framatome

Response to Request for Additional Information – ANP-10349P

ANP-10349Q1NP
Revision 0

Topical Report

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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

Acronym	**Definition**
AFW	Auxiliary Feedwater
BOC	Beginning of Cycle
CWO	Core Wide Oxidation
EM	Evaluation Model
EOC	End of Cycle
EOL	End of Life
FPC	Fuel Performance Code
HHSI	High Head Safety Injection
LHGR	Linear Heat Generation Rate
LOCA	Loss of Coolant Accident
MLO	Maximum Local Oxidation
MOC	Middle of Cycle
MWR	Metal Water Reaction
PCT	Peak Cladding Temperature
RAI	Request for Additional Information
RCP	Reactor Coolant Pump
RLBLOCA	Realistic Large Break Loss of Coolant Accident
SBLOCA	Small Break Loss of Coolant Accident
SI	Safety Injection
W3	Westinghouse 3-Loop

INTRODUCTION

A request for additional information (RAI) related to the Topical Report ANP-10349P is documented in Reference 1. The response to this RAI is provided herein.

1.0 RAI-1

Question:

Section 2, "GALILEO Implementation in S-RELAP5," of ANP-10349P summarizes implementation of GALILEO in S-RELAP5 thermal hydraulic system code for performing LOCA analyses. Section 2, states in part that [

]

a. Provide details of the [ ] The details must include fuel performance code (FPC) parameters involved in the iterative process for convergence.

b. Provide examples to show that [ ] with GALILEO and S-RELAP5 [ ] with COPERNIC code and S-RELAP5.

Response:

Response to RAI.1.a:

A key to performing a LOCA analysis is the model used for calculating fuel rod performance. In particular, the initial operating temperature of the fuel pellets (stored energy), the internal fuel rod gas pressure, and the transient gap conductance are significant parameters which affect the calculated PCT. Framatome will use GALILEO to calculate the required fuel characteristics as a function of fuel rod exposure and power history for LOCA analysis as part of ANP-10349P.

The GALILEO fuel rod performance code was originally developed and NRC-approved for use by Framatome with respect to fuel rod mechanical design. The GALILEO code was incorporated in S-RELAP5 to permit coupled calculations of fuel rod thermal properties (thermal conductivity, heat capacity, and gap conductance) during both the steady-state and the transient phases of an S-RELAP5 LOCA analysis.

The fuel rod analysis for an S-RELAP5-based RLBLOCA/SBLOCA calculation proceeds in three steps:

[ ]

The data exchange between the GALILEO sub-code in S-RELAP5 and S-RELAP5 is presented in Figure 1-1.

[ ]

[

]

Response to RAI.1.b:

As discussed in the response to RAI 1(a), [

]

[

]

For example, a case from the W3 sample problem was selected and analyzed further.

[

]

[

]

Table 1-1 provides a summary of the information extracted [

]

The information presented in Table 1-1 indicates the [

]

Based on Table 1-1, the range of times to focus in are as follows:

- 0.0 to 2.0 seconds
- 2.0 to 4.0 seconds
- 4.0 to 6.0 seconds

- 8.0 to 10.0 seconds
- 13.7 to 13.9 seconds
- 20.6 to 20.8 seconds

Figure 1-2 through Figure 1-7 provides the fuel centerline temperature for [ ] for the time periods of interest at the PCT node [ ]

Figure 1-8 through Figure 1-13 provides the cladding temperature for [ ] for the time periods of interest at the PCT node [ ]

Figure 1-2 through Figure 1-13 shows [ ]

Figure 1-1
GALILEO/S-RELAP5 Data Exchange

Figure 1-2
Centerline Temperature at PCT Node – [ ] – 0.0 to 2.0 Seconds

[ ]

Figure 1-3
Centerline Temperature at PCT Node – [ ] – 2.0 to 4.0 Seconds

[

]

Figure 1-4
Centerline Temperature at PCT Node – [ ] – 4.0 to 6.0 Seconds

[

]

Figure 1-5
Centerline Temperature at PCT Node – [ ] – 8.0 to 10.0 Seconds

Figure 1-6
Centerline Temperature at PCT Node – [ ] – 13.7 to 13.9 Seconds

[

]

