FLUOR DANIEL

ATTACHMENT 1

SUMMARY REPORT ON SAMPLING STUDY TO EVALUATE THE EFFECT OF TORSIONAL MOMENT ON PIPE STRESS QUALIFICATION.

PRAIRIE ISLAND AND KEWAUNEE NUCLEAR POWER PLANTS

Project No. 834486
Report No. R.834486-1 Rev.1
Date: April 20, 1989

Prepared By: R. N. Patel
Reviewed By: B. L. Dickerson
J. K. Kaliyadan
Approved By: A. Casillo

FLUOR DANIEL

Report No. R.834486-1 Rev. 1
Project No. 834486

TABLE OF CONTENTS

1.0 INTRODUCTION/SUMMARY

During the recent NRC audit, the question was raised regarding the interpretation of the term "longitudinal stress" in USAS B31.1.0-1967 Power Piping Code, which is the licensing basis for Prairie Island and Kewaunee Nuclear Generating Plants (References 2 and 7). The question was raised: "Does the Fluor Daniel interpretation of using two bending moments in pipe stress calculation for Upset and Faulted loading combinations adequately meet the intent of the code?" In response to this question, in addition to the technical justification provided in Reference 6, this study is performed to determine the effect of the torsional moment and show that the piping systems are within the limits of the USAR criteria.

The results of this study shows that it is not necessary to include the torsional moment in the stress calculation and that the interpretation of the term "longitudinal stress" is correct. The inclusion of torsional moment is considered outside the design basis for these plants.

This study is based on the statistical method of selecting samples and analyzing them. The evaluation is performed in accordance with the procedure contained in Reference 4. According to the procedure, the size of the randomly selected sample should be 58 to achieve a 95% confidence level that the total population conforms to the results and conclusions.

Section 2.1 describes the random selection of samples. These samples are screened in regard to the minimum stress levels defined in the procedure to determine the relevant samples. There are a total of 14 analytical parts found as relevant as 1
discussed in section 2.2. These relevant analytical parts are analyzed for pipe stress qualification, including the effect of torsional moment. The result show that all of the 14 1
relevant samples meet the USAR criteria.

2.0 EVALUATION

There are a total 1,428 safety-related piping analytical parts existing for Prairie Island and Kewaunee Projects combined. A sampling study, based on a random selection method, is adopted for this study. The following subsections describe and document the evaluation performed.

2.1 SELECTION OF SAMPLES

To randomly select the required samples of analytical parts, a PC program written in BASIC with the Random Generator function is used. Each of the 1,428 analytical parts is assigned a unique record number from 1 to 1,428. Reference 5 of this report contains the documentation of the random selection process and the list of all analytical parts. The 58 randomly selected analytical parts, which are used in this study, are listed in Table 2.2. This sample size achieves a 95% confidence level and is consistent with the sample size requirement of IE Bulletin 79-02.

2.2 SCREENING OF SAMPLES

The objective of screening the samples is to eliminate those analytical parts having a stress level too low to cause an overstress when the torsional moment is included in the pipe stress calculation. The screening criteria, as discussed in Reference 4, is as follows:

