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June 14, 1983

Mr. A. Schwencer, Chief
Licensing Branch No. 2
Division of Licensing
U. S. Nuclear Regulatory Commission
Washington, DC 20555

Docket Nos. 50-352
50-353

Subject: Limerick Generating Station, Units 1 & 2
Request for Additional Information (RAI)
from NRC Materials Engineering
Branch, Materials Application Section

Reference: Letter A. Schwencer to E. G. Bauer, Jr.,
dated March 8, 1983

Dear Mr. Schwencer:

Enclosed, in response to the reference letter, are draft responses to RAI's 252.1 through 252.7 and related draft FSAR text changes.

The information contained on these draft responses and draft FSAR page changes will be incorporated into the FSAR, exactly as it appears on the attachments, in the revision scheduled for July 1983.

Sincerely,

[signature]

Copy to: See Attached Service List

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1/1

cc:	Judge Lawrence Brenner	(w/o enclosure)
	Judge Richard F. Cole	"
	Judge Peter A. Morris	"
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QUESTION NO. 252.1
(5.3)

For each reactor vessel beltline weld:

a. indicate the post weld heat treatment received by each production weld and its associated sample test weld,

b. indicate the filler material, flux material, and weld process,

c. indicate whether the sample test welds are prepared using excess base material from the beltline,

d. provide CVN impact test results and drop weight test results,

e. report the copper, nickel and phosphorus chemical composition.

RESPONSE

a. The typical post weld heat treatment data is referenced in Section 5.3.1.7 and provided in Tables 5.3-9 and 5.3-10.

b. Referring to Section 5.3.1.7, the filler material and weld process are identified in Table 5.3-4. The flux material for the submerged arc weld is LINDE 124.

c. The sample test welds are prepared in accordance with the ASME Code and do not include base material from the beltline.

d. The test results are discussed in Section 5.3.1.7.1 and shown in Tables 5.3-3 and 5.3-4.

e. The significant chemical compositions, including copper, nickel, and phosphorus, are listed in Tables 5.3-4 and 5.3-5.

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QUESTION NO. 252.2
(5.3)

For each reactor vessel beltline plate or forging:

a. provide CVN impact test results and drop weight test results,

b. report the copper, nickel and phosphorus chemical composition, material specification and plate identification.

RESPONSE

a. The test results are discussed in Section 5.3.1.7.1 and shown in Tables 5.3-3 and 5.3-4.

b. See Tables 5.3-5 and 5.3-6.

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QUESTION NO. 252.3
(5.3)

For each beltline plate or weld that has not been tested to the CVN impact test and drop weight test requirements of Section III, Summer 1972 Addenda of the ASME Code and the upper shelf requirements of Paragraph IV.B of Appendix G, 10CFR Part 50 submit CVN impact test and drop weight test results from alternative test materials that demonstrates the beltline materials comply with these requirements. The alternative weld material must be fabricated using the same flux type, filler wire type, weld process as the production sample, must be welded by the same manufacturer as the production sample, and heat treated to a equivalent metallurgical condition as the production weld. The alternative plate material must be fabricated by the same manufacturer as the production plate and must be fabricated to the same material specification and heat treated to the same metallurgical condition as the production plate.

RESPONSE

The alternative plate and weld comparison data are referenced and discussed in Section 5.3.1.7.3.

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QUESTION NO. 252.4
(5.3)

For all ferritic RCPB valve materials and piping materials that were not fracture toughness tested to the requirements of the Summer 1972 Addenda and Winter 1972 Addenda of ASME Code, respectively, provide CVN impact and drop weight test data from alternative test materials that demonstrates the valve and piping material would have met ASME Code requirements, had they been tested. The alternative material must be fabricated by the same manufacturer as the production materials and must be fabricated to the same material specification and heat treated to the same metallurgical condition as the production plate.

RESPONSE

The alternative test data for the main steam isolation valves, which were not fracture toughness tested, are referenced and discussed in Section 5.3.1.8.2.4. All other ferritic RCPB valve materials and piping materials were either tested as required by Appendix G or exempted from such testing as discussed in Section 5.3.1.8.2.

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PCY:hmm/D051012*
5/19/83

QUESTION NO. 252.5
(5.3)

To justify an exemption to the requirements of Paragraph IV.A.2.b of Appendix G, 10CFR Part 50:

a. indicate all flange and shell regions near geometric discontinuities that, during vessel operation, will not provide margins of safety in accordance with Appendix G, Section III of the ASME Code,

b. for all locations in Item a, estimate the critical crack size during normal operation which provides a margin of safety equivalent to Appendix G, Section III of the ASME Code. Indicate the method of analysis,

c. indicate which non-destructive test methods can be performed during in-service inspection to examine for cracks of the size and location identified in Item a and b.

RESPONSE

a. The effect of the main closure flange discontinuity is considered by adding 60°F and 90°F to the RT_{NDT} to establish the minimum temperature for bolt-up and pressurization, respectively, as shown in Figure 5.3-4. The minimum bolt-up temperature of 80°F for Limerick Unit 1, which is shown in Figure 5.3-4, is based on an initial RT_{NDT} of +20°F for the shell plate which connects to the closure flange. The minimum bolt-up temperature of +70°F for Limerick Unit 2, which is shown in Figure 5.3-5 is based on an initial RT_{NDT} of +10°F for the closure flange forgings.

Because all toughness testing needed for strict compliance with 10CFR50, Appendix G was not required at the time of vessel procurement, the effect of the reactor vessel discontinuities is considered by adjusting the results of a BWR/6 reactor discontinuity analysis to the Limerick reactors. The BWR/6 analysis performed in accordance with 10CFR50 Appendix G includes the margin of safety implicit in the Appendix G requirements. The adjustment is made by increasing the minimum temperatures required by the difference between the Limerick and BWR/6 feedwater nozzle forging RT_{NDT}'s. The discontinuity adjustment is based on the RT_{NDT} of 40°F for Limerick Unit 1.

This information is documented in the revised Section 5.3.1.5.3.

b,c. As shown in Table 5.3-1a, Item IV.A.2.b, 60°F is added to the RT_{NDT} for the reactor vessel flanges. For other vessel discontinuities, the results of the BWR/6 analysis are adjusted to Limerick Unit 1 RT_{NDT} conditions. In-service inspection will consist of those examinations required by the appropriate editions of ASME Section XI.

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QUESTION NO. 252.6
(5.3)

In order for us to complete our review of the applicant's reactor vessel surveillance program, report the copper, nickel and phosphorus chemical composition, the unirradiated CVN impact test results, the unirradiated drop weight test results, the plate material specification, filler wire type and flux type for all surveillance materials.

RESPONSE

The requested information is referenced and discussed in Sections 5.3.1.6 and 5.3.1.9.

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PCY:hmm/D051012*
5/19/83

QUESTION NO. 252.7
(5.3)

In order for us to complete our review of the applicant's pressure temperature limits:

a. estimate the end-of-life maximum neutron irradiation fluence (E > 1 MeV) at the 1/4 thickness and 3/4 thickness locations in the beltline region,

b. indicate the inside diameter and wall thickness of the beltline region.

RESPONSE

a. The estimated end-of-life maximum neutron irradiation fluences at (1/4)T and (3/4)T are 1.1 E18 n/cm^2 and 4.4 E17 n/cm^2, respectively.

b. For conservative flux calculations, 251 inches is used as the inside diameter of the beltline region. The wall thickness is 6 3/16 inches.

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5.3 REACTOR VESSEL

5.3.1 REACTOR VESSEL MATERIALS

5.3.1.1 Materials Specifications

The materials used in the reactor pressure vessel (RPV) and appurtenances are shown in Table 5.2-4 together with the applicable specifications.

5.3.1.2 Special Processes Used for Manufacturing and Fabrication

The RPV is primarily constructed from low-alloy, high strength steel plate and forgings. Plates are ordered to ASME SA 533 Grade B, Class 1, and forgings to ASME SA 508, Class 2. These materials are melted to fine grain practice and are supplied in the quenched and tempered condition. Further restrictions include a requirement for vacuum degassing to lower the hydrogen level and improve the cleanliness of the low-alloy steels.

Studs, nuts, and washers for the main closure flange are ordered to ASME SA 540, Grade B 23, or Grade B 24. Welding electrodes are low hydrogen type ordered to ASME SFA 5.5.

All plate, forgings, and bolting are 100% ultrasonically tested and surface examined by magnetic particle methods or liquid penetrant methods in accordance with ASME Code, Section III standards. Fracture toughness properties are also measured and controlled in accordance with Section III requirements.

All fabrication of the RPV is performed in accordance with General Electric (GE) approved drawings, fabrication procedures, and test procedures. The shells and vessel heads are made from formed plates, and the flanges and nozzles from forgings. Welding performed to join these vessel components is in accordance with procedures qualified in accordance with ASME Code, Section III and IX requirements. Weld test samples are required for each procedure for major vessel full penetration welds. Tensile and impact tests are performed to determine the properties of the base metal, heat affected zone, and weld metal.

Submerged arc and manual stick electrode welding processes are employed. Electroslag welding is not permitted. Preheat and interpass temperatures employed for welding of low-alloy steel meet or exceed the requirements of ASME Code, Section III. Post-weld heat treatment at 1100°F minimum is applied to all low-alloy steel welds.

Radiographic examination is performed on all pressure-containing welds in accordance with requirements of ASME Code, Section III, Paragraph N-624 including Summer 1975 Addenda. In addition, all welds are given a supplemental ultrasonic examination.

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The materials, fabrication procedures, and testing methods used in the construction of boiling water reactor (BWR) RPVs meet or exceed requirements of ASME Section III Class I vessels.

5.3.1.3 Special Methods for Nondestructive Examination

The materials and welds on the RPV were examined in accordance with methods prescribed, and met the acceptance requirements specified by ASME B&PV Code, Section III. In addition, the pressure-retaining welds were ultrasonically examined using manual techniques. The ultrasonic examination method, including calibration, instrumentation, scanning sensitivity, and coverage is based on the requirements imposed by ASME Code, Section XI in Appendix I. Acceptance standards are equivalent to, or more restrictive than, those required by ASME Code, Section XI.

5.3.1.4 Special Controls For Ferritic and Austenitic Stainless Steels

5.3.1.4.1 Compliance With Regulatory Guides

5.3.1.4.1.1 Regulatory Guide 1.31, Control of Ferrite Content in Stainless Steel Weld Metal

Controls on stainless steel welding are discussed in Section 5.2.3.4.2.1.

5.3.1.4.1.2 Regulatory Guide 1.34, Control of Electroslag Weld Properties

Electroslag welding is not employed for the RPV fabrication.

5.3.1.4.1.3 Regulatory Guide 1.43, Control of Stainless Steel Weld Cladding of Low-Alloy Steel Components

RPV specifications require that all low-alloy steel be produced to fine grain practice. The requirements of this regulatory guide are not applicable to BWR vessels.

5.3.1.4.1.4 Regulatory Guide 1.44, Control of the Use of Sensitized Stainless Steel

Controls to avoid severe sensitization are discussed in Section 5.2.3.4.1.1.

5.3.1.4.1.5 Regulatory Guide 1.50, Control of Preheat Temperature for Welding Low-Alloy Steel

Preheat controls are discussed in Section 5.2.3.3.2.1.

5.3.1.4.1.6 Regulatory Guide 1.71, Welder Qualification for Areas of Limited Accessibility

Welder qualification for areas of limited accessibi'.ity is discussed in Section 5.2.3.4.2.3.

5.3.1.4.1.7 Regulatory Guide 1.99, Effects of Residual Elements on Predicted Radiation Damage to Reactor Pressure Vessel Materials

Predictions for changes in transition temperature and upper shelf energy are made in accordance with the guidelines of Regulatory Guide 1.99.

5.3.1.5 Fracture Toughness

This section is supplemented by Section 5.3.1.7 and 5.3.1.8 in discussing the compliance to the intent of 10CFR50, Appendix G.

5.3.1.5.1 Assessment of 10 CFR Part 50, Appendix G

A major condition necessary for full compliance to Appendix G is satisfaction of the requirements of the Summer 1972 Addenda to Section III of the ASME Code. This is not possible with components that were purchased to earlier code requirements. For the extent of compliance see Tables 5.3-1a and 5.3-2a.

Ferritic materials complying with 10 CFR, Part 50, Appendix G must have both drop weight tests and Charpy V-notch (CVN) tests with the CVN specimens oriented transverse to the maximum material working direction to establish the RT_{NDT}. The CVN tests must be evaluated against both an absorbed energy and a lateral expansion criteria. The maximum acceptable RT_{NDT} must be determined in accordance with the analytical procedures of ASME Code Section III, Appendix G. Appendix G of 10 CFR, Part 50 requires a minimum of 75 ft-lb upper shelf CVN energy for beltline material. It also requires at least 45 ft-lb CVN energy and 25 mils lateral expansion for bolting material at the lower of the preload or lowest service temperature.

By comparison, materials for the Limerick Units 1 and 2 reactor vessels are qualified by drop weight tests and/or in most cases longitudinally oriented CVN tests (both not required), confirming that the material nil-ductility transition temperature (NDTT) longitudinal is at least 60°F below the lowest service temperature. When the CVN test was applied, a 30 ft-lb energy level was used in defining the NDTT. There was no upper shelf CVN energy requirement on the Limerick Units 1 and 2 beltline material. The bolting material was qualified to a 30 ft-lb CVN energy requirement at 60°F below the minimum preload temperature.

To determine operating limits in accordance with 10 CFR, Part 50, Appendix G, estimates of the beltline material RT_{NDT} and the highest RT_{NDT} of all other material were made, as explained in

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Section 5.3.1.5.3. The method for developing these operating limits is also described therein.

5.3.1.5.2 Method of Compliance

The method of compliance is based on the last paragraph on p. 19013 of the July 17, 1973 Federal Register. 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 ensure that a margin of safety against a nonductile failure of this vessel is very nearly the same as 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, its justification and the results of an NRC review are given in GE Licensing Topical Report NEDO-21778-A.

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A minimum boltup and pressurization temperature of 80°F is called for, which is at least 60°F above the flange region RT_{NDT} for Limerick 1. This exceeds the minimum RT_{NDT} temperature required by ASME Code Section III, Paragraph G-222(c), Summer 1976 and later editions. A flange region flaw size less than 0.24 inch critical flaw depth can be detected at the outside surface of the flange to shell and head junctions where stresses due to boltup are most limiting.

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5.3.1.5.3 Methods of Obtaining Operating Limits Based on Fracture Toughness

Operating limits that define minimum metal temperatures versus reactor pressure during normal heatup and cooldown, and during inservice hydrostatic testing, are established using the methods of Appendix G of Section III of the ASME B&PV Code, 1971 Edition including the Summer 1972 Addenda. The results are shown in Figure 5.3-4 (Limerick Unit 1) and 5.3-5 (Limerick Unit 2).

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 were evaluated and the operating limit curves are based on the limiting location. The boltup limits for the flange and adjacent shell regions are based on a minimum metal temperature of RT_{NDT} + 60°F. The maximum throughwall temperature gradient from continuous heating and cooling at 100°F per hour was considered. The safety factors applied were as specified in ASME Code Appendix G and GE BWR 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 Code to which the vessels are designed and manufactured. These toughness test data, CVN and/or dropweight NDT are analyzed to permit compliance with the intent of 10 CFR, Part 50, Appendix G. Because all toughness testing needed for strict compliance with Appendix G was not required at the time of vessel procurement some toughness results are not available. For example, longitudinal CVN's, instead of transverse, were tested, usually at a single test temperature of +10°F or +40°F, for absorbed energy. Also, at the time, either CVN or dropweight testing was permitted; therefore, in many cases both tests were not performed as is currently required. To substantiate the design adequacy, toughness property correlations are derived for the vessel materials in order to give a conservative estimate of RT_{NDT}, compliant with the intent of Appendix G criteria.

These toughness correlations vary, depending on the specific material analyzed, and are derived from the results of WRC Bulletin 217, "Properties of Heavy Section Nuclear Reactor Steels," and from toughness data from the Limerick Unit 1 and 2 vessels and 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. NDT values are available for all beltline and some other Limerick 1 and 2 vessel plates. Where NDT results are missing, NDT is estimated as the longitudinal CVN 35 ft-lb transition temperature. The transverse CVN 50 ft-lb transition temperature is estimated from longitudinal CVN data in the

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following manner. The lowest longitudinal CVN ft-lb value is adjusted to derive a longitudinal CVN 50 ft-lb transition temperature by adding 2°F per ft-lb to the test temperature. If the actual data equals or exceeds 50 ft-lb, the test temperature is used. Once the longitudinal 50 ft-lb temperature is derived, an additional 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.

For forgings (SA-508 Class 2), the predicted limiting property is the same as for vessel plates. CVN and dropweight values are available for the vessel flange, closure head flange, and feedwater nozzle materials for Limerick Units 1 and 2. RT_{NDT} is estimated in the same way as for vessel plate.

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 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 NDT or the 50 ft-lb temperature minus 60°F. When NDT is not available, the RT_{NDT} shall not be less than -50°F, since lower values are not supported by the correlation data.

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

Closure bolting material (SA-540 Grade B24) toughness test requirements for Limerick Units 1 and 2 are for 30 ft-lb at 60°F below the boltup temperature. Current Appendix G requirements are for 45 ft-lb and 25 mils lateral expansion (MLE) at the preload or lowest service temperature, including boltup. All Limerick Unit 1 closure stud materials meet current requirements at +10°F. All but one heat, for which records were not available, of the Limerick Unit 2 closure stud materials meet current requirements at +10°F. The purchase requirement for Limerick Unit 2 closure stud material was for 30 ft-lb at +10°F, and no deviation is reported. Thus, 60°F is added to the specified test temperature for Limerick Unit 2 to derive the boltup temperature.

Using this general approach, an initial RT_{NDT} of 20°F is established for the core beltline region for Limerick Unit 1 and later for Limerick Unit 2.

The effect of the main closure flange discontinuity is considered by adding 60°F and 90°F to the RT_{NDT} to establish the minimum temperature for boltup and pressurization respectively. The minimum boltup temperature of 80°F for Limerick Unit 1, which is

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shown in Figure 5.3-4 is based on an initial RT_{NDT} of +20°F for the shell plate which connects to the closure flange. The minimum boltup temperature of +70°F (preliminary) for Limerick Unit 2, which is shown in Figure 5.3-5, is based on an initial RT_{NDT} of +10°F for the closure flange forgings.

