Department of Energy
Washington, D.C. 20545

Docket No. 50-537
HQ:S:82:160

DEC 21 1982

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:

STRUCTURAL MARGIN BEYOND DESIGN BASE LOADS ON THE REACTOR VESSEL SUPPORT LEDGE

Enclosed is the subject analysis that was requested at the December 9, 1982, meeting between the Applicant and the Nuclear Regulatory Commission staff.

If you have any questions, please call W. Pasko (FTS 626-6096) of the Project Office Public Safety Division.

Sincerely,

John R. Longenecker

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

Enclosure

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SMBDB ANALYSIS

REACTOR VESSEL SUPPORT LEDGE

1. Requirements, Loads and Allowable Stresses

The SMBDB is a third level margin design loading. The SMBDB conditions are defined by a dynamic load on the ledge from the Reactor System. The layout of the reactor vessel ledge support is shown in Fig. 1. The dynamic load was provided as time-histories of vertical and toroidal loads. Figures 2 and 3 show the time-histories of the loads. In addition to the dynamic load, dead load, live load and thermal loads due to normal operating conditions were included. The aplicable load combination is:

$$1.6\ S = D + L + To + A$$

Where:

D	=	Dead Load
L	=	Live Load
To	=	Thermal Loads Due to Normal Operating Conditions
A	=	SMBDB Load
S	=	Required section strength based on the elastic design methods and the allowable stresses defined in Part 1 of the AISC Manual of Steel Construction

For plate elements the allowable stresses are the same as for load combinations 6, 8 or 10 of the Design Basis Conditions (Table I). For buckling the allowable stresses are those given in Table II for load combinations 5 to 10. Load combinations are given in Table III.

2. Method of Analysis

The analysis was performed using the computer program STARDYNE. It consisted of two parts. The first part was simplified dynamic analysis to obtain an equivalent dynamic load factor. The second part consisted of an equivalent static analysis on a detailed finite element model, with a load equal to the peak of the time-history multiplied by the equivalent dynamic load factor.

The first part of the analysis used four different models.

The first model consisted of a two degree of freedom system representing respectively the ledge and the

Reactor Cavity below. Parametric studies conducted with this model showed that the ledge responses were relatively insensitive to the cavity properties. An equivalent dynamic load factor of 1.6 was calculated from this model.

The other three models for dynamic analysis consisted of finite element representations of 10° sectors of the ledge. 10° is the typical angle between brackets. The models represented respectively, sections with a full bracket, with a cut-out bracket, and with a cut-out bracket with a box column. The cavity was represented by an equivalent mass and spring. It was found that if an equivalent dynamic factor of 2 was used, the highest stresses in all the models were enveloped. Therefore, a dynamic load factor of 2 was adopted.

The detailed stress analysis was conducted with the same 90° model used for the design basis conditions. The peaks of the SMBDB force time-histories were multiplied by a factor of two and applied as equivalent static forces.

In the static analysis four cases were considered. They represented the four possible combinations of signs of the two loads. The results of the four cases were enveloped.

