AREVA

OPERABILITY ASSESSMENT
(CR #2012-8084 Revision 1)

Issue Description:

CR2011-2274 identifies an issue with the approved ACE correlation for the ATRIUM™ 10XM* fuel design with regard to the calculation of K-factor within the ACE correlation. [

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This issue was discussed with the USNRC during the review of a licensing amendment request to add the ATRIUM 10XM version of the ACE correlation to the list of approved COLR references in the Brunswick Technical Specifications. As part of the approval of this licensing amendment (Reference 1), the USNRC imposed a license condition that requires follow-on operability assessments. The specifics of this license condition were modified in the Reference 2 submittal to add the SAFLIM3D methodology to the list of approved COLR references in the Brunswick Technical Specifications. The license condition expected upon approval of the Reference 2 submittal is:

> *Safety Limit Minimum Critical Power Ratio (SLMCPR), setpoint, and core operating limit values determined using the ANP-10298PA, ACE/ATRIUM 10XM Critical Power Correlation (i.e., TS 5.6.5.b.21), shall be evaluated to verify the values determined using the NRC-approved method remain applicable and the core operating limits include margin sufficient to bound the effects of the K-factor calculation issue described in AREVA Operability Assessment CR 2011-2274, Revision 1. SLMCPR shall be evaluated with methods described in AREVA Document ANP-3086(P), Revision 0, "Brunswick Unit 1 and Unit 2 SLMCPR Operability Assessment Critical Power Correlation for ATRIUM 10XM Fuel – Improved K-factor Model." Setpoint and core operating limit values shall be evaluated with methods described in AREVA Operability Assessment CR 2011-2274, Revision 1. The results of the evaluation shall be documented and submitted to the NRC, for review, at least 60 days prior to startup of each operating cycle.*

This is the operability assessment for Brunswick Unit 2 Cycle 21 and as such addresses impacts on information provided in Reference 3. The Reference 3 report utilizes the SAFLIM3D methodology and therefore requires that the Reference 2 submittal and requested changes to the licensing condition be approved by the USNRC prior to Cycle 21 operation.

References:

1. *Brunswick Steam Electric Plant, Units 1 and 2 – Issuance of Amendments regarding Addition of Analytical Methodology Topical Report to Technical Specification 5.6.5 (TAC Nos. ME3856 and ME3857)*, Accession No. 111010234, April 8, 2011.
2. *Brunswick Steam Electric Plant, Units 1 & 2 – Request for License Amendments – Addition of Analytical Methodology Topical Report to Technical Specification 5.6.5, "CORE OPERATING LIMITS REPORT (COLR)" and Revision to Technical Specification 2.1.1.2 Minimum Critical Power Ratio Safety Limit,* Accession No. 12076A062, March 6, 2012.
3. ANP-3175(P) Revision 0, *Brunswick Unit 2 Cycle 21 Reload Safety Analysis,* AREVA NP, December 2012.
4. ANP-3086(P) Revision 0, *Brunswick Unit 1 and Unit 2 SLMCPR Operability Assessment Critical Power Correlation for ATRIUM 10XM Fuel – Improved K-factor Model*, AREVA NP, February 2012.

Affected Projects

Customer, Reload or Project Identifier	Customer	Reactor (if applicable)
BRK2-21	Duke - Progress Energy Carolinas	Brunswick Unit 2

* ATRIUM is a trademark of AREVA NP.

Assessment:

The USNRC approved ACE correlation was used in Cycle 21 core design and licensing analyses. It will also be used in the POWERPLEX®-III core monitoring system to ensure Technical Specifications compliance of the fuel operating limits during operation. This assessment addresses the licensing and subsequent monitoring of the Cycle 21 core in regard to the potential impacts of the ACE correlation issue described above.

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These are the same methods previously utilized in the Operability Assessment CR2011-2274 Revision 1 and their use is therefore consistent with the license condition imposed by Reference 1 and the proposed license condition in Reference 2.