TABLE 2.2
SUMMARY OF EXISTING STRESS LEVELS FOR 58 SAMPLES

RECORD NO.	REPORT NO.	PART NO.	SYSTEM ID	INDEX NO.	PIPE SIZE♦	MAX STRESS RATIO UPSET	FAULTED	STRESSES** OBE♦♦	1/2 Sh	
662	PI-233-50	16	CL	126	S	0.3288	0.2598	1124	7500	
* 442	PI-216-3	3	RH	010	S	0.4712	0.5404	5309	6500	
* 737	PI-233-27	33B	CC	547	L/S	0.4329	0.5681	8073	7500	1
* 424	PI-213-9	2CA-2	CS	018	S	0.4520	0.5840	7641	7500	
992	PI-233-44	47B	CC	653	S	0.1275	0.1000	863	7500	
308	PI-211-14	10F	WG	037	S	0.0630	0.0052	540	7500	
996	PI-233-34	7B	CC	657	L/S	0.1440	0.1660	1889	7500	1
* 792	PI-234-19	3B	RC	039	S	0.8135	0.6240	3671	5550	
397	PI-211-22	8A-1	WG	134	S	0.1380	0.0967	176	7500	
670	PI-233-51	25	CL	134	L/S	0.2457	0.2480	2291	7500	
* 18	PI-205-IV	48	SI	011	L	0.7033	0.7567	6748	6500	
323	PI-211-15	11NB	WG	052	S	0.0687	0.0540	220	7500	
929	PI-326-I	D	FO	034	L	0.1420	0.1060	246	7500	
170	PI-206-40	35A	VC	557	S	0.3413	0.2771	2367	6683	
967	PI-233-38	28A	CC	628	S	0.1400	0.1770	2281	7500	
788	PI-234-18	2F	RC	035	S	0.2600	0.3230	4609	8138	
734	PI-233-27	32A(UPPER)	CC	544	L/S	0.4660	0.4070	2674	7500	
953	PI-233-37	15B	CC	614	S	0.1111	0.1053	1290	7500	
* 440	PI-216-3	1	RH	008	S	0.5560	0.6750	7148	7500	
247	PI-206-59	39B	VC	634	S	0.0217	0.0208	293	9375	
* 581	PI-233-XV	VI	CL	012	L	0.6210	0.7490	9062	7500	
* 448	PI-216-V	9A AND B	RH	014	L	0.6600	0.7307	8306	7625	
650	PI-233-12	1	CL	114	L/S	0.1230	0.0986	690	7500	
959	PI-233-38	19A	CC	620	S	0.1794	0.2344	2266	7500	

TABLE 2.2 (Continued)
SUMMARY OF EXISTING STRESS LEVELS FOR 58 SAMPLES

RECORD NO.	REPORT NO.	PART NO.	SYSTEM ID	INDEX NO.	PIPE SIZE♦	MAX STRESS RATIO UPSET	FAULTED	STRESSES** OBE♦♦	1/2 Sh
744	PI-233-29	32B	CC	554	L/S	0.2069	0.2350	2709	7500
* 837	PI-310-2	4A	HC	008	S	0.5480	0.6110	8379	7500
205	PI-206-44	40-II	VC	592	S	0.0680	0.0520	156	8825
508	PI-221-14	MS-24	MS	061	S	0.4420	0.3962	3849	7500
722	PI-233-24	36	CC	532	L/S	0.1985	0.1531	790	7500
554	PI-224-3	3	AF	014	S	0.2605	0.2212	1674	7500
972	PI-233-40	27B	CC	633	L/S	0.0470	0.0345	310	7500
248	PI-206-59	39C	VC	635	S	0.0217	0.0208	293	9375
* 24	PI-205-VIII	V	SI	017	L	0.5010	0.4610	3496	7156
293	PI-211-12	4D	WG	022	S	0.3358	0.3057	2064	7000
604	PI-233-VI	CL-SFP	CL	035	L	0.1108	0.0845	289	7500
875	PI-221-23	2MS-6R	MS	102	S	0.2124	0.1565	460	7500
136	PI-206-26	10Q	VC	523	S	0.3270	0.3939	5372	8482
* 802	PI-234-22	RC-25	RC	049	S	0.5068	0.4049	1747	7215
647	PI-233-14	8	CL	111	S	0.4400	0.4150	3317	7500
853	PI-321-1	8	EG	008	L	0.1160	0.0800	85	5400
924	PI-326-8	29A	FO	029	S	0.0916	0.0810	951	7500
*1118	CC-31-011	31-011	CC	007	L	0.5050	0.6360	8441	7500
1094	KEW-206-16	15	CVC	051	S	0.4190	0.3325	1729	8963
1030	KEW-016-1	4B	RBV	004	S	0.1705	0.1440	1525	7500
*1107	KEW-206-15	8(INT.)	CVC	064	S	0.6176	0.7448	10419	8688
*1100	KEW-206-14	2(INT.)	CVC	057	S	0.6126	0.5862	6483	8688
1289	KEW-MS-5	19	SW	045	S	0.0994	0.0803	658	7500

