NuScale Power

RAIO-0618-60325

June 06, 2018

Docket No. 52-048

U.S. Nuclear Regulatory Commission
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**SUBJECT:** NuScale Power, LLC Supplemental Response to NRC Request for Additional Information No. 362 (eRAI No. 9315) on the NuScale Design Certification Application

**REFERENCES:**
1. U.S. Nuclear Regulatory Commission, "Request for Additional Information No. 362 (eRAI No. 9315)," dated February 05, 2018
2. NuScale Power, LLC Response to NRC "Request for Additional Information No. 362 (eRAI No. 9315)," dated April 06, 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 Enclosure to this letter contains NuScale's supplemental response to the following RAI Question from NRC eRAI No. 9315:

- 03.08.02-14

This letter and the enclosed response 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,

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Enclosure 1: NuScale Supplemental Response to NRC Request for Additional Information eRAI No. 9315

**Enclosure 1:**

NuScale Supplemental Response to NRC Request for Additional Information eRAI No. 9315

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

**eRAI No.:** 9315
**Date of RAI Issue:** 02/05/2018

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**NRC Question No.:** 03.08.02-14

10 CFR 52.47 requires the design certification applicant to include a description and analysis of the structures, systems, and components with sufficient detail to permit understanding of the system designs.

Per NuScale FSAR Tier 2, Section 6.3.2.3, the emergency core cooling system (ECCS) components (including valves, hydraulic lines, and actuator assemblies) are Quality Group A, Seismic Category I components designed to ASME BPV Code, Section III, Subsection NB.

For consistency, Table 3.2-1, Classification of Structures, Systems, and Components, should be revised to clarify the specified ECCS valves are intended to include the valves, hydraulic lines, and actuator assemblies being Quality Group A, Seismic Category I components.

Per FSAR Tier 2, Section 6.3.2.2, the body of the ECCS actuator assembly serves as both a containment vessel (CNV) pressure boundary and reactor coolant pressure boundary (RCPB). General Design Criteria (GDCs) 14 and 16 require that:

- The reactor coolant pressure boundary shall be designed, fabricated, erected, and tested so as to have an extremely low probability of abnormal leakage, of rapidly propagating failure, and of gross rupture.
- 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.

The ECCS actuator assembly currently protects both the CNV boundary and RCPB; therefore it is crucial that the welds and actuator assembly itself be designed to ensure and extremely low probability of leakage or failure in accordance with GDCs 14 and 16.

The NRC staff requests the applicant to clarify the inservice inspection (ISI) that will be performed to provide assurance of the structural integrity of the containment nozzle to safe end welds and safe end to ECCS actuator assembly welds, i.e. will they be full volumetric? FSAR Tier 2, Table 6.6-1, Examination Categories, should also be revised to include this information.

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Also, will the material the actuator assembly body is manufactured from be volumetrically examined as part of the valve fabrication requirements? And what are the fabrication NDE requirements for the entire RCPB portion for this valve?

Also, Per FSAR 6.3.2.2, Equipment and Component Descriptions, valve bonnet seals on each pilot valve establish the pressure boundaries internal to the valve assembly body. And in TR-1116-51962-NP "NuScale Containment Leakage Integrity Assurance Technical Report," Section 3.2 "Containment Penetrations," it describes a portion of the ECCS actuator pressure boundary that is accomplished by a bolted enclosure (body-to-bonnet) with a dual metal o-ring seal.

In generic technical specifications (TS) Subsection 3.4.5, "RCS Operational LEAKAGE," LCO 3.4.5 states that RCS operational LEAKAGE shall be limited to: a) no pressure boundary LEAKAGE, b) 0.5 gpm unidentified LEAKAGE, c) 2 gpm identified LEAKAGE from the RCS, and d) 150 gallons per day primary to secondary LEAKAGE.

