

AURORA-B: Addressing L&Cs 11, 12, and 18

ANP-10300
Revision 1
Supplement 1NP
Revision 0

Topical Report

June 2025

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Nature of Changes

Item	Section(s) or Page(s)	Description and Justification
1	All	Initial Issue

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Nomenclature
(If applicable)

Acronym	Definition
AOO	Anticipated Operational Occurrence
BWR	Boiling Water Reactor
CDF	Cumulative Distribution Function
[]
EOOS	Equipment Out Of Service
FoM	Figure(s) of Merit
FWCF	Feedwater Controller Failure
[]
GDC	General Design Criteria
HPCI	High Pressure Coolant Injection
IPM	Integral Power Multiplier
IHPS	inadvertent HPCI pump start
[]
K-S	Kolmogorov-Smirnov Test
L&C	Limitation and Condition
LHGR	Linear Heat Generation Rate
LRNB	Load Rejection No Bypass
MCPR	Minimum Critical Power Ratio
[]
NRC	Nuclear Regulatory Commission
RAI	Request for Additional Information
[]
[]
RSAR	Reload Safety Analysis Report
[]
SAFDL	Specified Acceptable Fuel Design Limits
SE	Safety Evaluation
2RPT	Two Recirculation Pump Trip

1.0 INTRODUCTION

As part of the continuous improvement at Framatome, several improvements and simplifications to the AURORA-B AOO method, Reference 1, have been identified. The intent of this supplement is to provide additional information and/or guidance to address items documented in the Limitations and Conditions (L&Cs) of the Safety Evaluation (SE) for the approved topical report ANP-10300P-A Revision 1 (Reference 1) to simplify the overall licensing process.

The AURORA-B methodology was originally approved in Reference 1 and was developed to predict the dynamic response of boiling water reactors (BWRs) during transient, postulated accident, and beyond-design basis accident scenarios. The method is broadly applicable to many BWR events and calculational procedures (e.g. deterministic or statistical procedures). The NRC review of this method identified several L&Cs that require that additional information be submitted on a plant specific basis. In particular, this supplement provides information related to L&Cs 11, 12, and 18b which were identified as candidates that could be generically addressed rather than relying on plant specific submittals.

L&C 11 documents a requirement that the uncertainties for SL02 [

], R01 [

], R02 [

], and C12 [] be provided on a plant specific basis.

Framatome has developed a generic procedure to assess the uncertainty associated with SL02. This procedure defines how to determine the [] uncertainty as well as the process for determining the appropriate probability distribution.

L&C 12 implements a requirement that the NRC review any method that is used to credit [

]

[

]

L&C 18 includes a requirement that a description of the use of conservative measures be submitted as part of the initial implementation licensing application and places requirements on the use of conservative measure in follow on cycles. These conservative measures are used in place of a full statistical evaluation. Framatome has developed a procedure to validate the conservative measures for follow on cycles to replace the current procedure which relies on changes in the Figure of Merit (FoM).

2.0 SUMMARY

This supplement is intended to address the requirements of L&C 11, L&C 12, and L&C 18 of Reference 1. The processes defined in this supplement are to address these L&Cs on a generic basis to standardize the process and simplify the plant specific implementation.

Section 4.0 defines a process for addressing the uncertainty in the [

]. Note that this only addresses item SL02. The remaining items identified in L&C 11 will still need to be addressed on a plant specific basis. Section 4.0 provides a process and criteria to use in determining both the uncertainty and the distribution to use in statistical cases. This section also provides for a conservative deterministic evaluation of [].

Section 5.0 provides a description of a generic method for evaluating the [

] to comply with L&C 12. This includes a description of the calculation, benchmarking of the code used in the evaluation, and how the [] is applied within the S-RELAP5 code.

Section 6.0 provides a detailed description of the use of conservative measures to bound statistical variations in the AURORA-B AOO methodology to comply with L&C 18. This definition of conservative measures is defined for [].

Events such as [] will still need to comply with the requirements of L&C 18. This section defines the conservative measures to use, how to determine the magnitude during the initial cycle, and how to validate the continued use for follow-on cycles.

