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RBG-46478

September 21, 2005

U.S. Nuclear Regulatory Commission
Attn: Document Control Desk
Washington, DC 20555

Subject: River Bend Station
Docket Nos. 50-458 and 72-49
License No. NPF-47
Revised License Amendment Request (LAR) 2004-26, "Use of the Fuel Building Cask Handling Crane for Dry Spent Fuel Cask Loading Operations"

References:

1. License Amendment Request (LAR) 2004-26, "Use of the Fuel Building Cask Handling Crane for Dry Spent Fuel Cask Loading Operations" Dated March 8, 2005

2. Entergy Operations letter to NRC, "Response to NRC Bulletin 96-02, 'Movement of Heavy Loads Over Spent Fuel, Fuel in the Reactor Core, or Over Safety Related Equipment,'" dated August 29, 1996

3. Supplement to License Amendment Request (LAR) 2004-26, "Use of the Fuel Building Cask Handling Crane for Dry Spent Fuel Cask Loading Operations" Dated April 19, 2005

4. Supplement to License Amendment Request (LAR) 2004-26, "Use of the Fuel Building Cask Handling Crane for Dry Spent Fuel Cask Loading Operations" Dated July 12, 2005.

5. NRC request for additional information dated August 19, 2005.

Dear Sir or Madam:

In Reference 1, Entergy Operations Incorporated (Entergy) requested an operating license amendment for River Bend Station (RBS). The proposed license amendment requested approval for the use of the Fuel Building Cask Handling Crane (FBCHC) for dry spent fuel cask handling operations. Specifically, consistent with the requirements of 10 CFR 50.59 and the guidance in NUREG-0612 and Bulletin 96-02, certain heavy load drop events had been postulated and analyzed, which Entergy has determined will require NRC review and approval prior to implementing dry storage cask operations at RBS. This submittal contains the following information:

Attachment 1 is a revision of the original Attachment 1 of Reference 1 and incorporates several corrections and clarifications to the original submittal.

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Attachment 2 contains the figures provided in the original submittal.

The proposed amendment includes new commitments. These new commitments are summarized in Attachment 3 to this letter and supersede the commitments provided in the original LAR.

Attachment 4 of this request responds to NRC Requests for Additional Information (RAI), provides additional clarification and certain corrections of data.

Attachment 5 contains photographs of the crane rigging in response to the RAI.

Attachment 6 is the initial review of the NUREG-0612 AND NUREG-0554 Comparison Matrix for the RBS FBCHC submitted in Reference 3 with clarifications identified.

Changes have been marked with revision bars to assist in your review.

The proposed amendment was evaluated in accordance with 10 CFR 50.90(a)(1) using criteria in 10 CFR 50.92(c) and it was determined to involve no significant hazards considerations. The bases for these determinations are included in the attached submittal. The no significant hazards considerations are not affected by the responses to the RAI.

Entergy requests approval of the proposed amendment as soon a practicable but no later than November 1, 2005 to allow loading the three casks this year and maintain full core offload capability. Once approved, the amendment will be implemented prior to using the FBCHC for dry spent fuel cask operations.

If you have any questions or require additional information, please contact Mr. Bill Brice at 601-368-5076.

I declare under penalty of perjury that the foregoing is true and correct. Executed on September 21, 2005

Sincerely,

Rick J. King
Director, Nuclear Safety Assurance

RJK/WBB

Attachments:
1. Analysis of RBS Spent Fuel Cask Handling in the Fuel Building
2. Figures
3. List of Regulatory Commitments
4. Responses to RAIs for LAR 2004-26
5. Photographs of Redundant Rigging
6. NUREG-0612 AND NUREG-0554 Comparison Matrix for the RBS Fuel Building Cask Handling Crane

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Attachment 1

RBG-46478

Analysis of RBS Spent Fuel Cask Handling in the Fuel Building

1.0 DESCRIPTION

This letter is a revised request to amend Operating License NPF-47, for Energy Operations Incorporated's (Entergy's) River Bend Station (RBS) in support of dry spent fuel storage cask operations in the Fuel Building. As a result of a review recently performed, certain hypothetical heavy load drop events associated with dry spent fuel cask handling operations have been identified and evaluated. A preliminary evaluation of these drop events under 10 CFR 50.59 has resulted in a determination that a license amendment is required to implement the operating procedure changes associated with dry spent fuel storage cask operations at RBS.

This request has been revised to incorporate several corrections and clarifications to the original submittal. The request has also been revised to incorporate the responses to several Requests for Additional Information (RAI). Changes have been marked with revision bars to assist in your review.

2.0 PROPOSED CHANGES

The proposed amendment will require changes to the RBS Updated Safety Analysis Report (USAR) to reflect the use of the non-single-failure-proof Fuel Building Cask Handling Crane (FBCHC)[1] for dry spent fuel cask component lifting and handling operations. Specifically, lifting and handling of the spent fuel canister, canister lid, and transfer cask is required. The existing discussion pertaining to a shipping cask drop will be augmented to discuss the spent fuel storage component drops. A new USAR subsection will be added to summarize the activities in support of dry spent fuel storage that take place in the RBS Fuel Building. The existing discussion related to the spent fuel shipping cask drop will be modified to add a new discussion of spent fuel storage cask component drops.

This proposed amendment does not involve any changes to the RBS operating license or technical specifications. Further, Entergy is not requesting NRC approval of an upgrade in designation of the FBCHC from non-single-failure-proof to single-failure-proof or from non-safety-related to safety-related. Rather, this submittal demonstrates that the FBCHC is adequately designed and is operated, inspected, tested, and maintained in a manner that makes it acceptable for use in spent fuel transfer cask lifting and handling activities. NRC approval of this proposed amendment is requested based on the fact that, despite the lack of single-failure-proof design, FBCHC load drop events remain highly unlikely and the consequences of certain hypothetical load drop events have been analyzed and found to be acceptable.

3.0 BACKGROUND

3.1 <u>Fuel Building Cask Handling Crane Design and Licensing History</u>

The RBS FBCHC was designed, procured, and installed in the RBS Fuel Building in the late 1970s and early 1980s. It is a non-safety-related, commercial-grade crane originally designed and licensed to lift and handle a spent fuel shipping cask. The crane has been used from time to time since RBS commercial operation began in 1985 to move radwaste containers (e.g., high integrity containers) onto transportation vehicles for shipment to a disposal site. The FBCHC is

[1] The FBCHC is also referred to as the Spent Fuel Cask Trolley (SFCT) in the USAR and other design documents. The term FBCHC is used throughout this document for consistency.

a bridge-and-trolley design that is not single-failure-proof as defined in NUREG-0612 (Reference 6.1) or NUREG-0554 (Reference 6.2). However, the crane does meet many of the criteria in these documents. Entergy will submit a matrix comparing the RBS FBCHC to NUREG-0554 and NUREG-0612 criteria to support the NRC review.

The FBCHC main hoist has a rated load of 125 tons and the auxiliary hoist has a rated load of 15 tons. The subject of this amendment request is only the main hoist because only the main hoist is used to lift the heavy loads associated with dry spent fuel cask loading operations.

A review of the FBCHC design, maintenance and operational history was conducted. This review concluded that with additional analysis, modifications and inspections, spent fuel casks can be handled with a load drop being a very unlikely event. Analysis was performed to demonstrate the crane can handle the rated load under the appropriate loading conditions including seismic. Inspections of welds, bolting, structural steel and concrete were performed to provide reasonable assurance that the crane and supporting structure are installed in accordance with the applicable design drawings and specifications. Aside from routine preventive maintenance activities and installing the redundant rigging discussed latter in this section, no additional modifications, test or inspections are required to support cask handling operations.

The main hoist is capable of lifting its rated load and moving it in a north-south direction between the spent fuel cask pool inside the Fuel Building to an adjacent area outside the Fuel Building designated for the cask transport vehicle to receive the cask (hereafter referred to as the "truck bay"). See existing USAR Figure 9.1-9 and Figure 1 in Attachment 2 to this submittal for details. The FBCHC is not capable of moving in the east-west direction.

The current licensing basis for the FBCHC permits the lifting and movement of a spent fuel shipping cask inside the Fuel Building. A hypothetical drop of a 125-ton shipping cask was analyzed as discussed in the RBS USAR in support of the proposed licensing basis because the FBCHC is not single-failure-proof. No significant damage to any safety-related structures, systems, or components (SSCs) was predicted by this analysis. However, the current licensing basis does not provide a bounding scenario for all of the lifting and handling evolutions required for the spent fuel storage cask system chosen for use at the RBS Independent Spent Fuel Storage Installation (ISFSI) under a 10 CFR 72 general license. The system chosen for use is the Holtec International HI-STORM 100 System™, which includes the HI-TRAC 125D™ transfer cask and the multi-purpose canister (MPC) that, together with necessary rigging, comprise the heaviest load lifted by the FBCHC during dry storage loading operations in the Fuel Building.

The HI-TRAC 125D™ transfer cask and the MPC must be lifted and moved several times during fuel loading operations in the Fuel Building. At various points in the operation, the empty transfer cask, the empty MPC, the MPC lid, the fuel-loaded MPC, and the loaded transfer cask must be lifted and handled by the FBCHC. Because the FBCHC is not single-failure-proof and will not be upgraded to single-failure-proof, certain drops of the transfer cask, MPC, and MPC lid must be postulated. The locations where drops are postulated and evaluated were chosen to comply with applicable Part 50 licensing requirements, NUREG-0612, and NRC Bulletin 96-02 (Reference 6.3). Licensing basis information for the dry storage cask system was also incorporated in this evaluation, as appropriate, from the HI-STORM 100 System™ 10 CFR 72 Certificate of Compliance (CoC) (Reference 6.4) and associated Final Safety Analysis Report (FSAR) (Reference 6.5). A summary of the Fuel Building cask handling operational sequence and postulated drops germane to this amendment request is provided in Appendix A to this attachment.

To mitigate the consequences of two of these postulated drops, engineered design features (i.e., impact limiters) will be employed in locations over which the transfer cask must be moved in the vertical direction. In most cases, for locations where the load is moved only in the horizontal direction, redundant crane rigging is employed to provide temporary single-failure-proof drop protection and preclude the need to postulate drops in these locations. More detail is provided on these design features in Section 4.7.2 of this attachment.

3.2 Fuel Building Loading Operations Summary

The HI-STORM 100 System™ will be used for dry cask storage of nuclear fuel at the RBS ISFSI. The HI-STORM 100 System™ consists of a multi-purpose canister (MPC-68™), which is capable of holding up to 68 BWR fuel assemblies; a transfer cask (HI-TRAC 125D™), which contains the MPC during loading, unloading, and transfer operations; and a storage cask (HI-STORM 100S™ overpack), which provides shielding, heat removal capability, and structural protection for the MPC during storage operations at the ISFSI. The FBCHC is required to lift and handle the HI-TRAC transfer cask and MPC (both empty and loaded with spent nuclear fuel), and the MPC lid in support of dry storage cask loading. The combined maximum lifted weight, including rigging and lift yoke will not exceed 125 tons, which is the design rated (maximum critical) load of the FBCHC.

During each cask loading campaign, spent fuel assemblies are moved, one at a time, from the RBS spent fuel pool wet storage racks into the MPC, which is resting inside the HI-TRAC transfer cask in the cask pool on the lower shelf (Position 5 on USAR Figure 9.1-9). The cask pool will have been previously flooded with water to approximately the same elevation as the spent fuel pool and the gate separating the cask pool and spent fuel pool will have been opened. Once the desired number of fuel assemblies has been loaded into the MPC, the MPC lid is installed under water and the transfer cask is lifted by the FBCHC and placed on the cask pool upper shelf (Position 4 on USAR Figure 9.1-9) to allow changes in rigging equipment (see Figure 1 in Attachment 2 to this submittal). Then, the transfer cask is lifted out of the cask pool and moved northward to a dry cask washdown area (Position 3 on USAR Figure 9.1-9, hereafter referred to as the "cask pit").

