September 25, 2017

Docket: PROJ0769

U.S. Nuclear Regulatory Commission
ATTN: Document Control Desk
One White Flint North
11555 Rockville Pike
Rockville, MD 20852-2738

SUBJECT: NuScale Power, LLC Response to NRC Request for Additional Information No. 8931 (eRAI No. 8931) on the NuScale Topical Report, "NuScale Power Critical Heat Flux Correlation NSP2," TR-0116-21012, Revision 0

REFERENCES:
1. U.S. Nuclear Regulatory Commission, "Request for Additional Information No. 8931 (eRAI No. 8931)," dated July 30, 2017
2. NuScale Topical Report, "NuScale Power Critical Heat Flux Correlation NSP2," TR-0116-21012, Revision 0, dated October 2016

The purpose of this letter is to provide the NuScale Power, LLC (NuScale) response to the referenced NRC Request for Additional Information (RAI).

The Enclosures to this letter contain NuScale's response to the following RAI Questions from NRC eRAI No. 8931:

- 04.04-4
- 04.04-5
- 04.04-6
- 04.04-7
- 04.04-8
- 04.04-9

Enclosure 1 is the proprietary version of the NuScale Response to NRC RAI No. 8931 (eRAI No. 8931). NuScale requests that the proprietary version be withheld from public disclosure in accordance with the requirements of 10 CFR § 2.390. The enclosed affidavits (Enclosures 3 and 4) support this request. Enclosure 3 pertains to the NuScale proprietary information to be withheld from the public. Encosure 4 pertains to the AREVA proprietary information to be withheld from the public. NuScale proprietary is denoted by double braces (i.e., "{{ }}) while AREVA proprietary is denoted by brackets (i.e., "[ ]"). Enclosure 1 has also been determined to contain Export Controlled Information. This information must be protected from disclosure per the requirements of 10 CFR Part 810.

Enclosure 2 is the nonproprietary version of the NuScale Response to NRC RAI No. 8931 (eRAI No. 8931).

This letter and the enclosed responses make no new regulatory commitments and no revisions

to any existing regulatory commitments.

If you have any questions on this response, please contact Darrell Gardner at 980-349-4829 or at dgardner@nuscalepower.com.

Sincerely,

Zackary W. Rad
Director, Regulatory Affairs
NuScale Power, LLC

Distribution: Gregory Cranston, NRC, OWFN-8G9A
Samuel Lee, NRC, OWFN-8G9A
Bruce Bavol, NRC, OWFN-8G9A

Enclosure 1: NuScale Response to NRC Request for Additional Information eRAI No. 8931, proprietary

Enclosure 2: NuScale Response to NRC Request for Additional Information eRAI No. 8931, nonproprietary

Enclosure 3: Affidavit of Zackary W. Rad, AF-0917-56097

Enclosure 4: Affidavit of Nathan E. Hottle

Enclosure 1:

NuScale Response to NRC Request for Additional Information eRAI No. 8931, proprietary

NuScale Power, LLC
1100 NE Circle Blvd., Suite 200 Corvalis, Oregon 97330, Office: 541.360.0500, Fax: 541.207.3928
www.nuscalepower.com

Enclosure 2:

NuScale Response to NRC Request for Additional Information eRAI No. 8931, nonproprietary

NuScale Power, LLC
1100 NE Circle Blvd., Suite 200 Corvalis, Oregon 97330, Office: 541.360.0500, Fax: 541.207.3928
www.nuscalepower.com

Response to Request for Additional Information
Docket: PROJ0769

eRAI No.: 8931
Date of RAI Issue: 07/30/2017

NRC Question No.: 04.04-4

Title 10 of the *Code of Federal Regulations* (10 CFR) Part 52, Section 47 and Section 79 require a final safety analysis report (FSAR) to analyze the design and performance of the structures, systems, and components (SSCs). Safety evaluations, performed to support the FSAR, include accident analyses to (1) demonstrate that specified acceptable fuel design limits (SAFDLs) are not exceeded during normal operation, including the effects of anticipated operational occurrences (AOOs), and (2) determine the number of fuel failures associated with critical heat flux (CHF) that need to be included in the radiological consequences for postulated accidents. An approved CHF correlation is used in establishing a SAFDL for use in such analyses. Thus, an approved CHF correlation is used to establish a partial basis for demonstrating compliance with the following applicable regulations from Title 10 of the Code of Federal Regulations (10 CFR) which include the General Design Criteria (GDCs) of Appendix A to 10 CFR Part 50:

GDC 10, *Reactor design*, which requires that the reactor core and associated coolant, control, and protection systems be designed with appropriate margin to assure that SAFDLs are not exceeded during any condition of normal operation, including the effects of AOOs.

