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December 19, 2022

U.S. Nuclear Regulatory Commission
Attention: Document Control Desk
Washington, D. C. 20555

Serial No.	22-362
NRA/SS	R0
Docket Nos.	50-336/423
	50-338/339
	50-280/281
License Nos.	DPR-65/NPF-49
	NPF-4/7
	DPR-32/37

**VIRGINIA ELECTRIC AND POWER COMPANY (DOMINION ENERGY VIRGINIA)
NORTH ANNA AND SURRY POWER STATIONS UNITS 1 AND 2
DOMINION ENERGY NUCLEAR CONNECTICUT, INC. (DENC)
MILLSTONE POWER STATION UNITS 2 AND 3
REQUEST FOR APPROVAL OF APPENDIX F OF FLEET REPORT DOM-NAF-2-P
QUALIFICATION OF THE FRAMATOME ORFEO-GAIA AND ORFEO-NMGRID CHF CORRELATIONS IN THE DOMINION ENERGY VIPRE-D COMPUTER CODE**

By letters dated September 30, 2004 and January 13, 2005 [Serial Nos. 04-606 (ADAMS Accession No. ML042800118) and 05-020 (ADAMS Accession No. ML050180257), respectively], Dominion Energy Virginia and DENC (collectively, Dominion Energy) submitted Topical Report DOM-NAF-2, "Reactor Core Thermal-Hydraulics Using the VIPRE-D Computer Code," and associated Appendices A and B, as supplemented by letters dated June 30 and September 8, 2005 [Serial Nos. 05-328 (ADAMS Accession No. ML051870070) and 05-020A (ADAMS Accession No. ML052510484), respectively] for NRC review and approval. NRC approval of DOM-NAF-2, including Appendices A and B, was obtained by letter dated April 4, 2006 (ADAMS Accession No. ML060790496) as revised by the NRC in a letter dated June 23, 2006 (ADAMS Accession No. ML061740212).

By letter dated April 4, 2008 [Serial No. 08-0174, (ADAMS Accession No. ML080980229)], Dominion Energy submitted Appendix C of DOM-NAF-2-A for NRC review and approval. NRC approval of Appendix C of DOM-NAF-2-A was obtained by letter dated April 22, 2009 (ADAMS Accession No. ML091030639). By letter dated August 28, 2009, as supplemented by letter dated November 20, 2009 [Serial Nos. 09-528 (ADAMS Accession No. ML092430338) and 09-528A (ADAMS Accession No. ML093310330), respectively], Dominion Energy requested approval of the removal of a restriction on the WRB-1 CHF correlation. NRC approval was obtained by letter dated June 21, 2010 (ADAMS Accession No. ML101620034). Dominion Energy provided the approved version of DOM-NAF-2, Rev. 0.2-P-A to the NRC by letter dated August 20, 2010 [Serial No. 10-486 (ADAMS Accession No. ML102390421)].

By letter dated June 26, 2013 [Serial No. 13-145 (ADAMS Accession No. ML13179A014)], Dominion Energy submitted Appendix D of DOM-NAF-2-A for NRC review and approval. NRC approval of Appendix D of DOM-NAF-2-A was obtained by letter dated August 12, 2014 [Serial No. 14-410 (ADAMS Accession No. ML14169A359)].

Finally, by letter dated February 11, 2021, and supplemented by letters dated May 13, 2021, September 15, 2021, and February 17, 2022 [Serial No. 21-042 (ADAMS Accession No. ML21042B321), Serial No. 21-042A (ADAMS Accession No. ML21133A285), Serial No. 21-042B (ADAMS Accession No. ML21259A085), and Serial No. 21-042D (ADAMS Accession No. ML22052A064), respectively], Dominion Energy submitted Appendix E of DOM-NAF-2-P for NRC review and approval. NRC approval of Appendix E of DOM-NAF-2-P-A was obtained by letter dated September 7, 2022 [Serial No. 22-290 (ADAMS Accession No. ML21320A007)].

Dominion Energy is hereby submitting Appendix F to Fleet Report DOM-NAF-2-P, "Qualification of the Framatome ORFEO-GAIA and ORFEO-NMGRID CHF Correlations in the Dominion Energy VIPRE-D Computer Code," for NRC review and approval.

Associated with this request for NRC approval of DOM-NAF-2-P, Appendix F, the following three documents are provided as Attachments 1, 2, and 3, respectively:

1. Appendix F to DOM-NAF-2-P, "Qualification of the Framatome ORFEO-GAIA and ORFEO-NMGRID CHF Correlations in the Dominion Energy VIPRE-D Computer Code" (**Proprietary**),

2. Appendix F to DOM-NAF-2-NP "Qualification of the Framatome ORFEO-GAIA and ORFEO-NMGRID CHF Correlations in the Dominion Energy VIPRE-D Computer Code" (Non-Proprietary), and

3. Framatome Affidavit for Withholding Proprietary Information from Public Disclosure.

Attachment 1 contains information proprietary to Framatome Inc. and is supported by an affidavit (Attachment 3) signed by Framatome, the owner of the information. The affidavit sets forth the basis on which the information may be withheld from public disclosure by the Commission and addresses with specificity the considerations listed in paragraph (b)(4) of Section 2.390 of the Commission's regulations. Accordingly, it is respectfully requested the proprietary information be withheld from public disclosure in accordance with 10 CFR 2.390.

Dominion Energy requests approval of the generic application of Appendix F to DOM-NAF-2-P. Plant specific applications of this Fleet Report, including applicable appendices, will be submitted to the NRC for review and approval in accordance with Section 2.1 of DOM-NAF-2-P-A.

If you have questions or require additional information, please contact Mr. Shayan Sinha at (804) 273-4687.