TABLE 2.2 (Continued)
SUMMARY OF EXISTING STRESS LEVELS FOR 58 SAMPLES

RECORD NO.	REPORT NO.	PART NO.	SYSTEM ID	INDEX NO.	PIPE SIZE♦	MAX STRESS RATIO UPSET	MAX STRESS RATIO FAULTED	STRESSES** OBE♦♦	STRESSES** 1/2 Sh
1195	KEW-MS-8	56	GWP	038	S	0.2685	0.1931	1004	7500
1042	KEW-205-6A	3A	SI	011	S	0.2790	0.2432	2706	9155
1291	KEW-MS-6	24	SW	048	S	0.1940	0.1795	1355	7500
1388	SW-02-002	02-002	SW	093	L	0.2199	0.2421	2901	7500
1098	KEW-206-16	19	CVC	055	S	0.1717	0.1205	818	9375
1126	KEW-210-6	VI	CC	018	S	0.2084	0.1769	1692	7500
1279	KEW-233-10	IV.BB	SW	034	L	0.2688	0.3136	3683	7500
1258	SW-02-016	02-016	SW	010	L	0.1490	0.1206	1021	7500
1063	KEW-206-7	12	CVC	018	S	0.2320	0.1985	2892	8963
1358	RHR-34-004	34-004	RHR	001	L	0.4522	0.4467	3918	7025
1287	KEW-MS-3	14(A)	SW	043	S	0.1526	0.1374	1236	7500

NOTES: * These samples are the relevant analytical parts.
**Stresses are in psi.
♦ Pipe size, S = small bore and L = large bore
♦♦Includes torsional stresses.

Any of the analytical parts having either -

a) maximum Upset or Faulted stress ratio to the allowable ≥ 0.5,

or

b) maximum OBE stress, including the effect of torsion, ≥ ½ S_h, (S_h = material allowable stress at design temperature) is considered relevant and is evaluated further.

For each of the 58 samples, the existing maximum stress ratios for Upset and Faulted conditions and the maximum OBE stress values are obtained from the Analysis of Record (AOR). Table 2.2, which is extracted from Reference 3 and included in this report, summarizes the existing maximum stress ratios and maximum OBE stress, along with the ½ S_h values for each of the 58 analytical parts.

After screening the 58 samples, there are 14 relevant samples which are chosen for further study. These relevant samples are identified in Table 2.2. 1

2.3 ANALYSIS OF RELEVANT SAMPLES

USAS B31.1.0-1967 Code (Reference 1) does not provide an equation to calculate the combined pipe stress due to pressure, sustained and occasional loads. The method used to calculate the combined stress including the effect of torsional moment is provided in Reference 4. The resultant moment due to deadweight and seismic loadings are calculated using the square root of the sum of squares (SRSS) of the three moments with the stress intensification factor applied, as appropriate, to the two bending moments. This approach of including torsional moment is consistent with the calculation of expansion stress presented in the Code (Reference 1). If USAS B31.1.0-1967 Power Piping Code had required the inclusion of torsional moments, then the method used in this study would have been appropriate.

Reference 3 documents the pipe stress analysis for 14 relevant samples, for the inclusion of torsional moment. The revised Upset and Faulted stress ratios to the allowable are tabulated as shown in Table 3.1. 1

3.0 RESULT

All of the 14 relevant analytical parts meet the USAR criteria 1
when the torsional moment is included in the pipe stress calculation. Table 3.1 provides the summary of Upset and Faulted stress ratios for "without torsion" and "with torsion"
cases for each of the 14 relevant analytical parts. The 1
distribution of 58 samples, in regards to the pipe size (small bore and large bore) is shown in Table 3.1 as supplementary information. Increases in combined stresses for Upset and Faulted loadings are nominal when the torsional moment is included in the stress calculation. For the worst case, which is Report No. PI-234-19, Part No. 3B, the Upset stress ratio is increased from 0.813 to 0.870 after the torsional moment is included.