10 CFR 52.47(a)(2)(iv)(A), 10 CFR 52.47(a)(2)(iv)(B), and GDC 19 as they relate to the evaluation and analysis of the radiological consequences of postulated accidents.

NRC staff conducted an audit of the calculations supporting the development of the NSP2 CHF correlation at the NuScale office in Rockville, MD on June 13-15, 2017 (ML17138A113). During the audit NRC staff identified additional information that needed to be added to Appendix A of TR-0116-21012. This information is necessary for NRC staff to establish a finding that the correlation coefficients and limit were calculated from an appropriate database using appropriate methods. Accordingly, NRC staff request that NuScale update Appendix A of TR-0116- 21012 to include columns for (1) the Tong Factor, (2) measured-to-predicted values, and (3) inlet subcooling temperature.

NuScale Response:

TR-0116-21012, Appendix A has been updated to include columns for the Tong factor, measured-to-predicted values and the inlet subcooling. Additionally, the inlet flow and subcooling data columns are for test matrix specifications and are not measured test data. The revised Appendix A has been incorporated into the topical report as depicted by the markup included in the RAI response.

Impact on Topical Report:
Topical Report TR-0116-21012, NuScale Power Critical Heat Flux Correlation NSP2, has been revised as described in the response above and as shown in the markup provided with the response to question 04.04-9.

Response to Request for Additional Information
Docket: PROJ0769

eRAI No.: 8931
Date of RAI Issue: 07/30/2017

NRC Question No.: 04.04-5

Title 10 of the *Code of Federal Regulations* (10 CFR) Part 52, Section 47 and Section 79 require a final safety analysis report (FSAR) to analyze the design and performance of the structures, systems, and components (SSCs). Safety evaluations, performed to support the FSAR, include accident analyses to (1) demonstrate that specified acceptable fuel design limits (SAFDLs) are not exceeded during normal operation, including the effects of anticipated operational occurrences (AOOs), and (2) determine the number of fuel failures associated with critical heat flux (CHF) that need to be included in the radiological consequences for postulated accidents. An approved CHF correlation is used in establishing a SAFDL for use in such analyses. Thus, an approved CHF correlation is used to establish a partial basis for demonstrating compliance with the following applicable regulations from Title 10 of the Code of Federal Regulations (10 CFR) which include the General Design Criteria (GDCs) of Appendix A to 10 CFR Part 50:

GDC 10, *Reactor design*, which requires that the reactor core and associated coolant, control, and protection systems be designed with appropriate margin to assure that SAFDLs are not exceeded during any condition of normal operation, including the effects of AOOs.

10 CFR 52.47(a)(2)(iv)(A), 10 CFR 52.47(a)(2)(iv)(B), and GDC 19 as they relate to the evaluation and analysis of the radiological consequences of postulated accidents.

TR-0116-21012 does not contain plots to demonstrate the measured-to-predicted performance of the CHF correlation. NRC staff relies upon such information to support a finding that the CHF correlation and limit establish a 95/95 limit. Accordingly, NRC staff request that NuScale provide the following plots:

a. Measured-to-Predicted vs Pressure
b. Measured-to-Predicted vs Mass Flux
c. Measured-to-Predicted vs Quality
d. Measured-to-Predicted vs Boiling Length
e. Measured-to-Predicted vs Inlet Enthalpy
f. Measured-to-Predicted vs Hydraulic Diameter Ratio

NuScale Response:

Measured-to-predicted (M/P) bias plots for pressure, mass flux, quality, boiling length, hydraulic-to-heated diameter ratio, and inlet enthalpy are illustrated below in Figures 1 through 6, respectively, for NuFuel-HTP2™ data (K9000 - K9300 tests) using the NSP2 CHF correlation within the range of applicability from Table 7-2 of TR-0116-21012:

Parameter	Range of Applicability
pressure, psia	300 to 2,300
local mass flux, Mlb/hr-ft^2	0.110 to 0.700
local equilibrium quality, %	≤ 90%
inlet equilibrium quality, %	< 0%

1. The upper limit for the correlation quality range has been revised from 0.95% to 0.90% in response to eRAI 8931, Question 04.04.06 .

These figures indicate that there is distinct conservative bias (i.e. under-predicting data) and the M/P data lie above the correlation limit. The M/P limit is calculated from the correlation limit with:

$$LIMIT_{M/P} = \frac{1}{LIMIT_{P/M}} = \frac{1}{LIMIT_{correlation}} = \frac{1}{1.17}$$

The trends of a linear fit to the data are not flat, but this trend is expected because the NSP2 CHF correlation was not directly correlated to the NuFuel-HTP2™ CHF data. Overall, the NSP2 CHF correlation provides conservative predictions of CHF.