3.0 REGULATORY REQUIREMENTS SUMMARY

Regulatory General Design Criteria (GDC) for anticipated operational occurrences (AOOs) is provided in NUREG-0800, "Standard Review Plan for the Review of Safety Analysis Reports for Nuclear Power Plants (Reference 2). In particular, GDC 10, Reactor Design, requires that the reactor core and associated coolant, control, and protection systems shall be designed with appropriate margin to ensure that Specified Acceptable Fuel Design Limits (SAFDLs) are not exceeded during any condition of normal operation, including the effects of AOOs. The range of transient classes are described in Section 3.1.2 of Reference 1.

4.0 L&C 11 [] UNCERTAINTY

11. AREVA will provide justification for the uncertainties used for the highly ranked plant-specific PIRT parameters C12, R01, R02, and SL02 on a plant-specific basis, as described in Table 3.2 of this SE.

L&C 11 documents a requirement that the uncertainties for SL02 [

], R01 [

], R02 [

], and C12 [

] be provided on a plant specific basis. Current

practice is to treat [

] For licensing

calculations, the most conservative [

] is used.

Subsequent reviews of [] have shown that the data can be described by a [

]. This section defines a new process to sample on [

] as part of the standard statistical calculations. This section will define

procedures to specify data needs as well as determining the sampling distribution to use.

4.1 Data Requirements

In order to ensure a consistent data set, [

]

4.2 *Sampling Distributions*

For this method, [

] . The use of any other distributions will require a plant specific submittal and review.

4.2.1 []

To determine if a set of [] data can be described by [

]

If a [] distribution is supported, then the standard deviation of the data at [] is calculated. The steam line pressure drop will be sampled up to a range of [] consistent with the approved AURORA-B AOO methodology, Reference 1.

4.2.2 []

If a [] distribution cannot be supported, then a [] distribution may be conservatively assumed [].

For this distribution, []

4.2.3 Deterministic application

If statistical sampling of the [] is not desired, then a deterministic approach can be taken. In this case, the data is reviewed and the minimum and maximum [] are determined. []

[]. Follow-on licensing analyses will utilize a [] corresponding to the most conservative condition.

4.2.4 Implementation in AURORA-B AOO Licensing

[]

4.2.5 Example Data Processing

A set of sample []. A total of [] data points were identified with a mean [] with a standard deviation of []. A histogram of this data can be seen in Figure 4-1.

In order to test the hypothesis that the data can be described by [

]. Assuming [] data points, the critical value was found to be []. This is compared against the K-S test statistic (D) of []. As D is found to be less than the critical value, then this implies that the statistics do not contradict the claim that the [].



Figure 4-1: [] Histogram

5.0 L&C 12 [

]

12. When applying the AURORA-B EM to the [, any changes to AURORA-B to enhance [

] on a plant-specific basis without prior NRC review and approval are not approved as part of this SE, as described in Table 3.2 of this SE.

[

]

Section 3.5.2.7 documented the NRC’s review of this response as such:

However, the NRC staff does not agree with AREVA’s third response. [

]

The result of this conclusion was Limitation and Condition 12 of AURORA-B AOO which requires plant-specific approval for any changes made to the [

] This section provides the description of a generic method to be used to determine a



[

]

[

]

[

]

[

]



Figure 5-1: [

]

5.3.1 []

[

]