The NRC staff requests that the applicant clarify the periodic testing and inspection provisions it will implement to ensure no leakage past the O-ring seals of the ECCS actuator pressure boundary during normal operating conditions. Also, explain how LCO 3.4.5 limits a), b), and c) would apply to leakage past the ECCS actuator O-ring seals or through the valve body. Explain how such RCS leakage outside of containment would be detected, identified, and quantified during operation." Were such leakage to occur without being identified but within the limit of LCO 3.4.5, what would the possible consequences be at the onset of an event?

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**NuScale Response:**

In a public meeting held on May 2, 2018, NuScale agreed to supplement RAI 9315, question 03.08.02-14 by specifying in the FSAR that the emergency core cooling system (ECCS) trip/reset actuator valve will have a seal verification test performed to RCS design pressure and the applicability of this same requirement to the chemical and volume control system (CVCS) containment isolation valves (CIV) in-service insert seals.

Technical specification 3.4.5 and technical specification 3.6.1 identify that the ECCS trip/reset actuator valve seals, between the valve body and bonnet, and CVCS CIV test plate seals will be tested to reactor coolant system (RCS) operating pressure following the requirements of American Society of Mechanical Engineers (ASME) Boiler and Pressure Vessel Code (BPVC) Section XI, Table IWB-2500-1 (B-P) for a system leakage test at RCS operating pressure as well as the Appendix J, Type B testing to containment accident pressure.

The body-to-bonnet seals on the ECCS trip/reset actuator valve form the reactor coolant pressure boundary and require testing to RCS operating pressure prior to going into operation. Since this valve is located in the reactor pool during start-up there is no means to perform the required Section XI, Table IWB-2500-1 (B-P) VT-2 examination during the RCS system pressure test. To confirm the seal integrity prior to start-up a seal verification test will be performed. The seal verification test will use the test port to pressurize the space between the inner and outer o-ring to RCS design pressure using a gas while the NuScale Power Module (NPM) is located in the dry dock. The seal verification test will be performed to the requirements of Section XI, Table IWB-2500-1 (B-P).

The in-service inserts on the CVCS CIVs are also exposed to RCS pressure as well as containment accident pressure. The CIV in-service inserts are located between the isolation valve and the containment vessel. When the RCS system leakage test is performed any leakage from the seals on the CIV test plate can be detected during the RCS system leakage test by temperature sensors located under the bio-shield and RCS mass inventory balance. The seals would also have been tested to containment accident pressure during the Type B test prior to being put into service. The detection systems satisfy the ASME BPVC Subsubarticle IWA-5240 VT-2 visual examination requirements for leakage detection.

FSAR Section 5.2.4.1 has been modified to specify the seal verification test for the ECCS trip/reset actuator valve. Section 6.2.6.2 has also been modified to identify the seal verification test is needed and reference Section 5.2.4.1 for the test details. Since the seal verification test is not an Appendix J requirement, TR-1116-51962, NuScale Containment Leakage Integrity Assurance Technical Report, has been modified to remove reference to a seal verification test to RCS design pressure and only discuss the Type B test. Since the bio-shield detection systems can detect changes in conditions if leakage occurs during the RCS system leakage test a seal verification test is not required for the CVCS CIV in-service inserts.

**Impact on DCA:**

FSAR Tier 2 Section 5.4.2, Section 6.2.6, and Technical Report 1116-51962 have been revised as described in the response above and as shown in the markup provided in this response.

The inspection and testing program addresses the unique inspection and testing requirements for each NPM to ensure plant safety is maintained for the operating life.

The NPM inspection, testing, and maintenance strategy is: (1) design the NPM components to anticipate required inspections and (2) develop an ISI program to identify aspects such as interval and inspection frequencies, selection of components and welds for inspection, and expansion criteria.

Development of the NuScale inspection program consists of the following:

- identification of the appropriate ISI or testing requirements for the NuScale design (code version, overall inspections and tests required)
- identification of the structures, systems, and components (SSC), the subset inspections or test elements associated with SSC and those SSC which are subject to inspection and testing
- identification of appropriate ISI and testing requirements for each structure, system, and component
- assessment of each inspection and test element
- development of a comprehensive ISI and testing plan

The ISI schedule and requirements for Class 1 systems and components are in accordance with ASME BPVC, Section XI.