{{[

]}}[2(a),(c)]

Figure 1. NSP2 Measured-to-Predicted CHF vs. Pressure for NuFuel-HTP2™ Data

{{[

]}}[2(a),(c)]

Figure 2. NSP2 Measured-to-Predicted CHF vs. Mass Flux for NuFuel-HTP2™ Data

{{[

]}}$^{2(a),(c)}$

Figure 3. NSP2 Measured-to-Predicted CHF vs. Quality for NuFuel-HTP2™ Data

{{[

]}}$^{2(a),(c)}$

Figure 4. NSP2 Measured-to-Predicted CHF vs. Boiling Length for NuFuel-HTP2™ Data

{{[

]}}2(a),(c)

Figure 5. NSP2 Measured-to-Predicted CHF vs. Cold Wall Factor for NuFuel-HTP2™ Data

{{[

]}}2(a),(c)

Figure 6. NSP2 Measured-to-Predicted CHF vs. Inlet Enthalpy for NuFuel-HTP2™ Data

Impact on Topical Report:
There are no impacts to the Topical Report TR-0116-21012, NuScale Power Critical Heat Flux Correlation NSP2, as a result of this response.

Response to Request for Additional Information
Docket: PROJ0769

eRAI No.: 8931
Date of RAI Issue: 07/30/2017

NRC Question No.: 04.04-6

Title 10 of the *Code of Federal Regulations* (10 CFR) Part 52, Section 47 and Section 79 require a final safety analysis report (FSAR) to analyze the design and performance of the structures, systems, and components (SSCs). Safety evaluations, performed to support the FSAR, include accident analyses to (1) demonstrate that specified acceptable fuel design limits (SAFDLs) are not exceeded during normal operation, including the effects of anticipated operational occurrences (AOOs), and (2) determine the number of fuel failures associated with critical heat flux (CHF) that need to be included in the radiological consequences for postulated accidents. An approved CHF correlation is used in establishing a SAFDL for use in such analyses. Thus, an approved CHF correlation is used to establish a partial basis for demonstrating compliance with the following applicable regulations from Title 10 of the Code of Federal Regulations (10 CFR) which include the General Design Criteria (GDCs) of Appendix A to 10 CFR Part 50:

GDC 10, *Reactor design*, which requires that the reactor core and associated coolant, control, and protection systems be designed with appropriate margin to assure that SAFDLs are not exceeded during any condition of normal operation, including the effects of AOOs.

10 CFR 52.47(a)(2)(iv)(A), 10 CFR 52.47(a)(2)(iv)(B), and GDC 19 as they relate to the evaluation and analysis of the radiological consequences of postulated accidents.

NRC staff conducted an audit of the calculations supporting the development of the NSP2 CHF correlation at the NuScale office in Rockville, MD on June 13-15, 2017 (ML17138A113). An analysis of the measured-to-predicted data, conducted during the audit, showed a subregion of reduced margin exists within the application domain of the NSP2 CHF correlation. This caused NRC staff to question whether the NSP2 correlation limit, proposed in Rev. 0 of TR-0116-21012, is suitable for application within this subregion. Accordingly, NRC staff is requesting that NuScale provide a means for adequate treatment of the low-margin subregion such that the correlation will ensure at the 95/95 level that CHF will not be experienced at the CHF correlation limit.

NuScale Response:

A 3D plot of pressure, mass flux and quality is illustrated in Figure 1 for the NuFuel-HTP2™ data (K9000 - K9300) using the NSP2 CHF correlation. The red points represent the lowest 5% of M/P values and the black points represent the remaining 95% of M/P values. In Figure 1 it is evident that the red points are predominantly clustered in a limited location of the domain (i.e. intermediate pressure, low mass flux, and high quality). This observation is consistent with the issue raised by the RAI question. This same issue is not evident in the Stern CHF data with the NSP1 CHF correlation as illustrated in Figure 2. When the upper quality limit is reduced from 95% to 90% the red points spread out again as illustrated in Figure 3. Therefore, the upper limit on the quality range of applicability has been lowered to 90% and Tables 4-5 and 7-2 of TR-0116-21012 have been revised as follows:

Parameter	Range of Applicability
pressure, psia	300 to 2,300
local mass flux, Mlb/hr-ft^2	0.110 to 0.700
local equilibrium quality, %	$\leq$ 90%
inlet equilibrium quality, %	< 0.0%

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}}[2(a),(c)]

Figure 1. 3D plot of P, G, and X for NuFuel-HTP2™ Data with NSP2

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}}[2(a),(c)]

Figure 2. 3D Plot of P, G, and X for Stern Data with NSP1

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}}[2(a),(c)]

Figure 3. 3D plot of P, G, and X for NuFuel-HTP2™ Data with NSP2 (90% Quality limit)

Impact on Topical Report:
Topical Report TR-0116-21012, NuScale Power Critical Heat Flux Correlation NSP2, has been revised as described in the response above and as shown in the markup provided with the response to question 04.04-9.