In the cask pit, the MPC lid is seal welded and the canister is drained, dried and backfilled with helium in accordance with the 10 CFR 72 cask CoC and FSAR. The transfer cask containing the sealed MPC is decontaminated, lifted out of the cask pit, and moved by the FBCHC through the Fuel Building outer doors into the truck bay (Position 2 on USAR Figure 9.1-9) where it is placed on top of the empty storage overpack, which has previously been prepared to receive the transfer cask with a mating device. The FBCHC is disengaged from the transfer cask lifting trunnions and rigged to lift the MPC by its lift cleats. The MPC is lifted slightly to remove the weight from the transfer cask bottom (pool) lid. The pool lid is detached and lowered into the mating device, the mating device drawer is opened to provide a pathway through to the overpack, and the MPC is lowered into the overpack. After MPC transfer, the overpack lid is installed and the overpack is transported to the ISFSI using a cask crawler.

4.0 TECHNICAL ANALYSIS

4.1 General Basis

The River Bend Station FBCHC was designed and procured as a non-safety-related, non-single-failure-proof lifting system that would hold its suspended load in the event a safe shutdown earthquake occurred during load handling. This design and procurement process took place in the mid- to late-1970's and pre-dated the issuance of NUREG-0554, NUREG-0612, and associated NRC Generic Letters. The FBCHC design is in accordance with Crane Manufacturer's Association of America (CMAA) Standard 70 (1970); ANSI B30.2, "Overhead and Gantry Cranes" (1967); and Occupational Safety and Health Administration (OSHA) regulations (1973), as well as contemporaneous commercial structural, welding, and electrical design codes. The issues surrounding NUREG-0612 were addressed as part of the RBS license application review process, but the crane was not upgraded to single-failure-proof or safety-related.

A review of RBS historical records shows that, while the crane was not formally designated as safety-related with quality assurance controls under 10 CFR 50 Appendix B applied, there were appropriate inspections, tests, and documentation required by the procurement specification and performed at the time of construction to verify that the construction met the design requirements. As part of the RBS dry cask storage project, a comprehensive evaluation was undertaken by Entergy to review the original design and construction documents and compare them to what would be required of a safety-related design and installation today. From this review and the results of additional inspections and testing, it was concluded that the crane and superstructure were actually constructed in accordance with the design documents and are suitable for use in dry storage cask loading operations.

However, the crane does perform an important design function in lifting and handling the loaded transfer cask. Therefore, the classification of the FBCHC has been upgraded to "Quality Assurance Program Applicable" in the RBS configuration management and work control systems. With this upgrade in classification, all future modifications, inspections, testing, and maintenance of the FBCHC will be performed under the RBS 10 CFR 50 Appendix B Quality Assurance program (i.e., as if it *was* a safety-related component).

The outdoor portion of the FBCHC crane structure extends out from the Fuel Building doors in the north direction approximately 100 feet and is 27 feet wide, column line to column line (see Reference 6.6). There are a total of twelve vertical columns supporting the crane trolley. The structural members are carbon steel with cross-bracing for lateral stability. There are a number of bolted and welded joints that bear the dead load of the structure, including the crane bridge and trolley, and the live load of the suspended spent fuel transfer cask. Each element of the crane structure and certain key design criteria are addressed separately below.

4.2 Crane Foundations

Twelve reinforced concrete pedestals support the outdoor crane superstructure columns. All 12 of the crane columns are bolted to 5 ft. long by 3 ft. wide pedestals. The four southernmost pedestals are 3'-4½" high and rest atop a single 48 ft. long by 25 ft. wide by 3½ ft thick footing. Each of the center six pedestals rests atop individual 5ft. by 5 ft. by 2½ ft. high footings. The two northernmost pedestals rest atop a single 34 ft. long by 16 ft. wide by 3½ ft. thick footing. The pedestals protrude approximately one foot above grade. Finish concrete is provided between the column rows to form the truck bay.

Entergy engineering performed a review to document the inspections and tests performed to demonstrate that there is reasonable assurance that the crane foundation, including the concrete pours, base plates and anchor bolts, was constructed in accordance with the design. A ground-penetrating radar investigation of the crane foundation was also performed in May, 2004 during the ground excavation that was being performed in support of a modification to the truck bay concrete. The results of this investigation show that the crane pedestals and footings are in the locations and are of the dimensions specified on the design drawing. Evidence of reinforcing steel in the top mat of the foundation footings was also confirmed by the radar.

Additional excavation to expose more of the footings in an attempt to gain more information is not practical. The proximity of the footings to the RBS condensate storage tank (CST) precludes any significant additional excavation without the threat of undermining the CST foundation. No additional investigative work on the outdoor crane foundation is planned. No foundation modifications are required for the FBCHC to perform its design functions during dry spent fuel cask loading operations.

4.3 Crane Structural Steel

An engineering review was also performed to document the inspections and tests performed and to demonstrate that there is reasonable assurance that the crane steel structure, including materials used and the bolted and welded connections that bear load or provide structural rigidity, was constructed in accordance with the design. All inspections conducted under this review were satisfactory in confirming the integrity of the crane structure.

As part of the operational review for dry storage cask loading activities, it was discovered that a header beam in the outdoor crane structure needed to be raised to provide adequate clearance for the overpack and cask crawler. Upon removal of the beam from its existing location, its root weld was observed to have a lack of fusion in a number of areas. As a result, the affected weld was repaired and the weld inspection scope was increased to include ultrasonic inspection of all critical (load bearing) welds of a similar type that support the crane rails and a sampling of other welds not in the load path but which contribute to the rigidity of the structure. No other occurrence of degraded welds was found.

4.4 Crane Inspections and Tests

The FBCHC receives inspections on a daily basis when the crane is in use, with additional inspections and preventive maintenance on an 12-month frequency. These inspections are performed as a good practice to ensure the crane is in good working order prior to use. Discrepancies that are encountered during the inspections are resolved as part of the inspection or entered into either the maintenance work control system or the corrective action program for resolution.

The frequent inspection is a prior to use visual inspection that verifies that a fire extinguisher is available in the cab; that warning and caution signs are intact and legible; that the hoist rope wire is free of kinking, crushing, birdcaging, corrosion, unacceptable broken wires or outer wire wear; that the crane hook is free of bending or distortion and the hook latches are operable; that the brakes, hydraulic system, couplings, bearings and gear reducer are free of excessive wear, breakage, deformation and leakage; and that the footwalks, handrails bumpers and stops are free of excessive wear, breakage, deformation or interference of operation.

The periodic inspection is a more in-depth inspection than the frequent inspection and includes checking for loose parts on the bridge or trolley; for gearbox gear and teeth excessive wear; for gearbox lubricant chemistry and oil change, if necessary; for control cab damage or obstruction; for walkway, ladder, handrail and trap door damage; for support and crane structure rail anchorage, cracks in steel, or loose bolts; for wheel and bearing inspection and lubrication; for brake wear and adjustment, if necessary; for chain drive, sheave, wire rope and pillow block bearing inspections; for coupling grease; for drum groove wear and wire rope anchor inspection; for non destructive examination of the hooks; for verification that the bumpers are intact and securely bolted; and for motor and electrical equipment checks. An operational test is conducted following the inspections. These inspections are performed without a load on the hook(s).

Load testing of the entire travel range of outdoor portion of the FBCHC was performed in 2004 at 125% of the 125-ton rated load, which is consistent with the guidance in NUREG-0554. This test also included testing of the redundant rigging appurtenance design modification, which is relied upon to preclude having to postulate load drops during most lateral moves of the crane (see Section 4.7.2 and Appendix A to this attachment). Load testing of the indoor portion of the FBCHC was performed during initial construction. The crane procurement specification required a 125% rated load test, which was performed during plant pre-operational functional testing. Because the load-bearing components of the inside portion of the crane structure have not been modified since original installation, another 125% load test of the crane inside the Fuel Building in support of dry spent fuel cask loading operations is not required.

4.5 <u>Crane Seismic Qualification</u>

The FBCHC was designed and procured as a seismically qualified structure. During the review of design documents for the RBS dry cask storage project it was discovered that the seismic analysis was performed with no load on the crane hook. This is contrary to the RBS USAR, which states that the crane is qualified to maintain the load during a design basis seismic event. This issue was entered into the RBS corrective action system and a re-analysis was performed which concluded that, with the exception of two welds, the crane system is qualified to hold the maximum critical load during a design basis seismic event. The two affected welds – the main girt to the two end trucks – were recently upgraded under an RBS modification package. Therefore, the crane is considered fully seismically qualified for dry storage cask loading operations.

4.6 Tornado Wind and Missile Loads

RBS currently has administrative controls in place that prohibit fuel handling and the Fuel Building outer doors from being opened if severe weather is imminent (Reference 6.7). If fuel handling is in progress when severe weather is detected, current procedures require fuel handling and radioactive material transport activities to cease except as required to move the material to a safe location. In addition, Entergy will evaluate meteorological conditions using information available from the National Oceanic and Atmospheric Administration (NOAA), National Weather Service (NWS), or other appropriate source to confirm that weather conditions are not expected to be conducive to tornado development over the time period when cask handing in the outdoor crane structure is planned. Cask handling operations in the outdoor crane superstructure would not commence if atmospheric conditions exist that are conducive to tornado formation. Thus, no specific evaluation of tornado wind or missile loads on the crane superstructure while a cask is suspended above the truck bay has been performed.

If outdoor cask handling is underway and weather conditions unexpectedly deteriorate rapidly, sufficient time exists to move the suspended cask to a safe location in a controlled, deliberate manner. A "safe location" can mean anything from closing the outer doors and lowering the transfer cask onto the overpack or to the ground (where, in either case, it would then be in an analyzed condition), to returning the transfer cask to the Fuel Building and closing the outer doors. The actual actions taken would depend on the estimated time available before severe weather arrives. RBS's severe weather procedures will be reviewed and modified appropriately, as necessary, to address cask handling operations. RBS's cask loading operations procedures will contain a requirement to check meteorological conditions prior to opening the Fuel Building outer doors and commencing outdoor cask handling operations, and periodically thereafter during outdoor cask handling operations.

4.7 FBCHC Cask Handling and Postulated Drop Events

4.7.1 Cask Loading Operations and Related Design Features

By design, the FBCHC cannot physically move a heavy load over irradiated fuel in the RBS spent fuel pool. The load path of the FBCHC main hoist is centered between, and parallel to, column lines FAA and FBA in the Fuel Building (see Reference 6.6). This keeps the loaded cask strictly above the cask pool, cask pit, and outdoor truck bay during cask loading operations. The step-by-step operational activities and hypothetical load drop events involving the FBCHC and the MPC/transfer cask are provided in Appendix A to this attachment based on the guidance of NUREG-0612. The following criteria govern cask handling operations as they pertain to the postulation of potential cask drop events (see Figure 1 in Attachment 2 to this submittal):

a) During applicable load movements, impact limiters are installed on the floor at elevation 70 ft. in the cask pool (known as the "lower shelf") and at elevation 98'-1" in the cask pit. The impact limiters are made of a crushable material encased in sheet stainless steel (see Figure 2 in Attachment 2 to this submittal).

b) No impact limiters are used at elevation 93 ft. in the cask pool upper shelf or under the overpack in the truck bay beneath the outdoor cask handling crane structure.

c) During certain horizontal cask movements between the cask pool and the outdoor truck bay, redundant rigging is engaged to the cask lift yoke, which provides temporary single-failure-proof protection against load drops and eliminates the need to postulate a load drop during these movements (Figure 3 in Attachment 2 to this submittal).

d) Cask drops must be postulated for locations where loads are suspended from the FBCHC and the redundant rigging is not engaged.

e) Drops of a loaded cask provide a bounding case for drops of an unloaded cask or empty MPC for a given location, provided other elements of the drop scenario (e.g., drop height or impact energy) are the same or bounded by the loaded cask drop.

f) Relevant elevations of the cask handling area horizontal surfaces and dimensions of cask components are:

   i. Cask pool lower shelf elevation: 70 ft.
   ii. Cask pool upper shelf elevation: 93 ft.
   iii. Wall elevation between upper cask pool shelf and cask pit: 113 ft.
   iv. Cask pit pedestal elevation: 98.08 ft.
   v. Truck bay elevation: 94.42'.
   vi. Impact limiter height: 26.25 in.
   vii. Spent fuel pool water level elevation: 111.75 ft.
   viii. HI-TRAC 125D pool lid thickness: 5.5 in.
   ix. MPC baseplate thickness: 2.5 in.
   x. MPC-68 basket height: 14.67 ft.
   xi. HI-STORM overpack height without lid:
   100S(243): 18.5 ft.,
   100S Version B (218): 16.625 ft.
   xii. HI-STORM baseplate thickness plus pedestal:
   100S(243): 19.25 in.,
   100S Version B: 8 in.
   xiii. HI-STORM mating device height: 10.75 in.

