ENCLOSURE 4:

Marked-up Copy – ANP-10349P, Draft Safety Evaluation – NON-PROPRIETARY

DRAFT SAFETY EVALUATION BY THE OFFICE OF NUCLEAR REACTOR REGULATION

FOR FRAMATOME, INC. TOPICAL REPORT ANP-10349P, REVISION 0,

"GALILEO IMPLEMENTATION IN LOCA METHODS"

PROJECT NO. 710; DOCKET NO. 99902041

(EPID: L-2020-TOP-0059)

1.0 INTRODUCTION

In ANP-10349P TR (Ref. 1), Framatome seeks NRC staff approval to implement the approved GALILEO fuel performance code (FPC) (Ref. 2) in S-RELAP5 in the small break Loss of Coolant Accident (SBLOCA) (Ref. 6) and Realistic Large Break LOCA (RLBLOCA) (Ref. 5) methodologies for Westinghouse and Combustion Engineering (CE) design Pressurized Water Reactors (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. Currently, the Loss of Coolant Accident (LOCA) evaluation models (EMs) for Westinghouse and CE designed PWRs use S-RELAP5 as system thermal hydraulics code, that uses input from FPC such as COPERNIC for realistic large-break LOCA (RLBLOCA) or RODEX2 for small-break LOCA (SBLOCA) (Refs. 3 and 4).

In order to confirm the analyses and references supporting any future licensing action, the NRC staff performed a virtual audit (Ref. 7) of the listed documents related to implementation of GALILEO code and methodology in Framatome's LOCA analyses on February 10-12, 2021. The audit generated a report (Ref. 8) and a list of requests for additional information (RAIs) (Ref. 9). Framatome, by letter dated April 23, 2021 (Ref. 10), responded to the RAIs.

The NRC staff has reviewed the TR, the response to the RAIs, and all the related documents. A safety evaluation (SE) for the TR follows.

2.0 REGULATORY EVALUATION

The NRC staff performed its review using the Standard Review Plan (SRP) for the Review of Safety Analysis Reports for Nuclear Power Plants: LWR Edition (NUREG-0800). Applicable chapters included Chapter 6.3, "Emergency Core Cooling System," and Chapter 15.6.5, "Loss of Coolant Accidents."

Chapter 6.3 of SRP provides guidance for performing reviews related to safety analysis regarding the ECCS for Boiling Water Reactors (BWRs) and PWRs. The specific areas include the requirements for 10 CFR 50.46, "Acceptance Criteria for ECCS for Light-water Nuclear Power Reactors," ECCS acceptance criteria and performing all the functions required by the design bases.

Chapter 15.6.5 of the SRP provides guidance for performing reviews of LOCA analyses for the spectrum of postulated pipe breaks within the reactor coolant pressure boundary.

These SRP chapters provide guidance to the NRC staff in performing the safety review of ANP-10349P, Revision 0. They describe methods or approaches that the NRC staff has found acceptable for meeting NRC requirements.

Additional requirements, which govern assumptions that must be employed in the ECCS evaluation, are contained in 10 CFR Part 50 Appendix A, "General Design Criteria for Nuclear Power Plants," General Design Criterion (GDC) 35, "Emergency Core Cooling," which states:

> A system to provide abundant emergency core cooling shall be provided. The system safety function shall be to transfer heat from the reactor core following any loss of reactor coolant at a rate such that: (1) fuel and clad damage that could interfere with continued effective core cooling is prevented and (2) clad metal-water reaction is limited to negligible amounts.
>
> Suitable redundancy in components and features, and suitable interconnections, leak detection, isolation, and isolation capabilities shall be provided to assure that for onsite electric power system operation (assuming offsite power is not available) and for offsite electric power system operation (assuming onsite power is not available) the system safety function can be accomplished, assuming a single failure.

3.0 TECHNICAL EVALUATION

This technical evaluation describes the NRC staff assessment of technical adequacy and regulatory compliance of the Framatome's process in replacing the COPERIC and RODEX2 FPCs with the NRC staff approved GALILEO (Ref. 2) in both RLBLOCA and SBLOCA evaluation models.