The following tables provide the applicable ISI examination categories and methods:

- Table 5.2-6 - Reactor Pressure Vessel Inspection Elements
- Table 5.2-7 - Reactor Vessel Internals Inspection Elements
- Table 5.2-8 - ASME Class 1 Piping Inspection Elements
- Table 5.2-9 - ASME Class 1 Support Inspection Elements

Prior to NPM startup following each refueling outage, a system leakage test is performed followed by a VT-2 examination for the RPV Class 1 pressure retaining boundary in accordance with the requirements specified in ASME BPVC, Section XI, Table IWB-2500-1 (B-P) and Articles IWA-5000 and IWB-5000. In the NuScale design, leakage is continuously monitored in the CNV or from the RPV to the CNV. This constitutes a VT-2 exam according to Section XI IWA-5241 (c). During normal operation, the CNV is in a vacuum, so leakage is from the pool to the inside of the CNV. The CNV leak detection system is able to detect leakage from both the RPV and CNV during normal operation.

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The body-to-bonnet seals on the ECCS trip/reset actuator valve form the reactor coolant pressure boundary and require testing to RCS operating pressure prior to going into operation. Since this valve is located in the reactor pool during start-up there is no means to perform the required Section XI, Table IWB-2500-1 (B-P) VT-2 examination during the system pressure test. To confirm the seal integrity prior to start-up a seal verification test will be performed. The seal verification test will use the test port to pressurize the space between the inner and outer o-ring to RCS design pressure using a gas while the NPM is located in the dry dock. The seal test will be performed to the requirements of Section XI, Table IWB-2500-1 (B-P).

A surface and a volumetric examination is performed for ASME Class 1 pipe welds greater than or equal to four nominal pipe size (NPS). Only a surface examination is performed for pipe welds associated with ASME Class 1 piping less than four NPS, Table IWB-2500-1 Category B-J.

The ASME Class 1 boundary valves (i.e., CIVs) are located outside of the NPM. The reduced inspection requirements for the small primary system pipe welds associated with less than four NPS piping are not applied to the welds between the containment and the CIVs because a break at one of these weld locations would result in a RCPB leak outside the containment. Therefore, ASME Class 1 welds between the containment and the CIVs are inspected with a volumetric and surface examination each interval in accordance with the requirements of ASME BPVC, Section XI, Subarticle IWB-2500.

Flanges on the RPV have dual O-rings with a leak port tube between the O-rings to allow for leakage testing. Leakage testing is performed following installation of the O-rings each time they are removed to ensure a good seal.

The RPV and containment main flange bolts are inspected in accordance with the requirements specified in ASME BPVC, Section XI, Table IWB-2500-1 (B-G-1).

Pressure retaining bolting that two inches or less in diameter is inspected in accordance with the requirements specified in ASME BPVC, Section XI, Table IWB-2500-1 (B-G-2). These bolting assemblies require a VT-1 visual examination each interval if removed.

NuScale reactor vessel internals inspection requirements are developed consistent with the approach in the Materials Reliability Program (MRP) 227 (Reference 5.2-9) to augment the inspection requirements of ASME BPVC, Section XI. No exceptions are identified in determining internal inspection criteria using the MRP approach. Table 5.2-7 includes the ISI examination categories and methods for the reactor vessel internals. Included in the list are core support components, internal structures, and steam generator supports.

Based on the high pressure and the safety function of the containment, enhanced inspection requirements are provided for the containment in excess of the Class MC requirements of ASME BPVC, Section XI, Subsection IWE. The containment is inspected to selected Class 1 requirements of ASME BPVC, Section XI, Subsection IWB as specified in Table 6.2-8. All ASME BPVC, Section XI, Subsection IWE required inspections are met.

