February 14, 2019

Docket No. 52-048

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

SUBJECT: NuScale Power, LLC Supplemental Response to NRC Request for Additional Information No. 433 (eRAI No. 9474) on the NuScale Design Certification Application

REFERENCES:
1. U.S. Nuclear Regulatory Commission, "Request for Additional Information No. 433 (eRAI No. 9474)," dated April 23, 2018
2. NuScale Power, LLC Response to NRC "Request for Additional Information No. 433 (eRAI No.9474)," dated September 24, 2018

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

The Enclosures to this letter contain NuScale's supplemental response to the following RAI Question from NRC eRAI No. 9474:

- 06.02.06-22

Enclosure 1 is the proprietary version of the NuScale Supplemental Response to NRC RAI No. 433 (eRAI No. 9474). NuScale requests that the proprietary version be withheld from public disclosure in accordance with the requirements of 10 CFR § 2.390. The enclosed affidavit (Enclosure 3) supports this request. Enclosure 2 is the nonproprietary version of the NuScale response.

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 Marty Bryan at 541-452-7172 or at mbryan@nuscalepower.com.

Sincerely,

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

Distribution: Gregory Cranston, NRC, OWFN-8H12
Omid Tabatabai, NRC, OWFN-8H12
Samuel Lee, NRC, OWFN-8H12

Enclosure 1: NuScale Supplemental Response to NRC Request for Additional Information eRAI No. 9474, proprietary

Enclosure 2: NuScale Supplemental Response to NRC Request for Additional Information eRAI No. 9474, nonproprietary

Enclosure 3: Affidavit of Zackary W. Rad, AF-0219-64518

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Enclosure 1:

NuScale Supplemental Response to NRC Request for Additional Information eRAI No. 9474, proprietary

Enclosure 2:

NuScale Supplemental Response to NRC Request for Additional Information eRAI No. 9474, nonproprietary

Response to Request for Additional Information
Docket No. 52-048

eRAI No.: 9474
Date of RAI Issue: 04/23/2018

NRC Question No.: 06.02.06-22

The regulatory bases for the question below are:

10 CFR 50.12 Specific Exemptions, (a)(1) The Commission may…grant exemptions from the requirements of the regulations which …will not present an undue risk to the public health and safety.

10 CFR 52.47, Contents of Applications; technical information, (a) The application must contain a final safety analysis report (FSAR) that describes the facility, presents the design bases and the limits on its operation, and presents a safety analysis of the structures, systems, and components and of the facility as a whole, and must include the following information: (2) A description and analysis of the structures, systems, and components (SSCs) of the facility, with emphasis upon performance requirements, the bases, with technical justification therefor, upon which these requirements have been established, and the evaluations required to show that safety functions will be accomplished. The description shall be sufficient to permit understanding of the system designs and their relationship to the safety evaluations.

10 CFR 52.47 Contents of Applications; technical information,

(a)(2)(iv) which states, in part "The applicant shall perform an evaluation and analysis of the postulated fission product release, using the expected demonstrable containment leak rate … to evaluate the offsite radiological consequences."

10 CFR 50, GDC 16—Containment design. Reactor containment and associated systems shall be provided to establish an essentially leak-tight barrier against the uncontrolled release of radioactivity to the environment and to assure that the containment design conditions important to safety are not exceeded for as long as postulated accident conditions require.

10 CFR 50, Appendix J, defines La as the maximum allowable containment leakage rate in weight percent per day at peak containment accident pressure, Pa. The combined leakage rate of all penetrations and valves subject to Type B and C tests shall be less than 0.60 La.

This is a followup to RAI 271-9147, question 6.2.6-4.

10 CFR 50, Appendix J, requires that primary reactor containments meet the containment leakage test requirements to provide for preoperational and periodic verification by tests of the leak-tight integrity of the primary reactor containment, and systems and components which penetrate containment.

NuScale, has selected La to be 0.20 weight percent of the containment air mass per day at the peak containment accident pressure, Pa. La is established as a safety analysis operational limit and the containment Technical Specification limit for operability for the NuScale design. This maximum allowed leakage rate is the basis for the accident radiological leakage to the environment.

NuScale is requested to describe how the maximum allowable leak rate, La, will be demonstrated. Typically this would be shown through a combination of preoperational and periodic Types A, B and C testing. Since NuScale has requested an exemption from Appendix J Type A test requirements, this demonstration should include the technical basis for concluding that Types B and C testing are sufficiently representative of accident conditions to provide confidence that the test results from Types B and C assure that the assumed leak rate, La, would not be exceeded. Additionally, as required by 10 CFR 50, Appendix J, the acceptance criteria for Types B and C tests is to show that the expected leakage from all local penetrations, Types B and C, is less than 0.60 La. This demonstration should consider the differences in test volume pressurization during Type A and Types B and C testing and their potential impact on the test results. For example, the stresses on a bolted connection would be significantly different during Type A testing, where the containment volume is held at accident pressure, than a Type B test, where only the volume between a double o-ring seal is pressurized.

NuScale Response:

The following is summary information taken from the containment vessel (CNV) bolted flange calculation, which was provided for Nuclear Regulatory Commission (NRC) audit. Methodology used to perform the CNV bolted flange calculation is provided in TR-1116-51962, “NuScale Containment Leakage Integrity Assurance.” This supplemental response provides additional

information to address questions discussed during a January 17, 2019 closed call, regarding the bolted flange calculation which was completed to show that the flanges maintain contact pressure under accident conditions. In addition, changes to FSAR Sections 3.8.2, 6.2 and Table 14.2-43, along with changes to TR-1116-51962, "Containment Leakage Integrity Assurance Technical Report that were discussed with the staff are included, as well.

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}}2(a),(c)

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}}2(a),(c)

The following information was provided, concerning the behavior of a typical bolted flange joint, during a closed NRC call held on January 24, 2019:

Maintaining contact pressure, with reference to a typical seal characteristic curve (see Figure 1) ensures that the seals remain within their operating range established in their corresponding characteristic curves. As preload is applied the seal begins to compress to a point where the seal can accommodate minor changes due to pressure and temperature, which is indicated by the GREEN dot in Figure 1. The seal continues to be compressed until it reaches its optimal condition at the RED dot in Figure 1. When flanges are loaded by pressure inside of the vessel, decompression of the seal (spring back) may occur with prying and follow the down arrow line in Figure 1 below. The BLUE dot indicates the largest spring back the seal could incur and still expect to maintain the same seal as the optimal condition. When flange contact is maintained it is ensured that the seal configuration stays at the RED dot (optimal compression) in the figure and no practical decompression of the seal occurs. Since the seals for the CNV bolted flange connections are placed in a groove the seals are displacement controlled. So the transition from the GREEN dot to the RED dot will be very flat with very little additional load being applied to

seal as the stud preload is applied. At this time, the stud preload begins compressing the flange surface. The margin for the seal in this case is the full useful elastic recovery of the seal.

