon material, respectively. Toughness was measured by the Charpy V-notch test.

The test results indicate that the toughness of the heat-affected zone was, in most cases, better than that of either the base metal or weld metal for carbon contents evaluated.

It was concluded that postweld heat treatment of ASTM A 487 Class 10Q castings containing up to and including 0.27 percent carbon is not required for producing acceptable microstructure and toughness in the heat-affected zone, provided a multipass weld technique is used.

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INTRODUCTION

Code Case N71-11 requires that welds made on ASTM A 487 Class 10Q material containing more than 0.23 percent carbon (C) be postweld heat treated (PWHT). Several castings fabricated from this material were weld repaired. The repaired castings, some of which contained between 0.24 and 0.27 percent C, were not PWHT because they had already been final machined. When the material is not PWHT, it is generally believed that an increase in carbon content results in a lower heat-affected zone (HAZ) toughness.

The thrust of this study was to compare the HAZ and the base metal toughness of as-welded ASTM A 487 Class 10Q material containing 0.23 and 0.27 percent C, respectively. Based on this comparison, it could be determined whether the absence of PWHT for the materials with greater than 0.23 percent C would be detrimental. The emphasis of the testing program was on fracture toughness measurements using the Charpy test.

SECTION 2

TECHNICAL ANALYSIS

2.1 BACKGROUND

2.1.1 Beneficial Effects of Postweld Heat Treatment

Postweld heat treatment (PWHT) performed at temperatures below the transformation temperature range is usually done to accomplish the following:

- Relieve welding residual stresses,
- Improve the microstructure and fracture toughness of the heat-affected zone (HAZ), and
- Remove hydrogen from the welded zone and thus prevent hydrogen cracking.

These effects of PWHT will be discussed as they relate to carbon and alloy content.

2.1.1.1 Residual Stresses

The magnitude and distribution of residual stresses depend mainly on the volume of the weld metal and strength of the material rather than on small variations of the base metal composition.

2.1.1.2 Improved Microstructure and Fracture Toughness in HAZ

The essential effect of PWHT on microstructure is to produce tempered HAZ. A tempered microstructure is preferred because its presence improves the mechanical properties, particularly fracture toughness.

The microstructure and the resulting mechanical properties of the HAZ depend on the chemical composition of the base metal and therefore, on carbon content.[1,2,3] The discussion below demonstrates that the relationship between chemistry and mechanical properties is not a simple one, however.

The maximum hardness of a heat-treated ferritic steel is dependent on its carbon content.[4]

The maximum hardness in the HAZ is realized in a narrow area only (near the fusion line), providing that 100 percent martensite is formed. The amount of martensite depends on the characteristics of the weld thermal cycle (cooling rate) and the chemical composition of the base metal. The effect of the chemical composition on the hardening capability of a steel is measured by its hardenability, which can be defined as the depth of hardness introduced by quenching. A measure of hardenability is the ideal critical diameter, D_I, which represents the diameter of a round bar that has 50 percent martensite at the center when quenched into an ideal quenching medium.

Most alloying elements increase the hardenability of ferritic steels. Alloy elements, including carbon, act synergistically. That is, the ideal diameter of an alloy steel is:

$$D_I = D_{I,C} \times D_{I,Mn} \times D_{I,Cr} \times \cdots$$

Factors $D_{I,C}$ etc. depend on the amount of each alloy element. If we assume that only the carbon content increased in one of the castings, then according to Grossman (Figure 90, pg. 122, for grain Size 4):

$$\frac{D_I\ (C = 0.27\%)}{D_I\ (C = 0.23\%)} = \frac{0.23}{0.21} = 1.1$$

In other words, an increase in carbon content from 0.23 to 0.27 percent would make such a steel more hardenable by about 10 percent.

Welding engineers often use the so-called "carbon equivalent (CE) parameter. A common way to express CE is as follows:

$$CE = \%C + \frac{\%Ni}{4} + \frac{\%Ni}{20} + \frac{\%Cr}{10} + \frac{\%Cu}{40} - \frac{\%Mo}{50} - \frac{\%V}{10}$$

The CE's for the two heats used in this study were 0.63 and 0.69 for the 0.23 percent C and the 0.27 percent C materials, respectively.

CE can be also used to describe hardenability, that is, the amount of martensite and its condition (degree of self tempering). As pointed out by Lorentz in the second edition of Stout and Doty's book, CE is essentially related to the martensite transformation temperature range. When that range is wider as a result of a higher martensite starting temperature (M_s), martensite formed at higher temperatures is self tempered. The Welding Institute has used this concept to predict HAZ toughness on the basis of steel composition and welding procedures. Fracture toughness of the HAZ in C-Mn steels has been related to CE and to heat input. As one would expect, the higher the CE, the lower the toughness in the HAZ. In Dolby's review paper on HAZ toughness, he concludes that such methods are[3] already proving valuable as a basis for the prediction of HAZ toughness.

The above shows that HAZ toughness can be affected not only by carbon content but also by an unfavorable overall chemical composition. Therefore, if PWHT is required to improve toughness of the HAZ, the criteria for such a requirement should be based on a formula similar to CE, rather than on carbon content alone. However, even if this approach is used, the resultant calculation would not define when PWHT is required unless the values are correlated to toughness properties as determined by testing.

2.1.1.3 Hydrogen Cracking

A higher carbon content in the base metal increases the susceptibility to hydrogen cracking in the HAZ. To minimize the possibility of hydrogen cracking, PWHT must be applied before the weldment cools below the preheat/interpass temperature. When the preheat temperature is maintained for a period of time after the weldment is completed, hydrogen will be removed to a degree sufficient to avoid cracking (see Code Case N71, para. 15.6). Furthermore, proper preheat/interpass temperatures and adequate electrode controls can effectively prevent hydrogen cracking.

