



UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D.C. 20555-0001

REGULATORY AUDIT PLAN FOR FRAMATOME, INC.

TOPICAL REPORT ANP-10349P, REVISION 0,

"GALILEO IMPLEMENTATION IN LOCA METHODS"

DOCKET NO. 99902041

PROJECT NO. 728

(EPID: L-2020-TOP-0059)

1.0 BACKGROUND

By letter dated October 7, 2020 (Agencywide Documents Access and Management System Package Accession No. ML20290A661), Framatome, Inc. (Framatome) submitted for review and approval, Topical Report (TR) ANP-10349P, Revision 0, "GALILEO Implementation in LOCA [Loss-of-Coolant Accident] Methods" (Ref. 1). Framatome stated in part that TR ANP-10349P, Revision 0, describes the implementation of the fuel performance code GALILEO (Ref. 2) into Framatome pressurized water reactor (PWR) LOCA methods (Refs. 5 and 6), and is requesting an approval by October 2021.

Framatome Inc. currently has U. S Nuclear Regulatory Commission (NRC) approved TRs for small-break and large-break LOCA methodologies for Westinghouse (W) 3- and 4-loop designs and Combustion Engineering (CE) 2 x 4 designed PWR. Currently, the LOCA evaluation models for W and CE designed PWRs use S-RELAP5 as system thermal hydraulics code, that uses input from fuel performance code (FPC) such as COPENIC for Realistic Large Break LOCA (RLBLOCA) or RODEX2 for small break LOCA (SBLOCA) (Refs. 3 and 4). In ANP-10349P TR, Framatome seeks NRC staff approval to implement the approved GALILEO FPC in S-RELAP5 in the SBLOCA and RLBLOCA methodologies for W and CE design PWRs with recirculation (U-tube) steam generators, fuel assembly lengths of 14 feet or less, and emergency core cooling system (ECCS) injection to the cold legs.

In order to confirm the analyses and references supporting the requested licensing action, the staff of the NRC intend to virtually audit the listed documents related to fuel and cladding related areas related to implementation of GALILEO code and methodology in Framatome's LOCA analyses. Details of the regulatory audit plan follows.

2.0 REGULATORY AUDIT BASES

The regulatory audit is based on the TR, ANP-10349P, Revision 0. The format of the regulatory audit is based on the Office of Nuclear Reactor Regulation Office Instruction, LIC-111, "Regulatory Audits."

The NRC staff considered the following regulatory requirement during its review of the TR:

Title 10 of the *Code of Federal Regulations* (10 CFR) 50.46, "Acceptance Criteria for Emergency Core Cooling Systems for Light-Water Nuclear Power Reactors," paragraph (a)(1)(i) requires that light water reactors with uranium dioxide (UO₂) fuel within Zircaloy or ZIRLO cladding must be provided with an ECCS. The ECCS must be designed so that its calculated cooling performance following postulated LOCAs conforms to the criteria set forth in 10 CFR 50.46(b), such as:

- Peak cladding temperature shall not exceed 2200 degrees-Fahrenheit (°F)
- Maximum cladding oxidation of the cladding shall nowhere exceed 0.17 times the total cladding thickness before oxidation
- Maximum hydrogen generation shall not exceed 0.01 times the hypothetical amount that would be generated if all of the metal in the cladding cylinders surrounding the fuel, excluding the cladding surrounding the plenum volume, were to react
- Coolable geometry shall be such that the core remains amenable to cooling
- Long term core cooling shall be maintained and decay heat shall be removed for an extended period of time required by the long-lived radioactivity remaining in the core

3.0 REGULATORY AUDIT SCOPE

The focus of the audit will be the processes for the implementation of the GALILEO FPC in the SBLOCA and RLBLOCA methodologies for W and CE design PWRs as described in the ANP-10349P TR, specifically the following topics:

