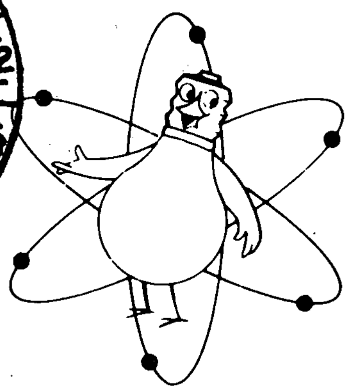
SUPPLEMENTARY INFORMATION

DRESDEN NUCLEAR POWER STATION UNITS 2 AND 3

AMENDMENT NUMBER 20 FOR UNIT 2
AND
AMENDMENT NUMBER 21 FOR UNIT 3



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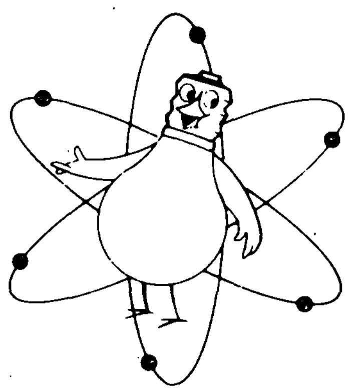

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The seismic dynamic analyses of the Dresden Unit 2 piping inside the drywell has been expanded to ensure that the systems meet the criteria and are conservatively designed. In addition, a summary of the statically evaluated systems for the Design Basis Earthquake are presented. Results of these additional studies show that the subject piping does meet the criteria discussed in the FSAR and the design is reasonably conservative.

A. Static Evaluation

Results of statically performed analyses are summarized in Table 1. Only the highest stressed sections of the various systems are listed. Intensification factors that were used are provided in column 7 of the Table and column 8 provides the horizontal static coefficient that was applied to the systems. It is noted that these latter coefficients are twice the values discussed in Amendments 13/14 and 19/20. The coefficients, as noted in the previous amendments, are highly conservative and were used in this evaluation to determine the design basis earthquake, i.e. the double earthquake, effects. Column 12 of the Table is a direct addition of stresses, which shows that in all cases except one, this conservative method of combining stresses results in less than the yield stress listed in column 13. The exception was further analyzed to verify that the criteria of the FSAR, Section 12, was met. This analysis showed that by summing the moment components first and then calculating stress (rather than the direct addition of stresses) results in a stress of 37,124 psi as compared to the yield stress of 35,000 psi. Although the result is only 6% beyond yield, the analysis was further continued to insure that the system would remain functional. The bases for the plastic deformation that can be safely permitted is described in terms of hinge moments and collapsing loads. The maximum moment that can be sustained at a cross-section where all points of the section are plastic is $M_u = 1.3\ M_{yield}$. M_u is called the "hinge moment", and M_{yield} is the moment attained

Table I

TABULATION OF MAXIMUM STRESSES IN DRESDEN STATICALLY ANALYZED PIPING
DESIGN BASIS EARTHQUAKE

1 Item	2 System	3 Point No.	4 Material	5 O.D. (In.)	6 Thk. (In.)	7 Intensif. Factor	8 Horiz. Static Coeff. K	9 Weight Stress (psi)	10 Press. Stress (psi)	11 Total Seismic Stress (psi)	12 Combin. Stress Sigma (psi)	13 Yield Stress (psi)
1	HPCI Turbine Exh.	105 Bend	ASTM A106 GR.B	24.000	.375	4.27	1.4	74	1529	7576	9179	30,000
2	HPCI Pump Suction	55 TGNT	ASTM A106 GR.B	16.000	.375	3.17	1.4	3935	744	5612	31,008	35,000
3	Core Spray Pump Suction	125 TGNTR	ASTM A106 GR.B	16.000	.375	4.97	1.4	1314	744	5068	32,463	35,000
4	Core Spray Pump Disch.	30 Bend	ASTM A106 GR.B	10.750	.593	1.83	1.4	534	1329	24,086	25,949	35,000
5	LPCI Pump Suction	145 TGNT BP	ASTM A106 GR.B	14.000	.375	4.57	1.4	1335	601	7324	40,173	35,000
6	LPCI Pump Discharge to Cont. Cool. HTXR	70 TGNT BP	ASTM A106 GR.B	12.750	.375	4.51	1.4	263	2327	5462	28,147	35,000
7	LPCI Pump Discharge from Cont. Cool HTXR to Drywell	330 TGNT BP	ASTM A106 GR.B	18.000	.438	3.38	1.4	416	2859	8818	34,070	35,000
8	Cont. Cool to HTXR	50 TGNT	ASTM A106 GR.B	16.000	.375	2.30	1.4	7168	2977	5634	32,422	35,000
9	Cont. Cool from HTXR TO 48" Stand Pipe	220 Bend	ASTM A106 GR.B	14.000	.375	2.94	1.4	706	601	33,422	34,729	35,000
10	Isolation Conds. Supply	60 Anchor	ASTM A358 TP 304	14.000	.638	1.00	2.50	2694	5935	3211	11,840	17,000
11	Isolation Conds. Return	90 Anchor	ASTM A358 TP 304	13.170	.585	1.00	2.50	2272	6112	5476	13,860	17,000
12	HPCI Pump Disch.	305 Bend	ASTM A106	14.000	1.093	3.34	1.4	2402	3710	21,608	27,720	35,000