Respectfully,

James E. Holloway
Vice President – Nuclear Engineering and Fleet Support

Commitments made in this letter: None

Attachments:

1. Appendix F to DOM-NAF-2-P, "Qualification of the Framatome ORFEO-GAIA and ORFEO-NMGRID CHF Correlations in the Dominion Energy VIPRE-D Computer Code" (**Proprietary**),

2. Appendix F to DOM-NAF-2-NP "Qualification of the Framatome ORFEO-GAIA and ORFEO-NMGRID CHF Correlations in the Dominion Energy VIPRE-D Computer Code" (Non-Proprietary), and

3. Framatome Affidavit for Withholding Proprietary Information from Public Disclosure.

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Millstone Power Station

NRC Senior Resident Inspector
North Anna Power Station

NRC Senior Resident Inspector
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Attachment 2

APPENDIX F TO DOM-NAF-2-NP, "QUALIFICATION OF THE FRAMATOME ORFEO-GAIA AND ORFEO-NMGRID CHF CORRELATIONS IN THE DOMINION ENERGY VIPRE-D COMPUTER CODE" (NON-PROPRIETARY)

Virginia Electric and Power Company (Dominion Energy)
North Anna and Surry Power Stations Units 1 and 2

Dominion Energy Nuclear Connecticut, Inc. (DENC)
Millstone Power Station Units 2 and 3

Qualification of the Framatome ORFEO-GAIA and ORFEO-NMGRID CHF Correlations in the Dominion Energy VIPRE-D Computer Code

NUCLEAR ENGINEERING AND FUEL DEPARTMENT
DOMINION ENERGY
RICHMOND, VIRGINIA
November 2022

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CLASSIFICATION/DISCLAIMER

ABSTRACT

This appendix documents Dominion Energy’s benchmark and qualification of the Framatome ORFEO-GAIA and ORFEO-NMGRID Critical Heat Flux (CHF) correlations with the VIPRE-D code. The benchmark was performed using the same CHF experimental database used in the initial development and licensing of the correlations. This appendix summarizes the data evaluations that were performed to benchmark and qualify the VIPRE-D/ORFEO-GAIA and VIPRE-D/ORFEO-NMGRID code/correlation pairs, and to develop the corresponding DNBR design limits.

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ACRONYMS AND ABBREVIATIONS

ARC	Alliance Research Center
CEA	French Alternative Energies and Atomic Energy Commission's (*Commissariat à l'énergie atomique*)
CHF	Critical Heat Flux
DDL	Deterministic Design Limit
DNB	Departure from Nucleate Boiling
DNBR	Departure from Nucleate Boiling Ratio
GAIA	Framatome's PWR fuel assembly and grid design
HMP	HMP Grid Design
HTRF	Columbia University's Heat Transfer Research Facility
IGM	Intermediate GAIA Mixer (Grid)
KATHY	Karlstein Thermal-Hydraulic test facility
MDNBR	Minimum Departure from Nucleate Boiling
M/P	Ratio of Measured-to-Predicted CHF
MVG	Mixing Vane Grid
NMVG	Non-Mixing Vane Grid
OD	Outer Diameter
ORFEO	Framatome's CHF correlation form for PWR fuel assemblies
P/M	Ratio of Predicted-to-Measured CHF (equivalent to DNBR)
PWR	Pressurized Water Reactor
SER	Safety Evaluation Report
STDEV	Standard Deviation
USNRC	US Nuclear Regulatory Commission
W 17x17	Westinghouse type 17x17 fuel assembly design for PWRs

F.1 PURPOSE

The ORFEO-GAIA and ORFEO-NMGRID Critical Heat Flux (CHF) correlations were developed for predicting departure from nucleate boiling ratio (DNBR) margin in the mixing vane grid (MVG) and non-mixing vane grid (NMVG) region of a fuel assembly, respectively (Reference F.1). The first is a mixing grid correlation based on the CHF tests performed for grids with mixing vanes (GAIA structural grid and Intermediate GAIA Mixer (IGM) grid). This correlation is referred to as ORFEO-GAIA; it is applicable to fuel assemblies that are equipped with GAIA grids, with or without IGM grids. The second is a non-mixing grid correlation based on the CHF tests performed without mixing devices. This correlation is referred to as ORFEO-NMGRID; it is applicable to fuel assemblies equipped with non-mixing grids.

To be licensed for use, a CHF correlation must be tested against experimental data that span the anticipated range of conditions over which the correlation will be applied. Furthermore, the population statistics of the database must be used to establish a DNBR design limit such that the probability of avoiding departure from nucleate boiling (DNB) will be at least 95% at a 95% confidence level.

This appendix documents Dominion Energy's qualification of the ORFEO-GAIA and ORFEO-NMGRID correlations with the VIPRE-D code. This qualification of these correlations was performed against the same CHF experimental database used by Framatome to develop and license the correlations (Reference F.1). This appendix summarizes the data evaluations that were performed to qualify the VIPRE-D/ORFEO-GAIA and VIPRE-D/ORFEO-NMGRID code/correlation pairs, and to develop the corresponding DNBR design limits for the correlations.

F.2 APPLICABILITY

Dominion Energy intends to use the VIPRE-D/ORFEO-GAIA code/correlation pair for the analysis of Framatome 17x17 fuel assemblies in regions with mixing vane grids and mid-span mixing grids. When evaluating these types of fuels outside of the range of validity of the VIPRE-D/ORFEO-GAIA CHF correlation (i.e., non-mixing vane grid regions of the fuel assembly and at lower system pressures and mass flux), Dominion Energy intends to use the VIPRE-D/ORFEO-NMGRID code/correlation pair.

The VIPRE-D/ORFEO-GAIA and VIPRE-D/ORFEO-NMGRID applications discussed in this appendix are consistent with the generic intended applications listed in Section 2.0 of the main body of this report. Also, more specifically, Dominion Energy intends to use VIPRE-D/ORFEO-GAIA and VIPRE-D/ORFEO-NMGRID to analyze the transients delineated in Table 2.1-1 in Section 2.0 of the main body of this report. The qualification of the correlations with the VIPRE-D code has been performed following the modeling guidelines described in Section 4.0 of this report.

This Appendix is submitted to the USNRC for review and approval in order to meet the USNRC's Requirement #2 listed in the VIPRE-01 SER, as outlined in Section 2.2 in the main body of this report.

F.3 DESCRIPTION OF THE FRAMATOME ORFEO-GAIA AND ORFEO-NMGRID CHF CORRELATIONS

In pressurized water reactor (PWR) cores, the energy generated inside the fuel pellets leaves the fuel rods at their surface in the form of heat flux, which is removed by the reactor coolant system flow. The normal heat transfer regime in this configuration is nucleate boiling, which is very efficient. However, as the capacity of the coolant to accept heat from the fuel rod surface degrades, a continuous layer of steam (a film) starts to blanket the tube. This heat transfer regime, termed film boiling, is less efficient than nucleate boiling and can result in significant increases of the fuel rod temperature for the same heat flux. Since the increase in temperature may lead to the failure of the fuel rod cladding, PWRs are designed to operate in the nucleate boiling regime and protection against operation in film boiling must be provided.

The heat flux at which the steam film starts to form is called CHF or the point of DNB. For design purposes, the DNBR is used as an indicator of the margin to DNB. The DNBR is the ratio of the predicted CHF to the actual local heat flux under a given set of conditions. Thus, DNBR is a measure of the thermal margin to film boiling and its associated high fuel rod surface temperatures that may lead to the failure of the fuel rod cladding. The greater the DNBR value (above 1.0), the greater the thermal margin.