Because the toughness testing in strict compliance with 10CFR50 Appendix G was not required at the time of vessel procurement, the effect of the reactor vessel discontinuities is considered by adjusting the results of a BWR/6 reactor discontinuity analysis to the Limerick reactors. The BWR6 analysis performed in accordance with 10CFR50 Appendix G includes the margin of safety implicit in the Appendix G requirement. The adjustment is made by increasing the minimum temperatures required by the difference between the Limerick and BWR/6 feedwater nozzle forging RT_{NDT}'s. The adjustment is based on an RT_{NDT} of 40°F for Limerick Unit 1 and an RT_{NDT} of <u>later</u> for Limerick Unit 2.

The reactor vessel closure studs have a minimum Charpy impact energy of 48 ft-lb and a 27 MLE at 10°F for Limerick Unit 1. The studs for Limerick Unit 2 have a specified Charpy energy of 30 ft-lb at 10°F. The lowest service temperature for boltup of Limerick Unit 2 is taken to be 60°F above the <u>later</u> value and is <u>later</u>. Charpy test results are discussed in Sections 5.3.1.7 and 5.3.1.8.

5.3.1.6 <u>Material Surveillance</u>

5.3.1.6.1 Compliance with "Reactor Vessel Material Surveillance Program Requirements"

The materials surveillance program monitors changes in the fracture toughness properties of ferritic materials in the reactor vessel beltline region resulting from their exposure to neutron irradiation and thermal environment.

Materials for the program are selected to represent materials used in the reactor beltline region. The specimens are manufactured from a plate actually used in the beltline region, and a weld typical of those in the beltline region, and thus represent base metal, weld metal, and the transition zone between base metal and weld. The plate and weld are heat treated in a manner that simulates the actual heat treatment performed on the core region shell plates of the completed vessel.

Further details of the vessel surveillance programs are provided in Section 5.3.1.9.

The surveillance program includes three capsule holders per reactor vessel.

For the specimen arrangement, see Table 5.3-16 as referenced in Section 5.3.1.9.

A set of out-of-reactor baseline CVN specimens is provided with the surveillance test specimens.

Charpy impact specimens for the reactor vessel surveillance programs are of the longitudinal orientation consistent with the ASME requirements prior to the issue of the 1972 Addenda and ASTM E185-73. Based on GE experience, the amount of shift measured by these irradiated longitudinal test specimens is essentially the same as the shift in an equivalent transverse specimen.

For Limerick Units 1 and 2, each set of surveillance specimens is loaded in six small capsules rather than one large capsule. Therefore, each capsule holder which contains all six small capsules can be considered to be the same as one surveillance capsule as defined in 10 CFR, Part 50, Appendix H. Three capsule holders are included in each reactor vessel. Since the predicted adjusted reference temperature of the beltline region is less than 100°F at end-of-life and the calculated peak neutron fluence is less than 5×10^{18} n/cm^2, the use of three capsule holders meets the requirements of 10 CFR, Part 50, Appendix H, and ASTM E185-73.

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

a. The first set is withdrawn when its exposure corresponds to the calculated exposure of the reactor vessel wall at 25% of the reactor design life.

b. The second set is withdrawn when its exposure corresponds to the calculated exposure of the reactor vessel wall at 75% of the reactor design life.

c. The third set is a spare to be withdrawn based on previously developed data.

For the extent of compliance to 10 CFR, part 50, Appendix H, see Tables 5.3-1b and 5.3-2b.

5.3.1.6.2 Neutron Flux and Fluence Calculations

A description of the methods of analysis is contained in Sections 4.1.4.5 and 4.3.2.8.

5.3.1.6.3 Predicted Irradiation Effects on Vessel Beltline Materials

Estimated maximum changes in RT_{NDT} (initial reference temperature) and upper shelf fracture energy as a function of the

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end-of-life (EOL) fluence at the 1/4 depth of the vessel beltline are provided in Section 5.3.1.7. The predicted peak EOL fluence at the 1/4 depth of the vessel beltline is 1.1×10^{18} n/cm^2 after 40 years of service. Transition temperature changes; and variations in upper shelf energy were calculated in accordance with the rules of Regulatory Guide 1.99. Reference temperatures were established in accordance with 10CFR50 Appendix G and NB-2330 of the ASME Code.

5.3.1.6.4 Positioning of Surveillance Capsules and Method of Attachment

Surveillance specimen capsules are located at three azimuths at a common elevation in the core beltline region. The sealed capsules are not attached to the vessel but are in welded capsule holders. The capsule holders are mechanically retained by capsule holder brackets welded to the vessel cladding as shown in Figure 5.3-3. The capsule holder brackets allow the capsule holder to be removed at any desired time in the life of the plant for specimen testing. These brackets are designed, fabricated, and analyzed to the requirements of Section III of the ASME code. A positive spring-loaded locking device is provided to retain the capsules in position throughout any anticipated event during the lifetime of the vessel.

5.3.1.6.5 Time and Number of Dosimetry Measurements

GE provides a separate neutron dosimeter so that fluence measurements may be made at the vessel ID during the first fuel cycle to verify the predicted fluence at an early date in plant operation. This measurement is made over this short period to avoid saturation of the dosimeters now available. Once the fluence-to-thermal power output is verified, no further dosimetry is considered necessary because of the linear relationship between fluence and power output.

5.3.1.7 <u>VESSEL BELTLINE PLATES & WELDS</u>

This section supplements Section 5.3.1.5 in discussing the compliance to the intent of 10CFR50, Appendix G.

5.3.1.7.1 Test Data

Available Charpy V-notch and Drop-Weight impact data are presented in Tables 5.3-3 and 5.3-4. There are two categories of beltline welds identified: "shop" welds and "field" welds. The shop welds represent vessel vertical seams which were made prior to shipment of pre-assembled ring segments to the Limerick 1 plant site. The field welds (i.e., girth welds) were made at the plant site. However, exact identification of weld materials used in the beltline girth weld seam is not available. Therefore, a

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conservative assumption is made to consider all electrodes which were released for field-welding the vessel shells.

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Figure 5.3-7 shows the beltline layout. It gives plate heat numbers and locations, as well as weld seam locations and identifications.

5.3.1.7.2 Effects of Irradiation

Copper and phosphorus values used to estimate the effects of irradiation on toughness are presented in Table 5.3-5.

Estimated starting (i.e., unirradiated) RT_{NDT} values for the beltline plate and weld materials are presented in Table 5.3-5. These values were calculated using the data in Tables 5.3-3 and 5.3-4 in accordance with ASME Code Section III, NB2300.

Estimated end-of-life (EOL) RT_{NDT} values (for 1/4 thickness location from the vessel ID) are also given in Table 5.3-5. The EOL RT_{NDT} are estimated in accordance with Regulatory Guide 1.99, Revision 1.

5.3.1.7.3 Upper Shelf Toughness Testing

Charpy V-notch upper shelf toughness testing was not required when the Limerick 1 vessel was manufactured. Appendix G of 10CFR50 requires a minimum of 70 ft-lb transverse upper shelf CVN energy for beltline material. Branch Technical Position MTEB 5-2 indicates that 70 ft-lbs is adequate for fluence levels less than 1×10^{19} n/cm^2.

All of the Limerick 1 beltline plates were CVN impact tested as longitudinal specimens at only one temperature, +40°F. The lowest CVN value obtained for beltline plate was 45 ft-lb with 50% shear, and the highest was 104 ft-lb with 70% shear. The 50% shear value suggests there is a considerable margin remaining before the upper shelf (i.e., 100% shear) level is reached.

Table 5.3-6 summarizes the test certificate for a representative Limerick 1 beltline plate. Similar data are also documented for all other plates. Supporting data from representative plate materials in other BWR plants are provided in Table 5.3-7. Compatibility of the supporting data from other BWRs, Plants A through E, with respect to Limerick is based on criteria such as similarity in material, fabrication, vendor source, welding procedure, etc. All listed plate materials were produced by Luken's Steel Co. These data show that plate with as low as 36 ft-lb (Plant E, heat no. C9570-1) of absorbed energy at +40°F can have longitudinal upper shelf energies in excess of 100 ft-lbs.

MTEB 5-2 states that longitudinal values should be reduced to 65% of the test value in order to estimate transverse upper shelf. To account for irradiation, a further shift in upper shelf toughness can be made using Regulator Guide 1.99, Rev. 1, resulting in a maximum reduction of approximately 14% for the

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highest Cu content of 0.12 wt% as shown in Table 5.3-5. Using these conservative assumptions with a goal of achieving at least 50 ft-lb transverse toughness at EOL, the following equation is derived:

$$50 = .65(L) - (.14)[.65(L)]$$ (where L is unirradiated longitudinal upper shelf value)

This equation predicts a minimum required unirradiated longitudinal upper shelf toughness requirement of 89 ft-lbs. Table 5.3-7 indicates that toughness in excess of 89 ft-lbs is to be expected for longitudinal upper shelf of this material.

Although upper shelf testing was not required for the beltline welds, Table 5.3-4 shows that the majority of the weld materials, both field and shop, meet the 75 ft-lb minimum upper shelf requirement. Of those heats where CVN toughness tests were run at only one temperature (usually +10°F) and the minimum requirement was not met, there is considerable margin for improved properties at higher test temperatures (e.g., heat#/lot# 07L8 57/B101A27A, 28 ft-lbs and 20% shear @ +10°F). Further upper shelf toughness data for similar welds, made by the same vendor as Limerick 1, are given in Table 5.3-8. Tables 5.3-9 and 5.3-10 present the typical weld procedures for this data base; these tables summarize surveillance program weld procedures (including that for Limerick 1) and other vessel material data representative of the Limerick 1 beltline welds. These data are in excess of 75 ft-lbs at the upper shelf. Furthermore, due to the relatively low quantities of Cu in the Limerick 1 beltline welds, no significant decrease in upper shelf toughness due to irradiation is predicted.

5.3.1.8 NONBELTLINE REGION AND FERRITIC PIPING AND VALVES

This section supplements Section 5.3.1.5 in discussing the compliance to the intent of 10CFR50, Appendix G.

5.3.1.8.1 Nonbeltline Region

Table 5.3-11 lists the estimated reference temperature (RT_{NDT}) for various components in the vessel nonbeltline region. These values were derived in accordance with the intent of the ASME Code Section III, Paragraph NB-2300.

5.3.1.8.2 Ferritic Piping and Valves

5.3.1.8.2.1 Piping

Toughness testing of the main steam piping is in compliance with 10CFR50 Appendix G, since it was tested at +70°F in accordance with the ASME Code Section III, 1971 edition with Summer 1972 Addenda.

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5.3.1.8.2.2 Safety Relief Valves

The SRVs are exempted by the ASME Code from toughness testing because of their 6-inch size. This is consistent with 10CFR50 Appendix G.

5.3.1.8.2.3 Flued Head Fittings

Testing of the flued head fittings is in compliance with 10CFR50 Appendix G. These materials were impact tested in accordance with the ASME Code Section III, 1971 Edition with Summer 1972 Addenda. The test temperature was 0°F.

5.3.1.8.2.4 Main Steam Isolation Valves

The MSIVs were procured to meet the requirements of the 1968 ASME Nuclear Draft for Pumps and Valves Code, which did not require toughness testing for the subject valve material. They were exempted because they are subjected to less than 20% of design pressure at temperatures less than 250°F.

The Limerick 1 MSIV body materials are A216 WCB carbon steel castings. Table 5.3-12 shows the significant chemical composition and heat treatment of these castings. Although impact tests were not run for Limerick 1, these materials are considered to have adequate toughness to meet the code requirements (i.e., 25 mils lateral expansion). Evidence of this design adequacy is provided in Table 5.3-13 which presents similar MSIV body material data from other BWR projects identified as Projects A through F. These materials received heat treatments equivalent to those experienced in Limerick 1.

The bonnet (i.e., cover) materials are A105 GR.2 forgings. Table 5.3-14 lists available information for a Cann & Saul heat which is used to fabricate the valve covers. Reference 1 shows Charpy V-notch in excess of 25 mils lateral expansion at +40°F, and RT values no greater than -10°F for SA105 material normalized at 1565°F for 4 hours and air cooled after forging.

Additional toughness data for SA105 forging materials obtained from fittings in another BWR plant is presented in Table 5.3-15. These materials were normalized at 1650°F for 4 hours and air cooled. The toughness data given is for longitudinally oriented specimens whereas the code requirements are for transverse specimens. However, prior GE impact test experience with carbon steel material indicates it is appropriate to approximate transverse properties at about 40% of the corresponding longitudinal properties. On this basis, the data given in Table 5.3-15 demonstrates that the transverse properties meet the 25 mils lateral expansion code requirements.

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5.3.1.9 RPV SURVEILLANCE PROGRAM

This section supplements Section 5.3.1.6 in discussing the complaince to the intent of 10CFR50, Appendix H.

The base plate and weld materials used to fabricate the surveillance test plate are identified in Table 5.3-5. The base metal from a core beltline plate heat No. C7689-1 was used for surveillance test material. With respect to initial RT_{NDT} and percent of copper by weight, this material is considered equivalent to other beltline plates and its utilization for test plate fabrication is in compliance with current recommendations for selection of surveillance materials. The test plate weld, like the core beltline vertical weld seams, was made using both Shielded Metal Arc (SMAW) and Submerged Arc (SAW) welding processes. The test plate weld procedure is presented in Table 5.3-10. For each of the two welding processes, only one heat of weld material was used. The SAW material heat/flux No. IP4218/3929-989, which was also used for beltline seams BE, BA, and BB (Figure 5.3-7), is considered suitable for surveillance monitoring because it represents the most limiting SAW material in terms of shift and predicted end-of-life RT_{NDT}. The SMAW material heat/lot 421A6811/F022A27A which was used for surveillance material was not used for production beltline welds; however, the weight percentages of copper and phosphorus which it contains (.09 Cu and .018 P) are generally greater than those for actual beltline material. Moreover, the unirradiated RT_{NDT} of this material is equivalent to the initial RT_{NDT} of the beltline weld materials. The CB&I weld procedure for test plate fabrication involves utilizing stick electrode to fuse back-up bars and completing the major volume of the weld with SAW. This includes backgouging of the back-up bar to complete the back side of the weld. Therefore, the test plate weld metal is essentially submerged-arc-welded material. Table 5.3-5 indicates that all beltline materials, both plate and weld, are highly resistant to irradiated degradation of notch toughness.

Table 5.3-16 lists the actual number of specimens and their orientations in each surveillance capsule (including tensile specimens). The number and orientation of the Charby impact specimens are consistent with the ASME requirements prior to the issuance of the Summer 1972 Addenda and ASME 185-73.

Prior surveillance experience indicates the amount of radiation-induced shift in properties measured by longitudinally oriented specimens is applicable to equivalent transverse-oriented specimens. Therefore, the shift when determined can be used for the transverse RT_{NDT} values for the beltline materials. Referring to Table 5.3-16, the longitudinal orientation of the base metal HAZ specimens are such that they simulate beltline vertical seams in this manner.

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5.3.1.10 Reactor Vessel Fasteners

The reactor vessel closure head (flange) is fastened to the reactor vessel shell flange by multiple sets of threaded studs and nuts. The lower end of each stud is installed in a threaded hole in its vessel shell flange. A nut and washer are installed on the upper end of each stud. The proper amount of preload can be applied to the studs by a sequential tensioning using hydraulic tensioners. The design and analysis of this area of the vessel is in full compliance with all Section III Class I Code requirements. The material for studs, nuts, and washers is SA-540 Grade B23 or B24. The maximum reported ultimate tensile stress for the bolting material is 164,000 psi which is less than the 170,000 psi limitation in Regulatory Guide 1.65. Also, the Charpy impact test recommendations of Paragraph IV.A.4 of Appendix G to 10 CFR, Part 50 were not specified in the vessel order since the order was placed prior to issuance of Appendix G to 10 CFR 50. However, impact data from the certified materials report shows that all bolting materials meet the Appendix G impact properties.

A phosphate coating is applied to threaded areas of studs and nuts and bearing areas of nuts and washers to act as a rust inhibitor and to assist in retaining lubricant on these surfaces.

5.3.2 PRESSURE-TEMPERATURE LIMITS

5.3.2.1 Limit Curves

The basis for setting operational limits on pressure and temperature for normal, upset, and test conditions for the reactor pressure vessel is described in Section 5.3.1.5.

5.3.2.1.1 Temperature Limits for Boltup

A minimum temperature of 10°F is required on Limerick 1 and later on Limerick 2 for the closure studs. A sufficient number of studs can be tensioned at a temperature between 10°F and 80°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 80°F (Limerick Unit 1) and later (Limerick Unit 2) before they are stressed by the full intended bolt preload (all bolts tensioned). The fully preloaded boltup limits are shown on Figures 5.3-4 and 5.3-5.

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5.3.2.1.2 Temperature Limit for Preoperational Tests and Inservice Inservice Inspection

Based on the NRC general revision to 10CFR50, Appendix G Document No. [7590-1] Paragraph IV.A.4, the preoperational system hydrostatic test at 1563 psig prior to fuel loading may be performed at a minimum temperature of 100°F for Limerick Unit 1 without fuel in the reactor, and later for Limerick Unit 2. These limits are established by the 40°F maximum RT_{NDT} of the reactor vessel materials.

The fracture toughness analysis for system pressure tests with fuel in the reactor yields the curves labeled A shown in Figures 5.3-4 and 5.3-5. The curves labeled "core beltline" are based on an initial RT_{NDT} of 20°F for Limerick Unit 1 and later for Limerick Unit 2. The predicted shift in the RT_{NDT} from Figure 5.3-6, 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.

5.3.2.1.3 Operating Limits During Heatup, Cooldown, and Core Operation

The fracture toughness analysis is done for the normal heatup or cooldown rate of 100°F/hour. The temperature gradients and thermal stress effects corresponding to this rate are included. The results of the analyses are a set of operating limits for nonnuclear heatup or cooldown shown as curves labeled B in Figures 5.3-4 and 5.3-5. Curves labeled C in these figures apply whenever the core is critical. The basis for the C curves is described in GE BWR Licensing Topical Report NEDO-21778-A.

5.3.2.1.4 Reactor Vessel Annealing

Inplace annealing of the reactor vessel because of radiation embrittlement is not anticipated to be necessary because the predicted value of adjusted reference temperature does not exceed 200°F (see 10 CFR, Part 50, Appendix G, Paragraph IV.C).

