May 2, 2016

MEMORANDUM TO: Mark Tonacci, Chief
Licensing Branch 1
Division of New Reactor Licensing
Office of New Reactors

FROM: Demetrius Murray, Project Manager ***/RA/***
Licensing Branch 1
Division of New Reactor Licensing
Office of New Reactors

SUBJECT: AUDIT PLAN FOR NUSCALE CRITICAL HEAT FLUX TESTING AT KATHY (PROJ0769)

NuScale Power, LLC (NuScale) is expected to submit a topical report (TR) titled, "NuScale Critical Heat Flux Correlation," on the NSP-1 critical heat flux (CHF) correlation for U.S. Nuclear Regulatory Commission (NRC) review in September 2016 (Reference 1 in Enclosure below). Initial testing to develop the NSP-1 correlation was performed for NuScale by STERN Laboratories (STERN) in Ontario, Canada. Subsequently, NuScale has selected a different fuel vendor AREVA, Inc. (AREVA). During a pre-application meeting associated with the NSP-1 CHF correlation, NRC staff was informed by NuScale of fuel tests to be performed on AREVA fuel that is the type that will be used in the NuScale plant, at the KATHY facility in Karlstein, Germany (Reference 2). This additional testing is being performed to obtain data for AREVA HMP/HTP fuel in the ranges appropriate for safety analyses of the NuScale power module.

The purpose of the audit is to prepare for the expected submittal of the NSP-1 CHF TR in September 2016, such that a more efficient and timely review can be conducted. Issues intended to be addressed during this audit are characterized into two groups, issues associated with new phenomena and issues encountered in past reviews.

New phenomena, associated with a low flow rate, has been observed in tests previously conducted at STERN. NRC staff has questions regarding these observations, how it was inferred from the STERN data, and what does the KATHY data show about the impact of the HTP mixing grids.

Standard considerations that NRC staff has encountered during CHF reviews have been identified. A series of questions that NRC staff intends to address during the audit are provided in Attachment 1 to this Audit Plan.

CONTACT: Demetrius Murray, NRO/DNRL
301-415-4676

Project No.: PROJ0769

Enclosure:
As stated

cc: DC NuScale Power LLC Listserv

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Enclosures:
As Stated
cc: DC NuScale Power LLC Listserv

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DATE	05/02/2016	04/28/2016	05/2/2016	04/28/2016

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NuScale Power, LLC
Audit Plan for NuScale Critical Heat Flux Testing at KATHY

APPLICANT: NuScale Power, LLC

APPLICANT CONTACT: Steve Mirsky
Bob Houser
Steve Pope, et al.

DATE: May 7, 2016 - May 12, 2016

LOCATION: AREVA NP in Karlstein
Seligenstädter Str. 100
Karlstein, Germany

REVIEWERS: Timothy Drzewiecki (NRO/DSRA/SRSB)

PROJECT MANAGER: Demetrius Murray (NRO/DNRL/LB1)

A. Background

NuScale Power, LLC (NuScale) is expected to submit a topical report on the NSP-1 critical heat flux (CHF) correlation for U.S. Nuclear Regulatory Commission (NRC) staff review in September 2016 (Reference 1). Initial testing to develop the NSP-1 correlation was performed at STERN Laboratories (STERN) in Ontario, Canada. During a pre-application meeting associated with the NSP-1 CHF correlation, NRC staff was informed of additional tests that were to be performed at the KATHY facility in Karlstein, Germany (Reference 2). This additional testing is being performed to obtain data for AREVA HMP/HTP fuel in the ranges appropriate for safety analyses of the NuScale Power Module.

The purpose of the audit is to prepare for the expected submittal of the NSP-1 CHF Topical Report (TR), in September 2016, such that a more efficient and timely review can be conducted. Issues intended to be addressed during this audit are characterized into two groups, issues associated with new phenomena and issues encountered in past reviews.

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Enclosure

B. Regulatory Audit Bases

This regulatory audit is based on the following:

- General design criteria (GDC) from Appendix A to Title 10 *Code of Federal Regulations* Part 50
    - GDC 10, “Reactor design”
- Standard Review Plan Section 4.4, “Thermal Hydraulic Design”

C. Regulatory Audit Scope or Methodology

The audit team will view the test procedures, test apparatus, existing data, and available calculations. The audit team will also meet with subject matter expert(s) to discuss the testing, data collection, data reduction, and analysis.

D. Information and other material necessary for audit

The NRC staff requests the following be made available at the test facility (if some documents are needed sooner, then they should be specified and a date when the document needs to be sent to the NRC staff) to complete the audit:

- Test procedures for the CHF testing to be performed at the KATHY facility;
- Facility instrumentation calibration records;
- A draft of the current NSP-1 CHF correlation TR;
- A sample calculation note associated with data reduction (e.g. VIPRE input decks, calculation results); and
- Sample STERN and KATHY data over the same (or similar) parameter space.