2.1.2 Detrimental Effects of PWHT

Detrimental effects to low alloy steels may result from PWHT. Paragraph 7.1 of Code Case N71 warns: "Consideration should be given to the possibility of reheat cracking and deterioration of toughness properties during PWHT of susceptible materials." These two factors are covered extensively in the metallurgical literature.

According to Gray et al[6] if the factor P where

$$P = Cr + 3.3\,Mo + 8.1\,V - 2$$

exceeds zero, so-called reheat or stress relief cracking in the HAZ during PWHT is a possibility. Factor P for A 487 Class 10Q castings may be positive depending on the actual composition. However, it is not indicated that reheat cracking is a strong factor for ASTM A 487 Class 10Q material.

In general, Ni-Cr-Mo steels are sensitive to a loss of fracture toughness (temper embrittlement), when heated in the temperature range between approximately 1000°F and 700°F. To prevent temper embrittlement, cooling from PWHT temperature has to be rapid; however, fast cooling can cause excessive distortion and even cracking.

2.2 EXPERIMENTAL PROCEDURE

The above considerations showed that an increase in the carbon content might affect HAZ toughness of an as-welded A 487 Class 10Q alloy, while the other aspects of PWHT effects were not strongly related to the carbon content. Because data from the abailable literature were not adequate to resolve this question, SWEC initiated the following test program, with an emphasis on Charpy toughness testing of weldments containing different levels of carbon.

2.2.1 Material

2.2.1.1 Base Metal

Two heats of ASTM A 487 Class 10Q steel material containing 0.23 percent C and 0.27 percent C, Heat No. 47764 and Heat No. 60641, respectively, were selected for testing.

The 0.23 percent C steel was selected because it contains the maximum carbon content exempted from PWHT by Code Case N-71. The 0.27 percent C material was selected bacause it represents the maximum carbon content of the weld-repaired production castings.

Chemical composition of the two heats is given in Table 2-1.

TABLE 2.1

CHEMICAL COMPOSITION (Percent)

Heat No.	C	S	P	MN	Si	Cr	Ni	Mo	Cu	V	W
47764	.23	.004	.019	.90	.31	.83	1.94	.33	.14	.01	.02
60641	.27	.005	.011	.96	.36	.86	1.92	.31	.17	.01	.013
A487C1.10Q*	.30**	.045**	.04**	.6- 1.0	.80**	.35- .90	1.40- 2.00	.20- .40	.50**	.03**	.10**

*Chemical requirements of the ASTM specification
**Maximum content

Two pieces, 4 x 4 x 12 inches and 4 x 4 x 10 inches from Heat No. 47764 and three pieces, 2 3/4 (maximum thickness) x 6 x 8 inches from Heat No. 60641 were heat treated as follows:

Austenitized at 1800°F for 6 hours, air cool
Austenitized at 1700-1725°F for 4 to 6 hours, water quench
Tempered at 1100°F for 6 hours, air cool

In addition, the test coupons were stress relieved at 1075°F for 6 hours to simulate the PWHT performed by the casting manufacturer. Note: the weldments fabricated for this study did not receive PWHT.

Table 2-2 reports the tensile properties of the heat-treated materials.

TABLE 2-2

ROOM TEMPERATURE TENSILE PROPERTIES
(Base Metal)

Heat No.	YS (ksi)	UTS (ksi)	El (%)	RA (%)
47764(0.23% C)	129.6	138.7	13.5*	43.8
60641(0.27% C)	118.9	133.8	20.0	55.0
A 487 Cl.10Q**	100	125	15.0	35.0

*This value is below the 15 percent requirement of ASTM A 487 Class 10Q. Because the major concern of this study is HAZ toughness, the low elongation value is not relevant.

**Minimum tensile requirements of the ASTM specification.

2.2.1.2 Welding Electrode Material

The electrode welding material was E12018M, size 3/16 x 14 inches. The material satisfies the requirements of ASME Code Section II, Part C, SFA 5.5.

2.2.2 Welding Procedure

The weldments were made using the shielded metal arc process with the following parameters:

Current:	160-170 A
Voltage range:	24-25 V
Travel speed:	10-12 inches/minute
Preheat temperature:	300°F minimum
Interpass temperature:	375°F maximum

The sizes and types of weldments are shown in Figures 1 and 2.

2.2.3 Testing Procedure

2.2.3.1 Charpy Tests

The location, sizes, orientations, and number of Charpy specimens were in accordance with Subsection NF of ASME III.

2.2.3.2 Microhardness

Microhardness was measured for the base metal, weld metal and HAZ using the Knoop 500-gram test.

2.3 RESULTS

2.3.1 Charpy Tests

Figures 3 and 4 show the Charpy test results obtained on both welded samples.

2.3.2 Microhardness and Metallography

Two microhardness traverses were made across the weld metal, the HAZ and the base metal on each weldment. Results for the 0.23 percent C and the 0.27 percent C samples are shown in Figures 5 and 6, respectively. In both cases, the HAZ was harder than the base metal and the weld metal. The maximum hardness values in both HAZ were similar.

Metallographic examination of both welded samples revealed similar microstructures in the base metal, the weld metal and the HAZ, respectively.

