Department of Energy
Washington, D.C. 20545

FEB 24 1983

Docket No. 50-537
HQ:S:83:224

Dr. J. Nelson Grace, Director
CRBR Program Office
Office of Nuclear Reactor Regulation
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555

Dear Dr. Grace:

SUPPLEMENTAL INFORMATION ON MECHANICAL ENGINEERING BRANCH (MEB) LOW TEMPERATURE ITEMS 26 AND 70

References:

(1) Letter HQ:S:83:182, J. R. Longenecker to P. S. Check, "Additional Information on MEB Items 4, 26, 64, 68, 69, and 72," dated January 11, 1983

(2) Letter HQ:S:83:192, J. R. Longenecker to P. S. Check, "Additional Information on MEB Items 50 and 70," dated January 24, 1983

(3) Letter HQ:S:83:215, J. R. Longenecker to J. Nelson Grace, "Additional Information on MEB Low Temperature Questions 26 and 70," dated February 15, 1983

Enclosed are revised responses to MEB Questions 26 and 70 previously submitted in the references. The enclosed pages provide additional information requested by the MEB staff in discussions with the Project Office and will be included in the next amendment to the Preliminary Safety Analysis Report.

Any questions concerning enclosed pages may be directed to Mr. D. Robinson (FTS 626-6098) of the Project Office Oak Ridge staff.

Sincerely,

J. E. Stader
for
John R. Longenecker
Acting Director, Office of
Breeder Demonstration Projects
Office of Nuclear Energy

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Enclosure

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MEB Item 26: The NRC expressed concern at the November 22-24, 1982, meeting at Waltz Mill that no specific criterion was identified for the evaluation of flow induced vibration (FIV) test results. It was suggested that a limiting value of 50 percent of the Code endurance limit at 10^6 cycles would be appropriate.

Response: The information presented at the same meeting for MEB Item 64 indicated that for load controlled conditions the high cycle loadings for CRBRP require evaluation at about 10^9 to 10^{10} cycles. Since the endurance limit decreases by approximately a factor of 2 in going from 10^6 to 10^9 cycles, the CRBRP procedures are equivalent to the suggested limiting value. In any event, the steady state vibration ~~FIV~~ results must be within the component design limits* or corrective action will be required as noted in PSAR Section 3.9.1.

* The component design limits are less than 1/2 the 10^6 cycle limit. Test result acceptance shall be based on observing measurement corresponding to less than the above defined design limit.

3.9.1.6 Analytical Methods fcr ASME Code Class 1 Comp ients 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 discus ed in the FSAR. The evaluation of ASME Code Class 1 components will comly with the requirements of the ASME Boiler and Pressure Vessel Code Section III, Subsection NB, supplemented by the following:

(1) Low Temperature Components (below 800°F) for austentic steels and below 720°F for ferritic steels):

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

NUREG-0800, Section 3.9.3, ASME Code Class 1, 2, and 3 components, component supports, and core support structures.

(2) Elevated Temperature Components:

(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) NUREG-0800, Section 3.9.3.

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 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 code editions and addenda are those shown in Table 3.2-5 for the appropriate components

The elevated temperature Code Case places the following limits on the maximum accumulated inelastic strain for 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

The complete set of load combinations for ASME Code Class 1, 2, and 3 components is summarized in Tables 3.9-5a and 5b. 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 plate and shell type and linear supports for faulted conditions are those defined in ASME Code, Section III, Appendix F.

The load combinations for ASME Class 1 Component Supports are given in Table 3.9-5a and 5b for normal, upset, emergency and faulted plant conditions. The stress limits to be used in the design of the Class 1 supports for the various service loadings are provided in Table 3.9-5c.

Component supports may be designed using the following three design procedures: (1) Design by Analysis, (2) Experimental Stress Analysis, and (3) Load Rating. Plate and shell type supports shall be designed and analyzed in accordance with the rules of paragraph NF-3220 of Subsection NF. Elastic analysis based on maximum stress theory in accordance with the rules of NF-3230 and Appendix XVII-2000 (Section III) shall be used for the design of linear type supports. For component support configurations where compressive stresses occur, the critical buckling stress shall be taken into account. To avoid column buckling in compression members, local instability associated with compression in flexual members and web/flange buckling in plate members, the allowable stress shall be limited to one-half of the critical buckling stress for plate and shell type supports and to two-thirds of the critical buckling stress for linear type supports. The calculation of the critical buckling stress shall account for the member slenderness ratio, width-to-thickness ratio of member flange, depth-to-thickness ratio of the member web and laterally unsupported length. Dynamic buckling as well as static buckling shall be considered when calculating critical buckling stress. The critical buckling is defined as the CRC curve (Column Research Council).

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 Code, Section III, respectively.

The stress limits for the Emergency Conditions may be increased by one-third over the values for the normal/upset conditions. For the Faulted Conditions, the allowable stresses obtained for the normal conditions may be increased by a factor of 1.2 (Sy/Ft). In no case shall the allowables for the Emergency/Faulted Conditions exceed the yield strength of the material at temperature.