5.3.2.2 Operating Procedures

By comparison of the pressure versus temperature limits in Section 5.3.2.1 with intended normal operating procedures for the most severe upset transient, it is shown that the limits are not exceeded during any foreseeable upset condition. Reactor operating procedures are established so that actual transients are not more severe than those for which the vessel design adequacy has been demonstrated. Of the design transients, the upset condition producing the most adverse temperature and pressure condition anywhere in the vessel head and/or shell areas yields a minimum fluid temperature of 250°F and a maximum pressure peak of 1180 psig. Scram automatically occurs with

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initiation of this event, prior to the reduction in fluid temperature, so the applicable operating limits are given by curve A Figures 5.3-4 and 5.3-5. For a temperature of 250°F, the maximum allowable pressure exceeds 1180 psig for the intended margin against nonductile failure. The maximum transient pressure of 1180 psig is therefore within the specified allowable limits.

5.3.3 REACTOR VESSEL INTEGRITY

The reactor vessels are fabricated for GE's Nuclear Energy Division by Chicago Bridge and Iron Company; and are subject to the requirements of GE's Quality Assurance program.

Measures are established to ensure that purchased material, equipment, and services associated with the reactor vessels and appurtenances conform to the requirements of the purchase documents. These measures include provisions, as appropriate, for source evaluation and selection, objective evidence of quality furnished, inspection at the vendor source, and examination of the completed reactor vessels.

GE provides inspection surveillance of the reactor vessel fabricator's in-process manufacturing, fabrication, and testing operations in accordance with GE's Quality Assurance program and approved inspection procedures. The reactor vessel fabricator is responsible for the first level inspection of his manufacturing, fabrication, and testing activities and GE is responsible for the first level of audit and surveillance inspection.

Adequate documentary evidence that the reactor vessel material, manufacture, testing, and inspection conform to the specified quality assurance requirements contained in the procurement specification is available at the fabricator's plant site.

5.3.3.1 <u>Design</u>

5.3.3.1.1 Description

5.3.3.1.1.1 Reactor Vessel

The reactor vessel shown in Figure 5.3-1 is a vertical, cylindrical pressure vessel of welded construction. The vessels for Limerick are designed, fabricated, tested, inspected, and stamped in accordance with the ASME Code Section III, Class A including the Summer Addenda 1969. Design of the reactor vessel and its support system meets seismic Category I requirements. The materials used in the reactor pressure vessel are shown in Table 5.2-4.

The cylindrical shell and bottom head sections of the reactor vessel are fabricated of low-alloy steel, the interior of which

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is clad with stainless steel weld overlay. Nozzle and nozzle weld zones are unclad except for those mating to stainless steel piping systems.

Inplace annealing of the reactor vessel is unnecessary because shifts in transition temperature caused by irradiation during the 40-year life can be accommodated by raising the minimum pressurization temperature. Radiation embrittlement is not a problem outside of the vessel beltline region because the irradiation in those areas is less than 1×10^{18} nvt with neutron energies in excess of 1 MeV.

Quality control methods used during the fabrication and assembly of the reactor vessel and appurtenances ensure that design specifications are met.

The vessel top head is secured to the reactor vessel by studs and nuts. These nuts are tightened with a stud tensioner. The vessel flanges are sealed with two concentric metal seal-rings designed to permit no detectable leakage through the inner or outer seal at any operating condition, including heating to operating pressure and temperature at a maximum rate of 100°F/hr in any one-hour period. To detect seal failure, a vent tap is located between the two seal-rings. A monitor line is attached to the tap to provide an indication of leakage from the inner seal-ring seal.

5.3.3.1.1.2 Shroud Support

The shroud support is a circular plate welded to the vessel wall. This support is designed to carry the weight of the shroud, shroud head, peripheral fuel elements, neutron sources, core plate, top guide, the steam separators, the jet pump diffusers, and to laterally support the fuel assemblies. Design of the shroud support also accounts for pressure differentials across the shroud support plate, for the restraining effect of components attached to the support, and for earthquake loadings. The shroud support design is specified to meet appropriate ASME code stress limits.

5.3.3.1.1.3 Protection of Closure Studs

The BWR does not use borated water for reactivity control. This section is therefore not applicable.

5.3.3.1.2 Safety Design Basis

The design of the reactor vessel and appurtenances meets the following safety design bases:

a. The reactor vessel and appurtenance will withstand adverse combinations of loading and forces

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resulting from operation under abnormal and accident conditions

b. To minimize the possibility of brittle fracture of the nuclear system process barrier, the following are required:

   1. Impact properties at temperatures related to vessel operation are specified for materials used in the reactor vessel

   2. Expected shifts in transition temperature during design life as a result of environmental conditions, such as neutron flux, are considered in the design. Operational limitations ensure that RT_{NDT} temperature shifts are accounted for in reactor operation.

   3. Operational margins to be observed with regard to the transition temperature are specified for each mode of operation.

5.3.3.1.3 Power Generation Design Basis

The design of the reactor vessel and appurtenances meets the following power generation design bases:

a. The reactor vessel has been designed for a useful life of 40 years.

b. External and internal supports that are integral parts of the reactor vessel are located and designed so that stresses in the vessel and supports that result from reactions at these supports are within ASME Code limits.

c. Design of the reactor vessel and appurtenances allows for a suitable program of inspection and surveillance.

5.3.3.1.4 Reactor Vessel Design Data

The reactor vessel design pressure is 1250 psig and the design temperature is 575°F. The maximum installed test pressure is 1563 psig.

5.3.3.1.4.1 Vessel Support

The reactor vessel support assembly consists of a ring girder and the various bolts and shims necessary to position and secure the assembly between the reactor vessel support skirt and the support pedestal. The concrete and steel support pedestal is constructed as an integral part of the structure foundation. Steel anchor bolts are set in the concrete with their threads extending above

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the surface. The anchor bolts extend through the ring girder bottom flange. High strength bolts are used to secure the flange of the reactor vessel support skirt to the top flange of the ring girder. The ring girder is fabricated of ASTM A-36 structural steel according to AISC specifications.

5.3.3.1.4.2 Control Rod Drive (CRD) Housings

The CRD housings are inserted through the CRD penetrations in the reactor vessel bottom head and are welded to the reactor vessel. Each housing transmits loads to the bottom head of the reactor. These loads include the weights of a control rod, a CRD, a control rod guide tube, a four-lobed fuel support piece, and the four fuel assemblies that rest on the fuel support piece. The housings are fabricated of Type 304 austenitic stainless steel.

5.3.3.1.4.3 Incore Neutron Flux Monitor Housings

Each incore neutron flux monitor housing is inserted through the incore penetrations in the bottom head and is welded to the inner surface of the bottom head.

An incore flux monitor guide tube is welded to the top of each housing and either a source range monitor/intermediate range monitor (SRM/IRM) drive unit or a local power range monitor (LPRM) is bolted to the seal/ring flange at the bottom of the housing (see Sections 7.6 and 7.7).

5.3.3.1.4.4 Reactor Vessel Insulation

The reactor vessel top head insulation is designed to permit complete submersion in water during shutdown without loss of insulating material, contamination of the water, or adverse effect on the insulation efficiency after draining. All reactor vessel insulation is of the stainless steel, reflective type. The top head insulation framework is designed to seismic Category I requirements and is used as an anchor point for reactor vessel head spray and vent piping.

The insulation above the reactor vessel stabilizer brackets is close-fitting, freestanding insulation designed to be 100% removable for inservice inspection of the reactor vessel.

The insulation below the stabilizer brackets is suspended from the brackets to allow a minimum of 8 inches annular clearance between the reactor vessel and the insulation for remote inservice inspection of the reactor vessel. The suspended insulation is also equipped with removable access ports.

Reactor vessel bottom head insulation includes horizontal flat panels connected to a cylindrical shell covering the inside of the reactor support skirt. The top row of the cylindrical shell

panels are removable to expose the bottom head for inservice inspection.

Quick removable insulation is provided around all reactor vessel nozzles to allow manual or remote automatic examination of nozzle-to-vessel and nozzle-to-piping welds.

5.3.3.1.4.5 Reactor Vessel Nozzles

All piping connected to the reactor vessel nozzles is designed to not exceed the allowable loads on any nozzle.

The vessel top head nozzles are provided with a flange with large groove facings. The drain nozzle is of the full penetration weld design. The recirculation inlet nozzles (located as shown in Figure 5.3-1), feedwater inlet nozzles, the RHR low pressure coolant injection inlet nozzles, and the core spray inlet nozzles all have thermal sleeves.

Nozzles connecting to stainless steel piping have safe ends made of stainless steel or Inconel/ASME Code Section III, SB-166 . These safe ends are welded to the nozzles after the pressure vessel has been heat treated to avoid furnace sensitization of the stainless steel safe ends. The material used is compatible with the material of the mating pipe.

The nozzle for the standby liquid control injection pipe is designed to minimize thermal shock effects on the reactor vessel, if the use of the standby liquid control system is required.

5.3.3.1.4.6 Materials and Inspections

The reactor vessel is designed and fabricated in accordance with the appropriate ASME Code as defined in Section 5.2.1. Table 5.2-4 defines the materials and specifications. Section 5.3.1.6 defines the compliance with reactor vessel material surveillance program requirements.

5.3.3.1.4.7 Reactor Vessel Schematic (BWR)

The reactor vessel schematic is contained in Figure 5.3-1. Trip system water levels are indicated as shown in Figure 5.3-2.

5.3.3.2 <u>Materials of Construction</u>

All materials used in the construction of the RPV conform to the requirements of ASME Code Section II materials. The vessel heads, shells, flanges, and nozzles are fabricated from low-alloy steel plate and forgings purchased in accordance with ASME specifications SA533 Grade B Class I and SA508 Class 2. Special requirements for the low-alloy steel plate and forgings are discussed in Section 5.3.1.2. Cladding employed on the interior

surfaces of the vessel consists of austenitic stainless steel weld overlay.

These materials are selected because they provide adequate strength, fracture toughness, fabricability, and compatibility with the BWR environment. Their suitability is demonstrated by long-term successful operating experience in reactor service.

5.3.3.3 Fabrication Methods

The RPV is a vertical, cylindrical pressure vessel of welded construction fabricated in accordance with ASME Section III, Class I requirements. All fabrication of the RPV is performed in accordance with GE approved drawings, fabrication procedures, and test procedures. The shell and vessel head are made from formed low-alloy steel plates, and the flanges and nozzles from low-alloy steel forgings. Welding performed to join these vessel components is in accordance with procedures qualified in ASME Section III and IX requirements. Weld test samples are required for each procedure for major vessel full penetration welds.

Submerged arc and manual stick electrode welding processes are employed. Electroslag welding is not permitted. Preheat and interpass temperatures employed for welding of low-alloy steel meet or exceed the requirements of ASME Code Section III, subsection NA. Postweld heat treatment of 1100°F minimum is applied to all low-alloy steel welds.

All previous BWR pressure vessels employed similar fabrication methods. These vessels have operated for periods of up to 16 years and their service history is excellent.

The vessel fabricator, Chicago Bridge and Iron Co., has had extensive experience with GE reactor vessels dating back to 1966. CBI Nuclear Co. was formed in 1972 from a merger agreement between Chicago Bridge and Iron Co. and GE and has continued as the primary supplier for GE domestic reactor vessels.

5.3.3.4 Inspection Requirements

All plate, forgings, and bolting were 100% ultrasonically tested and surface examined by magnetic particle methods or liquid penetrant methods in accordance with ASME Code Section III requirements. Welds on the reactor pressure vessel were examined in accordance with methods prescribed and meet the acceptance requirements specified by ASME Code, Section III. In addition, the pressure retaining welds were ultrasonically examined in accordance with ASME Code, Section XI requirements prior to shipping.

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5.3.3.5 Shipment and Installation

The Limerick reactor vessels were assembled at the site. Methods and procedures are discussed in the PSAR, Appendix G. Suitable measures were taken during installation to ensure that vessel integrity was maintained; for example, access controls were applied to personnel entering the vessel, weather protection was provided, and periodic cleanings were performed.

5.3.3.6 Operating Conditions

Procedural controls on plant operation are implemented to hold thermal stresses within acceptable ranges. These restrictions on coolant temperature are:

a. The average rate of change of reactor coolant temperature during normal heatup and cooldown shall not exceed 100°F during any one-hour period.

b. If the coolant temperature difference between the dome (inferred from P_{SAT}) and the bottom head drain exceeds 145°F, the reactor recirculation pumps shall not be started, and neither reactor power nor recirculation pump flow shall be increased.

c. The pump in an idle reactor recirculation loop shall not be started unless the coolant temperature in that loop is within 50°F of average reactor coolant temperature.

The limit regarding the normal rate of heatup and cooldown (item a.) ensures that the vessel closure, closure studs, vessel support skirt, and CRD housing and stub tube stresses and usage remain within acceptable limits. The limit regarding a vessel temperature limit on recirculation pump operation and power level increase restriction (item b.) augments the item a. limit in further detail by ensuring that the vessel bottom head region is not warmed at an excessive rate caused by rapid sweep out of cold coolant in the vessel lower head region by recirculation pump operation or natural circulation (cold coolant can accumulate as a result of control drive inleakage and/or low recirculation flow rate during startup or hot standby). The item c limit further restricts operation of the recirculation pumps to avoid high thermal stress effects in the pumps and piping, while also minimizing thermal stresses on the vessel nozzles.

The above operational limits are maintained to ensure that the stress limits within the reactor vessel and its components are within the thermal limits to which the vessel is designed for normal operating conditions. To maintain the integrity of the vessel if these operational limits are exceeded, the reactor vessel is also designed to withstand a limited number of transients caused by operator error. Also, for abnormal

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operating conditions where safety systems or controls provide an automatic temperature and pressure response in the reactor vessel, the reactor vessel integrity is maintained since the severest anticipated transients are included in the design conditions. Therefore, it is concluded that vessel integrity is maintained during the most severe postulated transients, since all such transients are evaluated in the design of the reactor vessel. The postulated transient for which the vessel has been designed is shown in Figure 5.2-5 and discussed in Section 5.2.2.

5.3.3.7 Inservice Surveillance

Inservice inspection of the RPV is in accordance with the requirements of the 1974 Edition of the ASME B&PV Code, Section XI, including the Summer 1975 Addenda. The vessel is examined once prior to startup to satisfy the preoperational requirements of the ASME Code, Section XI. Subsequent inservice inspection is scheduled and performed in accordance with the requirements of 10 CFR Part 50.55a, Subparagraph (g).

The materials surveillance program monitors changes in the fracture toughness properties of ferritic materials in the reactor vessel beltline region resulting from their exposure to neutron irradiation and the thermal environment. Specimens of actual reactor beltline material are exposed in the reactor vessel and periodically withdrawn for impact testing. Operating procedures are modified in accordance with test results to ensure adequate brittle fracture control.

Material surveillance programs and inservice inspection programs are in accordance with applicable ASME code requirements, and provide ensurance that brittle fracture control and pressure vessel integrity are maintained throughout the service life of the RPV.

Inservice inspection and testing of the reactor coolant pressure boundary is discussed in detail in Section 5.2.4.

5.3.4 REFERENCE

1. Metal Progress, July 1978, pp. 35-39.

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TABLE 5.3-1a

APPENDIX G MATRIX FOR LIMERICK UNIT 1

APPENDIX G PARA. NO.	TOPIC	COMPLY YES/NO OR N/A	ALTERNATE ACTIONS OR COMMENTS
I,II	Introduction; definitions	--	--
III.A	Compliance With ASME Code, Section NB-2300	Yes	See Section 5.3.1.5.1.2 for discussion
III.B.1	Location and orientation of impact test specimens	Yes	See III.A, above.
III.B.2	Materials used to prepare test specimens	No	Compliance except for CVN orientation and CVN upper shelf
III.B.3	Calibration of temperature, instrumentation, and Charpy test machines	No	Paragraph NB-2360 of the ASME B&PV Code Section III was not in existence at the time of purchase of the Limerick Unit 1 RPV. However, the requirements of the 1971 edition of the ASME B&PV Code, Section III Summer 1971 addenda, are met. For the discussions of the GE interpretations of compliance and NRC acceptance see Refs 1 and 2. The temperature instruments and Charpy test machines calibration data are retained until the next calibration. This is in accordance with Reg Guide 1.88 Rev 2, GE Alternative Position 1.88 (see Section 1.8) and ANSI N45.2.9, 1974. Therefore, the instrument calibration data for Limerick Unit 1 are not currently available.
III.B.4	Qualification of testing personnel	No	No written procedures were in existence as now required by the regulation; however, the individuals were qualified by on-the-job training and past experience. For a discussion of the GE interpretation of compliance and NRC acceptance see Refs 1 and 2.
III.B.5	Test results recording and certification	Yes	See Refs 1 and 2.
III.C.1	Test conditions	No	See III.A, III.B.2, above.
III.C.2	Materials used to prepare test specimens for reactor vessel beltline	Yes	Compliance on base metal and weld metal tests. Test welds are not necessarily made on the same heat as that of the base plate.
IV.A.1	Acceptance standard of materials	--	--
IV.A.2.a	Calculated stress intensity factor	Yes	--

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TABLE 5.3-1a (Cont'd)

APPENDIX G PARA. NO.	TOPIC	COMPLY YES/NO OR N/A	ALTERNATE ACTIONS OR COMMENTS
IV.A.2.b	Requirements for nozzles, flanges and shell region near geometric discontinuities	No	Plus 60°F added to the RT_{NDT} for the reactor vessel flanges. For feedwater nozzles, the results of the BWR/6 analysis are adjusted to Limerick Unit 1 RT_{NDT} conditions.
IV.A.2.c	RPV metal temperature requirement when core is critical	No	Regulation change in process (See LTR NEDO-21778A)
IV.A.2.d	Minimum permissable temperature during hydro test	Yes	
IV.A.3	Materials for piping, pumps, and valves	No	See Section 5.2.3.3.1.
IV.A.4	Materials for bolting and other fasteners	Yes	Meet requirements for closure studs at 10°F
IV.B	Minimum upper shelf energy for RPV beltline	No	No upper shelf tests run. However, recommend acceptance based on lowest CVN for plate of 45 ft-lb (L) at +40°F with 50% shear and Cu of 0.11 to 0.12% which by Regulatory Guide 1.99 indicates shelf decrease of only 14%. Lowest CVNs for welds are 35 ft-lb and 50% shear of +10°F, and 31 ft-lb and 30% shear at +10°F with Cu of 0.02 to 0.09% which by Regulatory Guide 1.99 indicates shelf decrease of only 11%. End-of-life upper shelf values (100% shear) are predicted to be in excess of 50 ft-lb based on the preceding data. Upper shelf tests will be run on surveillance specimens to verify adequacy.
IV.C	Requirement for annealing when RT_{NDT} >200°F	NA	
V.A	Requirements for material surveillance program	--	See Table 5.3-1b
V.B	Conditions for continued operation	Yes	Meet requirements of IV.A.2
V.C	Alternative if V.B. cannot be satisfied	NA	
V.D	Requirement for RPV thermal annealing if V.C. cannot be met	NA	

TABLE 5.3-1a (Cont'd)

APPENDIX G PARA. NO.	TOPIC	COMPLY YES/NO OR N/A	ALTERNATE ACTIONS OR COMMENTS
V.E	Reporting requirement for V.C and V.D	NA	

References

(1) Letter MFN-414-77, G.G. Sherwood (GE) to Edson G. Case (NRC) dated October 17, 1977.
(2) Letter, Robert B. Minogue (NRC) to G.G. Sherwood (GE) dated February 14, 1978.