4.7.2 Redundant Crane Rigging

4.7.2.1 Operational Description and Design Criteria

The FBCHC has been modified to add upper "lift links," which are redundant, load-bearing structural connections to the crane main girt. These upper lift links include pins, around which fixed-length slings are looped. Lower lift links are attached to the bottom of the slings and connect to the lift yoke to create redundant rigging that is capable of holding the full 125-ton rated load of the crane in the event of a failure of the main hoist's ability to hold the load for any reason (Figure 3 in Attachment 2 to this submittal). The upper crane links are considered a crane modification and are designed with safety factors of three and five to yield and ultimate stress allowables, respectively. The slings are designed in accordance with ASME B30.9, "Slings." The lower crane links and lift yoke are designed as special lifting devices in accordance with the guidance in ANSI N14.6 (Reference 6.8). The RBS cask lift yoke is designed as shown in Figure 3 in Attachment 2 to this submittal to mate with the lower lift links as described below. The upper crane link modification has been successfully installed and load tested at 125% of the rated load. The lower crane links were also shop tested at 150% of the rated load in accordance with ANSI N14.6.

Referring to Figures 1 and 3 in Attachment 2 to this submittal, the redundant crane rigging is engaged whenever a loaded cask is moved horizontally at its maximum suspended elevation. That is, when the bottom of the transfer cask is at about elevation 114'-0".

The redundant crane rigging is engaged for the following specific horizontal moves of a loaded transfer cask, for either a cask loading or cask unloading evolution:

- Between the cask pool and the cask pit—The move is between a position above the impact limiter at the cask pool lower shelf and a position above the impact limiter on the pedestal in the cask pit.
- Between the cask pit and the MPC transfer stack up—The move is between a position above the impact limiter on the pedestal in the cask pit and a position above the spiral wound gasket on the mating device mounted on a HI-STORM overpack cask.

During these lifts, the main hook is attached to the cask lift yoke and the lift yoke is attached to the lifting trunnions of the transfer cask with ANSI N14.6-designed lift links. The cask is lifted vertically with the main hoist until the crane block and lift yoke are high enough that the lower lift links of the redundant rigging fit inside the lift yoke and the engagement mechanisms of both lower links are aligned with the holes in the lift yoke. Air actuators are used to engage the lower lift links with the lift yoke, providing a redundant load path through the slings and upper lift links into the crane support structure. Successful engagement of the redundant rigging is visually confirmed. After initial engagement with the lift yoke, the slings have some slack in them. To eliminate the slack, and therefore, minimize the dynamic loading in the event of a sudden load transfer, the load is lowered slightly to make the slings taut without placing any significant load on them. We will ensure that cask loading procedures include visual confirmation that redundant rigging is properly engaged and slack is removed from redundant rigging slings prior to horizontal movement whenever a loaded cask is moved horizontally at its maximum suspended elevation.

After successful engagement of the redundant rigging, vertical movement of the load is not necessary and horizontal movement of the cask may proceed. When the cask reaches a point where vertical movement is again required, the redundant rigging is disengaged and the main hoist may be operated normally to lower and raise the load. The redundant rigging may be engaged and disengaged as many times as necessary during cask handling operations with the FBCHC. Load drops are not postulated during times when the redundant rigging is engaged.

4.7.2.2 Load Transfer during Postulated Failure Scenarios

As described above, operating administrative controls are used to ensure the slings in the redundant load path have a minimal amount of slack without carrying any significant portion of the load. The absence of significant load in the redundant load path under normal conditions eliminates having to evaluate some, or the entire load being suddenly shifted to the primary load path if a failure of the redundant load path is postulated.

In a postulated failure scenario where the load is suddenly shifted from the primary load path (the crane hook) to the redundant rigging, a dynamic load is applied to the slings and other members of the redundant load path. The magnitude of that dynamic load has been calculated to verify that the load is within the capacity of the redundant rigging system (Reference 6.9). The dynamic analysis code used is VisualNastran, a commercial dynamic simulation code that has been used by Holtec International in other dynamic analysis work reviewed and approved by the NRC. The acceptance criterion for this analysis is that, due to the shift of the load from the primary load path to the redundant load path, the design limits of all components must not be violated by the expected increase in stress or load level.

Key assumptions used in this analysis are:

1. The crane trolley is assumed to be positioned over a support when the event occurs. This is conservative because no structural dampening from the crane girders is available to reduce the dynamic amplification.

2. The redundant lift links are assumed to behave as non-linear elastic members. The crane hoist primary load is modeled as a rope element; no compression is permitted in the crane main load path member. These are realistic assumptions.

3. When the event occurs, the load is transmitted instantaneously to the redundant load path. This is conservative.

4. The crane ascent or descent speed is constant throughout the computer simulation. This is realistic and makes the solution independent of the speed.

5. The redundant load path slings are assumed to have no slack. This is realistic and control by operating procedures.

6. The redundant load path links are unloaded when the load transfer occurs. This is conservative because any initial tensile loading in the redundant links would serve to reduce the dynamic amplification.

7. The damping available in the redundant load path system is the same as the structural damping in steel from a safe-shutdown seismic event. This is conservative because the sling material and built-up woven construction increases internal friction and produces higher damping values.

Key input data used in this analysis are:

1. A spring constant for the redundant link system is calculated using data from the sling manufacturer to develop a non-linear load-stretch relation, $K = 2 \times 10^5$ lbf/in.

2. Redundant link damping = 7 percent.

3. Weight of lifted load = 250,000 lbs.

4. Weight of load block = 5,000 lbs.

5. Weight of trolley = 55,000 lbs.

The results of the analysis indicate that the peak dynamic load in the redundant load support system due to a sudden shift of the 125-ton load from the primary load path to the redundant load path is 492 kips or, stated differently, a dynamic amplifier of 1.97. Other load cases executed to determine the sensitivity of the results to higher damping (arbitrarily chosen to be 21%) and starting with some load in the redundant load path (28 kips and 127 kips) show that the 7% damping and zero load in the redundant load path provide a bounding set of results.

The crane girders, secondary load-bearing members, the trolley, and the crane hook and attachments are all qualified for a load of 596 kips based on the seismic analysis of the FBCHC. Because the supports for the redundant load support system transmit load to the trolley main girt directly, safety factors for the main girt were re-computed for the 492-kip maximum load calculated for the sudden load transfer event plus the girt self weight. The safety factor based on 90% of yield for the girt material and assuming a pin-ended connection for the main girt is 1.162. The safety factor for the weld group (defined as allowable load per unit length divided by the calculated load per unit length) assuming a one-inch weld and fixed-end connections at the ends of the main girt is 1.07.

The redundant load support system components have a safety factor of 1.06 for the normal 125-ton load condition (over and above the minimum requirements of 3.0 on yield and 5.0 on ultimate for members in tension or combined shear). The safety factor is for a bending stress in the top pin of the lift yoke load latch assembly. Under the peak dynamic load induced in the redundant load path by the load transfer event, the bending stress in the pin is 42.7 ksi, which is well below the yield strength of 95 ksi for the SA 193-B7 material.

The two slings in the redundant load support system are rated for a combined load of 300,000 lbs with a safety factor of 5.0 for a total sling capacity of 1,500 kips. For the peak dynamic load of 492 kips in the load transfer event, the safety factor is slightly more than 3.0.

In summary, all load-bearing members of the redundant load support system are qualified to support the dynamic load resulting from a hypothetical loss of the primary load support system during cask handling operations with the redundant rigging engaged.

4.7.3 MPC Lid Drop

The drop of the MPC lid during installation into the canister after fuel loading in the cask pool is addressed as a unique event. Due to its weight (10,000 lbs), the MPC lid is a heavy load as defined in NUREG-0612. The combined weight of the lid and rigging apparatus is approximately 15,600 lbs. The 125-ton rated load of the FBCHC is nearly 16 times the weight of the lifted load. Therefore, all crane safety factors calculated based on the rated load are 16 times higher for lid-only lifts, making a lid drop event extremely unlikely.

The slings and special lifting devices used to lift the MPC lid exceed all applicable NUREG-0612, Section 5.1.6 design guidance to preclude having to postulate a load drop due to a failure in a load-bearing component in the load path below the crane hook. However, as discussed above, the crane design does not meet all NUREG-0612 and NUREG-0554 guidance to be considered single-failure-proof (e.g., it does not have dual rope reeving). Absent a single-failure-proof crane design, a drop of the MPC lid needs to be evaluated.

Section 5.1.4 of NUREG-0612 specifically addresses handling heavy loads over irradiated fuel inside the reactor building of a BWR. While the MPC lid handling activity at RBS does not occur in the Reactor Building (it takes place in the Fuel Building), this guidance is deemed to be applicable because the lid is suspended over irradiated fuel in the canister located in the cask pool. The NUREG-0612 guidance recommends several alternative approaches for addressing heavy load handling over irradiated fuel, including:

- Upgrade the crane to single-failure-proof status in accordance with Section 5.1.6 of the guidance (which includes NUREG-0612, Appendix C for existing cranes), or
- Analyze the drop of the load in accordance with Appendix A of the guidance to ensure the acceptance criteria of NUREG-0612, Section 5.1 are met.

Entergy has chosen to evaluate the consequences of an MPC lid drop into the loaded spent fuel canister. A discussion of that evaluation is provided in Section 4.7.4 below.

4.7.4 MPC Lid Drop Evaluation

As discussed previously, the MPC lid and associated rigging weigh approximately 15,600 lbs and will be handled by the FBCHC, which has a rated load of 250,000 lbs, making the safety factors for the lid lift 16 times higher than those for the rated load. An NRC safety evaluation report for Zion Nuclear Power Station (Reference 6.10) provides a licensing precedent for considering a crane single failure proof based on high safety factors for the load being lifted. In the case described in the Zion SER, the crane is to be used to lift spent fuel racks, some of which would contain spent fuel assemblies during the lift. However, the racks would only be lifted six inches above the pool floor and would not be carried over irradiated fuel. Despite the high safety factor for the MPC lid lift with the FBCHC and this licensing precedent, Entergy determined that it would be prudent to evaluate the consequences of an MPC lid drop onto the loaded MPC in the cask pool as a conservative licensing approach.

4.7.4.1 Lid Drop into the MPC

After the spent fuel is loaded into the MPC, the MPC lid is installed using the FBCHC. The rigging, attached to four symmetrically located lift points in the lid, ensures that the lid is held in the horizontal position during lowering so that it will fit into the MPC, which has a very close shell-to-lid dimensional clearance. Because there is approximately 20 feet of water above the MPC during lid installation, if a failure of a crane mechanical component (rather than a wire rope) results in an uncontrolled lowering of the lid, the lid will initially remain horizontal.

If the lid is dropped from a significant height, the column of water below the falling lid will eventually cause the lid to drift laterally and not physically be able to enter the open MPC. Therefore, the first analysis of this event assumes the lid is three feet above the MPC and perfectly positioned for insertion when the failure occurs, allowing the lid to drop straight down into the MPC fuel cavity in the horizontal orientation. In this scenario, the lid will accelerate as it falls and impart an impact load on the four lift lugs welded to the inside of the MPC shell. (The lift lugs are designed to support the dead weight of the lid until the lid is welded to the canister shell.) The lift lugs are designed with very large safety factors to preclude failure and dropping of the lid onto the top of the fuel basket. The analysis evaluates the ability of the lift lugs to withstand the impact load of the lid drop using manual structural mechanics computational techniques (Reference 6.11).

The acceptance criterion for this analysis is no damage to the spent fuel assemblies in the MPC.

Key assumptions used in this analysis are:

1. The lid remains horizontal during the drop through the water and enters the MPC without obstruction. This is conservative for the 3 ft. drop height assumed because the lid would actually likely drift laterally to some extent and be prevented from entering the MPC without impacting the MPC shell or transfer cask upper flange.

2. The lid is considered as a rigid mass. This is realistic for this application.

3. The MPC shell is assumed to be instantaneously expanded out by the increase in internal pressure caused by the "piston" effect to the diameter where it contacts the transfer cask inner shell. This is conservative because it provides the largest drop cross-sectional area and a smaller resisting force is applied to the dropped lid.

4. Fluid drag is considered in computing the lid velocity during the free fall. This is realistic.

5. The water is considered approximately incompressible in that the change in density is assumed to be proportional to the lid velocity. The proportionality constant affords a simple way to account for the expected reduction in the water velocity escaping through the lid-to-shell gap as the water density increases. This is a simplifying assumption.