The CHF cannot be predicted from first principles, so it is empirically correlated as a function of the local thermal-hydraulic conditions, the geometry, and the power distribution measured in the experiments. Since a CHF correlation is an analytical fit to experimental data, it has an associated uncertainty, which is quantified in a Deterministic Design Limit (DDL), also referred to as the DNBR design limit. A calculated DNBR value greater than this design limit provides assurance that there is at least a 95% probability at the 95% confidence level that a departure from nucleate boiling event will not occur.

Framatome has developed ORFEO-GAIA and ORFEO-NMGRID CHF correlations (Reference F.1). The ORFEO-GAIA correlation applies to fuel assemblies with GAIA structural mixing vane grids and with or without IGMs. The ORFEO-NMGRID is applicable to fuel assemblies equipped with non-mixing grids, and is also applied conservatively to fuel assemblies equipped with GAIA grids, with or without IGM grids. This Appendix describes the CHF tests that provide the basis for the correlations, analyzes the performance of the correlation for each fuel type, and provides limits and ranges of applicability for their application.

The functional form of the ORFEO CHF correlation is the following (Reference F.1):

$$CHF = \frac{F_{BASE} \cdot F_{SPACER}}{FNU}$$

where:

F_{BASE} - CHF general representation term, based on local conditions, MW/m^2

F_{SPACER} - fuel design specific multiplier, based on grid specific designs

FNU - axial power factor, accounts for non-uniform axial power profiles

The F_{BASE} term incorporates the generic dependency on local thermal-hydraulic conditions (pressure, mass flux, effective quality) and burnout length (Z_{BO}). **[**

] The F_{SPACER} term incorporates the specific CHF dependency of the fuel assembly geometry and spacer grid design. The form of the F_{SPACER} term is the same for both correlations, ORFEO-GAIA and ORFEO-NMGRID; however, the coefficients are different. The ORFEO correlation form incorporates an axial power factor, *FNU* to describe the memory effects observed when comparing CHF test data based on uniform versus non-uniform axial power profiles. The axial power factor is based on Tong's formulation. The specific formulations for each one of these components, as well as the corresponding constants are Framatome proprietary and can be found in Reference F.1.

F.4 DESCRIPTION OF THE VIPRE-D/ORFEO-GAIA AND VIPRE-D/ORFEO-NMGRID DATABASES AND TEST ASSEMBLIES

This section lists the heat transfer facilities at which all CHF testing was conducted and provides a summary of the test series (cell type, heated length, grid spacing, etc.) used in the qualification of the VIPRE-D/ORFEO-GAIA and VIPRE-D/ORFEO-NMGRID code/correlation pairs.

Framatome developed the two CHF correlations discussed in this appendix based on the experimental data obtained at four facilities. The CHF tests identified with the prefix "K" in this report were performed in the KATHY loop, a test facility located in Karlstein, Germany. Tests performed at the Babcock and Wilcox's Alliance Research Center (ARC) test facility are identified with the prefix "AR". Tests performed at the Columbia University's Heat Transfer Research Facility (HTRF) are identified with the prefix "SI". This facility has been extensively used as a source of CHF test data for correlations approved by the USNRC. The test performed at CEA's OMEGA loop located in Grenoble, France is identified with the prefix "O". These facilities are discussed in more detail in Reference F.1.

[**]** test campaigns at the KATHY loop generated **[** **]** test points to support the development of the ORFEO-GAIA correlation. Table F.4-1 summarizes the key aspects of these campaigns which include guide tube and unit cell configurations, uniform, cosine and upskew power shapes, and various heated lengths. **[** **]** of the test campaigns included IGM grids.

[**]** test campaigns generated **[** **]** test points at each of the four facilities to support the development of the ORFEO-NMGRID correlation. Table F.4-2 summarizes the key aspects of these campaigns which include guide tube and unit cell configurations, uniform, cosine and upskew power shapes, and various heated lengths.

All of the test bundles are 5x5 sections. The guide tube tests include a non-heated rod in the center position.

Table F.4-1

ORFEO-GAIA CHF Test Series Parameters

[ ]

Notes for Table F.4-1:

[ ]

Table F.4-2

ORFEO-NMGRID CHF Test Series Parameters

Notes for Table F.4-2:

F.5 VIPRE-D/ORFEO-GAIA AND VIPRE-D/ORFEO-NMGRID BENCHMARKING AND QUALIFICATION RESULTS

Reference F.1 describes the mathematical model for each separate test section of the ORFEO Experimental Database by providing the bundle and cell geometry, the rod radial peaking values, the rod axial flux shapes, the spacer grid information and the thermocouple locations.

Each test section was modeled for analysis with the VIPRE-D thermal-hydraulic computer code as a full assembly model following the modeling methodology discussed in Section 4 in the main body of this report. For each set of bundle data, VIPRE-D produces the local thermal-hydraulic conditions (mass flux, thermodynamic quality, heat flux, etc.) at every axial node along the heated length of the test section. The ratio of measured-to-predicted CHF (M/P) is the variable that is normally used to evaluate the thermal-hydraulic performance of a code/correlation pair. The measured CHF is the local heat flux at a given location, while the predicted CHF is calculated by the code using the ORFEO-GAIA or ORFEO-NMGRID CHF correlation. The ratio of these two values provides the M/P ratio, which is the inverse of the DNBR ratio. M/P ratios are frequently used to validate CHF correlations instead of DNB ratios, because their distribution is usually a normal distribution, which simplifies their manipulation and statistical analysis.

One-sided tolerance theory (Reference F.2) is used for the calculation of the VIPRE-D/ORFEO-GAIA DNBR design limit and VIPRE-D/ORFEO-NMGRID DNBR design limit. This theory allows the calculation of a DNBR limit so that, for a DNBR equal to the design limit, DNB will be avoided with 95% probability at a 95% confidence level.

The general methodology applied to determine a one-sided 95/95 DNBR limit for the application of the ORFEO-GAIA and ORFEO-NMGRID correlations is as follows. First normality tests are performed on the entire database as well as individual groupings such as subchannel type and axial power profile type. The normality test used is the D' test. The individual groupings are next evaluated in an equal means, or poolability, assessment. The poolability test employed, regardless of normality, is known as the t-test assuming unequal variances. Each grouping in the complete database must be determined to be poolable before the entire ORFEO-GAIA or ORFEO-NMGRID data set can be treated as a single population. Depending on the result of the normality tests for each non-poolable population, a parametric DDL is calculated if the population is normally distributed, while a non-parametric limit is determined if the population is not normally distributed. The largest, most conservative limit is then considered as the ORFEO-GAIA or ORFEO-NMGRID DDL.