Figure 2 shows an example plot illustrating what happens with a bolted joint. As internal pressure increases there are three distinct regions that can be clearly identified:

- Region 1 (Maintaining Contact Region): The bolt (stud) load (RED line) changes very little from the preload that is applied, contact pressure is maintained on the flanges and no gap forms (BLUE line). So there is no reliance of the seals spring back to maintain the seal.
- Region 2 (Prying Region): Load on the bolt increases in a non-linear fashion and contact pressure begins to reduce in a progressive manner along the flange mating surfaces. This is a highly non-linear region and separation increases with small increases in internal pressure.
- Region 3 (Joint Open Region): The contact surface between the flange mating surfaces are entirely overcome and the joint physically separates. In this region any increase in internal pressure will linearly increase stud load. The seal is lost in this region and eventually the stud strength exhausted.

NuScale considers that a tight joint, as required by the ASME code, is as described further below in this supplemental response and is maintained in Region 1 and Region 2 of Figure 2. The transition from Region 1 to Region 2 is effected by the preload applied to the stud. The higher the preload the farther to the right in Figure 2 the transition to the prying and opening region occurs.

Since the seal design is displacement controlled, by maintaining contact pressure the containment vessel bolted flange joints are always operating at the location of the red dot in Figure 1, regardless if the joint is at peak pressure or Type B test conditions. Until the flanges separate the seal will be maintained in the same condition. The preload that is applied to the containment vessel bolted flange connections places the joint behavior during peak accident pressure at the end of the maintaining contact pressure region or start of the prying region shown in Figure 2.