The NRC staff reviewed the analysis where the FPC COPERNIC is replaced with recently approved FPC GALILEO (Ref. 2) in the thermal hydraulics code, S-RELAP5. The NRC staff review included verification of original Phenomena Identification and Ranking Table (PIRT) phenomena inputs into the S-RELAP5 code coupled with GALILEO and compare the results from the S-RELAP5/GALILEO combination with the results from original S-RELAP5/COPERNIC combination for RLBLOCA calculations and also compare the results from the S-RELAP5/GALILEO combination for the SBLOCA calculations and compare the results from the S-RELAPP5/RODEX2 combination.

The NRC staff review also included the simulation of LOCA using the Loss of Fluid Test (LOFT) facility which is a scaled down version of a 4-loop Westinghouse PWR. The review included the verification of the reproducibility of LOFT for PWR LOCA, verification of inputs to LOFT test and review of the results from the LOFT test to examine whether the results conform with the previous LOFT experiments with RLBLOCA and SBLOCA. The NRC staff review also focused on Framatome's execution of sample problem for both RLBLOCA and SBLOCA. Framatome executed sample problem using a Westinghouse 3-loop design with dry atmospheric containment. The loop contains three reactor coolant pumps (RCPs), three U-tube steam generators, and a pressurizer. The sample problem analysis was reviewed by the NRC staff to determine whether the results conform with the applicable SRP guidelines and regulations mentioned in Section 2.0, "Regulatory Evaluation."

The technical evaluation consists of brief description of computer codes used in this TR (Section 3.1, "Computer Codes Relevant to Topical Report ANP-10349P"), review of how GALILEO code is implemented in S-RELAP5 and in RLBLOCA analysis (Sections 3.2, "GALILEO Implementation in S-RELAP5," and 3.3, "GALILEO Implementation in RLBLOCA EM"), LOFT experiments and analysis of results (Section 3.4, "Assessment of S-RELAP5/GALILEO Results from Integral LOFT Large Break Tests"), and sample problem and verification of results (Section 3.5, "RLBLOCA Sample PWR Problem with GALILEO"). Section 3.6, "GALILEO Implementation in the SBLOCA EM," of the SE describes how the Framatome used GALILEO in the SBLOCA analysis and review details of the results from LOFT tests and sample problems.

3.1 COMPUTER CODES RELEVANT TO TOPICAL REPORT ANP-10349P

S-RELAP5

NRC-approved S-RELAP5 evolved from Framatome's ANF-RELAP code which is a modified RELAP5/MOD2 used by Framatome for performing PWR plant licensing analyses including RLBLOCA and SBLOCA analyses, steam line break analysis, and PWR non-LOCA SRP Chapter 15 event analyses. The code structure of S-RELAP5 is modified to be essentially the same as that for RELAP5/MOD3, with the similar code portability features.

GALILEO

NRC-approved GALILEO is a best-estimate FPC that predicts the thermal-mechanical behavior of PWR fuel rods. ANP-10323 (GALILEO TR) (Ref. 2) presents a methodology for the realistic evaluation of the thermal-mechanical performance of fuel rods for PWRs. The GALILEO TR has two components. The first component is the best estimate fuel rod performance code GALILEO. The GALILEO code models the thermal-mechanical behavior of the fuel rods during normal operation and transient scenarios. The second component of the realistic thermal-mechanical fuel rod performance methodology is the application of the code for evaluating the behavior of rods under normal operation and transient conditions by providing initial conditions for the analyses.

3.2 GALILEO IMPLEMENTATION IN S-RELAP5

For each time step calculations in S-RELAP5, the fuel rod models are coupled with the FPC (GALILEO code) to recalculate fuel rod thermal properties. The coupling scheme used for GALILEO is [ ] Framatome, in response to an NRC-staff RAI (Ref. 10) describe [ ] The data exchange between GALILEO and S-RELAP5 [ ] The GALILEO FPC code coupled with S-RELAP5 uses [ ] In response to RAI 1.b, Framatome provided the results obtained from [ ] The NRC staff reviewed the details of the [ ] and the NRC staff determined that the fuel rod properties that are passed from GALILEO to S-REAP5 solved the Peak Cladding Temperature (PCT) and Maximum Local Oxidation (MLO) which are [ ] coupled calculations.