Key input data used in the analysis are:

1. Drop height above MPC = 3 ft.

2. Distance from top of MPC to top of lift lugs = 9.5 inches

3. MPC lid weight = 10,000 lbs.

4. MPC lid diameter = 67.25 in.

5. MPC shell inner diameter = 67.75 in.

6. Other cask component dimensions and material properties are taken from the HI-STORM 100 FSAR.

The results of the analysis show that the lift lugs will withstand the impact force and prevent the lid from coming into contact with the fuel basket or fuel.

4.7.4.2 MPC Lid Drop onto the Transfer Cask Top Flange

A second MPC lid drop event was analyzed where the dropped lid lands on the transfer cask top flange, pivots, and falls into the MPC. This analysis (Reference 6.12) was performed using the LS-DYNA computer code, which has been used in previous NRC-reviewed and approved dynamic analysis work performed by the cask vendor. The acceptance criterion for this analysis is no unacceptable fuel damage and that the deformation of the fuel basket in the MPC, if any, must not extend to the top of the active fuel region, where the fixed neutron poison panels are located. This second criterion is chosen to ensure the licensing basis criticality analysis is preserved.

Key assumptions used in this analysis are:

1. The lid is dropped from the surface of the cask pool through the water to the upper flange of the transfer cask. This is a realistic assumption because the lid will only be carried high enough to avoid making contact with the cask pool prior to being lowered into the MPC. See Figure 1 in Attachment 2 to this submittal.

2. The MPC and the transfer cask structural components behave as bilinear elastic-plastic materials characterized by five material parameters (i.e., Young's modulus, yield strength, ultimate strength, failure strain, and Poisson's ratio). This is a reasonable assumption based on good engineering practice.

3. Material damping and water resistance during the impact are neglected. This is conservative since both damping and resistance will be non-zero.

4. The lid impacts the transfer cask flange at a 2-inch offset between the radial centers of the MPC/transfer cask and the lid such that the lid does not fall directly into the MPC in a horizontal orientation and a minimal amount of energy is dissipated in the first impact with the transfer cask prior to the lid falling into the MPC.

Key input data used in this analysis are:

1. Weight of MPC lid = 10,000 lb.

2. Thickness of MPC lid = 9.5 in.

3. Distance between top of the fuel basket and top of the active fuel region = 14.625 in.

4. Lid drop height = 319.25 in.

5. Other cask component dimensions and material properties are taken from the HI-STORM 100 FSAR.

The analysis shows that the lid hits the transfer cask top flange with a velocity of 212.6 in/sec. The impact does not cause any damage to the transfer cask because the maximum stress (10,300 psi) is well below the material yield stress. The subsequent impact between the MPC lid and the MPC shell does result in local plastic deformation; the maximum plastic strain (0.3123) is below the failure strain limit of the material (0.38). The fuel basket is also locally damaged with plastic deformation in four fuel cells, extending down two inches from the top of the basket. This damage is well above the active fuel region and the neutron absorber panels remain undamaged. Conservatively, up to four fuel assemblies could experience some damage, but major relocation of fuel material would not be expected.

4.7.4.3 Radiological Evaluation

The potential radiological consequences of an MPC lid drop onto irradiated fuel in the canister and subsequent damage to the fuel were compared to the existing RBS fuel handling accident analysis described in USAR Section 15.7.4 and with the data in Tables 2.1-1 and 2.1-2 of NUREG-0612. While the MPC lid drop has the potential to damage more fuel assemblies than the drop of a single fuel assembly (see Section 4.7.4.2), the fuel in the spent fuel storage canister will have decayed at least three years in order to be authorized for dry storage in the HI-STORM 100 System[2]. The decay time for the fuel considered in the fuel handling accident is 24 hours. A significant amount of decay of the radionuclides available for release will have taken place between 24 hours and three years. No significant iodine will be available for release after three years[3] and the key noble gas elements that contribute to the whole body dose, xenon and krypton, will have decayed to very low levels.

Table 2.1-1 of NUREG-0612 shows that, for 90 days of decay and no credit for halogen filtration, the calculated thyroid doses from damage to a single BWR fuel assembly at the Exclusion Area Boundary (EAB) and Low Population Zone (LPZ) are 40 millirem and zero, respectively. The whole body doses at the EAB and LPZ are zero. No doses for the control room are estimated. Also from Table 2.1-1 of NUREG-0612, the number of fuel assemblies that would need to be damaged at 90-days decay to produce doses that are 25% of the 10 CFR 100 dose limits is 1,900. Based on the lid drop analysis described in Section 4.7.4.2 above, at most there may be four fuel assemblies damaged. A conservative evaluation has been performed, as described below, that bounds all four assemblies being damaged.

The generic NUREG-0612 analysis assumes a thermal power level of 3,000 Mwt and X/Q values for the EAB and LPZ of 1.0×10^{-3} sec/m^3 and 1.0×10^{-4} sec/m^3, respectively, as shown in Table 2.1-2 of that document. The power level used in the River Bend Station fuel handling accident is 3,100 Mwt and the X/Q values are: 8.58×10^{-4} sec/m^3 (EAB), 1.13×10^{-4} sec/m^3 (LPZ, 0-8 hour maximum), and 1.62×10^{-3} sec/m^3 (control room, 0-20 minute maximum). Other differences include peaking factor (1.2 in NUREG-0612 and 2.0 in the RBS fuel handling accident) and halogen decontamination factor (100 in NUREG-0612 and 200 in the RBS fuel handling accident).

To determine whether the RBS fuel handling accident radiological consequences provide a bounding case for an MPC lid drop into the canister, the number of fuel assemblies in the canister required to be damaged to reach 25% of the 10 CFR 100 dose limits[4] and the GDC 19 control room dose limits was estimated using the NUREG-0612 value (1,900) and the ratios of the differences in the generic NUREG-0612 and site-specific RBS fuel handling accident analysis inputs to see if the number of assemblies remains above four. The difference in dose due to the difference in halogen decontamination factor is ignored due to the three-year decay time. This is conservative because the RBS site-specific analysis uses a higher

[2] The limit in Amendment 1 (the current version) of the HI-STORM 100 CoC is five years minimum cooling time. This limit has tentatively been approved to be decreased to three years in Holtec HI-STORM 100 CoC Amendment 2, which is currently being prepared for rulemaking. Therefore, three years is used as a bounding value in this evaluation.

[3] I-131 has a half-life of approximately eight days. All other isotopes of iodine except I-129 have half lives of 20 hours or less. The half-life of I-129 is 1.6×10^7 years but it emits a very low-energy gamma photon (0.04 MeV), making it an insignificant dose contributor for short duration exposures.

[4] The RBS licensing basis for offsite dose is the alternate source term limits specified in 10 CFR 50.67. The dose limits in 10 CFR 50.67 are equivalent to the GDC 19 control room limits and 25% of the 10 CFR 100 off-site limits.

decontamination factor and would, therefore, reduce the dose. The difference in dose due to the lower source term produced by the longer decay time is not evaluated because it is not a linear relationship. This is conservative because the longer decay time would yield even lower doses.

Power Level: 3,000 / 3,100 = 0.968

X/Q: 1.0×10^{-3} sec/m^3 / 1.62×10^{-3} sec/m^3 = 0.617

Peaking Factor: 1.2 / 2.0 = 0.600

N = Minimum number of RBS fuel assemblies required to reach 25% of Part 100 dose limits in a fuel handling accident:

N = (0.968)(0.617)(0.600) x 1,900 = 680 assemblies

This means that, assuming 90 hours decay time, at least 170 (680/4) times the number of fuel assemblies that could possibly be damaged in a lid drop event at RBS would need to be damaged to reach 25% of the 10 CFR 100 and GDC 19 dose limits (equivalent to the 10 CFR 50.67 dose limits) considering River Bend site–specific licensing basis inputs instead of the NUREG-0612 generic inputs. Accounting for the three years of minimum decay time required by the HI-STORM 100 CoC and the fact that the peak X/Q value for all dose locations and all times was used in the evaluation above, the number of fuel assemblies required to approach the Part 100 dose limits would actually be significantly higher. Therefore, the existing fuel handling analysis in USAR Section 15.7.4 (which assumed 24 hours decay time and more realistic, time-dependent X/Q values) provides a limiting case accident event that bounds the potential consequences from fuel damage due to an MPC lid drop.

4.7.4.4 Criticality Evaluation

Both of the analyses performed for the MPC lid drop and described in Section 4.7.4.1 and 4.7.4.2 confirm that no damage to the fuel basket occurs to the extent that the neutron absorber panels would be prevented from performing their criticality safety function. In addition, there would be no significant relocation of fuel material to create a critical geometry. Therefore the existing generic cask vendor licensing basis criticality analysis remains applicable and bounding and no additional analysis is necessary.

4.7.5 Storage Cask Component Load Drop Summary

4.7.5.1 Drops Inside the Fuel Building

Referring to Appendix A to this attachment, the unique and/or bounding load drops inside the Fuel Building that are required to be evaluated and analyzed, as appropriate, due to a lack of single-failure-proof crane design features (by operational step) are:

1. Step 4: 4.5 ft. empty MPC vertical drop[5] onto the cask pit north wall (see note at end of Section 4.7.6).

2. Step 26(a): <1 ft. loaded transfer cask drop onto cask pool upper shelf corner with cask top-to-side wall impact (no impact limiter). This evaluation bounds those drops specified in Steps 4 and 31(a).

3. Step 26(b): <1 ft. loaded transfer cask vertical drop onto cask pool upper shelf (no impact limiter). This evaluation bounds the drop specified in Step 30.

4. Step 32: 42.5 ft loaded transfer cask vertical drop onto cask pool lower shelf (with impact limiter). This evaluation bounds those drops specified in Steps 25 and 31.

5. Step 35: 17.5 ft. loaded transfer cask vertical drop into cask pit (with impact limiter). This evaluation bounds the drop specified in Step 40.

4.7.5.2 Drops Outside the Fuel Building

When the cask moves from inside the Fuel Building to outdoors, the applicability of NUREG-0612 and the requirement to postulate load drops become less clear. As previously discussed, the focus of the guidance in NUREG-0612 is to ensure protection of operating plant equipment in general and safe shutdown equipment in particular, as well as irradiated fuel in the reactor and spent fuel pool. There is no safe shutdown equipment located under the outdoor crane truck bay. However, because the FBCHC is not single-failure-proof, a drop of the loaded transfer cask onto the top of the overpack and mating device is postulated in the truck bay when the redundant rigging is not engaged. For any drop in the truck bay, the concern is protection of the MPC, the transfer cask, and the contained spent fuel. Therefore, the dry storage system 10 CFR 72 licensing basis documents (FSAR and CoC) were consulted to determine the appropriate acceptance criteria for the drop evaluations.

The HI-STORM 100 CoC includes requirements for the design of a Cask Transfer Facility (CTF), which is used for cask lifting and handling using lift devices not governed by 10 CFR 50. This set of requirements was considered the most appropriate to use as a basis for determining the acceptance criteria for evaluating drops in the truck bay due to functional similarities between the CTF and the FBCHC outdoor crane structure. Section 3.5.2.1.4 of Appendix B to the HI-STORM 100 CoC states that "The CTF shall be designed, constructed, and evaluated to ensure that if the MPC is dropped [into the overpack] during inter-cask transfer operations, its confinement boundary would not be breached. *This requirement applies to either stationary or mobile lift devices* [emphasis added]." That is, notwithstanding the design features required of the device used to lower the MPC into the overpack (i.e., the CTF or a mobile crane), a drop of the MPC during transfer operations must be postulated, with maintenance of confinement boundary integrity as the acceptance criterion for the evaluation.

Based on the above assessment of truck bay operations, the following two additional drops (drops 6 and 7) require evaluation:

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[5] Drop distances, where cited, are approximate and are measured from the bottom of the dropped load to the top of the target (i.e., the cask pool or cask pit floor, the impact limiter, the top of the HI-STORM mating device, or the top of the overpack pedestal). See the detailed analysis section for actual drop distances evaluated.

6. Step 43: <1 ft. loaded transfer cask vertical drop onto HI-STORM mating device.

7. Step 44: 18.5 ft. to 19.5 ft. loaded MPC vertical drop into HI-STORM overpack (no impact limiter)

It is appropriate, based on the CoC requirements for a CTF, to establish the acceptance criterion for Drop Number 7 as maintaining of confinement boundary integrity.

