NuScale Power

RAIO-0917-56289

September 28, 2017

Docket No. 52-048

U.S. Nuclear Regulatory Commission
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11555 Rockville Pike
Rockville, MD 20852-2738

SUBJECT: NuScale Power, LLC Response to NRC Request for Additional Information No. 81 (eRAI No. 8877) on the NuScale Design Certification Application

REFERENCE: U.S. Nuclear Regulatory Commission, "Request for Additional Information No. 81 (eRAI No. 8877)," dated July 07, 2017

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

The Enclosures to this letter contain NuScale's response to the following RAI Question from NRC eRAI No. 8877:

- 19.05 Aircraft Impact Assessment (APR1400)-1

NuScale requests that the security-related information in Enclosure 1 be withheld from public disclosure in accordance with the requirements of 10 CFR § 2.390. Enclosure 2 contains a public 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

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Enclosure 1: NuScale Response to NRC Request for Additional Information eRAI No. 8877, nonpublic

Enclosure 2: NuScale Response to NRC Request for Additional Information eRAI No. 8877, public

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Enclosure 1:

NuScale Response to NRC Request for Additional Information eRAI No. 8877, nonpublic Security-Related Information - Withhold Under 10 CFR §2.390

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Enclosure 2:

NuScale Response to NRC Request for Additional Information eRAI No. 8877, public

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

eRAI No.: 8877
Date of RAI Issue: 07/07/2017

NRC Question No.: 19.05 Aircraft Impact Assessment (APR1400)-1

Fire Protection

10 CFR 50.150 requires the applicant to perform a design-specific assessment of the effects on the facility of the impact of a large, commercial aircraft. Using realistic analyses, the applicant is required to identify and incorporate into the design those design features and functional capabilities that show that, with reduced use of operator actions, the reactor core remains cooled, or the containment remains intact; and the spent fuel cooling or spent fuel pool integrity is maintained. Also required is for the FSAR to include a description of the design features and functional capabilities identified in the design-specific assessment and how these features and capabilities meet the requirements identified in the design-specific assessment.

FSAR Tier 2, Subsection 19.5.4.3 states that "additional details for the site fire protection system are provided in Section 9.5.1."

The staff does not understand the purpose of the above statement, why the fire protection systems are referenced, and in what capacity they play a role in the aircraft impact assessment (AIA). Fire protection systems usually only include suppression and detection systems; besides, the NRC-endorsed guidance NEI 07-13, "Methodology for Performing Aircraft Impact Assessments for New Plant Designs," does not allow crediting of suppression systems. And yet, FSAR Tier 2, Subsection 19.5.1 indicates that the AIA follows the NEI 07-13 guidance without deviation.

The application also misses the requirements of 10 CFR 50.150 when it comes to clearly identifying all design features, their capabilities and roles in response to the consequences of an aircraft impact. For example:

- FSAR Tier 2, Subsection 19.5.4.3 does not clearly identify which fire barriers are credited as key design features. Note that when crediting 5-psid features, the entire barrier, not just the openings and penetrations, must be credited as a 5-psid barrier.
- FSAR Tier 2, Subsection 19.5.4.3 does not mention any role for floor/ceiling assemblies. If indeed floor/ceiling assemblies do have a role in response to the consequences of an aircraft impact, these features must be credited and indicated in the application.
- FSAR Tier 2, Subsection 19.5.4.3 mentions that the design restricts fire propagation to the

vestibules and stairwells … and yet it does not mention these interior walls are credited key design features.

The applicant is requested to **clearly** identify and describe **all** the **key** design features **credited** in the applicant's AIA as well as these features' role in helping mitigate the consequences of the aircraft impact. Figures and drawings would be helpful to clarify the requested information." The FSAR should be modified accordingly.

NuScale Response:

FSAR Section 19.5, Adequacy of Design Features and Functional Capabilities Identified and Described for Withstanding Aircraft Impacts, has been rewritten in its entirety to address this RAI question. The format, terminology, and guidance of NEI 07-13, Methodology for Performing Aircraft Impact Assessments for New Plant Designs, has been followed.

Impact on DCA:

FSAR Tier 2 Section 19.5, Section 9.4.2.2, Section 9.1.4.3, Section 9.1.5.2, and Section 3.5.3.1 and FSAR Tier 2 Figure 1.2-16, Figure 1.2-17, Figure 1.2-18, Figure 1.2-23, Figure 9.4.2-1, Figure 19.5-1, Figure 19.5-2, Figure 19.5-3 and Figure 19.5-4 have been revised as described in the response above and as shown in the markup provided with this response.

19.5 Adequacy of Design Features and Functional Capabilities Identified and Described for Withstanding Aircraft Impacts

19.5.1 Introduction and Background

The plant design accounts for potential effects of a beyond-design-basis impact of a large commercial aircraft in accordance with 10 CFR 50.150(a). A design-specific aircraft impact assessment (AIA) has been performed using realistic analyses to demonstrate that:

1) the reactor core remains cooled or the containment remains intact; and

2) spent fuel cooling or spent fuel pool integrity is maintained

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The NuScale Power Plant meets ~~all~~three of the four criteria (i.e., core cooling, containment ~~integrity~~intact, ~~spent fuel cooling,~~ and spent fuel pool integrity) as discussed in the following sections.

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The specific assumptions, including aircraft characteristics for the AIA are based on the guidance provided by Regulatory Guide (RG) 1.217, Revision 0, "Guidance for the Assessment of Beyond-Design-Basis Aircraft Impacts." This guidance endorses NEI 07-13, "Methodology for Performing Aircraft Impact Assessments for New Plant Designs," Revision 8 (Reference 19.5-1). The guidelines provided in NEI 07-13 are followed with no exceptions. The assessments were performed by qualified personnel with experience in applying the approved methodology.

19.5.2 Scope of the Assessment

The following effects of a large commercial aircraft impact are assessed:

1) physical damage resulting from the impact of the aircraft fuselage and wing structure and penetration of hardened aircraft components, such as engine rotor shafts and landing gear

2) shock damage resulting from shock-induced vibration on systems, structures, and components (SSCs)

3) fire damage resulting from aviation fuel-fed fire

19.5.3 Assessment Methodology

The methodology provided in NEI 07-13 is used to assess the effects of the aircraft impact on the structural integrity of the Reactor Building (RXB) and to evaluate the physical, vibration, and fire effects on SSCs in the RXB to ensure continued core cooling and spent fuel cooling capability.

19.5.3.1 Structures of Concern

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Structures of concern are those structures that contain SSCs necessary to ensure adequate cooling of the fuel in the reactor cores and spent fuel pool (SFP). ~~All 12 NuScale Power Modules (NPMs) and the SFP are located inside the RXB. Containment is integral to each NPM. The 10 CFR 50.150(a) functions are accomplished if the RXB resists the impact loading and prevents wreckage and fire from perforating the exterior walls. Thus, the RXB is the only structure of concern and the only structure evaluated for aircraft impact.~~All 12 NuScale Power Modules (NPMs), the ultimate heat sink, and the SFP are located inside the RXB. Containment is integral to each NPM. The 10 CFR 50.150(a) functions are accomplished if the RXB resists the impact loading and prevents wreckage and fire from perforating the exterior walls of the RXB. Therefore, the RXB is a building of concern. The Control Building (CRB) is a building of concern for core cooling to accomplish operator control actions upon notification of an imminent aircraft impact. The arrangement of core cooling equipment inside the RXB and CRB, as shown on Figure 1.2-10 through Figure 1.2-18 and Figure 1.2-21 through Figure 1.2-25, is a key design feature.

