ENCLOSURE 2

MFN 16-011

Supporting Discussion, Information and GESTAR II Markups

Non-Proprietary Information– Class I (Public)

IMPORTANT NOTICE

This is a non-proprietary version of Enclosure 1, which has the proprietary information removed. Portions of the enclosure that have been removed are indicated by an open and closed double square bracket as shown here [[ ]].

Supporting Discussion, Information and GESTAR II Markups

Global Nuclear Fuel - Americas (GNF-A) is in the process of updating its core monitoring system for compatibility with Windows-based computer platforms and operating systems, and to streamline the cybersecurity aspects of core monitoring. Further, the user interface is being improved to be consistent with modern functionalities and expectations. As a result, GNF-A has changed the name of the updated core monitoring system from 3D-MONICORE to ACUMEN.

From a technical standpoint, the inputs, internal algorithms and models, and key outputs of GNF-A's new core monitoring system ACUMEN are the same as 3D-MONICORE. The same PANACEA nuclear core simulator methodology is used in both 3D-MONICORE and ACUMEN. The change in name from 3D-MONICORE to ACUMEN does not affect the power uncertainty basis approved by the NRC and the design methodologies referenced below.

In order to support the assertion that 3D-MONICORE and ACUMEN are equivalent from a nuclear core monitoring aspect, Attachment 1 documents a study of thermal margin outputs from the two systems using the same inputs. The observed maximum difference in thermal margins between the two core monitoring systems is insignificant based on the perspective of core monitoring operational experience. This comparison demonstrates that 3D-MONICORE and ACUMEN are equivalent for fuel bundle and nodal power distribution and the associated uncertainties applied in the design methodologies are unchanged.

There are references to 3D-MONICORE in numerous licensing documents. However, there are a limited number of topical reports (TRs) that literally have a basis depending on the 3D-MONICORE name. References 1-3 are specific TRs that fall into the group that depends on the 3D-MONICORE name. Reference 4 is an example of a TR that mentions 3D-MONICORE but does not depend on it.

Because the change in name is in effect a commercial decision and not a methodology change, GNF-A does not intend to change all of the current 3D-MONICORE citations to ACUMEN. When a plant implements a change in the core monitoring system from 3D-MONICORE to ACUMEN, the methodologies submitted to the NRC for generic review and approval (as documented in the NRC SER for the specific application in the references below) are not changed. The term ACUMEN can be used interchangeably with 3D-MONICORE in the documentation contained in NEDE–24011 General Electric Standard Application for Reactor Fuel (GESTAR II) and in the references below.

Attachment 2 provides the marked up portions of GESTAR II to provide clarity to the name change from 3D-MONICORE to ACUMEN. Two sections are affected:

- GESTAR II Main - Section 3.2.2.2 Power Distribution Accuracy
- GESTAR II US Supplement - S.5.2 Operating Flexibility Options

For other casual references of 3D-MONICORE, the new core monitoring system ACUMEN is viewed as technically equivalent.

References:

1 NEDC-32694P-A, "Power Distribution Uncertainties for Safety Limit MCPR Evaluations," August 1999.
2 NEDC-32601P-A, "Methodology and Uncertainties for Safety Limit MCPR Evaluations," August 1999.
3 NEDC-33173P-A, Revision 4, "Applicability of GE Methods to Expanded Operating Domains," November 2012.
4 NEDC-33006P-A, Revision 3, "General Electric Boiling Water Reactor Maximum Extended Load Line Limit Analysis Plus," June 2009.

Attachment 1 - ACUMEN and 3D-MONICORE Thermal Margin Comparison

Introduction

The ACUMEN core monitoring system was installed in a test network at the Global Nuclear Fuel facility in Wilmington, North Carolina. Its database was loaded from a 3D-MONICORE (3DM) core monitoring case for a plant running ACUMEN in a test mode and expecting to make a complete transition to ACUMEN later in 2016. The objective of this study was to compare the output of ACUMEN and 3DM when the same input data is fed to both systems. The test data file was created from one set of plant process data taken at rated power and was the basis for all data entered into ACUMEN and 3DM. Parameters in the test data file were manually changed to simulate different plant power and flow conditions allowing calculated thermal margin comparison between the respective core monitoring systems in a typical power maneuver situation.

This attachment summarizes a comparison of two thermal margins. Given the same data feed, the two thermal margins are calculated at essentially the same time. The two thermal margins are:

- Fraction of Limiting Critical Power Ratio (CPRRAT) – related to fuel bundle power
- Fraction of Limiting Power Density (FLPD) – related to fuel pin local power

Test Environment

The 3DM core monitoring system at the reference plant is based on the Virtual Memory System (VMS) platform and uses the core simulator PANACEA also on the VMS platform to calculate the core monitoring parameters such as the thermal margins CPRRAT and FLPD. The 3DM system was rebuilt in Wilmington and was run from the test input data file. 3DM initiated a pull sequence which read the test data nominally every 15 seconds to calculate incremental core energy. Once an hour a 3DM routine called for the automatic initiation of a core monitoring analysis which calculated incremental core energy, thermal margins, and a wide variety of datasets used to monitor core component performance and lifetime.

The ACUMEN core monitoring system is a Windows-based system which analyzes the core and performs the same functions as 3DM using the same core simulator PANACEA qualified for use on the Windows environment. ACUMEN in this test system received the test input data file also with a nominal interval of approximately 15 seconds.

