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Evaluation of BEACON-COLSS Core Monitoring System Benefits

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1. Introduction

In Korean Standard Nuclear Power Plant COLSS (Core Operating Limit Supervisory System) is used to monitor the DNBR Power Operating Limit (DNBRPOL) and Linear Heat Rate POL (KWPFPOL). Westinghouse and KNFC have developed an upgraded core monitoring system by combining the BEACON™ core monitoring system[1] (Best Estimate Analyzer for Core Operation – Nuclear) and COLSS into an integrated product that is called BEACON-COLSS. BEACON-COLSS generates the 3-D power distribution corrected by the in-core detectors measurements. The 3-D core power distribution methodology in BEACON-COLSS is significantly better than the synthesis methodology in COLSS. BEACON-COLSS uses the CETOP-D[2] thermal hydraulic code instead of CETOP-1. CETOP-D is a multi-channel thermal hydraulics code that will provide more accurate DNBR calculations than the DNBR calculators currently used in COLSS.

2. Snapshot Files for YGN4 C6 and C7

To evaluate the power margin improvement of the BEACON-COLSS, as compared to the COLSS, a simulated BEACON-COLSS operation was performed by using the snapshot files from YGN Unit 4 Cycle 6 and Cycle 7. Each snapshot file was processed to generate the following information for the BEACON-COLSS simulation and comparison of the results;

a. Generation of the snapshot file in the BEACON format,
b. Selection of a core neutronics model file at the nearest burn-up to the snapshot file,
c. Collection of the COLSS information contained on the snapshot file,
   i. KWPFPOL and DNBRPOL
   ii. Fq, Fr, azimuthal tilt and axial shape index (ASI)
   iii. 40 node hot pin axial power distribution

3. BEACON-COLSS Simulation

The BEACON-COLSS simulation is performed by a standalone simulation program, which uses the selected core model files specified in input files and the in-core detector snapshot files in the BEACON format generated as described in Section 2. Differences between BEACON-COLSS and COLSS are as follows;

	BEACON-COLSS	COLSS
Power Distributions	3-D Measured	Conservatively synthesized
DNBR Calculator	CETOP-D	CETOP-1
Over Power Margin	Same	
Uncertainties	Plant Type Specific	Plant-Cycle Specific

KWPFPOL and DNBRPOL results from the BEACON -COLSS simulation program are compared to the corresponding COLSS results. The BEACON-COLSS POLs are significantly higher than the COLSS POLs. The major benefit of the BEACON-COLSS system is achieved by using the predicted 3-D power distribution corrected by the in-core detector measurements.

The BEACON-COLSS benefit, defined as a ratio of BEACON-COLSS POL to COLSS POL, and its breakdown analysis was performed. For KWPFPOL it is seen that the 3-D power peaking factor, Fq, difference is the main contributor to the KWPFPOL difference. The difference of the uncertainties and the tilt factor treatment has small contributions. These profiles are shown in Figure 1.

The benefit and breakdown analysis for the DNBR-POLs are shown in Figure 2. The benefit contribution due to the power distribution can be evaluated with the BEACON-COLSS simulation program by using the COLSS power distribution. After subtracting a small benefit due to the uncertainties and tilt difference, the remainder is considered to be the POL benefit due to use of the advanced DNBR calculator, CETOP-D, in stead of CETOP-1, which is the DNBR calculator in COLSS.

Due to the importance of the power distribution for the POL evaluations, typical comparison of the power distributions of BEACON-COLSS and COLSS is shown

in Figure 3. Substantial differences are noticed, because of the licensing requirement of using a burn-up independent (cycle maximum) Fxy in COLSS for the YGN plant.

4. Conclusion

It has been demonstrated that the BEACON-COLSS monitoring system provides a substantial benefit in power margin over the COLSS system in the YGN plants. Detailed analysis of the plant data of YGN4 Cycle 6 and 7 cores shows the achieved benefit is more than 8.7% power margin on a cycle average basis.

A majority of the benefit is attributed to use of more accurate power distributions as shown in Figure 3. Use of an advanced DNBR calculator provides additional 3% benefit in POL.