4.7.6 Transfer Cask Drop Evaluations

A description of the evaluation of each of the transfer cask drops is provided in the subsections below, along with the results of each evaluation. In general, the impact velocity of the dropped cask was calculated using an equation of motion that takes into account all applicable fluid effects, as applicable (e.g., cask pool water), and the height of the drop. The derivation of this equation of motion is based on Reference 6.13 and is described in Reference 6.14. After calculating the impact velocity, a dynamic simulation computer code, such as VisualNastran (VN) or LSDYNA, was used to simulate the dynamic impact and resultant effects on the cask and/or building structure. The results from the dynamic simulation establish the peak g-force on the cask/fuel, the extent of crush of the impact limiter (as applicable), and the maximum deformation in the floor slab or wall. The VisualNastran and LSDYNA computer codes have been used in prior dynamic simulation work by Holtec International and reviewed by the NRC, as described in Sections 3.4 and 3.6 of the HI-STORM 100 System™ FSAR.

The general acceptance criteria for each drop analysis are (as applicable)[6]:

- Maintain deceleration of the cask to ≤ 60 g's to protect the fuel inside the cask and to ensure the MPC design basis deceleration limit is not exceeded. It should be noted that the design basis g-load deceleration limit for the HI-STORM 100 System™ is 45 g's. However, it has been demonstrated that the fuel assembly deceleration limit for a vertical drop is 64.8 g's (HI-STORM FSAR Section 3.5). The MPC is designed for 60 g's based on the HI-STAR 100 storage FSAR (Docket 72-1008). Therefore, 60 g's is chosen as the fuel assembly and MPC acceptance criterion for these evaluations to provide an additional margin of safety.

- Ensure primary stress levels in the HI-TRAC 125D™ transfer cask structure remain with ASME Code Level D limits,

- Ensure that any cask-to-pool wall impact does not cause a collapse of the pool wall.

The general assumptions used in the analyses are (as applicable):

- The cask and contents are modeled as rigid bodies with known geometry and weight. This is conservative because all energy loss associated with cask structural deformation is neglected, which imparts maximum energy into the drop target.

[6] The Fuel Building floor is already qualified for a 125-ton shipping cask drop under the current RBS licensing basis and is, therefore, not re-analyzed.

- At the interface between the dropped cask and the target (impact limiter or the floor slab), a contact force-crush relationship is specified. This represents the force-crush relationship of the impact limiter or the force-deformation behavior of the floor slab if no impact limiter is present. This is a realistic assumption that permits actual impact limiter test data to be used to represent impact limiter performance.

- If the cask is dropped through water, buoyancy effects, fluid virtual mass, and fluid hydrodynamic mass are included in the simulation after the cask breaks the surface of the water. This is a realistic assumption. The effect of "squeezing out" the fluid between the cask and the impact surface are neglected in calculating impact velocity. This is conservative because this effect, if included, would decrease the impact velocity.

- The energy lost by splashing of the cask as it enters the water is neglected. This is conservative because that energy is assumed to remain with the dropped cask.

- During the post-impact phase, all effects of the surrounding fluid (e.g., drag, added mass) are ignored. This is conservative because these effects tend to decelerate the cask as it falls.

- For those drops occurring before the MPC lid is welded to the MPC shell, the MPC lid is treated as a separate body in order to determine the potential for separation of the lid from the MPC shell. The mass assigned to the MPC lid in the computer model represents the combined mass of the lid, the lift yoke, crane hook, and a portion of the hoist chain, which were assumed to have separated from the crane in the hypothetical failure that caused the load drop.

Appropriate cask component dimensions and masses, lift yoke and rigging component masses, and characteristics of the building structure were taken from the applicable design documents (e.g., drawings) and the HI-STORM 100 System FSAR. The design of the impact limiters was confirmed based on the analyses, which included the necessary crush strength for the devices, and manufacturer's data for the foam installed inside the impact limiters' steel housing.

Other assumptions and inputs unique to a particular drop analysis are included in the discussion of that particular analysis.

Note: Drops of heavy loads, discussed herein, that do not contain fuel or pass over fuel are bounded by drop analysis in accordance with the existing 10 CFR 50 license, and are included for information only.

4.7.6.1 Drop 1 - Empty MPC Drop onto the Cask Pit North Wall

The effects of this drop on the adjacent floor slab at elevation 93'-0" are bounded by the current licensing basis analysis of an RBS shipping cask drop described in River Bend USAR Section 9.1.4.3. The drop of an empty MPC-68 (approximately 39,000 lbs) from 4.5 feet above the doorway opening results in significantly less kinetic energy when impacting the floor slab than the 125-ton analyzed drop of the shipping cask from 0.5 feet above the door opening. No significant damage to safety-related SSCs was predicted by the shipping cask drop analysis. Therefore, the empty MPC drop will not damage any safety-related SSCs. Because the MPC does not contain spent fuel during this postulated drop, there is no need to evaluate damage to the cask's contents.

4.7.6.2 Drop 2 - Loaded Transfer Cask Drop onto Cask Pool Upper Shelf Corner with Cask Top-to-Side Wall Impact

After the spent fuel and MPC lid are installed under water, the transfer cask containing the loaded MPC is lifted to an elevation just high enough to clear the elevation of the cask pool upper shelf. The cask is then moved horizontally toward a position over the upper shelf. The movement of the transfer cask to and from the cask pool lower shelf from and to the upper shelf, respectively, are the only horizontal movements of the transfer cask performed without the crane redundant rigging installed (see Section 4.7.2). This is because a lift yoke extension is used to place the cask on the cask pool lower shelf to avoid contaminating the crane block due to immersion in the pool water (see Figure 1 in Attachment 2 to this submittal).

The redundant rigging cannot be installed with the lift yoke extension in use. The lift yoke extension is installed and removed when the cask is on the cask pool upper shelf. Therefore, a drop of the loaded transfer cask is postulated when it is located over the edge of the cask pool upper shelf before the whole cask clears the corner of the shelf, as a bounding analysis. The cask is postulated to drop onto the shelf corner and pivot to the south, toward the lower shelf area, impacting the cask pool south wall. This drop analysis (Reference 6.15) evaluates the structural integrity of the cask pool south wall, including the steel liner.

Two drop orientations were analyzed to determine the worst case impact on the cask pool south wall. The first case assumes the impact of the outer edge of the transfer cask pool lid on the corner of the upper shelf with the resulting rotation of the cask about that point and impact with the wall. The second case assumes the central portion of the cask pool lid impacts the corner of the upper shelf and rotates toward the pool wall. Two drop heights, 1.37 inches and 4 inches, were evaluated for each drop scenario in order to determine sensitivity and identify a bounding case for further evaluation of the pool wall structural integrity. The limiting case (producing the peak force on the cask pool wall) is the 4-inch drop with impact at the edge of the cask pool lid. This limiting drop case was then re-analyzed to include the non-linear behavior and ductility of the concrete wall to more precisely evaluate the effect of the impact on the cask pool wall.

The results of the limiting case analysis are:

Peak Vertical Force on Upper Shelf: 13,220 kips

Peak Horizontal Local Impact Force on Pool Wall: 1,071 kips

Peak Force in Wall Spring: 939 kips

Vertical Cask Speed at Impact with Upper Shelf: 51.36 inches/sec

HI-TRAC Angular Velocity at Impact with Pool Wall: 53.53 degrees/sec

The ductility ratio of the pool wall is calculated to be 5.48. The maximum permitted ductility ratio for a concrete plate supported is 30 (Table 4-4 in Reference 6.16). Therefore, the cask pool wall will not collapse as a result of a hypothetical cask drop onto the upper shelf and rotation impact into the wall.

4.7.6.3 Drop 3 - Loaded Transfer Cask Vertical Drop onto Cask Pool Upper Shelf

A second hypothetical drop of the loaded transfer cask during horizontal movement without the redundant rigging engaged was analyzed (Reference 6.17) for when the cask clears the corner of the cask pool upper shelf. This is a vertical drop of the transfer cask onto the upper shelf from an arbitrarily chosen bounding carry height. This height limit, or less will be incorporated as an operating limit in the cask loading procedures. The dynamic analysis computer code LS-DYNA was used for this simulation.

The acceptance criteria for the analysis are as follows:

- No stress levels in the MPC may exceed the allowable limits established in the cask system FSAR for load handling accidents, and the fuel deceleration (Reference 6.5) shall not exceed 64.8 g's.

- The reduction in cask shielding, if any, shall be limited such that the dose emitted by the cask is less than any analyzed loss-of-shielding event in the cask FSAR.

- The MPC and transfer cask must not deform to the extent that prevents retrievability of the MPC and the fuel assemblies.

- The deformation of the fuel basket in the MPC, if any, must not lead to the loss of fuel cladding integrity such that reactivity of the system is increased compared to normal conditions.

- The deformation of the MPC, if any, shall not produce an internal helium flow configuration that stifles heat rejection.

Key assumptions used in this analysis are:

1. The transfer cask structural components behave as bilinear elastic-plastic materials characterized by five material parameters (i.e., Young's modulus, yield strength, ultimate strength, failure strain, and Poisson's ratio). This is a reasonable assumption based on good engineering practice.

2. Material damping is neglected. This is conservative because the energy absorption associated with damping is ignored.

3. The load block, crane wire rope, and cask lift yoke, weighing a total of approximately 10,000 lbs, are resting atop the transfer cask during the drop event. This is conservative because it increases the total mass of the dropped cask.

4. The drop height is approximately 3.5 inches. This was assumed as a reasonable carry height necessary to ensure clearance over the upper shelf corner.

5. The dropped transfer cask remains stable after impacting the target. VisualNastran simulations demonstrate that a dropped transfer cask will not tip over under the conservatively postulated worst scenario.

The analysis was performed assuming a drop through air. This is conservative because the cask would actually be falling through water, which would create drag resistance on the cask body. A drop through water would result in a lower impact velocity of the cask and less severe consequences compared to a drop through air.

The results of the dynamic simulation show that the cask velocity upon impact with the target after a fall of approximately 3.5-inch freefall is 55.01 in/sec. The maximum deceleration of the MPC is 45 g's, which is below the fuel acceptance limit of 64.8 g's. Therefore, the drop would not cause fuel cladding damage or fuel relocation resulting in an unanalyzed criticality configuration.

The MPC enclosure experiences a maximum Von Mises stress at the MPC lid-to-shell weld above the material yield stress of 20,050 psi, but well below the failure stress of the material. Other than at the lid-to-shell weld, the MPC enclosure vessel does not experience any plastic deformation. The maximum Von Mises stress on the transfer cask inner shell is less than the material yield stress of 33,150 psi. Therefore, there is no deformation of the transfer cask inner shell. Results indicate that the MPC and transfer cask will retain their structural configurations sufficiently to permit retrieval of the MPC after the drop.

Because of the relatively low yield stress of the pure lead shielding material, some slumping will occur due to the drop. This slump is predicted by the computer simulation to be less than 0.5 inch. While this may allow a small amount of local radiation streaming, but does not have an offsite does consequence. Therefore, it is an acceptable consequence for an accident event.

4.7.6.4 Drop 4 - Loaded Transfer Cask Vertical Drop onto Cask Pool Lower Shelf

In this event, the loaded transfer cask is assumed to drop vertically 42'-6" onto the cask pool lower shelf with the impact limiter installed on the floor at elevation 70 ft. The first portion of the drop is through air and the remaining portion of the drop is through water (normal pool water elevation is assumed to be 111'-9"; water bubble was taken to be 2' 4" below normal water level). The top of the impact limiter is at elevation 72'-2¼". In order to determine sensitivity, different impact limiter resistances were evaluated: 80%, 100%, 120%, and 140%. The 80-120% range covers the manufacturer's standard tolerance range for the foam material and the 140% resistance addresses the scenario where a larger impact area contributes to increased resistance. The analysis yielded the following results:

CASE	MAXIMUM CASK DECELERATION (g's)	IMPACT LIMITER CRUSH (inches)	MAXIMUM CRUSH STRAIN (%)
100% Resistance*	48.0	12.84	55.24
80% Resistance	53.54	14.61	62.9
120% Resistance*	45.9	11.46	49.30
140% Resistance*	48.5	10.30	44.32

* Table values based on normal pool water elevation

All cask deceleration values are less than 60 g's. Therefore, no fuel damage is predicted and all MPC stresses remain below allowable values established in the HI-STAR 100 System™ FSAR.

