JUSTIFICATION FOR THE INCREASE IN THE MAXIMUM ALLOWABLE REACTOR PROTECTION SYSTEM HIGH PRESSURE TRIP SETPOINT

INTRODUCTION

This report has been prepared to justify the increase in the Reactor Protection System (RPS) high pressure trip setpoint at Three Mile Island Unit 1 from the current technical specification value of 2355 psig to that of 2405 psig. The safety analyses summarized in this report supplement the TMI-1 FSAR Chapter 14 analyses. These analyses demonstrate that a Reactor Protection System trip setpoint of 2405 psig is acceptable and prevents the safety limit of 2750 psig from being exceeded. The differences in the analyses reported here and those in the FSAR are made possible because the key nuclear parameters affecting those accidents that result in high reactor coolant system pressure are less limiting after the beginning of Cycle 1 and are sufficiently less restrictive toward the end of Cycle 1 and into Cycle 2 that the increases in the RPS high pressure trip setpoint may be justified.

SUMMARY AND CONCLUSION

The purpose of the high pressure trip is to provide first protection against RCS overpressure transients, and to function as a backup trip for other system transients. The RCS pressure safety limit that must not be exceeded in any transient is 2750 psig.

In the event of a loss of load accident the RCS pressure excursion following turbine trip is such that a high RCS pressure trip could occur if the setpoint is kept at the present level of 2355 psig. With the high pressure trip setpoint set at 2405 psig, the probability of a reactor trip on a loss of load transient would be greatly reduced and potentially the plant availability would be increased.

The accidents reported in the FSAR which result in the most limiting RCS pressure excursions were selected for analysis. The analyses of these accidents were performed using Cycle 2 data and a 2355 psig trip setpoint, to show that the resulting RCS peak pressure is lower than for the corresponding Cycle 1 transient, due to the more favorable Doppler and moderator coefficients characterizing Cycle 2. The analyses for Cycle 2 and a 2405 psig setpoint show that even in these conditions the peak pressure is well below 2750 psig and, in all accidents but one, below first cycle peak pressure.

Sensitivity studies were performed for the most severe pressure transient previously analyzed on Doppler and moderator coefficients, which are the parameters most responsible for the differences in peak pressure between Cycle 1 and Cycle 2. These sensitivity studies cover both Cycle 1 and Cycle 2 parameters. Furthermore, they bound the end of first cycle, making the results of the study applicable to end of Cycle 1 conditions.

The results of this analysis support the conclusion that the high pressure trip setpoint can be safely increased up to 2405 psig at the end of first cycle.

ANALYSIS

The purpose of the high pressure trip is to provide protection against RCS pressure transients, in order to prevent the RCS pressure from reaching the safety limit of 2750 psig. Chapter 14 of the FSAR shows that for all accidents analyzed, a high pressure trip setpoint of 2355 psig will provide protection against exceeding the safety limit.

The results of these analyses show that even increasing the setpoint to 2405 psig at the end of Cycle 1 and during Cycle 2 the RCS pressure is still prevented from reaching the safety limit of 2750 psig for all possible transients. Of all the accidents analyzed in the FSAR, the startup accident and the rod ejection accident from 10^{-3} F.P. result in the highest peak RCS pressure. In addition to these two accidents, the feedwater line break accident is analyzed. The analysis of these accidents has been performed at the beginning of the second cycle, although the changes in the RPS trip setpoint may be made at the end of the first cycle, because:

a. For operation during any given cycle, the three accidents are most severe at the beginning of that cycle, when the Doppler and moderator coefficients are the most positive for that cycle.

b. The moderator temperature coefficient is much less negative at the beginning of Cycle 2 than at the end of Cycle 1, as shown in Table 1. The less negative coefficient will result in calculating a higher RCS transient peak pressure.

c. Although the Doppler coefficient is slightly more negative at the beginning of Cycle 2 than at the end of Cycle 1, as shown in Table 1, and the less negative coefficient would result in calculating a higher RCS transient peak pressure, sensitivity studies have shown that the differences in pressure are small compared to those resulting from the changes in moderator coefficient.

