9.1.5 Overhead Heavy Load Handling System

The U.S. EPR design includes material handling systems which are required to handle heavy loads. A heavy load is defined as a load the weight of which is greater that the combined weight of a single spent fuel assembly and its handling tool. For the U.S. EPR, the weight of a heavy load is above 1730 lb.

There are various cranes, hoists and load handling devices which are used to handle material and lift heavy loads. These include:

- Double and single girder top running overhead and underhung cranes.
- Gantry cranes.
- Monorail hoists.
- Floor and wall mounted jib cranes.
- Stationary hoists attached to lifting lugs in various locations throughout the power plant.

This section focuses on critical load handling. This is defined as those load handling operations with the potential for inadvertent movement or equipment malfunction leading to:

- A significant release of radioactivity.
- A loss of margin to subcriticality.
- Uncovering of the irradiated fuel in the reactor vessel or spent fuel pool.
- Damage to safety-related equipment needed to achieve or maintain safe shutdown.

The Fuel Handling System (FHS) is described in Section 9.1.4.

9.1.5.1 Design Bases

Heavy load handling equipment (HLHE) satisfies the following general design criteria (GDC) and design basis requirements:

1. Structures, systems and components (SSC) important to safety are designed, fabricated, erected, and tested to quality standards (GDC 1).
2. HLHE is located inside structures which are designed to withstand the effects of natural phenomena, such as earthquake, tornados, and hurricanes (GDC 2).
3. HLHE is designed to provide protection against the effects of internally generated missiles (i.e., dropped loads) (GDC-4). The control of heavy loads in the Fuel Building meets the guidance presented in RG 1.13, position C.5.

4. SSC important to safety are not shared with other reactor units (GDC 5).

5. For those items designated as single failure-proof, the design meets the applicable portions of NUREG-0554 (Reference 1) as modified by Generic Letter 83-042 (Reference 2). In addition, all HLHE meets the guidance of NUREG-0612 (Reference 3) as modified by Generic Letter 85-011 (Reference 4).

The safety and seismic classifications of heavy load handling systems are based on the functions they perform and on their location relative to spent fuel, fuel in the core, nuclear materials, or equipment that may be required to achieve safe plant shutdown. Table 3.2.2-1 provides the safety and seismic classifications for the heavy-load handling cranes.

In addition to equipment design (single failure-proof systems and interlocks) other means are used to reduce the consequences of load handling incidents. These include:

- Design of power plant and arrangement of systems to limit movement of heavy loads over or near safety-related or safe shutdown components.
- Minimizing the elevation between the lifted load and the plant structures.
- Establishment of safe load paths over robust power plant structures.
- Analyses of heavy load drops to confirm damage is acceptable.

The equipment that is used to lift heavy loads is designed and fabricated to codes consistent with the seismic category assigned by RG 1.29 and industry standard specifications, as described in Section 3.2.

The cranes for the U.S. EPR are designed in accordance with the requirements of ASME NOG-1 (Reference 5) and ASME NUM-1 (Reference 6). These standards have been developed using guidance provided by Reference 3, Reference 1, ASME B30.2 (Reference 7) and CMAA-70 (Reference 8). Cranes are designated as NOG-1, Type I, II, or III based on their requirements to handle critical loads and their seismic design criteria.

9.1.5.2 System Description

9.1.5.2.1 General Description

Table 9.1.5-1—Heavy Load Handling Equipment, includes a listing of the primary HLHE which are located in areas containing safety-related equipment that could be potentially impacted by drops of heavy loads.

Other cranes capable of making heavy load lifts are also employed throughout the power plant. These cranes are designed to meet regulatory and power plant restrictions with regard to heavy load handling.

9.1.5.2.2 Reactor Building Polar Crane

The RB polar crane is designed in accordance with ASME NOG-1 as a single failure-proof crane (Type I) capable of handling the maximum critical load (i.e., not drop the load) during and following a safe shutdown earthquake (SSE). The maximum critical load is defined as the maximum load, not necessarily the rated load, the uncontrolled movement or release of which could adversely affect any safety-related system when such a system is required for unit safety or could result in potential offsite exposure in excess of established limits. This designation meets the requirements of RG 1.13. Single failure-proof cranes are designed in conformance with Reference 1, Reference 2, Reference 3 and Reference 4. See Section 3.8.3.4.4 for a description of the seismic analyses for the polar crane.