The evaluation for the SLMCPR calculation was performed using methods as described in document ANP-3086(P) Revision 0 (Reference 4), as required by the proposed Reference 2 licensing condition.

Methods Used for Operability Evaluation

In the licensed methodology, a K-factor is determined by [

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For the setpoint and core operating limit evaluation a version of the ACE correlation was constructed in which the K-factor [

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For the SLMCPR evaluation, [ ] as described in ANP-3086(P) Revision 0 was utilized.

Justification of the Evaluation Tool

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Justification for the critical power correlation used in the SLMCPR evaluation is provided in Reference 4.

Monitoring During Cycle 21 Operation

The Brunswick Unit 2 Cycle 21 core is composed of the following fuel types:

	Fuel Design	No. Bundles	CPR Correlation
Fresh	ATRIUM 10XM	226	ACE (10XM)
Once-Burnt	ATRIUM 10XM	224 *	ACE (10XM)
Twice-Burnt	ATRIUM-10	110	SPCB

* The once-burnt batch includes one bundle that was discharged in the middle of Cycle 20 operation. This bundle has since been repaired and is being reinserted into a non-limiting location near the core periphery.

As noted earlier, the concern identified in the condition report affects the K-factor calculation within the ACE correlation. This only affects the ATRIUM 10XM fuel in the Cycle 21 core since the co-resident ATRIUM-10 fuel utilizes a different CPR correlation.

Once Cycle 21 begins operation, compliance to the operating limits will be performed using the POWERPLEX®-III core monitoring system which contains the approved version of the ACE correlation.

The nominal design step-through depletion was recalculated with the modified version [ ] of the ACE correlation in order to evaluate potential non-conservatisms in monitoring during Cycle 21 operation.

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Figure 1 Impact on Core Limiting MFLCPR during Cycle 21

Figure 1 shows that there is no significant non-conservative impact to the limiting CPR margin throughout most of the cycle. [

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Figure 2 Change in ATRIUM 10XM CPR at Rated Conditions

It is also useful to quantify the impact of the modified correlation on the calculated CPR for the ATRIUM 10XM

fuel design (on an absolute ΔMCPR basis). For the same rated power cases, the maximum change in the calculated CPR was determined to be [

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This evaluation was then expanded to look at a number of off-rated cases to determine if the rated power ΔMCPR results are representative for operation at reduced power conditions. The off-rated cases were performed for a subset of the cycle exposure points presented in Figure 2. The results of this evaluation are summarized in Figure 3.

The primary results of this off-rated evaluation include:

[

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Figure 3 Change in ATRIUM 10XM CPR at Rated and Off-Rated Conditions

The off-rated evaluation described above was performed for power levels at and above [

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[

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Impact on the Safety Limit MCPR (SLMCPR)

An evaluation of the impact on the SLMCPR was performed consistent with the Reference 2 proposed licensing condition. The critical power correlation described in Reference 4 was used in the assessment. The results using the Reference 4 critical power correlation support a 0.01 lower SLMCPR for both TLO and SLO than the calculations with the ACE correlation described in ANP-10298PA. Overall, the results from Reference 3 and the operability assessment support the proposed Brunswick Unit 2 TLO SLMCPR of 1.08 and SLO SLMCPR of 1.11 presented in Reference 2.

It should be noted MCPR is monitored relative to the OLMCPR and not directly to the SLMCPR. Therefore, there is no need in this SLMCPR evaluation to [

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Impact on CPR Operating Limits (OLMCPR)

The licensing analyses result in OLMCPRs that are a combination of power-dependent ($MCPR_p$) and flow-dependent ($MCPR_f$) limits. These are calculated from a series of quasi-steady-state and transient pressurization analyses. The quasi-steady-state events that have the potential to contribute to the $MCPR_p$ limits are the Control Rod Withdrawal Error (CRWE) and the Loss of Feedwater Heating (LFWH).