19.5.3.2 Impact Locations

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Below grade portions of the RXB are not susceptible to a direct impact by an aircraft. ~~All elevations above grade are vulnerable. Elevations or portions of elevations may be screened from aircraft impact if intervening or adjacent structures meet the design requirements of NEI 07-13. For the structural analysis, the Radioactive Waste Building (RWB) is credited with protection of a portion of the west wall of the RXB. This credit is applied when determining wall thicknesses and configurations. No credit is taken for the Control Building or the Turbine Generator Buildings. For the heat removal assessment, no credit is taken for any intervening structures because crediting the RWB as an intervening structure does not change the results of the analysis. As such, the heat removal assessment assumed that any portion of the RXB at or above the 100'-0" elevation is vulnerable to aircraft impact. This does not negate or invalidate the results or conclusions of the structural analysis.~~Elevations or portions of elevations may be screened from aircraft impact if intervening or adjacent structures meet the design requirements of NEI 07-13. The location of the RWB in relation to the RXB is a key design feature that limits potential strike locations to the west end of the RXB. The design of the exterior walls of the RWB, as described in Section 3.5.3.1.1, is a key design feature for crediting the RWB as an intervening structure. The RWB is located 25 feet to the west of the RXB, as described in Section 3.8.4.1.3. The roof of the RWB is approximately 49 feet above grade, as shown on Figure 1.2-33. For the structural analysis, the RWB is credited with protection of a portion of the west wall of the RXB. This credit is applied when determining wall thicknesses and configurations. No credit is taken for the Control Building (CRB) or the Turbine Generator Buildings as intervening structures. For the heat removal assessment, the RWB is credited as an intervening structure that protects portions of the west wall of the RXB from shock effects from impacts on the 100 foot elevation. All other RXB elevations and faces above grade are vulnerable.

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19.5.3.3 ~~Effect on Fuel Cooling Equipment~~Assessment of Effects on Fuel Cooling Equipment

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To assess the effects on fuel cooling equipment, physical damage, shock damage, and fire damage footprints are overlaid on the RXB and CRB general arrangement drawings. Fuel cooling equipment that is within these damage footprints is assumed to lose the ability to perform its function due to the associated physical, shock, or fire effects. The remaining fuel cooling equipment is evaluated to determine if adequate cooling of fuel in the reactors and SFP is maintained.

19.5.4 Assessment Results

19.5.4.1 Physical Damage

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The RXB external walls have been assessed and shown to resist physical damage from all postulated aircraft strikes. The design of the RXB as described in Section 3B.2 is a key design feature. The design of the reactor building equipment door to the RXB as described in this section is a key design feature for protecting core cooling equipment from impacts through the RWB Trolley Bay. The reactor building equipment door is a large concrete door that is on a series of rails. It can be moved in place for normal operations, and out of place when large equipment is moved into and out of the reactor building. The door fits like a plug into the exterior wall of the reactor building in that it is tapered along the top and sides and is sealed against the building. The door is five foot thick with steel plate along the outside, and filled with 7000 psi reinforced concrete. The steel plates are either 1" or 2" thick, and the reinforced concrete consists of three layers of #11 bars at 12 inches on center on each face of the door, and #6 set ties that are staggered (see Figure 19.5-1 through Figure 19.5-3).

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The design of the RXB HVAC intake awnings and the design of the pipe shields, shown on Figure 1.2-17 through Figure 1.2-19 and described in this section are key design features for preventing physical damage and fire from entering the RXB. The awnings protecting the HVAC intakes and pipe penetrations are constructed of 7000 psi concrete with (4) #11 bars at 12" on center each way, top and bottom. In addition, the horizontal portion of the awning protection has (2) #6 shear ties at 12" on center (see Figure 19.5-4).

Based on NEI 07-13 criteria, physical damage from strikes to external openings in the RXB external walls is shown to be restricted to a single vestibule on the exterior of the RXB. There is no equipment in that location that could impact fuel cooling capability.

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~~There are two independent, safety-related, passive decay heat removal systems (DHRS) that provide redundant core cooling capability for each NPM. An impact that ruptures main steam or feedwater piping results in DHRS initiation. DHRS initiation includes~~

~~closure of the associated main steam and feedwater isolation valves, thereby preventing a loss of secondary side water through the damaged piping. (See Section 5.4.3)~~

~~If main steam or feedwater system piping were to rupture inside the RXB, the limited liquid inventory within the system would not result in a flooding concern. There are no systems with open-water sources (e.g., circulating water system) located in the RXB physical damage footprint for any strike. As such, flooding is not an issue of concern.~~

~~In the event of a concurrent loss of both AC and DC power, in addition to the DHRS actuation described above, the passive, safety-related, emergency core cooling system (ECCS) will also actuate, providing an additional source of core cooling (See Section 6.2). Core cooling and spent fuel cooling are passive systems that have no dependency on any AC or DC power to meet their design function.~~The trolley on the Reactor Building Crane (RBC) cannot be struck and dislodged, because there is no perforation of the RXB outer wall. The design of the RBC is a key design feature for ensuring that impact loads from an aircraft impact on the exterior wall of the RXB prevent the crane from falling into the reactor pool area and either damaging the NPMs or tearing the reactor pool lining. The design and location of the RBC, as described in Section 9.1.5, is a key design feature for protecting the NPMs and reactor pool lining. Similarly, the design and location of the Fuel Handling Machine (FHM), as described in Section 9.1.4, is a key design feature for ensuring that impact loads from aircraft impact prevent the crane and trolley from falling into the SFP and damaging the liner.

19.5.4.2 Shock Damage

The impact of a commercial aircraft on the RXB structure causes a short duration, high acceleration, high frequency vibration. Shock damage distances are measured from the center of the initial impact along a structural pathway to the affected equipment.

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The shock effect is at its greatest at the 100' elevation, and propagates into the ultimate heat sink, which consists of the reactor pool, refuel pool, and spent fuel pool. Reactor modules are shut down by operator action prior to impact, and core cooling is provided by passive systems (i.e., DHRS~~ or ECCS~~). ~~Similarly, passive cooling is provided by direct conduction and convection for fuel in the spent fuel pool. There are no SSCs susceptible to shock (sensitive electronics or active components) on the NPMs that would interrupt or prevent successful core cooling.~~There are no SSCs susceptible to shock (sensitive electronics or active components) on the NPMs that would interrupt or prevent successful core cooling once the reactor is tripped and decay heat removal systems (DHRS) is actuated and the containment is isolated.

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There is no impact of concern at or below the 50' elevation, other than for SFP cooling. Affected equipment at the 62', 75', 86', and 125' elevations is not required to maintain core cooling or spent fuel cooling.

19.5.4.3 Fire Damage

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The RXB design prevents fire propagation. Exterior walls, vestibule walls, and stairwell walls provide at least a 3-hour fire barrier against fire propagation. The RXB exterior doors, including the equipment door, are designed as 5-psid, 3-hour barriers; piping penetrations have 5-psid, 3-hour seals; and the external HVAC penetrations have 5-psid, 3-hour dampers. In addition, the HVAC dampers and the main steam and feed water penetrations are protected by concrete shrouds.