The RB polar crane is primarily used during plant outages to assist in refueling and maintenance activities. The major heavy loads it normally handles include:

- The multiple-stud tensioning machine – 93 metric tons.
- The reactor vessel closure head – 185 metric tons.
- Reactor cavity cover slab – 80 metric tons.
- The RB platform – 10 metric tons.
- The drive rod shafts – one metric ton.
- The upper and lower internals lifting rigs – 30 metric tons, 15 metric tons.
- The upper and lower internals – 80 metric tons, 195 metric tons.
- The pool liner slot and the setdown area partition gates – 25 metric tons.

In addition, the RB polar crane can be used as a backup tool for handling of fuel assemblies due to the unavailability of the refueling machine. When used in this capacity, interlocks are provided to prevent:

- Continued lowering of the load (other than full down position) upon receipt of a reduced load signal.
- Continued hoisting of the load upon receipt of an increased load signal (load hang-up).
- Continued upward travel of the hoist on a preset limit (two-blocking event).
- Simultaneous horizontal and vertical movement.
- Continued travel of the bridge and trolley beyond established limits.

Physical limits (hard-stops) are also provided on the bridge and trolly end of travel and on the hoist upper limit.

The RB polar crane is supported by a circular runway, which rests on brackets attached to the containment structure. The structure is a rigid assembly. The bridge framework consists of two girders and two end trucks. The two main girders are welded box sections which are attached with end ties and are supported on the crane end trucks. The end trucks consist of structural frames containing wheel assemblies (bogies). The polar crane girders are provided with full-length walkways that allow access to the associated electrical and mechanical components.

The RB polar crane is equipped with trolleys that traverse the length of the bridge. The trolleys provide structural support for the associated hoisting equipment.

The RB polar crane is provided with three electric hoists. The main hoist is supported by a single trolley and has a rated capacity of 320 metric tons. The secondary trolley supports two hoist units, one rated at 35 metric tons and another rated at five metric tons.

Special lifting devices used with this crane will satisfy the design criteria specified in ANSI N14.6 (Reference 9). If special lifting devices are not used, slings will be selected that satisfy the criteria of ANSI/ASME B30.9 (Reference 10). In addition, slings for use with single-failure-proof handling systems will be constructed of metallic material (chain or wire rope). Special lifting devices and slings will have either dual independent load paths or a single load path with twice the design safety factor.

9.1.5.2.3 Fuel Building Auxiliary Crane

The FB auxiliary crane, located over the spent pool, is designed in accordance with ASME NOG-1 as a single failure-proof crane (Type I). As a Type I crane, the FB auxiliary crane is capable of handling the maximum critical load (i.e., not drop the load) during an SSE. The FB auxiliary crane is designed to Seismic Category II criteria and in conformance with Reference 1, Reference 2, Reference 3 and Reference 4.

The heavy loads the FB auxiliary crane normally handles include:

- Slot gates – 11.2 metric tons (includes lifting beam and lower load block).
- New fuel containers – 5 metric tons.

In addition, the auxiliary crane can be used to handle spent fuel assemblies in the event that the spent fuel mast bridge is not available. When used in this capacity, interlocks are provided to prevent:

- Continued lowering of the load (other than full down position) upon receipt of a reduced load signal.

- Continued hoisting of the load upon receipt of an increased load signal (load hang-up).
- Continued upward travel of the hoist on a preset limit (two-blocking event).
- Simultaneous horizontal and vertical movement.
- Continued travel of the bridge and trolley beyond established limits.

Physical limits (hard-stops) are also provided on the bridge and trolly end of travel and on the hoist upper limit.

Special lifting devices used with this crane will satisfy the design criteria specified in ANSI N14.6 (“Special Lifting Devices for Shipping Containers Weighing 10000 Pounds (4500 kg) or More”). If special lifting devices are not used, slings will be selected that satisfy the criteria of ASME B30.9 (“Slings”). In addition, slings for use with single-failure-proof handling systems will be constructed of metallic material (chain or wire rope). Special lifting devices and slings will have either dual independent load paths or a single load path with twice the design safety factor.