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Therefore, the analyses performed at the beginning of the second cycle, with appropriate sensitivity studies on Doppler and moderator coefficients on the most severe FSAR transient, will bound also the end of the first cycle.

The analyses were performed with CADD(1), which is the digital point kinetics computer code presently used to analyze RCS transients. This is an improved version of KAPPB, which is the code used for the TMI-1 FSAR analyses. For all the three accidents, the highest peak pressure was calculated for Cycle 2, BOL conditions, using a high pressure setpoint of 2355 psig. The same CADD cases were rerun with Cycle 1, BOL Doppler and moderator coefficients. The Cycle 2 cases were rerun with setpoint of 2405 psig. For all cases, peak pressure was found to be well below 2750 psig.

Startup Accident

Figure 1 shows the results of the analysis. Peak RCS pressure occurs for the highest withdrawal rate resulting in a high pressure trip. Figure 1 shows that in going from Cycle 1 to Cycle 2 moderator and Doppler coefficients, RCS peak pressure is reduced from 2733 psia to 2562 psia. Raising the setpoint to 2405 psig, RCS peak pressure increases only about 15 psi for all withdrawal rates resulting in a high pressure trip. The reason for such a small increase in peak pressure is that in all the transients terminated by the high pressure trip, the trip occurs about 20 to 30 seconds after the beginning of the accident. However, at the time of trip, RCS pressure is raising so rapidly that the increase of the setpoint to 2405 psig only delays the trip by about 0.5 seconds. The energy added in that half second is very small as compared to the energy already added to the system in the previous 20 to 30 seconds.

This accident results in the most severe pressure transient of all the FSAR accidents. Furthermore, in this accident, the system takes a long time to trip as compared, for example, with the feedwater line break accident, so that this is the accident most sensitive to moderator and Doppler coefficient variation. Therefore, the sensitivity studies on Doppler and moderator were performed for this accident. The results are shown in Figures 2 and 3. Both sensitivity studies cover both BOL and EOL conditions for Cycle 1 and Cycle 2 (see Table 1). In particular, the results show that the BOL, Cycle 2 results bound the EOL, Cycle 1 results. Going from BOL, Cycle 2 coefficients to EOL Cycle 1 coefficients would cause an increase in peak pressure of about 14 psi due to the Doppler feedback, a decrease of about 32 psi due to the moderator temperature feedback, and thus an overall reduction of about 18 psi. Changes in other parameters between EOL first Cycle and BOL second cycle will not substantially affect these results.

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Rod Ejection Accident

Figure 4 shows the results of this analysis. The peak pressure response in this analysis is similar to the one for the startup accident. Increasing the setpoint to 2405 psig results in less than 15 psi increase in peak pressure for all ejected rod worths resulting in a high pressure trip. All results are well below the 2750 psig safety limit.

Feedwater Line Break Accident

This accident was simulated through a conservative forcing function for the steam generator heat demand following the break. The results of the analysis are shown in Table 2. Trip occurs so rapidly that peak pressures for Cycle 1 and Cycle 2 are almost identical. Increasing the trip setpoint to 2405 psig, the peak pressure increases to 2655 psia, still well below 2750 psig.

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(1) "CADD - Computer Application to Direct Digital Simulation of Transients in Water Reactors," BAW-10080, Rev. 1, Babcock & Wilcox, October 1974.