When applying the fire spread rule sets in NEI 07-13 for strikes at external openings, the RXB design restricts fire propagation to only the vestibules and associated stairwells. There is no equipment required to maintain core cooling or spent fuel cooling located in these areas. Additional details for the site fire protection system are provided in Section 9.5.1.

A concurrent loss of both AC and DC power is not an issue of concern. Core cooling and spent fuel cooling are passive systems that have no dependency on any AC or DC power to meet their design functions.The design and location of 3-hour fire barriers and 3-hour, 5-psid fire barriers, including walls, floors, fire dampers, doors, equipment access door and penetration seals within the RXB and Control Building, are key design features for the protection of core cooling equipment from the impact of a large commercial aircraft. The assessment credited the design and location of fire barriers, as depicted on Figure 1.2-10 through Figure 1.2-18 and Figure 1.2-21 through Figure 1.2-25, to limit the effects of internal fire within the RXB to just the access vestibules and stairwells. There is no equipment required to maintain core cooling or spent fuel cooling in the access vestibules and stairwells. In addition, the design and location of 5-psid, fast-acting blast dampers in RXB HVAC system air intakes and exhaust lines (as described in Section 9.4.2.2.1 and shown on Figure 9.4.2-1) are key design features.

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These key design features ensure that necessary core cooling equipment are protected from fire damage for all postulated strikes.

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19.5.5 Review of Design FeaturesAssessment of Acceptance Criteria

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19.5.5.1 Design Features for Core CoolingContainment Intact

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Once shutdown of a NPM is initiated, the only design feature necessary for core cooling is the ultimate heat sink. The passive design of the DHRS and ECCS ensures continued core cooling capability for all postulated strike locations. The NPMs, DHRS components, ECCS components, and ultimate heat sink are located within the RXB and are not

~~susceptible to physical, fire, or shock damage resulting from an aircraft impact to the RXB. (See Section 19.5.5.5 for additional details of the RXB design feature).~~The containment system (CNTS) is an integral part of the NuScale Power Module (NPM) and provides primary containment for the Reactor Coolant System (RCS). The CNTS includes the containment vessel (CNV), CNV supports, containment isolation valves (CIVs), passive containment isolation barriers, and containment instruments.

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The CNV is an evacuated pressure vessel fabricated from low alloy steel and austenitic stainless steel, as described in Section 3.1.5, Section 3.8.2 and Section 6.2.1 through Section 6.2.4. The CNV is maintained partially immersed in a below-grade, borated-water filled, stainless steel lined, reinforced concrete pool to facilitate heat removal.

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The containment remains intact if the ultimate pressure capability of the CNV, as described in Section 3.8.2.4.5, is not reduced as a result of the aircraft impact. As stated in Section 19.5.4.1 and Section 19.5.4.3, there is no physical damage or fire damage to equipment required for fuel cooling in the RXB, including the CNTS. There is far shock that reaches the CNTS, but there are no components necessary for maintaining the containment intact that would be affected. Therefore, the containment remains fully intact.

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The design of the CNTS, as described in Section 6.2.1 through Section 6.2.4, and the location of the CNTS, shown on Figure 1.2-5, are key design features for maintaining an intact containment.

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19.5.5.2 ~~Design Features for Maintaining the Containment Intact~~Core Cooling

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~~The NPM design includes an integral containment. The NPMs are located within the RXB and are not susceptible to physical, fire, or shock damage resulting from an aircraft impact to the RXB. (See Section 19.5.5.5 for additional details of the RXB design feature).~~The NuScale Power Module (NPM), described in Section 4.1, is a self-contained nuclear steam supply system comprised of a reactor core, a pressurizer, and two steam generators integrated within the reactor pressure vessel (RPV) and housed in a compact steel containment vessel. The Reactor Coolant System (RCS), as described in Section 5.1, is a subsystem of the NPM and is located in the CNV. During normal operation, the RCS transports heat from the reactor core to the steam generators through natural circulation. Heat is removed by the main condensers located in the Turbine Building.

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Post reactor trip, there are two independent, safety-related, passive DHRS, as described in Section 5.4.3, that provide redundant core cooling capability for each NPM without reliance on external power. An impact that ruptures the main steam or feedwater piping in the Turbine Building does not affect DHRS passive cooling capability. DHRS initiation includes closure of the associated main steam and feedwater isolation valves inside the RXB, thereby preventing a loss of secondary side water through the damaged piping.

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Upon notification of an imminent aircraft threat, the operators in the Main Control Room scram the reactors, actuate DHRS and isolate containment. Heat from the DHRS is passively transferred to the reactor pool that serves as the Ultimate Heat Sink (described in Section 9.2.5 and Section 3B.2) that is located below grade in the RXB.

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There are no systems with open-water sources (e.g., circulating water system) located in the RXB physical damage footprint for any strike. As such, internal flooding is not an issue of concern.

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All containment penetrations are on the CNV which is protected from impact by the RXB exterior walls. The location of the CNV penetrations and isolation valves as described in Section 6.2.4 is a key design feature that ensures containment isolation.

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There are no control or protective functions that are necessary after aircraft impact for 72 hours, as described in Section 9.2.5.4.

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The NPMs, RCS, CNV, DHRS, containment isolation valves, and UHS are key design features for ensuring core cooling, as described above. The closure of the MSIVs and FWIVs, as described in Section 5.4.3.2 and Section 6.2.4, are key design features for ensuring DHRS operation. The ability to scram the reactors, isolate containment, and actuate DHRS from the MCR, as described in Section 7.0.4.1.2, Section 7.0.4.1.3, Section 5.4.3.2, and Section 6.2.4, are key design features for ensuring the reactor is tripped, containment is isolated, and DHRS is actuated prior to aircraft impact. Since there is no physical damage to any core cooling equipment in the RXB, the Control Rod Drive System is undamaged and available to initiate a scram, either manually from the MCR or by manually tripping the reactor trip breakers. The design and location of the Control Rod Drive System, as described in Section 4.6, is a key design feature for ensuring a scram can be initiated after impact if the reactor was not scrammed prior to impact.

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19.5.5.3 ~~Design Features for Spent Fuel Cooling~~Spent Fuel Pool Integrity

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~~The nonsafety-related spent fuel pool cooling system is assumed to fail. Spent fuel cooling is provided by the large water mass of the ultimate heat sink. No additional cooling is required. The integrity of the ultimate heat sink is ensured by the RXB~~

~~structure as described in Section 19.5.5.5.~~The SFP is constructed of thick, reinforced concrete walls and floor, as described in Section 3B.2 with a stainless steel liner, as described in Section 3.8.4. The SFP is integrated into the RXB structure and is located below grade. Because the SFP is completely below grade, an aircraft impact cannot strike the pool or the pool liner. Because there is no damage to the pool structure or liner, there is no loss of water level and SFP integrity is maintained. The location of the SFP as described in Section 9.1.2 and shown on Figure 1.2-10 through Figure 1.2-16 is a key design feature for maintaining SFP integrity from a direct aircraft impact.

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There are three hoist systems inside the RXB that can be operated over the SFP area: the Fuel Handling Machine (FHM), the New Fuel Jib Crane (NFJC), and the New Fuel Elevator (NFE). Provisions are in place to prevent the RBC from being moved over the SFP, as described in Section 9.1.5.3 and shown on Figure 9.1.5-1 and Figure 9.1.5-2. There are seismic restraints on the RBC, as shown on Figure 9.1.5-3. Because the exterior wall of the RXB is not perforated, the trolleys cannot be dislodged to fall into the Reactor Pool. Additionally, there are seismic restraints on the FHM, as described in Section 9.1.4.2.2 and shown on Figure 9.1.4-2. The design and location of the fuel handing equipment, as described above, is a key design feature for ensuring the hoists remain intact and cannot fall into the SFP and perforate the SFP liner.