3.3 GALILEO IMPLEMENTATION IN THE RLBLOCA EM

This section describes how the NRC staff reviewed the process where GALILEO code is implemented in RLBLOCA analysis replacing the use of COPERNIC FPC with GALILEO. The PIRT process in Table 5-1, "Phenomena Identification and Ranking Table for PWR LBLOCA," of Reference 5, provides the application domain for RLBLOCA EM for prioritizing the importance of the LOCA associated phenomena. The NRC staff reviewed the selected PIRT parameters which are specific to the transients and the power plant type analyzed. The new FPC, GALILEO [ ] The supplemental RLBLOCA EM (ANP-10349P) with replaced GALILEO FPC [ ] This means that [ ] selected by Framatome as listed in Table 3-1, "Phenomena Identification and Ranking Table for EM Changes to PWR RLBLOCA," of Reference 1 [ ] The NRC staff checked the priority and validity of the PIRT parameters with the original PIRT parameters in the approved RLBLOCA methodology TR, EMF-2103-P-A Revision 3 (Ref. 5). The NRC staff verified the PIRT parameters which are the processes during a LOCA such as blowdown, refill and reflood and [ ] For all the fuel performance parameters that had been used in the GALILEO/RLBLOCA, the NRC staff confirmed that the corresponding applicable uncertainties have been used from the GALILEO methodology TR (Ref. 2).

The NRC staff verified these PIRT parameters and determined that they are in line with the PIRT parameters associated with the original PIRT parameters used in the approved RLBLOCA methodology TR, EMF-2103-P-A Revision 3.

3.4 ASSESSMENT OF S-RELAP5/GALILEO RESULTS FROM INTEGRAL LOFT LARGE BREAK TESTS

The LOFT tests were used to assess the base for the supplemental RLBLOCA EM (Ref. 1) and benchmark the results using the coupled S-RELAP5/GALILEO. The LOFT facility was designed by the NRC to simulate the nuclear and thermal-hydraulic phenomena that occurs in PWR during LBLOCA. It is a scaled down PWR facility designed to simulate the system response of a 4-loop Westinghouse PWR during a hypothetical LBLOCA (Figures 3-4, "Schematic View of the LOFT Test Facility," and 3-5, "LOFT Large Break Model Nodalization," of Ref. 1). The facility description, large break tests, and input development have been included in Section 3.6.1, "LOFT Large Break Tests L2-3, L2-5, LP-02-6 and LP-LB-1," of Reference 1. The NRC staff reviewed four different LOFT tests: L2-3, L2-5, LP-02-6 and LP-LB-1, inputs to these tests and the results obtained from these tests. These tests were repeated for this TR to compare the results of GALILEO/S-RELAP5 to COPERNIC/S-RELAP5 combination. Table 1 below shows conditions under which these tests were conducted.

Table 1: LOFT Tests and their Conditions

Test	Test Conditions	Test Results
L2-3	4-Loop PWR, Unpressurized nuclear fuel rods, Reactor power heat source, Double ended cold-leg guillotine break, test initiated at 75	Table 3-5, "Comparison of S-RELAP5 and LOFT L2-3 Steady-State Conditions," of Reference 1

	percent thermal power, 11.9 kilowatt-per foot (kW/ft) linear heat generation rate (LHGR)	S-RELAP5/GALILEO results agree with test results.
L2-5	Similar conditions as L2-3; 12.2 kW/ft LHGR	Table 3-8, "Comparison of S-RELAP5 and LOFT L2-5 Steady-State Conditions," of Reference 1 S-RELAP5/GALILEO results agree with test results.
L2-6	Pressurized nuclear fuel rods, minimum ECCS injection rates, maximum linear heat generation rate (MLHGR) is 14.9 kW/ft (Typical for 15x15 fuel array).	Table 3-11, "Comparison of S-RELAP5 and LOFT LP-02-6 Steady-State Conditions," S-RELAP5/GALILEO results agree with test results.
LP-LB01	Initiated from conditions representative of a PWR operating in its licensing limits, 50 megawatt thermal (MWt) with MLHGR of 15.8, Loss-of offsite power (LOOP), rapid RCP coastdown, minimum safeguards ECCS injection.	Table 3-14, "Comparison of S-RELAP5 and LOFT LP-LB-1 Steady-State Conditions," S-RELAP5/GALILEO results agree with test results.

As seen from Table 1, the LOFT tests were simulated with all possible combination of reactor conditions. The NRC staff reviewed the initial conditions used in each of the tests, event sequences for each of the tests, and the results as listed in Tables 3-5, 3-8, 3-11 and 3-14 of Reference 1. The NRC staff's review confirmed that Framatome used similar procedures for these tests as in the approved RLBLOCA EM and methodology TR (EMF-2103-P-A, Revision 3). The LP-LB01 test complies with GDC-35 since it requires that a system be designed to provide abundant core cooling with suitable redundancy such that the capability is maintained during LOOP.