Response to Request for Additional Information
Docket: PROJ0769

eRAI No.: 8931
Date of RAI Issue: 07/30/2017

NRC Question No.: 04.04-7

Title 10 of the *Code of Federal Regulations* (10 CFR) Part 52, Section 47 and Section 79 require a final safety analysis report (FSAR) to analyze the design and performance of the structures, systems, and components (SSCs). Safety evaluations, performed to support the FSAR, include accident analyses to (1) demonstrate that specified acceptable fuel design limits (SAFDLs) are not exceeded during normal operation, including the effects of anticipated operational occurrences (AOOs), and (2) determine the number of fuel failures associated with critical heat flux (CHF) that need to be included in the radiological consequences for postulated accidents. An approved CHF correlation is used in establishing a SAFDL for use in such analyses. Thus, an approved CHF correlation is used to establish a partial basis for demonstrating compliance with the following applicable regulations from Title 10 of the Code of Federal Regulations (10 CFR) which include the General Design Criteria (GDCs) of Appendix A to 10 CFR Part 50:

GDC 10, *Reactor design*, which requires that the reactor core and associated coolant, control, and protection systems be designed with appropriate margin to assure that SAFDLs are not exceeded during any condition of normal operation, including the effects of AOOs.

10 CFR 52.47(a)(2)(iv)(A), 10 CFR 52.47(a)(2)(iv)(B), and GDC 19 as they relate to the evaluation and analysis of the radiological consequences of postulated accidents.

TR-0116-21012 mathematically defined the application domain of the NSP2 correlation. As with all application domains, the NSP2 application domain contains regions which contain no data and regions in which the correlation wil not be used. Therefore, NuScale should identify the expected domain and ensure that the expected domain contains an adequate number of data points. NRC staff needs to establish a finding that there is adequate data density throughout the expected domain. Accordingly, NRC staff request that NuScale provide, at a minimum, the following plots to identify the expected domain of the NSP2 correlation (i.e., the region on each plot where the NSP2 correlation is expected to be used during steady state and transient analysis):

a. Pressure vs Mass Flux
b. Pressure vs Quality

c. Mass Flux vs Quality

NuScale Response:

Subchannel analyses of transient events, including anticipated operation occurrences, infrequent events and accidents are expected to remain in the domain defined by:

Pressure: 1,700 to 2,200 psia

Mass Flux: 0.11 to 0.5 Mlb/hr-ft^2

Quality: -40% to 20%

This operation domain is compared to the NuFuel-HTP2™ (K9000 through K9300 tests) and Stern CHF data in Figures 1 through 6. Although Figures 2 and 3 indicate that the operation domain occurs at local quality levels below the majority of the CHF test data, the data density is sufficient to perform all statistical assessments within operation domain and therefore the number of data points is adequate.

In CHF testing the inlet subcooling, mass flux and pressure are fixed and the power is increased until CHF is detected by one of the heated rod thermocouples. In this framework the power is independent of the mass flux. In the NuScale Power Module (NPM) the mass flux increases primarily with core power due to the operating characteristics of the natural circulation reactor coolant system. Therefore, low mass flux values occur in conjunction with low core power in the NPM and conversely high mass flux values occur in conjunction with high core power. This operating characteristic is not evident in the CHF testing since CHF data are only obtained at qualities much greater than would be expected in application domain. This inherent margin to CHF is demonstrated by the figures.

Due to the unique operating characteristics of the NPM design, an additional comparison, based on inlet conditions, is presented. Figures 4, 5 and 6 demonstrate that the test boundary conditions for both Stern and NuFuel-HTP2^{TM} are consistent with the operational domain of the NPM.

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}}[2(a),(c)]

Figure 1. Local Mass Flux vs. Pressure with Mass Flux and Pressure Operation Domain

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}}[2(a),(c)]

Figure 2. Local Quality vs. Pressure with Quality and Pressure Operation Domain

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}}[2(a)(c)]

Figure 3. Local Quality vs. Local Mass Flux with Quality and Mass Flux Operation Domain

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}}[2(a),(c)]

Figure 4. Inlet Mass Flux vs. Pressure with Mass Flux and Pressure Operation Domain

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}}[2(a),(c)]

Figure 5. Inlet Quality vs. Pressure with Quality and Pressure Operation Domain

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}}[2(a),(c)]

Figure 6. Inlet Quality vs. Inlet Mass Flux with Quality and Mass Flux Operation Domain

Impact on Topical Report:
There are no impacts to the Topical Report TR-0116-21012, NuScale Power Critical Heat Flux Correlation NSP2, as a result of this response.