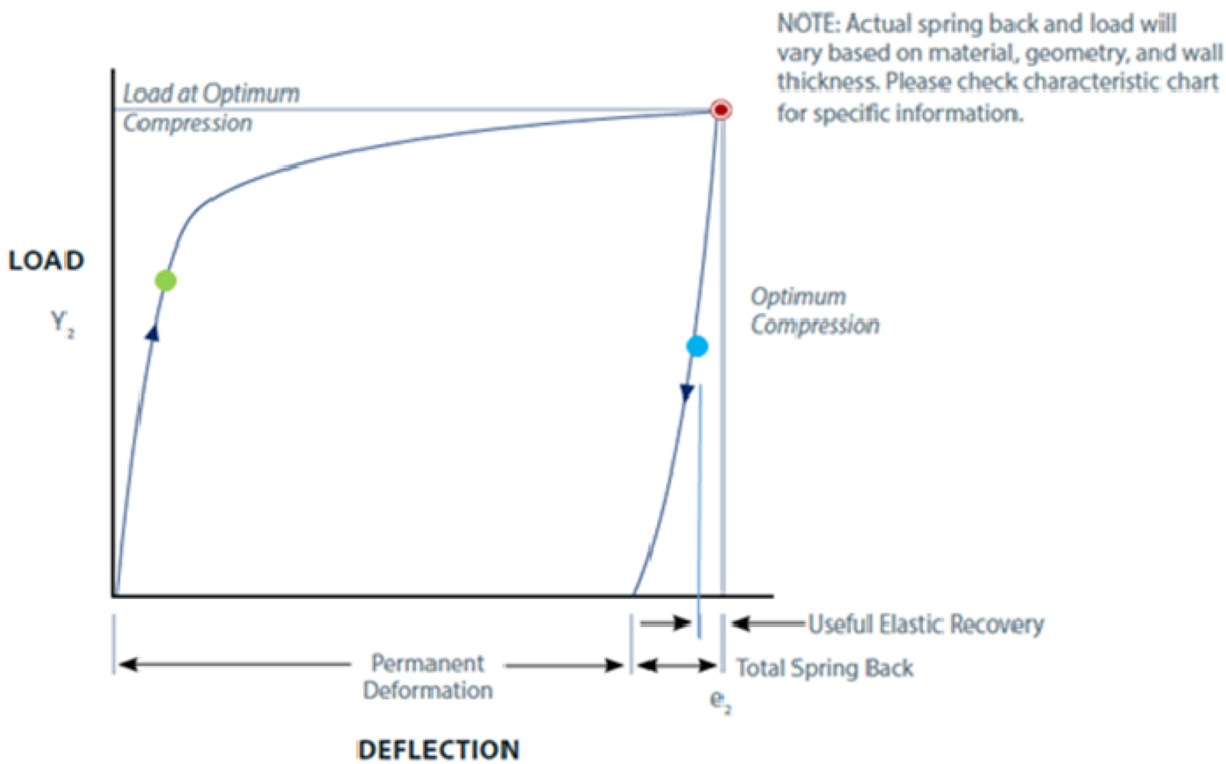

Figure 1 Typical seal characteristic curve

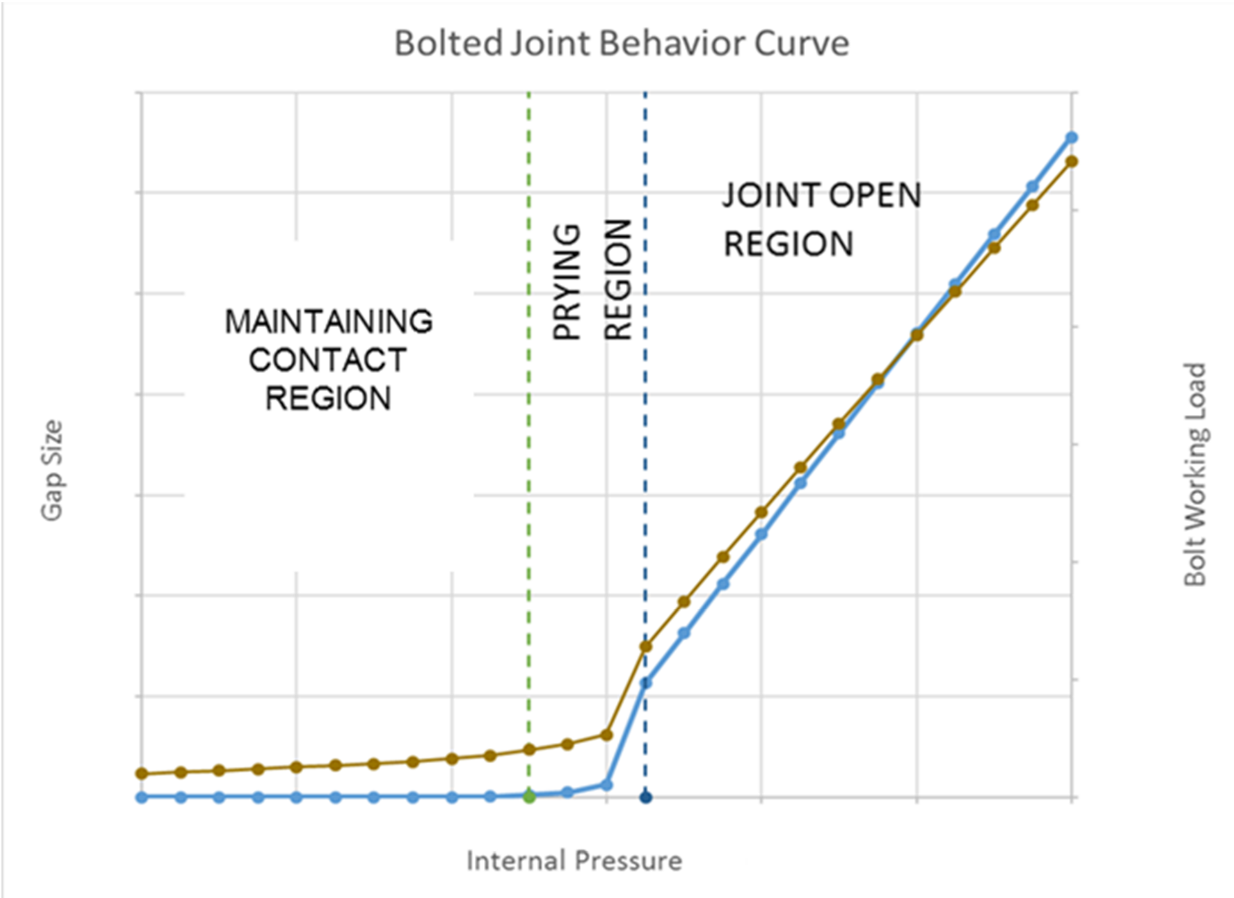

Figure 2 Example plot of bolted joint behavior

The American Society of Mechanical Engineers (ASME) Boiler and Pressure Vessel Code (B&PVC) does not provide a specific definition for “tight joint”, but provides discussion of a “tight joint” in multiple locations of the ASME B&PVC, such as Subsection NG and the Appendices. The clearest discussion on “tight joint” is provided in ASME B&PVC, Subparagraph XI-1122.1 of mandatory Appendix XI, which says:

> *“The Design Conditions are those required to resist the hydrostatic end force of the Design Pressure tending to part the joint and to maintain on the gasket or joint contact surface sufficient compression to assure a tight joint, all at the Design Temperature. The minimum load is a function of the Design Pressure, the gasket material, and the effective gasket or contact area to be kept tight under pressure [as calculated by eq. XI-3221.1(1) and determines one of the two requirements for the amount of bolting A_{m1}. This load is also used for the design of the flange in eq. XI-3223(3).”*

Eq. XI-3221.1(1):

$$W_{m1} = H + H_p = 0.785\,G^2 P + (2b + 3.14\,GmP)$$

NuScale's definition of a “tight joint” as used in internal flange calculations assures that contact on the mating surface is maintained and that the internal pressure of the vessel does not overcome the compression of the flange applied by the preload of the stud, causing the stud to begin to carry more load than the preload that was applied (Region 1 and Region 2 in Figure 2). Because of prying, which typically occurs on a joint, a larger preload may need to be applied to assure that the flanges remain in contact (Region 1 in Figure 2) which provides reasonable assurance that the seal would demonstrate similar flange gaps at peak accident pressure as would be shown during the Type B test.

Impact on DCA:

FSAR Sections 3.8.2, 6.2 and 14.2 and related Technical Report TR-1116-51962, NuScale Containment Leakage Integrity Assurance, have been revised as described in the response above and as shown in the markup provided with this response.

RAI 06.02.06-22S1

After fabrication of the CNV is completed, a shop hydrostatic test of the vessel is performed to Article NB-6000 requirements. Prior to hydrostatic testing, 100 percent of the pressure boundary welds are inspected. Inspection is performed in accordance with Subarticle NB-5280 and Subarticle IWB-2200 using examination methods of ASME Code, Section V except as modified by ASME Code, Section III, Paragraph NB-5111. The hydrostatic pressure and temperature are held for a minimum of 10 minutes. The pressure is then decreased to design pressure and held, then ~~for a minimum of four hours and~~ the CNV is inspected for leaks. After the test is completed, pressure boundary welds are inspected again to the same requirements used prior to the test. The ASME Code, Section III, Article NB-6000 hydrostatic test is performed to a greater pressure than required by Article NE-6000. That is, Paragraph NE-6321 specifies a minimum test pressure of only 110 percent and Paragraph NE-6322 specifies a maximum test pressure of 116 percent. The CNV is tested to a pressure 15 percent greater than conventional steel containment structures and 25 percent greater than design pressure in accordance with NB-6221.

RAI 03.06.02-6, RAI 06.02.01.01.A-18S1

The CNV design pressure and temperature of 1,050~~00~~ psia and 550 degrees F bounds design basis events including a LOCA. The design condition pressure exceeds the requirements of ASME Code, Section III, Paragraph NCA-2142.1(a) and NB-3112.1(a) by bounding the most severe Level A service level pressure and the requirements of Paragraph NE-7120(b) by the design not exceeding service limits specified in the design specification.

RAI 03.06.02-6

The design does not have a typical postulated LOCA compared to traditional PWR reactor coolant systems. Reactor coolant in the NuScale design is captured by the CNV and passively recirculated through the RPV and core by the ECCS (see Section 6.3). The reactor coolant level is never below the level of the core and reactor coolant makeup is not required. The reactor coolant piping within the CNV is NPS 2. Secondary-side piping for feedwater and main steam are larger. Breaks in the feedwater and main steam pipes within the CNV are not considered because of leak-before-break design and monitoring. Breaks in these piping systems outside containment are excluded as discussed in Section 3.6.2.1.2. Pipe breaks for reactor coolant piping inside containment and spurious opening of a reactor safety valve or reactor vent valves are addressed in Appendix 3A. Pipe breaks and spurious valve openings inside the CNV are evaluated as DBPBs. The DBPB load is evaluated to Level C service limits and, when combined with SSE loads, is evaluated to Level D service limits. Reactor Coolant System Chemical and Volume Control System (RCS CVCS) line breaks outside of the CNV are evaluated to Level D service limits. Blast effects, pipe whip, and jet impingement caused by a pipe break are discussed in Section 3.6.2.2.1, Section 3.6.2.2.2, and Section 3.6.2.2.3, respectively.

The guidelines of RG 1.57 recommend DBPB loads to be evaluated to Level B service limits and DBPB combined with SSE loads to be evaluated to Level C service limits. Because the CNV is designed, fabricated, inspected, and tested as an NB Class 1 vessel, evaluation of these loads to more restrictive allowable limits is conservative. The

The Type B test pressure is the containment peak accident pressure. The leak rate is established by containment leakage rate program.

Pneumatic testing at a pressure not to exceed 25 percent of design pressure may be applied prior to a hydrostatic test, as a means of locating leaks, in accordance with ASME Code, Section III, Paragraph NB-6112.1(b).

RAI 06.02.01.01.A-18S1, RAI 06.02.06-22S1

Hydrostatic testing of the CNV is done in accordance with the requirements of NB-6000. The CNV is pressurized using water to a minimum pressure of 1,2981,250 psig and a maximum pressure of 1,3751,325 psig, the pressure being measured at the bottom of the CNV. The test is performed with the CNV at a minimum temperature of 70 degrees F and a maximum temperature of 140 degrees F. Following a minimum time of 10 minutes at the hydrostatic test pressure, pressure is reduced to design pressure and held for at least four hours beforewhile examining for leaks.

If the CNV is hydrostatically tested with the RPV installed, both primary and secondary sides of the RPV are vented to the CNV to preclude a differential pressure external to the RPV greater than considered for design of the RPV.

The hydrostatic test procedure includes measures for sampling the test fluid (water) which contacts the CNV during hydrostatic testing.