when the stress at the extreme fiber is at yield. M_{yield} is then the yield stress times the section modulus. When other loads such as internal pressure are present the M_u is less than 1.3 M_{yield}. Interaction for all types of loading at a section were determined by the use of interaction curves. These curves are given in Volume 4 of "Nuclear Engineering Design" (1966) by Stokey, Peterson and Wunder in the section "Limit Loads for Tubes Under Internal Pressure, Bending Moment, Axial Force and Torsion." For a structure to collapse, at least three hinge moments must form. The additional load required to create these hinge moments, the collapsing load, is considerably above the load required to just produce yield stress. For example, if a fixed-fixed beam under uniform load requires a load of w/lbs/ft to just reach yield stress due to bending, then 1.3 w is required to produce the first two hinges which form simultaneously at the end restraints and 1.7 w is required to produce 3 hinges or collapse. Since functional operation should be available until actual collapse, the system could be said to meet the criteria up to a load of 1.7 the load which produced yield. However, the first degree of conservatism in the criteria limits the loads to the first hinge moment load or 1.3 w. Simultaneous occurrence of the first and second hinges is only for uniform load on a symmetrical beam which is not the case for an actual system. This conservatism accounts for such factors as stress reversal which gives rise to low cycle fatigue, pipe wall potential buckling that could lead to greater strains than those calculated and the calculation of stresses on an elastic basis. To allow a second level of conservatism a 1.2 safety factor is also used when comparing the moment ratios from the referenced curves. Hence, when using the curves, instead of an allowable ratio of 1.00 being used on the load to form the first hinge, a ratio of .83 was selected. The net safety factor on collapse is then better than 1.5:1 (from $\frac{1.7}{1.3}$ X 1.2). Use of the referenced method for item 5 of column 1 of Table 1 is summarized as follows. Total bending stress when combining moments rather than direct addition is 36,523 psi. Yield stress remains 35,000 psi. The referenced family of curves consider internal pressure stresses, shear stresses and bending stresses as ratios of a yield stress function. The read out is an allowable moment to M_u ratio which for the case considered is 1.00 allowable, but the criteria is to reduce the allowable by 1.2. Allowable is, therefore, .83, whereas the actual ratio is .82. Hence, it is considered that although yield is slightly exceeded, the subject system meets the criteria and remains functional with a safety factor greater than 1.5 on collapse.

B. Dynamic Analyses

The seismic analyses performed on the Dresden Main Steam, Feedwater, 16" LPCI Shutdown, 16" Shutdown and Recirculation Piping were performed using a method generally described in answer to Question 2.9 of Amendment 7/8. However, the inertia forces were calculated separately for each mode, and a final loading was obtained by taking the square root of the sum of the squares of these modal inertia forces. From this loading, the internal moments and stresses were caluclated by the usual structural analysis techniques. The stress equations are presented in answer to Question 7.9 of AMendment 7/8. In the summaries which follow this method of analysis will be identified as Method I.

An expansion of the seismic analysis on the above piping lines has been made using a method described on pages 15, 16, 17, 18 and 20 of Amendment 19/20. The mode shapes and frequencies are calculated in the same manner as referred to above for Method I. However, beyond this point, the following alteration to Method I was made.

The inertia forces for each mode were used to determine each mode's contribution to the total internal forces, moments and stresses in the pipe. The total combined results were obtained by taking the square root of the sum of the square of each parameter; i.e., forces, moments and stresses. This will be identified

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as Method II.