Response to Request for Additional Information
Docket: PROJ0769

eRAI No.: 8931
Date of RAI Issue: 07/30/2017

NRC Question No.: 04.04-8

Title 10 of the *Code of Federal Regulations* (10 CFR) Part 52, Section 47 and Section 79 require a final safety analysis report (FSAR) to analyze the design and performance of the structures, systems, and components (SSCs). Safety evaluations, performed to support the FSAR, include accident analyses to (1) demonstrate that specified acceptable fuel design limits (SAFDLs) are not exceeded during normal operation, including the effects of anticipated operational occurrences (AOOs), and (2) determine the number of fuel failures associated with critical heat flux (CHF) that need to be included in the radiological consequences for postulated accidents. An approved CHF correlation is used in establishing a SAFDL for use in such analyses. Thus, an approved CHF correlation is used to establish a partial basis for demonstrating compliance with the following applicable regulations from Title 10 of the Code of Federal Regulations (10 CFR) which include the General Design Criteria (GDCs) of Appendix A to 10 CFR Part 50:

GDC 10, *Reactor design*, which requires that the reactor core and associated coolant, control, and protection systems be designed with appropriate margin to assure that SAFDLs are not exceeded during any condition of normal operation, including the effects of AOOs.

10 CFR 52.47(a)(2)(iv)(A), 10 CFR 52.47(a)(2)(iv)(B), and GDC 19 as they relate to the evaluation and analysis of the radiological consequences of postulated accidents.

TR-0116-21012 mathematically defined the application domain of the NSP2 correlation. Based on past experience reviewing CHF correlations, NRC staff is concerned about the potential for regions within the application domain, where non-physical CHF behavior could be exhibited. A “Corner-to-Corner” analysis consists of predicting the CHF value at extreme locations within the application domain of the CHF correlation, and is used to identify regions where the CHF correlation is not applicable. NRC staff relies upon such analyses to identify limitations in the application of a CHF correlation. Accordingly, NRC staff requests that NuScale perform a “Corner-to-Corner” analysis of the NSP2 correlation over it application domain.

NuScale Response:

A corner-to-corner analysis demonstrates performance of the critical heat flux (CHF) correlation at the extremes of its applicable domain. The minimum and maximum points are:

Pressure: 300 and 2300 psia

Mass Flux: 0.11 and 0.70 Mlb/hr-ft^2

Quality: -60 and 90%

Boiling Length: 0.0 and 78.74 in.

Cold Wall Factor: {{ }}$^{2(a)(c)}$

The NSP2 CHF values at all combinations of the above are tabulated in Table 1. There are six cases that have high NSP2 CHF values where the predicted CHF value is greater than 2.0 MBtu/hr-ft^2 and is considered unreliable. Cases 9 and 10 have a boiling length and quality that are mutually exclusive, because a boiling length of 0.0 in. suggests quality must be above 0% for entire length, so -60% quality is not possible. Similarly, cases 15 and 16 have a boiling length and quality that are mutually exclusive, because a boiling length of 78.74 in. suggests quality must be below 0% for entire length, so 90% quality is not possible. The remaining two cases (cases 11 and 12) occur at low pressure (300 psia) and high mass flux (0.7 Mlb/hr-ft^2), which is also not a condition that will be reached in the NuScale power module (NPM). A pressure of 300 psia corresponds to a saturation temperature of 417 °F. In order to be at a temperature of 417 °F the NPM must be in Mode 3 (safe shutdown), at which point the flow must be low due to its first order relationship with power. Therefore, a high flow (greater than that of full operating conditions) is not feasible at such a low pressure. Since these six points are not truly feasible, they are not considered, and the remaining points behave in a predictable manner.

Table 1. Corner-to-Corner points with NSP2 CHF Values

Case	Pressure *psia*	Mass Flux *Mlb/hr-ft^2*	Quality	Boiling Length *in.*	Cold Wall Factor	NSPX Factor	NSP2 *MBtu/hr-ft^2*
1	300	0.110	-0.600	0.000	{{	{{	{{
2	300	0.110	-0.600	0.000			
3	300	0.110	-0.600	78.740			
4	300	0.110	-0.600	78.740			
5	300	0.110	0.900	0.000			
6	300	0.110	0.900	0.000			
7	300	0.110	0.900	78.740			
8	300	0.110	0.900	78.740			
9	300	0.700	-0.600	0.00			
10	300	0.700	-0.600	0.000			
11	300	0.700	-0.600	78.740			
12	300	0.700	-0.600	78.740			
13	300	0.700	0.900	0.000			
14	300	0.700	0.900	0.000			
15	300	0.700	0.900	78.740			
16	300	0.700	0.900	78.740			
17	2300	0.110	-0.600	0.000			
18	2300	0.110	-0.600	0.000			
19	2300	0.110	-0.600	78.740			
20	2300	0.110	-0.600	78.740			
21	2300	0.110	0.900	0.000			
22	2300	0.110	0.900	0.000			
23	2300	0.110	0.900	78.740			
24	2300	0.110	0.900	78.740			
25	2300	0.700	-0.600	0.000			
26	2300	0.700	-0.600	0.000			
27	2300	0.700	-0.600	78.740			
28	2300	0.700	-0.600	78.740			
29	2300	0.700	0.900	0.000			
30	2300	0.700	0.900	0.000			
31	2300	0.700	0.900	78.740			
32	2300	0.700	0.900	78.740	}}$^{2(a),(c)}$	}}$^{2(a),(c)}$	}}$^{2(a),(c)}$

Impact on Topical Report:
There are no impacts to the Topical Report TR-0116-21012, NuScale Power Critical Heat Flux Correlation NSP2, as a result of this response.