2.4 DISCUSSION

2.4.1 Review of the Test Data Obtained in This Work

2.4.1.1 Fracture Toughness Tests

The following is an analysis of the data from the Charpy test based on a comparison of properties obtained in all three components of the weldment; i.e., the weld metal, the base metal, and the HAZ:

- o ASME Code evaluates HAZ toughness relative to base metal toughness by comparing the temperatures where the minimum toughness requirements are met (25 mils lateral expansion (MLE) or 35 ft-lb for this alloy in Subsection NF). To meet the requirement of NF 4335.2, the temperature difference is defined as:

$$\Delta T = \left[\begin{array}{l}\text{Temp. where HAZ} \\ \text{has 25 MLE or 35 ft-lbs}\end{array}\right] - \left[\begin{array}{l}\text{Temp. where base metal} \\ \text{has 25 MLE or 35 ft-lb}\end{array}\right]$$

must be zero or negative.

The T values for the 0.23 percent C sample and the 0.27 percent C sample are -24°F and -56°F, respectively at the 25 MLE level. (ΔT at the 35 ft-lb level is also negative.)

- o The data in Figures 3 and 4 show that average toughness of the base metal is somewhat better than that of the HAZ at room temperature. However, both are well above 25 MLE or 35 ft-lb. As the temperature decreases, the HAZ toughness is better than that of the base metal.

Figures 3 and 4 also show that the average HAZ toughness is better than that of the weld metal. This result, when combined with the result above, shows that the HAZ in these weldments has a resistance to brittle fracture superior to the other parts of the weldment.

- o The above results do not show a clear effect of carbon content on the HAZ toughness. When the steel with 0.23 percent C is compared with the 0.27 percent C heat, the ΔT for the latter is significantly better.

It is interesting to note that despite the CE being higher for the 0.27 percent C material than for the 0.23 percent C material the overall toughness is better for the former. This is not to be interpreted as higher carbon is better for toughness, but rather that HAZ toughness is dependent on other factors in addition to chemistry.

2.4.1.2 Microstructure and Microhardness

Metallographic examination of the base metals in both steels containing 0.23 and 0.27 percent C showed that microstructure consisted of fine-grained tempered martensite and some tempered bainite. No obvious differences were observed between the two steels.

The HAZ microstructure is more complex because of the temperature gradient across the zone and overlapping thermal effects of successive weld beads. However, the microstructure is generally fine-grained tempered martensite. Even in the areas near the fusion line where coarse grains might be expected, grain growth was not excessive.

Microhardness measurements showed that HAZ hardness exceeds hardness in the base metals (see Figures 5 and 6). The maximum hardness in both steels was about 420 Knoop units, which corresponds to 42 Rockwell C Units. This is below the maximum hardness that can be obtained by the carbon contents in these steels, showing that the HAZ was tempered by subsequent weld passes. The location of the maximum hardness in the HAZ varies. This is most likely because of the tempering effect of subsequent weld beads. The width of the HAZ shown in Figures 5 and 6 was estimated by optical microscopy. This method cannot precisely define the transition from the HAZ to the base metal, which is at least a partial explanation of the apparent differences in the HAZ width for traverses 1 and 2 in Figure 5.

2.4.2 Comparison with Literature Values

The results obtained in this work indicate that HAZ toughness is very good and generally better than toughness of the unaffected base metal. This apparently differs from the statements usually found in the literature. For example, Stout comments:

> The notch toughness of the coarse-grained heat-affected zone resulting from the welding thermal cycle may increase or decrease with more rapid cooling rates, depending principally on the carbon content of the steel. In steels of less than 0.15 percent C, rapid cooling is beneficial because it suppresses ferrite and favors lower-temperature-transformation products of higher toughness. In higher-carbon steels, the low-temperature products (bainite and martensite) are relatively brittle and reduce the notch toughness, if cooling is fast enough to induce their formation.

Savage and Owczarski reached a somewhat different conclusion. According to their 1966 paper, relatively brittle martensite is anticipated when the carbon content exceeds 0.25 percent.

Most of the literature pertaining to HAZ toughness discusses steels with carbon contents of less than approximately 0.23 percent. Only limited information was available on the HAZ toughness of the as-welded low-alloy steels with a medium carbon content. Alasvuo and Vihavainen conducted a study that can be directly related to this work. These authors studied the mechanical properties and the susceptibility to cold cracking of weldments made of a low carbon steel (0.05 percent C low-alloy cast steel). For comparison, they tested weldments made of C-Mn (0.22 percent C) and Cr-Mo (AISI 4140-0.39 percent C) cast steels. Charpy specimens were machined from the base metal and from the HAZ of single V-groove butt welds. The notch in the HAZ test was machined at the fusion line in the HAZ. Toughness at the fusion line was, in all the cases, better than that in the base metal.

The results of Alasvuo and Vihavainen's study and the results obtained from the experimental procedure used in this study suggest that the HAZ toughness of steels containing more than 0.23 percent C does not have to be low. This can be explained by the fact that in both cases multiple-pass welds were tested. Stout comments: "The heat-affected zones of multiple-pass welded joints will be altered by the refining and tempering effects of overpasses. The notch toughness may be improved compared to a single-pass weld (of the same heat input), even though maximum hardness may not be greatly reduced."

In addition to Stout's explanation mentioned above, note that the temperature at which martensite starts to form (Ms point) is rather high for ASTM A 487 Class 10Q steel. (Achtalik and Motz measured Ms temperature for a similar steel to be 660°F.) Therefore, the effect mentioned previously of self-tempering could produce good toughness in spite of a higher carbon content.

SECTION 3

CONCLUSIONS

Postweld heat treatment of ASTM A 487 Class 10Q castings containing up to and including 0.27 percent carbon is not required for the purpose of producing acceptable microstructure and toughness in the heat-affected zone, provided a multipass weld technique is used.