Following are summaries of the three highest stresses calculated by Method II for Dresden 2-3 Main Steam, Feedwater, 16" LPCI Shutdown, 16" Shutdown and Recirculation Piping. The stresses at corresponding points as calculated by Method I are also listed for purposes of comparison.

SUMMARY

RECIRCULATION PIPING

Pipe Identification	Method I Stress KSI	Location (Point No.)	Method II Stress KSI	Earthquake Combination
28 Inch Pump	1.52	7 (Straight Run)	1.17	X & Y
Suction P.3	1.32	11 (Elbow)	0.95	X & Y
	1.39	121 (Elbow)	0.85	X & Y
	1.97	10 (Elbow)	1.52	Z & Y
	1.59	11 (Pump Nozzle)	1.26	Z & Y
	1.56	7 (Straight Run)	1.23	Z & Y
12 Inch Riser	1.09	41 Nozzle	2.93	X & Y
	2.93	30 T-Branch	2.82	X & Y
	1.51	40 Elbow	2.77	X & Y
P. 1	3.43	30 T-Branch	3.08	Z & Y
	0.57	41 Nozzle	2.96	Z & Y
	1.59	40 Elbow	2.94	Z & Y
22 Inch Header	2.46	71 T-Branch	1.84	X & Y
	2.16	75 T-Branch	1.55	X & Y
	2.27	79 T-Branch	1.49	X & Y
P. 1	2.60	71 T-Branch	2.49	Z & Y
	2.27	75 T-Branch	2.08	Z & Y
	1.20	42 T-Branch	2.06	Z & Y
28 Inch Pump	3.01	150 Nozzle	2.60	X & Y
Suction P. 2	2.27	123 Straight Run	2.44	X & Y
	2.42	6 T-Branch	2.30	X & Y
	2.55	123 Straight Run	2.53	Z & Y
	2.27	6 T-Branch	2.41	Z & Y
	2.09	127 Elbow	2.20	Z & Y

The stresses listed above are for the operating basis earthquake. The above values increased by a factor of 2 will give the stresses for the design basis earthquake.

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The three highest stresses calculated by Method II are 3.08 ksi at point 30, 2.96 ksi point 41 and 2.93 ksi at point 40 with an average of 2.99 ksi.

The three highest stresses calculated by Method I are 3.43 ksi at point 30, 3.04 ksi at point 32 and 3.01 at point 150 with an average of 3.16 ksi.

For the 28" Pump Suction, P.3, the highest stresses calculated by Method II are all less than those obtained from Method I.

For the 12" Risers, the highest stresses as calculated by Method II have stresses at 4 points greater than those obtained from Method I. The average of the three highest stresses for the 12" risers by Method II is 2.90 ksi; the average by Method I is 1.19 ksi for the corresponding points.

For the 22" Header P.1, the highest stresses as calculated by Method II are all less than those obtained from Method I except for Point No. 40 in Z & Y combination - Method II gives 2.06 ksi and Method I 1.20 ksi.

For the 28" Pump Suction P.2, the highest stresses as calculated by Method II have stresses at 3 points greater than those obtained from Method I. The average of the three highest by Method II is 2.35 ksi; the average by Method I is 2.21 ksi for the corresponding points.

In the low stress range, less than 1 ksi, the number of points having the higher stress obtained by Method I and II are as follows:

Pipe Identification	Method I	Method II
28" Pump Suction - P.3		
X & Y Earthquake	6	1
Z & Y Earthquake	4	1
Risers-Header-Pump Discharge - P.1		
X & Y Earthquake	20	11
Z & Y Earthquake	9	13
28" Pump Suction - P.2		
X & Y Earthquake	9	2
Z & Y Earthquake	3	5

A comparison of the stresses at corresponding points as calculated by Method I are generally in agreement with the stresses calculated by Method II. For the recirculation lines on Dresden 2-3, either Method I or II gives results reasonably close and using the seismic results as given in John A. Blume's report entitled "Earthquake Analysis Recirculation Loop Piping, Dresden Units 2 and 3 Nuclear Plant" dated December 6, 1968 gives a conservative design to the recirculation piping lines and their supports.

16" REACTOR SHUTDOWN PIPING

Tabulated below is a summary of the three highest seismic stresses for Method II in the 16" reactor shutdown piping for Dresden 2-3. The corresponding stresses as calculated by Method I are also listed for purposes of comparison. The stresses tabulated are for the OBE loads. The stresses corresponding to the DBE loads can be obtained by multiplying the tabulated values by a factor of two.