TABLE 5.3-1b

APPENDIX H MATRIX FOR LIMERICK 1

APPENDIX H PARA. NO.	TOPIC	COMPLY YES/NO OR N/A	ALTERNATE ACTIONS OR COMMENTS
I	Introduction	NA	
II.A	Fluence $<10^{17}$ n/cm² - surveillance program not required	NA	
II.B	Standards requirements (ASTM) for surveillance	No	Noncompliance with ASTM E185-73 in that the surveillance specimens are not necessarily from the limiting beltline material. Specimens are from representative beltline material, however, and can be used to predict behavior of the limiting material. Heat and heat/lot numbers for surveillance specimens are to be supplied.
II.C.1	Surveillance specimen is taken from locations alongside the fracture test specimens (Section III.B of Appendix G)	No	Noncompliance in that specimens are not necessarily taken from alongside specimens required by Section III of Appendix G and transverse CVNs are employed. However, representative materials are used, and RT_{NDT} shift appears to be independent of specimen orientation.
II.C.2	Locations of surveillance capsules in RPV	Yes	Code basis is used for the attachment of brackets to vessel cladding. See Section 5.3.1.6.4.
II.C.3.a	Withdrawal schedule of capsules, $RT_{NDT} \leq 100°F$	Yes	Three capsules planned. Starting RT_{NDT} of limiting material is based on alternative action (see paragraph III.A of Appendix G).
II.C.3.b	Withdrawal schedule of capsules, $100 < RT_{NDT} \leq 200°F$	NA	
II.C.3.c	Withdrawal schedule of capsules, $RT_{NDT} > 200°F$	NA	
III.A	Fracture toughness testing requirements of specimens	No	CVN tests only
III.B	Method of determining adjusted reference temperature for base metal, HAZ and weld metal	No	II.B and II.C.1 above
IV.A	Reporting requirements of test results	Yes	
IV.B	Requirement for dosimetry measurement	Yes	

TABLE 5.3-1b (Cont'd)

APPENDIX H PARA. NO.	TOPIC	COMPLY YES/NO OR N/A	ALTERNATE ACTIONS OR COMMENTS
IV.C	Reporting requirements of pressure/temperature limits	Yes	

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TABLE 5.3-2a

APPENDIX G MATRIX FOR LIMERICK UNIT 2

APPENDIX G PARA. NO.	TOPIC	COMPLY YES/NO OR N/A	ALTERNATE ACTIONS OR COMMENTS
I,II	Introduction; definitions	--	
III.A	Compliance with ASME Code, Section NB-2300	Yes	See Section 5.3.1.5.1.2 for discussion
III.B.1	Location and orientation of impact test specimens	Yes	See III.A, above.
III.B.2	Materials used to prepare test specimens	No	Compliance except for CVN orientation and CVN upper shelf
III.B.3	Calibration of temperature, instrumentation, and Charpy test machines	No	Paragraph NB-2360 of the ASME B&PV Code Section III was not in existence at the time of purchase of the Limerick Unit 2 RPV. However, the requirements of the 1971 edition of the ASME B&PV Section III Code, Summer 1971 Addenda, were met. For the discussions of the GE interpretations of compliance and NRC acceptance see Refs 1 and 2. The temperature instruments and Charpy test machines calibration data are retained until the next recalibration. This is in accordance with Reg Guide 1.88 Rev 2, GE Alternative Position 1.88 (see Section 1.8) and ANSI N45.2.9, 1974. Therefore, the instrument calibration data for Limerick Unit 2 are not currently available.
III.B.4	Qualification of testing personnel	No	No written procedures were in existence as now required by the regulation; however, the individuals were qualified by on-the-job training and past experience. For the discussion of the GE interpretation of compliance and NRC acceptance see Refs 1 and 2.
III.B.5	Test results recording and certification	Yes	See Refs 1 and 2.
III.C.1	Test conditions	No	See III.A, III.B.2, above.
III.C.2	Materials used to prepare test specimens for reactor vessel beltline	Yes	Compliance on base metal and weld metal tests. Test welds are not necessarily

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TABLE 5.3-2a (Cont'd)

APPENDIX G PARA. NO.	TOPIC	COMPLY YES/NO OR N/A	ALTERNATE ACTIONS OR COMMENTS
			made on the same heat as the base plate.
IV.A.1	Acceptance standard of materials	--	
IV.A.2.a	Calculated stress intensity factor	Yes	
IV.A.2.b	Requirements for nozzles, flanges, and shell region near geometric discontinuities	No	Plus 60°F was added to the RT_{NDT} for the reactor vessel flanges. For feedwater nozzles the results of the BWR/6 analysis were adjusted to Limerick Unit 2 PT_{NDT} conditions.
IV.A.2.c	RPV metal temperature requirement when core is critical	No	Regulation change in process (see ITR NEDO-21778A).
IV.A.2.d	Minimum permissible temperature during hydro test	Yes	
IV.A.3	Materials for piping, pumps, and valves	No	See Section 5.2.3.3.1.
IV.A.4	Materials for bolting and other fasteners	Yes	See Section 5.2.3.3.1.1 for discussion
IV.B	Minimum upper shelf energy for RPV beltline	No	No upper shelf tests run. However, recommend acceptance based on lowest CVN for plate of 61,35,37 ft-lb (50,30,30% shear), longitudinal, 0.14% Cu for heat B3416-1. Regulatory Guide 1.99 indicates only 14% shelf decrease; therefore, end-of-life upper shelf is estimated to be at least 50 ft-lb based on preceding CVN results at +40°F. Lowest CVN's for welds are 28 ft-lb (no % shear records), for 0.03% Cu, at +10°F; 35 ft-lb (50% shear), for 0.03% Cu, at +10°F; and 31 ft-lb (30% shear), for 0.04% Cu, at +10°F. End-of-life upper shelf values (100% shear) are predicted to be in excess of 50 ft-lb, based upon preceding data and Regulatory Guide 1.99.
IV.C	Requirement for annealing when $RT_{NDT} > 200°F$	NA	
V.A	Requirements for material surveillance program		See Table 5.3-2b
V.B	Conditions for continued operation	Yes	Meet requirements of IV.A.2

TABLE 5.3-2a (Cont'd)

APPENDIX G PARA. NO.	TOPIC	COMPLY YES/NO OR N/A	ALTERNATE ACTIONS OR COMMENTS
V.C	Alternative if V.B cannot be satisfied	NA	
V.D	Requirement for RPV thermal annealing if V.C cannot be met	NA	
V.E	Reporting requirement for V.C and V.D	NA	

References

1. Letter MFN-414-77, G.G. Sherwood (GE) to Edson G. Case (NRC) dated October 17, 1977.
2. Letter, Robert B. Minogue (NRC) to G.G. Sherwood (GE) dated February 14, 1978.

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TABLE 5.3-2b

APPENDIX H MATRIX FOR LIMERICK UNIT 2

APPENDIX H PARA. NO.	TOPIC	COMPLY YES/NO OR N/A	ALTERNATE ACTIONS OR COMMENTS
I	Introduction	NA	
II.A	Fluence $<10^{17}$ N/cm^2 - surveillance program not required	NA	
II.B	Standards requirements (ASTM) for surveillance	No	Noncompliance with ASTM E185-73 in that the surveillance specimens are not necessarily from the limiting belt-line material. Specimens are from representative beltline material, however, and can be used to predict behavior of the limiting material. Heat and heat/lot numbers for surveillance specimens are to be supplied.
II.C.1	Surveillance specimens are taken from locations alongside the fracture test specimens (Section III.B of Appendix G)	No	Noncompliance in that specimens are not necessarily taken from alongside specimens required by Section III of Appendix G and transverse CVNs are not employed. However, representative materials are used, and RT_{NDT} shift appears to be independent of specimen orientation.
II.C.2	Locations of surveillance capsules in RPV	Yes	Code basis is used for the attachment of brackets to vessel cladding. See Section 5.3.1.6.4.
II.C.3.a	Withdrawl schedule of capsules, $RT_{NDT} \le 100°F$	Yes	Three capsules planned. Starting RT_{NDT} of limiting material is based on alternative action (see paragraph III.A of Appendix G).
II.C.3.b	Withdrawl schedule of capsules, $100 < RT_{NDT} \le 200°F$	NA	
II.C.3.C	Withdrawl schedule of capsules, $RT_{NDT} > 200°F$	NA	
III.A	Fracture toughness testing requirements of specimens	No	CVN tests only
III.B	Method of determining adjusted reference temperature for base metal, HAZ, and weld metal	No	II.B and II.C.1 above
IV.A	Reporting requirements of test results	Yes	

TABLE 5.3-2b (Cont'd)

APPENDIX H PARA. NO.	TOPIC	COMPLY YES/NO OR N/A	ALTERNATE ACTIONS OR COMMENTS
IV.B	Requirements for dosimetry measurement	Yes	
IV.C	Reporting requirements of pressure/temperature limits	Yes	

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TABLE 5.3-3 LIMERICK 1 BELTLINE PLATE TOUGHNESS DATA

SHELL COURSE	HEAT #/ SLAB #	NDT (°F)	ORIENTATION[1]	CHARPY TEST TEMP. (°F)	ENERGY (FT-LB.)			LAT. EXPANSION (MILS.)			% SHEAR		
NO. 1													
I.D. 14-1	C7688-1	TOP -10	L	+40	84	78	58	62	48	64	40	50	50
		BOTTOM -10	L	+40	78	58	85	78	58	85	40	50	50
I.D. 14-3	C7688-1	TOP -10	L	+40	69	84	79	75	67	58	50	50	50
		BOTTOM -10	L	+40	104	90	86	66	72	78	70	70	70
I.D. 14-2	C7698-2	TOP -10	L	+40	77	88	73	75	66	52	50	50	70
		BOTTOM -10	L	+40	100	98	87	79	72	64	50	60	60
NO. 2													
I.D. 17-3	C7698-1	TOP -10	L	+40	82	84	84	61	63	61	50	50	50
		BOTTOM -10	L	+40	85	96	80	69	63	66	50	50	50
I.D. 17-1	C7689-1	TOP -10	L	+40	87	93	77	73	69	62	50	60	60
		BOTTOM -10	L	+40	75	86	81	61	71	78	50	60	60
I.D. 17-2	C7677-1	TOP -10	L	+40	71	71	61	52	48	56	40	40	40
		BOTTOM -10	L	+40	71	45	65	54	58	55	40	50	50

(1) Longitudinal or transverse

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PCY:rm:csc/A05122*-1
6/3/83

TABLE 5.3-4 BELTLINE WELD TOUGHNESS DATA

BELTLINE SHOP WELD TOUGHNESS DATA[(1)]

IDENTITY	PROCESS	HEAT NO.	FLUX LOT	CV TEMP.(°F)	ABSORBED ENERGY (FT-LBS)			LATERAL EXP. (MILS)			% SHEAR		
N17-Nozzle	SMAW	07L669	K004A27A	+10	50	50	54	44	44	46	50	60	40
Weld B-E N-17 Nozzle	SMAW	411A3531	H004A27A	+10	60	60	68	51	52	54	60	50	60
Welds B-A B-D, B-E, B-F	SMAW	06L165	F017A27A	+10	60	61	62	40	52	46	70	60	70
N-17 Nozzle	SMAW	401Z9711	A022A27A	+10	98	99	104	70	69	73	80	70	80
Welds B-A B-D, B-E, B-F, N-17 Nozzle	SMAW	662A746	H013A27A	+10	35	38	47	35	31	43	50	50	50
Welds B-A, B-B, B-C, N-17 Nozzle	SAW	3P4000	3932-989	+10	97	95	88	85	82	64	88	88	70
Weld B-F N-17 Nozzle	SAW	S3986	Run #934	+10	46	51	49	38	44	43	40	40	40
Weld B-A, B-D, B-E	SAW	1P4218	3929-989	+10	98	100	102	72	65	83	82	65	83
				+10	94	91	90	58	66	77	98	95	95
Surveillance Test Plate Weld	SAW	421A6811	F022A27A	+10	80	85	91	64	73	72	70	75	75

(1) This table is complemented by Table 5.3-5.

PCY:rm/A05122*-2
5/17/83

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TABLES 5.3-4 BELTLINE WELD TOUGHNESS DATA

BELTLINE FIELD WELD TOUGHNESS DATA

Test No.:	983
Trade Name:	Atom Arc 8018 NM
Diameter Size:	1/8"
	1,400 LBS
Lot Number:	B101/427A
Heat Number:	07L857

CHEMICAL TEST RESULTS

Carbon:	.060
Manganese:	1.20
Nickel:	.97
Silicon:	.42
Molybdenum:	.55
Copper:	.03
Phosphorus:	.012
Sulfur:	.017

MECHANICAL TEST RESULTS

Test Specimen PW ht @ 1100°F to 1150°F for 62 1/2 hrs.

TENSILE PROPERTIES

Specimen Type: .505"
UTS: 89,000 psi
YKP: 76,000 psi
Elongation in 2 inches: 30%
Red of Area: 71.7%

IMPACT PROPERTIES

Specimen Type: Charpy V-Notch
Test Temp: +10°F
Energy (Ft.-lbs.): 28, 36, 39
Lateral Expansion (mils): 27, 41, 45
% Shear: 20, 40, 50

OTHER TESTS

Concentricity: 4%
Moisture @ 1800°F: 0.18%

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TABLE 5.3-4

BELTLINE FIELD WELD TOUGHNESS DATA (Cont'd)

Test No.:	38
Trade Name:	Atom Arc 8018NM
Diameter Size:	5/32"
	6,750 lbs.
Lot Number:	C115A27A
Heat Number:	402C4371

MECHANICAL TESTS

Test Specimen PW @ 1100°F to 1150°F for 62 1/2 hrs

TENSILE PROPERTIES

Specimen Type: .505"
UTS: 94,000 psi
YLP: 87,000 psi
Elongation in 2 inches: 26%
Red of Area: 71.3%

CHEMICAL TEST RESULTS

Carbon:	.033
Manganese:	1.22
Nickel:	.92
Silicon:	.49
Molybdenum:	.57
Copper:	.02
Phosphorus:	.009
Sulfur:	.014

IMPACT PROPERTIES

Specimen Type Charpy V-Notch
Test Temp: +10°F
Energy (ft-lbs.): 82, 81, 92
Lateral Expansion (mils): 62, 61, 66
% Shear Area: 80, 70, 70

OTHER TESTS

Concentricity: 5%
Moisture @ 1800°F: 0.18%

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TABLE 5.3-4

BELTLINE FIELD WELD TOUGHNESS DATA (Cont'd)

Test No.:	WO #11-D
Type Electrode:	E8018NM
Trade Name:	Atom Arc 8018NM
Electrode Diameter:	3/16"
Lot Number:	H004A27A
Heat Number:	411A3531

MECHANICAL TESTS

Heat Treatment 1100-1150°F for 62 1/2 hrs.

TENSILE PROPERTIES

Specimen Type: .505"
UTS: 84,500 psi
YLP: 71,500 psi
Elongation in 2 inches: 29%
Red of Area: 72.5%

CHEMICAL TEST RESULTS

Carbon:	.066
Manganese:	1.13
Nickel:	.96
Silicon:	.51
Molybdenum:	.47
Copper:	.02
Phosphorus:	.018
Sulfur:	.017

IMPACT PROPERTIES

Specimen Type: Charpy V-Notch
Test Temperature: -20°F
Energy (Ft.-Lbs.): 41, 68, 48
Lateral Expansion (mils): 39, 53, 41
% Shear: 35, 35, 25

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TABLE 5.3-4

BELTLINE FIELD WELD TOUGHNESS DATA (Cont'd)

Test No.: 27

Trade Name: Atom Arc 8018NM

Diameter Size: 7/32"

13,800 lbs

Lot Number: C109A27A

Heat Number: 09M057

CHEMICAL TEST RESULTS

Carbon:	.063
Manganese:	1.18
Nickel:	.89
Silicon:	.47
Molybdenum:	.53
Copper:	.03
Phosphorus:	.009
Sulfur:	.021

MECHANICAL TESTS

Test Specimen PW ht @ 1100°F to 1150°F for 62 1/2 hrs

TENSILE PROPERTIES

Specimen Type: .505"

UTS: 94,500 psi

YLP: 85,000 psi

Elongation in 2 inches: 27%

Red of Area: 69.8%

IMPACT PROPERTIES

Specimen Type: Charpy V-Notch

Test Temp: +10°F

Energy (Ft.-lbs): 43, 43, 44

Lateral Expansion (mils): 40, 41, 41

% Shear: 50, 60, 50

OTHER TESTS

Concentricity: 4%

Moisture @ 1800°F: 0.18%

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TABLE 5.3-4

BELTLINE FIELD WELD TOUGHNESS DATA (Cont'd)

Test No.:	346
Trade Name:	Atom Arc 8018NM
Diameter Size:	3/16"
	7,950 lbs.
Lot Number:	J417B27AF
Heat Number:	412P3611

MECHANICAL TESTS

Stress relieved 50 hrs @ 1150°F

TENSILE PROPERTIES

UTS: 87,500 psi

YLP: 75,000 psi

Elongation in 2 inches: 28%

Red of Area: 71.2%

CHEMICAL TEST RESULTS

Carbon:	.07
Manganese:	1.10
Chromium:	.03
Nickel:	.93
Silicon:	.36
Molybdenum:	.47
Copper:	.03
Phosphorus:	.016
Sulfur:	.019
Vanadium	.02
Aluminum	<.01

IMPACT PROPERTIES

See next page for impact values

OTHER TESTS

Concentricity: 3%

Moisture @ 1800°F: 0.2%

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TABLE 5.3-4

BELTLINE FIELD WELD TOUGHNESS DATA (Cont'd)