The MPC lid shows no tendency to separate from the MPC shell. Therefore, no lid restraint system is required.

The following limiting Von-Mises Stresses were calculated for the transfer cask for a bounding deceleration value of 61.3 g's:

LOCATION	VON-MISES STRESS (ksi)
Inner Shell	10.3
Water Jacket End Plate	11.4
Outer Shell	9.22
Water Jacket Bottom Ring	22.1

As interpolated from the data in Table 3.1.12 of the HI-STORM 100 System™ FSAR, the allowable primary membrane stress intensity and primary membrane plus bending stress intensity at 350°F and are 39.75 ksi and 59.65 ksi, respectively. Von Mises stresses are closely related to stress intensity at a point. Therefore, the Level D stress allowables are met for all values of deceleration calculated for this drop event.

4.7.6.5 Drop 5 - Loaded Transfer Cask Vertical Drop into Cask Pit

This drop is postulated to occur while the loaded transfer cask is suspended 19'-9" above the cask pit floor. The cask pit is dry and has a 26.25 inch thick impact limiter located on the pedestal at elevation 98'-1". A cask drop height of 17.5 ft. through air onto the impact limiter was analyzed. The analysis was performed considering the pedestal elevation at 95' resulting in additional conservatism in the results. Like drop No. 4, cask deceleration and impact limiter performance are analyzed, except that the 80% resistance case was not run. The results are as follows:

CASE	MAXIMUM CASK DECELERATION (g's)	IMPACT LIMITER CRUSH (inches)	MAXIMUM CRUSH STRAIN (%)
100% Resistance	32.4	9.67	41.61
120% Resistance	34.2	8.45	36.34
140% Resistance	42.2	7.10	30.56

All cask deceleration values are less than 60 g's. Therefore, no fuel damage is predicted and all MPC stresses remain below allowable values established in the HI-STAR 100 System™ FSAR. The MPC lid shows no tendency to separate from the MPC shell. Therefore, no lid restraint system is required. Because the deceleration values are all less than 61.3 g's, the conclusions drawn under Drop 4 for transfer cask structural integrity are applicable and bounding for this drop.

4.7.6.6 Drop 6 - Loaded Transfer Cask Vertical Drop onto HI-STORM Mating Device

Once the loaded transfer cask is moved horizontally by the FBCHC into the truck bay through the Fuel Building doors and positioned directly over the overpack with the mating device installed, the redundant rigging is removed in preparation for lowering the transfer cask onto the mating device. A cask drop is postulated at this point and analyzed. The analysis (Reference 6.17) assumes a free vertical drop from a height of eight and one half inches. This height was assumed as a reasonable bounding value for the carry height necessary to ensure clearance over the mating device. This height limit, or less, will be incorporated as an operating limit in the cask loading procedures. The details of this analysis are described in Section 4.7.6.3.

In this scenario, the pool lid, which protrudes approximately 5.5 inches below the transfer cask bottom flange, would not experience an impact because it would fit into the open drawer of the mating device. The impact location, therefore, is the transfer cask bottom flange. This drop simulation results in the same deceleration loads on the MPC and fuel as that previously discussed in Section 4.7.6.3. However, unique to this drop scenario, the structural integrity of the transfer cask bottom flange and pool lid are evaluated to ensure that the MPC does not break through the pool lid and drop into (or through) the mating device drawer. This drop scenario also credits a flexible, spiral wound gasket mounted on the top of the mating device for limiting fuel deceleration to the limits described in Section 4.7.6.3.

The analysis results show that the 2-inch thick bottom flange has a safety factor of 1.51 against shear failure when the limiting deceleration of 64.8 g's is assumed. This result bounds the pool lid as well because the pool lid is 5.5 inches thick. Moreover, even if the pool lid bolts were to fail by tension, the disconnected pool lid would stay in the mating device due to the vertical support provided by the overpack.

4.7.6.7 Drop 7 - Loaded MPC Vertical Drop into HI-STORM Overpack

After the transfer cask pool lid has been unbolted and removed by the mating device, a path to transfer the MPC into the overpack exists. A drop of the MPC into the overpack has been analyzed for this scenario. The acceptance criterion for this event is no breach of the MPC enclosure vessel, as justified in Section 4.7.5.2. The drop analysis (Reference 6.18) is performed using the LS-DYNA dynamic simulation computer program.

Key assumptions used in the analysis are:

1. The stainless steel used to manufacture the MPC is a bilinear, elasto-plastic material with a failure strain of 0.38 in/in.

2. The contents of the MPC (fuel basket and fuel) are modeled as a rigid mass with no energy dissipation capability.

3. The MPC lid-to-shell weld is explicitly modeled with full recognition of the discontinuity stresses that are expected to develop at the weld location. The material behavior of the weld joint is conservatively assumed to be the same as the MPC shell material.

4. The impact target is modeled as an infinite half-space of steel using the bounding overpack baseplate material properties. This conservatively bounds the actual target, which is one of two overpack designs resting atop the cask staging pad. The cask staging pad is a 36-inch (maximum) thick concrete pad (compressive strength $\leq$ 4,200 psi at 28 days) founded upon a subgrade with a soil effective modulus of elasticity no greater than 28,000 psi. The HI-STORM 100S and HI-STORM 100S Version B overpack pedestals are constructed using a combination of steel and/or concrete as shown on the drawings in the HI-STORM 100 System FSAR.

5. Yield and ultimate stresses for the target are taken at room temperature.

Key input data used in the analysis are:

1. The loaded MPC weighs 90,000 lbs. This is a conservative, bounding value from Reference 6.5.

2. The MPC drop height is 25 feet. This is conservative because the height of the taller overpack design plus the mating device is just under 20 feet.

3. The impact velocity of the MPC is $(2gh)^{1/2}$ = 481.5 in/sec.

The result of the dynamic simulation show that the maximum Von Mises stress in the MPC shell is 44,515 psi, indicating that the shell is plastically deformed. However, the calculated stress is well below the ultimate stress of the material (64,000 psi). The maximum plastic strain is less than 21.25%, which is below the failure strain of 38%. The MPC shell is deformed most at the bottom because of impact-induced local bending. Therefore, the "no breach" acceptance criterion is met and this hypothetical drop has acceptable consequences.

4.8 Summary

The FBCHC is adequately designed and has been appropriately maintained, inspected and tested to provide reasonable assurance that the cask handling loads can be safely handled with a load drop being a very unlikely event. We will ensure cask loading procedures restrict loaded transfer cask lift height over cask pool lower shelf, cask pool upper shelf, cask washdown area, and mating device to values less than or equal to the values used in the drop analyses. Evaluations of hypothetical drop events during spent fuel storage cask component lifting and handling resulted in no unacceptable consequences for the plant, the MPC, the transfer cask, the cask contents, and the public.

5.0 REGULATORY ANALYSIS

The hypothetical load drops associated with using the FBCHC for dry spent fuel cask handling require the use of an impact limiter in certain locations to ensure the consequences of the drop are acceptable. As such, they create a malfunction of an SCC with a different result than previously evaluated in the USAR. Furthermore, the cask drop onto the cask pool upper shelf resulting in a secondary impact against the pool wall is an accident of a different type than previously evaluated in the USAR. Thus, a 10 CFR 50.59 evaluation for the procedure changes needed to implement dry spent fuel storage at RBS would result in the need for a license amendment. In addition, Entergy's response to NRC Bulletin 96-02 for River Bend Station includes a statement that a license amendment request would be submitted if an activity creates a potential load drop accident not previously evaluated in the FSAR. While its consequences are clearly bounded by a previously evaluated accident, the drop of an MPC lid has not previously been evaluated in the FSAR. For these reasons, NRC approval of this amendment request is requested to support implementation of dry storage cask loading activities inside the Part 50 facility at RBS.

5.1 Applicable Regulatory Requirements/Criteria

The USAR and plant procedure changes required to implement dry spent fuel storage at RBS have been evaluated to determine whether applicable requirements and regulations continue to be met.

Entergy has determined that the proposed amendment does not require any exemptions or relief from regulatory requirements and do not affect conformance with any 10 CFR 50, Appendix A General Design Criterion (GDC) differently than described in the USAR.

NRC regulatory guidance applicable to this proposed amendment includes NUREG-0612, "Control of Heavy Loads at Nuclear Power Plants" (Reference 6.1); associated Generic Letters 80-113, 81-07, 83-42, and 85-11; NUREG-0554, "Single Failure Proof Cranes" (Reference 6.2); and ANSI N14.6, "American National Standard for Radioactive Material - Lifting Devices for Shipping Containers Weighing 10,000 lbs (4500 kg) or More" (Reference 6.8). NUREG-0612 and its associated generic letters required Part 50 licensees and holders of construction permits to demonstrate to the NRC how the criteria in NUREG-0612 are met for the handling of heavy loads. NUREG-0612 was issued in July 1980 and GL 80-113 was issued in December 1980 as part of the resolution of Generic Technical Activity A-36, "Control of Heavy Loads near Spent Fuel."

Appendix I to the River Bend Station Supplemental Safety Evaluation Report (Reference 6.19) provides NRC's approval of River Bend's response to NUREG-0612 and the associated generic letters. At that time, the River Bend licensing basis for spent fuel cask handling addressed only a generic, 125-ton shipping cask. The presumption was that the shipping cask would be certified under 10 CFR 71 and, as such, would be qualified to withstand a 9 meter (30 ft.) drop without radioactive release or damage to the fuel. Therefore, no analysis of the consequences of a shipping cask drop on the cask or cask contents was performed as part of Part 50 licensing for RBS.

The Part 50 licensing basis includes qualification of the RBS Fuel Building for handling a 125-ton shipping cask in the area of the cask pool, cask pit, and outdoor crane structure. This licensing basis remains bounding for the handling of the 125-ton spent fuel transfer cask (HI-TRAC 125D™) as it relates to drop effects on the Part 50 structure. However, the HI-TRAC 125D™ transfer cask is not a 10 CFR 71-certified transport package. Therefore, because the FBCHC is not going to be upgraded to single-failure-proof, the spent fuel storage canister (MPC-68), the fuel inside, and the transfer cask require evaluation for certain hypothetical drops postulated based on the guidance in NUREG-0612.

NRC Bulletin 96-02 (Reference 6.3) was issued in April 1996 in response to a heavy load handling issue that arose in the industry pertaining to spent fuel cask handling. This Bulletin reiterated to licensees NRC's expectations regarding heavy load control established in NUREG-0612. Bulletin 96-02 states, in part: "For licensees planning to perform activities involving the handling of heavy loads over spent fuel, fuel in the reactor core, or safety-related equipment while the reactor is at power...and that involve a potential load drop accident that has not been previously evaluated in the FSAR, submit a license amendment request in advance..." RBS responded to Bulletin 96-02 in August 1996 (Reference 6.20) and the NRC approved that response in May 1998 (Reference 6.21).

Section 5.5 of Appendix A to the HI-STORM 100 System™ Certificate of Compliance (CoC) states: "For lifting of the loaded TRANSFER CASK or OVERPACK using devices which are integral to a structure governed by 10 CFR Part 50 regulations, 10 CFR 50 requirements apply." Because the FBCHC is integral to the RBS Fuel Building, this amendment request is governed by the regulations in 10 CFR 50, consistent with that CoC provision. However, the acceptance criteria for verifying the integrity of the spent fuel, the spent fuel transfer cask, and the multi-purpose canister are drawn from the 10 CFR 72 cask licensing basis documents. The cask system being used at RBS under a Part 72 general license is certified under 10 CFR 72, Subpart L. The CoC and FSAR for the HI-STORM 100 System™ provide the design criteria for verifying protection of the cask components and fuel, which have been previously approved by the NRC. Absent applicable acceptance criteria in 10 CFR 50 for these components and fuel, the acceptance criteria developed under 10 CFR 72 during cask licensing were chosen for use in evaluating the consequences of postulated load drops related to cask handling in the Fuel Building and the adjacent outdoor crane structure.

5.2 <u>No Significant Hazards Consideration</u>

The proposed amendment will revise the Updated Safety Analysis Report pertaining to spent fuel management, ISFSI operations, heavy load handling, and associated drop event analyses. The proposed amendment will add an overview of dry storage cask loading operations and a discussion of the transfer cask, MPC, and MPC lid drop events to augment the existing USAR discussion of the shipping cask drop event. The changes to the USAR will be made after approval of this amendment request.