Drain water is tested following hydrostatic testing for compliance with the purity requirements. The hydrostatic test procedure includes corrective actions to be taken (e.g. circulating flushes or fill and drains) in the event the exit fluid exceeds purity requirements.

Immediately following hydrostatic testing, the CNV is drained and dried by circulating air until the exit air dew-point temperature is less than 50 degrees F. The circulating air is oil free and does not to contain combustion products from the heating source. The temperature of the dry heated air is controlled to preclude damage to the SGs due to excessive differential temperature.

The shop hydrostatic tests of the CNV are witnessed by an authorized nuclear inspector and a NuScale inspector.

No leakage indications at the examination pressure are acceptable.

3.8.2.8 References

3.8.2-1 U.S. Nuclear Regulatory Commission, "Effect of LWR Coolant Environments on the Fatigue Life of Reactor Materials," NUREG/CR-6909, Draft Report for Comment.

3.8.2-2 U.S. Nuclear Regulatory Commission, "Containment Integrity Research at Sandia National Laboratories - An Overview," NUREG/CR 6906, July 2006.

RAI 03.09.03-1

The CES is isolated during design basis and beyond design basis events. However, the monitors can be used for combustible gas control and accident management, including emergency planning. This is described in more detail by Reference 6.2-3, Section 2.7.

6.2.6 Containment Leakage Testing

Containment leakage rate testing is designed to verify the leak tight integrity of the reactor containment. The CIVs on CNV piping penetrations, and the passive containment isolation barriers are designed to permit the periodic leakage testing described in GDCs 53 and 54 to ensure leakage through the CNTS and components does not exceed the allowable leakage rate specified in Technical Specifications. Compliance with GDCs 52, 53 and 54 is further described in Section 3.1. The NuScale design supports an exemption from the integrated leak rate testing specified in the GDC 52 criterion. Further details are provided by Reference 6.2-6.

The preoperational and periodic containment leakage testing requirements and acceptance criteria that demonstrate leak-tight integrity of the CNTS and associated components are prescribed in 10 CFR 50, Appendix J and implemented through the reactor containment leakage rate testing program described in Section 5 of the Technical Specifications.

The design of containment penetrations support performance of local leak rate tests (Type B and Type C tests) in accordance with the guidance provided in ANSI/ANS 56.8, Regulatory Guide 1.163, and NEI 94-01. The NuScale system design, in conformance with 10 CFR 50.54(o), accommodates the 10 CFR 50, Appendix J, test method frequencies of Option A or Option B.

COL Item 6.2-1: A COL applicant that references the NuScale Power Plant design certification will develop a containment leakage rate testing program that will identify which option is to be implemented under 10 CFR 50, Appendix J. Option A defines a prescriptive-based testing approach whereas Option B defines a performance-based testing program.

RAI 06.02.06-22, RAI 06.02.06-23

COL Item 6.2-2: A COL applicant that references the NuScale Power Plant design certification will verify that the final design of the containment vessel meets the design basis requirement to maintain flange contact pressure at accident temperature, concurrent with peak accident pressure.

RAI 06.02.06-22, RAI 06.02.06-22S1, RAI 06.02.06-23

A containment flange bolting calculation demonstrates each containment flange design at design bolting preload, maintains flange contact pressure at accident temperature, concurrent with peak accident pressure. Maintaining flange contact pressure is demonstrated by analysis showing that the flange surfaces of the bolted connection have no separation of the flanges from the inboard seal to the containment inner surface when peak accident pressure is applied to the inside of the containment vessel. This provides reasonable assurance that the seal would demonstrate similar flange gaps at peak accident

pressure as would be shown during the Type B test. Therefore, the leakage rate measured during the Type B test would be representative of leakage at peak accident pressure.

To verify the leak tightness of the reactor containment, a preservice design pressure leakage test and Type B and Type C tests are performed prior to initial operations and Type B and Type C tests are periodically performed thereafter to assure that leakage rates through the containment and the systems or components that penetrate containment do not exceed the maximum allowable leak rate. The CNV preservice design pressure leakage test is performed as specified in Section 6.2.6.5. Flange preload verifications are performed to ensure that flange bolting is preloaded to design requirements.

The specified maximum allowable containment leak rate, La, is 0.20 weight percent of the containment air mass per day at the calculated peak accident pressure, Pa, identified in Section 6.2.1. Containment leak rate testing is designed to verify that leakage from containment remains within the prescribed Technical Specification limits.

The reactor containment, containment penetrations, and isolation barriers are designed to permit periodic leakage rate testing in accordance with GDC 53 and GDC 54 independent of other NuScale Power Modules.

6.2.6.1 Containment Integrated Leakage Rate Test

The NuScale CNV design is different from traditional containments and exempt from GDC 52 criterion because integrated leakage rate testing as described of 10 CFR 50 Appendix J, Type A tests, are not required to meet the purpose of the rule. Specifically, the CNV is

- a high pressure vessel.
- an ASME Class MC component constructed to ASME Class 1 vessel rules.
- constructed of all stainless steel clad or stainless materials.
- designed with penetrations that are either ASME Class 1 flanged joints capable of Type B testing or ASME Class 1 welded nozzles with isolation valves capable of Type C testing.
- inaccessible (interior) to personnel during startup, shutdown and normal operation.
- under a vacuum and partially immersed in borated water during normal operation.
- constantly monitored during normal operation for containment vacuum and leakage into containment.
- disassembled by separating the upper and lower CNV shells during outages for refueling, maintenance and inspection.

GDC 52 requires that containments are designed so that periodic integrated leakage rate testing can be conducted at containment design pressure. The purpose of GDC 52 is to provide design capability for testing to verify leakage tightness to ensure continued leakage integrity of the CNTS. The CNTS meets the purpose of the rule due to the unique features of the NuScale Power containment design.

- Manufacturing and preservice test and inspections are similar to RPV requirements.
- All known leakage pathways will be Type B or Type C tested.
- Comprehensive ISI will meet ASME Class 1 criteria to ensure no new leakage pathways develop.

RAI 06.02.06-22, RAI 06.02.06-23

The CNV is an ASME Subsection NE, Class MC containment, and is designed, fabricated, and stamped as an ASME Subsection NB, Class 1 pressure vessel, except that overpressure protection is in accordance with NE 7000, see Subsection 3.8.2. The CNV is made of corrosion resistant materials, has a low number of penetrations, and no penetrations have resilient seals. The use of all welded nozzles and testable flange seals at every containment penetration ensure that Type B and C testing provides an adequate assessment of containment leak rate. A containment flange bolting calculation provides assurance that containment flanges maintain contact pressure at accident temperature concurrent with peak accident pressure.

The NuScale design has fewer and smaller potential leak pathways than traditional, large pressurized water reactors, which provides a meaningful safety advantage. The small size of the containment allows for factory fabrication, which facilitates increased quality and testing control than field construction.

Pressure retaining and integrally attached materials meet the requirements of ASME Subsections NB-5000 and NF-5000 using the examination methods of ASME Section V. All surfaces to be clad will be magnetic particle or liquid penetrant examined in accordance with ASME Subsections NB-2545 or NB-2546, respectively.

