Department of Energy
Washington, D.C. 20545
Docket No. 50-537
HQ:S:83:192

JAN 24 1983

Mr. Paul S. Check, Director
CRBR Program Office
Office of Nuclear Reactor Regulation
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555

Dear Mr. Check:

ADDITIONAL INFORMATION ON MECHANICAL ENGINEERING BRANCH (MEB) ITEMS 50 AND 70

Reference: Letter HQ:S:82:093, J. R. Longenecker to P. S. Check, "Meeting Summary for MEB/CRBRP September 8 and 9, 1982, Meeting," dated September 21, 1982

Enclosed are responses to MEB concerns 50 and 70, and associated revised Clinch River Breeder Reactor Plant Preliminary Safety Analysis Report (PSAR) pages, that will be included in a future PSAR amendment. This submittal provides the remaining responses due the MEB on low temperature concerns identified in the referenced letter.

Questions regarding the enclosures may be addressed to Mr. D. Robinson (FTS 626-6098) or Mr. D. Florek (FTS 626-6188) of the Oak Ridge Project Office staff.

Sincerely,

John R. Longenecker

John R. Longenecker
Acting Director, Office of
Breeder Demonstration Projects
Office of Nuclear Energy

2 Enclosures

cc: Service List
Standard Distribution
Licensing Distribution

D001
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ENCLOSURE

Item #3.1-17 Title: MEB Item 50

Description: Does the reactor coolant boundary design, which was made to Code Editions and Code Cases at least five years old, provide a comparable level of safety to a similar design made to current Code Editions and Code Cases.

Response: A thorough review has been completed, for CRBRP primary system components, of the impact of changes between the 1974 Edition of the ASME Boiler and Pressure Vessel Code, and the 1980 Edition, including Addenda through the Summer of 1982. All the specific changes that have occurred in the design rules have been examined, and Table 1 attached lists the design rule changes that are more restrictive than the prior rules. Table 2 lists the Class 1 primary pressure boundary components whose low-temperature design criteria were evaluated (changes in the design rules for the elevated temperature portions have previously been identified and evaluated). Table 3 summarizes the potentially applicable design Code Cases.

The structural integrity significance of each item in Table 1 to each primary coolant pressure boundary component in Table 2 has been determined, and the results are provided in Attachment A. Based upon the results of this review, it is concluded that the CRBRP primary pressure boundary components have a higher level of assured structural integrity than the minimum values provided by the current Code design rules.

TABLE 1

ASME BOILER CODE SUBSECTION NB-3000 (SUMMER 1982)

CHANGES THAT ARE MORE RESTRICTIVE THAN 1974 CODE

NB-3100

1. Standard Products Table NB-3132-1 - The referenced standards are updated and further restrictions were added to several standards.

2. The NB-3136 exemption from post-weld heat treating of ferritic nozzle and branch connection welds was removed.

3. The vessel fillet weld requirements were extended to cover all components (NB-3123.2).

4. The stress categorization of shell-to-head junction bending stresses was changed from Q to P when bending edge constraint is necessary to meet the head bending stress limits.

5. An additional P_L+P_b limit based on the fully plastic section factor was added to NB-3221.3.

6. An additional P_m limit was added to NB-3224 for pressure loadings of ferritic components.

7. The P_m+P_b limit for testing was reduced when $P_m>0.67\ S_y$.

8. The peak stress indices for openings in shells of NB-3338.2(d) and NB-3339 were restricted to cases where the opening d is less than $.8\sqrt{D_t}$.

9. The peak stress indices for openings in shells of NB-3338.2(d) and NB-3339 were restricted to cases where at least 40% of the reinforcement is on the outside of the shell.

10. The piping "B" indices of NB-3600 were restricted to cases where $D/t\leq50$ and other indices were changed.

Note: This list does not include changes in NB-3400 or NB-3500. No primary system components have been located that use these two subarticles. No CRBRP primary system design related Code Cases have been found that result in more restrictive rules in 1982 than in 1974.

TABLE 2

LIST OF ASME CONSTRUCTION CODES, CODE CLASSIFICATIONS, AND CODE CASES FOR LOW TEMPERATURE CRBRP PRIMARY PRESSURE BOUNDARY COMPONENTS