The $MCPR_f$ limits are based on the quasi-steady-state flow run-up analysis. [

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The Cycle 21 flow run-up results were reviewed to determine the margin to the $MCPR_f$ limits presented in Reference 3. This review confirmed that for $MCPR_f$ limits above 1.35 (the lowest rated power MCPR limit), the margin to the limit is more than adequate to compensate for the K-factor [ ] in setting the $MCPR_f$ limits and the steady-state CPR monitoring concern.

The $MCPR_p$ limits are a combination of the results from the pressurization analyses, CRWE, and potentially LFWH.

Pressurization Transient Impacts. This K-factor issue [

] the later cycle pressurization transient analysis results are only minimally affected

by this K-factor issue. This was verified with analyses using the modified version of the ACE correlation.

Pressurization transient analyses are also performed [

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The results of the analyses at all power levels show that in all cases (including the equipment out of service scenarios) the change in ΔCPR was such that there remains sufficient margin to the $MCPR_p$ limits. The margin is also large enough to account for the MCPR monitoring concern discussed above.

CRWE Impacts. CRWE analyses have been performed using both the as-approved version of the ACE correlation [ ] The CRWE results reported in Table 5.10 of Reference 3 are the most limiting from both sets of calculations.

The CRWE event is limiting for some conditions and sets the $MCPR_p$ limit for nominal scram speed with equipment in-service. For this reason, [

] For the 108% HTSP selected for Cycle 21 operation, the minimum margin to the ATRIUM 10XM $MCPR_p$ limits meet or exceed the [ ] at all power levels, as shown below:

	100% P	85% P	65% P	40% P	
ATRIUM 10XM $MCPR_p$	1.35	1.415 *	1.555 *	1.870 *	Table 8.1, Ref. 3
$OLMCPR_{CRWE}$	[ ]	[ ]	[ ]	[ ]	
Margin to $MCPR_p$	[ ]	[ ]	[ ]	[ ]	[ ]

* Values obtained by interpolation

The RBM operability requirements specified in Table 5.11 of Reference 3 [

] are valid for both the as-approved and modified version of the ACE correlation.

LFWH Impacts. The LFWH event is non-limiting with significant margin to the Cycle 21 $MCPR_p$ limits. This was confirmed for Cycle 21 with the performance of cycle-specific calculations using the modified ACE correlation. This calculation verified that the generic LFWH methodology continues to bound the cycle specific results including the impact of the ACE K-factor [ ]. Adequate margin exists at all power levels to offset the potential monitoring impact of the K-factor [ ].

Summary of MCPR impacts: The Reference 3 $MCPR_f$ and $MCPR_p$ limits have sufficient margin to account for the K-factor [ ] on the Cycle 21 quasi-steady-state and pressurization transient analysis results. This evaluation confirms [ ] for the use of the as-approved ACE correlation in the POWERPLEX-III core monitoring system.

Impact on Instrumentation Setpoints

The licensing analyses for Cycle 21 support CPR-based instrumentation setpoints for both the Rod Block Monitor (RBM) and for the Oscillation Power Range Monitor (OPRM).

The RBM setpoints are based upon the CRWE event which in turn has been analyzed based on the analytical high power trip setpoints listed in Table 5.10 of Reference 3. Since it was confirmed that the $MCPR_p$ limits continue to bound the CRWE ΔCPR results, the use of the Table 5.10 setpoints continues to be supported for Cycle 21 operation.

The OPRM setpoints are based upon a combination of the cycle-specific DIVOM (Delta over Initial CPR Versus Oscillation Magnitude), the plant-specific HCOM (Hot Channel Oscillation Magnitude), and cycle-

specific 2PT (2 recirculation pump trip) results. The cycle-specific DIVOM and 2PT results are the two components of this calculation that are potentially impacted by a CPR correlation error. Two sets of operating limits are reported for each OPRM setpoint, OLMCPR(SS) and OLMCPR(2PT). The DIVOM can impact both OLMCPRs and the 2PT results can only impact the OLMCPR(2PT) results.