Sections F.5.1 and F.5.2 summarize the results, descriptive statistics, and DDL of the Experimental Databases for the VIPRE-D/ORFEO-GAIA and VIPRE-D/ORFEO-NMGRID code/correlation pairs, respectively. The Experimental Database for ORFEO-GAIA is defined as the **[ ]** test series described in Reference F.1 and summarized in Table F.4-1 above. The Experimental Database for ORFEO-NMGRID is defined as the **[ ]** test series described in Reference F.1 and summarized in Table F.4-2 above.

F.5.1 VIPRE-D/ORFEO-GAIA EXPERIMENTAL DATABASE RESULTS AND DETERMINISTIC DESIGN LIMIT

This section summarizes the VIPRE-D results for the Experimental Database described in Reference F.1 using the ORFEO-GAIA CHF correlation. This section also provides the VIPRE-D overall statistics for the ORFEO-GAIA experimental tests and generates the DDL for the VIPRE-D/ORFEO-GAIA Experimental Database code/correlation pair.

The ORFEO-GAIA correlation was developed by Framatome by correlating the CHF experimental results obtained in the tests as described in Reference F.1. Framatome used these test data to calculate a design limit of 1.12 for the ORFEO-GAIA correlation (Reference F.1). Dominion Energy used these experimental data to develop the DDL for the VIPRE-D/ORFEO-GAIA code/correlation pair. Table F.5.1-1 summarizes the relevant statistics of each test for the ORFEO-GAIA Experimental Database. The DNB results used to determine the limit were the minimum values predicted by the code versus pulling results that correspond to the measured location listed in Reference F.1. **[ ]** statepoints from the **[ ]** statepoints generated at the KATHY loop are not included in this table because they were determined to have **[ ]**. This is consistent with Framatome's approach in Reference F.1.

Table F.5.1-1

Summary of VIPRE-D/ORFEO-GAIA Experimental Database Results

[ ]

Normality and Poolability Evaluation

Normality is evaluated using the D' test at 5% significance level on the overall ORFEO-GAIA population and on the following subgroup populations: GAIA grid, GAIA and IGM grids, unit cell, guide tube cell, uniform power profile, and non-uniform power profile. Only the unit cell subgroup passed the D' test. The entire ORFEO-GAIA and all groups other than the unit cell population did not pass the D' test. A summary of the normality tests is provided in Table F.5.1-2. Figure F.5.1-1 is a histogram of the ORFEO-GAIA dataset with an overlay of a normal distribution (with the same mean and standard deviation as the ORFEO-GAIA data). Figure F.5.1-1 shows the overall ORFEO-GAIA population has a greater kurtosis than a normal distribution. Therefore, application of one-sided theory will give a conservative value for the DNBR limit calculation.

The equality of means is evaluated for each subgroup using a t-test assuming unequal variances. The t-test is performed at a 5% significance level. Table F.5.1-3 provides the subgroup statistics. This table provides mean and standard deviation values of the M/P population based on grid, cell type and axial power profile type. Table F.5.1-4 provides the results of the t-tests. The t-tests for grid type and cell type both passed and are concluded to be poolable. The t-test for the axial power profile failed, indicating that the uniform and non-uniform data are not poolable.

Table F.5.1-2

Summary of VIPRE-D/ORFEO-GAIA Normality Test Results

[ ]

Table F.5.1-3

Summary of VIPRE-D/ORFEO-GAIA Subgroup Statistics

Grid Type	No. of Statepoints	Average M/P	Standard Deviation
GAIA			
GAIA + IGM			
Cell Type	**No. of Statepoints**	**Average M/P**	**Standard Deviation**
Guide Tube			
Unit			
Axial Power Profile	**No. of Statepoints**	**Average M/P**	**Standard Deviation**
Uniform			
Non-Uniform			

Table F.5.1-4

Summary of VIPRE-D/ORFEO-GAIA t-Test Results for Subgroups

Subgroup	t-Statistic	t-Critical (2 tail)	Pass/Fail
Grid Type	-0.54	1.97	Pass
Cell Type	0.47	1.96	Pass
Axial Power Profile	-2.45	1.96	Fail

Figure F.5.1-1
ORFEO-GAIA Data Set Histogram

DNBR Design Limit

Per the results of the normality and t-tests above, several potential limits are calculated, and the most conservative limit is selected for the VIPRE-D/ORFEO-GAIA code/correlation pair. Each limit is calculated for a 95% probability at a 95% confidence level. A one-sided parametric limit is determined for the entire ORFEO-GAIA population despite the population being non-normal. The Grid and Cell groups are poolable and no separate limits are required. Separate limits are determined for uniform and non-uniform power shape subgroups using non-parametric methods because the subgroups are non-normal and not poolable. The most limiting results for both a parametric and non-parametric design limits are presented below.

Parametric Design Limit

The parametric DDL for the entire ORFEO-GAIA population is calculated in accordance with one-sided tolerance theory for a normal distribution using Owen's factors obtained from Reference F.2. The DNBR design limit is calculated using Equation F.5.1.1.

$$DNBR_L = \frac{1.0}{M/P - K_{N,C,P} \cdot \sigma_{M/P}} \qquad \text{[F.5.1.1]}$$

where

M/P = average measured to predicted CHF ratio

$\sigma_{M/P}$ = standard deviation of the measured to predicted CHF ratios of the database

$K_{N,C,P}$ = one-sided tolerance factor based on N degrees of freedom, C confidence level, and P portion of the population protected. This number can be obtained from Reference F.2.

Normally, the number of degrees of freedom would be the total number of datapoints minus one. However, because Framatome used test data to correlate the **[ ]** (Section 6 of Reference F.1) constants and coefficients that appear in the ORFEO-GAIA correlation, the total number of degrees of freedom must be corrected. The constants and coefficients considered include those listed in Reference F.1 Tables 6-1, 6-2, and 6-6, as well as X_1, X_2, C_{damp}, d_0, and d_1, which are included in the F_{BASE} term (Reference F.1, Pages 6-10 and 6-11). Of the **[ ]** constants and coefficients appearing in the ORFEO-GAIA correlation, one coefficient in the F_{SPACER} term is zero. Only the total number of non-zero constants and coefficients **[ ]** is considered when deriving the number of degrees of freedom. In addition, the standard deviation of the database needs to be corrected accordingly to account for this reduced number of degrees of freedom:

$$N = n - 1 - \textbf{[\quad]}$$
$$\sigma_N = \sigma_{M/P} \cdot [(n-1)/N]^{1/2} \qquad \text{[F.5.1.2]}$$

The 'N' value, corrected to include the **[ ]** constants and coefficients in the ORFEO-GAIA correlation, is then used to calculate an appropriate one-sided tolerance factor ($K_{N,C,P}$). The corrected 'N' value is also used to calculate a corrected standard deviation, σ_N. The new values of σ_N and $K_{N,C,P}$ are then used in Equation F.5.1.1, alongside the average M/P value of the database, to calculate the corrected DNBR design limit.