For all of the above tests, the results from the S-RELAP5/GALILEO coupled method [ ] Therefore, the NRC staff determined that the replacement of COPERNIC FPC with GALILEO FPC in S-RELAP5 [ ] thereby confirming that the supplemental evaluation model is acceptable for LBLOCA analysis.

The NRC staff reviewed the Framatome's LOFT benchmarking of S-RELAP5 thermal hydraulics code with the NRC approved GALILEO FPC and confirmed that the parameters obtained from this benchmarking [ ]

The NRC staff reviewed the LOFT tests that were originally benchmarked using S-RELAP5 with the COPERNIC FPC as part of the RLBLOCA methodology development. The NRC staff reviewed the revised LOFT input models for the S-RELAP5 system code with both the GALILEO and the COPERNIC FPCs to provide a direct comparison. For each LOFT RLBLOCA test benchmarked the S-RELAP5 coupled with GALILEO FPCs [ ] The NRC staff reviewed the details of the benchmarking and LOFT results and determined that the Framatome's methodology to replace COPERNIC with GALILEO in RLBLOCA methodology is acceptable.

In summary, the NRC staff reviewed the LOFT tests, the test configuration and test results and determined that the S-RELAP5 benchmarking and LOFT RLBLOCA tests [ ]

3.5 RLBLOCA SAMPLE PWR PROBLEM WITH GALILEO

This section provides details of a sample problem performed by Framatome for RBLOCA analysis for a Westinghouse 3-loop PWR. This sample problem is similar to the sample problem presented in the approved RLBLOCA evaluation and methodology TR (Appendix B, EMF-2103-P-A, Revision 3) presented to provide representative solutions to the RLBLOCA evaluation. The sample problem uses Framatome fuel with M5 cladding and utilizes the GALILEO code for the fuel calculations with S-RELAP5 and additional rods added to the COPERNIC model. The generic plant is a Westinghouse 3-loop design with dry atmospheric containment, the loop contains three RCPs, three U-tube steam generators, and a pressurizer.

A typical calculation using S-RELAP5 begins with the establishment of a steady-state, initial condition with all loops intact. The input parameters and initial conditions for this steady-state calculation are chosen to reflect plant technical specifications or to match measured data. Following the establishment of an acceptable steady-state condition, the transient calculation is initiated by introducing a break into one of the loops. Table 3-19, "Technical Changes from the Approved RLBLOCA EM Included in the Sample Problem," of Reference 1 lists the technical changes from approved (COPERNIC) RLBLOCA EM in the sample problem. Table 3-20, "3-Loop Westinghouse - Plant Parameter Values and Ranges," of Reference 1 lists 3-loop Westinghouse plant physical parameter, plant operating conditions, and plant parameter values and ranges. Table 3-21, "3-Loop Westinghouse - Statistical Distributions Used for Process Parameters," of Reference 1 lists statistical distributions used for the process parameters such as, [ ]

[ ] were performed for the RLBLOCA sample problem. Table 2 below provides comparison of results for the limiting PCT GALILEO hot rod and the corresponding COPERNIC hot rod. The PCT and MLO shows that the ECCS acceptance criteria and GDC-35 for LOOP and metal-water reaction is confirmed. Table 3 below provides comparison of results from sample problem for the rod rupture calculations.

Table 2: Comparison of Results from Sample Problem (Ref. 1)

[ ]

Table 3: Comparison of Results from Sample Problem for the Rod Rupture

[ ]

The NRC staff reviewed the results from the sample problem for RLBLOCA for several parameters in the acceptance criteria for LBLOCA such as PCT, oxidation, hydrogen formation, and core cooling. Figure 3-52, "Comparison of GALILEO and COPERNIC PCT Independent of Elevation for Fresh UO_2 Rod – Case 018," of Reference 1 shows PCT independent of elevation and [ ] Figure 3-53, " Comparison of GALILEO and COPERNIC Peak Node Surface Temperature for Fresh UO2 Rod – Case 018," of Reference 1 compares the cladding temperature at the PCT node [ ] while Figure 3-54, "Comparison of GALILEO and COPERNIC Fuel Centerline Temperature for Fresh UO_2 Rod – Case 018," of Reference 1 compares the fuel centerline temperature at the same elevation. Figure 3-55, "Comparison of GALILEO and COPERNIC Rod Pressure for Fresh UO_2 Rod – Case 018," of Reference 1 compares the rod internal pressure (RIP). Comparisons for results are also made for burned UO_2 fuel and fresh fuel with Gadolinia (Gd_2O_3) for PCT, fuel centerline temperatures, and RIP. The cladding temperatures and fuel [ ]