SECTION 4

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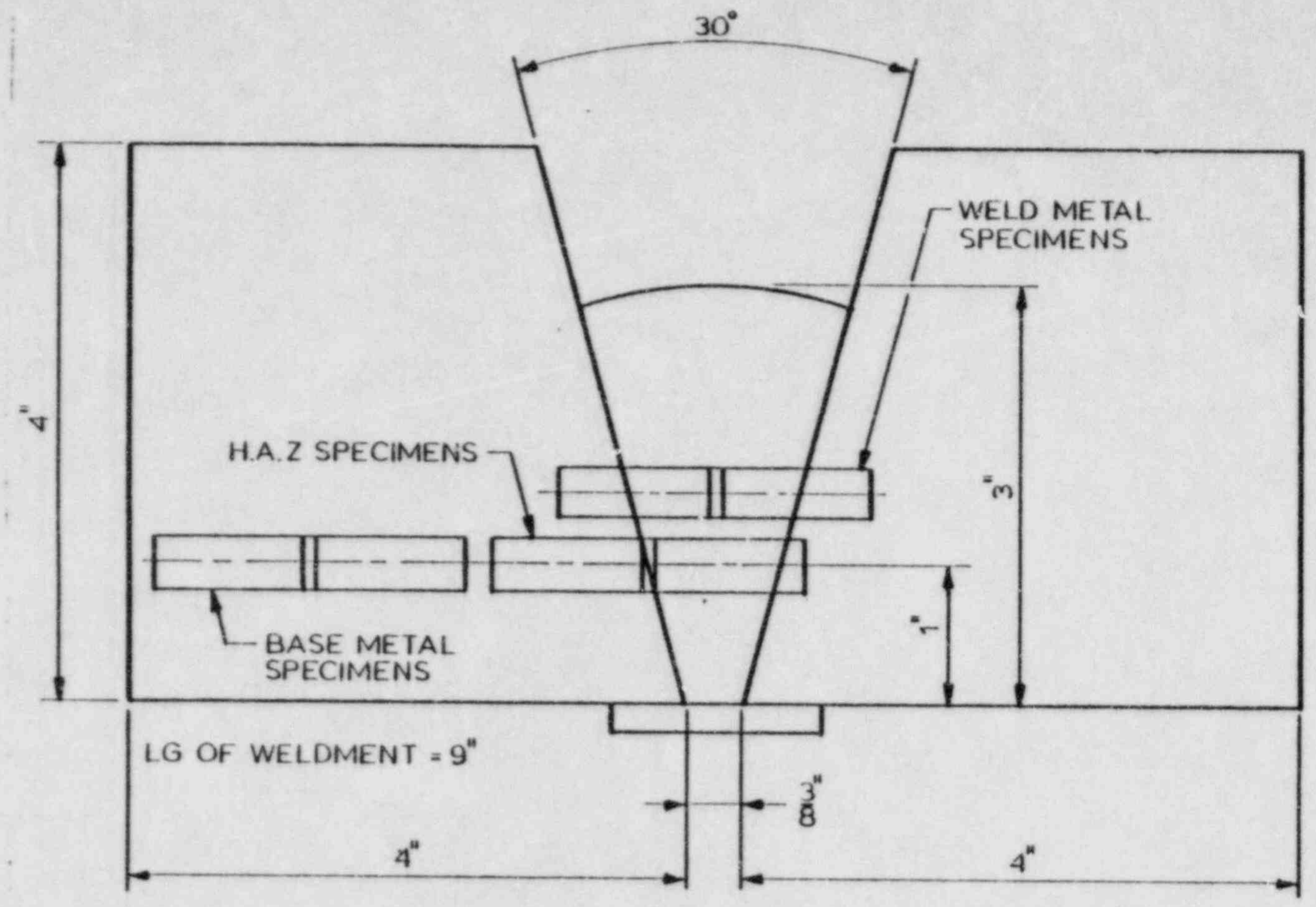