TABLE 3.1

RESULTS OF SAMPLING STUDY

DISTRIBUTION OF 58 SAMPLES:

	PRAIRIE ISLAND	KEWAUNEE
ORIGINAL SAMPLES	41	17
STRICTLY LARGE BORE	7	5
SMALL-LARGE BORE	8	0
STRICTLY SMALL BORE	26	12

RELEVANT ANALYTICAL PARTS		MAXIMUM STRESS RATIO				
		WITHOUT TORSION		WITH TORSION		
REPORT NO.	PART NO.	UPSET	FAULTED	UPSET*	FAULTED*	
PI-216-3	3	0.471	0.540	0.490	0.560	
PI-233-27	33B	0.433	0.568	0.580	0.680	1
PI-213-9	2CA-2	0.452	0.584	0.520	0.630	
PI-234-19	3B	0.813	0.624	0.870	0.690	
PI-205-IV	48	0.703	0.757	0.780	0.810	
PI-216-3	1	0.556	0.675	0.740	0.800	
PI-233-XV	VI	0.621	0.749	0.650	0.770	
PI-216-V	9A&9B	0.660	0.731	0.720	0.790	
PI-310-2	4A	0.548	0.611	0.640	0.720	
PI-205-VIII	V	0.501	0.461	0.560	0.510	
PI-234-22	RC-25	0.507	0.405	0.530	0.430	
CC-31-011	31-011	0.505	0.636	0.530	0.670	
KEW-206-15	8(INT)	0.618	0.745	0.640	0.760	
KEW-206-14	2(INT)	0.613	0.586	0.660	0.650	

* NOTE: The stress ratios are conservatively calculated according to Reference 4.

4.0 CONCLUSION

All of the 58 sample analytical parts satisfy the USAR criteria when the torsional moment is included in the combined pipe stress calculation for Upset and Faulted conditions. From this study, it is concluded that the torsional moment does not contribute significantly to the pipe stresses.

5.0 REFERENCES

(1) USAS B31.1.0-1967, Nuclear Power Piping Code.

(2) USAR for Prairie Island Nuclear Generating Plant, Revision dated February 20, 1986.

(3) "Evaluation of pipe stress, including the effect of torsional moment for 58 sample analytical parts," Calculation No. M.834486.02, Rev. 1 Dated 4-21-89, Project No. 834486. 1

(4) "Procedure to perform sampling study to evaluate the effect of torsional moment on pipe stress qualification," Procedure No. 834486-1, Project No. 834486, Dated February 3, 1989.

(5) "Random selection of samples from the total population of analytical parts contained in Prairie Island and Kewaunee Projects," Calculation No. M.834486.01, Project No. 834486, Dated February 10, 1989.

(6) "Documentation of Methodology used for combination of moments for piping constructed to the USAS B31.1-1967 Power Piping Code," prepared by R.F. Petrokas and E.O. Swain, Dated February, 1989.

(7) USAR for Kewaunee Nuclear Power Plant, Revision dated July 1, 1986.

Attachment 2

Criteria for Determining Justification For Continued Operation When Encountering Major Discrepancies in "As-built" Safety Related Piping

May 5, 1989

Wisconsin Public Service Corporation

Kewaunee Nuclear Power Plant

Table of Contents

1.0 Introduction & Scope

These criteria are intended to assure the operability requirements of safety related piping and associated supports if it is determined that stresses exceed allowables presented in the Kewaunee USAR. These criteria permit operation for an interim period only. Modifications will be made which return the system to within USAR allowables by the next refueling outage or sooner if operation permits.

These criteria are intended to expeditiously perform necessary evaluations to determine interim operability and not to delay appropriate actions.

For cases involving components classified as ASME Code Class I where USAR allowables are exceeded, WPSC shall be notified upon discovery and WPSC shall evaluate reportability requirements per 10 CFR 50.

2.0 Criteria

2.1 Piping Operability Criteria

The piping analysis shall be in accordance with ASME, Section III NC-3600 service level D limits (Ref. 1). The design loading conditions to be applied in the analysis shall include the DBE earthquake.