Preservice examinations for ASME Class 1 pressure boundary items will be performed in accordance with ASME Subsection NB-5280 and ASME Section XI, Subsection IWB-2200 using the examination methods of ASME Section V, except as modified by ASME Subsection NB-5111. These preservice examinations include 100 percent of the pressure boundary welds.

Final preservice examinations will be performed after hydrostatic testing but prior to code stamping.

RAI 06.02.06-22, RAI 06.02.06-22S1, RAI 06.02.06-23

The CNV is hydrostatically tested in accordance with ASME Subsection NB-6000. The test is conducted with the RPV installed and vented. The water-filled CNV is pressurized to a minimum of 25 percent over design pressure for at least ten minutes. Pressure is then reduced to design pressure and held ~~for at least four hours~~ ~~prior to~~while examining for leaks. The acceptance criterion is no leakage indications at the examination pressure (design pressure). Each CNV undergoes a preservice design pressure leakage test which tests all CNV bolted flange connections under design preload at design pressure, as described in Section 6.2.6.5. The acceptance criterion is no observed leakage from CNV bolted flange connections at examination pressure.

ASME Class MC, Section IWE, only requires visual examination for SSC subject to normal degradation and aging. Surface areas that are subject to accelerated degradation and

6.2.6.2 Containment Penetration Leakage Rate Test

The CNV is designed for Type B pneumatic tests (local penetration leak tests) to detect and measure leakage across the pressure retaining, leakage limiting boundaries that include flange openings (bolted connections), flanges, I&C penetration assemblies, and electrical penetration assemblies. The leakage limiting boundary is pressurized with air or nitrogen and the pressure decay or the leak flow rate is measured.

Preoperational and periodic Type B leakage rate testing is performed in accordance with 10 CFR 50, Appendix J, NEI 94-01, and ANSI-56.8 within the defined test intervals. The containment penetrations subject to Type B tests are identified in Table 6.2-4.

The following containment penetrations are subject to preoperational and periodic Type B leakage rate tests:

- flange openings with bolted connections
- main CNV flange
- electrical penetration assemblies
- ECCS trip/reset valve body-to-bonnet connection

RAI 06.02.06-22S1

All CNV bolted closures have dual ~~o-ring~~ seals and a testing port between the seals.

RAI 06.02.06-22S1

All CNV flange openings that have bolted connections are designed and constructed to ASME Class 1. All of these openings have ~~an~~ identical double ~~o-ring~~ seals with a test port to facilitate Type B testing by pressurizing between the seals. The main CNV flange has a similar double ~~o-ring~~seal and test port arrangement. Flanges that are under water during normal operation shall be provided with the capability to evacuate water between the flange seals prior to performing any Type B test. All flanges shall have no excess water between the flange seals prior to startup.

Electrical penetration assemblies (EPAs) use an established glass-to-metal sealing technology that is not vulnerable to thermal or radiation aging, do not require periodic maintenance, and will achieve a less than minimum detectable leak rate. These EPAs are installed in a CNV penetration which includes a testable flange connection. Installed EPAs are limited to local leak rate test acceptance criteria. The NuScale design includes the ability to test the double ~~o~~O-ring seals by pressurizing between the seals. An EPA would only be disassembled for modification or if leakage was indicated.

RAI 03.08.02-14S1

There are five ECCS main valves supported by eleven trip and reset valves for actuation. Each actuation valve has redundant testable seals between the valve body and bonnet. A test port between the seals facilitates Type B testing. Since the actuator valve is both a containment and RCS pressure boundary, a seal test on the ECCS trip/reset actuator valve seals to RCS pressure will be performed. See Section 5.2.4.1 for the details of the seal test to be performed.

The leakage test summary report includes descriptions of the containment inspection method, any repairs necessary to meet the acceptance criteria, and the test results. The summary report includes periodic leakage test results from the Type B and C tests. Leakage test results from Type B and C tests that failed to meet the acceptance criteria are included in a separate accompanying summary report that includes an analysis and interpretation of the test data, the least squares fit analysis of the test data, the instrumentation error analysis, and the structural conditions of the containment or components, if any, that contributed to the failure in meeting the acceptance criteria. Results and analyses of the supplemental verification test employed to demonstrate the validity of the leakage rate test measurements are also included.

6.2.6.5 Special Testing Requirements

RAI 06.02.06-22, RAI 06.02.06-23

6.2.6.5.1 Testing Following Major Component Modification or Replacement

Major modifications or replacement of components that are part of the containment boundary performed after preoperational leakage rate testing is followed by a Type B or Type C test as applicable for the area affected by the modification. The measured leakage from the test is included in the summary report.

RAI 06.02.06-22, RAI 06.02.06-23

6.2.6.5.2 Preservice Design Pressure Leakage Test

RAI 06.02.06-22, RAI 06.02.06-22S1, RAI 06.02.06-23

Each CNV undergoes a preservice design pressure leakage test which tests CNV bolted flange connections under design preload at CNV design pressure. The preservice design pressure leakage test is performed with the containment vessel filled with water similar to a hydrostatic test. The preservice design pressure leakage test of the initial as-built containment vessel is performed on an assembled containment vessel using the as-designed flange covers, installed with the design bolting materials, design bolting preloads and design seals installed. Covers with electrical and instrumentation penetrations may be substituted with blank covers having the same bolting and sealing design as the inservice covers. The test configuration may utilize blanked off pipe ends in place of the containment isolation valves. The upper and lower halves of subsequent containment vessels may be tested separately. At design pressure, and a test temperature of a minimum of 70 degrees F and a maximum of 140 degrees F, a leakage check of the CNV bolted flange connections is performed after a minimum of a 30 minute hold time at design pressure. The acceptance criterion is no observed leakage from seals at examination pressure.

RAI 06.02.06-22, RAI 06.02.06-23

Each ECCS trip valve and reset valve contains a body-to-bonnet joint that is also subject to Type B test requirements. The body-to-bonnet seal is designed for RCS design pressure. This seal is tested to meet both Type B and RCPB criteria every

RAI 06.02.06-22S1

Table 14.2-43: Containment System Test # 43

Preoperational test is required to be performed for each NPM.		
The CNTS is described in Section 6.2 and the functions verified by this test are:		
System Function	**System Function Categorization**	**Function Verified by Test #**
1. The CNTS supports the RXB by providing a barrier to contain mass, energy, and fission product release from a degradation of the reactor coolant pressure boundary.	safety-related	Test #43-1
2. The CNTS supports the ECCS operations by providing a sealed containment.	safety-related	Test #43-1
3. The ECCS supports CNTS by providing a portion of the containment boundary for maintaining containment integrity.	safety-related	Test #43-1
The CNTS functions verified by other tests are:		
System Function	**System Function Categorization**	**Function Verified by Test #**
The CNTS supports the DHRS by closing containment isolation valves (CIVs) for the main steam and feedwater systems when actuated by the MPS for DHRS operation.	safety-related	MPS Test #63-6
The CNTS supports the RCS by closing the CIVs for pressurizer spray, RCS injection, RCS discharge, and reactor pressure vessel (RPV) high point degasification when actuated by the MPS for RCS isolation.	safety-related	MPS Test #63-6
The CNTS supports the RXB by providing a barrier to contain mass, energy, and fission product release by closure of the CIVs upon a containment isolation signal.	safety-related	MPS Test #63-6
The CNTS supports the Reactor Building crane (RBC) by providing lifting attachment points that the RBC can connect to so that the module can be lifted.	non-safety related, risk-significant	RBC Test #52-1 RBC Test #52-2
The CNTS supports the MPS by providing post-accident monitoring (PAM) nonsafety-related information signals	non-safety related	SDIS Test #66-2
Prerequisites Verify an instrument calibration has been completed, with approved records and within all calibration due dates, for all instruments required to perform this test.		