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TABLE 1

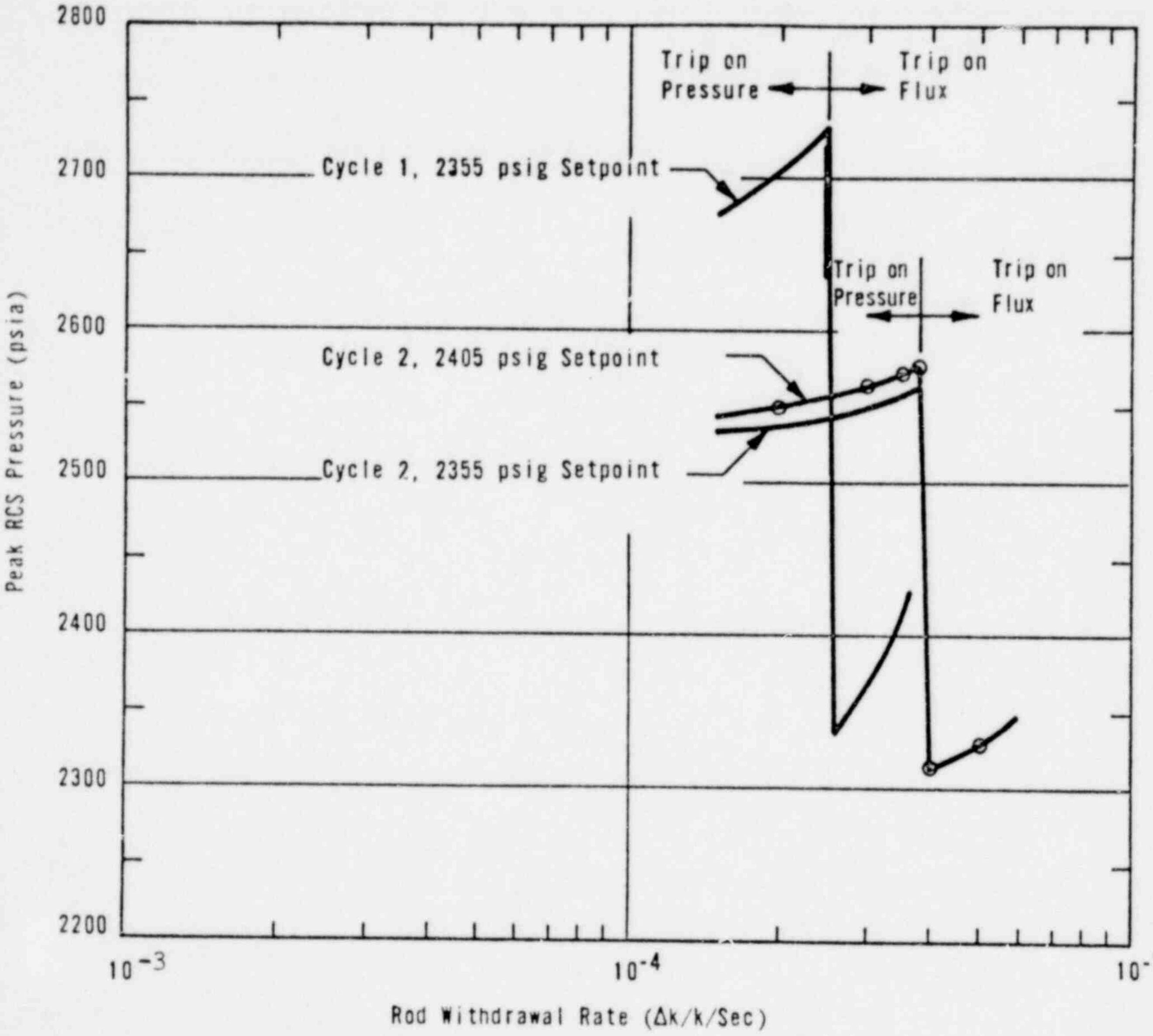
Doppler and Moderator Temperature Coefficients (Δk/k/F)

		FSAR	Cycle 2
Doppler	BOL	-1.17×10^{-5}	-1.49×10^{-5}
	EOL	-1.33×10^{-5}	-1.53×10^{-5}
Moderator	BOL	$+0.5 \times 10^{-4}$	-1.06×10^{-4}
	EOL	-3.0×10^{-4}	-2.63×10^{-4}

TABLE 2

Feedwater Line Break Accident Results

Case	High Pressure Trip Setpoint, psig	Pressure, psia	Trip Time, s
1. Cycle 1	2355	2637	5.15
2. Cycle 2	2355	2633	5.175
3. Cycle 2	2405	2655	5.65