The parametric DNBR design limit for the VIPRE-D/ORFEO-GAIA is calculated as shown in Table F.5.1-5. A preliminary design limit of 1.095 is calculated using a standard deviation of **[ ]** and a corrected standard deviation of **[ ]**. Tables F.5.1-6, F.5.1-7, and F.5.1-8 show **[ ]** statepoints with M/P values lower than the inverse of 1.095 for subregions within the pressure, mass flux, and equilibrium quality ranges. The majority of those statepoints are in subregions of **[**

]. Consistent with Framatome's approach in Reference F.1, a "bounding standard deviation" is defined as the largest standard deviation of any subregion of the database including those that are potentially non-conservative, thereby ensuring potentially non-conservative subregions are adequately protected. This "bounding standard deviation" is defined as **[ ]** and corresponds to the subregion of **[**
]. This bounding standard deviation is used to recalculate a parametric design limit of 1.117 in Table F.5.1-5 for the VIPRE-D/ORFEO-GAIA population. The application of the bounding standard deviation increases the design limit by ~2%. Tables F.5.1-6, F.5.1-7 and F.5.1-8 show **[ ]** statepoints with M/P values lower than the inverse of the design limit of 1.117.

<u>Non-Parametric (Distribution Free) Limit</u>

The non-parametric method described in Reference F.4 requires the ranking of all M/P values in ascending order for the population being considered. Table A-31 of Reference F.4 gives the largest value of 'm' such that we can state with at least 95% certainty that 95% of a population lies above the m^{th} smallest of a random sample of 'n' from that population. The most conservative non-parametric DNBR limit is determined using the Uniform Power Shape Population. Table A-31 of Reference F.4 determines the rank of the value from the sorted M/Ps to be used to determine the design limit is **[ ]** for **[ ]** samples. The **[ ]** smallest M/P value is 0.89475. The inverse (1.118) is the non-parametric limit for the VIPRE-D/ORFEO-GAIA code/correlation pair. Table F.5.1-9 provides a summary of the calculation of the non-parametric DNBR design limit for the VIPRE-D/ORFEO-GAIA.

<u>Deterministic Design Limit (DDL)</u>

The DDL for the VIPRE-D/ORFEO-GAIA code/correlation pair is the limiting DNBR limit of the parametric and non-parametric limits rounded up. The non-parametric analysis of the uniform power shape population results in the most conservative DNB limit of 1.118, which is slightly larger than the parametric limit of 1.117. The limit of 1.118 is rounded up to 1.12. In accordance with Reference F.1, a bias of 0.01 is added to the DNBR limit to account for geometric variations between the test sections and the production fuel assembly. Thus, the DDL for VIPRE-D/ORFEO-GAIA code/correlation pair is 1.13.

Figures F.5.1-2 through F.5.1-5 display the performance of the Measured CHF versus Predicted CHF and the distributions of M/P as a function of the pressure, mass flux and quality. These plots show that there are no biases in the M/P ratio distribution, and that the performance of the ORFEO-GAIA CHF correlation is independent of the three variables of interest. The plots show a mostly uniform scatter of the data and no obvious trends or slopes.

Table F.5.1-10 summarizes the ranges of validity for the VIPRE-D/ORFEO-GAIA code/correlation pair as defined by the Experimental Database. These ranges are identical to those submitted by Framatome and approved by the USNRC (Reference F.1).

Table F.5.1-5

VIPRE-D/ORFEO-GAIA Parametric Design Limit For ORFEO-GAIA Population

Datapoints	n		[
Degrees of Freedom	N	= n – 1– **[ ]**	
Average M/P	M/P		
Standard Deviation of M/P	$\sigma_{M/P}$		
Corrected Standard Deviation	σ_N	$= \sigma_{M/P} * [(n-1)/N]^{1/2}$	
Owen's Factor	K(N,0.95,0.95)	Reference F.2	]
Raw Design Limit	$DNBR_{raw}$		1.095
Bounding Standard Deviation	$\sigma_{bounding}$	M/P standard deviation for pressures > 17 MPa	[
Adjusted Bounding Standard Deviation	$\sigma_{bounding\ adjusted}$	$= \sigma_{bounding} * [(n-1) / N]^{1/2}$	
Owen's Factor	K(N,0.95,0.95)	Reference F.2	]
Parametric Design Limit	$DNBR_{para}$		1.117

Table F.5.1-6

VIPRE-D/ORFEO-GAIA M/P Distribution by Pressure Ranges

[ ]

Table F.5.1-7

VIPRE-D/ORFEO-GAIA M/P Distribution by Mass Flux Ranges

[ ]

Table F.5.1-8

VIPRE-D/ORFEO-GAIA M/P Distribution by Qualities Ranges

[ ]

Table F.5.1-9

VIPRE-D/ORFEO-GAIA Non-Parametric Design Limit For ORFEO-GAIA Population

Group Name	Population Size	m	m^{th} smallest M/P	Non-Parametric DNBR Limit
Uniform Power Shape Population	[	]	0.89475	1.118

Table F.5.1-10

Range of Validity for the VIPRE-D/ORFEO-GAIA

Parameter	**Units**	**Minimum Value**	**Maximum Value**
Pressure	psia	1446.0	2530.9
Mass Flux	Mlbm/hr-ft^2	0.5012	3.1878
Equilibrium Quality	fraction	---	0.7992

Figure F.5.1-2

Measured CHF vs. Predicted CHF for VIPRE-D/ORFEO-GAIA Database

[ ]

Figure F.5.1-3

M/P vs. Pressure for VIPRE-D/ORFEO-GAIA Database

Figure F.5.1-4

M/P vs. Mass Flux for VIPRE-D/ORFEO-GAIA Database

[ ]

Figure F.5.1-5

M/P vs. Quality for VIPRE-D/ORFEO-GAIA Database

F.5.2 VIPRE-D/ORFEO-NMGRID EXPERIMENTAL DATABASE RESULTS AND DETERMINISTIC DESIGN LIMIT

This section summarizes the VIPRE-D results for the Experimental Database described in Reference F.1 using the ORFEO-NMGRID CHF correlation. This section also provides the VIPRE-D overall statistics for the ORFEO-NMGRID experimental tests and generates the DDL for the VIPRE-D/ORFEO-NMGRID code/correlation pair.