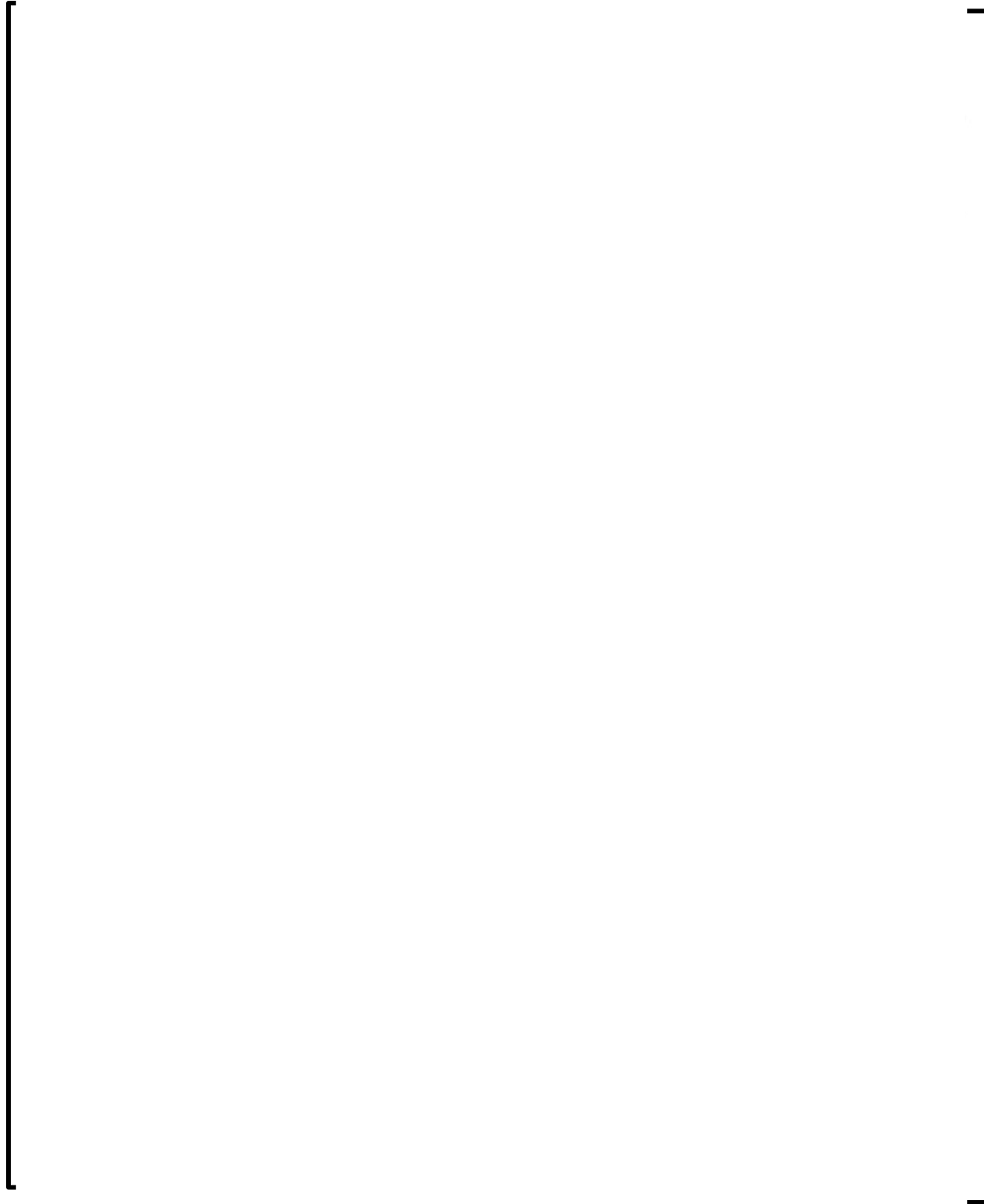


Figure 5-2: [

]

[

]

[

]

Table 5-1: [

]

[

]

[

]

Table 5-2: [

]

[

]

5.3.1.1 []

[

]

[

]

Table 5-3: [

]

[

]

5.3.1.2 Results

[

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Figure 5-3: [

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[

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[

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Figure 5-4: [

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[

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[

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Figure 5-5: [

]

[

]



Figure 5-6: [

]

[

]



Figure 5-7: [

]

[

]