Table 14.2-43: Containment System Test # 43 (Continued)

Component Level Tests		
Test Objective	**Test Method**	**Acceptance Criteria**
i. Verify the CNTS safety-related check valves change position under design differential pressure and flow. ii. Verify each CNTS instrument is available on an MCS or PCS display. (Test not required if the instrument calibration verified the MCS or PCS display.) iii. Verify each hydraulic skid supplies sufficient pressure for valve operation.	i. The check valves are tested in accordance with the requirements of ASME OM code, ISTC-5220, check valves. ii. Initiate a single real or simulated instrument signal from each CNTS transmitter. iii. Start hydraulic skid.	i. Each CNTS safety-related check valve strokes fully open and closed under forward and reverse flow conditions, respectively. [ITAAC 02.01.21] ii. The instrument signal is displayed on an MCS or PCS display, or is recorded by the applicable control system historian. iii. Pump maintains required system pressure.
System Level Test #43-1		
Test Objective	**Test Method**	**Acceptance Criteria**
Verify the leaktightness of the containment system.	Perform 10 CFR Part 50, Appendix J local leak rate tests (Type B and Type C tests) of the CNTS in accordance with the guidance provided in ANSI/ANS 56.8,RG 1.163, and NEI 94-01.	Local leak rate tests are completed on containment penetrations listed in Table 6.2-49 which require Appendix J, Type B or C testing. [ITAAC 02.01.07]

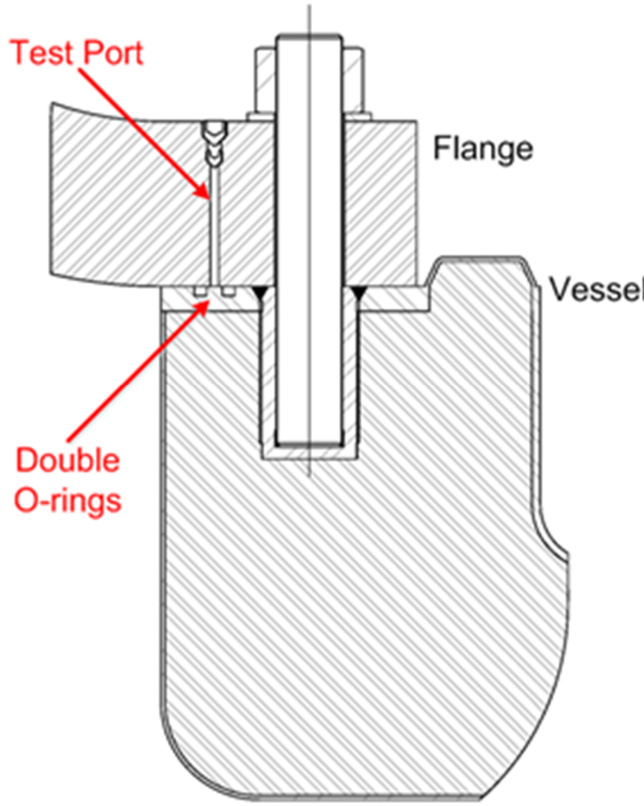

Figure 3-4 Containment vessel head/port flange (typical)

Maintaining flange contact pressure is demonstrated by analysis showing that the flange surfaces of the bolted connection have no separation of the flanges from the inboard seal to the containment inner surface when peak accident pressure is applied to the inside of the containment vessel. This provides reasonable assurance that the seal would demonstrate similar flange gaps at peak accident pressure conditions as would be shown during the Type B test.

The following CNV bolted flanged openings are evaluated for maintaining contact pressure between the flanges from the inboard seal to the containment inner surface to show there is no separation of the flanges due to the inadvertent reactor recirculation valve (RRV) opening and chemical and volume control system (CVCS) injection line accident events:

- Closure flange – 170 inch
- Pressurizer (PZR) heater access ports – 44 inch (CNV31/32)
- Steam generator (SG) inspection ports – 38 inch (CNV27/28/29/30)
- Manway (shell) port – 38 inch (CNV26)
- Control rod drive mechanism (CRDM) access opening – 67 inch (CNV25)
- CRDM power penetration – 17 inch (CNV37)
- Rod position indication (RPI) penetrations – 10 inch (CNV 38/39)

- Manway (head) – 18 inch (CNV24)
- PZR power penetrations – 12 inch (CNV15/16)
- Instrumentation & control (I&C) – channel A/B/C/D penetrations – 8 inch (CNV17/18/19/20)
- I&C – division 1/2 penetrations – 3 inch (CNV8/9)

This evaluation ensures that the flanges maintain contact pressure and therefore do not pry apart while under peak accident pressure at a minimum. This provides reasonable assurance that the seal would demonstrate similar flange gaps at peak accident pressure as would be shown during the Type B test. Therefore, the leakage rate measured during the Type B test would be representative of leakage at peak accident pressure.

The seals for all of the CNV bolted flange connections are comprised of two concentric grooves with a seal positioned in each groove at each bolted flange connection. The seal material is a metal alloy and plated for improved sealing ability. The seal metal and plating are corrosion resistant based on exposure to the borated water chemistry. The seals are capable of a service temperature greater than the 550°F CNV design temperature. The preload applied to the bolted flange connections is sufficient to apply the seal seating load with sufficient preload remaining to maintain flange contact pressure at peak accident pressure conditions.

An analysis to demonstrate that the NuScale flange designs would maintain contact pressure, at peak bounding pressure, for assumed seal characteristics, was performed in the CNV bolted flange calculation. This calculation resulted in the stud preload values for each flange and these values are provided in Table 3-1 below. COL Item 6.2-2 ensures that the final design of the containment vessel, including the final seal design, meets the design basis requirement to maintain flange contact pressure at accident temperature concurrent with peak accident pressure.

{{

}}2,(a),(c)

{{

}}2,(a),(c)

Table 3-1 CNV bolted flange calculation applied preloads

{{

}}2,(a),(c)

The metal temperature of the CNV is taken from a heat transfer analysis of accident conditions at the time CNV peak pressure occurs. The accident event pressure transient is evaluated by analyzing a pressure equal to or greater than the peak pressure for that accident.

The temperature transient inside of the CNV and the reactor pool outside of the CNV for the accident conditions are used as the bulk fluid temperature for inside and outside of the CNV respectively. The CNV metal surface temperatures are used to calculate the heat transfer coefficients on the CNV model.

The differential temperature between the cooler pool side of the CNV and the inside surface of the CNV creates additional compression at the inside surface of a bolted flange due to thermal expansion of metal nearer the inside surface.