The NRC staff reviewed the results from the sample problem and confirmed that the cladding temperatures, fuel centerline temperatures, and RIP [ ] This comparison of results from the sample problem demonstrates [ ] Therefore, the NRC staff has determined that the replacement of COERNIC with GALILEO code for RLBLOCA analysis for PWR is acceptable because [ ] Therefore, the NRC staff has determined that the replacement of COPERNIC FPC with GALILEO will ensure compliance with LBLOCA regulations, 10 CFR 50.46 and GDC 35 as wells as the guidance of applicable SRP Sections, SRP 6.3 for ECCS performance analysis.

3.6 GALILEO IMPLEMENTATION IN THE SBLOCA EM

This section details the processes by which the GALILEO code is implemented in SBLOCA analysis replacing the use of RODEX2 FPC. The EM requirements for approved SBLOCA are described in References 6 and 13. The postulated SBLOCA is defined as a break in the PWR primary coolant system pressure boundary having a break area equal to or less than 10 percent of the cross sectional area of the cold leg or vessel inlet pipes. The approved SBLOCA EM (Ref. 6 and Ref. 13) clad deformation and rupture model are specific to the cladding type but are implemented in S-RELAP5. The overall evaluation model remains the same, but the RODEX2 FPC is replaced with GALILEO.

The approved SBLOCA EM uses RODEX2 coupled with SRELAP5. The supplemental EM (ANP-10349P) replaces RODEX2 with the approved GALILEO code in SBLOCA analysis. The use of RODEX2 in the process is similar to the GALILEO implementation in S-RELAP5 described in Section 3.2 of this SE. The major difference [ ] described in Section 3.2 of this SE.

3.6.1 Assessment of GALILEO Implementation in SBLOCA Methodology

The evaluation model changes in supplemental SBLOCA methodology is described in Sections 4.4, "Assessment Data Base Summary," and 4.5, "Evaluation Model Description," of Reference 1 and supplemented by the response to RAI 2. The NRC staff reviewed the information provided in the TR and RAI response as summarize in this section. The SBLOCA analysis consists of a series of break spectrum, delayed RCP trip, attached piped breaks, and sensitivity calculations. The flow of calculation is identical to the evaluation model using RODEX2 but using GALILEO. One exception is [ ] The rest of the calculation is consistent with the base methodology in References 6 and 13. Calculation flow includes three steps:

- An initialization calculation with GALILEO
- S-RELAP5 calculation for overall thermal-hydraulic response of the system
- Additional sensitivity calculations

RODEX2-2A/GALILEO calculations are used to set up the initial conditions for the S-RELAP5 calculations. The break spectrum calculations are performed [ ] For plans with [ ] As part of the implementation of the GALILEO FPC, a [ ]

NRC staff reviewed Framatome's technical evaluation of the cladding thermal response during an SBLOCA transient performed as part of the implementation of the GALILEO fuel rod code. The cladding thermal response was found affected [ ] Sensitivity studies were initiated for SBLOCA using the input model. The NRC staff reviewed the sensitivity studies performed by Framatome described in the TR, in the response to RAIs as well as in the audited documents [ ]

Framatome in a response to RAI 2b provided similarity between the replacement of COPERNIC and RODEX2 with GALILEO in SBLOCA and RLBLOCA, respectively. Both RODEX2 and GALILEO [ ] The NRC staff reviewed the processes and determined that the differences in the S-RELAP5 integration between RODEX2 and GALILEO consist [ ] For RODEX2, [ ] in S-RELAP5/RODEX2. The NRC staff reviewed the entire process of what was done for the SBLOCA and determined that the key input parameters listed in Table 4-4, "GALILEO Key Input Parameters for SBLOCA," of Reference 1 and the fuel design data have been incorporated in to the SBLOCA evaluation model [ ]

3.6.2 S-RELAP5 SBLOCA Model of LOFT Facility (L3-6, L8-1)

The NRC staff reviewed the process by which the Framatome benchmarked the S-RELAP5 code against the LOFT L3-8 and L8-1 tests to justify the S-RELAP5 physical models and modeling techniques to SBLOCAs with the RCPs running. This test simulates a 2.5 percent small break (4 inch equivalent) in the cold leg of a large PWR. During the test, the accumulators, and Low Pressure Injection System (LPIS) were not activated. The High Pressure Injection System (HPIS) provides safety injection (SI) into the downcomer. The S-RELAP5 benchmark analysis performed by Framatome demonstrated the code's ability to accurately simulate the overall system response following a 4-inch diameter SBLOCA event in the cold leg with the primary coolant pump running during the blowdown phase.