E. Team Assignments

The audit team includes:

Timothy Drzewiecki, NRC staff (Reactor Systems, Nuclear Performance, and Code Review)

F. Logistics

Date: May 9, 2016 – May 11, 2016

Location: AREVA NP in Karlstein
Seligenstädter Str. 100
Karlstein, Germany

G. Special Requests

The NRC staff requests that NuScale provide:

1. A subject matter expert be made available to discuss the testing, data collection, data reduction, and analysis. Additionally, NRC staff wishes to discuss the content and expected modifications of the current draft NSP-1 CHF TR.

H. Deliverables

The audit team will issue an audit summary within 30 days of audit completion.

I. References

1. LO-0116-21371, "NuScale Power, LLC – Final Schedule for Topical Report Submittals", Jan. 28, 2016 (Agencywide Access and Management System (ADAMS) Accession No. ML16029A315)

2. PM-1115-19264-NP. Rev. 0, "NuScale Critical Heat Flux Correlation Topical Report Pre-Application Engagement with NRC," December 10, 2015 (ADAMS Accession No. ML15335A010)

Attachment 1 – Critical Heat Flux Audit Questions

1. Test Facility and General
    a. What is the history of the test facility?
    b. What are the biggest past mistakes and what things do you watch out for?
    c. How does the test facility replicate actual plant conditions?
    d. How does the test section produce the same flow field as a fuel bundle in the reactor?
    e. How do you demonstrate that you have representative geometry and appropriate scaling?
    f. What measurements are taken (e.g., power, flow, inlet subcooling, pressure)?
    g. What instruments are used to take the measurements?
    h. What is the uncertainty on the instruments?
    i. How are the instrument uncertainties addressed in the final critical heat flux (CHF) value?
    j. How are the instrument calibrated and how often?
    k. How is the power shape chosen?
    l. How is the power shape applied?
    m. How is it determined that it is the limiting power shape?
    n. What impact do heat losses have on the measurement of CHF (since not accounting for heat losses is non-conservative)?
    o. How often are measurements taken?
    p. How are measurements averaged?
    q. How do you take test points given the facility limitations and the Design of Experiment guidance (e.g., randomizing every input when you can't actually do that due to restrictions on the test facility)?

2. Quality Assurance
    a. Does the facility have a mandated quality assurance program?
    b. What are the test procedures and acceptance criteria?
    c. How is instrumentation calibrated? How often?

3. CHF state point data collection
    a. How is steady-state reached and maintained?
    b. What is the criteria for an established steady-state?
    c. What happens if the steady-state criteria is not maintained?
    d. What happens if the steady-state criteria is maintained but the measured CHF is much different than expected?
    e. Once steady-state has been reached, how is CHF approached?
    f. How is CHF measured?
    g. What signifies that CHF has occurred for a steady-state point?
    h. Do you examine the rods afterwards to determine that CHF has not occurred at another location (or that it is occurring where you believe it is)?
    i. Have you performed those observations for the NuScale assembly? What did you find?
    j. What data from the actual experiment is used to determine the CHF?
    k. What does the output file from the experiment look like?

4. Test repeatability
    a. What are issues in repeating the same test point over and over?
    b. How close can you get to repeating the same test parameters (i.e., pressure, flow, heat flux, inlet subcooling)?
    c. How strongly is repeatability influenced by system parameters (e.g. does a lower mass flow produce greater variance in my results)?
    d. How close is the resulting measured CHF value?
    e. How is uncertainty associated with test repeatability captured in the experimental data?

5. CHF transient data
    a. How is transient data used?
    b. How is steady-state reached and maintained prior to initiation of a transient?
    c. What parameters can be changed during a transient? How do these reflect the worst anticipated operational occurrence that can happen in a nuclear plant?
    d. What signifies that CHF has occurred for a transient point?

6. Data reduction
    a. How is data reduction performed (i.e. how the instrument values from the experiment turn into the parameters of interest (e.g., mass flow turns into a local mass flux))?
    b. How do you determine the "predicted" CHF value? Is it the value at the same rod and axial location as the test? Is it determined some other way?
    c. How is the experimental uncertainty incorporated into the measured or predicted CHF value?

7. Correlational Development
    a. How did you develop the CHF correlation form?
    b. How did you determine the CHF correlation coefficients?
    c. Given the non-linear form, how "sensitive" are you typically to the initial guess?
    d. Can you provide a phenomenological explanation of CHF at the various points in the application domain?
    e. Do you reserve any data for determining the uncertainty which was not used in generating the correlation's coefficients?

8. Correlation Behavior
    a. Are your M/P errors independent of location in the application domain?