The ORFEO-NMGRID correlation was developed by Framatome by correlating the CHF experimental results obtained in the tests as described in Reference F.1. Framatome used these test data to calculate a design limit of 1.15 for the ORFEO-NMGRID correlation (Reference F.1). Dominion Energy used these experimental data to develop the VIPRE-D/ORFEO-NMGRID code/correlation pair DDL. Table F.5.2-1 summarizes the relevant statistics of each test for the ORFEO-NMGRID Experimental Database. The DNB results used to determine the limit were the minimum values predicted by the code versus pulling results that correspond to the measured location listed in Reference F.1.

Table F.5.2-1

Summary of VIPRE-D/ORFEO-NMGRID Experimental Database Results

Normality and Poolability Evaluation

Normality is evaluated using the D' test at 5% significance level on the overall ORFEO-NMGRID population and on the following subgroup populations: unit cell and guide tube cell, and uniform power profile and non-uniform power profile. The subgroups consisting of the guide tube cell, uniform power profile, and non-uniform power profile populations passed the D' test. However, both the entire ORFEO-NMGRID and the unit cell populations did not pass the D' test. A summary of the normality tests is provided in Table F.5.2-2. Figure F.5.2-1 is a histogram of the ORFEO-NMGRID dataset with an overlay of a normal distribution (with the same mean and standard deviation as the ORFEO-NMGRID data). Figure F.5.2-1 shows the overall ORFEO-NMGRID population has a greater kurtosis than a normal distribution. Therefore, application of one-sided theory will give a conservative value for the DNBR limit calculation.

The equality of means is evaluated for each subgroup using a t-test assuming unequal variances. The t-test is performed at a 5% significance level. Table F.5.2-3 provides the subgroup statistics. This table provides mean and standard deviation values of the M/P population based on cell type and axial power profile type. Table F.5.2-4 provides the results of the t-tests. The t-tests for both subgroups fail, indicating that the guide tube cell and unit cell data are not poolable and the uniform and non-uniform data are not poolable.

Table F.5.2-2

Summary of VIPRE-D/ORFEO-NMGRID Normality Test Results

Table F.5.2-3

Summary of VIPRE-D/ORFEO-NMGRID Subgroup Statistics

Cell Type	**No. of Statepoints**	**Average M/P**	**Standard Deviation**
Guide Tube			
Unit			
Axial Power Profile	**No. of Statepoints**	**Average M/P**	**Standard Deviation**
Uniform			
Non-Uniform			

Table F.5.2-4

Summary of VIPRE-D/ORFEO-NMGRID t-Test Results for Subgroup

Subgroup	**t-Statistic**	**t-Critical (2 tail)**	**Pass/Fail**
Cell type	-3.8077	1.9624	Fail
Axial Power Profile	-8.0734	1.9636	Fail

Figure F.5.2-1
ORFEO-NMGRID Data Set Histogram

DNBR Design Limit

Per the results of the normality and t-tests above, several potential limits are calculated and the most conservative limit is selected for the VIPRE-D/ORFEO-NMGRID code/correlation pair. Each limit is calculated for a 95% probability at a 95% confidence level. A one-sided parametric limit is determined for the entire ORFEO-NMGRID population despite the population being non-normal. None of the analyzed subgroups are poolable. A DNBR limit is determined for each subgroup with the type of limit, parametric or non-parametric, being dependent by whether the subgroup was determined to be normal or non-normal. The most limiting results for both the parametric and non-parametric design limits are presented below.

Parametric Design Limit

The parametric DDL is calculated in accordance with one-sided tolerance theory for a normal distribution using Owen's factors obtained from Reference F.2. The most conservative parametric DNBR limit is determined using the ORFEO-NMGRID population. The DNBR design limit is calculated using Equation F.5.2.1.

$$DNBR_L = \frac{1.0}{M/P - K_{N,C,P} \cdot \sigma_{M/P}} \quad \text{[F.5.2.1]}$$

where

- M/P = average measured to predicted CHF ratio
- $\sigma_{M/P}$ = standard deviation of the measured to predicted CHF ratios of the database
- $K_{N,C,P}$ = one-sided tolerance factor based on N degrees of freedom, C confidence level, and P portion of the population protected. This number can be obtained from Reference F.2.

Normally, the number of degrees of freedom would be the total number of datapoints minus one. However, because Framatome used test data to correlate the **[ ]** (Section 6 of Reference F.1) constants and coefficients that appear in the ORFEO-NMGRID correlation, the total number of degrees of freedom must be corrected. The constants and coefficients considered include those listed in Reference F.1 Tables 6-1, 6-2, and 6-6, as well as X_1, X_2, C_{damp}, d_0, and d_1, which are included in the F_{BASE} term (Reference F.1, Pages 6-10 and 6-11). Of the **[ ]** constants and coefficients appearing in the ORFEO-NMGRID correlation, two coefficients in the F_{SPACER} term are zeros. Only the total number of non-zero constants and coefficients **[ ]** is considered when deriving the number of degrees of freedom. In addition, the standard deviation of the database needs to be corrected accordingly to account for this reduced number of degrees of freedom:

$$N = n - 1 - [\ \ ]$$
$$\sigma_N = \sigma_{M/P} \cdot [\,(n - 1) / N\,]^{1/2} \quad \text{[F.5.2.2]}$$

The 'N' value, corrected to include the **[ ]** constants and coefficients in the ORFEO-NMGRID correlation, is then used to calculate an appropriate one-sided tolerance factor ($K_{N,C,P}$). The corrected 'N' value is also used to calculate a corrected standard deviation, σ_N. The new values of σ_N and $K_{N,C,P}$ are then used in Equation F.5.2.1, alongside the average M/P value of the database, to calculate the corrected DNBR design limit.

The parametric DNBR design limit for the VIPRE-D/ORFEO-NMGRID is calculated as shown in Table F.5.2-5. A preliminary design limit of 1.145 is calculated using a standard deviation of **[ ]** and a corrected standard deviation of **[ ]**. Tables F.5.2-6, F.5.2-7, and F.5.2-8 show **[ ]** statepoints with M/P values lower than the inverse of 1.145 for subregions within the pressure, mass flux, and equilibrium quality ranges. The majority of those statepoints are in subregions of **[** .