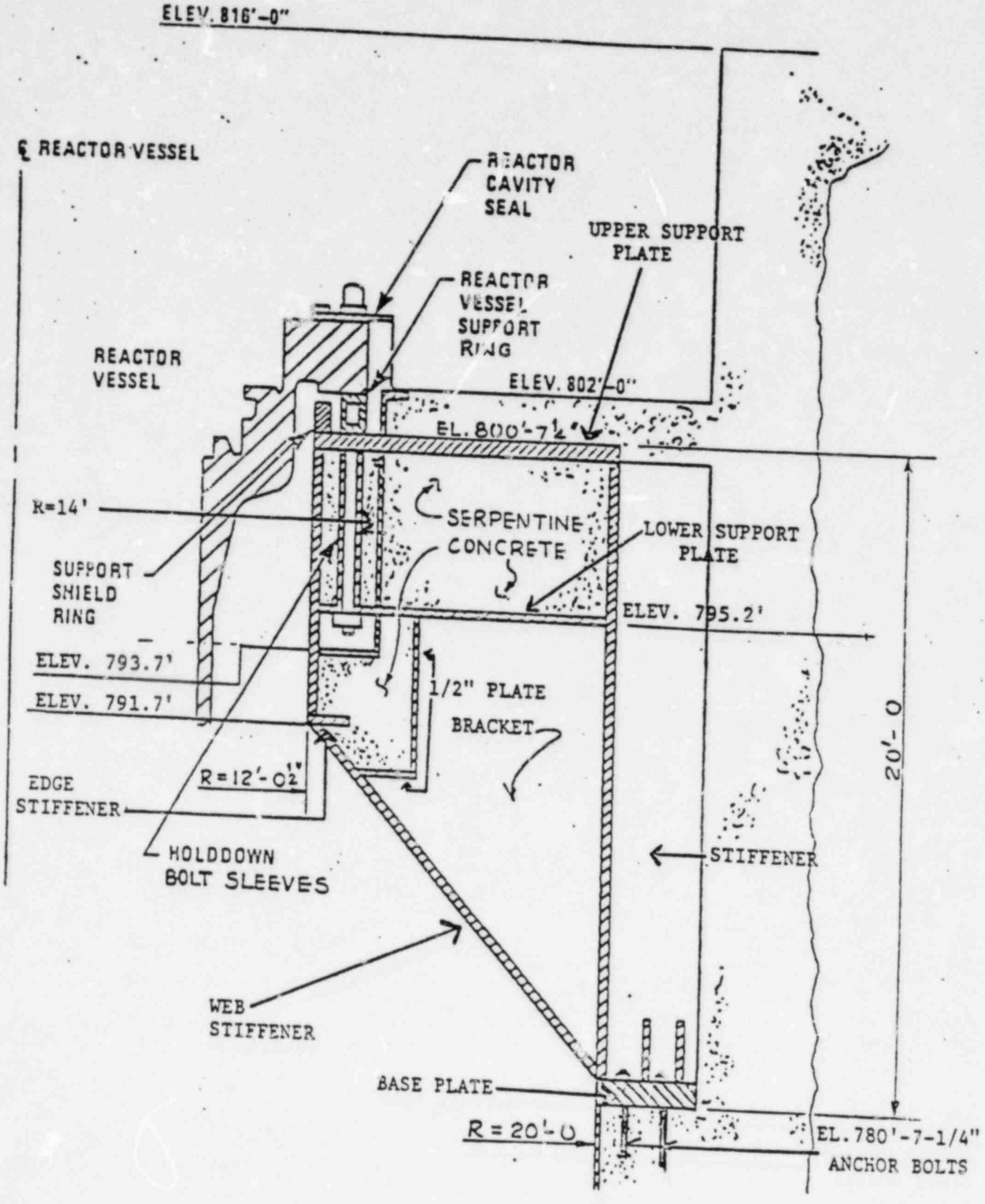
3. Results

Tables IV and V summarize the calculated stresses and compare them with the allowable values.

In all cases the calculated stresses did not exceed the stress limits.