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19.5.5.4 ~~Design Features for Maintaining Spent Fuel Pool Integrity~~Spent Fuel Pool Cooling

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~~The SFP is constructed of thick, reinforced concrete walls and floor. The SFP is integrated into the RXB structure and is located below grade. This design is a key design feature that prevents SFP perforation and maintains SFP integrity.~~Spent fuel pool cooling is not maintained for all postulated strike locations due either to shock or to loss of power. However, as described in Section 19.5.5.3, SFP integrity is maintained, and SFP cooling is not required. Although forced cooling is lost, the SFP is part of the UHS which provides a very large water inventory and ensures adequate water level is maintained above the spent fuel assemblies for beyond the mission time, even with the loss of forced SFP cooling, as described in Section 9.1.3.3.5.

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19.5.5.5 ~~Reactor Building~~Plant Monitoring and Control

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~~The RXB is a reinforced concrete structure that prevents aircraft perforation, limits physical damage, and prevents fire from entering the building. Vulnerable exterior openings are protected with aircraft impact resistant barriers (e.g., awnings, equipment door). The combination of the RXB exterior wall and roof thickness, rebar ratios, concrete strength, structural supports (including roof and crane supports), and external penetration fire barriers are key design features for ensuring continued core cooling and spent fuel cooling capability. (See Section 3.8.4 for a description of the RXB structure.)~~Once the operators scram the reactors and initiate DHRS and containment isolation upon warning of a potential aircraft impact, no further operator actions are necessary to maintain fuel cooling.

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19.5.5.6 General Arrangement

The general arrangement of the structures, specifically the location of the RWB in relation to the RXB, is a key design feature that limits potential strike locations to the west end of the RXB. The RWB is located approximately 16'-6" to the west of the RXB (Figure 1.2-1 and Figure 1.2-4). The roof of the RWB is approximately 49 feet above grade. For the structural analysis, the RWB is credited as an intervening structure and protects of a portion of the west wall of the RXB. However, for the heat removal analysis, crediting intervening structures did not reduce the consequences of an aircraft impact, so no credit for intervening structures was used. (See Section 3.8.4 for a description of the RWB structure.)

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19.5.5.7 Plant Systems

The locations and functions of the main control room and remote shutdown station are key design features that allow monitoring and control of the plant. The main control room is located on the 76'-6" elevation of the Control Building, which is located to the east of the RXB. The remote shutdown station is located on the 75'-0" elevation at the west end of the RXB. Figure 1.2-4 shows the overall site layout, Figure 1.2-13 shows the location of the remote shutdown station, and Figure 1.2-22 shows the location of the main control room. Physical separation between the main control room and remote shutdown station ensures at least one location will remain operable after a postulated aircraft impact. The module protection system cabinets and associated DC power equipment are available to monitor reactor pressure, reactor temperature, reactor water level, containment pressure, and containment water level after an aircraft strike.

The DHRS and ECCS, including any supporting equipment, are key design features for maintaining core cooling.

The Reactor Building crane design meets ASME NOG-1, Type 1 requirements and accommodates the effects of an aircraft impact to the RXB structure without falling. When not in use the crane is parked over the west end of the reactor pool (east of the spent fuel pool) with the trolley positioned at the north side over the drydock fence area. Additional information for the RXB crane is provided in Section 9.1.5.

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19.5.6 Use of Operator Actions

Operator action is required to manually trip the operating reactors to comply with the requirements of 10 CFR 50.150. If notified of an imminent aircraft threat or actual impact, operators manually initiate reactor trips from the main control room. If the main control room is or becomes inoperable prior to tripping all operating reactors, a remote shutdown station is located at the west end of the RXB on the 75'-0" elevation. Based on physical

~~separation, no single aircraft impact could result in a failure of both the main control room and the remote shutdown station.~~

19.5.7 Conclusion

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The aircraft impact assessment concludes that the NuScale Power Plant design and functional capabilities provide adequate protection of public health and safety in the event of an impact of the NRC defined large commercial aircraft. Containment ~~integrity~~intact, core cooling capability,~~ spent fuel cooling capacity, ~~and spent fuel pool integrity are not impaired as a result of the postulated aircraft impacts.

19.5.8 References

19.5-1 NEI 07-13, "Methodology for Performing Aircraft Impact Assessments for New Plant Designs," Revision 8, April 2011.

19.5-2 American Society of Mechanical Engineers, ASME NOG-1, “Rules for Construction of Overhead and Gantry Cranes (Top Running Bridge, Multiple Girder),” 2004.

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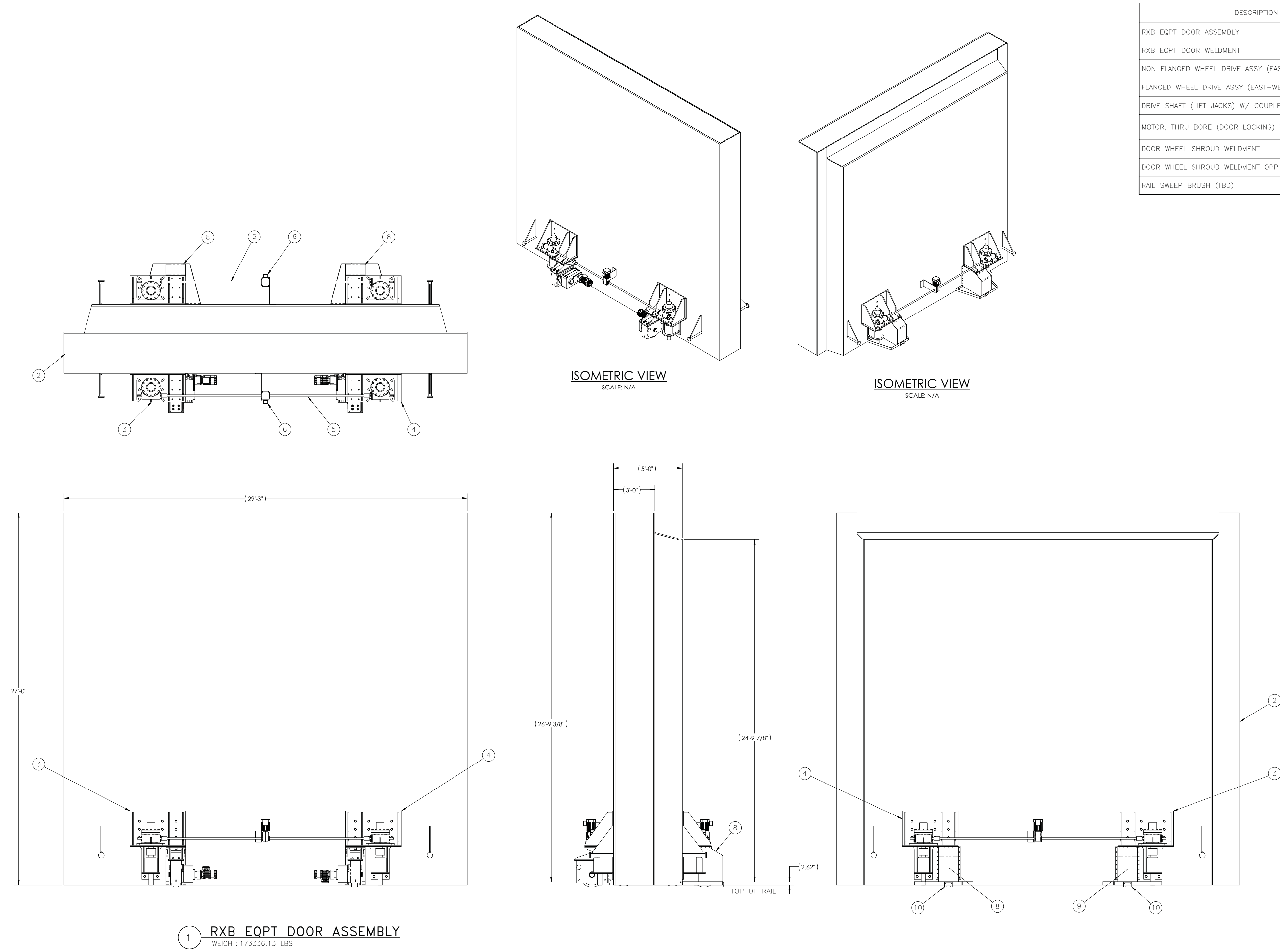
Figure 19.5-1: Reactor Building Equipment Door