Table 4-2, "Initial Conditions for Test LOFT L3-6," of Reference 1 compares the S-RELAP5 calculated initial conditions for L3-6 test using either GALILEO or RODEX2 as the FPC with the conditions reached during the experiment. Details of the L3-6 test is provided in Section 4.6.1, "LOFT Small Break Tests L3-6 and LB-1," of Reference 1. The NRC staff has reviewed the documents including those documents during the audit (Ref. 10) and determined that the results from the LOFT tests and their analysis results using GALILEO [ ] and the experiments have validated the use of GALILEO as the FPC in the SBLOCA EM. NRC staff finds that S-RELAP5 adequately captures the phenomena experienced during the LOFT L3-6 and L8-1 test sequence. The use of GALILEO as the fuel performance code [ ]

3.6.3 SBLOCA Sample Problem with GALILEO

The NRC staff reviewed a sample problem that simulates the SBLOCA analysis for a CE 2x4-loop PWR. This sample problem provides a comparative evaluation of a representative solution to the SBLOCA evaluation using the approved EM with RODEX2 and the supplemental EM using GALILEO. This sample problem simulates a representative core operating power and peaking factors similar or higher than found in the current operating fleet. The sample problem uses Framatome fuel with M5 cladding and utilizes the GALILEO code for fuel calculations within S-RELAP5. The sample problem plant is a CE 2x4-loop design with [ ]

The NRC staff reviewed the inputs, event sequence used in the sample problem and the results obtained from the sample problem. Table 4-6, "SBLOCA Sample Problem Design Inputs," of

Reference 1 lists the inputs to the sample problem for the generic power plant. Table 4 below lists a comparison of results of limiting break size from GALILEO and RODEX2.

Table 4: Comparison of Results for the Limiting Break Size from Sample Problem

[ ]

The NRC staff reviewed the results presented in the TR. Figure 4-15, "Comparison of GALILEO and RODEX2 PCT Results," of Reference 1 illustrates the results from the entire spectrum of breaks. Figure 4-16, "Comparison of GALILEO and RODEX2 MLO Results," of Reference 1 illustrates the calculated results for the MLO from the two FPCs and it indicates that [ ] Figure 4-17, "Comparison of GALILEO and RODEX2 PCT Independent of Elevation – [ ] " of Reference 1 compares the PCT independent of elevation. Figure 4-19, "Comparison of GALILEO and RODEX2 Fuel Centerline Temperature – [ ] " of Reference 1 compares the fuel centerline temperature at the same location. The cladding temperatures [ ]

The NRC staff verified the transient results from the sample problem with the original SBLOCA methodology. The transient results from comparing GALILEO and RODEX2 results of SBLOCA EM show that [ ] as implemented in the SBLOCA EMF-2328 EM (Refs. 6 and 13). The NRC staff confirmed that [ ] These results demonstrate that [ ]

The NRC staff reviewed the results as presented in Reference 1 and the documents during audit and determined that the use of GALILEO instead of RODEX2 for SBLOCA EM is acceptable based on the behavior of SBLOCA parameters as prescribed in its acceptance criteria. The NRC staff determined that the SBLOCA EM with GALILEO continues to comply with 10 CFR 50.46 acceptance criteria and the guidance as prescribed by SRP 6.3 for ECCS performance analysis.

Comparison of SBLOCA Results Using RODEX2 and GALILEO

The NRC staff reviewed the results as presented in Reference 1 and the documents during audit and determined that the use of GALILEO instead of RODEX2 for SBLOCA EM is an acceptable based on the behavior of SBLOCA parameters as prescribed in its acceptance criteria. The NRC staff determined that the SBLOCA EM with GALILEO continues to comply with 10 CFR 50.46 acceptance criteria and the guidance as prescribed by SRP 6.3 for ECCS performance analysis.

4.0 LIMITATIONS AND CONDITIONS

The NRC staff is specifying the following limitation on the approval of ANP-10349P.