DIVOM Impacts: The discussion in the DIVOM approved topical report (BAW-10255PA Revision 2) indicates that the DIVOM analysis is [

] Therefore, there is no DIVOM impact on the OLMCPR(SS) and OLMCPR(2PT) results.

2PT Impacts: The recirculation pump trip cases provide a ratio of the CPR before and after the 2PT trip. An increase in this ratio will result in an increase in the required MCPR prior to the pump trip, that is OLMCPR(2PT). This evaluation considers both the impact on the selection of the OPRM setpoint and on whether operation with the selected setpoint retains adequate CPR margin to compensate for monitoring the core with the unmodified ACE correlation.

The OLMCPR(SS) and OLMCPR(2PT) values provided in Table 4.3 of Reference 3 [

]. The use of these setpoints remains supported with the unmodified ACE correlation in the POWERPLEX-III core monitoring system.

Impact on Fuel Loading Error (FLE)

The FLE (misorientation and mislocation) is an infrequent event that is analyzed to assure the off-site dose criteria defined in Section 15.4.7 of NUREG-0800 is not exceeded. [

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Impact on Loss-of-Coolant Accident (LOCA)

A MCPR limit is assumed in the LOCA analyses to apply an upper limit on the hot channel power. A MCPR of 1.34 was used in the Brunswick ATRIUM 10MX LOCA analysis and is based on a conservatively low K-factor which results in a higher hot assembly power. [

] Therefore, the results of the Brunswick ATRIUM 10XM LOCA analysis remain applicable for Brunswick Unit 2 Cycle 21.

Conclusion

This evaluation used a combination of calculations and first principal arguments to address the impacts of the ACE correlation concern on planned Brunswick Unit 2 Cycle 21 licensing and operation. The calculations were performed using the modified version of the ACE correlation, [

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The fuel in the Cycle 21 core that is impacted by the ACE K-factor [ ] is the fresh and once-burnt ATRIUM 10XM fuel type. The co-resident twice-burnt ATRIUM-10 fuel design is licensed and will be monitored with the SPCB correlation and is therefore not impacted.

This operability assessment has evaluated the potential impact on all CPR related limits or analyses associated with the limits reported in the Reference 3 Reload Safety Analysis report. This evaluation has determined the SLMCPR and corresponding MCPR operating limits remain applicable to Brunswick Unit 2 Cycle 21 operation. The potential impact on the core monitoring system was conservatively addressed and was also found to be bounded by both the $MCPR_p$ and $MCPR_f$ values.

The $MCPR_p$ limits were set based in part upon the use of the 108% RBM setpoint and this remains supported with the current $MCPR_p$ values. The RBM operability limits were also confirmed to be applicable for Cycle 21 operation.

The OPRM setpoints were evaluated using the modified ACE correlation and confirmed to remain applicable for Cycle 21 operation.

The fuel loading error infrequent event was evaluated and it was confirmed that the required offsite dose criteria continues to be met.

There is no impact on the LOCA analysis.

In conclusion, no changes are required in the operating limits or instrument setpoints supplied in the Reference 3 Reload Safety Analysis report. These limits may be used to support operation and monitoring with the current POWERPLEX-III core monitoring system.

APPROVALS:

Approved:	Earl E Riley	Date:	1-16-2013
	Issue Evaluator – E. E. Riley (Neutronic Design and Analysis)		
Approved:	Donald G. Carr	Date:	1-14-2013
	Issue Evaluator – D. G. Carr (T/H Applications)		
Approved:	M Evans	Date:	1/16/13
	Peer Review – S. W. Evans (Neutronic Design and Analysis)		
Approved:	D R Tinkler	Date:	1/17/13
	Peer Review – D. R. Tinkler (T/H Applications)		
Approved:	M. T. Bunker	Date:	1-18-2013
	Peer Review – M. T. Bunker (T/H Codes and Methods)		
Approved:	Earl E Riley	Date:	1-18-2013
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