DROP WEIGHT TESTS	SPECIMEN	TEST TEMPERATURE (°F)	RESULTS
MATERIAL: 8018 NM LOT: J417B27AF	1	-90	Break
	2	-80	No Break
	3	-70	No Break
	4	-70	No Break

NDT TEMPERATURE = -80°F

CVN IMPACT TESTS

SPECIMEN	TEST TEMPERATURE (°F)	ENERGY (FT. LBS)	LATERAL EXPANSION (MILS)	% SHEAR
1	-100	8	6	3
2	-100	12	10	5
3	-80	15	13	10
4	-80	16	14	10
5	-80	19	15	10
6	-20	52	41	30
7	-20	65	54	50
8	-20	69	53	45
9	+40	100	80	90
10	+40	103	68	80
11	+72	133	91	90
12	+72	138	92	90
13	+130	136	89	100
14	+130	137	95	100
15	+130	146	97	100

T_{CV} = -20°F

REFERENCE TEMPERATURE

Material	T_{NDT} (Drop Weight)	T_{CV} (Charpy V-Notch)	RT_{NDT} (References)
Weld Metal	-80°F	-20°F	-80°F

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TABLE 5.3-4

BELTLINE FIELD WELD TOUGHNESS DATA (Cont'd)

Test No.: 46
Trade Name: Atom Arc 8018NM
Diameter Size: 3/16"
7,900 lbs.
Lot Number: C118A27A
Heat Number: 03M014

CHEMICAL TEST RESULTS

Carbon:	.041
Manganese:	1.23
Nickel:	.94
Silicon:	.53
Molybdenum:	.58
Copper:	.01
Phosphorus:	.012
Sulfur:	.015

MECHANICAL TEST RESULTS

Test Specimen PW ht @ 1100°F to 1150°F for 62 1/2 hrs

TENSILE PROPERTIES

Specimen Type: .505"
UTS: 92,500 psi
YLP: 82,500 psi
Elongation in 2 inches: 26%
Red of Area: 69.5%

IMPACT PROPERTIES

Specimen Type: Charpy V-Notch
Test Temp: +10°F
Energy (Ft.-lbs.): 42, 44, 47
Lateral Expansion (mils): 37, 37, 51
% Shear: 40, 40, 40

OTHER TESTS

Concentricity: 5%
Moisutre @ 1800°F: 0.16%

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TABLE 5.3-4

BELTLINE FIELD WELD TOUGHNESS DATA (Cont'd)

Test No.:	242
Trade Name:	Atom Arc 8018NM
Diameter Size:	1/8"
	2,100 lbs.
Lot Number:	S411B27AD
Heat Number:	L83355

CHEMICAL TEST RESULTS

Carbon:	.07
Manganese:	1.25
Chromium:	.03
Nickel:	1.08
Silicon:	.38
Molybdenum:	.53
Copper:	.03
Phosphorus:	.017
Sulfur:	.018
Vanadium	.02
Aluminum	<0.01

MECHANICAL TEST RESULTS

Stress relieved 50 hrs @ 1150°F

TENSILE PROPERTIES

UTS: 87,600 psi

YLP: 77,900 psi

Elongation in 2 inches: 25%

Red of Area: 71.4%

IMPACT PROPERTIES

See next page for impact values

OTHER TESTS

Concentricity: 5%

Moisture @ 1800°F: 0.2%

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TABLE 5.3-4

BELTLINE FIELD WELD TOUGHNESS DATA (Cont'd)

DROP WEIGHT TESTS	SPECIMEN	TEST TEMPERATURE (°F)	RESULTS
MATERIAL: 8018 NM	1	-90	Break
LOT: S411B27AD	2	-80	No Break
	3	-80	No Break

NDT TEMPERATURE = -90°F

CVN IMPACT TESTS

SPECIMEN	TEST TEMPERATURE (°F)	ENERGY (FT.LBS)	LATERAL EXP. (MILS)	% SHEAR
1	-105	7	6	5
2	-105	8	7	5
3	-90	19	11	8
4	-90	21	11	10
5	-90	21	13	10
6	-30	27	25	25
7	-30	30	24	25
8	-30	34	29	25
9	-20	31	26	30
10	-20	36	29	30
11	-20	45	37	30
12	-10	51	39	40
13	-10	52	37	40
14	-10	63	52	50
15	+40	112	83	80

T_{CV} = -10°F

REFERENCE TEMPERATURE

Material	T_{NDT} (Drop Weight)	T_{CV} (Charpy V-Notch)	RT_{NDT} (References)
Weld Metal	-90°F	-10°F	-70°F

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TABLE 5.3-4

BELTLINE FIELD WELD TOUGHNESS DATA (Cont'd)

Test No.:	374
Trade Name:	Atom Arc 8018NM
Diameter Size:	5/32"
	2,000 lbs
Lot Number:	J424B27AE
Heat Number:	640892

MECHANICAL TEST RESULTS

Stress relieved 50 hrs @ 1150°F

TENSILE PROPERTIES

UTS: 90,000 psi

YLP: 76,500 psi

Elongation in 2 inches: 27%

Red of Area: 71%

CHEMICAL TEST RESULTS

Carbon:	.08
Manganese:	1.20
Chromium:	.014
Nickel:	1.00
Silicon:	.44
Molybdenum:	.55
Copper:	.09
Phosphorus:	.015
Sulfur:	.018
Vanadium:	.02
Aluminum:	.02

IMPACT PROPERTIES

See next page for impact values

OTHER TESTS

Concentricity: 3%

Moisture @ 1800°F: 0.2%

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TABLE 5.3-4

BELTLINE FIELD WELD TOUGHNESS DATA (Cont'd)

DROP WEIGHT TESTS	SPECIMEN	TEST TEMPERATURE (°F)	RESULTS
MATERIAL: 8018 NM LOT: J424B27AE	1	-70	Break
	2	-60	No Break
	3	-60	No Break

NDT TEMPERATURE = -70°F

CVN IMPACT TESTS

SPECIMEN	TEST TEMPERATURE (°F)	ENERGY (FT.LBS)	LATERAL EXP. (MILS)	% SHEAR
1	-108	14	3	3
2	-108	16	3	3
3	-70	15	8	5
4	-70	20	9	10
5	-70	27	15	10
6	-10	38	26	30
7	-10	42	31	30
8	-10	45	31	30
9	0	55	38	35
10	0	62	44	40
11	0	62	48	40
12	+40	56	42	50
13	+40	75	55	60
14	+130	118	87	100
15	+130	122	89	100
16	+130	130	82	100

T_{cv} = -10°F

REFERENCE TEMPERATURE

Material	T_{NDT} (Drop Weight)	T_{CV} (Charpy V-Notch)	RT_{NDT} (References)
Weld Metal	-70°F	0°F	-60°F

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TABLE 5.3-4

BELTLINE FIELD WELD TOUGHNESS DATA (Cont'd)

Test No.:	261
Trade Name:	Atom Arc 8018NM
Diameter Size:	7/32"
	2,400 lbs
Lot Number:	S419B27AG
Heat Number:	401P6741

MECHANICAL TEST RESULTS

Stress relieved 50 hrs @ 1150°F

TENSILE PROPERTIES

UTS: 85,000 psi

YLP: 78,000 psi

Elongation in 2 inches: 30%

Red of Area: 73%

CHEMICAL TEST RESULTS

Carbon:	.06
Manganese:	1.16
Chromium:	.03
Nickel:	.92
Silicon:	.34
Molybdenum:	.47
Copper:	.03
Phosphorus:	.013
Sulfur:	.014
Vanadium:	.02
Aluminum:	<0.01

IMPACT PROPERTIES

See next page for impact values

OTHER TESTS

Concentricity: 3%

Moisture @ 1800°F: 0.2%

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TABLE 5.3-4
BELTLINE FIELD WELD TOUGHNESS DATA (Cont'd)

DROP WEIGHT TESTS	SPECIMEN	TEST TEMPERATURE (°F)	RESULTS
MATERIAL: 8018 NM	1	-70	Break
LOT: S419B27AG	2	-60	No Break
	3	-60	No Break

NDT TEMPERATURE = -70°F

CVN IMPACT TESTS

SPECIMEN	TEST TEMPERATURE (°F)	ENERGY (FT.LBS)	LATERAL EXP. (MILS)	% SHEAR
1	-90	13	8	5
2	-90	14	8	5
3	-70	11	12	10
4	-70	13	14	8
5	-70	16	16	15
6	-10	31	24	25
7	-10	44	30	30
8	-10	76	57	40
9	0	51	37	45
10	0	57	44	40
11	0	68	50	40
12	+40	83	61	50
13	+40	100	80	70
14	+130	136	93	100
15	+130	139	94	100
16	+130	146	94	100

T_{cv} = 0°F

REFERENCE TEMPERATURE

Material	T_{NDT} (Drop Weight)	T_{CV} (Charpy V-Notch)	RT_{NDT} (References)
Weld Metal	-70°F	0°F	-60°F

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TABLE 5.3-4

BELTLINE FIELD WELD TOUGHNESS DATA (Cont'd)

Test No.:	CN-165
Electrode Specification:	WMS-444F, Rev. 1
Electrode Type:	CBI 1NMM
Trade Name:	Raco 1NMM
Electrode Diameter:	3/32"
Heat Number:	5P6756

MECHANICAL TEST RESULTS

Heat Treatment: 1150°F for 50 hrs

TENSILE PROPERTIES

Specimen Type: .505"

UTS: 90,500 psi

YLP: 84,000 psi

Elongation in 2 inches: 25%

Red of Area: 64.1%

CHEMICAL TEST RESULTS

Carbon:	.13
Manganese:	1.89
Chromium	.08
Nickel:	.96
Silicon:	.07
Molybdenum:	.48
Copper:	.08
Phosphorus:	.008
Sulfur:	.012
Vanadium:	.006
Aluminum:	.02

IMPACT PROPERTIES

Specimen Type: Charpy V-Notch

Orientation: Perpendicular to weld direction

See next page for impact values

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TABLE 5.3-4
BELTLINE FIELD WELD TOUGHNESS DATA (Cont'd)

DROP WEIGHT TESTS	SPECIMEN	TEST TEMPERATURE (°F)	RESULTS
MATERIAL: CBI 1NMM HEAT: 5P6756	1	-40	No Break
	2	-60	Break
	3	-50	No Break
	4	-50	No Break

NDT TEMPERATURE = -60°F

CVN IMPACT TESTS (@ 1/2T LOCATION)

SPECIMEN	TEST TEMPERATURE (°F)	ENERGY (FT.LBS)	LATERAL EXP (MILS)	% SHEAR
1	-20	97	60	60
2	-20	115	75	75
3	-20	105	45	70
4	-20	107	74	65
5	-20	94	65	65
6	0	134	55	100
7	0	121	78	100
8	0	124	75	100

T_{CV} = 0°F

REFERENCE TEMPERATURE

Material	T_{NDT} (Drop Weight)	T_{CV} (Charpy V-Notch)	RT_{NDT} (References)
Weld Metal	-60°F	0°F	-60°F

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PCY:hmm:csc/D05171*
5/18/83

TABLE 5.3-5

LIMERICK 1 BELTLINE PLATE AND WELDS EOL RT_{NDT}

(PEAK EOL FLUENCE = 1.1×10^{18} n/cm² @ ¼T)

A. Plates

I.D.	Heat	Wt % Cu	Wt % P	Wt % Ni	ASME NB-2300 Start RT_{NDT} (°F)	R.G. 1.99 Extrap. ΔRT_{NDT} (°F)	Estimated EOL RT_{NDT} (°F)
14-1	C7688-1	.12	.011	.51	+10	32	42
14-2	C7698-2	.11	.010	.48	+10	27	37
14-3	C7688-2	.12	.011	.51	+10	32	42
17-1(1)	C7689-1	.11	.007	.48	+10	23	33
17-2	C7677-1	.11	.016	.50	+20	36	56(3)
17-3	C7698-1	.11	.010	.48	+10	26	36

B. Welds

1. Shop Welds (i.e., Vertical Seams)

Heat/Lot	Seams Used In	Wt % Cu	Wt % P	ASME NB-2300 Start RT_{NDT} (°F)	R.G. 1.99 Extrap. ΔRT_{NDT} (°F)	Estimated EOL RT_{NDT} (°F)
411A3531/ H004A27A	BE	.02	.018	-50	30	-20
06L165/ F017A27A	BA, BD BE, BF	.03	.021	-50	35	-15(3)
662A746/ H013A27A	BA, BD BE, BF	.03	.021	-20	35	+15
3P4000/(2) 3932-989	BC, BB BA	.02	.015	-50	25	-25
S3986/(2) Run #934	BF	.05	.019	-42	32	-10
1P 4218/(1)(2) 3929-989	BE, BA BB	.06	.010	-50	17	-33
421A6811/(1) F022A27A	Weld Test Plate	.09	.018	-50	33	-17

(1) - Surveillance Program Material
(2) - Submerged Arc Welding
(3) - The most limiting value

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PCY:rm/A05121*-10
6/3/83

TABLE 5.3-5 (Continued)

Heat/Lot	Wt % Cu	Wt % P	ASME NB-2300 Start RT_{NDT} (°F)	R.G. 1.99 Extrap. ΔRT_{NDT} (°F)	Estimated EOL RT_{NDT} (°F)
2. Field Welds (i.e., Girth)					
07L857/B101A27A	.03	.012	-6	20	+14
402C4371/C115A27A	.02	.009	-50	15	-35
411A3531/H004A27A	.02	.018	-50	30	-20
09M057/C109A27A	.03	.009	-32	15	-17
412P3611/J417B27AF	.03	.016	-80	27	-53
03M014/C118A27A	.01	.012	-34	20	-14
L83355/S411B27AD	.03	.017	-70	28	-42
640892/J424B27AE	.09	.015	-60	28	-32
401P6741/S419B27AG	.03	.013	-60	23	-37
5P6756/	.08	.008	-60	13	-47
3. LPCI Nozzle Welds(3)					
07L669/K004A27A	.03	.014	-50	23	-27
401Z9711/A022A27A	.02	.021	-50	35	-15
411A3531/H004A27A					
662A746/H013A27A					
3P4000/3932-989		Data Previously Provided Under "Shop" Welds			
53986/Run #934					

(3) The shell plate and weld are subjected to fluence level in excess of 10^{17} n/cm^2; see Note (1) of Table 5.3-11.

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PCY: rm/A05121*-11
5/19/83

TABLE 5.3-6 LIMERICK 1 TYPICAL BELTLINE PLATE (SURVEILLANCE PLATE)

Mill Order No: 27265-1

Requirements: SA-533 GR. B. Class 1

Melt No: 7689

TEST RESULTS CHEMICAL (Wt%)

Carbon	0.20
Manganese	1.33
Nickel	0.48
Silicon	0.23
Molybdenum	0.48
Phosphorous	0.007
Sulfur	0.014

MECHANICAL TEST RESULTS

Tensile Properties

UTS: 84,600 psi
85,100 psi

YLP: 63,900 psi
64,400 psi

% Elongation in 2": 26
28

Impact Properties

Specimen Type: Charpy V-Notch
Test Temp: +40°F
Energy (Ft-lb): 87, 93, 77
75, 86, 81
Lateral Exp. (mils): 73, 69, 62
61, 71, 78

% Shear: 50, 60, 60
50, 60, 60

Dropweight Test

TEST TEMP (°F)	TOP/BOTTOM RESULTS
+30	1 No Break
+20	1 No Break
+10	1 No Break
0	2 No Break
-10	1 Break
-20	1 Break
-30	1 Break

NDT=-10°F

PCY:pc/L05183
5/18/83

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TABLE 5.3-6 (Cont.)

Test Location

Drop Weights - Top and Bottom - Longitudinal
Bend - Top Middle - Tranverse
Tensions - Top and Bottom - Transverse
Impacts - Top and Bottom - Longitudinal
Tests 1/4T from rolled surface
No closer than "T" from quenched and tempered edge

Specification
A.S.M.E SA-533 Gr. B CL-1 Pressure Vessel Quality

Ultrasonic Testing
per Procedure LS-U.T.-4

Heat Treatment
Procedure LS-102 Rev. 5

Plates
Austenitized at 1650° held 1/2 hr./inch. min., and water quenched
Tempered at 1260° held 1/2 hr./inch. min., and air cooled.
Stress relieved at 1075° held 1 hr. min. and air cooled.
Test coupons then cut from plate.

Tests only
Stress relieved @ 1150° held 50 hrs. and furnace cooled to below 600°F., then air cooled.

Maximum Heating Rate	Maximum Cooling Rate
100°F/hr.	100°F/hr.

Mechanical Property Requirements

Tensile:	80/100,000 psi
Yield:	50 min. .2% offset
Elong:	18% in 2" min.
Impacts:	30 ft.-lbs @ + 40°F. Lateral Expansion and % Shear Fracture for information only.
Drop Weights:	Type P-3 specimens with a NDT temperature no higher than +40°F.
Grain Size:	Final Plate Grain Size #5 or finer determined on a fully heat-treated test coupon.

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PCY:csc/I05182-1

Table 5.3-7

SA-533 GRADE B, CLASS 1 PLATE
TOUGHNESS DATA BASE INCLUDING UPPER SHELF
(VENDOR- LUKENS STEEL CO.)

