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DESCRIPTION

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(1 page)

PLANT NAME: OCONEE UNITS 1-3
jcm

ENCLOSURE

Consists of Proposed revision to BAW 10094 transmitted by B&W Ltr. dated Jan. 24, 1977 to Mr. S. A. Varga, superseded the earlier revision....

(9 pages)

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ACKNOWLEDGED

FOR ACTION/INFORMATION

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NRC FORM 195 (2-76)

DUKE POWER COMPANY
POWER BUILDING
422 SOUTH CHURCH STREET, CHARLOTTE, N. C. 28242

WILLIAM O. PARKER, JR.
VICE PRESIDENT
STEAM PRODUCTION

TELEPHONE: AREA 704
373-4083

March 1, 1977

Mr. Benard C. Rusche, Director
Office of Nuclear Reactor Regulation
U. S. Nuclear Regulatory Commission
Washington, D. C. 20555

Attention: Mr. A. Schwencer, Chief
Operating Reactor Branch No. 1

Reference: Oconee Nuclear Station
Docket Nos. 50-269, -270, -287

Dear Sir:

My letter of January 13, 1977 provided a proposed revision to the Babcock and Wilcox Company; THETA computer code as described in Topical Report BAW 10094, which was submitted by B&W letter dated December 20, 1976 to Mr. S. A. Varga. The attached proposed revision to BAW 10094 was transmitted by B&W letter dated January 24, 1977 to Mr. S. A. Varga and supersedes the earlier revision. LOCA calculations performed for the Oconee class reactors at the two and six foot elevations indicate that the Oconee Nuclear Station Technical Specifications remain valid to assure that the requirements of Appendix K to 10CFR50.46 are met.

Very truly yours,

W. O. Parker, Jr.

William O. Parker, Jr. By [signature]

MST:ge

Attachment

1. Introduction

It has been determined by NRC Staff that the post-CHF heat transfer calculations performed in the B&W THETA6F computer code may not be consistent with the requirements set forth in Appendix K of 10 CFR 50. In particular, the calculation of local heat transfer by nucleate boiling subsequent to the occurrence of CHF as is performed in THETA6F was considered questionable. An investigation was undertaken at B&W to establish an alternate post-CHF heat transfer model for implementation in the THETA code. The scope of resulting modifications to be proposed includes both revisions of the post-CHF switching logic and elimination of the post-CHF return to nucleate boiling.

2. THETA Code Modification

According to BAW-10094 (p. 26-4):

"If departure from nucleate boiling (DNB) has been calculated to have occurred for a particular axial node, both transition flow boiling and nucleate boiling will be calculated; the lower heat flux is used." Examination of the THETA6F switching logic showed that the comparison of transition boiling heat flux to nucleate boiling heat flux was not made. Rather, referring to Figure 1, a trial value of the heat flux was calculated for a particular axial node according to the fluid void fraction.

for: $0 \leq \alpha \leq .80$	nucleate boiling (mode 2)
$.80 < \alpha < .90$	interpolation between nucleate boiling (mode 2) and forced convection vaporization (mode 3)
$.90 \leq \alpha < 1.0$	forced convection vaporization

If the trial heat flux was less than CHF, the trial value was taken as the local heat flux. If the trial value exceeded CHF, transition boiling (mode 4) heat flux was used. To correct this, the post-CHF switching logic was modified so that, subsequent to CHF at a particular axial node, regression on the transition boiling curve is restricted to heat fluxes (1) less than CHF for local fluid void fractions less than 80 percent, (2) less than the heat flux calculated by interpolation between nucleate boiling (mode 2) and forced convection vaporization (mode 3) for local void fractions between 80 percent and 90 percent, or (3) less than the heat flux calculated by forced convection vaporization (mode 3) for local void fractions greater than 90 percent. That is, transition boiling heat fluxes are restricted to values less than those calculated using pre-CHF correlations appropriate to local fluid conditions.

In the event that the local transition boiling (mode 4) heat flux is calculated to exceed the heat flux calculated using pre-CHF correlations according to local fluid conditions, the local heat flux is determined by switching to film boiling (modes 5 and 7). Thus, with this modification, the return to nucleate boiling is replaced by a temporary switch to film boiling.

3. Case Studies

One additional version of the THETA code was prepared to investigate the effects of the modification presented in Section 2. Hot channel thermal analysis was perfomred with this modified THETA version for an 8.55 ft^2 split break (C_D = 0.8) on a 177 FA lowered loop plant. This split break case is the benchmark used in Section 3 of Reference 1. This benchmark case is not part of any evaluation model. Rather, this case was chosen for its particular sensitivity to the post-CHF switching logic in the THETA code. As such the magnitude of the peak clad temperature differences are not applicable to cases reported in References 2,3, and 4. These case studies and code versions are described below and summarized in Table 1.

