MTC Effect with the COLR for Reload Cores

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1. Introduction

For the almost nuclear plants, an adequate license amendments cycle by cycle might be required to bound the values of core operating limits in its Technical Specification (T.S). Since the T.S change could be burdened on licensing authority, it would be necessary to develop a simplified and generalized licensing process. An alternative is to submit a formal report called Core Operating Limits Report (COLR). The COLR provides the value of the core operating limits that have been established using licensing authority approved methodology and consistent with all applicable limits of the safety analysis. The COLR contains Moderator Temperature Coefficient (MTC), Shutdown Margin during reactor shutdown, Boron Dilution Alarms, Power Dependent Insertion Limit of CEA, Peak Linear Heat Generation Rate, DNBR, Azimuthal Power tilt and Axial Shape Index of the core operating limits in the T.S.

Some of the reload core designs in Westinghouse have been performing according to a procedure of the safety analysis with the COLR that has more relaxed limits than the T.S [1]. With the results, the reload core safety analysis with the COLR ensured a little more operating margin. Also the licensing issue which is caused by some changes of the core operating limits is able to be performed easily by confirming the COLR change. Therefore, a more simple licensing process could be established.

The introduction of COLR has already been considered on YGN-3 Cycle 2 design, but it is not being applied until collective data acquisition at the current nuclear design and safety analysis [2].

This paper describes the importance of the MTC upper limits in the COLR items. The first, the methodology of MTC upper limits determination at near BOC in the COLR for OPR1000 plant is explained. The last, the operating margin was evaluated by using MTC limits determined in the COLR.

2. Methods and Results

In this section the subsequent operating margin as well as the determinations of MTC limits related the COLR are described.

2.1 MTC Limits in the T.S

Generally speaking, the core is to be maintained to have a negative MTC at any power level. This MTC plays the important role in safety analysis. During the moderator cooldown transient, a negative MTC gives a positive reactivity insertion into a core. On the other hand, a positive MTC gives a positive reactivity insertion during the moderator heatup transient. The core operating limits as Limiting Condition for Operation (LCO) on MTC value are shown in Figure 1. The MTC upper limit sensitive events are moderator heatup transients such as Feedwater Line Break, Loss of Condenser Vacuum, CEA Withdrawal, CEA Ejection, etc. The MTC lower limit induced events are CEA Drop, Steam Line Break, etc.

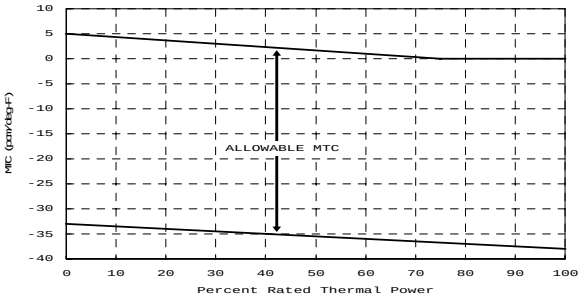

Fig. 1. MTC Limits – MODES 1 and 2 for OPR1000 Reload Core [3]

2.2 MTC Upper Limits Determination for COLR

In order to determine the MTC upper limits in the COLR, the least negative MTC values around BOC are collected from the OPR1000 reload core predicted data. The least negative MTC values with uncertainty are evaluated at BOC with No Xenon condition. The Figure 2 shows the evaluated least negative MTC value for OPR1000 reload cores. The least negative MTC value satisfied the MTC upper limits in the T.S and has sufficient margin. Also, the measured MTC has a good agreement with the predicted data within criteria. Thus, the COLR on MTC upper limits in COLR could be determined using the predicted MTC value of OPR1000 reload core design.

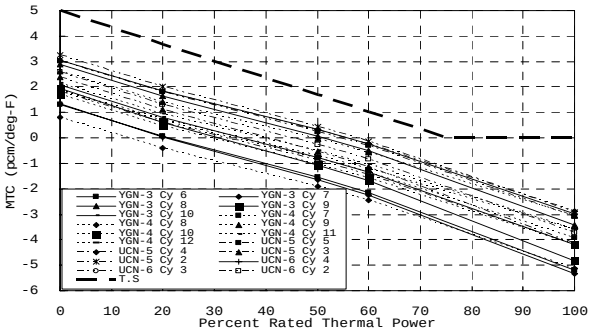

Fig. 2. Least Negative MTC of ORP1000 reload core as a function of power

The MTC upper limits for COLR are established by the sum of the least negative MTC value and additional uncertainty (about 10%). But the MTC value at HZP is equal to that in the T.S conservatively. Table I shows the determined MTC upper limits for COLR. The determined MTC upper limits are relaxed about 1.5pcm/˚F at 20%, 1.1pcm/˚F at 50%, 1.0pcm/˚F at 60% and 2.6pcm/˚F at 100% power to the T.S, respectively.