9.1.5.2.4 Other Overhead Load Handling Systems

Other than the RB polar crane, other major cranes in the RB include four single girder bridge cranes used for servicing heating, ventilation and air conditioning (HVAC) equipment, four jib cranes located within the steam generator cubicles and an assembly crane located near an accumulator tank. These cranes provide lifting capabilities during plant outages.

The Fuel Building contains bridge cranes in the equipment lock area. These cranes are used to move equipment and material from the plant grade elevation up to the equipment hatch level. These cranes are located in areas remote from the spent fuel pool such that movement of loads in the vicinity of the spent fuel pool by these cranes is not possible.

The Safeguard Buildings, Emergency Power Generating Buildings, and ultimate heat sink/essential service water structures are also equipped with cranes that are rated for heavy loads. For these divisionally separated buildings, the local effect of a load drop is restricted to the affected division. Accordingly, the loss of a safety system inside the affected division is acceptable from a nuclear safety standpoint.

If one division is unavailable because of maintenance, load handling over in-service safety-related equipment and systems of other divisions is prohibited. During a seismic event, the design of Type II cranes results in the cranes remaining in place and not impacting safety-related equipment and systems below the cranes. The design of Type II cranes requires electrical power to enable the crane hoist brakes to open. In the event of a common mode failure causing a loss of electrical power, the hoist brakes close enabling the load to be placed in a safe condition.

For buildings that are not completely divisionally separated (Containment Building, Reactor Building Annulus, and the FB), analyses are performed to determine if a simultaneous loss of more than one redundancy of a system is possible due to a postulated local load drop. If it is possible, the acceptability is evaluated. If single failure-proof crane designs are used, load drop analyses are not required.

In accordance with Section 5.1 of Reference 3, the use of non-single failure-proof cranes is allowed in certain applications when handling heavy loads.

9.1.5.2.5 System Operation

A COL applicant that references the U.S. EPR design certification will provide site-specific information on the heavy load handling program, including a commitment to procedures for heavy load lifts in the vicinity of irradiated fuel or safe shutdown equipment, and crane operator training and qualification.

A description of the operation of the polar crane is provided in this section.

The polar crane is used for handling loads during plant refueling and maintenance outages. During normal plant operation the polar crane is seismically restrained with the trolley parked at the ends of the girders. The crane in its unloaded condition is designed to withstand the containment environmental conditions, including rapid pressure changes within the containment.

The polar crane is controlled by an operator using a portable remote control station, or a fixed control station located on the operating floor. These units are designed with keylock systems which only allow the operation of the crane from one control station at a time.

In addition to operation during normal refueling and maintenance periods, the crane structure is designed to allow its use during construction and component replacement periods. The bridge girders are tied together using a central arch connected at the midspan of each girder. This arch allows attachment of a hoisting winch which can be used to lift temporary lifting devices onto the crane girders for use in component installation and replacement. The crane is also provided with an A-frame maintenance gantry, rated at 15 metric tons, which allows maintenance activities to be performed on the main and auxiliary/secondary hoists and trolleys.

9.1.5.3 Safety Evaluation

Movement of heavy loads is restricted by design (including interlocks) and/or administrative controls to areas away from stored fuel and equipment necessary for the safe shutdown of the reactor. HLHE located in safety-related areas of the plant include those in the RB, FB, Safeguard Buildings, and Emergency Power Generating Buildings. These buildings are designed to withstand the effects of earthquakes, tornadoes, hurricanes, floods, external missiles, and other similar natural phenomena. Section 3.3, Section 3.4, Section 3.5, Section 3.7, and Section 3.8 provide the bases for the adequacy of the structural design of these buildings.