Component	Code/Code Class Edition/Addenda	Design Applicable Subarticles	Low Temperature Code Cases and Revisions
Reactor Vessel & Primary Heat Transport System			
Reactor Vessel (1)	ASME III/1 1974/Winter '74	NB-3100, NB-3200, and NB-3300	1521-1, 1682, 1690
Closure Head (1)	ASME III/1 1974/Winter '74	NB-3100, NB-3200, and NB-3300	1521-1, 1682, 1690
Primary Sodium Pump (1) Casing	ASME III/1 1974/Winter '74	NB-3100, NB-3200, and NB-3300	1521-1, 1682
Intermediate Heat Exchangers, IHX (Rubes and Shell)	ASME III/1 1974/Summer '74	NB-3100, NB-3200, and NB-3300	1521-1
Primary Piping	ASME III/1 1974/Summer '75	NB-3100 and NB-3600	1644-4
Primary Sodium Overflow Vessel	ASME III/1 1974/Summer '76	NB-3100, NB-3200, and NB-3300	
Primary Sodium Makeup Pumps	ASME III/1 1974/Summer '76	NB-3100, NB-3200, and NB-3300	1685-1
Overflow and Primary Sodium Makeup Piping and Fittings	ASME III/1 1974/Summer '75	NB-3100 and NB-3600	
Thermal Transient Valves	ASME III/1 1974/Summer '76	NB-3100, NB-3200, and NB-3300	1539, 1685, N62-2
Check Valve	ASME III/1 1974/Summer '76	NB-3100, NB-3200, and NB-3300	1685
Overflow Heat Exchanger	ASME III/1 1974/Summer '76	NB-3100, NB-3200, and NB-3300	1644-6, 1681-1

Notes:

(1) Code cases 1682 and 1690 are permitted for use if the supplier elects to use them.

TABLE 3

CODE CASES THAT COULD HAVE BEEN USED FOR THE CRBR PRIMARY COOLANT REACTOR PRESSURE BOUNDARY COMPONENTS

Code Case Number	Subject	Relevant to Design	Explanation
1521	Use of H Grades of Stainless Steel	No	Use of H-Grades is irrelevant to low temperature rules
1539	Metal Bellows & Metal Diaphragm Stem Sealed Valves	Not to Pressure Boundary	Valve must be designed with metal seal presumed to be ineffective
1644	Additional Materials for Component Supports and Alternate Design Requirements for Bolted Joints	Not to design of Class 1 items	Relates to component supports - not to Class 1 components themselves
1681	Organizations Accepting Overall Responsibility for Section III Construction	No	Not design specific
1682	Alternative Rules for Material Manufacturers	No	Only a material supplier qualification issue
1685	Furnace Brazing	No - used only for brazing valve seals	Not as used in CRBRP
1690	Stock Materials for Section III Construction	No	Only a material supply question
N-62-2 (1621)	Internal and External Valve Items	Not used in the CRBR valves	The design was based on design-by-analysis

ATTACHMENT A

AN EVALUATION OF THE TEN POTENTIALLY SIGNIFICANT CHANGES
IN THE ASME CODE CASE 1 DESIGN RULES FOR
THE CRBR PRIMARY COOLANT PRESSURE BOUNDARY COMPONENTS

Note: See Table 1 for the list of the ten potentially significant Code design rule changes.

Main Coolant Pump

Item

1. No Standard Products were used in the pump.

2. Not applicable because component is austenitic steel.

3. Fillet welds are not used on the pressure boundary thus the changes are not applicable.

4. The head bending stress values are low, and thus the head pressure-induced bending limit can be met with fully free to rotate head supports.

5. The cross-sections are solid rectangular thus the new α factor limits result in no change.

6. The component is austenitic steel so that the change is not applicable to the pump.

7. The test pressure stresses are low thus the modified stress limit is not encountered.

8, 9. The peak stresses were determined using detailed analysis, not the stress indices of NB-3338 or NB-3339.

10. Not applicable because the pump was designed using vessel (not pump) design rules.

Main Primary Coolant System Piping

Item

1. The changes in the referenced standards are not signficant to these components.

2. Not applicable because NB-3136 refers to ferritic nozzles while the CRBR primary piping is austenitic.

3. Not applicable because fillet welds are not used in the main primary coolant system piping.

4. Not applicable because the piping does not involve a shell to formed head junction.

5-9. Not applicable because the main primary coolant system piping is designed as piping not as a vessel.

10. The revised piping stress indices do not result in a singificant (to the main coolant piping) change in stress limits. The main coolant piping uses only a few of the indices, some of the indices are reduced which partially offsets the increases in other indices, and the margins by which the existing rules are met assure that the revised indices can be accommodated.

Intermediate Heat Exchanger

Item

1. No Standard Products were used.

2. Not applicable because the IHX is austenitic.

3. Not applicable because structural fillet welds are not used.

4. The only places where significant center-of-head bending stresses occur are in the two tubesheets. In one tubesheet the pressure bending stresses are low enough that it is clear that edge effects are not significant. In the other tubesheet, while the tubesheet pressure-induced bending stresses are high, the shell thickness is so low (1 1/2 inches) compared to the head (11 inches thick) that edge constraint (if released) cannot cause the P_L+P_b limit to be exceeded.