Consistent with Framatome's approach in Reference F.1, a "bounding standard deviation" is defined as the largest standard deviation of any subregion of the database including those that are potentially non-conservative, thereby ensuring potentially non-conservative subregions are adequately protected. This "bounding standard deviation" is defined as **[ ]** and corresponds to the subregion of **[ ]**. This bounding standard deviation is used to recalculate a parametric design limit of 1.201 in Table F.5.2-5 for the VIPRE-D/ORFEO-NMGRID population. The application of the bounding standard deviation increases the design limit by ~5%. Tables F.5.2-6, F.5.2-7 and F.5.2-8 show **[ ]** statepoints with M/P values below the inverse of the design limit of 1.201.

<u>Non-Parametric (Distribution Free) Limit</u>

The non-parametric method described in Reference F.4 requires the ranking of all M/P values in ascending order for the population being considered. Table A-31 of Reference F.4 gives the largest value of 'm' such that we can state with at least 95% certainty that 95% of a population lies above the m^{th} smallest of a random sample of 'n' from that population. The most conservative non-parametric DNBR limit is determined using the ORFEO-NMGRID population. Table A-31 of Reference F.4 determines the rank of the value from the sorted M/Ps to be used to determine the design limit is **[ ]** for **[ ]** samples. The **[ ]** smallest M/P value is 0.87379. The inverse (1.144) is the non-parametric limit for the VIPRE-D/ORFEO-NMGRID code/correlation pair. Table F.5.2-9 provides a summary of the calculation of the non-parametric DNBR design limit for the VIPRE-D/ORFEO-NMGRID.

<u>Deterministic Design Limit (DDL)</u>

The DDL for the VIPRE-D/ORFEO-NMGRID code/correlation pair is the limiting DNBR limit of the parametric and non-parametric limits round up. The parametric limit for the entire ORFEO-NMGRID database (1.201) is more limiting than the non-parametric limit for the same database (1.144). Hence, DDL for the VIPRE-D/ORFEO-NMGRID code/correlation pair is rounded up to 1.21.

Table F.5.2-10 summarizes the ranges of validity for the VIPRE-D/ORFEO-NMGRID code/correlation pair as defined by the Experimental Database. These ranges are identical to those submitted by Framatome and approved by the USNRC (Reference F.1) except for the quality, where the more restrictive Dominion Energy calculated upper limit will be used.

Figures F.5.2-2 through F.5.2-5 display the performance of the Measured CHF vs. Predicted CHF and the distributions of M/P as a function of the pressure, mass flux and quality. These plots show that there are no biases in the M/P ratio distribution, and that the performance of the ORFEO-NMGRID CHF correlation is independent of the three variables of interest. The plots show a mostly uniform scatter of the data and no obvious trends or slopes.

Table F.5.2-5

VIPRE-D/ORFEO-NMGRID Parametric Design Limit

For ORFEO-NMGRID Population

Datapoints	n		
Degrees of Freedom	N	= n – 1– [ ]	
Average M/P	M/P		
Standard Deviation of M/P	$\sigma_{M/P}$		
Corrected Standard Deviation	σ_N	$= \sigma_{M/P} * [(n-1)/N]^{1/2}$	
Owen's Factor	K(N,0.95,0.95)	Reference F.2	
Raw Design Limit	$DNBR_{raw}$		1.145
Bounding Standard Deviation	$\sigma_{bounding}$	M/P standard deviation for qualities between -1.0 and 0.0	
Adjusted Bounding Standard Deviation	$\sigma_{bounding\ adjusted}$	$= \sigma_{bounding} * [(n-1) / N]^{1/2}$	
Owen's Factor	K(N,0.95,0.95)	Reference F.2	
Parametric Design Limit	$DNBR_{para}$		1.201

Table F.5.2-6

VIPRE-D/ORFEO-NMGRID M/P Distribution by Pressure Ranges

Table F.5.2-7

VIPRE-D/ORFEO-NMGRID M/P Distribution by Mass Flux Ranges

Table F.5.2-8

VIPRE-D/ORFEO-NMGRID M/P Distribution by Quality Ranges

Table F.5.2-9

VIPRE-D/ORFEO-NMGRID Non-Parametric Design Limit

For ORFEO-NMGRID Population

Group Name	Population Size	m	m^{th} smallest M/P	Non-Parametric DNBR Limit
ORFEO-NMGRID Population	[	]	0.87379	1.144

Table F.5.2-10

Range of Validity for the VIPRE-D/ORFEO-NMGRID

Parameter	**Units**	**Minimum Value**	**Maximum Value**
Pressure	psia	291.5	2532.4
Mass Flux	Mlbm/hr-ft^2	0.2997	3.5584
Equilibrium Quality	fraction	---	0.808

Figure F.5.2-2
Measured CHF vs. Predicted CHF for VIPRE-D/ORFEO-NMGRID Database

Figure F.5.2-3
M/P vs. Pressure for VIPRE-D/ORFEO-NMGRID Database

[ ]

Figure F.5.2-4
M/P vs. Mass Flux for VIPRE-D/ORFEO-NMGRID Database

Figure F.5.2-5
M/P vs. Quality for VIPRE-D/ORFEO-NMGRID Database

F.6 CONCLUSIONS

The ORFEO-GAIA and ORFEO-NMGRID correlations have been qualified with Dominion Energy's VIPRE-D computer code.

Table F.6-1 summarizes the DNBR design limits for these code/correlation pairs that yield a 95% non-DNB probability at a 95% confidence level.

Table F.6-1

DNBR Limits for the VIPRE-D/ORFEO-GAIA

and

VIPRE-D/ORFEO-NMGRID Code/Correlation Pairs

VIPRE-D/ORFEO-GAIA	**1.13**
VIPRE-D/ORFEO-NMGRID	**1.21**

Based on the calculations performed herein, a DDL of **1.13** was determined to provide 95/95 protection for the ORFEO-GAIA correlation using the VIPRE-D computer code. The following table provides the range of applicability for the ORFEO-GAIA correlation using the VIPRE-D computer code and is consistent with the range of applicability documented in Table 7-12 of Reference F.1.