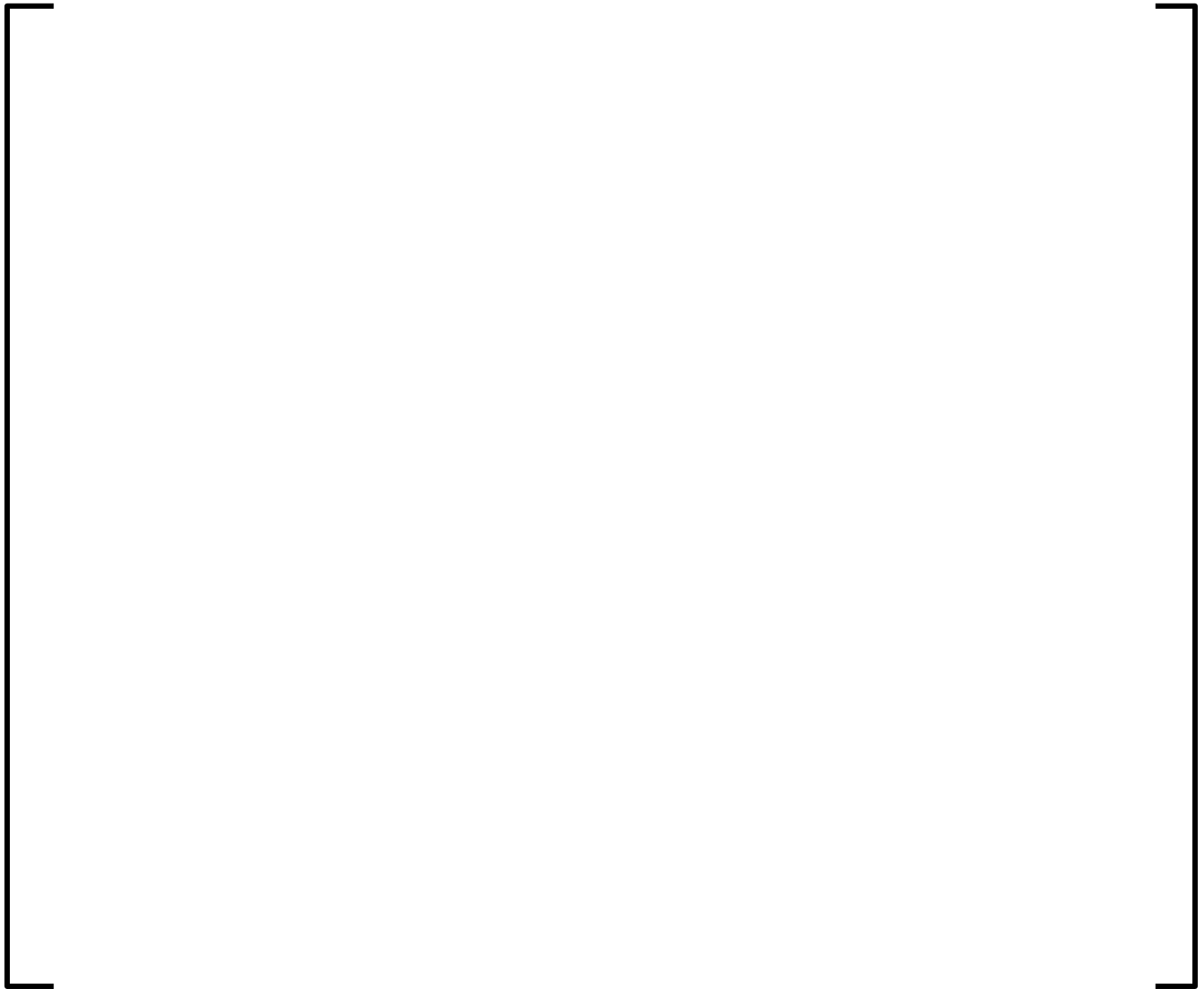


Figure 5-8: [

]

[

]

5.3.2 []

[

]

5.3.3 []

[

]

Table 5-4: []

A large, empty rectangular frame with a thin black border, positioned centrally on the page. It is intended to contain the data for Table 5-4, but the content is currently blank.