PLANT A

Heat No.	NDT (°F)	Charpy Temp (°F)	Orient. (L or T)	Energy (ft-lbs)	Lateral Expansion (mils)	% Shear
C5978-1	+10	-40	L	7.0, 7.0, 11.0	5, 3, 7	0, 0, 0
		+10		25.0, 33.0, 30.0	23, 25, 23	10, 10, 10
		+40		53.0, 48.0, 48.0	40, 35, 36	20, 20, 20
		+110		118.0, 116.0, 109.0	79, 76, 74	80, 80, 80
		+160		123.0, 136.0, 136.0	82, 84, 84	90, 95, 95
C5978-2	-10	-40	L	22.0, 24.0, 24.0	17, 18, 19	0, 0, 0
		+10		49.0, 46.0, 42.0	38, 36, 33	25, 25, 25
		+40		62.0, 60.0, 41.0	46, 44, 34	35, 35, 25
		+110		98.0, 90.0, 100	73, 67, 75	80, 70, 80
		+160		119.0, 120.0, 118.0	88, 86, 82	99, 100, 100
C5979-1	-10	-40	L	9.0, 11.0, 19.0	5, 7, 13	0, 0, 0
		+10		61.0, 57.0, 43.0	45, 41, 32	30, 30, 20
		+40		73.0, 92.0, 65.0	51, 63, 43	35, 45, 35
		+110		117.0, 116.0, 100.0	78, 76, 68	80, 80, 70
		+116		134.0, 136.0, 134.0	87, 86, 85	99, 99, 100
C6345-1	-40	-80	L	8, 6	4, 4	0, 0
		-40		29, 15, 23	21, 13, 16	5, 0, 1
		+10		109, 88, 77	76, 58, 56	50, 35, 35
		+40		103, 96, 122	68, 65, 77	45, 40, 60
		+110		147, 147	84, 82	100, 100
		+160		151, 165	87, 94	100, 100
C6318-1	-20	-40	L	25, 17, 14	18, 11, 9	1, 0, 0
		+10		80, 66, 72	57, 47, 50	35, 30, 30
		+40		85, 95, 112	64, 68, 75	40, 40, 50
		+110		126, 145, 117	81, 89, 76	90, 100, 90
		+160		140, 140, 139	86, 89, 88	100, 100, 100
C6345-2	-40	-80	L	10, 12	7, 9	0, 0
		-40		32, 16, 49	20, 11, 33	10, 0, 20
		+10		93, 94, 67	69, 66, 48	40, 40, 25
		+40		109, 125, 128	70, 72, 82	50, 60, 70
		+110		127, 165	81, 82	85, 100
		+160		153, 161	86, 88	100, 100

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Table 5.3-7

SA-533 GRADE B, CLASS 1 PLATE
TOUGHNESS DATA BASE, INCLUDING UPPER SHELF
(VENDOR- LUKENS STEEL CO.)

PLANT A

Heat No.	NDT (°F)	Charpy Temp (°F)	Orient (L or T)	Energy (ft-lbs)	Lateral Expansion (mils)	% Shear
C5979-2	-10	-80	L	8.0, 11.0	5, 9	0, 0
		-40		28.0, 17.0, 18.0	20, 16, 14	15, 10, 10
		+10		64.0, 63.0, 49.0	44, 44, 34	30, 30, 20
		+40		72.0, 76.0, 79.0	47, 49, 50	35, 35, 35
		+110		107.0, 102.0	77, 74	85, 80
		+160		134.0, 141.0	79, 83	100, 100
C5996-1	-10	-40	L	12.0, 53.0, 12.0	10, 20, 11	0, 15, 0
		+10		65.0, 60.0, 77.0	46, 42, 54	30, 30, 40
		+40		88.0, 113.0, 78.0	56, 70, 54	40, 60, 40
		+110		111.0, 126.0, 134.0	74, 85, 83	80, 90, 90
		+160		146.0, 148.0, 143.0	86, 89, 86	100, 100, 100
C6318-1		-40	T	7.5	5.0	1
		-10		32.5, 31.0	27.0, 28.5	5, 5
		+10		41.5, 42.0	36.0, 37.0	25, 25
		+40		31.5, 60, 49, 63	26.0, 44.0 34.0, 49.0	35, 30, 40, 40
		+61		70, 71.0	57.2, 57.5	50, 50
		+120		95	70.5	99
		+200		100.0, 91.0, 90.0	75.0, 63.5, 69.5	99, 100, 100

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TABLE 5.3-7
SA-533 GRADE B, CLASS 1 PLATE
TOUGHNESS DATA BASE, INCLUDING UPPER SHELF
(VENDOR- LUKENS STEEL CO.)

PLANT A

Heat No.	NDT (°F)	Charpy Temp (°F)	Orient. (L or T)	Energy (ft-lbs)	Lateral Expansion (mils)	% Shear
A5333-1	-10	-40	L	21, 13, 11	17, 11, 9	5, 0, 0
		+10		56, 67, 53	41, 47, 40	20, 30, 20
		+40		82, 100, 84	56, 70, 60	40, 50, 40
		+110		126, 120, 133	87, 81, 84	80, 80, 80
		+160		155, 155, 145	92, 90, 89	100, 100, 100
B-0078-1	-10	-40	L	10, 14, 25	10, 13, 21	0, 0, 5
		+10		73, 49, 70	54, 39, 53	40, 30, 40
		+40		94, 100, 100	65, 68, 70	60, 60, 60
		+110		118, 128, 140	82, 86, 89	90, 90, 100
		+160		151, 136, 143	90, 84, 88	100, 100, 100
C6123-2	-10	-80	L	11, 8	9, 7	0, 0
		-40		28, 38, 10	22, 28, 9	10, 10, 0
		+10		77, 60, 73	56, 45, 53	40, 35, 40
		+40		113, 108, 122	73, 71, 75	65, 60, 75
		+110		120, 149	89, 91	90, 100
		+160		149, 151	91, 93	100, 100
C5987-1	-10	-40	L	19, 13, 14	14, 10, 13	0, 0, 0
		+10		63, 55, 35	47, 41, 26	35, 35, 30
		+40		80, 99, 87	59, 68, 61	50, 70, 55
		+110		122, 134, 122	84, 86, 84	100, 100, 100
		+160		122, 134, 127	86, 86, 84	100, 100, 100
C5987-2	-10	-40	L	15.0, 8.0, 10.0	7, 7, 7	0, 0, 0
		+10		76.0, 79.0, 51.0	54, 59, 57	35, 35, 30
		+40		57.0, 76.0, 75.0	42, 57, 54	30, 35, 35
		+110		106.0, 102.0, 113.0	72, 68, 76	80, 80, 80
		+160		140.0, 133.0, 138.0	87, 81, 84	100, 100, 100
C6003-2	-10	-40	L	10, 7.0, 8.0	7, 4, 3,	0, 0, 0
		+10		37.0, 31.0, 51.0	28, 22, 37	20, 20, 30
		+40		65.0, 49.0, 50.0	44, 34, 36	35, 30, 30
		+110		81.0, 95.0, 82.0	60, 67, 61	60, 70, 60
		+160		121.0, 107.0, 120.0	82, 78, 87	100, 99, 100
C5996-2	-10	-80	L	7.0, 10.0	5, 8	0, 0
		-40		18.0, 25.0, 25.0	14, 20, 19	10, 10, 10
		+10		62.0, 71.0, 66.0	45, 50, 47	20, 30, 25
		+40		81.0, 100.0, 91.0	52, 71, 64	35, 50, 40
		+110		124.0, 130.0	83, 88	90, 90
		+160		149.0, 151.0	89, 91	100, 100

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TABLE 5.3-7
SA-533 GRADE B, CLASS 1 PLATE
TOUGHNESS DATA BASE, INCLUDING UPPER SHELF
(VENDOR- LUKENS STEEL CO.)

PLANT B

Heat No.	NDT (°F)	Charpy Temp (°F)	Orient (L or T)	Energy (ft-lbs)	Lateral Expansion (mils)	% Shear
C4882-1	-60	-80	L	16.0, 14.0	15, 11	0, 0
		-40		41.0, 32.0, 54.0	28, 22, 38	20, 20, 25
		+10		75.0, 68.0, 48.0	52, 49, 35	30, 30, 25
		+40		83.0, 95.0, 100.0	59, 65, 70	45, 50, 60
		+110		104.0, 116.0	75, 82	85, 90
		+160		130.0, 131.0	86, 84	100, 100
C4882-2	-40	-80	L	10.0, 7.0	10, 8	0, 0
		-40		46.0, 43.0, 30.0	36, 35, 26	10, 10, 10
		+10		75.0, 50.0, 66.0	58, 44, 52	30, 20, 20
		+40		90.0, 80.0, 88.0	71, 62, 63	40, 35, 40
		+110		120.0, 107.0	84, 82	85, 80
		+160		137.0, 129.0	94, 90	100, 100
C4882-2		-80	T	19.0	15.5	1
		-50		41.0, 25.0, 37.5	29.0, 16.5, 26.0	20, 10, 20
		-30		41.0, 40.0	30.0, 29.5	20, 20
		+10		61.0, 68.0	45.0, 49.5	30, 30
		+39		77.0, 71.0	54.0, 54.5	50, 30
		+70		91.0, 71.0	62.0, 53.0	75, 40
		+121		113.0	79.0	95
		+200		115.5, 113.5	82.5, 74.0	95, 95

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TABLE 5.3-7
SA-533 GRADE B, CLASS 1 PLATE
TOUGHNESS DATA BASE, INCLUDING UPPER SHELF
(VENDOR - LUKENS STEEL CO.)

PLANT C

Heat No.	NDT (°F)	Charpy Temp (°F)	Orient (L or T)	Energy (ft-lbs)	Lateral Expansion (mils)	% Shear
C9481-1	-30	+40	L	74, 74, 81	61, 58, 60	50, 50, 50
		+40		103, 61, 85	48, 66, 72	40, 50, 50
C9481-1		-40	T	17.0	15.0	5
		+10		23.5, 22.0	21.0, 20.5	10, 10
		+25		36.0	31.0	20-25
		+40		45.0, 35.0, 42.0	42.0, 34.2 38.0	30-35, 30, 30-35
		+51		40.5	35.0	30
		+70		51.0, 50.0	44.5, 42.5	40, 40
		+93		71.0	58.5	70
		+120		93.0	69.5	90-95
		+200		93.5, 100.0, 93.0	74.0, 72.0 69.0	95, 95, 95

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TABLE 5.3-7
SA-533 GRADE B, CLASS 1 PLATE
TOUGHNESS DATA BASE, INCLUDING UPPER SHELF
(VENDOR - LUKENS STEEL CO.)

PLANT D

Heat No.	NDT (°F)	Charpy Temp (°F)	Orient (L or T)	Energy (ft-lbs)	Lateral Expansion (mils)	% Shear
C4374-2	-30	-80	L	8.0, 16.0	6, 13	0, 0
		-40		34.0, 32.0, 27.0	25, 24, 20	10, 10, 5
		+10		48.0, 49.0, 60.0	36, 37, 43	15, 15, 20
		+40		76.0, 63.0, 69.0	56, 47, 51	30, 20, 25
		+110		98.0, 103.0	72, 76	95, 95
		+160		121.0, 119.0	85, 82	100, 100
C4374-2		-20	T	22.0	17.5	1
		+10		32.0, 35.0	22.5, 27.5	5, 5
		+40		50.0, 52.5	35.5, 41.5	10, 10
		+65		64.0, 55.0	47.0, 42.5	30, 30
		+102		75.0	60.5	50
		+119		108.0, 88	75.0, 66.0	100, 85
		+201		112.5	83.5	100
		+202		108.5	79.0	100

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TABLE 5.3-7

SA-533 GRADE B, CLASS 1 PLATE
TOUGHNESS DATA BASE, INCLUDING UPPER SHELF
(VENDOR - LUKENS STEEL CO.)

PLANT E

HEAT NO.	NDT (°F)	CHARPY TEMP (°F)	ORIENT (L OR T)	ENERGY (FT-LBS)	LATERAL EXPANSION (MILS)	% SHEAR
C9533-2	0/10	-50	L	7-12	7-4	1-1
		-30		9-7	7-4	1-1
		-20		9-14*/19-40*	11-7*/5-30*	10-10/20-20
		+10		34-26/45-47	28-23/36-35	20-20/30-30
		+70		48-64/70-76	48-40/57-60	40-40/40-40
		+100		82-62/82-71	53-65/63-61	60-60/60-60
		+130		72-68/92-86	60-57/72-69	60-60/80-80
		+212		88-81/110-99	75-73/87-81	99-99/99-99
C9570-2 (top)	-40	-70	L	6-4	5-4	1-1
		-50		10-13	20-20	10-10
		-20		14-27	23-14	20-20
		+10		30-42	29-39	30-30
		+70		70-64	56-54	40-40
		+100		76-79	64-63	60-60
		+212		106-108	66-81	90-90

*Top/Bottom

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TABLE 5.3-7

SA-533 GRADE B, CLASS 1 PLATE
TOUGHNESS DATA BASE, INCLUDING UPPER SHELF
(VENDOR - LUKENS STEEL CO.)

PLANT E

HEAT NO.	NDT (°F)	CHARPY TEMP (°F)	ORIENT (L OR T)	ENERGY (FT-LBS)	LATERAL EXPANSION (MILS)	% SHEAR
C9570-2 (Bottom)	-50	-70	L	5-7	3-5	1-1
		-40		12-12	16-18	10-10
		-20		36-45	30-36	20-20
		+10		35-46	29-34	30-30
		+40		48-56	47-49	50-50
		+70		79-81	74-75	70-70
		+100		90-110	70-82	80-80
		+130		114-112	86-85	99-99
C9570-1	-20/-10	-20	L	11-8*/13-12*	8-10*/12-12*	1-1/10-10
		-10		20-21/15-14	20-20/15-14	10-10/10-10
		+10		19-19/43-43	18-18/34-33	10-10/30-30
		+40		36-44	37-41	30-30
		+72		60-62/69-70	52-50/56-56	40-40/40-40
		+100		72-75/79-80	65-62/64-65	50-50/60-60
		+130		84-83/94-88	69-71/74-71	70-70/80-80
		+212		96-110/105-103	82-78/81-80	90-90/90-90

*Top/Bottom

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TABLE 5.3-8

UPPER SHELF TOUGHNESS FOR BELTLINE WELDS

PLANT A

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

Heat No/ Flux Lot	NDT (°F)	Charpy Temp (°F)	Wire(1) (S or T)	Energy (ft-lbs)	Expansion (mils)	% Shear
KN203/0171	-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
	-80	-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

(1) Single or Tandem

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TABLE 5.3-8

UPPER SHELF TOUGHNESS FOR BELTLINE WELDS (Continued)

PLANT A

E8018-G WELD ELECTRODE, SHIELDED METAL ARC
(TRADE NAME - ATOM ARC 8018 NM)
POST WELD 1150°F FOR 50 HRS TYPICAL

Heat No/ Flux Lot	NDT (°F)	Charpy Temp (°F)	Energy (ft-lbs)			Lateral Expansion (mils)			% Shear		
640967/ D502B27AF	-80	-105	13	14		4	4		5	5	
		-80	16	22	28	11	13	18	10	12	15
		-20	58	76	86	18	42	56	15	50	50
		+40	102	106	119	69	74	86	90	80	90
		+72	119	127		86	82		90	90	
		+130	130	140	150	90	92	80	100	100	100

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TABLE 5.3-8

UPPER SHELF TOUGHNESS FOR BELTLINE WELDS (Continued)

PLANT B

E8018-G WELD ELECTRODE, SHIELDED METAL ARC
(TRADE NAME - E8018 NM)
POST WELD 1150°F FOR 50 HRS TYPICAL

Heat No/ Flux Lot	NDT (°F)	Charpy Temp (°F)	Energy (ft-lbs)			Lateral Expansion (mils)			% Shear		
401P2871/ H430B27AF	-50	-90	7	10		7	11		3	5	
		-70	15	16	16	14	15	16	8	8	10
		-20	66	76	64	58	61	58	15	15	15
		-20	63	81		50	61		15	15	
		-10	27	39	54	25	35	46	35	35	35
		0	27	50	56	25	42	46	40	45	45
		+10	75	76	107	60	62	74	60	50	80
		+40	90	100		71	76		70	80	
		+130	130	140	142	91	94	93	100	100	100
402P3162/ H426B27AE	-70	-70	11	7	14	9	6	8	5	5	5
		-40	33	52	32	27	42	22	10	15	10
		-20	65	62	37	52	48	30	20	10	20
		-20	52	55		36	38		15	15	
		-10	60	54	53	44	37	--	40	30	30
		+40	96	99		57	68		60	60	
		+212	119	122	124	93	90	68	100	100	100

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PCY:rm/A051816*
5/18/83

TABLE 5.3-8

UPPER SHELF TOUGHNESS FOR BELTLINE WELDS (Continued)

PLANT B

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

Heat No/ Flux Lot	NDT (°F)	Charpy Temp (°F)	Wire (S or T)(2)	Energy (ft-lbs)			Expansion (mils)			% Shear		
5P7397/(1) 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	-70	S	20	34	27	16	32	22	5	5	5
		-10		54	50	59	47	47	53	25	20	20
		+10		65	59	69	60	56	65	50	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

(1) This material is in Plant B's vessel surveillance program.
(2) Single or Tandem

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TABLE 5.3-8

UPPER SHELF TOUGHNESS FOR BELTLINE WELDS (Continued)

PLANT C

E8018NM WELD ELECTRODE (TRADE NAME - ATOM ARC E8018NM)
SHIELDED METAL ARC
POST WELD 1150°F FOR 50 HRS TYPICAL

Heat No/ Flux Lot	NDT (°F)	Charpy Temp (°F)	Energy (ft-lbs)			Lateral Expansion (mils)			% Shear		
492L4871/ A421B27AE	-60	-108	10	11		5	4		4	4	
		-90	25	30	32	6	6	6	8	10	10
		-30	19	28	31	19	23	25	20	25	25
		-20	22	26	30	23	21	27	25	25	30
		-10	38	41	43	28	32	30	30	30	30
		0	50	51	57	36	38	40	30	40	45
		+40	135	137		84	80		90	80	
		+130	151	160	161	80	82	81	100	100	100
422K8511/ G313A27AD	-80	-90	14	17		15	16		5	5	
		-80	14	16	20	15	16	20	10	10	10
		-40	26	26	40	26	24	33	30	30	30
		-20	65	74	127	44	48	76	40	50	60
		+25	107	108		74	80		80	70	
		+40	125	125	140	84	89	82	100	100	90
		+50	153	143	156	95	81	91	90	80	90
		+68	153	143	165	85	96	91	100	100	100
640892/ J424B27AE	-60	-108	14	16		3	3		3	3	
		-70	15	20	27	8	9	15	5	10	10
		-10	38	42	45	26	31	31	30	30	30
		0	55	62	62	38	44	48	35	40	40
		+40	56	75		42	55		50	60	
		+130	118	122	130	87	89	82	100	100	100
40150371/ B504B27AE	-60	-60	42	45	23	35	36	20	5	5	5
		-20	61	84	77	48	66	62	30	25	25
		-20	68	67		51	52		25	25	
		0	80	85	82	63	62	60	35	50	35
		+40	95	97		71	76		40	75	
		+70	111	107	109	87	85	77	80	90	80
		+212	122	114	130	92	92	69	100	100	100
402P3162/ H426B27AE	-70	-70	11	7		9	6		5	5	
		-40	33	52	32	27	42	22	10	15	10
		-20	65	62	37	52	48	30	20	10	20
		-20	52	55		36	38		15	15	
		-10	60	54	68	44	37	53	40	30	30
		+40	96	99		57	68		60	60	
		+212	119	122	124	93	90	68	100	100	100

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TABLE 5.3-8

UPPER SHELF TOUGHNESS FOR BELTLINE WELDS (Continued)

PLANT C

E8018NM ELECTRODE (TRADE NAME - ATOM ARC E8018NM)
SHIELDED METAL ARC
POST WELD 1150°F FOR 50 HRS TYPICAL

Heat No/ Flux Lot	NDT (°F)	Charpy Temp (°F)	Energy (ft-lbs)			Lateral Expansion (mils)			% Shear		
401P2871/ H430B27AE	-50	-90	7	10		7	11		3	5	
		-70	15	16	16	14	15	16	8	8	10
		-10	27	39	54	25	35	46	35	35	35
		0	27	50	56	25	42	46	40	45	45
		+10	75	76	107	60	62	74	60	50	80
		+40	90	100		71	76		70	80	
		+130	130	140	142	91	94	93	100	100	100
07R458/ S403B27AG	-60	-70	9	9		7	7		5	5	
		-60	10	11	13	9	9	11	15	10	10
		0	59	61	70	51	52	58	50	50	60
		+40	99	101		77	78		80	75	
		+72	106	110		85	87		80	80	
		+130	129	131	132	81	78	81	100	100	100
03L048/ B525B27AF	-60	-105	8	9		2	3		3	3	
		-80	10	16	19	7	10	11	10	10	10
		-20	31	50	65	22	37	50	30	30	30
		-10	36	53	58	34	43	45	40	40	40
		0	61	75	79	44	58	59	50	60	60
		+40	104	108		75	77		80	80	
		+130	122	123	126	89	83	91	100	100	100
02R486/ J404B27AG	-70	-100	12	13		3	5		3	5	
		-90	16	17	19	6	8	7	8	8	10
		-30	17	30	31	15	24	23	15	20	20
		-20	41	42	44	33	34	35	30	30	30
		-10	52	64	66	39	45	46	40	40	40
		+40	84	87		63	68		60	60	
		+130	121	124	129	91	96	95	100	100	100
L83978/ J414B27AD	-80	-100	10	12		6	7		4	5	
		-80	14	15	24	10	12	18	10	10	12
		-20	51	52	81	37	40	63	35	50	40
		-20	64	63	69	51	47	55	15	15	15
		-20	67	56		53	45		15	10	
		+40	120	123		72	73		80	80	
		+72	128	140		78	81		90	90	
		+130	148	156	168	90	81	87	100	100	100

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TABLE 5.3-8

UPPER SHELF TOUGHNESS FOR BELTLINE WELDS (Continued)

PLANT C

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

Heat No/ Flux Lot	NDT (°F)	Charpy Temp (°F)	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 5.3-9

WELD PROCEDURE SPECIFICATION FOR VESSEL MATERIAL

REPRESENTATIVE OF LIMERICK 1 BELTLINE WELDS

(Note: This specification is extracted from the surveillance program of another BWR plant with similar beltline weld material.)