Figure 1-7
Centerline Temperature at PCT Node – [ ] – 20.6 to 20.8 Seconds

[

]

Figure 1-8
Cladding Temperature at PCT Node – [ ] – 0.0 to 2.0 Seconds

[

]

Figure 1-9
Cladding Temperature at PCT Node – [ ] – 2.0 to 4.0 Seconds

[

]

Figure 1-10
Cladding Temperature at PCT Node – [ ] – 4.0 to 6.0 Seconds

[ ]

Figure 1-11
Cladding Temperature at PCT Node – [ ] – 8.0 to 10.0 Seconds

[

]

Figure 1-12
Cladding Temperature at PCT Node – [ ] – 13.7 to 13.9 Seconds

Figure 1-13
Cladding Temperature at PCT Node – [ ] – 20.6 to 20.8 Seconds

[ ]

Table 1-1 Summary of GALILEO [ ]

[ ]

2.0 RAI-2

Question:

Section 4.7.1, "Evaluation Model Implementation Changes," of ANP-10349P provide a short summary of how GALILEO code and methodology are implemented in SBLOCA analysis in combination with S-RELAP5 code. Also, the document [ ] describes in detail the guidelines for PWR SBLOCA analysis using S-RELAP5.

a. Provide details of GALILEO implementation in the SBLOCA evaluation model and related sensitivity analyses that are described in [ ] except the item [ ]

b. Discuss the differences in coupling between RODEX2 with S-RELAP5 and GALILEO with S-RELAP5 in an SBLOCA analysis.

Response:

Response to RAI.2.a:

The SBLOCA analysis consists of a series of break spectrum, delayed RCP trip, attached piped breaks, and sensitivity calculations. The calculation flow for an SBLOCA analysis is [ ]

[ ]

[ ]

Response to RAI.2.b:

Both RODEX2 and GALILEO were integrated as sub-codes in S-RELAP5. The differences in the S-RELAP5 integration between RODEX2 and GALILEO consist primarily [ ]

[ ]

[

]

Table 2-1 GALILEO FPC [ ]

[ ]

3.0 RAI-3

Question:

Describe the deviation in process, if any, from RODEX2 implementation in SBLOCA analysis to GALILEO implementation in SBLOCA analysis.

Response:

The changes made to the SBLOCA analysis process for the implementation of GALILEO in the SBLOCA EM are limited to those described in Section 4.7.1 of the ANP-10349P-000 Topical Report (Reference 5).

4.0 RAI-4

Question:

Audit document, [

]

Provide details of analytical methodology, technical basis, thermo-mechanical response of fuel rod during normal plant operation and during SBLOCA, Summary of results and conclusion from the [ ]

Response:

As part of the implementation of the GALILEO fuel rode code, the study referenced in the RAI was performed in order to [

]

A detailed technical evaluation of the cladding thermal response during an SBLOCA transient was made. It was found that the cladding thermal response can potentially be affected by the following two important detrimental effects [

]

[ ]

Taking into account the conclusions from these sensitivity studies, the following recommendations for the implementation of GALILEO in the SBLOCA methodology were made:

[ ]

5.0 REFERENCES

1. Letter from N. Otto (U.S. NRC) to Gary Peters (Framatome Inc.), "Request for Additional Information regarding Framatome Topical Report, ANP-10349P, Revision 0, "GALILEO Implementation in LOCA Methods" (EPID L-2020-TOP-0059)," dated March 23, 2021.
2. EMF-2103(P)(A) Revision 3, Realistic Large Break LOCA Methodology for Pressurized Water Reactors, June 2016.
3. EMF-2328(P)(A) Revision 0, PWR Small Break LOCA Evaluation Model, S-RELAP5 Based, March 2001.
4. EMF-2328(P)(A) Revision 0 Supplement 1(P)(A) Revision 0 PWR Small Break LOCA Evaluation Model, S-RELAP5 Based, December 2016.
5. ANP-10349P, Revision 0, GALILEO Implementation in LOCA Methods, October 2020.