The CNV is also evaluated at a uniform 140°F temperature with a pressure equal to or greater than the CNV design pressure. This evaluation simulates the expected conditions for the preservice design pressure leakage test. Evaluation at these pressure and temperature conditions provides assurance that leakage will not be detected during the preservice design pressure leakage test. Additionally, this evaluation demonstrates the preservice design pressure leakage test is evaluating the bolted flanges under a condition that bounds what would be seen at peak accident pressure conditions.

The emergency core cooling system (ECCS) trip and reset pilot valve body-to-bonnet seals are tested and qualified per ASME QME-1 and designed per ASME B&PVC Section III, Subarticle NB-3500. These valves will be pressure tested and functionally qualified separately which will include a series of tests at reactor coolant system (RCS) operating pressure, which is above the containment design pressure. The trip and reset valves for the reactor vent valves (RVVs) will be tested under steam service at operating reactor pressure and temperatures which bounds accident conditions. The trip and reset valves for the RRVs are of a similar design. These qualification tests provide additional assurance of leakage integrity beyond what is done for the CNV bolted flanges as they are performed under steam service rather than water. Successful completion of the qualification tests will show that the body-to-bonnet joint does not develop a new leak pathway when pressurized with steam and justifies exclusion of these valves from a similar bolted flange analysis as performed for the other bolted connections. Additionally, this bolted connection is subject to 10 CFR Part 50, Appendix J, Type B testing and ASME Section XI in-service testing (IST) at RCS operating pressure before initial operation, as well as prior to going into operation after each outage.

The ECCS trip and reset pilot valve body-to-bonnet bolted connection will be Type B tested to CNV design pressure and leakage measured. The pressure will be increased to RCS design pressure exceeding the RCS operating pressure requirement, per FSAR Section 5.4.2.1, and examined for leakage. This testing at each start-up makes demonstrating by analysis how the bolted connection performs under pressure not necessary.

3.2.1 Electrical Penetration Assemblies

The NuScale EPAs use sheathed modules with a glass-to-metal sealing technology that is not vulnerable to thermal or radiation aging, does not require periodic maintenance, and can achieve a less-than-minimum detectable leak rate (Figure 3-5). See

Section 5.3.2 for further discussion. The performance of the glass-to-metal EPA seal has been proven in currently operating nuclear plants. The EPA with installed modules is bolted to CNV flange penetrations similarly to the flanged access ports. Figure 3-5 depicts the pressurizer heater power supply EPA. This configuration is typical for all NuScale EPAs. The NuScale design includes the ability to test the double O-ring seals by pressurizing between the seals of the EPA similarly to the flanged access ports. Modules would only be disassembled from an EPA for modification or if leakage was indicated. If disassembly was performed, then retest of the module or EPA seal would be required prior installing the EPA in the CNVEPA modules are provided with a test port for local leak rate testing (Figure 3-6) and are Type B tested periodically in accordance with the requirements of the owner's Appendix J testing program.

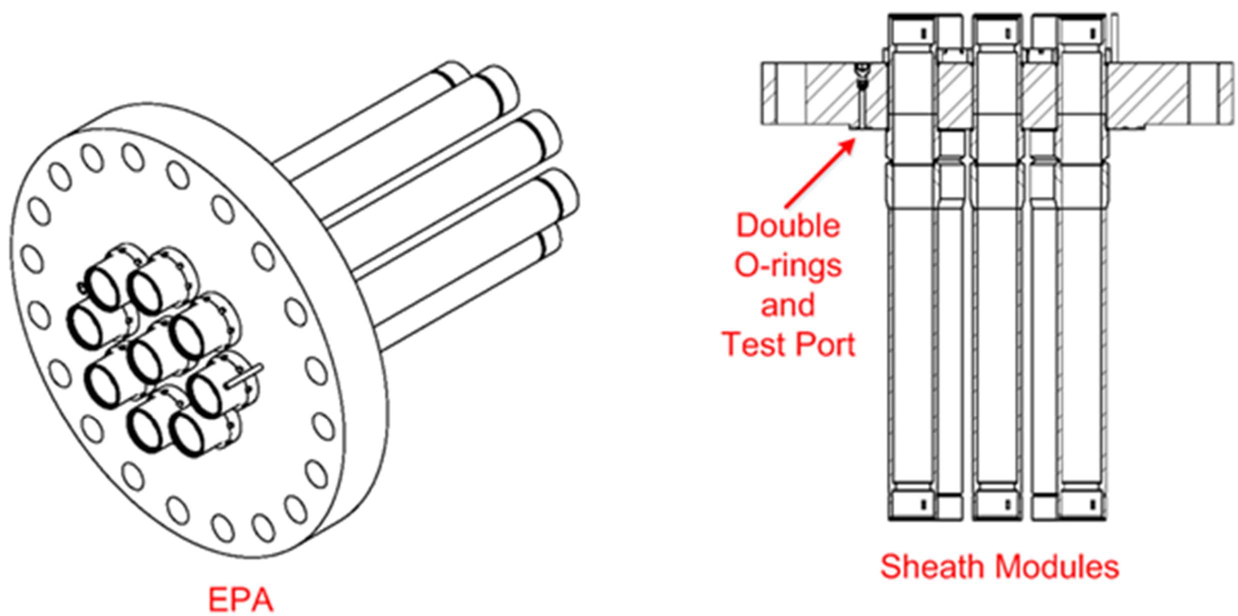

Figure 3-5 Electrical penetration assembly modules (typical)