HLHE is categorized, based on its design, to remain intact after an SSE. For this application, the cranes handling critical loads are designed as Type 1 equipment. A Type 1 crane is one that is required to remain in place and support the critical load during and after the seismic event, but does not have to be operational after this event. Single failure-proof features are included so that any credible failure of a single component will not result in the loss of potential to stop and hold the critical load. A critical load is defined as a heavy load being lifted over in-service safety-related or safe-shutdown equipment, or fuel, and in a path that if dropped, would affect unit safety or offsite release of radioactivity in excess of established limits. Items designed to meet this function requirement include mechanical and structural items in the load train (i.e., the hook, wire rope, lower and upper block, load brakes, gear train, hoist drum and supports, trolley frame and bridge girders). Section 3.8 provides the design loading conditions that were considered. Section 3.6, Section 3.8, and Appendix 9A provide the results of the required hazards analyses.

Details regarding the specific assumptions, sequences, and analyses of fuel handling or cask drop accidents are provided in Section 15.0.3.10.

Heavy load handling systems provide for the safe handling of loads by either designing them as single failure-proof systems or by making use of the plant equipment and system arrangements so that a load drop will be acceptable. The consequences of a postulated critical load drop are considered to be acceptable when the four evaluation criteria of Paragraph 5.1 of Reference 3 are satisfied. A heavy load that is lifted in a safety-related area is classified as a critical load unless the consequences of a load drop have been evaluated and found to be within acceptable limits.

For heavy loads to be handled by equipment not designated as single failure-proof, additional measures are implemented to make sure the load handling restrictions delineated in Reference 3 and associated load handling regulations are followed. These include limits on lift height of the heavy load (i.e., lifting the load no higher than necessary to reduce potential impact energy), restricting load handling activities to designated safe load paths which are clearly identified on plant structures and administratively controlled, and in certain circumstances evaluating plant SSC for potential load drops.

9.1.5.4 Inspection and Testing Requirements

The preoperational inspection and testing of the HLHE is in accordance with Reference 5. The tests include operational testing with a no-load test of the crane to demonstrate function and speed controls for bridge, trolley, and hoist drives and proper functioning of limit switches, locking, and safety devices. Additionally a full-load test of the crane loaded at 100 percent of the crane manufacturers rating is performed, along with a rated-load test performed at 125 percent of the manufacturers rated load. Refer to Section 14.2 (test abstracts #040 and #041) for the initial plant startup test program.

The inservice inspection of the HLHE is governed by site-specific procedures in accordance with Reference 7. Inservice inspection and testing of special lifting devices used in safety-related areas of the plant meet the criteria specified in ANSI N14.6 (Reference 9). Slings used in safety-related areas meet the criteria specified in ANSI/ ASME B30.9 (Reference 10).

9.1.5.5 Instrumentation Requirements

Included in the crane design are devices which provide additional measures for safe operation of the crane. These devices provide protection for overtravel, overspeed, overload, unbalanced load and proper spooling of the hoisting ropes onto the hoist drums.

The hoisting motions are provided with redundant limit switches which prevent overtravel of the hoist hook in hoisting and lowering operations. The primary limit is a control circuit switch which removes power to the hoist motor and sets the brakes. Motion out of this limit is allowed in the safe direction of travel. The secondary system consists of a power circuit-limit, which when activated directly interrupts power to the hoist motor and the brakes, causing the brakes to set. Motion out of this limit is not possible without corrective action.

The hoist drum is equipped with limit switches which are used to monitor hoist over-speed and to control proper threading of the wire rope onto the drum. Activation of either of these sends a signal to the control system causing the hoist motor to stop and the brakes to set. In addition, a balanced-load limit switch is installed in the upper hoist block which monitors movement of the equalizer. Tripping of this device initiates a flashing warning light visible to the crane operator and interrupts the hoist motion upon detection of excessive movement.

Travel limits installed at each end of the crane bridge girders control overtravel of the crane trolley. Actuation of these limits removes power from the travel motion, allowing the trolley to coast prior to engagement with the trolley bumper stops so that the kinetic energy imparted to the bumpers is within the acceptable design range.

9.1.5.6 References

1. NUREG-0554, “Single-Failure-Proof Cranes for Nuclear Power Plants,” U.S. Nuclear Regulatory Commission, 1979.

2. Generic Letter 83-042, NRC Letter to All Holders of Operating Licenses, Applicants for Operating Licenses and Holders of Construction Permits for Power Reactors, “Clarification to GL 81-07 Regarding Response to NUREG-0162, ‘Control of Heavy Loads at Nuclear Power Plants’”, U.S. Nuclear Regulatory Commission, December 19, 1983.