[

]

Table 5-5: [

]

[

]

5.3.4 []

[

]

[

]

5.3.5 Results

[

]

[

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[

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Figure 5-9: [

]

[

]



Figure 5-10: [

]

5.3.6 [

]

[

]

Table 5-6: [

]

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[

]

5.3.7 [

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[

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[

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[

]



Figure 5-11: [

]

5.3.8 Conclusion

[

]

[

]

6.0 L&C 18 USE OF CONSERVATIVE MEASURES

18. As discussed in Section 3.6.5 of this SE regarding conservative measures :
- a. Plant-specific licensing applications shall describe and provide justification for the method for determining and applying conservative measures in future deterministic analyses for each FoM (e.g., biasing calculational inputs, postprocessing adjustments to calculated nominal results) , and
 - b. If the 95/95 FoM for a given parameter calculated according to the defined conservative measures during a deterministic analysis shows a difference in magnitude exceeding 1σ from the corresponding value calculated in the most recent baseline full statistical analysis, AREVA must re-perform the full statistical analysis for the affected scenario and determine new conservative measures.

L&C 18 documents two restrictions that were imposed on the use of conservative measures with the AURORA-B AOO methodology. L&C 18a documents a requirement that a description of justification of any conservative measure that is used be submitted in a plant specific licensing application. This restriction was imposed as the approved topical report does not provide details on the conservative measures or how they are used. This supplement will provide a description of the conservative measures that are used for [] to generically satisfy the requirements of L&C 18a. For [], the restriction will still apply as the conservative measures may be event/plant dependent.

The second restriction, L&C 18b, defines a criteria that must be satisfied to use these conservative measures in follow-on cycles. This criteria states that if the 95/95 FoM for a given calculation changes by more than one standard deviation, then the full statistical calculation will need to be repeated. Framatome is proposing to replace this criteria with [] confirm that the conservative measures remain bounding.

6.1 Overview of L&C 18a

Section 49.3 in the response to RAI-49 of the Reference 1 topical report gives the basic process for applying conservative measures to bound the statistical calculations. However, as noted in Section 3.6.5 of the SE for Reference 1, insufficient detail was

provided as to the definition and application of conservative measures in the transient analyses. As such, Limitation and Condition (L&C) 18 was written to require that any use of conservative measures for use in bounding statistical variation must be submitted and approved by the NRC. This section is intended to provide the definition of conservative measures for generic review and approval.

The process described in this section is only applicable to [

]. This definition can encompass transients driven by [

]. This process is not intended to cover transients [

].

This section is intended to provide the definition of conservative measures for generic review and approval.

6.1.1 Conservative Measures

[

]

6.1.2 Process for Determining Conservative Measures

A full statistical evaluation of each FoM is required as part of the initial application of the AURORA-B AOO methodology at a given plant and should include statistical calculations for each limiting or potentially limiting event. An [] is then defined for each Figure of Merit (FoM) independently. To do this, [

]

[

]

Example [] validation results are shown in Figure 6-1 and Figure 6-2. No significant trends in results are seen over the range of analyzed cases and the [] evaluated in this example would be deemed to be appropriate.