### 5.2.4.2 Preservice Inspection and Testing Program

Preservice examinations required by the design specification and preservice documentation are in accordance with ASME BPVC, Section III, Paragraph NB-5281. Volumetric and surface examinations are performed as specified in ASME BPVC, Section III, Paragraph NB-5282. Components described in ASME BPVC, Section III, Paragraph NB-5283 are exempt from preservice examination.

port to facilitate Type B testing by pressurizing between the seals. The main CNV flange has a similar double o-ring and test port arrangement.

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-ring seals by pressurizing between the seals. An EPA would only be disassembled for modification or if leakage was indicated.

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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. ~~This seal is both a containment and RCS boundary and will be Type B tested at RCS design pressure.~~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.

Type B tests are performed by local pressurization at containment peak accident pressure, Pa, using either the pressure-decay or flowmeter method of detection. For the pressure-decay method, a test volume is pressurized with air or nitrogen to at least Pa. The rate of decay of pressure in the known test volume is monitored to calculate a leakage rate using the pressure-decay method. For the flowmeter method, the required test pressure is maintained in the test volume by making up air or nitrogen, through a calibrated flowmeter. The flowmeter fluid flow rate is the leakage rate from the test volume.

The combined leakage rate for all penetrations and valves subject to Type B and C tests is limited to less than 0.60 La.

In accordance with 10 CFR 50, Appendix J, Type B tests are performed during each reactor shutdown for refueling, or other convenient intervals in accordance with the Containment Leakage Rate Testing Program.

### 6.2.6.3 Containment Isolation Valve Leakage Rate Test

The CNV and CIVs are designed for Type C pneumatic tests. Preoperational and periodic Type C leakage rate testing of CIVs is performed in accordance with the 10 CFR 50, Appendix J requirements and ANSI-56.8.

The CIVs subject to Type C tests are identified in Table 6.2-4.

Isolation valves are tested using either the pressure decay or flowmeter method. For the pressure decay method the test volume is pressurized with air or nitrogen. The rate of decay of pressure in the known volume is monitored to calculate the leak rate. For the flowmeter method pressure is maintained in the test volume by supplying air or