FIGURE 1
WELDMENT MADE OF HEAT
47764 (0.23 PERCENT C)
MILLSTONE NUCLEAR POWER STATION
UNIT 3

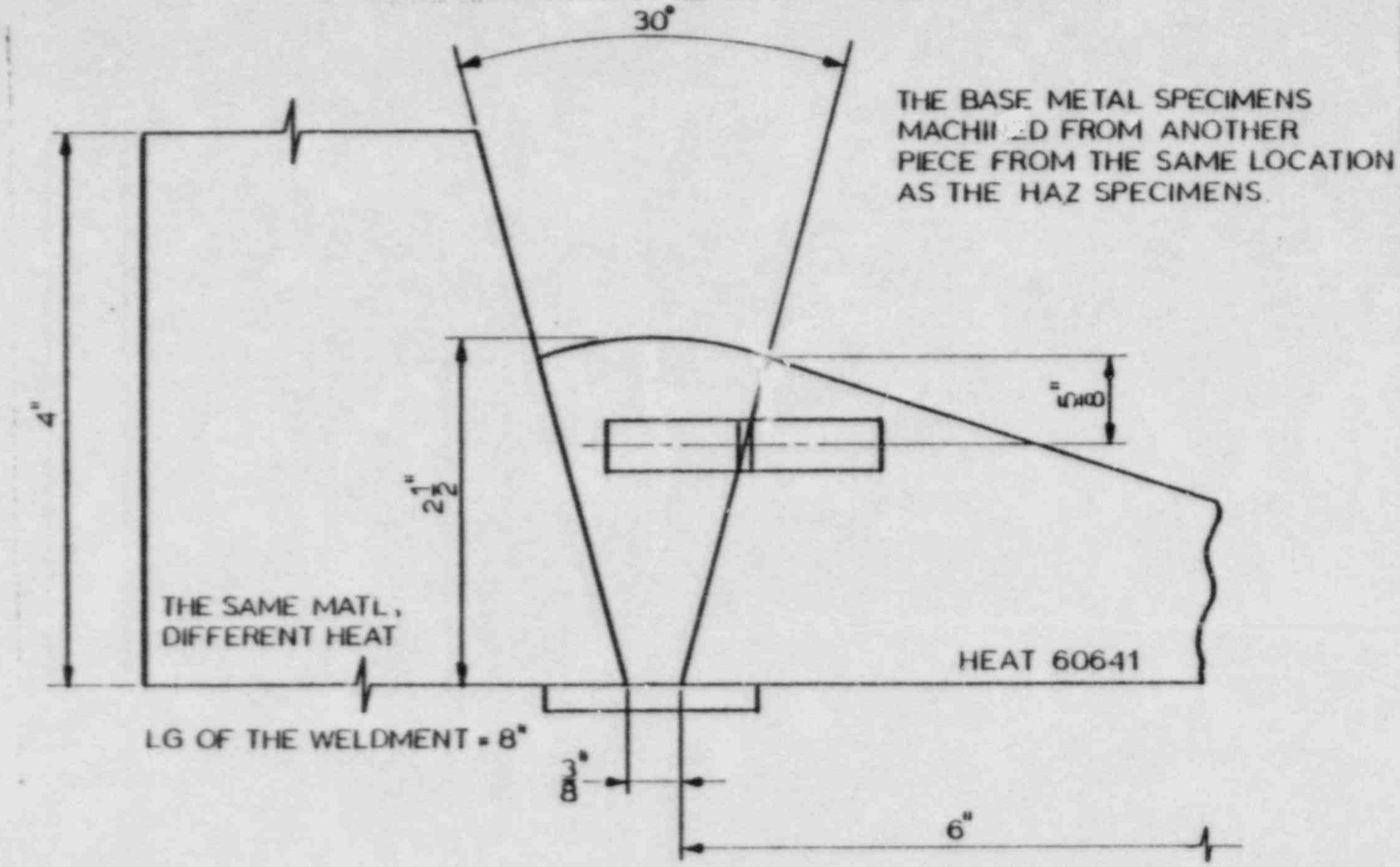

FIGURE 2
WELDMENT MADE OF HEAT 60641 (0.27 PERCENT C)
MILLSTONE NUCLEAR POWER STATION
UNIT 3

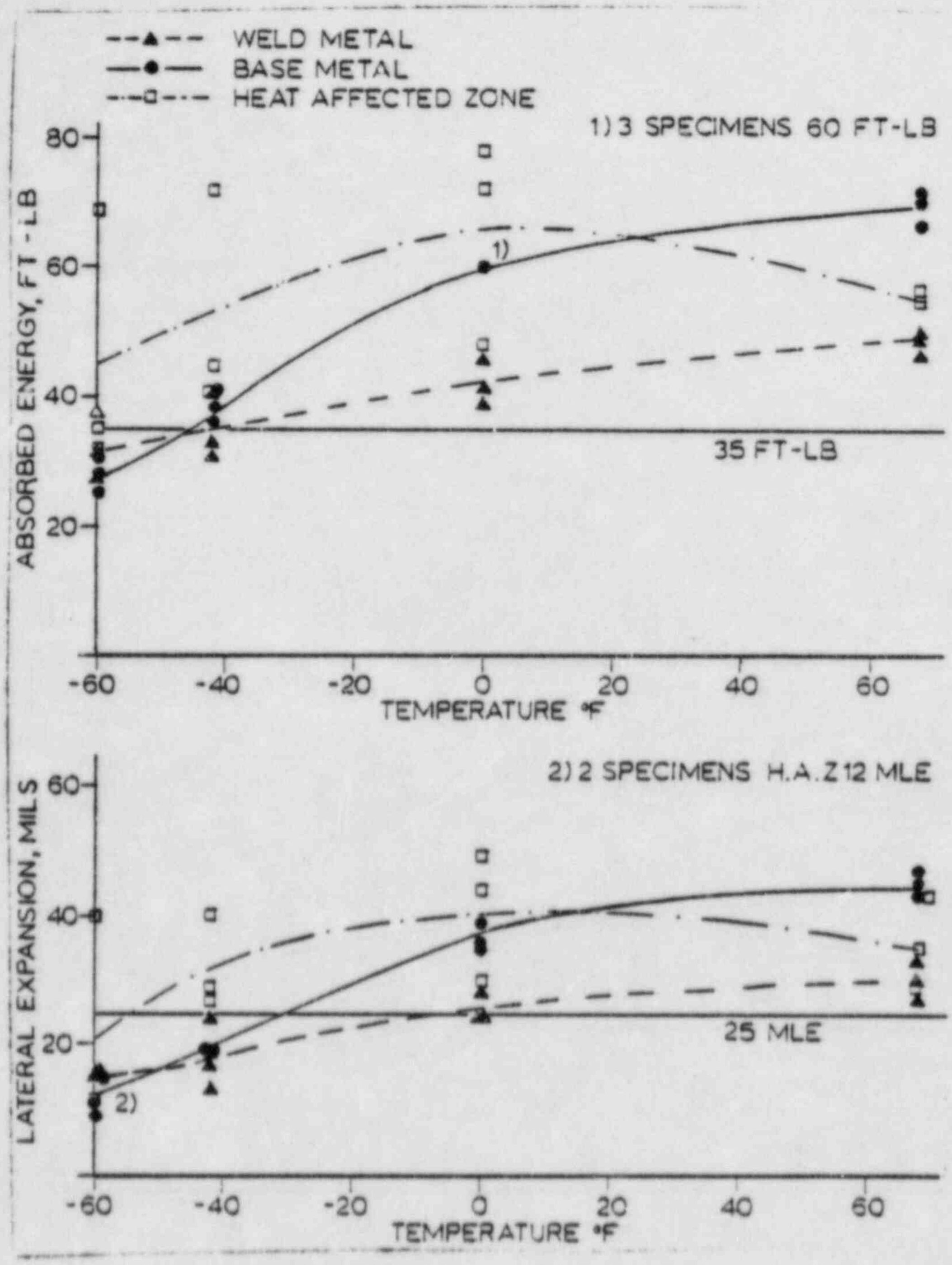

FIGURE 3
CHARPY TEST-HEAT
47764 (0.23 PERCENT C)
MILLSTONE NUCLEAR POWER STATION
UNIT 3

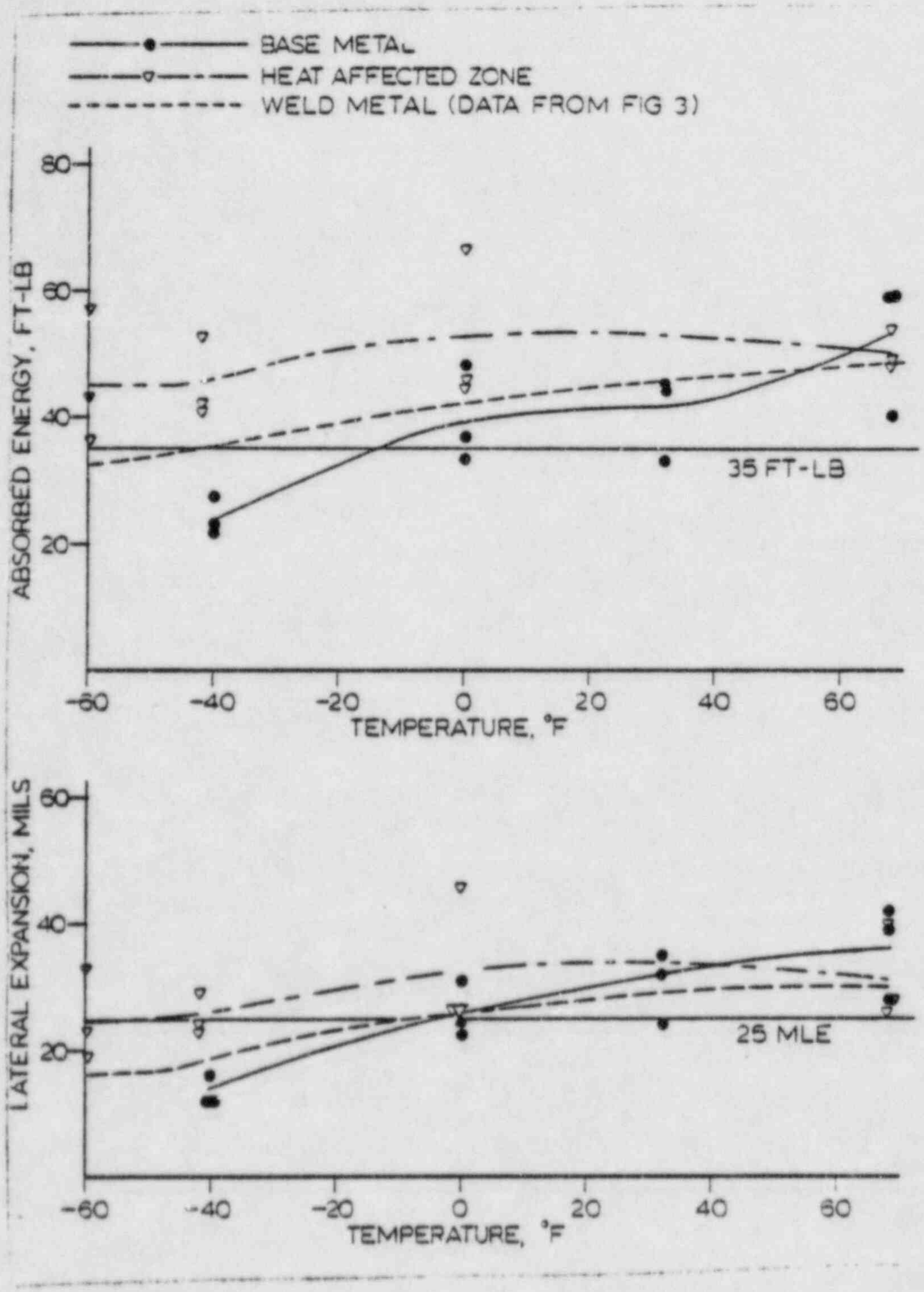

FIGURE 4
CHARPY TEST - HEAT
60641 (0.27 PERCENT C)
MILLSTONE NUCLEAR POWER STATION
UNIT 3

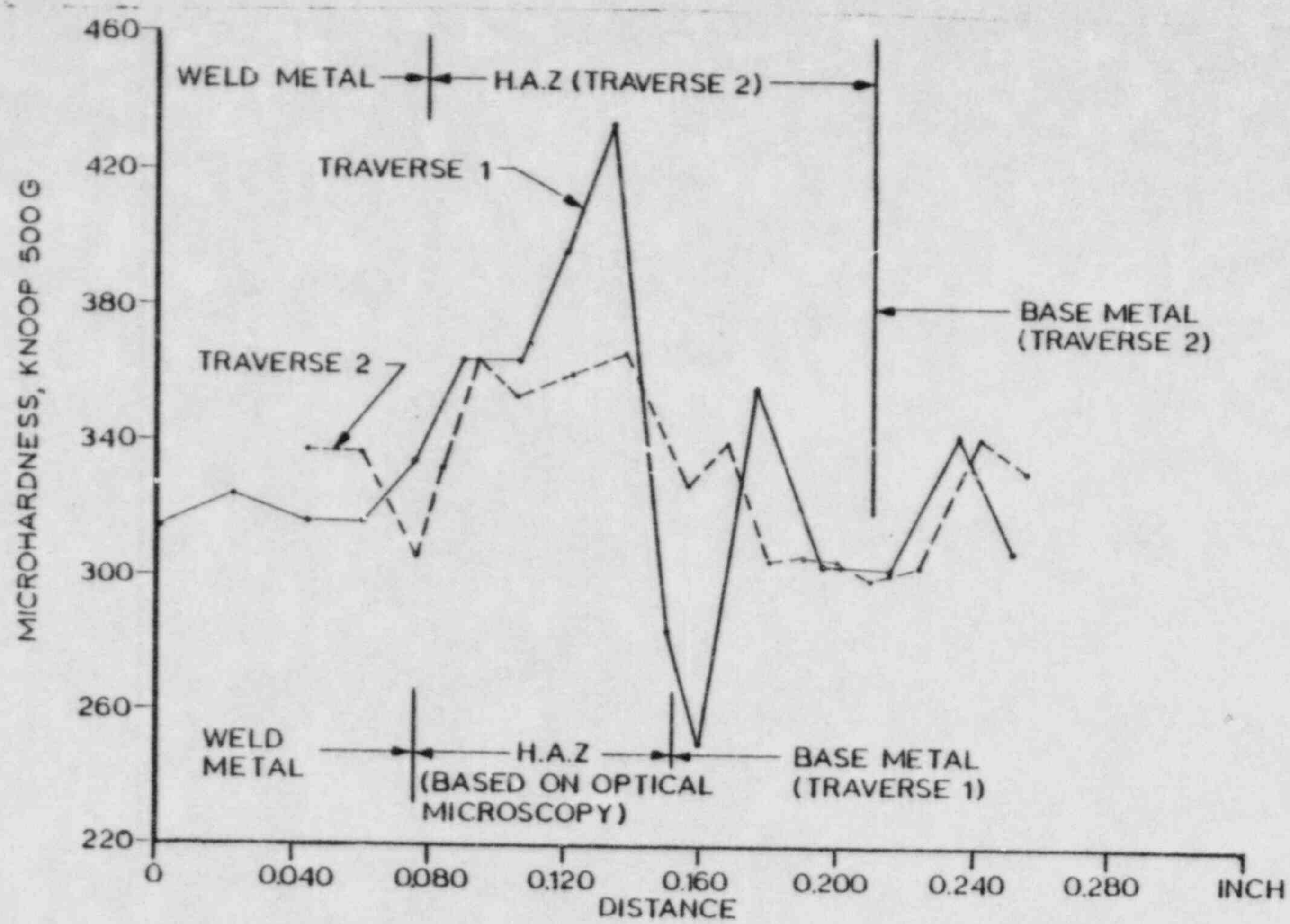

FIGURE 5
MICROHARDNESS - HEAT 4776-1
WELDMENT (0.23 PERCENT C)
MILLSTONE NUCLEAR POWER STATION
UNIT 3

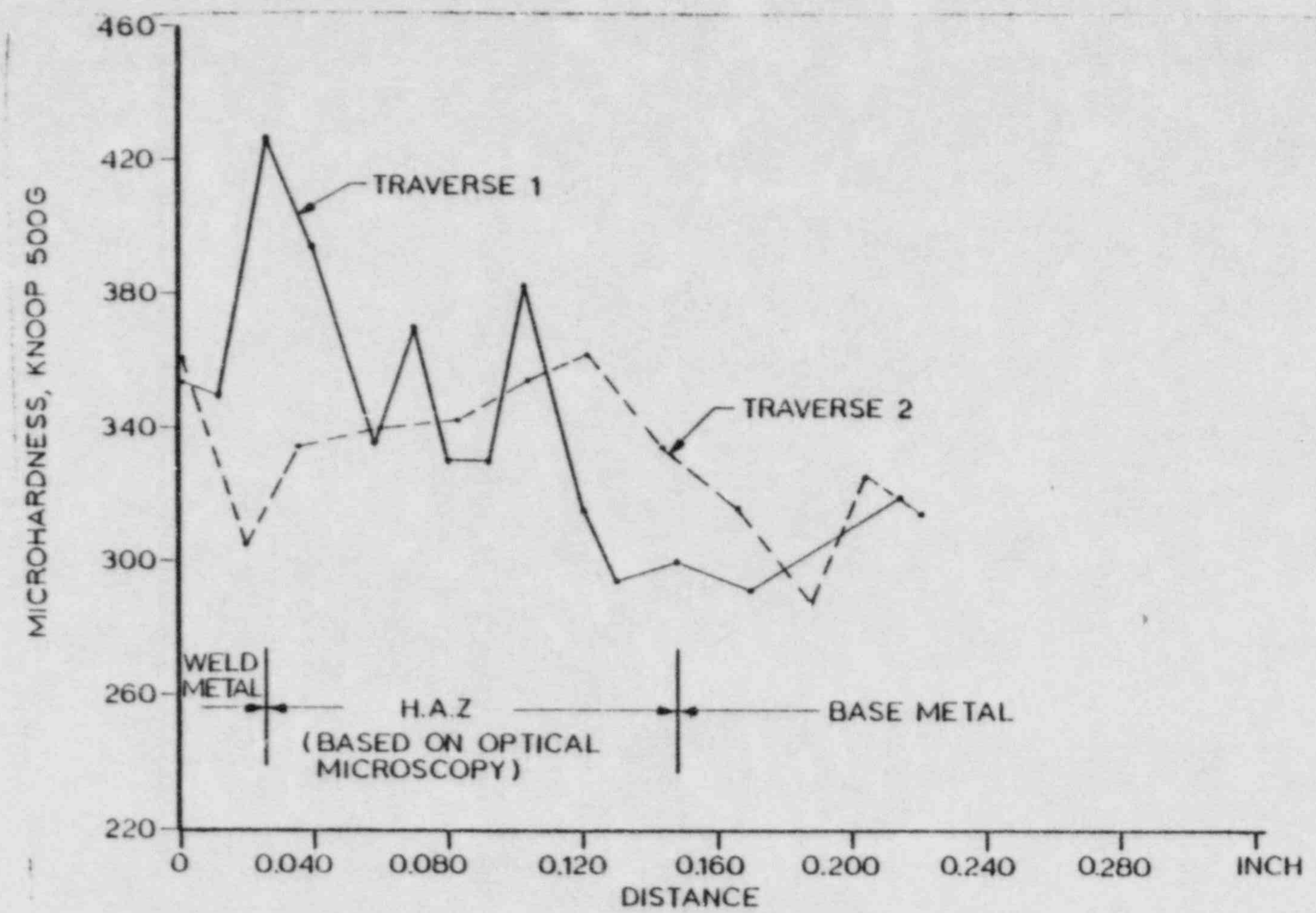

FIGURE 6
MICROHARDNESS-HEAT 60641
WELDMENT (0.27 PERCENT C)
MILLSTONE NUCLEAR POWER STATION
UNIT 3

ATTACHMENT II

CODE CASE N-407

Limited Weld Repair of A487, Class 10Q Steel Castings Without Post-Weld Heat Treatment.

ASME III, Division 1, Subsection NF, Class 1, 2, 3, and MC Component Supports.

INQUIRY

Is it permissible to use, for Section III, Division 1, Class 1, 2, 3, and MC Component Supports, steel castings which meet Specification ASTM A487, Class 10Q, with 0.27 percent maximum carbon content and weld-repaired without post weld heat treatment?