DESCRIPTION	NO.
RXB EQPT DOOR ASSEMBLY	1
RXB EQPT DOOR WELDMENT	2
NON FLANGED WHEEL DRIVE ASSY (EAST–WEST)	3
FLANGED WHEEL DRIVE ASSY (EAST–WEST)	4
DRIVE SHAFT (LIFT JACKS) W/ COUPLERS	5
MOTOR, THRU BORE (DOOR LOCKING) W/ MOUNT BRACKET	6
DOOR WHEEL SHROUD WELDMENT	8
DOOR WHEEL SHROUD WELDMENT OPP HAND	9
RAIL SWEEP BRUSH (TBD)	10

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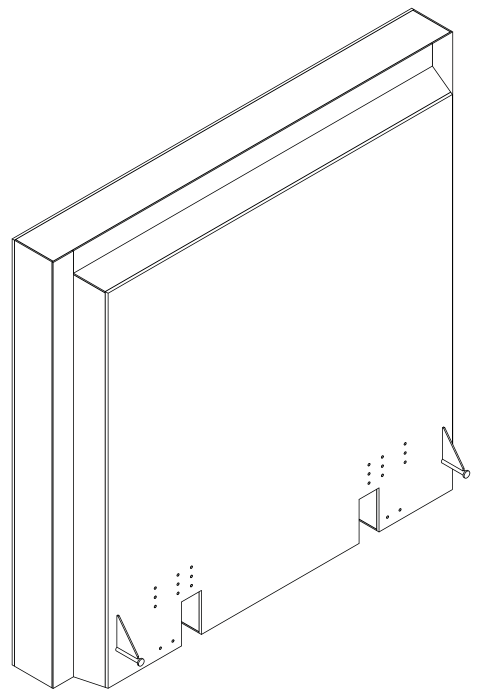
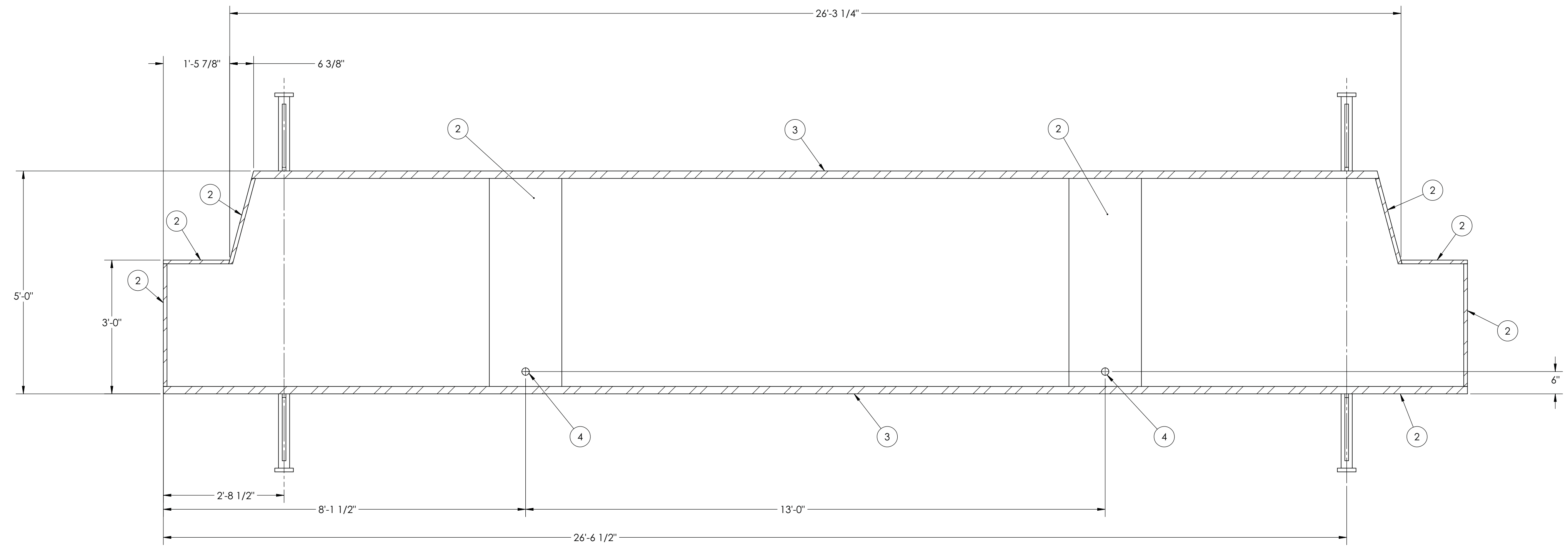
Figure 19.5-2: Reactor Building Equipment Door Weldment



ISOMETRIC VIEW
SCALE: N/A
NOTE: VIEW OF INSIDE OF DOOR



SECTION D-D
SCALE 1 : 16
SEE SHEET S03

PARTS/MATERIAL LIST		
DESCRIPTION	MATERIAL/REFERENCE	ITEM NO
RXB EQPT DOOR WELDMENT		1
PL 1" THK	ASTM A572 GRADE 50	2
PL 2" THK	ASTM A572 GRADE 50	3
PL 2" THK	ASTM A572 GRADE 50	3
RB 2"	ASTM A572 GRADE 50	4
RB 3"	ASTM A572 GRADE 50	5

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Figure 19.5-3: Reactor Building Equipment Door Assembly – Rebar Detail