Table F.6-2

Ranges of Validity for the VIPRE-D/ORFEO-GAIA

Parameter	**Units**	**Minimum Value**	**Maximum Value**
Pressure	psia	1446.0	2530.9
Mass Flux	Mlbm/hr-ft^2	0.5012	3.1878
Equilibrium Quality	fraction	---	0.7992

Based on the calculations performed herein, a DDL of **1.21** was determined to provide 95/95 protection for the ORFEO-NMGRID correlation using the VIPRE-D computer code. The following table provides the range of applicability for the ORFEO-NMGRID correlation using the VIPRE-D computer code and is consistent with the range of applicability documented in Table 7-23 of Reference F.1, except for the quality, where the more restrictive Dominion Energy calculated upper limit will be used.

Table F.6-3

Ranges of Validity for the VIPRE-D/ORFEO-NMGRID

Parameter	Units	Minimum Value	Maximum Value
Pressure	psia	291.5	2532.4
Mass Flux	Mlbm/hr-ft^2	0.2997	3.5584
Equilibrium Quality	fraction	---	0.808

F.7 Conditions and Limitations

The following conditions and limitations from USNRC's SER for Reference F.1 are applicable.

Conditions:

1. The inlet subcooling must be greater than 0 degrees. This is to ensure that the burnout length is limited to the fuel region.

2. It should be confirmed that any DNB analyses performed using ORFEO-NMGRID are far removed from the **[ ]**. If calculations are not far removed from this region, then an appropriate additional uncertainty of the region should be quantified and applied in the analysis.

3. The use of the ORFEO-GAIA and ORFEO-NMGRID correlations in the low quality region (i.e., equilibrium qualities below -0.1) have a minimal impact on the limiting minimum DNBR values. Limiting minimum DNBR is defined as the scenario in which the event is approaching the design limit. Application of the ORFEO-GAIA and ORFEO-NMGRID correlations for events in which the limiting DNBR is sufficiently far from the design limit is not subject to this condition regardless of the local quality. Should this assumption no longer be true and should the low quality domain become a limiting domain, additional analysis would be required to quantify the uncertainty in this domain.

Limitations:

The ORFEO-GAIA and ORFEO-NMGRID CHF models are limited as given by the following:

1. The ORFEO-GAIA is for use in predicting the CHF downstream of GAIA and IGM mixing grids in GAIA fuel. This prediction must be made in the subchannel code VIPRE-D with a design limit of 1.13 over the application domain specified in Table F.6-2 of Appendix F. The approved design limit contains a bias of 0.01 which the NRC staff judged was necessary to account for variations between the tested fuel assembly and the production fuel assembly that will be used in the reactor.

2. ORFEO-NMGRID is for use in predicting the CHF downstream of W 17x17 HMP non-mixing grids and GAIA and IGM mixing grids in GAIA fuel. This prediction must be

made in the subchannel code VIPRE-D with a design limit of 1.21 over the application domain specified in Table F.6-3 of Appendix F.

F.8 REFERENCES

F.1. Framatome Topical Report, ANP-10341P-A, Revision 0, “The ORFEO-GAIA and ORFEO-NMGRID Critical Heat Flux Correlations,” September 2018 and ANP-10341P-A, Revision 0, Errata 1P-000, October 2019.

F.2. Technical Report, “Tables for Normal Tolerance Limits, Sampling Plans and Screening,” R. E. Odeh and D. B. Owen, 1980.

F.3. Technical Report, “Assessment of the Assumption of Normality (Employing Individual Observed Values),” American National Standards Institute, ANSI N15.15-1974.

F.4. Handbook, “Experimental Statistics – Handbook 91,” M. G. Natrella for the United States Department of Commerce National Bureau of Standards, October 1996.

Attachment 3

FRAMATOME AFFIDAVIT FOR WITHHOLDING PROPRIETARY INFORMATION FROM PUBLIC DISCLOSURE

Virginia Electric and Power Company (Dominion Energy)
North Anna and Surry Power Stations Units 1 and 2

Dominion Energy Nuclear Connecticut, Inc. (DENC)
Millstone Power Station Units 2 and 3

AFFIDAVIT

1. My name is Morris Byram. I am Product Manager, Licensing & Regulatory Affairs for Framatome Inc. (Framatome) and as such I am authorized to execute this Affidavit.

2. I am familiar with the criteria applied by Framatome to determine whether certain Framatome information is proprietary. I am familiar with the policies established by Framatome to ensure the proper application of these criteria.

3. I am familiar with the Framatome information contained in Attachment 1 to Dominion Energy letter Serial No. 22-362, Rev. 0, entitled "Appendix F to DOM-NAF-2, 'Qualification of the Framatome ORFEO-GAIA and ORFEO-NMGRID CHF Correlations in the Dominion Energy VIPRE-D Computer Code,'" and referred to herein as "Document." Information contained in this Document has been classified by Framatome as proprietary in accordance with the policies established by Framatome for the control and protection of proprietary and confidential information.

4. This Document contains information of a proprietary and confidential nature and is of the type customarily held in confidence by Framatome and not made available to the public. Based on my experience, I am aware that other companies regard information of the kind contained in this Document as proprietary and confidential.

5. This Document has been made available to the U.S. Nuclear Regulatory Commission in confidence with the request that the information contained in this Document be withheld from public disclosure. The request for withholding of proprietary information is made in accordance with 10 CFR 2.390. The information for which withholding from disclosure is

requested qualifies under 10 CFR 2.390(a)(4) "Trade secrets and commercial or financial information."

6. The following criteria are customarily applied by Framatome to determine whether information should be classified as proprietary:

(a) The information reveals details of Framatome's research and development plans and programs or their results.

(b) Use of the information by a competitor would permit the competitor to significantly reduce its expenditures, in time or resources, to design, produce, or market a similar product or service.

(c) The information includes test data or analytical techniques concerning a process, methodology, or component, the application of which results in a competitive advantage for Framatome.

(d) The information reveals certain distinguishing aspects of a process, methodology, or component, the exclusive use of which provides a competitive advantage for Framatome in product optimization or marketability.

(e) The information is vital to a competitive advantage held by Framatome, would be helpful to competitors to Framatome, and would likely cause substantial harm to the competitive position of Framatome.

The information in this Document is considered proprietary for the reasons set forth in paragraph 6(c) and 6(d) above.

7. In accordance with Framatome's policies governing the protection and control of information, proprietary information contained in this Document has been made available, on a limited basis, to others outside Framatome only as required and under suitable agreement providing for nondisclosure and limited use of the information.

8. Framatome policy requires that proprietary information be kept in a secured file or area and distributed on a need-to-know basis.

9. The foregoing statements are true and correct to the best of my knowledge, information, and belief.

I declare under penalty of perjury that the foregoing is true and correct.

Executed on: (11/29/2022)

BYRAM Morris Digitally signed by BYRAM Morris Date: 2022.11.29 08:01:18 -08'00'

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