- GALILEO implementation in RLBLOCA evaluation model (GALILEO vs. COPENIC)
- GALILEO Implementation in SBLOCA evaluation model (GALILEO vs. RODEX2)
- FPC (GALILEO) model implementation in S-RELAP5
- Loss-of-Fluid Test (LOFT) Large-Break LOCA (LBLOCA) integral tests simulation details for LBLOCA and SBLOCA

4.0 INFORMATION NEEDS

1.
 - a) Details of the GALILEO implementation/coupling with S-RELAP5
 - b) Details of hybrid approach for achieving convergence- typical calculations
 - c) Does the hybrid approach produce more conservative results than conventional approach with COPENIC code
2. Details of GALILEO implementation in RLBLOCA evaluation model:
 - a) Alignment between Phenomena Identification and Ranking Table (PIRT) from the FPC and RLBLOCA evaluation model?

- b) Details of GALILEO uncertainties that are transferred to RLBLOCA analysis.
 - c) Justification to changes in PIRT from original RLBLOCA evaluation model.
- 3. Details of LOFT Large Break Tests:
 - a) Input model development
 - b) Steady-state and transient results; fidelity in the results
- 4. RLBLOCA Sample problem with GALILEO: Problem description, Analytical Methods, and Comparison of results using COPERNIC GALILEO.
- 5. Details of GALILEO implementation in the Small Break LOCA evaluation model:
 - a) Differences in coupling between RODEX2 and GALILEO with S-RELAP5
 - b) Changes in the SBLOCA evaluation model to accommodate GALILEO code
- 6. SBLOCA Sample problem with GALILEO: Problem description, Analytical Methods, and Comparison of results using RODEX2 and GALILEO.
- 7. Details of LOFT Small Break Tests:
 - a) Input model development
 - b) S-Relap5 code prediction from the listed LOFT tests
 - c) Comparison of results from RODEX2 and GALILEO

5.0 TEAM ASSIGNMENTS

The review team will consist of the following staff:

Mathew Panicker, NRC Technical reviewer (DSS/SFNB)

Ngola Otto (NRC Project Manager)

Robert Lukes, Chief, Nuclear Methods and fuel Analysis Branch (DSS/SFNB)

6.0 LOGISTICS

Audit Dates: February 10 – 12, 2021

Times: 9:00 a.m. – 3:00 p.m. Eastern Standard Time (EST)

The audit will begin with an entrance briefing at 9:00 a.m. EST on Wednesday, February 10, 2021. During the entrance briefing, Framatome is welcome to provide any overview presentations and address preliminary questions.

Framatome should provide details for using an online platform which supports video call for performing the audit (e.g., WebEx) or confirm that it is able to use the platform that can be provided by the NRC (i.e., Microsoft® Teams). As necessary, clarification calls will be requested regarding the documents under audit.

7.0 DELIVERABLES

A regulatory audit summary will be provided within 90 days of the completion of the audit. If necessary, requests for additional information on open audit issues will be completed after the closure of the audit.

8.0 REFERENCES

1. ANP-10349P Revision 0, "GALILEO Implementation in LOCA Methods," Framatome, Inc., October 2020.
2. ANP-10323P-A, Revision 1, "GALILEO Fuel Thermal-Mechanical Methodology for Pressurized Water Reactors," Framatome, Inc., December 2020.
3. BAW-10231 P-A, Revision 1, "COPERNIC Fuel Rod Design Computer Code," Framatome ANP, January 2004.
4. XN-NF-81-58PA, Revision 2, Supplements 1 and 2, RODEX2 Fuel Rod Thermal-Mechanical Response Evaluation Model, Exxon Nuclear Company, 1984.
5. EMF-2103(P)(A), Revision 3, Realistic Large Break LOCA Methodology for Pressurized Water Reactors, AREVA, June 2016.
6. EMF-2328(P)(A), Revision 0, Supplement 1 (P)(A), Revision 0, PWR Small Break LOCA Evaluation Model, S-RELAP5 Based, AREVA, December 2016.