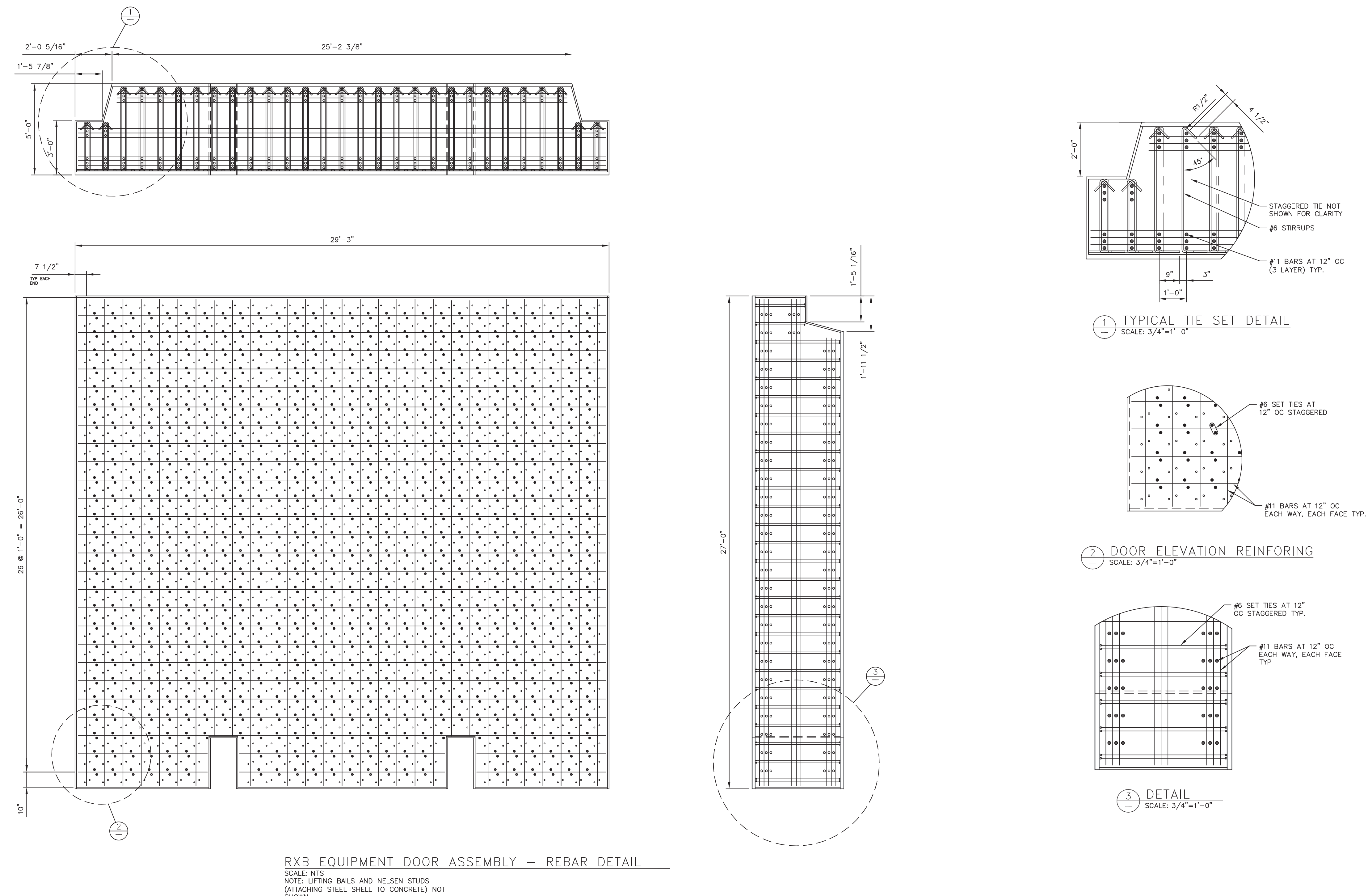

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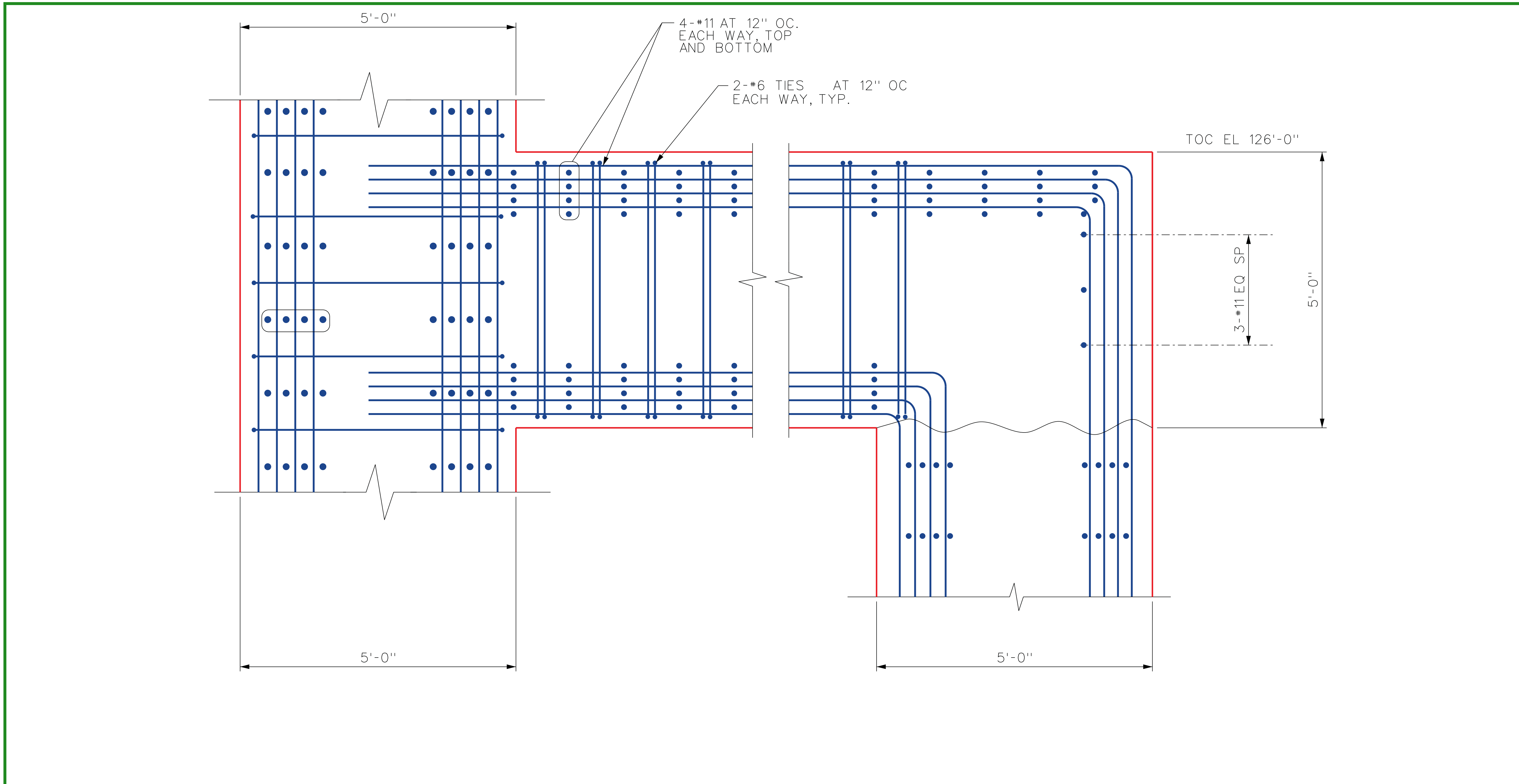
Figure 19.5-4: Reactor Building Structural Concrete



stack. The spent fuel exhaust subsystem is designed for continuous operation during all modes of plant operation.

Each NPM bay has an exhaust air vent that incorporates a fire damper and a blast damper.