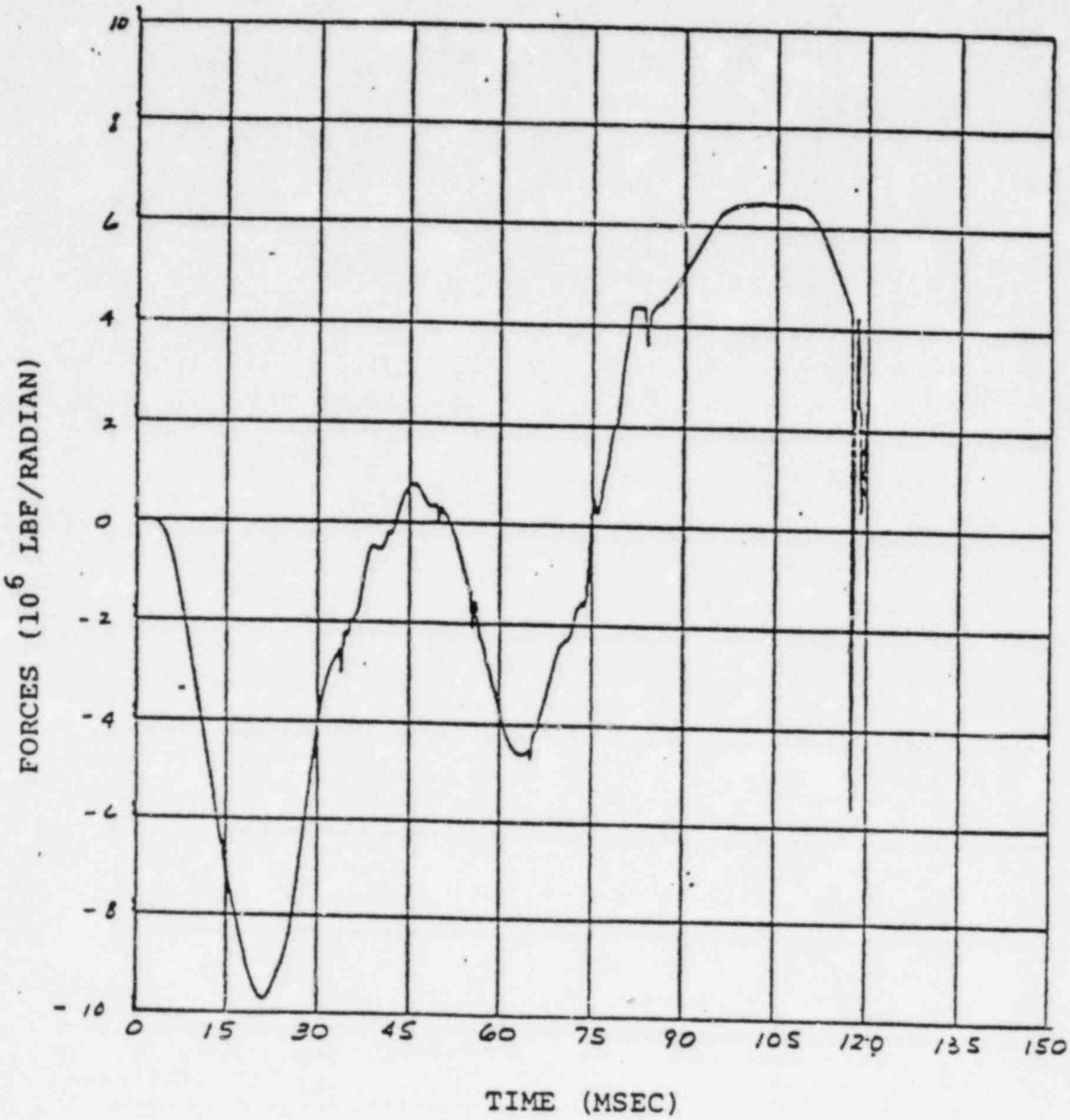
For the bolt sleeves, which are not listed in the Tables, buckling was verified using the interaction equations of Section 1.6.1 of the AISC Manual of Steel Construction and the requirements were met.

The maximum compressive stress in the box column is 30.5 ksi which is less than the limit, 34.6 ksi. In the box column verification the compressive stresses due to bending were added to the axial stresses and compared with the axial allowable. This is a conservative approach.