5. The cross sections are all solid rectangular thus the recent rules changes have no effect.

6. The component is austenitic.

7. The test pressure stresses do not exceed the current limits.

8. Fatigue stresses are obtained from detailed analyses, not from NB-3330 stress indices.

9. See the answer to ~~question~~ item 8.

10. Not applicable to vessels.

Check Valve

Item

1. No Standard Products were used.

2. Not applicable because the component is austenitic steel.

3. Not applicable because fillet welds were not used.

4. Not applicable because the center of head bending streses are well below Code limits.

5. All sections are solid-rectangular thus the changes are not significant.

6. Not applicable because the check valve is made of austenitic stainless steel.

7. The testing stresses are low thus the recent rules changes are not applicable.

8, 9. The fatigue stress indices of NB-3338 or -3339 are not used. Detailed analysis is used instead.

10. Not applicable to the check valve.

Note: This item was designed using vessel not valve design rules.

Reactor Vessel and Closure Head

1. Not applicable because Standard Components have not been used.
2. Not applicable because carbon or low-alloy steel nozzles have not been used.
3. Fillet welds have not been used on the primary coolant pressure boundary.
4. The only flat head is the closure head. The low head bending stresses due to pressure ($\sim$ 1000 psi) and the large head thickness preclude violation of footnote 5 to Table NB-3217-1.
5. All sections used α=1.5 and all sections are solid rectangular thus the change does not affect the reactor vessel and head.
6. There are no significant Level C pressure loads on the ferritic portions.
7. The margins for testing stress levels assure that the current P_L+P_b limits are satisfied.

8, 9. The fatigue evaluations of the nozzles were based on design-by-analysis, not the stress indices.

10. Not applicable to vessel and vessel closures.

Overflow/Makeup Piping

Item

1. No significant effect on the design.

2. Not applicable to this austenitic SS piping system.

3. No fillet welds were used.

4-9. Not applicable to piping.

10. The O/M system piping meets the limits with the current stress indices.

Overflow/Makeup Valves (Thermal Transient Valves)

Item

1-9. All the valves were designed to the elevated temperature rules. They were designed-by-analysis as vessels. They are all austenitic SS. None of the low temperature design rule changes thus are relevant.

10. The piping rules changes are not applicable.

Overflow/Makeup Vessel, Heat Exchanger, and Pump

Item

1. No structural impact.

2. These components are not ferritic.

3. No fillet welds are used.

4. The center-of-head pressure bending stresses are within Code limits without rotational edge constraint.

5. All α factors are 1.5.

6. These components are not ferritic.

7. These limits are satisfied.

8, 9. Where design-by-analysis rules were not used the openings are not large.

10. Not applicable to vessels.

Note: These components were all designed as vessels using design-by-analysis.

MEB Item 70: The information on load combinations and emergency limits in PSAR Sections 3.9.2/3.7A is incomplete. Coverage equivalent to that in current SARs (e.g., the Byron PSAR) should be provided.

Response: PSAR Section 3.9.1.6 has been modified to include requirements for component supports.

3.9.1.6 Analytical Methods for ASME Code Class 1 Components and Component Supports

The design transients for these components are described in Appendix B of this PSAR. The analytical methods and stress limits will be discussed in the FSAR. The evaluation of ASME Code Class 1 components and component supports will comply with the requirements of the 1974 Edition of the ASME Boiler and Pressure Vessel Code Section III, Subsection NB (components) and NF (supports). The subsection NB requirements for components are supplemented by the following:

(1) Low Temperature Components (below 800°F):

RDT Standard E15-2NB-T, October 1975.

Regulatory Guide 1.48, "Design Limits and Load Combinations for Seismic Category I Fluid System Components."

(2) Elevated Temperature Components (above 800°F):

(a) Interpretations of the ASME Boiler and Pressure Vessel Code Case 1592, "Class 1 Components in Elevated Temperature Service Section III".**

(b) RDT Standard F9-4T, "Requirements for Design of Nuclear System Components at elevated Temperatures" Jan. 1976.

(c) RDT Standard E15-2NB-T, October 1975.

(d) Regulatory Guide 1.48.

The inelastic and limit analysis methods having the stress and deformation (limits) established by the ASME Code, Section III, and Code Case 1592 (elevated temperature design) for normal, upset and emergency conditions may be used with the component dynamic analysis. For these cases, the limits are sufficiently low to assure that the dynamic elastic system analysis is not invalidated.

For the case of elevated temperature components designed in accordance with Code Case 1592, conservative deformation (or strain) limits have been formulated to help ensure the applicability of the other rules of the Code Case; i.e. the strain limits in Code Case 1592 are set conservatively low such that they effectively ensure that small deformation theory is applicable for most structural analyses of elevated temperature components. The small deformation assumptions, which have been the cornerstone for analyses of structures at low temperatures, are retained by the majority of current computer structural models being used for elevated temperature analysis.