Response to Request for Additional Information
Docket: PROJ0769

eRAI No.: 8931
Date of RAI Issue: 07/30/2017

NRC Question No.: 04.04-9

Title 10 of the *Code of Federal Regulations* (10 CFR) Part 52, Section 47 and Section 79 require a final safety analysis report (FSAR) to analyze the design and performance of the structures, systems, and components (SSCs). Safety evaluations, performed to support the FSAR, include accident analyses to (1) demonstrate that specified acceptable fuel design limits (SAFDLs) are not exceeded during normal operation, including the effects of anticipated operational occurrences (AOOs), and (2) determine the number of fuel failures associated with critical heat flux (CHF) that need to be included in the radiological consequences for postulated accidents. An approved CHF correlation is used in establishing a SAFDL for use in such analyses. Thus, an approved CHF correlation is used to establish a partial basis for demonstrating compliance with the following applicable regulations from Title 10 of the Code of Federal Regulations (10 CFR) which include the General Design Criteria (GDCs) of Appendix A to 10 CFR Part 50:

GDC 10, *Reactor design*, which requires that the reactor core and associated coolant, control, and protection systems be designed with appropriate margin to assure that SAFDLs are not exceeded during any condition of normal operation, including the effects of AOOs.

10 CFR 52.47(a)(2)(iv)(A), 10 CFR 52.47(a)(2)(iv)(B), and GDC 19 as they relate to the evaluation and analysis of the radiological consequences of postulated accidents.

The NSP2 CHF correlation uses boiling length as one of the correlation parameters. The parameter ranges, provided in Table 4-5 and Table 7-2 of TR-0116-21012, Rev. 0, do not specify a requirement on inlet subcooling. Based on the use of boiling length in the NSP2 CHF correlation and {{
}}$^{2(a),(c)}$, the application range for the NSP2 correlation should be restricted to an application domain with inlet subcooling. Accordingly, NRC staff requests that NuScale update the parameter range in TR-0116-21012 to require inlet subcooling.

NuScale Response:

The parameter range tables (TR-0116-21012; Table 4-5 and Table 7-2) were updated to include a limit on inlet equilibrium quality as depicted by Table 1.

Table 1. Parameter ranges of applicability for NSP2 CHF correlation

Parameter	Range of Applicability
pressure, psia	300 to 2,300
local mass flux, Mlb/hr-ft^2	0.110 to 0.700
local equilibrium quality, %	$\leq$ 90%
inlet equilibrium quality, %	< 0%

Impact on Topical Report:
Topical Report TR-0116-21012, NuScale Power Critical Heat Flux Correlation NSP2, has been revised as described in the response above and as shown in the markup provided in this response.

TABLES

FIGURES

Table 4-3. Data subsets for Stern preliminary prototypic data

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}}2(a),(b),(c)

Table 4-4. Tolerance limits for Stern preliminary prototypic data

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}}2(a),(c)

4.6 Range of Applicability

The range of applicability in Table 4-5 is determined from the data points used in the development of the base CHF correlation. The values for the most significant parameters are tabulated in Table 4-5. The range of data listed covers the data at the 95/95 level (using non-parametric two-sided tolerance limit methods). There is no lower limit on local quality because the trends with regards to quality indicate reasonable and predictable behavior at low qualities.

Table 4-5. Parameter ranges of applicability for base CHF correlation

Parameter	Range of Applicability
pressure, psia	300 to 2300
local mass flux, 10^6 lbm/hr-ft^2	0.110 to 0.700
local equilibrium quality, %	≤ ~~95~~90.0%
inlet equilibrium quality, %	< 0.0%

$q''_{NSP2,n}$ = non-uniform heat flux, 10^6 Btu/hr-ft^2

FNU = non-uniform flux factor

The NSP2 CHF correlation is validated against NuFuel-HTP2™ design specific CHF data obtained for NuScale at AREVA's KATHY test facility. The validation demonstrates that measured CHF values for KATHY NuFuel-HTP2™ data **[ ]** the Stern preliminary prototypic design for comparable operating conditions.