SUMMARY - HIGHEST STRESSES

Location Point No.	Method I Stress (ksi)	Method II Stress (ksi)	Earthquake Combination
147 (Anchor)	4.08	3.18	X & Y
411 (Anchor)	3.24	2.19	
145 (Elbow)	1.53	2.16	
4 (Anchor)	3.14	1.95	Z & Y
147 (Anchor)	1.88	1.91	
133 (St. Run)	2.61	1.67	

The three highest stresses by Method I are 4.90 ksi at point 4, 4.10 ksi at point 133 and 4.08 ksi at point 147. The average of these is 4.36 ksi.

The three highest stresses by Method II are 3.18 ksi at point 147, 2.19 ksi at point 411, and 2.16 ksi at point 145. The average of these is 2.51 ksi.

The highest stresses listed as calculated by Method II are all less than those obtained by Method I. The average of the three highest stresses as listed for Method II is 2.51 ksi. The average by Method I is 3.49 ksi for the corresponding points.

Considering all points in the lines, the number of points having the higher stress obtained by Method I and II are as follows:

	Method I	Method II
X & Y Earthquake	26	5
Z & Y Earthquake	20	11

A comparison of the stresses at corresponding points generally shows close agreement; however, stresses calculated by Method I are higher. Therefore, the design of these lines using the seismic results as calculated by John A. Blume & Associates Method I is conservative.

LPCI SHUTDOWN PIPING

Tabulated below is a summary of the three highest seismic stresses for Method II in the 16" LPCI shutdown piping for Dresden 2-3. The corresponding stresses as calculated by Method I are also listed for purposes of comparison. The stresses tabulated are for the OBE loads. The stresses corresponding to the DBE loads can be obtained by multiplying the tabulated values by a factor of two.

SUMMARY - HIGHEST STRESSES

Location Point No.	Method I Stress (ksi)	Method II Stress (ksi)	Earthquake Combination
132 (Anchor)	1.73	2.39	
72 (Anchor)	2.64	1.67	X + Y
129 (Valve)	1.44	1.62	
72 (Anchor)	2.16	2.04	
132 (Anchor)	1.42	1.83	Z + Y
120 (St. Run)	1.66	1.61	

The three highest stresses by Method I are 2.64 at point 72, 2.16 at point 72, and 2.04 at point 120. The average of these is 2.28 ksi.

The three highest stresses by Method II are 2.39 ksi at point 132, 2.04 ksi at point 72 and 1.83 ksi at point 132. These average 2.09 ksi.

The highest stresses listed as calculated by Method II are less than those obtained by Method I in 3 out of 6 cases. The average of the three highest stresses as listed for Method II is 2.09 ksi. The average by Method I is 1.77 ksi for the corresponding points.

Considering all points in the line, the number of points having the higher stress obtained by Method I and II are as follows:

	Method I	Method II
X & Y Earthquake	8	7
Z & Y Earthquake	5	10 (5 of these are below 1.0 ksi.)

A comparison of the stresses at corresponding points as calculated by Method I are generally in agreement with the stresses calculated by Method II. The LPCI shutdown piping on Dresden 2-3 and either method I or II gives a conservative design for this piping system.

MAIN STEAM PIPING

Tabulated below is a summary of the three highest seismic stresses for Method II in each of the four loops of the main steam lines inside the Drywell for Dresden 2-3. The corresponding stresses as calculated by Method I are also listed for purposes of comparison. The stresses tabulated are for the OBE loads. The stresses corresponding to the DBE loads can be obtained by multiplying the tabulated values by a factor of two.

SUMMARY - HIGHEST STRESSES
(MAIN STEAM)

Loop	Location Joint No.	Method I Stress (ksi)	Method II Stress (ksi)	Earthquake Combination
A-1 & A-3	326.1 (Y-Z Stop)	4.10	3.83	X & Y
	326 (St. Run)	2.37	2.67	
	327 (Valve)	2.76	2.64	
	326.1 (Y-Z Stop)	11.55	5.86	Z & Y
	329 (Anchor)	2.52	4.36	
	327 (Valve)	7.58	4.03	
A-2 & A-4	425.1 (Y-Z Stop)	5.39	3.81	X & Y
	425 (St. Run)	3.61	2.70	
	400 (Nozzle)	1.99	2.25	
	425.1 (Y-Z Stop)	9.99	6.51	Z & Y
	425 (St. Run)	6.76	4.82	
	400 (Nozzle)	3.18	3.91	

The three highest stresses by Method I are 11.55 ksi at Joint 326.1, 9.99 ksi at Joint 425.1 and 7.58 ksi at Joint 327. The three highest stresses by Method II are 6.51 ksi at joint 425.1, 5.86 ksi at joint 326.1, and 4.82 ksi at joint 425.