Both ACUMEN and 3DM received test input data from the same source. The test input data file process values were unchanged for approximately three days, allowing the test system xenon to reach near-equilibrium levels. After this stabilization period the test input data file values were changed once per hour, simulating a power maneuver. The change in the test input data occurred before the two system core monitors were scheduled to run, ensuring that both systems received the same test data although their respective core monitor start times were not synchronized.

Minor differences between the core monitor analyses of ACUMEN and 3DM are expected for the following reasons:

1. There are small platform differences in the numerical methods used in the Windows-based and the VMS-based core simulator PANACEA.
2. Starting ACUMEN core monitor processes required calculating a core gross energy increment. The respective cycle energies between ACUMEN and 3DM differed by [[ ]].

Test Methodology and Results

An analysis tool evaluated the time stamp for core monitors in the ACUMEN and 3DM core monitor output files. Valid test cases were created if these core monitors commenced at essentially the same time. The results are summarized in Table 1.

The analysis tool extracted the ACUMEN and 3DM CPRRAT values for every fuel bundle and computed the difference for each bundle. The tool likewise extracted the ACUMEN and 3DM FLPD values for every fuel node and computed the difference for each node. For each test case, a row in Table 1 is created which records the core-wide maximum magnitude (positive or negative) of these computed differences. Note that CPRRAT is calculated for each bundle in the core and FLPD is calculated for each node in the core.

- The maximum CPPRAT difference is in the column entitled "Delta CPRRAT (3DM – ACUMEN)"
- The maximum FLPD difference is in the column entitled "Delta FLPD (3DM – ACUMEN)"

The minimum and maximum CPRRAT and FLPD differences from Table 1 are shown below.

	Difference Minimum	Difference Maximum
CPRRAT difference	[[	
FLPD difference		]]

The statistical graphical summary for the distribution of the difference in CPRRAT is shown in Figure 1 and for FLPD in Figure 2. As seen from the figures, differences are centered on zero with some results at the maximum and minimum difference extremities.

Summary and Conclusion

The maximum difference in CPRRAT and FLPD thermal margins between ACUMEN and 3DM core monitor cases which ran from the same set of process variable inputs were compiled in Table 1. The observed maximum difference in thermal margins between the two core monitoring systems is insignificant based on the perspective of core monitoring operational experience.

The small differences between ACUMEN and 3DM results are attributed to the identified sources of variation. They are: (1) the differences in the two platforms for the same core simulator PANACEA embedded in ACUMEN and 3DM, and (2) small differences in fuel parameters from initial test setup.

Based on the ACUMEN and 3DM thermal margin comparison, it is concluded that ACUMEN and 3DM are essentially equivalent. The thermal margins that were examined are representative of the fuel bundle and nodal power distribution. Therefore, it is concluded that the two core monitoring systems are essentially equivalent for fuel bundle and nodal power distribution and the associated uncertainties applied in the design methodologies are unchanged.

Table 1

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Table 1, Continued

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Figure 1

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Figure 2

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Attachment 2 – Marked Up GESTAR II Pages

The new text is illustrated below in Italics.

GESTAR II Main

Section 3.2.2.2 Power Distribution Accuracy

The accuracy of the calculated power distributions is discussed in References 3–4, 3–5, 3–16, 3-17 and 3–18.

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GNF has chosen to not change the current 3D-MONICORE citations to ACUMEN. 3D-MONICORE is mentioned in References 3-17 and 3-18.

GESTAR II US Supplement

S.5.2 Operating Flexibility Options

The following operating flexibility options have been developed for BWRs:

(1) Single–Loop Operation.

(2) Load Line Limit.

(3) Extended Load Line Limit.

(4) Increased Core Flow.

(5) Feedwater Temperature Reduction.

(6) ARTS Program (BWR/3–5).

(7) Maximum Extended Operating Domain for BWR/6 and Maximum Extended Load Line Limit Analysis for BWR/3–5.

(8) Turbine Bypass Out of Service.

(9) Safety/Relief Valves Out of Service.

(10) ADS Valve Out of Service.

(11) End–of–Cycle Recirculation Pump Trip Out of Service.

(12) Main Steam Isolation Valves Out of Service.

(13) Maximum Extended Load Line Limit Analysis Plus.

Figure S-5 provides a general illustration of the history of power-flow domain changes.

The supplemental reload licensing report indicates if an option has been chosen.

Some plants referencing GESTAR II as the applied reload methodology may include the GE Licensing Topical Report, Applicability of GE Methods to Expanded Operating Domains (Reference S-101), as part of their licensing basis. For such a plant, the limitations, conditions, and requirements of Reference S-101 are included in the analysis and licensing basis for the reload. The applicability of Reference S-101 has been expanded to include GNF2 fuel by Reference S-108. Reference S-101 has been updated to reflect NRC approval of Supplement 2 (Reference S-109). This approval allows a reduction of the additional margin applied to the Safety Limit Minimum Critical Power Ratio (SLMCPR) in Revision 1. The limitations and conditions included in the NRC Safety Evaluation in Reference S-101 modify the SLMCPR margin to be applied to plants referencing NEDC-33173P, Applicability of GE Methods to Expanded Operating Domains (Reference S-101), as part of their licensing basis. The implementation of PRIME in downstream methods has been reviewed, approved, and audited by the NRC (Reference S-110).

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GNF has chosen to not change the current 3D-MONICORE citations to ACUMEN. 3D-MONICORE is mentioned in References S-101, S-108 and S-109.