Table 1. Evaluation of Margin Benefit

$(POL_{BEACON\text{-}COLSS} / POL_{COLSS} - 1) * 100$

	Minimum (% power)	Maximum (% power)	Average (%power)	
KWPFPOL	3.45	17.64	**8.74**	Y4C6
DNBRPOL	6.31	14.29	**10.13**	
KWPFPOL	7.19	20.06	**11.70**	Y4C7
DNBRPOL	6.65	13.28	**10.34**	

Figure 1. Benefit of BEACON-COLSS in KWPFPOL (Y4C7)

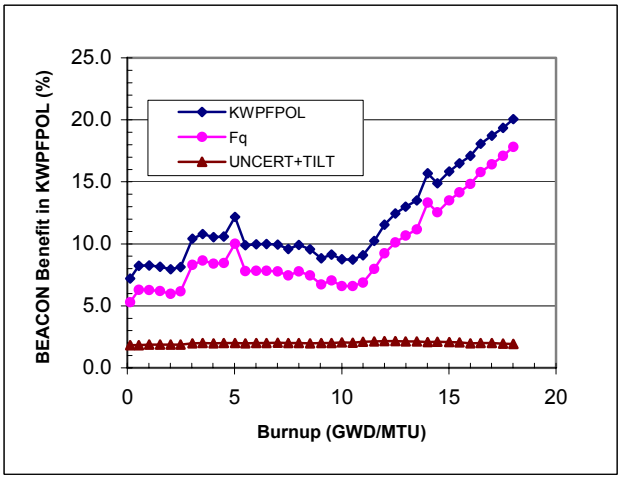


Figure 2. Benefit of BEACON-COLSS in DNBRPOL (Y4C7)

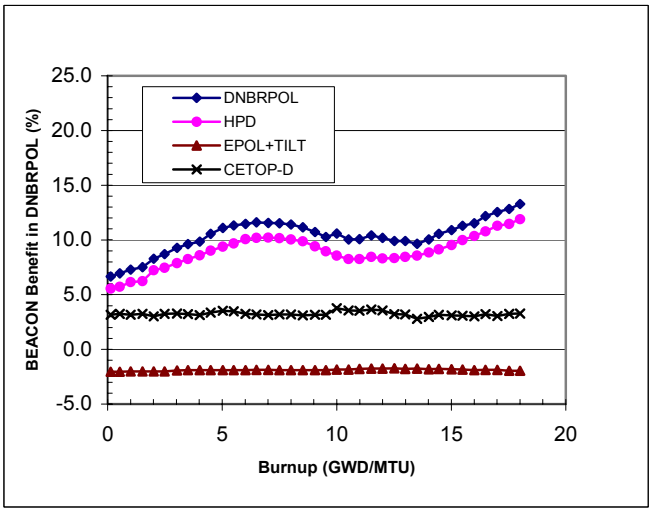
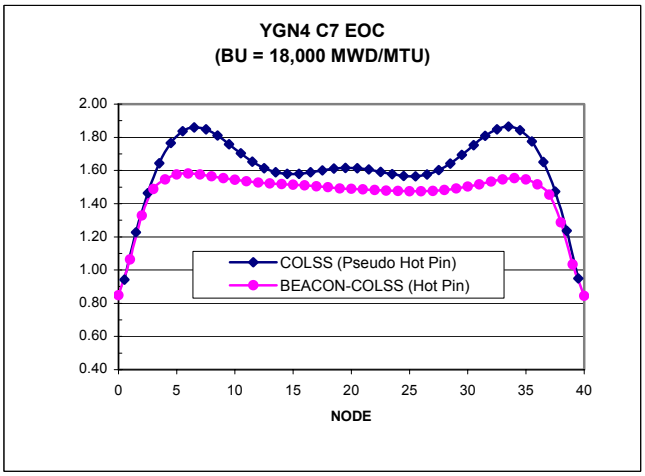


Figure 3. Hot Pin Power Distribution



REFERENCES

1. Morita, T., 'BEACON™ Core Monitoring and Operations Support System,' WCAP-12473-A, Addendum 1, Westinghouse Electric Corporation, May 1996

2. 'CETOP-D Code Structure and Modeling for San Onofre Nuclear Generating Station Unit 2 & 3,' CEN-160(s)-NP Revision 1-NP, September 1981.