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 hours 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. P12B Subgroup 1

Shielding Gas: None

Backup Gas: None

Flux: Linde 124

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TABLE 5.3-9 (Cont'd)

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 temperature 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 turnoff 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

Shielded Metal Arc

Specification - SFA-5.5
Classification - E8018-G
Analysis - A3 (except Ni 0.50 to 1.25)
Usability - F4
Trade Name - Alloy Rods E8018NM

Electrical Characteristics

SMA - DCRP
Submerger Arc
Tandem Wire
Lead Wire - DCRP
Trail Wire - AC
Single Wire - DCRP

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TABLE 5.3-10

TYPICAL SURVEILLANCE PROGRAM WELD PROCEDURE FOR LIMERICK 1 & OTHER BWRs

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 (SW)	F (Sub Arc) F, V (SMA)	2 3/4" to 8"

Post Heat Treatment

Procedure qualified with 50 hours at 1150°F + 25°/-50°F.

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

Base Metal

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

Shielding Gas: None

Backup Gas: None

Flux: Linde 124

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TABLE 5.3-10 (Cont'd)

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

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TABLE 5.3-10 (Cont'd)

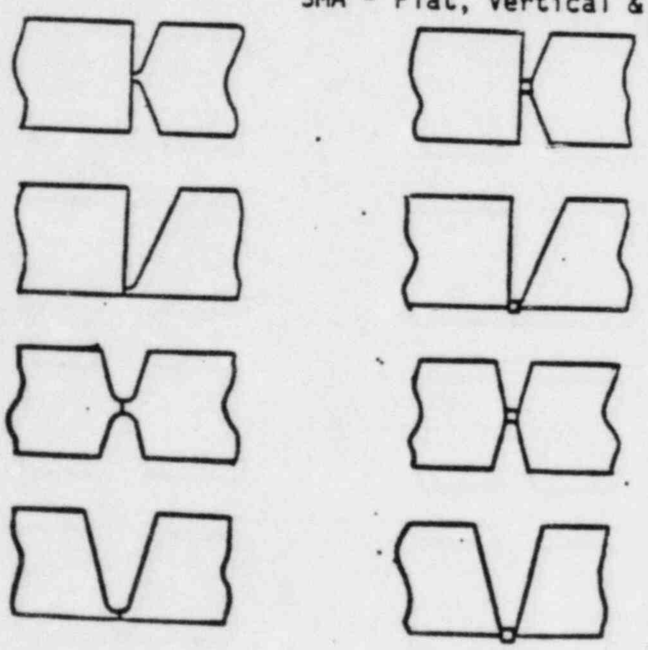
GENERAL WELDING TECHNIQUE

Operation Description	Beads Layer	Weld Proc.	Electrode Size	Electrode Type	Current (Amps)	Voltage (volts)	Travel
SMA	As Req'd	SMA	1/8"	E8018NM	90-135	23-25	
			5/32"		110-160	24-26	
			3/16"		150-220	24-26	
			7/32"		250-350	25-27	
			1/4"		300-400	25-27	
Submerged Arc Single Wire (DCRP)	As Req'd		*	Adcom 1NMM or Equal	550-650	28-32	10-18
Tandem Wire	As Req'd	Lead	*		650-750	32-36	24 min.
		Trail	*		550-650	34-37	

*5/32" or 3/16"

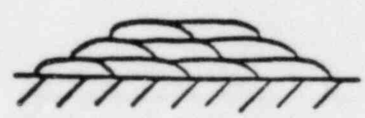
GROOVES

Submerged Arc - Flat
SMA - Flat, Vertical & Horizontal



The spacer bar shall be of the same material as the base material.

WELD BUILDUP



PCY:csc/I05182-4

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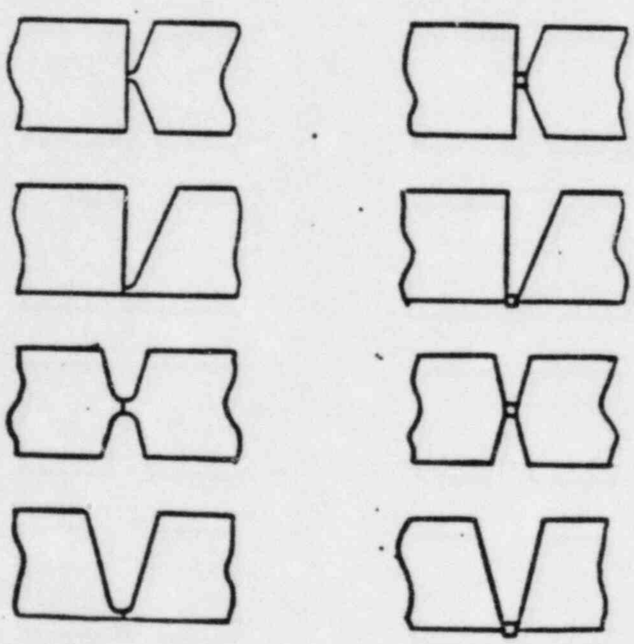
TABLE 5.3-10 (Cont'd)

GENERAL WELDING TECHNIQUE

Operation Description	Beads Layer	Weld Proc.	Electrode Size	Electrode Type	Current (Amps)	Voltage (volts)	Travel
SMA	As Req'd	SMA	1/8"	E8018NM	90-135	23-25	
			5/32"		110-160	24-26	
			3/16"		150-220	24-26	
			7/32"		250-350	25-27	
			1/4"		300-400	25-27	
Submerged Arc Single Wire (DCRP)	As Req'd		5/32" or 3/16"	Adcom 1NMM or Equal	450-700	28-35	8-18

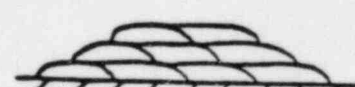
GROOVES

Submerged Arc - Flat
SMA - Flat & Vertical



The spacer bar shall be of the same material as the base material.

WELD BUILDUP



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PCY:csc/I05182-5

TABLE 5.3-11

ESTIMATED RT_{NDT} FOR COMPONENTS IN VESSEL NONBELTLINE REGION

	Component	Material	RT_{NDT} (°F)
1.	Vessel Flange	SA508 Cl.2	-30
2.	Top Head Flange	SA508 Cl.2	0
3.	Top Head Torus	SA533 Gr.B, Cl.1	+10
4.	Plate Connecting to Vessel Flange	SA533 Gr.B, Cl.1	+20
5.	Feedwater Nozzle	SA508 Cl.2	-10
6.	LPCI Nozzle(1)	--	-6
7.	Vessel Main Closure Stud(2)	--	--

(1) The Limerick 1 RPV design results in this component experiencing a predicted end-of-life (EOL) fluence of 1.6×10^{17} n/cm^2 at 1/4 of the thickness. This fluence, based on a conservatively assumed Cu content of 0.18% and a measured phosphorous content of 0.011%, yields an estimated EOL RT_{NDT} of +14°F. The EOL estimate is in accordance with Regulatory Guide 1.99, Revision 1.

(2) This component meets the CVN test requirements of 45 ft-lbs absorbed energy and 25 mils lateral expansion at +10°F.

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PCY:rm/A05121*-12
5/19/83

TABLE 5.3-12

LIMERICK 1 MSIV BODY DATA

Applicable Code: ASME Section III, W68, Draft Pump & Valve Code

Valve Vendor: Atwood & Morrill Company

Material Vendor: Quaker Alloy Casting Company

Material Spec: ASTM A216 GR.WCB

Heat Number: F8304-1

	C	Mn	Si	P	S
Chemical Composition (wt.%)	.26	.90	.30	.019	.012

Heat Treatment: Normalize 1700°F (7 hr. 10 min.) air cool

+Temperature 1340°F (7 hrs.) air cool

+Postweld heat treatment/stress relieve 1140°F/1170°F (5 hrs. 10 min.) air cool

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TABLE 5.3-13

MSIV BODY DATA FROM OTHER BWRs

Project: A

Applicable Code: ASME Section III, 1974

Valve Vendor: Atwood & Morrill Company

Material Vendor: Quaker Alloy Casting Company

Material Spec: ASME SA216 Grade WCB

Heat Number: F6406

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

Heat Treatment: 1680/1710°F (5 hrs., 30 min.) air cool
+Temperature 1350°F (5 hrs., 30 min.) air cool
+Post weld 1200°F (6 hrs.) air cool

Charpy V - Notch Impact Toughness

Test Temperature: +60°F

Energy (Ft-lb): 32, 31, 34

Exp. (Mils): 33, 32, 31

% Shear: 40, 40, 40

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TABLE 5.3-13

MSIV BODY DATA FROM OTHER BWRs

Project: B

Applicable Code: ASME Section III, 1974

Valve Vendor: Atwood & Morrill Company

Material Vendor: Atwood & Morrill Company

Material Spec: ASME SA216 Grade WCB

Heat Number: 35

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

Heat Treatment: 1650/1800°F (8 hrs.), air cool to 400°F

+Temperature 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

Energy (Ft-lb.) 31.5, 37.5, 39.5

Exp. (Mils): 33, 41, 40

% Shear: 10, 10, 10

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TABLE 5.3-13

MSIV BODY DATA FROM OTHER BWRs

Project: C

Applicable Code: ASME Section III, 1974 with Summer 1975 Addenda

Valve Vendor: Atwood & Morrill Company

Material Vendor: Quaker Alloy Casting Company

Material Spec: ASME SA216 Grade WCB

Heat Number: F3547

	C	Mn	Si	P	S
Chemical Composition (wt.%)	0.23	0.88	0.38	0.016	0.015

Heat Treatment: 1700/1725°F (6 hrs., 20 min.) air cool
+Temperature 1345°F (6 hrs., 45 min.) air cool
+Post weld 1200°/1225°F (6 hrs., 20 min.) air cool

Charpy V-Notch Impact Toughness

Test Temperature: +60°F

Energy (Ft-lb): 66, 56, 54

Exp. (Mils): 53, 50, 53

% Shear: 40, 40, 40

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TABLE 5.3-13

MSIV BODY DATA FROM OTHER BWRs

Project: D

Applicable Code: ASME Section III, 1971 with Summer 1973 Addenda

Valve Vendor: Rockwell International

Material Vendor: Rockwell International

Material Spec: ASME SA216 Grade WCC

Heat Number: 1750262

	C	Mn	Si	P	S	Al
Chemical Composition (wt.%)	0.21	1.19	0.43	0.011	0.009	0.043

Heat Treatment: 1700°F (10 hrs.) normalize

+1225°F (7.5 hrs.) temperature

+1100°F (6 hrs.) post weld

Charpy V-Notch Impact Toughness

Test Temperature: +40°F

Energy (Ft-lb): 29.0, 33.0, 35.0

Exp. (Mils): 25.0, 26.0, 30.0

% Shear: 15, 15, 15

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TABLE 5.3-13

MSIV BODY DATA FROM OTHER BWRs

Project: E

Applicable Code: ASME Section III, 1971 with Summer 1973 Addenda

Valve Vendor: Rockwell International

Material Vendor: Rockwell International

Material Spec: ASME SA216 Grade WCC

Heat Number: 3760171

	C	Mn	Si	P	S	Al
Chemical Composition (wt.%)	0.17	1.09	0.50	0.008	0.011	0.060

Heat Treatment: 1700°F (8 hrs.) normalize
+1275°F (8 hrs.) temperature
+1100°F (6 hrs.) post weld

Charpy V-Notch Impact Toughness

Test Temperature: +40°F

Energy (Ft-lb): 35, 38, 29

Exp. (Mils): 32, 36, 29

% Shear: 20, 20, 20

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TABLE 5.3-13

MSIV BODY DATA FROM OTHER BWRs

Project: F

Applicable Code: ASME Section III, 1974

Valve Vendor: Atwood & Morrill Company

Material Vendor: Quaker Alloy Casting Company

Material Spec: ASME SA216 Grade WCB

Heat Number: F7516

	C	Mn	Si	P	S
Chemical Composition (wt.%)	0.25	0.78	0.53	0.018	0.013

Heat Treatment: 1690/1710°F (6 hrs., 5 min.) air cool
+Temperature 1350/1360°F (6 hrs.) air cool
+Post weld 1200°F (6 hrs., 5 min.) air cool

Charpy V-Notch Impact Toughness

Test Temperature: +60°F

Energy (Ft-lb.): 30, 24, 34

Exp. (Mils.): 37, 27, 33

% Shear: 40, 40, 40

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TABLE 5.3-14

LIMERICK 1 - MSIV BONNET COVER MATERIAL

Applicable Code: 1968 ASME Nuclear Pump and Valve Code

Valve Vendor: Atwood & Morrill Company

Material Vendor: Cann & Saul Steel Company

Material Specification: ASTM A105, Gr. 2

Heat No. 219222

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

Heat Treatment: Normalize 1650°F (12 hours) - Air Cooled

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PCY:csc/I05182-6

TABLE 5.3-15

MAIN STEAM SWEEPOLET MATERIAL DATA FROM OTHER BWRs

Project:	A
Applicable Code:	ASME Section III, 1974 Edition, S74 Addendum
Vendor:	Bonney Forge Division, Gulf Western Manufacturing
Material Vendor:	Sharon Steel
Material Specification:	SA 105N
Heat No.:	631218 (Sharon Steel)

	C	Mn	Si	P	S
Chemical Composition (Wt. %)	.28	.87	.22	.014	.015
Heat Treatment	Normalize 1650°F (12 hours) - Air Cooled				

Charpy V-Notch Impact Toughness (Longitudinal)

Test Temperature:	+70°F
Energy (Ft-lb.)	68.2, 83.5, 76.0
Lat. Exp. (Mils)	64, 71, 69
% Shear:	80, 80, 80

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TABLE 5.3-15 (CON.)

Project:	A
Applicable Code:	ASME Section III, 1974 Edition, S74 Addendum
Vendor:	Bonney Forge Division, Gulf Western Manufacturing
Material Vendor:	Sharon Steel
Material Specification:	SA 105N
Heat No.:	630614 (Sharon Steel)

	C	Mn	Si	P	S
Chemical Composition (Wt. %)	.26	.86	.16	.022	.017

Heat Treatment: Normalize 1650°F (4 hours) - Air Cooled

Charpy V-Notch Impact Toughness (Longitudinal)

Test Temperature:	+70°F	
Energy (Ft-lb.):	76.6, 74.9, 62.0	107.7, 108.5, 109.3
Lat. Exp. (Mils)	68, 69, 63	75, 84, 85
% Shear:	80, 90, 80	100, 100, 100

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TABLE 5.3-16
SURVEILLANCE CAPSULE

Capsule	Tensile	Charpy V-Notch
No. 1 (Azimuth 300°)	3 Base Metal (BM) 4 Weld Metal (WM) 3 Heat Affected Zone (HAZ)	8 BM, Long. 8 WM 8 HAZ
No. 2 (Azimuth 120°)	3 BM 4 WM 3 HAZ	8 BM, Long. 8 WM 8 HAZ
No. 3 (Azimuth 30°)	3 BM 4 WM 3 HAZ	20 BM, Long. 16 WM 12 HAZ

NOTE: 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.