Additional Material Design Considerations

- The ASME Code, Winter 1982 Addenda, reduced fatigue design curves for austenitic materials cycled beyond 10^6 cycles will be evaluated.
- The design curves being developed by ASME Code Committees, Winter 1982, regarding the 2-1/4 Cr - 1 Mo elevated temperature fatigue design will be evaluated.
- Wherever the simplified elastic-plastic method of the ASME Code has been used, an evaluation of a conservative or actual plastic strain concentration and the resulting fatigue design life will be performed.

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-III Class 2 and 3 components which are not sodium-containing and high temperature, the CRBRP will fully conform with the requirements of ASME-III Code. The load combinations given in Tables 3.9-5a and 5b will be utilized.

ASME Class 2 and 3 Component Supports will be designed and analyzed to the rules and requirements of ASME Section III Subsection NF. The design and analysis of Class 2 and 3 component supports shall be as discussed in Section 3.9.1.6 for Class 1 supports.

The load combinations for ASME Class 2 and 3 Component Supports are given in Table 3.9-5a and 5b for normal, upset, emergency and faulted plant conditions. The stress limits to be used in the design of the Class 2/3 supports are provided in Table 3.9-5d.

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 of ASME Section III. In no case shall the allowables for the Emergency/ Faulted conditions exceed the yield strength of the material at temperature.

*The code editions and addenda are those shown in Table 3.2-5 for the appropriate components.

Table 3.9-5a

Load Combinations for Seismic Category I
Vessels, Piping and Non-Active Pumps and Valves and
Associated Component Supports (Class 1, 2 and 3)

System Operating Condition	Load Combination	ASME Service Stress Limits
Normal	Dead + Live + Operating + Thermal + Transients	Normal (or Level A)
Upset	Dead + Live + Operating + Thermal + Transients(1) +OBE	Upset (or Level B)
Emergency	Dead + Live + Operating + Thermal + Transients + DSL(2)	Emergency (or Level C)
Faulted	(a) Dead + Live + Operating + Thermal + Transients(3) + DSL(3) + SSE	Faulted (or Level D)
	(b) Dead + Live + Operating + Thermal + Transients(4) + SSE	Faulted (or Level D)
	(c) Dead + Live + Operating + Thermal + Transients	Faulted (or Level D)

(1) Includes worst normal operation transient with four OBEs and worst upset operation transient with one OBE, independently.

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

(3) Dynamic system loadings and transients associated with ex-containment IHTS design basis leaks and water/steam pipe rupture events.

(4) Includes only normal operating transients.

Table 3.9-5b

Load Combinations for Seismic Category I
Active Pumps and Valves and Associated Component
Supports (Class 1, 2 and 3)

System Operating Condition	Load Combination	ASME Service Stress Limits
Normal	Dead + Live + Operating Thermal + Transients	Normal (or Level A)
Upset	Dead + Live + Operating Thermal + Transients(1) + OBE	Upset (or Level B)
Emergency	Dead + Live + Operating Thermal + Transients +DSL(4)	Upset (or Level B) Upset (or Level B)
Faulted	(a) Dead + Live + Operating Thermal + Transients(2) + DSL(2) + SSE	Upset (or Level B)
	(b) Dead + Live + Operating Thermal + Transients(3) + SSE	Upset (or Level B)
	(c) Dead + Live + Operating Thermal + Transients	Upset (or Level B)

(1) Includes worst normal operation transient with four OBEs and worst upset operation transient with one OBE, independently.

(2) Dynamic system loadings and transients associated with ex-containment IHTS design basis leaks and water/steam pipe rupture events.

(3) Includes worst nominal operation transient with the SSE.

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

Table 3.9-5c

Stress Criteria for All ASME Code Class 1
Component Supports of Plate and Shell Type

Condition	Stress Limits (1) (2)
Design	$P_m \leq S_m$ $P_m + P_b \leq 1.5\ S_m$
Normal/Upset (or Level A/B)	$P_m \leq S_m$ $P_m + P_b \leq 1.5\ S_m$ $P_e \leq 3\ S_m$ $P_m + P_b + P_e \leq 3\ S_m$
Emergency (or Level C)	$P_m \leq 1.2\ S_m$ $P_m + P_b \leq \begin{cases} 1.8\ S_m \\ 0.8\ C_L \end{cases}$
Faulted (or Level D)	$P_m \leq \begin{cases} 1.5\ S_m \\ 1.2\ S_y \end{cases}$ $P_m + P_b \leq \begin{cases} 2.25\ S_m \\ 1.8\ S_y \end{cases}$

Notes:

(1) Terminology is as defined in the ASME Code, Subsection NF.
(2) For linear supports the stress limits given in NF-3231 of Subsection NF and Appendix XVII of Section III may be used.

Table 3.9-5d

Stress Criteria for All ASME Code Class 2/3 Component Supports of Plate and Shell Type

Condition	Stress Limits (1) (2)
Design	$\sigma_1 \leq S$ $\sigma_1 + \sigma_2 \leq 1.5$
Normal/Upset (or Level A/B)	$\sigma_1 \leq S$ $\sigma_1 + \sigma_2 \leq 1.5$
Emergency (or Level C)	1.2 x Normal Condition Limits
Faulted (or Level D)	1.5 x Normal Condition Limits

Notes:

(1) Terminology is as defined in ASME Code, Subsection NF.
(2) For linear supports use same limits as for Class 1.