**There are no deviations at present. All supplemental criteria will be fully identified and justified in the FSAR.

The elevated temperature Code Case places the following limits on the maximum accumulated inelastic strain for component parent material (Section T-1310 of Case 1592):

1. Strains averaged through the thickness, 1%

2. Strains at the surface due to an equivalent linear distribution of strain through the thickness, 2%

These limits are consistent with the NRC Standard Review Plan, Section 3.9.1, which states that small deformation methods of analysis typically tend to have acceptable effective strain limits in the range of 0.5 to 1.5 percent.

For components designed in accordance with the low temperature rules of Section III of the ASME Code, the 3 S_m limit on primary-plus-secondary stress ensure the applicability of small deformation theory: i.e., the 3 S_m limit ensures shakedown and precludes ratchetting.

For faulted conditions, the plastic and limit analysis stress and deformation limits are specified in Appendix F of the ASME Code, Section III. These limits are established in terms of an equivalent adopted elastic limit which can be used with a dynamic elastic system analysis. Particular cases of concern will be checked by use of simulated inelastic internals properties in the elastic system analysis.

At the component level, use of plastic or inelastic stress analysis or application of inelastic stress and deformation limits may be used with the elastically calculated dynamic external loads provided that shakedown occurs (as opposed to continuing deformation) or deformations do not exceed specified limits. Otherwise, readjustment to the elastic system analysis will be required. A list of components for which inelastic analysis has been performed or is planned is shown in Table 3.9-11.

Complete system inelastic methods of flexibility analysis combined with inelastic stress techniques may be used if there is justification.

Design loading combinations to be used for ASME Section III Class 1 components are those as given in Appendix 3.7-A with the additional combinations given below.

Normal and Emergency Conditions: Dead + Live + Operating + Thermal + Transients

Active components will be qualified for operability on a component by component basis in accordance with Reference 12, PSAR Section 1.6.

ASME Class 1 Component Supports will be designed and analyzed to the rules and requirements of ASME Section III Subsection NF. The methods for analysis and associated allowable limits that are used in the evaluation of linear supports for faulted conditions are those defined in ASME Section III Appendix F.

The load combinations for ASME Class 1 Component Supports are given in Table 3.9-5a for normal, upset, emergency and faulted plant conditions.

The design of bolts for ASME Class 1 Component Supports for normal and upset plant conditions will be in accordance with paragraph NF-3280 of ASME Section III Subsection NF. For emergency and faulted plant conditions, bolts will be treated as linear supports, and the methods for analysis and associated allowable limits are those defined in paragraph NF-3230, Subsection NF and paragraph F-1370, Appendix F of ASME Section III.

3.9.2 ASME Code Class 2 and 3 Components and Component Supports

3.9.2.1 Component Operating Conditions and Design Loading Combinations

Design pressure, temperature, and other loading conditions that provide the design basis for fluid system Code Class 2 and 3 components are described in Appendix B of this PSAR and referenced in the sections that describe the system functional requirements.

3.9.2.2 Design Loading Combinations

Design loading combinations for ASME Code Class 2 and 3 components, and piping, are given in Appendix 3.7-A which are the same as for Class 1 components. Corresponding stress and pressure limits for each case are specified in Section 3.9.2.3.

For ASME Section III Class 2 and 3 components which are not sodium-containing and high temperature, the CRBRP will fully conform with the requirements of ASME Section III Code. The load combination given in Appendix 3.7-A plus the additional load combination given below will be utilized.

Normal and Emergency Conditions: Dead + Live + Operating + Thermal + Transients

ASME Class 2 and 3 Component Supports will be designed and analyzed to the rules and requirements of ASME Section III Subsection NF. The methods for analysis and associated allowable limits that are used in the evaluation of linear supports for faulted conditions are those defined in ASME Section III Appendix F.

The load combinations for ASME Class 2 and 3 Component Supports are given in Table 3.9-5a for normal, upset, emergency and faulted plant conditions.

The design of bolts for ASME Class 2 and 3 Component Supports for normal and upset plant conditions will be in accordance with paragraph NF-3280 of ASME Section III Subsection NF. For emergency and faulted plant conditions, bolts will be treated as linear supports, and the methods for analysis and associated allowable limits are those defined in paragraph NF-3230, Subsection NF and paragraph F-1370, Appendix F of ASME Section III.

Table 3.9-5a

Load Combinations for
ASME Class 1, 2 and 3
Component Supports

System Operating Condition	Load Combination
Normal	Weight + Thermal + Transients
Upset	Weight + Thermal + Transients(1) + OBE
Emergency	Weight + Thermal + Transients + DSL(2)
Faulted	Weight + Thermal + Transients + DSL(3) + SSE

(1) Same as footnote (1), Page 3.7-A.16(a)

(2) Includes only those dynamic system loadings associated with sodium water reactions

(3) Dynamic system loadings associated with IHTS design basis leaks and water/steam rupture events.