For loops A-1 and A-3, the highest stresses listed as calculated by Method II are higher at two points than those listed for Method I. The average of the three highest stresses as listed for Method II is 4.75 ksi. The average by Method I is 7.22 ksi for the corresponding points.

For loops A-2 and A-4, the highest stresses listed as calculated by Method II are higher at only one point than those listed for Method I. The average of the three highest stresses as listed for Method II is 5.08 ksi. The average by Method I is 6.64 ksi for the corresponding points.

Considering all points in the lines, the number of points having the higher stress obtained by Method I and II are as follows:

Loop	Method I	Method II
A-1 & A-3		
X & Y Earthquake	6	25 (of these, 12 are less than 1.0 ksi.)
Z & Y Earthquake	18	13
A-2 & A-4		
X & Y Earthquake	15	16
Z & Y Earthquake	13	18

A comparison of the stresses at corresponding points per Method II and Method I shows that while Method II tends to yield higher values at the low stress levels, Method I generally yields higher stresses at the high stress levels. Therefore, Method I would produce a somewhat more conservative design of the steam lines and their supports. Using the seismic results as given in H. J. Sexton's report entitled "Earthquake Analysis Main Steam Lines" Dresden Nuclear Power Station dated May 27, 1968 produces a conservative design for the main steam lines and supports.

FEEDWATER PIPING

Tabulated below is a summary of the three highest seismic stresses for Method II in each of the four loops of the feedwater lines inside the drywell for Dresden 2-3. The corresponding stresses as calculated by Method I are also listed for purposes of comparison. The stresses tabulated are for the OBE loads. The stresses corresponding to the DBE loads can be obtained by multiplying the tabulated values by a factor of two.

SUMMARY - HIGHEST STRESSES

Loop	Location Joint No.	Method I Stress (ksi)	Method II Stress (ksi)	Earthquake Combination
A-10	A-11 (Nozzle)	4.48	6.24	X & Y
&	J-15(Elbow)	9.72	6.21	
A-11	138 (Elbow)	5.04	6.12	
	A-11 (Nozzle)	5.49	8.56	Z & Y
	138 (Elbow)	5.92	8.40	
	139 (Elbow)	5.63	7.64	
A-12	190	9.08	7.29	Z & Y
&	189.2	6.96	5.61	*
A-13	189.1	4.50	3.66	

* The stresses for the X & Y Earthquake Combination are not listed because they are not governing.

The three highest stresses for loop A-10 and A-11 by Method I are 9.72 ksi at joint J-15, 6.76 ksi at joint A-10and 6.26 ksi at joint156 . Their average is 7.58 ksi.

The three highest stresses for loop A-10 and A-11 by Method II are 8.56 ksi, 8.40 ksi and 7.64 ksi as listed above. Their average is 8.20 ksi.

The three highest stresses for loop A-12 and A-13 by Method I are 9.08 ksi at joint 190, 6.96 ksi at joint 189.2 and 6.03 ksi at joint 178. Their average is 7.36.

The three highest stresses for loop A-12 and A-13 by Method II are 7.29 ksi, 5.61 ksi and 3.66 ksi as listed above. Their average is 5.52 ksi.

For loops A-10 and A-11, the highest stresses listed as calculated by Method II are greater at all six points than those obtained by Method I. The average of the three highest listed for Method II is 8.20 ksi. The average by Method I is 5.68 ksi for the corresponding points. However, Method I yields the highest stress by either Method. (9172 ksi at joint J-15).

For loops A-12 and A-13, the highest stresses listed as calculated by Method II are less at all three points than those obtained by Method I. The average of the three highest listed for Method II is 5.52 ksi. The average by Method I is 6.85 ksi for the corresponding points.

Considering all points in the lines, the number of points having the higher stress obtained by Method I and II are as follows:

Loop	Method I	Method II
A-10 and A-11		
X & Y Earthquake	20	19
Z & Y Earthquake	11	28
A-12 and A-13		
Z & Y Earthquake	27	12

A comparison of the stresses at corresponding points as calculated by Method I are generally in agreement with the stresses calculated by Method II. For the feedwater lines on Dresden 2-3 either Method I or II gives results reasonably close, and using the seismic results as calculated by Method I gives a conservative design for the feedwater lines and their supports.