Following is the pipe stress criteria for justifying continued operation of the plant:

$[S_{LP} + S_{WT} + S_{DBE} \leq 2.0\ Sy]$ (Ref. 1 equation 9)

Where: S_{LP} = Longitudinal Pressure Stress

S_{WT} = Dead Weight Stress

S_{DBE} = Stresses Resulting from Design Basis Earthquake

S_Y = Material Yield Stress (Reference 1 Appendices)

Code Case N-411 allows for increased damping values, independent of pipe diameter, for seismic analysis. Therefore, increased damping values, in accordance with reference 2, will be acceptable when performing these analyses to meet operability. Should the piping stress analysis exceed the value of 2.0 Sy, or pipe supports do not meet their operable limits (see Sect. 2.2), then additional iterative analysis of the piping may be required. The iterative analysis may use the knowledge that a support is not capable of withstanding the loads, and can be removed from the analysis. Where feasible, the actual support stiffness may be included in the iterative analysis, along with other refinements.

For cases where piping secondary stresses are determined to exceed USAR allowables, a specific case-by-case approach will be used to determine interim operability.

2.2 Pipe Support & Hanger Operability Criteria

As a first step in evaluating the support, a linear elastic analysis method will be used to determine the stress in the support members. In addition to the loading in Section 2.1, the support loads must include pipe thermal loads and results from free end displacement and anchor motion. Supports will be analyzed using the allowables listed below to meet operability requirements.

Structural Steel	
Tension	F_t = 1.20 Sy but $\leq$ 0.70 Su
Banding	F_b = 1.20 Sy but $\leq$ 0.70 Su
Shear	F_v = 0.72 Sy but $\leq$ 0.42 Su
Compression	F_a < F_t but not to exceed 2/3 Pcr
Combined Stress	For axial compression and bending or axial tension and bending, use AISC 1.6 (Ref. 6).
Web Crippling	= 1.0 Sy
Weld Stress	F_w = 0.42 Su (of weld material)
Anchor Bolts	Use Factor of Safety of 2 against ultimate tension and shear values.
Snubbers	
Hydraulic	Load < manufacturer's one time load capacity. Movement < total travel.
Springs	Load within catalog range without bottoming out.
Struts	FS = 2 and < 2/3 Pcr

All remaining catalog items	Use manufacturer's published faulted load rating. Where level D allowables are not given, and the factor of safety is specified in the catalog, use design allowables but with FS = 2. (Typical catalog FS = 5, therefore use 2.5 x catalog capacity.)

Where: F_t = Allowable Tensile Stress

F_b = Allowable Bending Stress

F_v = Allowable Shear Stress

F_a = Allowable Axial Compressive Stress

F_w = Allowable Weld Stress

Pcr = Maximum Strength of Axially Loaded Compression Member

Sy = Specified Minimum Field Strength at Temperature (See Note 1)

Su = Specified Minimum Tensile Strength Temperature

FS = Factor of Safety

Note 1: Actual yield strength may be used where CMTR's are available for the material.

If a support fails using the linear elastic method, then a more refined analysis may be performed using plastic analysis techniques. The plastic analysis will follow the design rules of ASME Section III, Appendix F (Ref. 1).

3.0 Conclusion

If the above criteria cannot be met, reportability per 10 CFR 50 must be evaluated and system operability requirements per Plant Technical Specifications must be evaluated and appropriate actions taken.

4.0 References

1. American Society of Mechanical Engineers, Boiler and Pressure Vessel Codes, Section III, 1983 Edition, through Winter 1985 Addenda.

2. American Society of Mechanical Engineers, Boiler and Pressure Vessel Codes, Case N-411, dated September 17, 1984.

3. NRC IE Bulletin 79-02, "Pipe Support Base Plate Designs Using Concrete Expansion Anchor Bolts," Revision No. 1 (Supplement No. 1), dated August 20, 1979.

4. USAS B31.1.0-1967, Power Piping Code.

5. Updated Safety Evaluation Report for PINCF.

6. "Manual of Steel Construction," American Institute of Steel Construction, Inc., Eighth Edition, 1980.