Evaluation of the NSP2 CHF correlation indicates that the correlation provides a conservative prediction **[ ]** KATHY NuFuel-HTP2™ test data. A correlation limit of 1.17 ensures at the 95/95 level that CHF will not be experienced on a rod demonstrating a limiting value, which meets acceptance criterion 1 of Reference 8.1.3 demonstrating compliance with the requirements of 10 CFR 50, GDC 10. The NSP2 CHF correlation must be used in conjunction with local condition calculations from the VIPRE-01 subchannel code (Reference 8.2.3). Qualification of VIPRE-01 for use in NPM calculations is outside of the scope of this report and is addressed in the NuScale Subchannel Analysis Methodology topical report (Reference 8.2.3). The ranges of applicability for the NSP2 CHF correlation are tabulated in Table 7-2.

NuScale requests NRC approval to use the NSP2 CHF correlation in VIPRE-01, within its range of applicability in Table 7-2, along with its associated correlation limit of 1.17, for the NuScale DCA and safety analysis of the NPM with NuFuel-HTP2™ fuel. This correlation conforms to acceptance criteria given by the NuScale DSRS, Section 4.4, and the requirements of 10 CFR 50, Appendix A, GDC 10.

Table 7-2. Parameter ranges of applicability for NSP2 CHF correlation

Parameter	Range of Applicability
pressure, psia	300 to 2300
local mass flux, 10^6 lbm/hr-ft^2	0.110 to 0.700
local equilibrium quality, %	≤ ~~95~~90.0%
inlet equilibrium quality, %	< 0.0%

Appendix A. Local Conditions

Definitions:

TEST	Test identifier
POINT	Test point
Z	Elevation of CHF detection from bottom of heated length, in.
P	Pressure, psia
G_{in}	Approximate inlet mass flux (test matrix value), kg/s-m^2
ΔT_{sub}	Approximate inlet subcooling (test matrix value), °C
G	Local mass flux, Ml/hr-ft^2
X	Local equilibrium quality
Z_{boil}	Boiling length (elevation at which quality is 0.0), in.
{{	}}2(a),(c)
{{	}}2(a),(c)
q"(l_{chf})	Measured CHF, MBtu/hr-ft^2
F-factor	Modified Tong F-factor
M/P	Measured-to-predicted CHF ratio

Notes:

1) Stern and K8500 M/P values are for NSP1 correlation while NuFuel includes the NSPX factor

Table A-1. Local Conditions for Stern U1, U2 and C1 Tests

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}}2(a),(b),(c), ECI

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}}2(a),(b),(c), ECI

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}}2(a),(b),(c), ECI

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}}2(a),(b),(c), ECI

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}}2(a),(b),(c), ECI

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}}2(a),(b),(c), ECI

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}}2(a),(b),(c), ECI

Table A-2. Local Conditions for AREVA K8500 Test

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}}2(a),(b),(c), ECI

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}}2(a),(b),(c), ECI

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}}2(a),(b),(c), ECI

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}}2(a),(b),(c), ECI

Table A-3. Local Conditions for AREVA K9000, K9100, K9200 and K9300 Tests

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}}2(a),(b),(c), ECI

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Enclosure 3:

Affidavit of Zackary W. Rad, AF-0917-56097

NuScale Power, LLC
1100 NE Circle Blvd., Suite 200 Corvalis, Oregon 97330, Office: 541.360.0500, Fax: 541.207.3928
www.nuscalepower.com

NuScale Power, LLC

AFFIDAVIT of Zackary W. Rad

I, Zackary W. Rad, state as follows:

1. I am the Director, Regulatory Affairs of NuScale Power, LLC (NuScale), and as such, I have been specifically delegated the function of reviewing the information described in this Affidavit that NuScale seeks to have withheld from public disclosure, and am authorized to apply for its withholding on behalf of NuScale.
2. I am knowledgeable of the criteria and procedures used by NuScale in designating information as a trade secret, privileged, or as confidential commercial or financial information. This request to withhold information from public disclosure is driven by one or more of the following:
    a. The information requested to be withheld reveals distinguishing aspects of a process (or component, structure, tool, method, etc.) whose use by NuScale competitors, without a license from NuScale, would constitute a competitive economic disadvantage to NuScale.
    b. The information requested to be withheld consists of supporting data, including test data, relative to a process (or component, structure, tool, method, etc.), and the application of the data secures a competitive economic advantage, as described more fully in paragraph 3 of this Affidavit.
    c. Use by a competitor of the information requested to be withheld would reduce the competitor's expenditure of resources, or improve its competitive position, in the design, manufacture, shipment, installation, assurance of quality, or licensing of a similar product.
    d. The information requested to be withheld reveals cost or price information, production capabilities, budget levels, or commercial strategies of NuScale.
    e. The information requested to be withheld consists of patentable ideas.
3. Public disclosure of the information sought to be withheld is likely to cause substantial harm to NuScale's competitive position and foreclose or reduce the availability of profit-making opportunities. The accompanying Request for Additional Information response reveals distinguishing aspects about the methodology by which NuScale develops its critical heat flux correlation NSP2.