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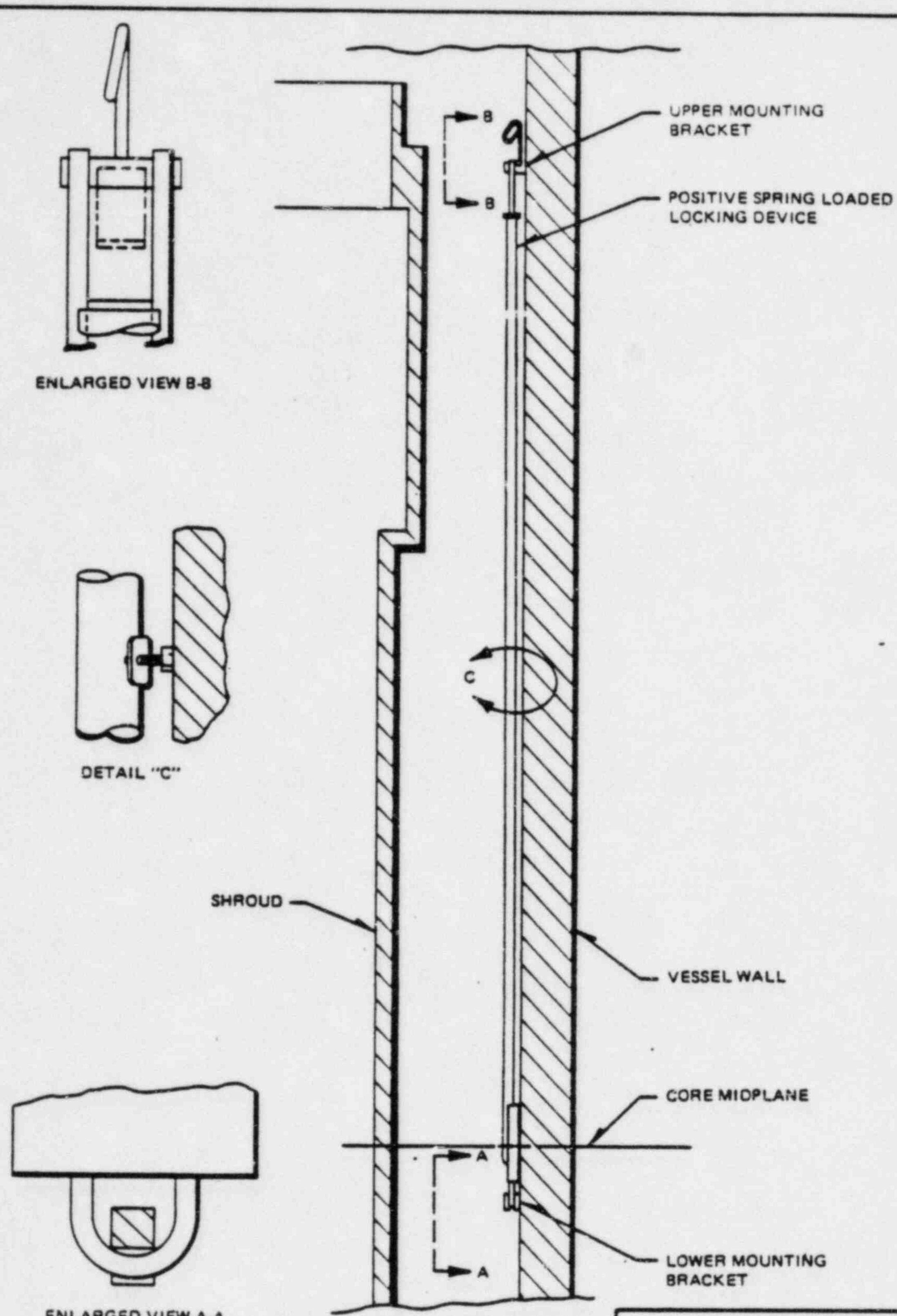

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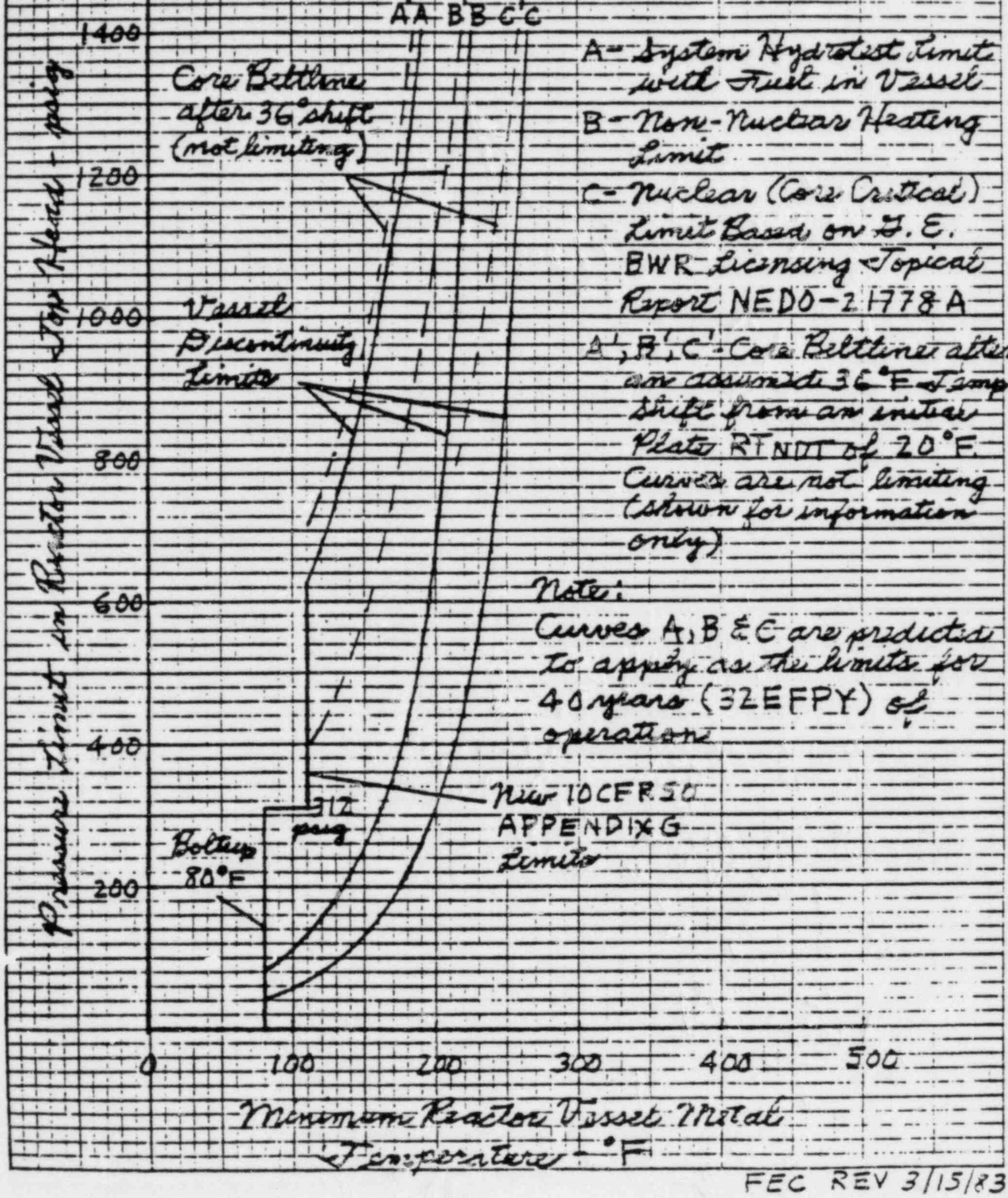
SURVEILLANCE CAPSULE

FIGURE 5.3-3

Figure 5.3-4 Limerick Unit 1

Minimum Temperature Required Vs. Reactor Pressure



FEC REV 3/15/83

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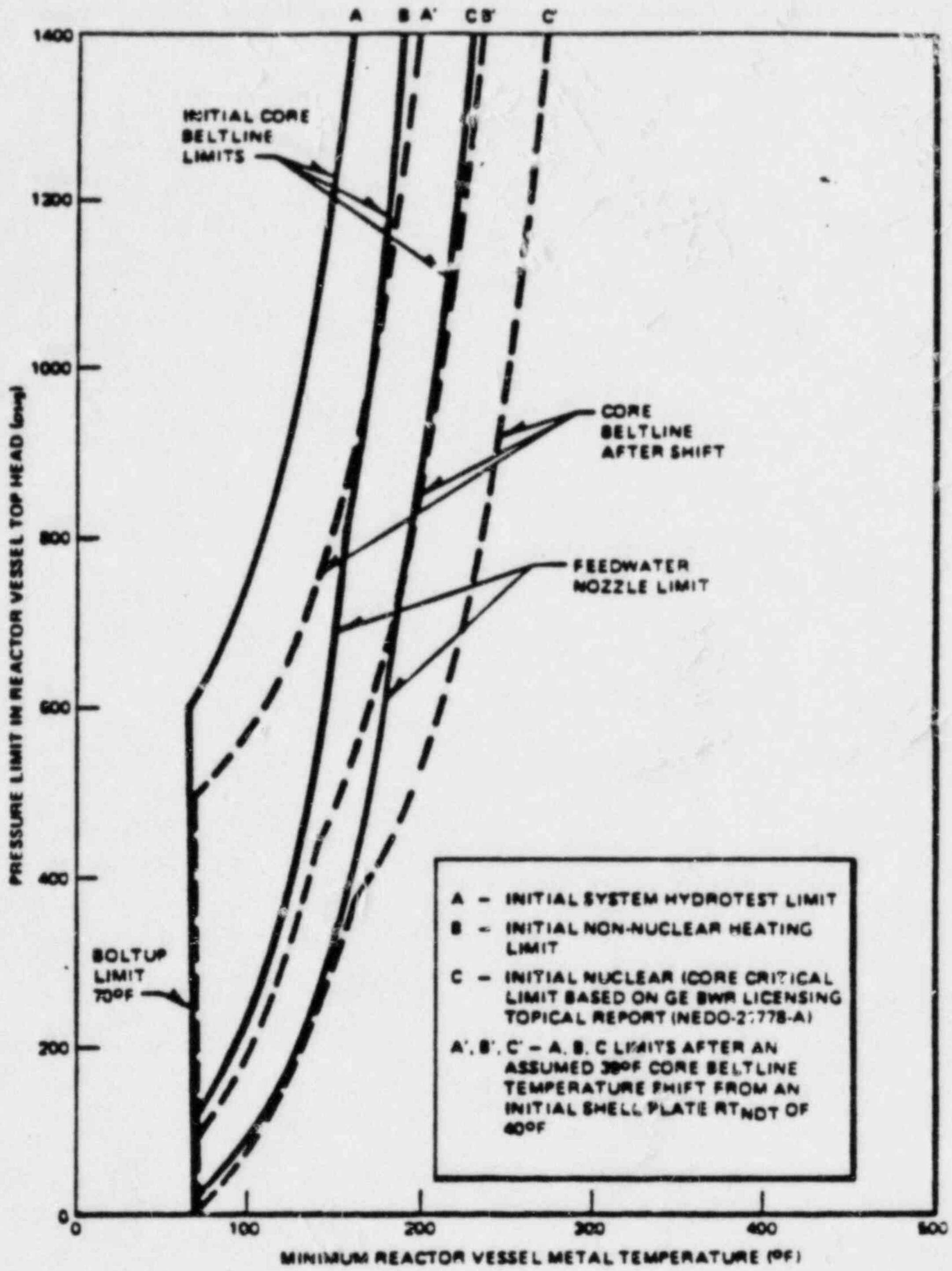

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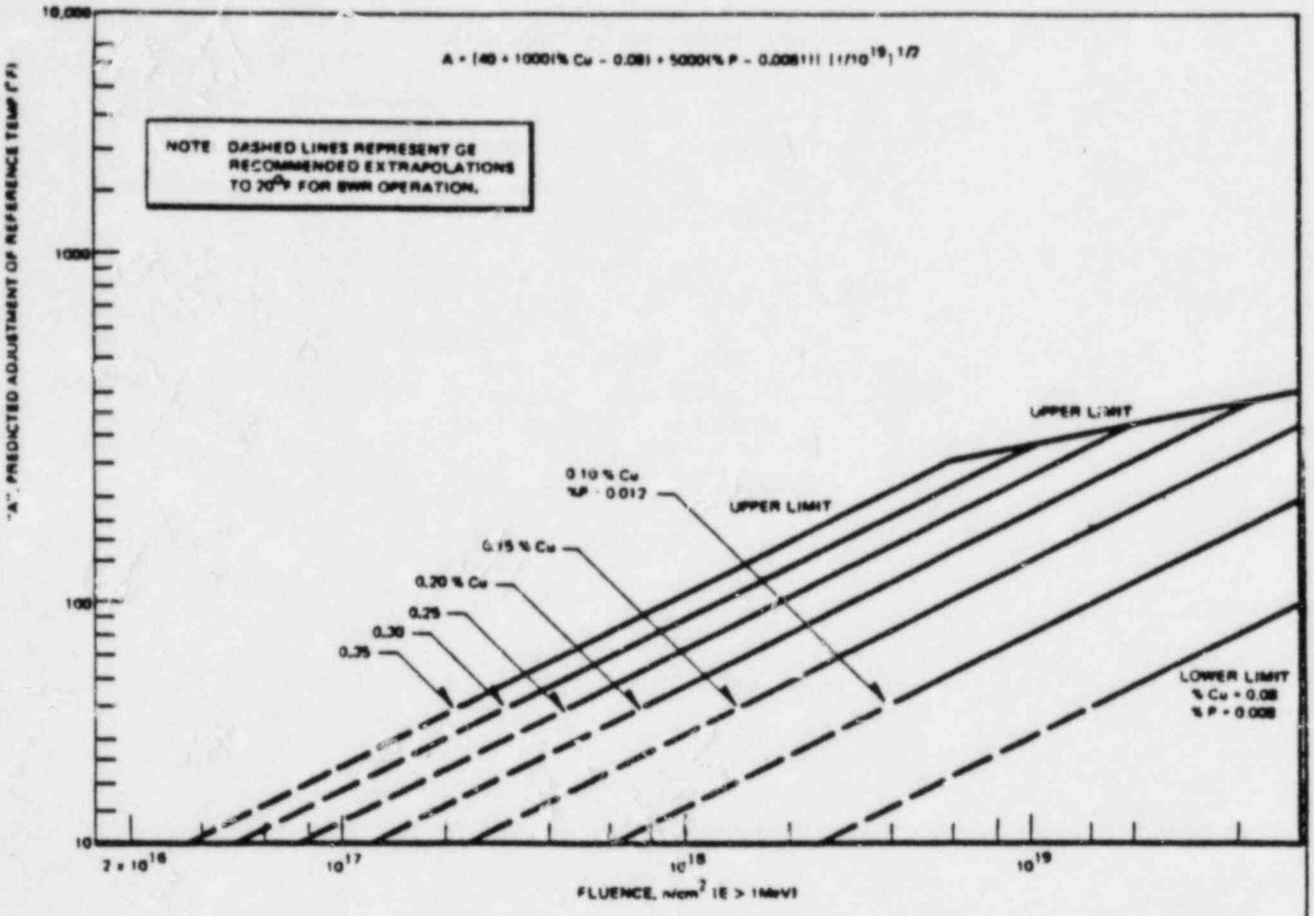
MINIMUM REACTOR VESSEL TEMPERATURES REQUIRED VERSUS REACTOR PRESSURE (UNIT 2)
(Preliminary)

FIGURE 5.3-5



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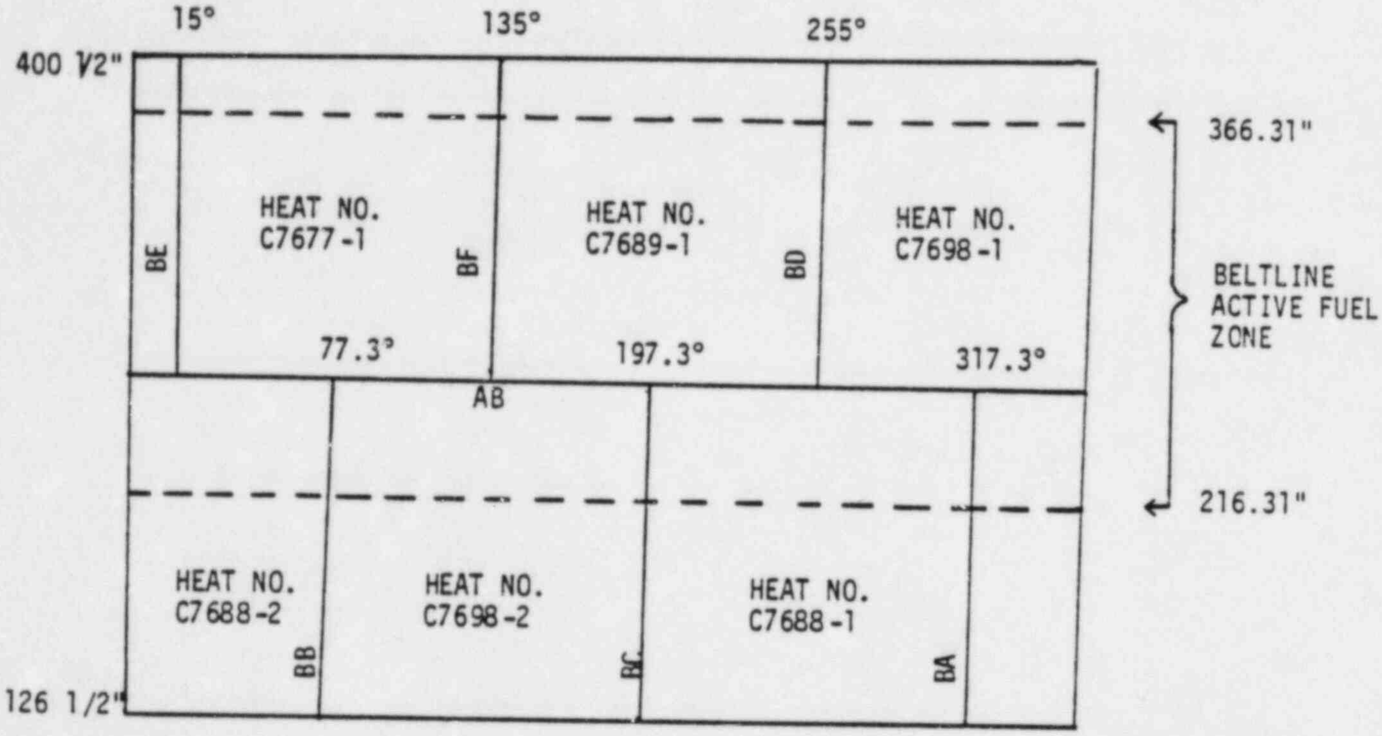
PREDICTED ADJUSTMENT OF REFERENCE TEMPERATURE, "A", AS A FUNCTION OF FLUENCE AND COPPER CONTENT

FIGURE 5.3-6



SHOP WELDS: SEAMS BA, BB, BC, BD, BE, BF

FIELD WELDS: SEAM AB

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Figure 5.3-7 BELTLINE PLATE AND WELD SEAM LOCATIONS FOR LIMERICK 1