PEAK RCS PRESSURE VERSUS WITHDRAWL RATE FOR A STARTUP ACCIDENT FROM SUBCRITICAL

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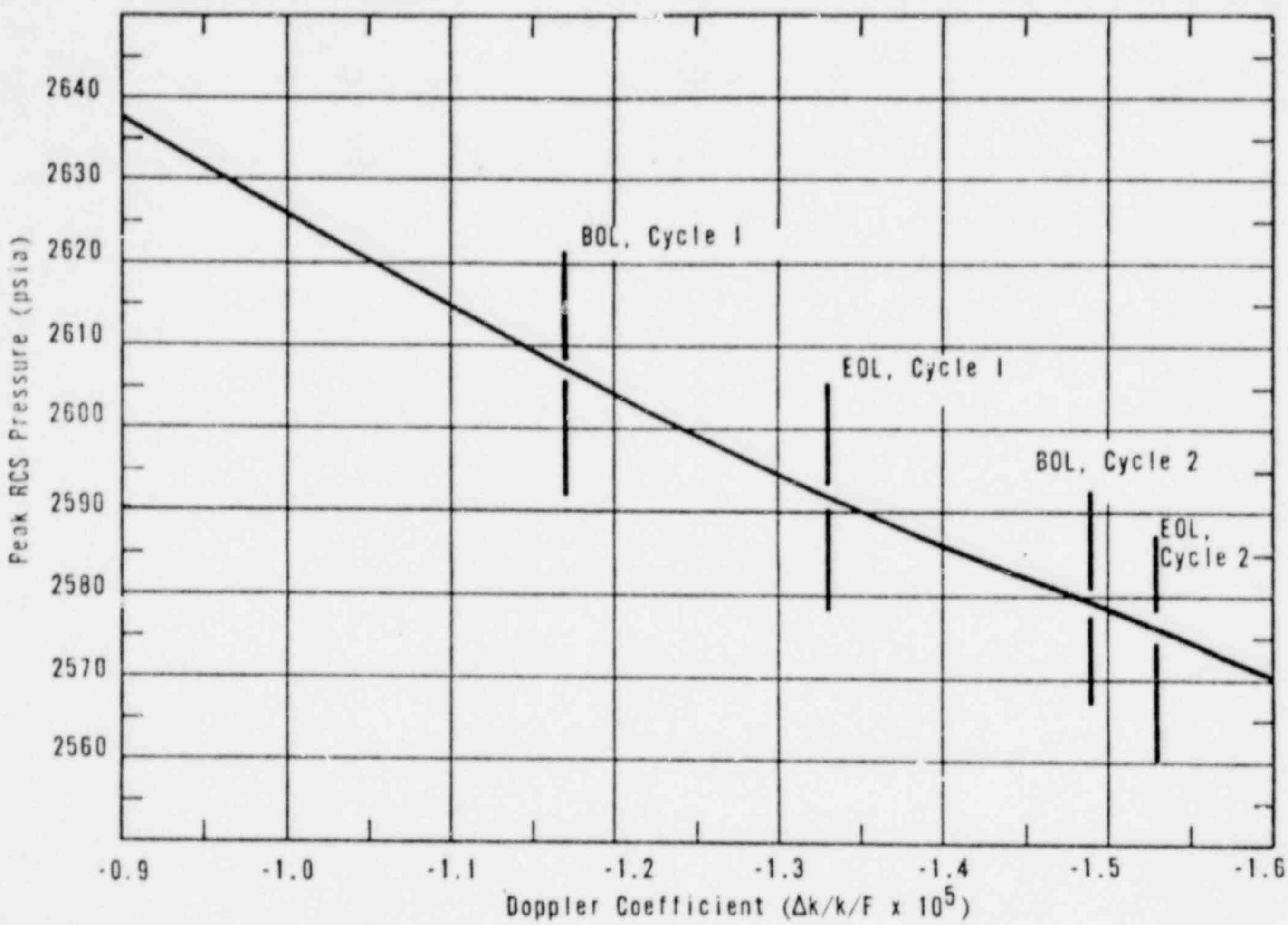
Figure 1



PEAK RCS PRESSURE VERSUS DOPPLER COEFFICIENT FOR A STARTUP ACCIDENT, USING FOR EACH COEFFICIENT THE WITHDRAWAL RATE THAT RESULTS IN THE HIGHEST RCS PEAK PRESSURE