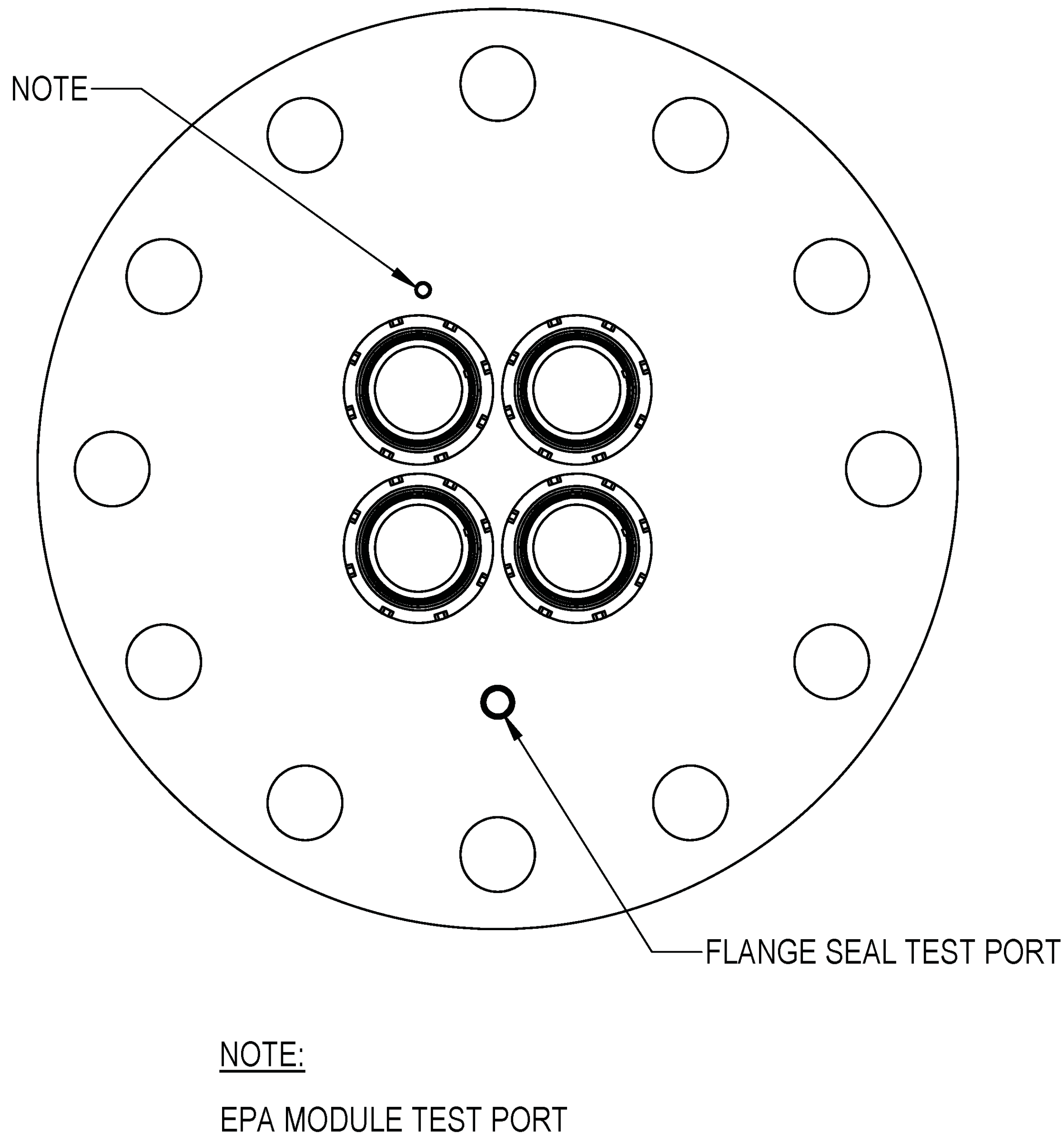

Figure 3-6 Electrical penetration assembly test ports (typical)

4.0 Preservice Inspection and Testing

4.1 Manufacturing Facility Testing and Inspection

The CNV is hydrostatically tested in the factory in accordance with ASME Subsection NB-6000. The water-filled CNV is pressurized to a minimum of 25 percent over design pressure ~~(1,250 psia)~~ for at least 10 minutes. Pressure is then reduced to design pressure ~~(1,000 psia) and held for at least four hours~~ prior to examining for leaks. The acceptance criterion is no leakage indications at the examination pressure (design pressure). Nondestructive examination of the CNV in the factory includes:

- All pressure-retaining and integrally-attached materials examination meets the requirements of NB-5000 and NF-5000 using examination methods of ASME Boiler and Pressure Vessel Code Section V.
- All clad surfaces are magnetic particle or liquid penetrant examined in accordance with NB-2545 or NB-2546, respectively, of Reference 7.1.7 prior to cladding.
- ASME Code Class 1 pressure boundary examinations are in accordance with NB-5280 and IWB-2200 using examination methods of ASME Boiler and Pressure Vessel Code Section V as modified by NB-5111. Preservice examinations shall include 100 percent of the pressure boundary welds.
- ASME Code Class MC examinations are subsumed by NB exam requirements. The Class MC examination is in accordance with IWE-2200. In addition, due to the high pressure design of the CNV, the preservice examination requirements of IWB-2200 are applied (Reference 7.1.7).
- Final preservice examinations are performed after hydrostatic testing, but prior to code stamping.

4.2 Preservice Design Pressure Leakage Testing

A separate preservice design pressure leakage test is performed on the CNV. This test is performed to ensure that the integrated leakage of the CNV meets design criteria. This test is performed on every NuScale CNV and shall contain the following elements:

- This test is required under a separate ITAAC.
- As-designed flange covers shall be installed with the design bolting materials, design bolting assembly preloads, and design seals installed.
- CNV bolted flanges shall be in place. Covers with electrical and instrumentation penetrations may be substituted with blank covers having the same sealing design.
- The upper and lower halves of the CNV are assembled for the first module of the initial NuScale plant. After the first CNV for the initial plant is tested successfully, the upper and lower halves of all other containment vessels may be tested separately.
- The CNV is pressurized with water to design pressure, held for 30 minutes, and no observed leakage shall be visible from any joint.
- A COL Item requires the applicant to verify that the CNV design meets the design basis requirement to maintain flange contact pressure at accident temperature.

defeats the purpose of performing an as-found and as-left containment leakage test, as this cannot reasonably be performed in the NuScale design if a full core offload is first required.

Testing with the ECCS valves closed would require that reactor pressure be safely above the containment test pressure, due to the passive nature of the ECCS valves which will begin to open when CNV pressure is close to or above RPV pressure. Reactor pressure would, therefore, have to be greater than approximately 1,100 psia, with a corresponding pressurizer temperature of approximately 556 degrees F. This scenario would present an unacceptable negative safety impact to ECCS operation and introduce additional significant impacts to containment gas space temperature. Testing in these conditions also would not eliminate the challenges already presented.

5.6.6 Integrated Leak Rate Testing Assessment Conclusions

NuScale has reviewed the requirements of GDC 52 and Appendix J Type A testing to assess the potential of performing integrated leakage testing within the NuScale design. The inherent safety features of the NPM limit the ability of the NuScale design to conform with Appendix J Type A testing acceptance criteria and limit the effectiveness of Type A tests for the NuScale design. The heat transfer mechanisms and high heat transfer ability of the NPM creates a variable temperature and pressure atmosphere within containment. The prescriptive Appendix J Type A testing requirements and acceptance criteria are impractical for the NuScale design. The temperature and pressure impacts on Type A testing and associated acceptance criteria for the NuScale design, increases the likelihood of inaccurate results, false test failures, and multiple testing iteration requirements. Application of Type A testing requirements to the NuScale containment would likely yield inaccurate leakage results due to the limited effectiveness of Type A acceptance criteria when applied to the NuScale design.

The evaluation of the bolted flange connections discussed in Section 3.2 provides reasonable assurance that the Type B measured leakage of the bolted flange connection will be representative of leakage at design basis conditions. This evaluation supports that the containment design does not require Type A testing to measure leakage while under pressure.

Accessibility constraints within containment, and the installation of a large quantity of additional CNV permanent or temporary instrumentation for Type A testing, would expose occupational radiation workers to unnecessary radiation doses to support testing without a commensurate safety benefit. This unnecessary exposure would be required to support installation, maintenance, and calibration of the equipment necessary to perform Type A tests.

Conformance with GDC 52 and Appendix J Type A testing requirements is impractical for the NuScale design. The CLIP, supported by the NuScale design, provides leakage integrity assurance for the NuScale containment.

Enclosure 3:

Affidavit of Zackary W. Rad, AF-0219-64518

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 method by which NuScale provides containment leakage integrity assurance.

   NuScale has performed significant research and evaluation to develop a basis for this method 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 response to NRC Request for Additional Information No. 9474, eRAI 9474. 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 February 14, 2019.

Zackary W. Rad