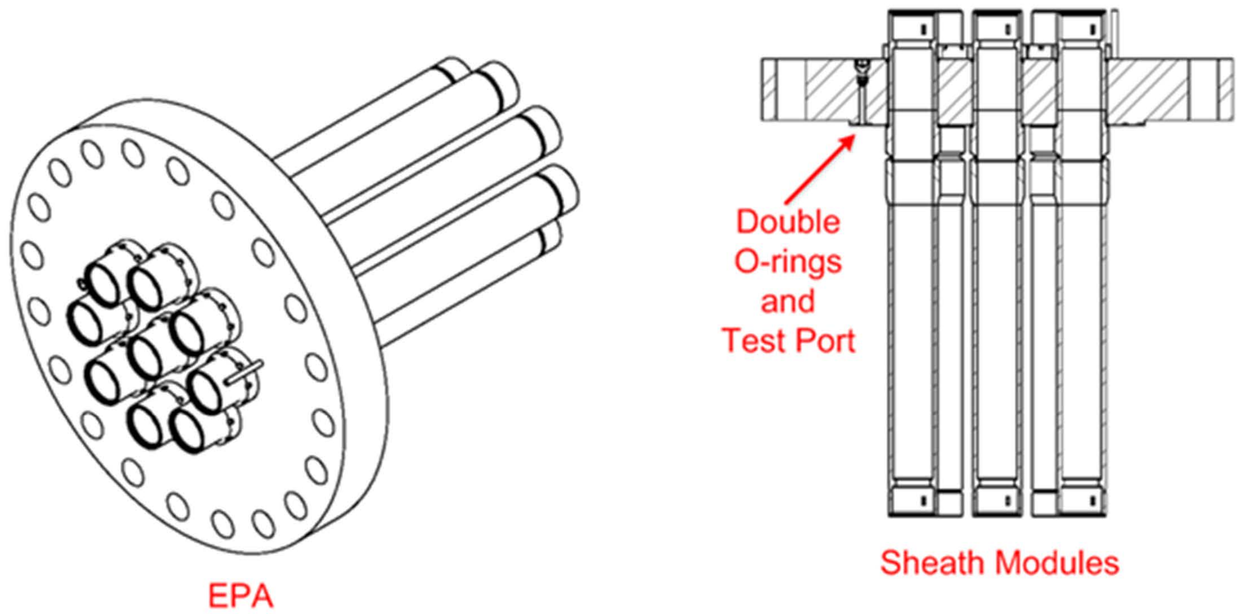


Figure 3-5 Electrical penetration assembly modules (typical)

### 3.2.2 Emergency Core Cooling System Trip and Reset Body-to-Bonnet Seals

There are five ECCS main valves supported by 11 trip and reset (pilot) valves for actuation. The 11 pilot valves are located on six penetrations on the upper CNV assembly. Each trip and reset valve body is located outside the CNV and is a component of the RCPB. The trip and reset valves are aligned to static RCS head during normal operation. The RCPB is the valve body welded to the CNV penetration safe end. The only joint is at the body-to-bonnet and is sealed with a double O-ring and test port arrangement similar to the rest of the Type B penetrations. The trip and reset valves have no containment or RCS isolation function; therefore, the test criteria for these penetrations is a Type B test of the double O-ring joint for each valve. Figure 3-6 shows the dual trip and reset valve design and the location of the body-to-bonnet joints. The test port is not shown. All trip and reset valve pressure boundaries are designed and constructed to ASME Code Class 1.

### 5.3.2 Electrical Penetration Assemblies

The EPA sheath modules are installed and tested at the factory. Glass-to-metal seals (penetrations), exclusive of the flange-to-nozzle seals, are designed for leakage rates not to exceed 1.0 x $10^{-3}$ standard $cm^3/s$ (1.27 x $10^{-4}$ SCFH) of dry nitrogen at design pressure and at ambient temperature, including after any design basis event (Reference 7.1.11). Glass-to-metal seals typically achieve leak rates in the undetectable range, 1.0 x $10^{-7}$ standard $cm^3/s$ of dry nitrogen at design pressure and at ambient temperature. The glass-to-metal module seal is an established sealing technology that is not vulnerable to thermal or radiation aging and does not require periodic maintenance or testing. The module-to-EPA seal does not require periodic testing. It would only be tested after completing maintenance activities that affect the seal. The EPA flange seal is the same double O-ring seal design of all Type B penetration seals. The required installation acceptance criterion for leakage rate of each EPA is 1.0 x $10^{-2}$ standard $cm^3/s$ (1.27 x $10^{-3}$ SCFH) per Reference 7.1.11. The leakage margin allotment for Type B testing is preliminarily selected to be 50 times the installation acceptance criterion. This leakage margin for EPA contribution to overall containment leakage supports maintaining overall containment leakage to less than (0.60) $L_a$.

### 5.3.3 Ports and Manways

All CNV access port seals and manway seals are the identical double O-ring design. The leakage performance of these seals is expected to be similar to the EPAs based on an evaluation of leakage performance for off-the-shelf metal seals.

### 5.3.4 Emergency Core Cooling System Pilot Valve Bodies

There are six NPS 3 containment penetrations for the ECCS trip and reset valve assemblies. ~~The valve bodies normally form part of the RCPB and a~~A Type B test is required at the double O-ring seal between the valve bonnet and body (see Figure 3-6). The rest of these valve bodies are self-contained metal barriers that form part of the containment pressure boundary. Leakage criteria for these seals is small compared to the other Type B boundaries due to the smaller size of the seals.

### 5.3.5 Containment Vessel Flange

The CNV flange is a large double O-ring design (~45-foot circumference). This seal maintains the containment boundary between upper and lower CNV assemblies (see Figure 3-2). The CNV flange leakage limit for the CLIP is estimated to be 0.4–0.5 SCFH based on the linear seal length and performance of off-the-shelf metal seals.