    NuScale has performed significant research and evaluation to develop a basis for this methodology and has invested significant resources, including the expenditure of a considerable sum of money.

    The precise financial value of the information is difficult to quantify, but it is a key element of the design basis for a NuScale plant and, therefore, has substantial value to NuScale.

    If the information were disclosed to the public, NuScale's competitors would have access to the information without purchasing the right to use it or having been required to undertake a similar expenditure of resources. Such disclosure would constitute a misappropriation of NuScale's intellectual property, and would deprive NuScale of the opportunity to exercise its competitive advantage to seek an adequate return on its investment.

4. The information sought to be withheld is in the enclosed Request for Additional Information Request for Additional Information No. 8931, eRAI No. 8931. The enclosure contains the designation "Proprietary" at the top of each page containing proprietary information. The information considered by NuScale to be proprietary is identified within double braces, "{{ }}" in the document.
5. The basis for proposing that the information be withheld is that NuScale treats the information as a trade secret, privileged, or as confidential commercial or financial information. NuScale relies upon the exemption from disclosure set forth in the Freedom of Information Act ("FOIA"), 5 USC § 552(b)(4), as well as exemptions applicable to the NRC under 10 CFR §§ 2.390(a)(4) and 9.17(a)(4).
6. Pursuant to the provisions set forth in 10 CFR § 2.390(b)(4), the following is provided for consideration by the Commission in determining whether the information sought to be withheld from public disclosure should be withheld:
    a. The information sought to be withheld is owned and has been held in confidence by NuScale.
    b. The information is of a sort customarily held in confidence by NuScale and, to the best of my knowledge and belief, consistently has been held in confidence by NuScale. The procedure for approval of external release of such information typically requires review by the staff manager, project manager, chief technology officer or other equivalent authority, or the manager of the cognizant marketing function (or his delegate), for technical content, competitive effect, and determination of the accuracy of the proprietary designation. Disclosures outside NuScale are limited to regulatory bodies, customers and potential customers and their agents, suppliers, licensees, and others with a legitimate need for the information, and then only in accordance with appropriate regulatory provisions or contractual agreements to maintain confidentiality.
    c. The information is being transmitted to and received by the NRC in confidence.
    d. No public disclosure of the information has been made, and it is not available in public sources. All disclosures to third parties, including any required transmittals to NRC, have been made, or must be made, pursuant to regulatory provisions or contractual agreements that provide for maintenance of the information in confidence.
    e. Public disclosure of the information is likely to cause substantial harm to the competitive position of NuScale, taking into account the value of the information to NuScale, the amount of effort and money expended by NuScale in developing the information, and the difficulty others would have in acquiring or duplicating the information. The information sought to be withheld is part of NuScale's technology that provides NuScale with a competitive advantage over other firms in the industry. NuScale has invested significant human and financial capital in developing this technology and NuScale believes it would be difficult for others to duplicate the technology without access to the information sought to be withheld.

I declare under penalty of perjury that the foregoing is true and correct. Executed on 9/25/2017.

Zackary W. Rad

Enclosure 4:

Affidavit of Nathan E. Hottle

NuScale Power, LLC
1100 NE Circle Blvd., Suite 200 Corvalis, Oregon 97330, Office: 541.360.0500, Fax: 541.207.3928
www.nuscalepower.com

AFFIDAVIT

COMMONWEALTH OF VIRGINIA)
) ss.
CITY OF LYNCHBURG)

1. My name is Nathan E. Hottle. I am Manager, Product Licensing, for AREVA Inc. (AREVA) and as such I am authorized to execute this Affidavit.

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

3. I am familiar with the AREVA information contained in the following document: "NuScale Power, LLC Response to NRC Request for Additional Information No. 8931 (eRAI No. 8931) on the NuScale Topical Report, 'Critical Heat Flux Correlation,' TR-0116-21012, Revision 0," referred to herein as "Document." Information contained in this Document has been classified by AREVA as proprietary in accordance with the policies established by AREVA Inc. 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 AREVA 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 AREVA to determine whether information should be classified as proprietary:

(a) The information reveals details of AREVA'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 AREVA.

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

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

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

7. In accordance with AREVA'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 AREVA only as required and under suitable agreement providing for nondisclosure and limited use of the information.

8. AREVA 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.

Martha E Hall

SUBSCRIBED before me this 13th

day of September, 2017.

Sherry L. McFaden
NOTARY PUBLIC, COMMONWEALTH OF VIRGINIA
MY COMMISSION EXPIRES: 10/31/18
Reg. # 7079129

SHERRY L. MCFADEN
Notary Public
Commonwealth of Virginia
7079129
My Commission Expires Oct 31, 2018