Condensation from RBVS equipment is directed to the radioactive waste drain system.

9.4.2.2.1 Component Description

Outside Air Intakes

The RBVS supply air intakes are located so that they are clear from the steam generator atmospheric dump valves, any relief valves, diesel tractor parking areas, the plant exhaust stack, and other gas emitters that may present a hazard to personnel or operations in the RXB.

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~~Air intake openings have tornado missile protection in the form of hardened shrouds. These shrouds also protect from aircraft impact.~~ Outdoor air intake openings are equipped with louvers, bird screens, security and debris screens, blast dampers, and fire dampers to minimize the effects of high winds, rain, snow, ice, trash, and other external forces on the operation of the system, including aircraft impact. Air intake openings are provided with hardened shrouds to protect the dampers from external events. The shrouds protecting the HVAC intakes are constructed of 7000 psi concrete with four #11 bars at 12" on center each way, top and bottom. In addition, the horizontal portion of the awning protection has two #6 shear ties at 12" on center.

Supply Air Handling Units and Fans

Cooling and heating of the ventilation air serving the RXB is provided by four AHUs with variable speed supply air fans. Each AHU is sized at one-third of the total capacity. Three of the units are normally in operation and one is in standby. The AHU housing consists of a prefilter bank, a high efficiency filter bank, a heating coil bank, a chilled water cooling coil bank, and a centrifugal supply fan. During winter conditions, outdoor air below 40 degrees Fahrenheit is preheated by a duct mounted preheat coil before entering the AHU.

General Area Exhaust Fan and Filter Units

There are nine general area exhaust fan and filter units. Eight are normally in service and one is in standby. Each unit includes a low efficiency filter bank followed by a HEPA filter bank. The filter unit is a draw-through type unit with a centrifugal exhaust fan downstream of the filter section. Each fan and filter set exhausts to the plant exhaust stack.

The filtration unit configurations, including housing, internal components, ductwork, dampers, fans, and controls, are designed, constructed, and tested to smoke. The combination fire and smoke dampers meet the design and installation requirements of UL 555 (Reference 9.4.2-11) and UL 555S (Reference 9.4.2-12).

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Blast Dampers

Blast dampers are included in the intake and exhaust ductwork to protect the RXB from explosions in adjacent areas. The exhaust blast dampers are located at the ductwork interface between the RXB and the RWB.

Plant Exhaust Stack

The plant exhaust stack is located in the northwest corner of the RWB. The minimum stack height is set in accordance with criteria in RG 1.194, Section 3.2.2. Per the Department of Energy Nuclear Air Cleaning Handbook (Reference 9.4.2-20), Section 5.5.2, the stack is designed to maintain a minimum stack exit velocity of 3,000 fpm to prevent downwash from winds up to 22 mph, to keep rain out, and to prevent condensation from draining down the stack. The plant exhaust stack is designed in accordance with ASME-STS-1 (Reference 9.4.2-19) and Reference 9.4.2-3, Section AA.

9.4.2.2.2 System Operation

9.4.2.2.2.1 Normal Operation

RAI 21.0-1

During normal plant operation, the RBVS main supply AHUs, the general exhaust, and the SFP exhaust units are active and servicing the RXB general area, the reactor pool area, the fuel handling area, and the equipment galleries. In addition, RBVS filters exhaust from the A~~N~~BVS and the RWBVS via the general exhaust subsystem.

The main supply AHUs and general exhaust filter units operate continuously and provide sufficient ventilation and air conditioning to maintain personnel comfort and equipment reliability. One of the general area fans and one of the filter units is in standby mode allowing flexibility for maintenance activities.

The general exhaust system also serves the battery rooms to maintain hydrogen concentrations to less than one percent by volume.

The SFP exhaust subsystem draws air near the surface of the SFP through vents located along the long sides of the SFP and the refueling dock pool. The SFP exhaust air bypasses the charcoal adsorbers of the filter units during normal operation. One of the two SFP exhaust fans and filter units is in service and the remaining exhaust fan and filter unit is in standby.

The recirculating cooling subsystem, located in the SFP area, is normally in operation, as are the AHUs servicing the input and output rooms, battery

Figure 9.4.2-1: Reactor Building HVAC System Diagram

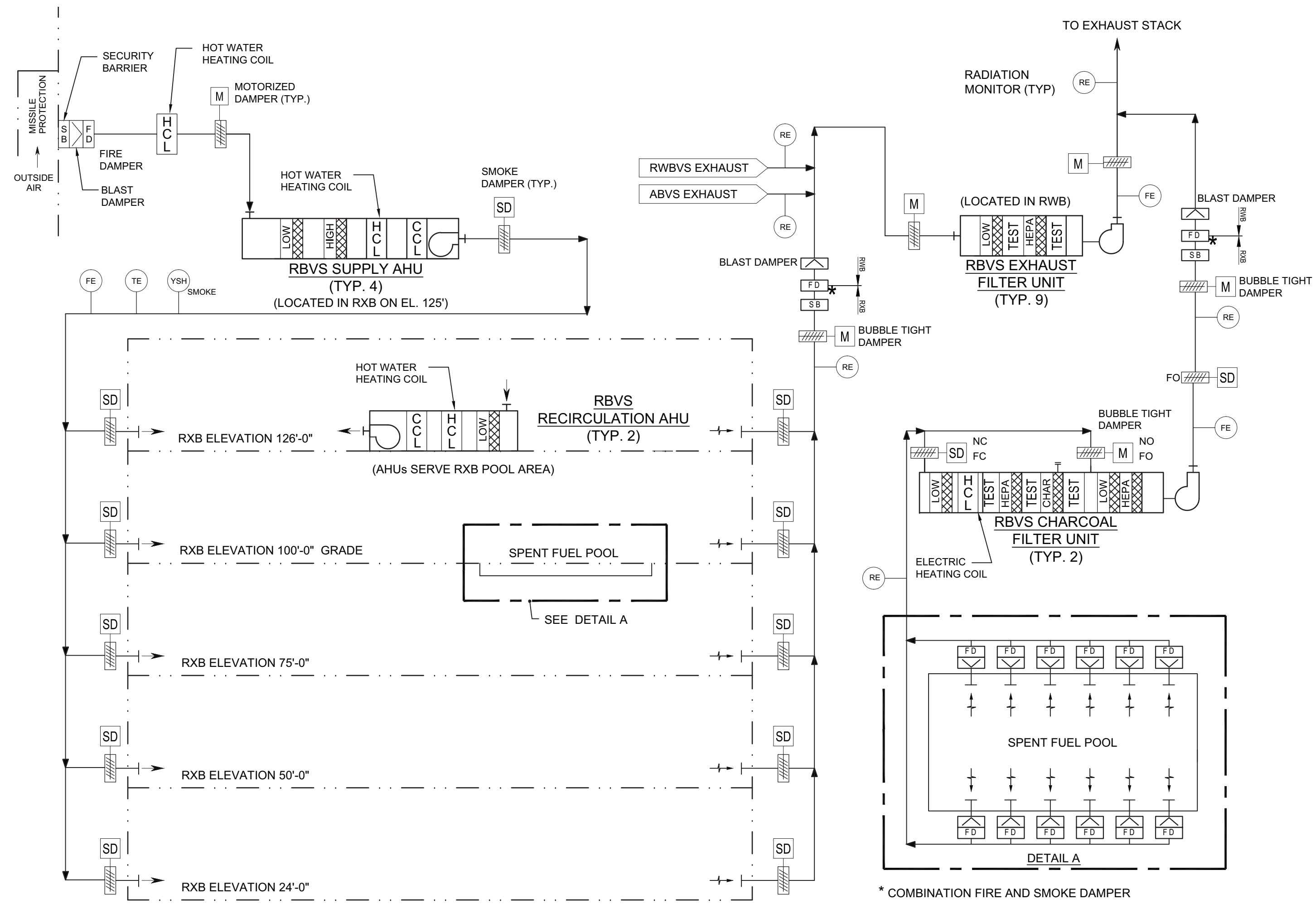

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Figure 1.2-16: Reactor Building 100'-0" Elevation