### 5.3.6 Bolting

The CNV bolting design for all EPAs, ports and manways is in accordance with ASME Section III, Division 1, NB-3231. Calculations were performed to verify the number and cross-sectional area of bolts required to withstand containment design pressure and maintain gasket reaction for leak tightness. The calculations were performed in accordance with ASME Boiler and Pressure Vessel Code Section III, Appendix E. The calculations determined the quantity, size, and spacing of the bolting for the ASME Code Class 1 flanges. The CNV bolted-closure design and preload design requirements ensure that Type B flange seals, including EPAs, remain sealed at design pressure.

## A.1 Type B Containment Penetrations

| Penetration[1] Identification | Component[2] | Nominal Size (Opening) | Quantity of EPA Sheath Modules |
|---|---|---|---|
| CNV8 | I&C Division 1 | NPS 3 | 1 |
| CNV9 | I&C Division 2 | NPS 3 | 1 |
| CNV15 | Pressurizer Heater Power (Elect-1) | NPS 12 | 9 |
| CNV16 | Pressurizer Heater Power (Elect-2) | NPS 12 | 9 |
| CNV17 | I&C Channel A | NPS 8 | 4 |
| CNV18 | I&C Channel B | NPS 8 | 4 |
| CNV19 | I&C Channel C | NPS 8 | 4 |
| CNV20 | I&C Channel D | NPS 8 | 4 |
| CNV24 | Head Manway | NPS 18 | N/A |
| CNV25 | CRDM Access Opening | 67 inch | N/A |
| CNV26 | Manway | 38 inch | N/A |
| CNV27 | SG Inspection Port 1 | 38 inch | N/A |
| CNV28 | SG Inspection Port 2 | 38 inch | N/A |
| CNV29 | SG Inspection Port 3 | 38 inch | N/A |
| CNV30 | SG Inspection Port 4 | 38 inch | N/A |

| Penetration[(1)] Identification | Component[(2)] | Nominal Size (Opening) | Quantity of EPA Sheath Modules |
|---|---|---|---|
| CNV31 | Pressurizer Port 1 | 44 inch | N/A |
| CNV32 | Pressurizer Port 2 | 44 inch | N/A |
| CNV33 | Reactor vent valve (RVV) Trip/Reset A~~[(4)]~~[(3)] | NPS 3~~[(5)]~~[(4)] | N/A |
| CNV34 | RVV Trip/Reset B~~[(4)]~~[(3)] | NPS 3~~[(5)]~~[(4)] | N/A |
| CNV35 | Reactor recirculation valve Trip/Reset A~~[(4)]~~[(3)] | NPS 3~~[(5)]~~[(4)] | N/A |
| CNV36 | Reactor recirculation valve Trip/Reset B~~[(4)]~~[(3)] | NPS 3~~[(5)]~~[(4)] | N/A |
| CNV37 | CRDM Power | NPS 18 | 16 |
| CNV38 | Rod position indication Group 1 | NPS 10 | 4 |
| CNV39 | Rod position indication Group 2 | NPS 10 | 4 |
| CNV40 | RVV Trip/Reset C-1~~[(4)]~~[(3)] | NPS 3~~[(5)]~~[(4)] | N/A |
| CNV41 | RVV Trip C-2~~[(4)]~~[(3)] | NPS 3~~[(5)]~~[(4)] | N/A |
| - | CNV flange | 170 inch | N/A |

(1) The penetration ID number CNV21 is not used.
(2) Type B test at containment design pressure ~~(except trip/reset valves – RCS design pressure), and ISI B-P, VT-2 for CNTS at normal operating pressure~~.
(3) RCPB valve.
(4) CNV33-36 and CNV40 are 3-inch penetrations for ECCS trip and reset valves. Each penetration has two bolted connections (trip and reset valve) that each require a Type B test. CNV41 is a 3-inch penetration for a single ECCS trip valve. This penetration has one bolted connection.