Figure 2

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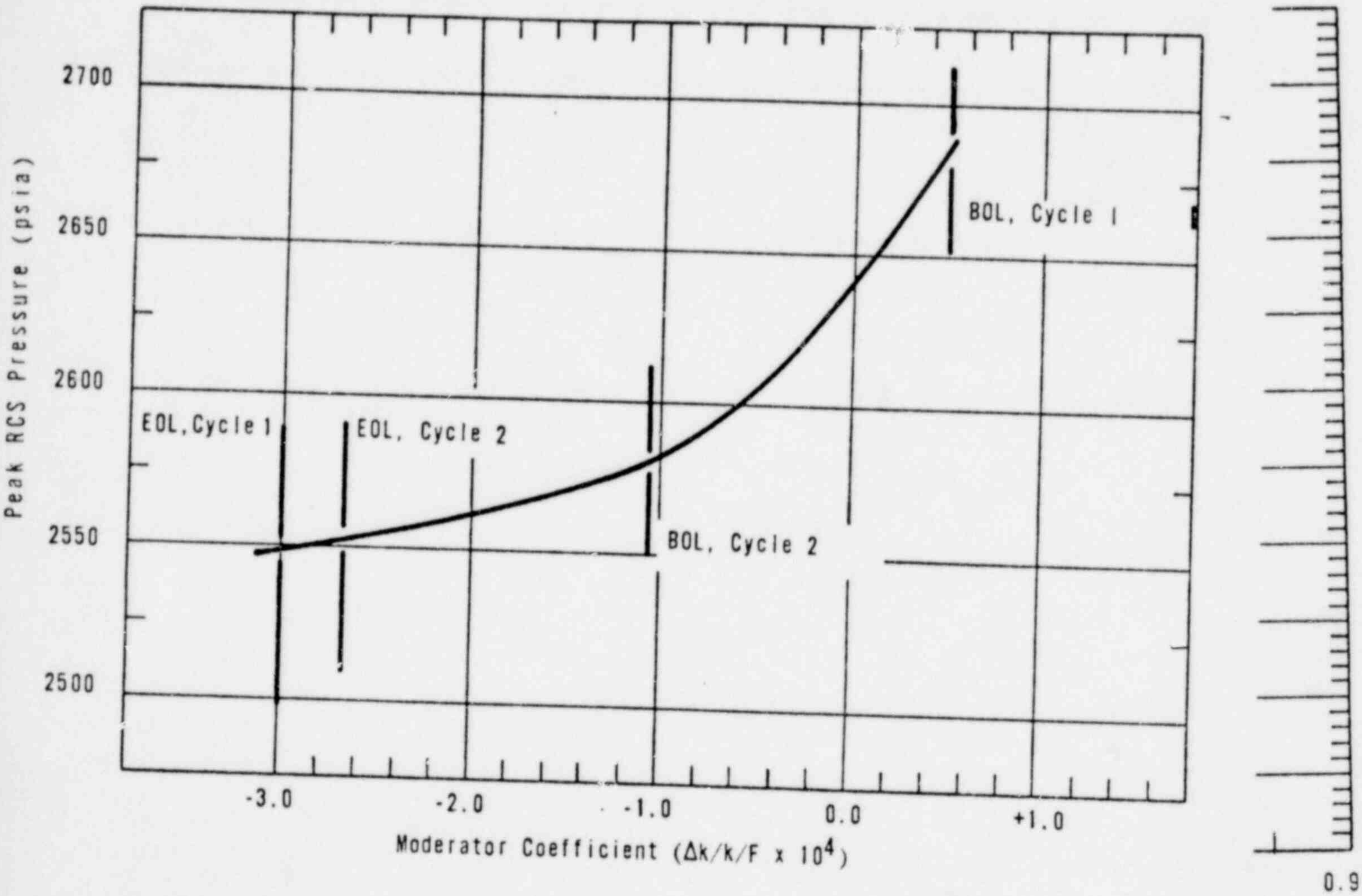

PEAK RCS PRESSURE VERSUS MODERATOR COEFFICIENT FOR A STARTUP ACCIDENT USING FOR EACH COEFFICIENT THE WITHDRAWAL RATE THAT RESULTS IN THE HIGHEST RCS PEAK PRESSURE

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Figure 3

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