{{

Withheld - See Part 9

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Figure 1.2-17: Reactor Building 126'-0" Elevation

{{

Withheld - See Part 9

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Figure 1.2-18: Reactor Building 145'-6" Elevation

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Withheld - See Part 9

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Figure 1.2-23: Control Building 76'-6" Elevation

{{

Withheld - See Part 9

}}

3) The SFA is lowered into the appropriate location in the fuel storage rack.

4) The FHM repeats this process until the core is fully offloaded.

5) The FHM then removes a CRA and places the CRA into a designated fuel assembly (new fuel assembly or SFA).

6) The FHM then picks up a fuel assembly and CRA and places it in the reactor core.

7) The FHM repeats this process until reactor refueling is complete.

Loading Spent Fuel Transfer Cask

The SFAs designated for removal from the RXB are moved from the SFP to a specially designed transfer cask located in the RFP. Cask-handling is addressed in Section 9.1.5.

COL Item 9.1-3: A COL applicant that references the NuScale Power Plant design certification will develop procedures related to the transfer of spent fuel to a transfer cask.

9.1.4.3 Safety Evaluation

The FHE supports the periodic refueling of the reactor as well as movement of control rods and other radioactive components within the reactor core, RFP and SFP. The FHE maintains fuel integrity and prevents criticality during fuel handling activities. The classification of the FHE is further discussed in Section 3.2.

The FHE is located within the confines of the Seismic Category I RXB that protects the FHE from the effects of natural phenomenon.

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The FHM is provided with seismic restraints to prevent the bridge and trolley from overturning or coming off rails during a seismic event. The FHM bridge rails are anchored more than 4.5 inches from the edge of the spent fuel pool. This design feature is consistent with the requirements of Regulatory Guide 1.29, position C.2 in that it precludes interactions of nonsafety-related SSC with safety-related SSC. The FHM trolley and mast are designed to be single-failure-proof and comply with the requirements of Reference 9.1.4-3 and Reference 9.1.4-4.

A seismic switch on or adjacent to the FHM shuts off power to the FHM. The FHM stops and its brakes set, and the machine comes to rest. These design features ensure that a fuel assembly continues to be suspended by the FHM during and after a seismic event.

The design of the FHM, per Reference 9.1.4-4, ensures that the FHM is able to withstand the highest expected seismic excitation. Large components (electrical cabinets, winches, masts, etc.) have also been analyzed to ensure these components do not come loose during a seismic event and become missiles potentially damaging other equipment. Manual methods of releasing brakes and performing the various functions

Other refueling devices that are used in support of the module refueling, assembly, and inspection are:

- CFT
- RFT
- Module inspection rack

The movement of the RBC is controlled with the position control system by a series of interlocks to ensure that load movement procedures are maintained. The RBC has provisions to limit the path and the maximum height so that the minimum required depth of water shielding is maintained. The position control system is described in Section 9.1.5.5.

A direct communication system is provided between the control room and the RBC control station.

9.1.5.2.2 Component Descriptions

Reactor Building Crane

The RBC is a bridge crane that rides on rails anchored to the RXB. The RBC consists of a bridge, trolley, main hoist, and two auxiliary hoists. The RBC is designed as a single-failure-proof crane in accordance with the requirements of NUREG-0554 and ASME NOG-1 for Type I cranes. The RBC is service class D per CMAA-70 (Reference 9.1.5-6).

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The RBC bridge is the main supporting structure of the RBC. It is supported by runway rails anchored to the RXB structure, more than 4.5 inches from the edge, and provides traveling motion across the length of the reactor pool, refueling pool, and dry dock. The bridge supports the RBC trolley, the attached main hoist, and the load. The wheels are double-flanged and fitted with sealed bearings.

The RBC trolley is the main structure for the hoisting equipment, providing the platform for the hoists. It is supported by the RBC bridge and travels across the width of the pool on the bridge rails. The trolley supports the lifted load and transfers the load to the bridge.

The trolley structure and end trucks are welded construction. The trolley drive system is constructed so that two opposite wheels are driven. The motor is fitted with a brake that can be manually released. A means is provided for attaching a hand wheel to the drive system and manually moving the trolley. Gear boxes and motors have drip pans to collect oil leakage. Figure 9.1.5-3 shows the RBC trolley.

A position feedback system provides trolley location information to the control system.

When a heavy load is detected by the RBC main hoist, the maximum trolley speed is limited to ASME NOG-1 values provided in Table 9.1.5-1. The trolley speed can be effects of missile impact loadings. The barrier design procedures discussed below may be used for both internal and external missiles.

3.5.3.1 Local Damage Prediction

The prediction of local damage in the impact area depends on the basic material of construction of the structure or barrier (i.e., concrete, steel, or composite). The analysis approach for each basic type of material is presented separately. It is assumed that the missile impacts normal to the plane of the wall on a minimum impact area.

3.5.3.1.1 Concrete Barriers

Concrete missile barriers are evaluated for the effects of missile impact resulting in penetration, perforation, and scabbing of the concrete using the Modified National Defense Research Committee formulas discussed in "A Review of Procedures for the Analysis and Design of Concrete Structures to Resist Missile Impact Effects," (Reference 3.5-3) as described in the following paragraphs. Concrete barrier thicknesses calculated using the equations in this section for perforation and scabbing are increased by 20%.

RAI 03.05.03-1

Concrete thicknesses to preclude perforation or scabbing from the design basis hurricane and tornado pipe and sphere missiles have been calculated for the 5000 psi and 7000 psi concrete used for the RXB, CRB and RWB external walls and roof using the below equations. The design basis hurricane and tornado automobile missile is incapable of producing significant local damage, therefore, it is not considered. The results are tabulated in Table 3.5-1. The RXB has five foot thick outer walls and a four foot thick roof. The missile protected portions of the CRB have three foot thick exterior walls and roof, consisting of a concrete slab with a steel cover, and the RWB has exterior walls that are two feet thick above grade and has a one foot thick roof.

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Additional design characteristics of the RXB and CRB are provided in Section 3B.2. The RWB exterior walls are 5000 psi concrete reinforced with a minimum of #8 reinforcing bars on 12-inch centers.

3.5.3.1.1.1 Penetration and Spalling Equations

The depth of missile penetration, x, is calculated using the following formulas:

$$x = \left[4KNWd\left\langle\frac{V}{1000d}\right\rangle^{1.8}\right]^{0.5} \text{ for } \frac{x}{d} \le 2.0 \qquad \text{Eq. 3.5-1}$$

$$x = KNW\left(\frac{V}{1000d}\right)^{1.8} + d \text{ for } \frac{x}{d} \ge 2.0 \qquad \text{Eq. 3.5-2}$$