> Framatome shall publish the accepted version of ANP-10349P as a supplemental document to the approved final versions of both RLBLOCA TR (EMF-2103) and SBLOCA TR (EMF-2328).

5.0 CONCLUSION

ANP-10349P describes the implementation of the GALILEO FPC in the SBLOCA and RLBLOCA methodologies for Westinghouse and CE PWR designs. This TR supplements the approved EMs and presents the implementation of the GALILEO FPC in S-RELAP5 and the LOCA EMs applicable to Westinghouse and CE plant designs. The NRC staff reviewed the results from the supplemental evaluation model (ANP-10349P) for both RLBLOCA and SBLOCA in which Framatome replaced the COPERNIC FPC and RODEX2 FPC with GALILEO FPC along with the respective LOFT test results and the sample problems. The NRC staff determined that GALILEO FPC is an acceptable replacement for COPERNIC FPC for RLBLOCA EM, and GALILEO FPC code is an acceptable replacement for RODEX2 FPC for SBLOCA EM. This determination is based on confirmatory benchmark calculations using LOFTs and sample problems for both RLBLOCA and SBLOCA. The LOFT tests and sample problems [ ]

The NRC staff has also determined that the RLBLOCA and SBLOCA supplemental evaluation models (ANP-10349) satisfies the guidance in SRP sections 6.3, 15.6.5, and requirements in GDC 35 for 1) peak cladding temperatures, 2) maximum oxidation, 3) maximum hydrogen generation, 4) coolable geometry, 5) long term cooling, and 6) decay heat removal. The LOFT test involves input with LOOP, thereby complying with GDC 35 requirement.

The NRC staff confirmed that the results from the RLBLOCA and SBLOCA supplemental evaluation models (ANP-10349) are reasonable and sufficiently close between each other. Therefore, the staff has determined that the supplemental evaluation model is acceptable for licensing application subject to the limitation condition specified in Section 4.0 of this SE.

6.0 REFERENCES

1. Submittal of ANP-10349P, Revision 0, "GALLEO Implementation in LOCA Methods," Framatome, Inc., October 2020 (ADAMS Package Accession No. ML20290A661).

2. Publication of ANP-10323(P)(A), Revision 1, "GALILEO Fuel Thermal-Mechanical Methodology for Pressurized Water Reactors," Framatome, Inc., December 2020 (ADAMS Package Accession No. ML21005A028).

3. BAW-10231-P-A, Revision 1, "COPERNIC Fuel Rod Design Computer Code," Framatome ANP, January 2004 (ADAMS Package Accession No. ML042930233).

4. XN-NF-81-58(P)(A), 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, September 2016 (ADAMS Package Accession No. ML16286A579).

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 (ADAMS Package Accession No. ML16356A396).

7. US NRC Letter from Dennis Morey to Gary Peters (Framatome), "February 10 - 12, 2021, Regulatory Audit Plan for Framatome INC. Topical Report, ANP-10349P, Revision 0, 'GALILEO Implementation in LOCA Methods,'" February 10, 2021 (ADAMS Package Accession No. ML21035A067).

8. USNRC Regulatory audit report for ANP-10349P, "GALILEO Implementation in LOCA Methods" (ADAMS Accession No. ML21070A314).

9. USNRC Letter from Ngola Otto to Gary Peters, "Request for Additional Information Regarding Framatome Topical Report, ANP-10349P, Revision 0, "GALILEO Implementation in in LOCA Methods" March 23, 2021 (ADAMS Package Accession No.ML21070A309).

10. Letter NRC:21:014 from Gary Peters (Framatome) to USNRC, "Response to Request for Additional Information Regarding ANP-10349P Revision 0, "GALILEO Implementation in LOCA Methods," April 23, 2021 (ADAMS Package Accession No. ML21119A140).

11. J. V. Cathcart and R.E. Pawel, Zirconium Metal-Water Oxidation Kinetics: IV. Reaction Rate Studies, ORNL/NUREG-17, August 1977 (ADAMS Accession No. ML052230079).

12. BAW-10227P Revision 2, "Evaluation of Advanced Cladding and Structural Material (M5) in PWR Reactor Fuel," Framatome, December 2019 (ADAMS Package Accession No. ML20003E125).

13. EMF-2328(P)(A), Revision 0, "PWR Small Break LOCA Evaluation Model, S-RELAP5 Based," March 2001 (ADAMS Package Accession No. ML011410426).

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