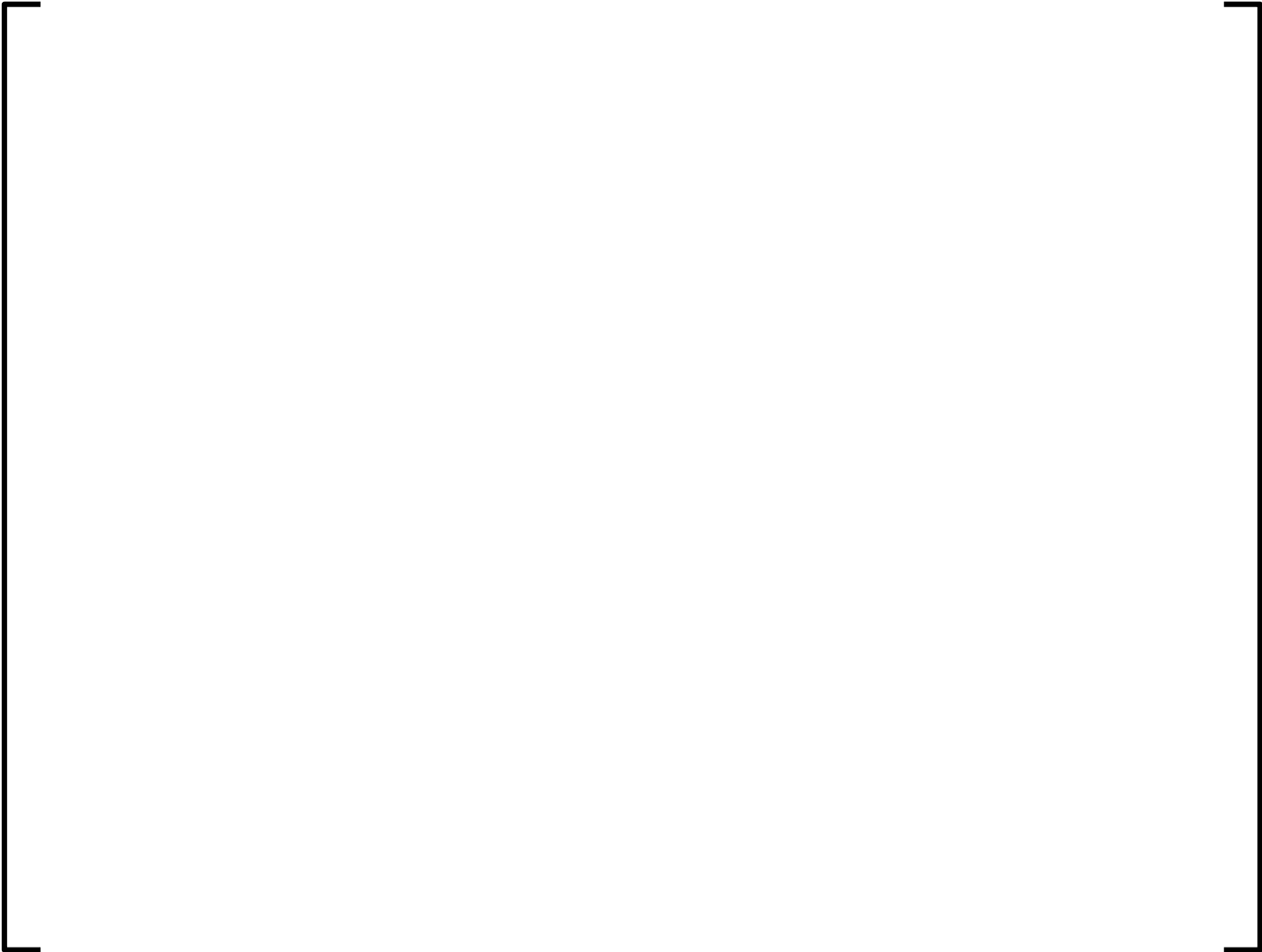


Figure 6-1: [

]



Figure 6-2: [

]

6.1.3 Application Scope of the Conservative Measure

The [

]. Each [] is defined for each Figure of Merit (FoM) independently.

6.2 *Application of Conservative Measures in Follow-On Cycles*

It is intended that the [] for a given FoM would be applicable to follow-on cycles. Section 3.6.5 of the SE for Reference 1, defines the process for determining whether the conservative measures remain valid for follow-on cycles. For major changes, such as those identified in Section 3.6.5 of the SE, the conservative measures will need to be re-evaluated to ensure that they remain valid. This section also provides a criteria to use when determining whether the conservative measures remain valid for normal follow on cycles. The SE defines that the conservative measures are determined to be valid if the FoM for a given application varies less than 1σ from the most recent full statistical analysis. [

],

Framatome proposes a new validation procedure to ensure the conservative measures remain conservative.

For any follow-on applications of the conservative measures, [

] If the statistical results are found to be more limiting, then a full statistical evaluation will need to be performed.

7.0 REFERENCES

1. ANP-10300P-A Revision 1, *AURORA-B: An Evaluation Model for Boiling Water Reactors; Application to Transient and Accident Scenarios*, Framatome Inc., January 2018.
2. USNRC Standard Review Plan, NUREG-800, Revision 3, March 2007.
3. NUREG-1475 Revision 1, *Applying Statistics*, March 2011.
4. []
5. []
6. []
7. []