REPLY

It is the opinion of the Committee that ASTM A487, Class 10Q, steel castings as specified in the inquiry, may be used and weld-repaired without post-weld heat treatment provided the following requirements are met:

1. Base Material

1.1 Chemistry and mechanical properties shall conform to ASTM A487, Class 10Q, except that carbon shall not exceed 0.27 percent and sulfur shall not exceed 0.020 percent.

2. Welding Qualifications

2.1 Welding procedure, welder, and welding operator qualifications shall be made in accordance with Section III and Section IX and as given herein. Separate welding procedure and performance qualifications are required for this material.

3. The following, in addition to the essential variables in Section IX, QW-250, shall be considered as essential variables requiring requalification of the welding procedure.

3.1 A change in the filler metal SFA classification.

3.2 A decrease in the minimum qualified preheat temperature or an increase in the maximum qualified interpass temperature. The specified range of preheat to interpass temperature shall not exceed 150°F (83.3°C).

3.3 A change in the type of current (ac/dc) or polarity, or a change in the specified range for amperage.

3.4 Electrodes shall conform to the requirements of SFA 5.5 Specification for Low-Alloy Steel Covered Arc Welding Electrodes. Only low hydrogen electrodes shall be used. Electrodes shall be purchased in hermetically-sealed containers or shall be dried at least 1 hour at temperatures between 700°F (370°C) and 800°F (430°C) before being used. Electrodes shall be dried prior to use if the hermetically sealed container shows evidence of damage. Immediately after the opening of the hermetically sealed container or removal of the electrodes from drying ovens, electrodes shall be stored in ovens held at a temperature of at least 250°F (120°C). Electrodes that are not used within 1/2 hour after the opening of the hermetically sealed container or removal of the electrodes from a drying or storage oven shall be dried before use unless evidence is presented to and accepted by the Authorized Nuclear Inspector which indicates that the brand of electrode used may be exposed for longer periods of time without exceeding the moisture requirements of SFA 5.5.

4. Preheat