This proposed amendment has been evaluated in accordance with 10 CFR 50.92(c). The amendment shall be deemed to involve a no significant hazards consideration if there is a positive finding in any of the following areas:

1. Will operation of the facility in accordance with this proposed amendment involve a significant increase in the probability or consequences of an accident previously evaluated?

   Response: No.

   The proposed amendment introduces no new mode of plant operations and does not affect Structures, Systems, and Components (SSCs) associated with power production, accident mitigation, or safe plant shutdown. The SSCs affected by this proposed amendment are the Fuel Building Cask Handling Crane (FBCHC), the spent fuel storage canister, the spent fuel transfer cask, and the spent fuel inside the storage canister. A hypothetical 30 ft. drop of a loaded spent fuel shipping cask from the FBCHC is part of the River Bend Station (RBS) current licensing basis. With the proposed spent fuel transfer cask design and procedural changes implemented, the FCHC will be used to lift and handle a fuel-loaded spent fuel transfer cask of the same maximum weight and approximately the same dimensions as previously evaluated in the RBS USAR. The proposed amendment involves the use of redundant crane rigging during most lateral moves with a loaded spent fuel transfer cask, which provides temporary single-failure proof design features to provide protection against an uncontrolled lowering of the load or load drop. In those cases where the spent fuel transfer cask is not supported with redundant rigging, certain hypothetical, non-mechanistic load drops have been postulated and evaluated, with due consideration of the use of impact limiters in some locations.

   With this amendment, the probability of a loaded spent fuel transfer cask drop is actually less likely than previously evaluated because the capacity of the spent fuel multi-purpose canister (68 fuel assemblies) is larger than the capacity of the shipping cask described in the current licensing basis (18 fuel assemblies), which means that fewer casks will be required to be loaded, lifted, and handled for a given population of spent fuel assemblies. The consequences of the hypothetical spent fuel transfer cask load drops on plant SSCs are bounded by those previously evaluated for a shipping cask. That is, there is no significant damage to the Fuel Building structure or any SSCs used for safe plant shutdown. New analyses of hypothetical drops of a loaded transfer cask or canister confirm that there is no release of radioactive material from the storage canister and no unacceptable damage to the fuel, MPC, or transfer cask.

   The hypothetical drop of a spent fuel canister lid into an open, fuel-filled canister in the spent fuel pool during fuel loading has also been evaluated. Again, this hypothetical accident is no more likely to occur than previously considered due to the higher capacity of the spent fuel transfer cask over the spent fuel shipping cask (i.e., fewer casks will need to be loaded for a given number of fuel assemblies). The radiological consequences of this event due to the potential damage of spent fuel assemblies in the canister onto which the lid could be dropped have been evaluated. While more total fuel assemblies could potentially be damaged from a spent fuel canister lid drop compared to that assumed for the fuel handling accident described in the RBS current licensing basis, the significantly longer decay time of the spent fuel assemblies in the canister results in a much smaller source term, such that the existing fuel handling accident described in USAR Section 15.7.4 provides a bounding evaluation for the radiological consequences MPC lid drop. There is no rearrangement of the fuel or deformation of the fuel basket in the canister such that a critical geometry is created as a result of an MPC lid drop.

The likelihood of a spent fuel canister lid drop due to the failure of a crane component due to overload is very unlikely because the rated load of the crane (250,000 lbs) is approximately 16 times the weight of components lifted to install the canister lid.

2. Will operation of the facility in accordance with this proposed amendment create the possibility of a new or different kind of accident from any accident previously evaluated?

   Response: No.

   The proposed amendment introduces no new mode of plant operations and does not affect SSCs associated with power production, accident mitigation, or safe plant shutdown. The SSCs affected by this proposed amendment are the non-single-failure-proof FBCHC, the spent fuel canister, the spent fuel transfer cask, and the spent fuel inside the canister. The design function of the FBCHC is not changed. The proposed amendment does not create the possibility of a new or different kind of accident due to credible new failure mechanisms, malfunctions, or accident initiators. The proposed amendment creates a new initiator of two accidents previously evaluated and caused by the non-mechanistic single failure of a component in the FBCHC load path.

   The current licensing basis accidents for which new initiators are created by this amendment are the spent fuel shipping cask drop and the fuel handling accident. The RBS current licensing basis includes evaluations of the consequences of a spent fuel shipping cask drop and the consequences of the drop of a spent fuel assembly into the reactor core shortly after shutdown and reactor head removal. The new initiators include the drop of a spent fuel transfer cask of the same maximum weight and approximately the same dimensions as the shipping cask, and the drop of a spent fuel canister lid into an open, fuel filled canister in the spent fuel pool. Both of these new initiators create hypothetical accidents that are comparable in consequences to those previously evaluated. For the drop of a spent fuel transfer cask, the consequences are bounded by the current licensing basis analysis of the spent fuel shipping cask drop. That is, there is no significant damage to the Fuel Building structure or any SSCs used for safe plant shutdown, and there is no release of radioactive material. New analyses of the drop of a loaded transfer cask confirm that there is no release of radioactive material from the storage canister and no unacceptable damage to the fuel, MPC, or transfer cask.

   For the drop of the spent fuel canister lid, the significantly longer decay time of the spent fuel assemblies in the canister compared to a spent fuel assembly in a recently shutdown reactor results in doses to the public that are less than the previously analyzed fuel handling accident. There is no rearrangement of the fuel in the canister such that a critical geometry is created as a result of an MPC lid drop.

3. Will operation of the facility in accordance with this proposed amendment involve a significant reduction in a margin of safety?

   Response: No.

   The proposed amendment introduces no new mode of plant operations and does not affect SSCs associated with power production, accident mitigation, or safe plant shutdown. The SSCs affected by this proposed amendment are the non-single-failure-proof FBCHC, the spent fuel storage canister, the spent fuel transfer cask, and the spent fuel inside the canister. Therefore, this amendment does not affect the reactor or fuel during power operations, the reactor coolant pressure boundary, or primary or secondary containment. All activities associated with this amendment occur in the Fuel Building or in the adjacent outdoor truck bay area. The design function of the FBCHC is not changed. The proposed changes to plant operating procedures needed to implement dry spent fuel storage at RBS do not exceed or alter a design basis or safety limit associated with plant operation, accident mitigation, or safe shutdown. The FBCHC is used to lift and handle the spent fuel canister lid over spent fuel in the canister while in the spent fuel pool, and to lift and handle the spent fuel transfer cask, both when it is empty and after it is loaded with spent fuel in the spent fuel pool.

   This proposed amendment results in a net safety benefit because a larger capacity cask is being used to move spent fuel out of the spent fuel pool that was previously evaluated (68 fuel assemblies versus 18 fuel assemblies), while maintaining the same maximum analyzed cask weight described in the USAR. This yields fewer casks to be loaded, fewer heavy load lifts, and, as a result, fewer opportunities for events such as load drops. Because the maximum weight of the loaded spent fuel transfer cask is the same as that assumed for the shipping cask and for which the FBCHC was designed, all design safety margins for use of the FBCHC remain unchanged. The rated capacity of the FBCHC is approximately 16 times that of components lifted to place the spent fuel canister lid, yielding significant safety margins for that particular lift.

Based on the above review, it is concluded that: (1) the proposed amendment does not constitute a significant hazards consideration as defined by 10 CFR 50.92; and (2) there is reasonable assurance that the health and safety of the public will not be endangered by the proposed amendment; and (3) this action will not result in a condition which significantly alters the impact of the station on the environment as described in the NRC Final Environmental Impact Statement.

5.3 Environmental Considerations

The proposed amendment does not involve (i) a significant hazards consideration, (ii) a significant change in the types or a significant increase in the amounts of any effluents that may be released offsite, or (iii) a significant increase in individual or cumulative occupational radiation exposure. Accordingly, the proposed amendment meets the eligibility criteria for categorical exclusion set forth in 10 CFR 51.22(c)(9). Therefore, pursuant to 10 CFR 51.22(b), no environmental impact statement or environmental assessment need be prepared in connection with the proposed amendment.

6.0 REFERENCES

6.1 NUREG-0612, "Control of Heavy Loads at Nuclear Power Plants," USNRC, July 1980.

6.2 NUREG-0554, "Single Failure Proof Cranes for Nuclear Power Plants," USNRC, May 1979.

6.3 USNRC Bulletin 96-02, "Movement of Heavy loads Over Spent Fuel, Over Fuel in the Reactor Core, or over Safety-Related Equipment," April 1996.

6.4 HI-STORM 100 10 CFR 72 Certificate of Compliance 72-1014, Amendment 1.

6.5 HI-STORM 100 System Final Safety Analysis Report, Revision 2.

6.6 Drawing EC-62-AM, "Foundation Plan & Details, Cask Handling Area, Fuel Building," Revision 2.

6.7 "Severe Weather Operation," RBS Abnormal Procedure AOP-0029, Rev. 14B.

6.8 ANSI N14.6, "American National Standards for Radioactive Material Lifting Devices for Shipping Containers Weighing 10,000 lbs (4500 kg) or More," 1993.

6.9 Holtec International Report No. HI-2043304, "Dynamic Analysis of Redundant Link System Subsequent to Loss of Primary Load Path in Cask Pit Crane," Revision 0.

6.10 U.S. NRC Safety Evaluation Report Related to License Amendments 142 and 139 for 10 CFR 50 Operating Licenses DPR-39 and DPR-48, respectively, Dockets 50-295 and 50-305, Zion Nuclear Power Station, Commonwealth Edison Company, February 23, 1993.

6.11 Holtec International Report No. HI-2043275, "Analysis of MPC Lid Drop during Cask Loading at River Bend," Revision 0.

6.12 Holtec International Report No. HI-2043312, "Analysis of a Postulated MPC Lid Drop Event over the HI-TRAC Transfer Cask Top Flange," Revision 0.

6.13 "The Effect of Liquids on the Dynamic Motion of Immersed Solids," R.J. Fritz, ASME Journal of Engineering for Industry, February 1972.

6.14 Holtec Position Paper DS-246, "Seismic Analysis of Submerged Bodies," Revision 1.

6.15 Holtec International Report No. HI-2022956, "HI-TRAC Impact Limiter Qualification at River Bend," Revision 1.

6.16 "Design of Structures for Missile Impact," Topical Report BC-TOP-9A, Bechtel Power Corporation, Revision 2.

6.17 Holtec International Report No. HI-2043278, "Evaluation of Postulated HI-TRAC 125D Transfer Cask Drop Accidents at the River Bend Station," Revision 2.

6.18 Holtec International Report No. HI-2043276, "Analysis of a Postulated MPC Drop Accident during MPC Transfer Operation," Revision 0.

6.19 Supplemental Safety Evaluation Report for River Bend Station, EG&G Idaho for USNRC, Appendix I, January 1985.

6.20 Entergy Operations' Response to NRC Bulletin 96-02 for River Bend Station, dated August 29, 1996.

6.21 USNRC letter to Mr. John R. McGaha, Jr., dated May 13, 1998, "Completion of Licensing Action for NRC Bulletin 96-02, "Movement of Heavy Loads over Fuel in the Reactor Core, or over Safety-Related Equipment, dated April 11, 1996, for River Bend Station, Unit 1."

Appendix A to

Attachment 1 to

RGB-46478

Cask Handling Operational Sequence

Cask Handling Operational Sequence

Refer to Figure 1 in Attachment 2 to this submittal for cask locations and Section 4.7 of this attachment for component dimensions and elevations. A transfer cask bottom elevation of approximately 114'is assumed to permit engagement of redundant rigging with the lift yoke. "IL" means an impact limiter is in place to protect the dropped component and the target, and "no IL" means no impact limiter. "PD" means postulated drop(s) for loads that are not bounded by drop analysis in accordance with the existing 10 CFR 50 license as discussed in Section 4.7.6 . Drop distances, where cited, are approximate. See the detailed analysis section for the actual drop distances evaluated.

This sequence is provided as information only and is intended to reflect a typical transfer. Variance from this sequence may be required as conditions dictate.