Table I: MTC upper limits in COLR vs. T.S [Unit: pcm/˚F]

Power [%]	Max. predicted value	COLR	T.S
0	3.3	5.0	5.0
20	2.0	2.2	3.7
50	0.5	0.6	1.7
60	-0.1	0.0	1.0
100	-2.9	-2.6	0.0

2.3 Operating Margin with MTC for COLR

The operating margin of OPR1000 plant is estimated from results of safety analysis. The performed safety analyses with the MTC upper limits are reactivity insertion events. It has been performed with the MTC limits of T.S and held conservatively sufficient operating margin at time. Since the impact of MTC change on single CEA withdrawal (SCEAW) is the most restrictive in moderator heatup events the SCEAW is analyzed to evaluate the effect of using COLR MTC instead of T.S MTC. For this study, operating margin with the COLR MTC is evaluated and compared with the results of T.S MTC for the SCEAW analysis. The Required Overpower Margin (ROPM) at minimum DNBR calculated from the SCEAW analysis is confirmed that the results do not violate the fuel design limit during transient. In general, because the result of SCEAW analysis at 95% power has the most severe ROPM, the ROPM of SCEAW with the COLR MTC upper limits is considered at only 95% power.

The MTC upper limit at 95% power in the COLR is relaxed about 2.3pcm/˚F with respect to that of the T.S. The result of SCEAW with COLR MTC upper limit is shown at Figure 3. From Figure 3, the major parameters important to ROPM during SCEAW transient are enhanced by followings.

- Heat flux: more less increase at early event stage and exponentially decrease as time than the T.S
- Tin: lower temperature about 10˚F than the T.S
- Mass flow: larger value about 2% than the T.S

The DNBR based on the COLR shows the minimum value at early event stage after 53 second. On the contrary, the T.S case is shown after 800 second. The determined DNBR based on the COLR at early event stage within 1 minute is larger than the T.S.

The Table II shows the ROPM calculated with the COLR MTC upper limit and the T.S, respectively. The Case 1 and Case 2 in Table II are arbitrary OPR1000 PLUS7 fuel loaded reload cores. The COLR MTC based ROPM is decreased about 5%. Above all the use of COLR MTC upper limits in the SCEAW analysis could get more operating margin.

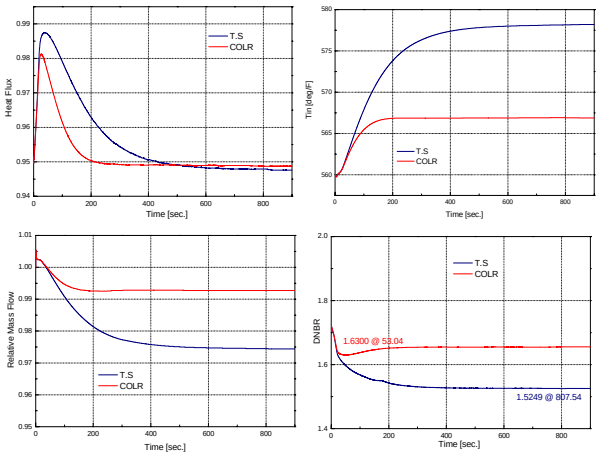

Fig. 3. Results of SCAEW analysis with COLR MTC upper limit vs. T.S [Case 1]

Table II: Comparison with ROPM with COLR and T.S

	ROPM	
	COLR	T.S
Case 1	109.98	115.29
Case 2	114.55	119.59
Avg.	112.27	117.44

3. Conclusions

The COLR based MTC upper limits determined for OPR1000 reload design and used to relax the part of safety analyses. The moderator heatup event analysis with the COLR MTC upper limits improves operating margin aspects relative to current safety analysis with T.S limits. Also the COLR MTC application in reload core design is able to simplify the licensing process in case of the T.S change for core operating limits.

In future, the improvement of procedures for nuclear and safety design, and the cooperative council of licensing authority will be necessary for the COLR application.

REFERENCES

[1] Entergy Operation Arkansas Nuclear One – Unit 2; Core Operating Limits Report for Cycle 20, ANO2-NE-08-00002 Rev. 0, 2008.
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[3] KHNP, Final Safety Analysis Report for UCN unit 5 & 6, Rev.02, Nov. 2005.