4.1 A minimum preheat temperature of 100°F (40°C) is required for thickness up to and including 1/2 in. (13 mm). A minimum preheat temperature of 200°F (90°C) is required for thicknesses above 1/2 in. (13 mm) up to and including 1 1/2 in. (38 mm). A minimum preheat temperature of 300°F (150°C) is required for thickness above 1 1/2 in. (38 mm).

4.2 The preheat temperature required by 4.1 (above) shall be maintained for a minimum of 2 hours after the weld repair is completed.

5. Impact Test Requirements

5.1 The material, including heat affected zone and weld metal shall meet the impact requirements given in Section III Subsection NF-2300.

6. Limit of Repair

6.1 Depth of weld groove or weld preparation shall not exceed 1 in. or 20 percent of the thickness, whichever is the smaller.

6.2 The repair shall be made with multiple weld passes.

7. Stress Values

7.1 The Design Stress Intensity shall be 41.7 ksi up to 700°F. The allowable stress shall be 31.3 ksi up to 700°F. The yield strength shall be as specified in Table I. The ultimate tensile strength shall be 125.0 ksi up to 700°F.

8. All other requirements of Subsection NF shall be met.

9. This case and revision number shall be shown in the documentation for the material.

Table I

Allowable Yield Strength (ksi), for metal temperatures (°F) not exceed:

(°F)	100	200	300	400	500	600	700
(ksi)	100.0	97.0	93.2	88.0	83.5	83.0	83.0