3. NUREG-0612, “Control of Heavy Loads at Nuclear Power Plants Resolution of Generic Technical Activity,” U.S. Nuclear Regulatory Commission, July 1980.

4. Generic Letter 85-011, NRC Letter to All Licensees for Operating Reactors, “Completion of Phase II of Control of Heavy Loads at Nuclear Power Plants,” U.S. Nuclear Regulatory Commission, June 28, 1985.

5. ASME NOG-1, “Rules for Construction of Overhead and Gantry Cranes,” The American Society of Mechanical Engineers, 2004.

6. ASME NUM-1, “Rules for Construction of Cranes, Monorails, and Hoists,” The American Society of Mechanical Engineers, 2004.

7. ASME B30.2-2005, “Overhead and Gantry Cranes – Top Running Bridge, Single or Multiple Girder, Top Running Trolley Hoist,” The American Society of Mechanical Engineers, January 2005.

8. CMAA 70-00, “Specifications for Top Running Bridge and Gantry Type Multiple Girder Electric Overhead Traveling Cranes,” Crane Manufacturers Association of America, 2000.

9. ANSI N14.6, “Special Lifting Devices for Shipping Containers Weighing 10,000 Pounds (4500 Kg) or More,” American National Standards Institute, 2004.

10. ANSI/ASME B30.9-2003, “Slings,” American National Standards Institute/The American Society of Mechanical Engineers, July 2003.

Table 9.1.5-1—Heavy Load Handling Equipment
Sheet 1 of 2

COMPONENT	CRANE / HOIST TYPE	LOCATION	MAXIMUM LOAD RATING	SINGLE FAILURE-PROOF	DESIGN CODE	CRANE TYPE
Reactor Building Polar Crane	Double Girder Electric Overhead Traveling (EOT) Bridge Crane	Containment Building	320 metric tons	Yes	NOG-1	I
Fuel Building Auxiliary Crane	Double Girder EOT Bridge Crane	Fuel Building	20 metric tons	Yes	NOG-1	I
HVAC Equipment Room Cranes	Single Girder Bridge Crane	Containment Building	2 metric tons	No	NUM-1	II
Steam Generator Cubicle Cranes	Jib Crane	Containment Building	2 metric tons	No	NUM-1	II
Assembly Crane	Electric Underhung Bridge Crane	Containment Building	5 metric tons	No	NUM-1	II
Equipment Lock Crane	Double Girder EOT Bridge Crane	Fuel Building	90 metric tons	No	NOG-1	II
Equipment Lock Crane	Electric Underhung Bridge Crane	Fuel Building	20 metric tons	No	NUM-1	II
Diesel Hall Cranes	Electric Underhung Bridge Crane	Emergency Power Generating Buildings	2 metric tons	No	NUM-1	II
Main Steam Valve Station Cranes	Electric Underhung Bridge Crane	Safeguard Buildings	5 metric tons	No	NUM-1	II
Hot Workshop Crane	Double Girder Crane	Nuclear Auxiliary Building	10 metric tons	No	NOG-1	III
Entrance Area Crane	Double Girder Bridge Crane	Radwaste Building	20 metric tons	No	NOG-1	III
Drum Storage Area Crane	Double Girder Crane	Radwaste Building	2 metric tons	No	NOG-1	III
Hot Workshop Crane	Double Girder Crane	Radwaste Building	16 metric tons	No	NOG-1	III

Table 9.1.5-1—Heavy Load Handling Equipment
Sheet 2 of 2

COMPONENT	CRANE / HOIST TYPE	LOCATION	MAXIMUM LOAD RATING	SINGLE FAILURE-PROOF	DESIGN CODE	CRANE TYPE
Decontamination Area Crane	Single Girder Crane	Radwaste Building	5 metric tons	No	NUM-1	III
Gantry Crane	Double Girder Crane	Outside Fuel Building	160 metric tons	No	NOG-1	II
Pump Room Cranes	Jib Crane	ESW Pump Structure	1 metric ton	No	NUM-1	II

NOTES:

One metric ton equals 1000 kg, or approximately 2205 lb.

Next File