TYPICAL SECTION THROUGH REACTOR VESSEL LEDGE SUPPORT

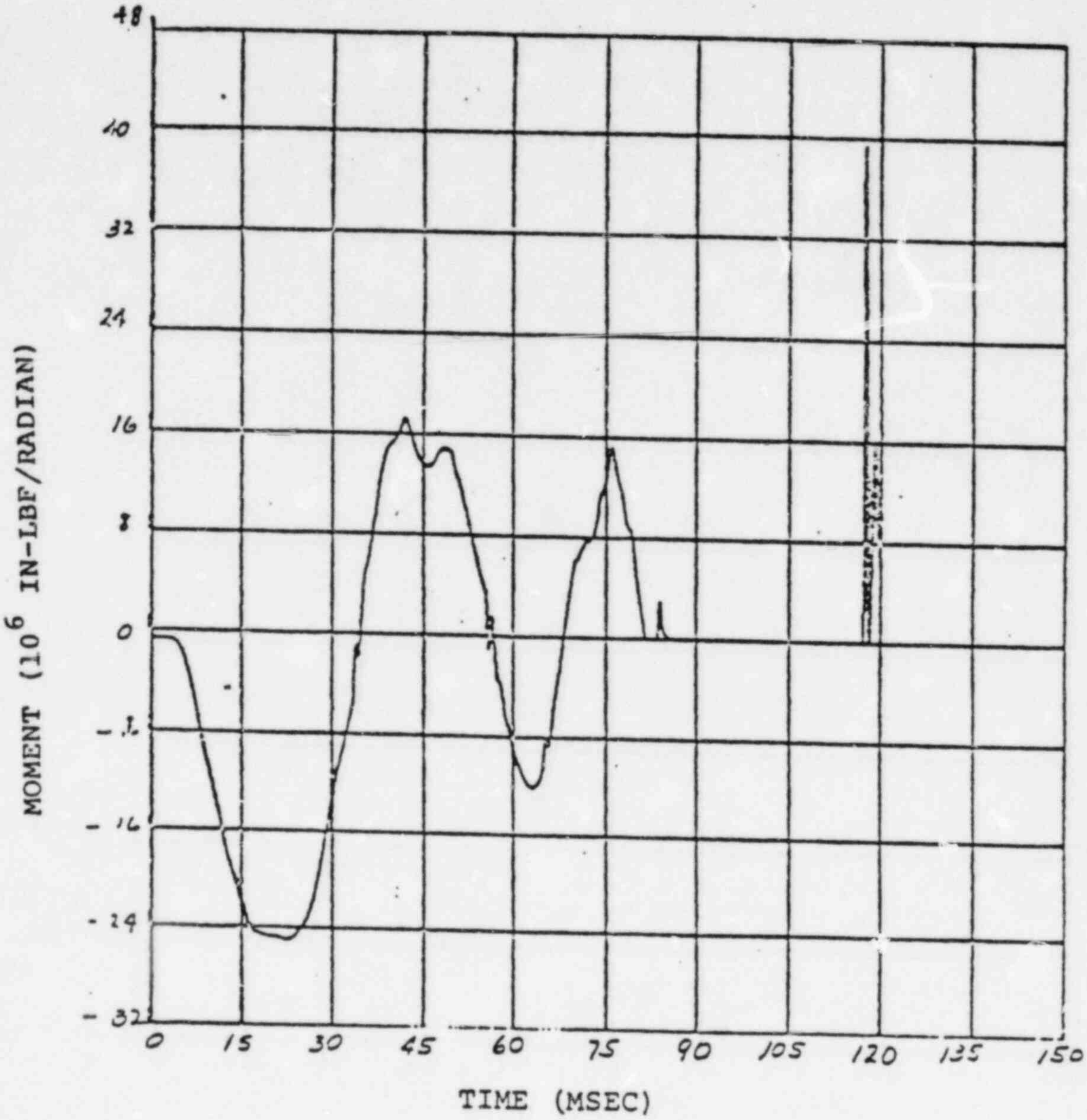
FIGURE 1



SMBDB

VERTICAL FORCE HISTORY FOR REACTOR VESSEL SUPPORT LEDGE

Figure 2



SMBDB

TOROIDAL MOMENT HISTORY FOR REACTOR VESSEL SUPPORT LEDGE
Figure 3

TABLE I

<u>STRESS INTENSITY LIMITS FOR PLATE ELEMENTS</u>

Units: ksi

Load Combinations		Primary Stresses		Primary Plus Secondary Stresses
		Membrane	Membrane Plus Bending	
1 to 4	Normal Upset	26.7 (23.3)	40.0 (35.0)	80.0 (70.0)
5 to 10	Faulted	56.0 (49.0)	56.0 (49.0)	80.0 (70.0)

( ) For plates of thickness greater than 4 inches

TABLE II

ALLOWABLE BUCKLING STRESSES (in ksi)

LOCATION OF PLATES	LC 1 & 2	LC 3 & 4	LC 5 - 10
1. Horizontal Plates			
At El. 800.33	30.0	45.0	48.0
At El. 795.21	36.0	54.0	57.6
At El. 793.67	36.0	54.0	57.6
At El. 791.67	34.0	51.0	54.4
At El. 780.83	30.0	45.0	48.0
2. Radial Plates			
3' Plate Embedded in Concrete	34.7	52.0	55.5
Above El. 795.21	34.7	52.0	55.5
Below El. 795.21*	30.8	46.2	49.3
3. Vertical Cylindrical Plates			
at r = 12.125'			
- 800.33 to 793.67	36.0	54.0	57.6
- 793.67 to 791.67	34.0	51.0	54.4
- 791.67 to 790.48	34.0	51.0	54.4
at r = 14.04'	36.0	54.0	57.6
at r = 20'			
- 800.33 to 795.21	34.7	52.0	55.5
- 795.21 to 780.83	30.9	46.3	49.4
4. Web Stiffner	30.8	46.2	49.3
5. Linear Elements			
Box Columns	25.8	38.7	41.3
Bolt Sleeves	33.6	50.4	53.8