Case 1

Case 1 was the benchmark case. This was the same case as Case 1 reported in Section 3 of Reference 1. The peak clad temperatures calculated for the unruptured node was 1992^{o}F and 1746^{o}F for the ruptured node.

Case 2*

Case 2* was executed on the modified (as presented in Section 2 herein) THETA code. The peak clad temperatures for the ruptured and unruptured nodes increased 67^{o}F and 31^{o}F respectively over the base case, Case 1. The clad temperature results are presented in Table 1.

4. Spectrum Studies

The validity of the Spectrum Analysis results and trends reported in References 3 and 4 was demonstrated by re-analyzing the worst spectrum case for each of these two plant categories. The results of this re-analysis are presented in Table 2. For both cases, the hot spot peak clad temperature increased less than $20^{o}F$. Since the worst spectrum cases were reanalyzed, the peak clad temperature increases should provide an upper bound for all other spectrum cases. Hence, the spectrum results and trends in References 3 and 4 are still valid. Furthermore, since the spectrum trends in Reference 2 are basically the same as those in References 3 and 4 and since the THETA analyses for the worst spectrum cases in References 2,3, and 4 all proceed in a similar manner, the spectrum results and trends presented in Reference 2 should also still be valid.

5. LOCA Limits Studies

The final modification (Case 5) presented in Reference 1 showed no significant impact on the LOCA limits presented in References 2,3, and 4. This lack of impact is due to the fact than in these base LOCA limit cases (those presented in References 2,3, and 4) minimal time is spent in transition boiling and oscillating between transition and nucleate boiling type heat fluxes. By approximately 0.8s the ruptured and the hot spot nodes are locked into film and/or film pool boiling by virtue of the $300^{o}F$ temperature difference criteria. Hence, for the THETA code modification presented herein (Section 2), no impact on the LOCA limits should be evidenced.

During the course of this THETA code modification program it was determined that by evaluating the ruptured and unruptured node temperature differences ($T_{modified} - T_{base\ case}$) once the forced convection to superheated steam cooling mode (mode 8) was established (∿13s) an accurate determination of the final effect on peak clad temperatures can be made. In fact, the Δts at approximately 13s translate one to one relative to the peak clad temperatures of the base cases. Use of this method allows an accurate determination of the ruptured and unruptured node peak clad temperatures by executing cases on modified THETA versions to only 15s. This method is restricted by assuring that significant changes in the volume average fuel temperatures, after establishing mode 8 heat transfer, do not exist.

The two foot elevation (ruptured node limited) and the six foot elevation (unruptured node limited) LOCA limits presented in References 3 and 4 were reanalyzed using the THETA code modification in Section 2. These cases were run to 15s, at which time mode 8 heat transfer was established in all nodes. At 14.5s the clad and fuel temperatures were compared to the base case results in References 3 and 4. These comparisons are shown in Table 3. Since no significant differences between the modified and the base cases exist at 14.5s, it can be concluded that, as anticipated, the THETA code modification presented herein does not impact the existing LOCA limits in References 3 and 4. Hence, the LOCA limits in References 3 and 4 are still valid. In the course of the analysis presented in Reference 1, Section 4, it was determined that the base LOCA limit cases reported in Reference 2 rapidly locked into mode 5 and/or mode 7 type heat transfer - thereby spending minimal time in transition boiling. In view of this fact and verification of its implications herein for the LOCA limits reported in References 3 and 4, it must be concluded that the LOCA limits reported in Reference 2 are also still valid.

REFERENCES

1. Letter, K.E. Suhrke to S.A. Varga (NRC), dated 12/20/76, Subject: THETA Code CHF Modifications.

2. BAW-10102, Rev. 02

3. BAW-10103, Rev. 02

4. BAW-10105, Rev. 01

TABLE 1

CASE COMPARISON

Case	1	2*
Version	Original 6F	THETA6 CY=1
Post-CHF	Old	New
Switch Logic	(Mode 2 or 3)	(Mode 4)
Returnable Modes from Mode 4	Mode 2 and 3	Mode 5 or 7
Peak T ^{o}F Ruptured Node	1746 (Base)	1813 (+67^{o}F)
Peak T ^{o}F Unruptured Node	1992 (Base)	2023 (+31^{o}F)

TABLE 2

SPECTRUM STUDIES

Topical Report	Break Type	Case	Rupture Time, s	Ruptured Node Temp. °F/Time,s	Unruptured Node Temp. °F/Time,s
BAW-10103, Rev. 02 (177-FA Low Loop)	8.55 ft^2 double ended, pump discharge, $C_D = 1$	Base	13.8	1916/43.5	2079/61.5
		Modified	14.0	1936/43.5	2091/61.5
BAW-10105, Rev. 01 (177-FA Raised Loop)	8.55 $ft.^2$ double ended, pump discharge, $C_D = 1.$	Base	16.3	1914/43	2066/67
		Modified	16.2	1932/43	2072/67

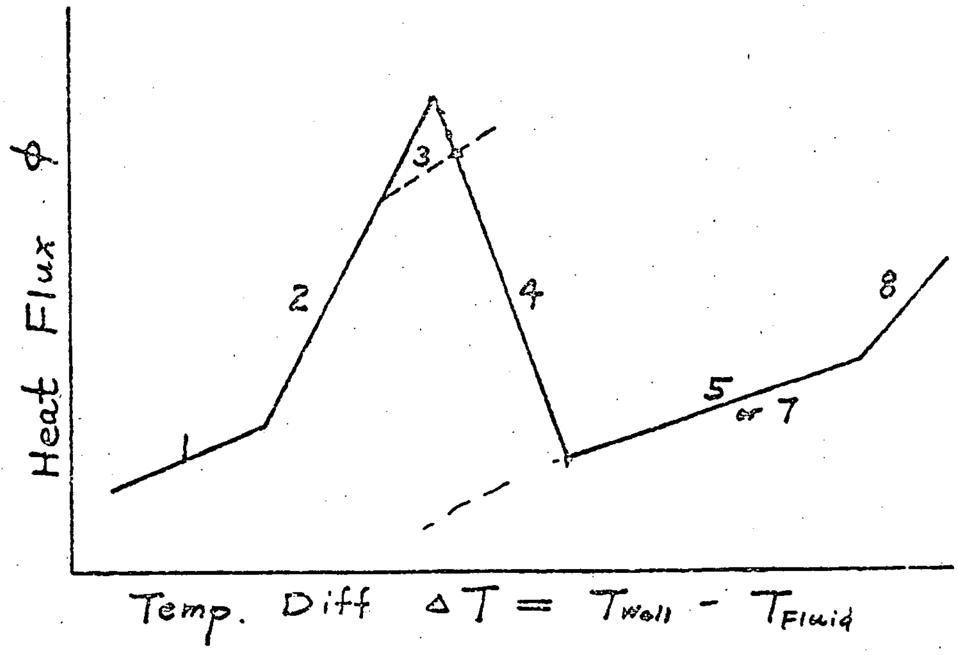
TABLE 3

LOCA LIMITS STUDIES

t = 14.5s

Topical Report	Elevation Ft.		Node	Temperature, °F Base	Modified	Δ
BAW-10103 Rev. 02	2	Clad	1	1316	1317	+1
			2	1531	1531	0
			3	1645	1645	0
			4(ruptured)	1530	1530	0
			5(hot spot)	1670	1670	0
			6	1645	1645	0
			7	1544	1547	+3
		Fuel	1	1402	1402	0
			2	1667	1667	0
			3	1824	1824	0
			4	1950	1950	0
			5	1872	1871	-1
			6	1847	1847	0
			7	1757	1761	+4
	6	Clad	1	1658	1658	0
			2	1687	1687	0
			3(ruptured)	1698	1698	0
			4(hot spot)	1698	1699	+1
			5	1691	1692	+1
			6	1675	1676	+1
			7	1644	1644	0
		Fuel	1	1855	1855	0
			2	1885	1885	0
			3	1893	1893	0
			4	1886	1888	+2
			5	1871	1872	+1
			6	1843	1844	+1
			7	1792	1792	0
BAW-10105, Rev. 01	2	Clad	1	1291	1291	0
			2	1591	1591	0
			3	1763	1764	+1
			4(ruptured)	1848	1847	-1
			5(hot spot)	1832	1832	0
			6	1751	1752	+1
			7	1686	1689	+3
		Fuel	1	1373	1373	0
			2	1688	1688	0
			3	1869	1869	0
			4	1968	1968	0
			5	1930	1930	0
			6	1854	1854	0
			7	1786	1789	+3
	6	Clad	1	1553	1560	+7
			2	1651	1651	0
			3(hot spot)	1667	1669	+2
			4(ruptured)	1674	1676	+2
			5	1666	1668	+2
			6	1652	1654	+2
			7	1625	1625	0
		Fuel	1	1716	1725	+9
			2	1840	1841	+1
			3	1855	1857	+2
			4	1857	1860	+3
			5	1840	1842	+2
			6	1813	1816	+3
			7	1765	1766	+1

FIGURE 1 HEAT TRANSFER MODES



Mode 1: Forced Convection to Liquid

Mode 2: Nucleate Boiling

Mode 3: Forced Convection Vaporization

Mode 4: Flow Transition Boiling

Mode 5: Flow Film Boiling

Mode 7: Pool Film Boiling

Mode 8: Forced Convection to Gas

Mode 10: Reflood Cooling