NOTE: Above stresses are for a metal temperature = 100°. Interpolate linearly from 1.0 to 0.8 for 100° to 350° for multiplication factor for above stresses

* For radial bracket elements between R = 12' and R = 14' and Elevations 793.67 ft. and 795.25 ft. use the same allowable stresses as for above Elevation 795.21 ft.

TABLE III

LOAD COMBINATIONS

A. For Service Load Conditions

1. S = D + L
2a. S = D + L + E
2b. S = D + L - E
3a. 1.5S = D + L + To + E
3b. 1.5S = D + L + To - E
4a. 1.5S = D + L + Tu + E
4b. 1.5S = D + L + Tu -E

B. For Factored Load Conditions

5a. 1.6S = D + L + To + E'
5b. 1.6S = D + L + To - E'
6a. 1.6S* = D + L + Ta + Pa + E
6b. 1.6S* = D + L + Ta + Pa - E
7a. 1.7S* = D + L + Ta + Pa + E'
7b. 1.7S* = D + L + Ta + Pa - E'
8a. 1.6S* = D + L + Ta + Pa + E
8b. 1.6S* = D + L + Ta + Pa - E
9a. 1.7S* = D + L + Ta + Pa + E'
9b. 1.7S* = D + L + Ta + Pa - E'
10a. 1.6S = D + L + Tu + E'
10b. 1.6S = D + L + Tu - E'

Notes for Load Combinations:

1. * Plastic section modulus "Z" may be used in lieu of elastic section modulus.

2. "S" is the required section strength based on the elastic design methods and the allowable stresses defined in Part 1 of the AISC Specification.

D	=	Dead Load
L	=	Live Load
E	=	OBE Loads
E'	=	SSE Loads
To	=	Thermal Loads Due to Normal Conditions
Tu	=	Thermal Loads Due Upset Conditions
Ta	=	Thermal Loads Due to Accident Conditions (DBA)
Pa	=	Pressure Loads Due to DBA

3. Load combinations 6 and 7 considered DBA conditions at 12 hours. Load combinations 8 and 9 considered DBA conditions at 80 hours.

TABLE IV

SMBDB

Summary of Maximum Stress Intensities in Plates

LOCATION	Pm		Pm + Pb		Pm + Pb + S	
	Calc.	Allow.	Calc.	Allow.	Calc.	Allow.
Bracket	55.8	56.0	55.9	56.0	55.9	80.0
Bracket	54.3	56.0	54.6	56.0	54.6	80.0
Stiffener	47.5	56.0	47.6	56.0	52.9	80.0
Stiffener	46.3	56.0	46.5	56.0	52.8	80.0
Stiffener	45.2	56.0	45.5	56.0	51.8	80.0
Pl. El. 800.3'	20.0	49.0	37.9	49.0	46.0	70.0

Units: ksi

Pm = Primary membrane stress intensity
Pb = Primary bending stress intensity
S = Secondary stress intensity

TABLE V

SUMMARY OF MAXIMUM PRINCIPAL MEMBRANE COMPRESSIVE STRESSES IN PLATES

SMBDB

LOCATION	f_{calc} ksi	f_{all} (+) ksi
Radial Stiffener	49.1* (41.3)	51.6
Bracket (Between R = 12' and R' = 14')	43.3* (29.5)	44.4
R = 12'	37.9*	48.4
Plate El. 800.3'	26.2*	40.3

* Peak Stress

( ) Average Stress

(+) Based on Steel temperature

FRONT-LINE AND SUPPORT SYSTEM RELIABILITY PROGRAMS

- Quantitative measures compatible with the overall measures
- Mechanisms for reliability tradeoff at system and component level
- Appropriate reliability information transfer
- Definition of performance requirements
- Assurance of continuing program continuity
- An auditable reliability program