1. Empty multi-purpose canister (MPC) located outdoors
2. Open Fuel Building door (no fuel movement permitted inside)
3. Lift MPC to point where bottom of MPC is approx. 117.5 ft. elevation
4. Move MPC laterally through Fuel Building door to point above cask pit (Impact Limiter (IL) and empty transfer cask (HI-TRAC), previously installed in cask pit. 4.5 ft empty MPC vertical drop onto cask pit north wall—no IL
5. Lower MPC into HI-TRAC transfer cask and close Fuel Building door.
6. Engage Lift Yoke to HI-TRAC transfer cask
7. Lift empty HI-TRAC / MPC to point where bottom of HI-TRAC is approx. 114'-7" ft. elevation
8. Move empty HI-TRAC / MPC laterally to point above upper shelf in cask pool
9. Lower HI-TRAC / MPC onto cask pool upper shelf, approx. 93'-0"
10. Disengage lift yoke from HI-TRAC transfer cask
11. Attach lift yoke extension and attach lift yoke
12. Engage lift yoke to empty HI-TRAC transfer cask
13. Lift empty HI-TRAC / MPC to approx. 93'-3" elevation (3 inches above cask pool upper shelf)

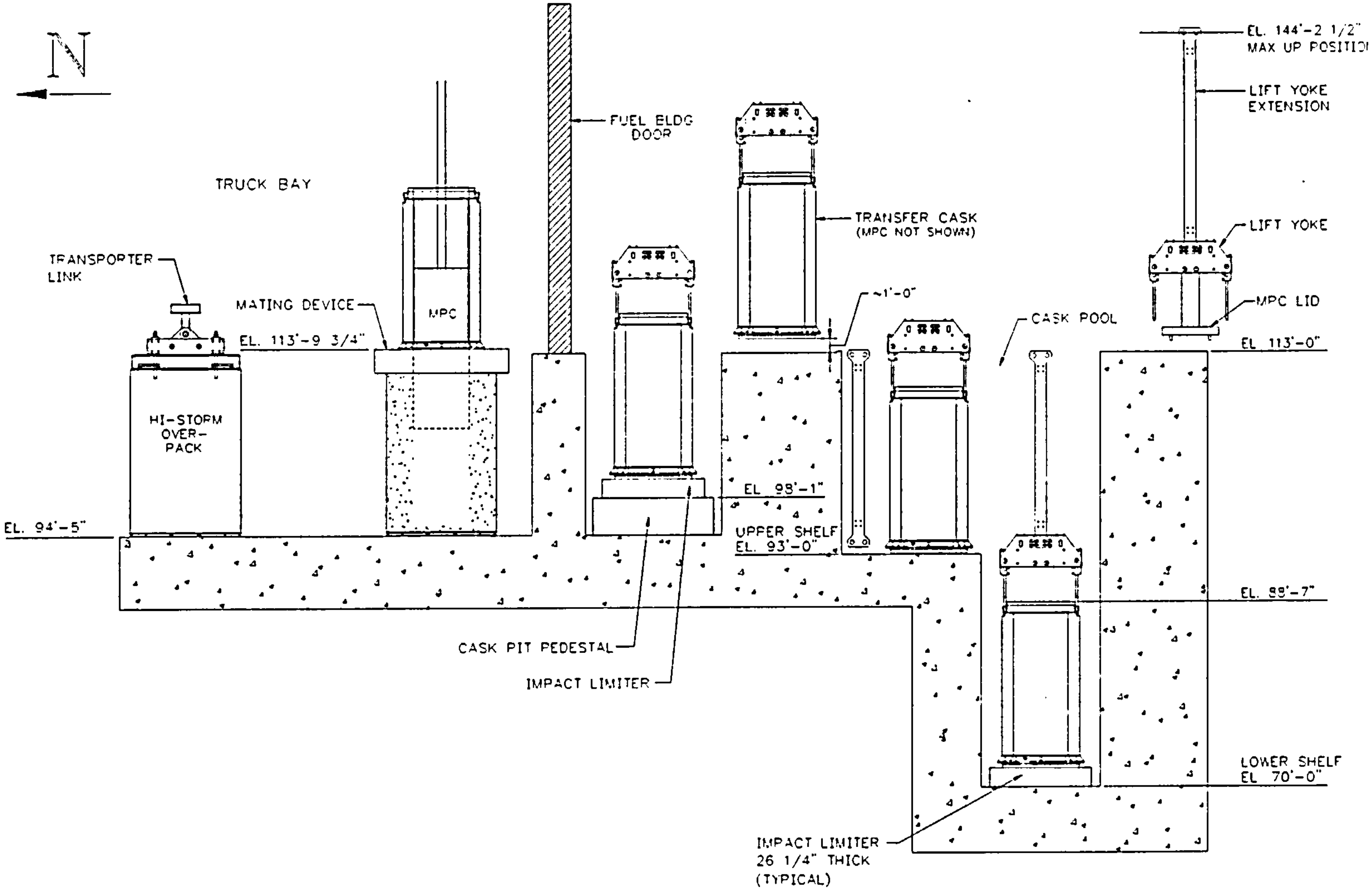
14. Move empty HI-TRAC / MPC laterally to a point above cask pool lower shelf
    PD-- < 1 ft empty HI-TRAC MPC drop onto corner of cask pool upper shelf—no IL
15. Lower empty HI-TRAC / MPC onto lower shelf on impact limiter
16. Detach and stow lift yoke and lift yoke extension
17. Open Cask Pool Gate
18. Load fuel into MPC
19. Close Cask Pool Gate
20. Rig MPC lid with drain tube installed
21. Move MPC lid into place above loaded HI-TRAC / MPC
    PD – 27 ft. drop of MPC lid onto MPC basket with fuel loaded
22. Lower MPC lid, install in loaded MPC, and disengage lid rigging
23. Attach lift yoke extension and lift yoke
24. Engage lift yoke with extension to HI-TRAC transfer cask

25. Lift loaded HI-TRAC / MPC to approx 93'-3" ft. elevation (3" above cask pool upper shelf)
    PD-- 22 ft. loaded cask vertical drop on to cask pool lower shelf – IL
26. Move loaded HI-TRAC / MPC laterally to point above cask pool upper shelf
    PD – (a): < 1 ft. loaded cask drop onto corner of cask pool upper shelf—no IL, and (b): < 1 ft. loaded cask vertical drop onto cask pool upper shelf – no IL
27. Lower loaded HI-TRAC / MPC onto cask pool upper shelf
28. Disengage lift yoke and extension
29. Engage lift yoke without extension to HI-TRAC transfer cask
30. Lift loaded HI-TRAC / MPC to approx. 93'-3" elevation (3" above cask pool upper shelf)
    PD -- < 1 ft. loaded cask drop onto cask pool with upper shelf – no IL
31. Move loaded HI-TRAC / MPC laterally to a point above cask pool lower shelf
    PD – (a): < 1 ft. loaded cask drop onto corner of cask pool upper shelf (no IL) and (b): 22 ft. loaded cask vertical drop onto cask pool lower shelf – IL
32. Raise loaded HI-TRAC / MPC to approx. 114'-1" elevation.
    PD – 42.5 ft. loaded cask vertical drop onto cask pool lower shelf – IL
33. Engage redundant rigging
34. Move cask laterally at approx. 113'-11" elevation to point above cask pit
35. Raise loaded HI-TRAC / MPC to approx 114'-1" and disengage redundant rigging
    PD – 17.5 ft. loaded cask vertical drop into cask pit – IL
36. Lower loaded HI-TRAC / MPC into cask pit on IL
37. Disengage lift yoke from HI-TRAC transfer cask
38. Finish MPC preparation and install HI-TRAC top lid
39. Engage lift yoke to HI-TRAC transfer cask
40. Lift loaded HI-TRAC / MPC to approx 114'-1"elevation
    PD – 17.5 ft loaded cask vertical drop into cask pit – IL
41. Engage redundant rigging
42. Move loaded HI-TRAC / MPC laterally at approx. 113'-11" elevation outdoors to point above empty HI-STORM with mating device installed
43. Raise loaded HI-TRAC / MPC to approx 114'-1" elevation and disengage redundant rigging
    PD -- < 1 ft loaded HI-TRAC / MPC vertical drop onto mating device — drop height varies with overpack model used and whether an overpack spacer ring or cribbing for the 100S Version B overpack is used – Spiral wound gasket limits impact
44. Remove HI-TRAC pool lid
    PD -- 18.5 to 19.5 ft. loaded MPC drop into empty overpack – drop height varies with overpack model used and whether an overpack spacer ring or cribbing for the 100S Version B overpack is used.
45. Download MPC into HI-STORM
46. Remove empty HI-TRAC and mating device
47. Install overpack lid and transport loaded overpack / MPC to ISFSI

Attachment 2

RBG-46478

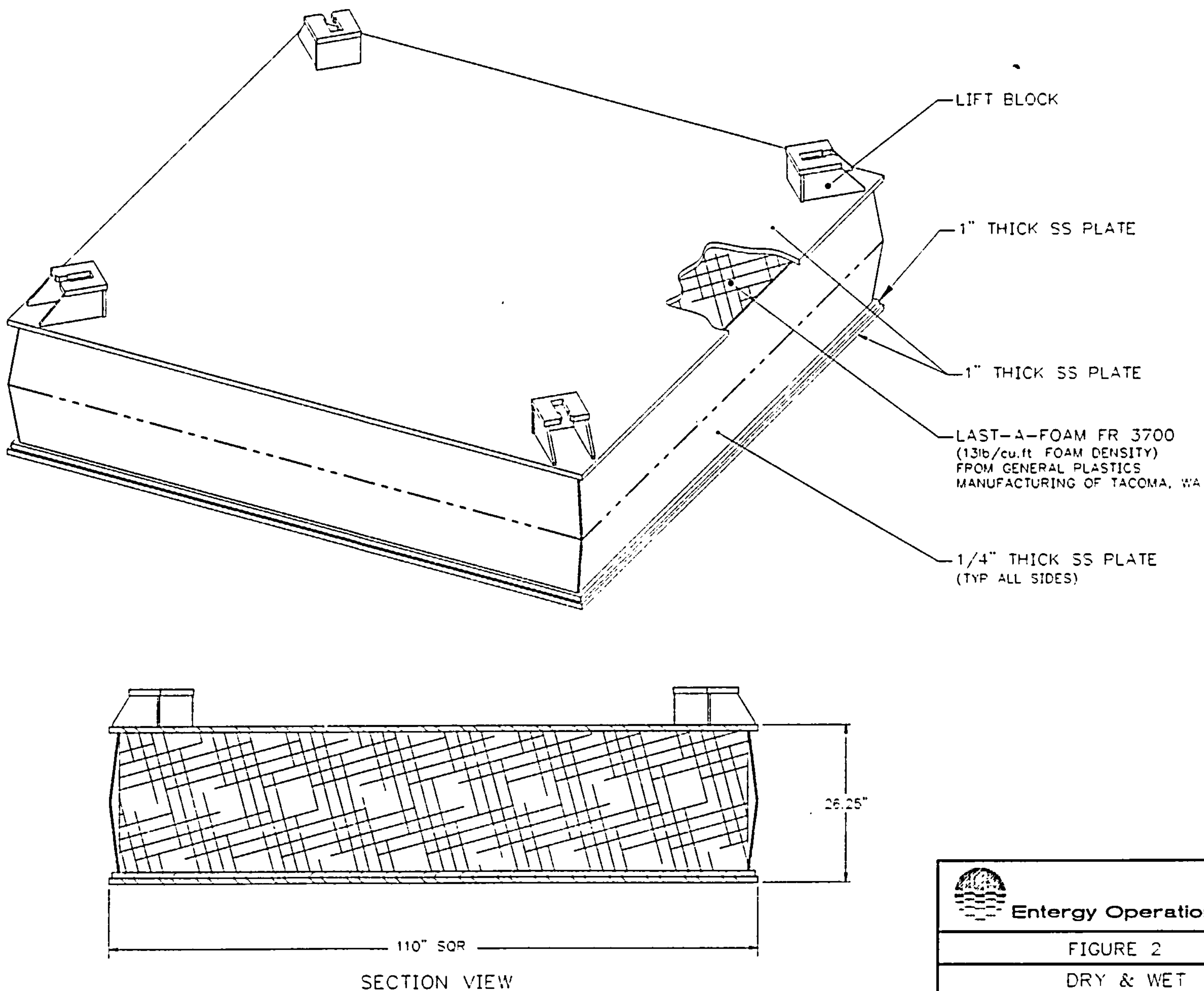
Figures



Entergy Operations, Inc.

FIGURE 1

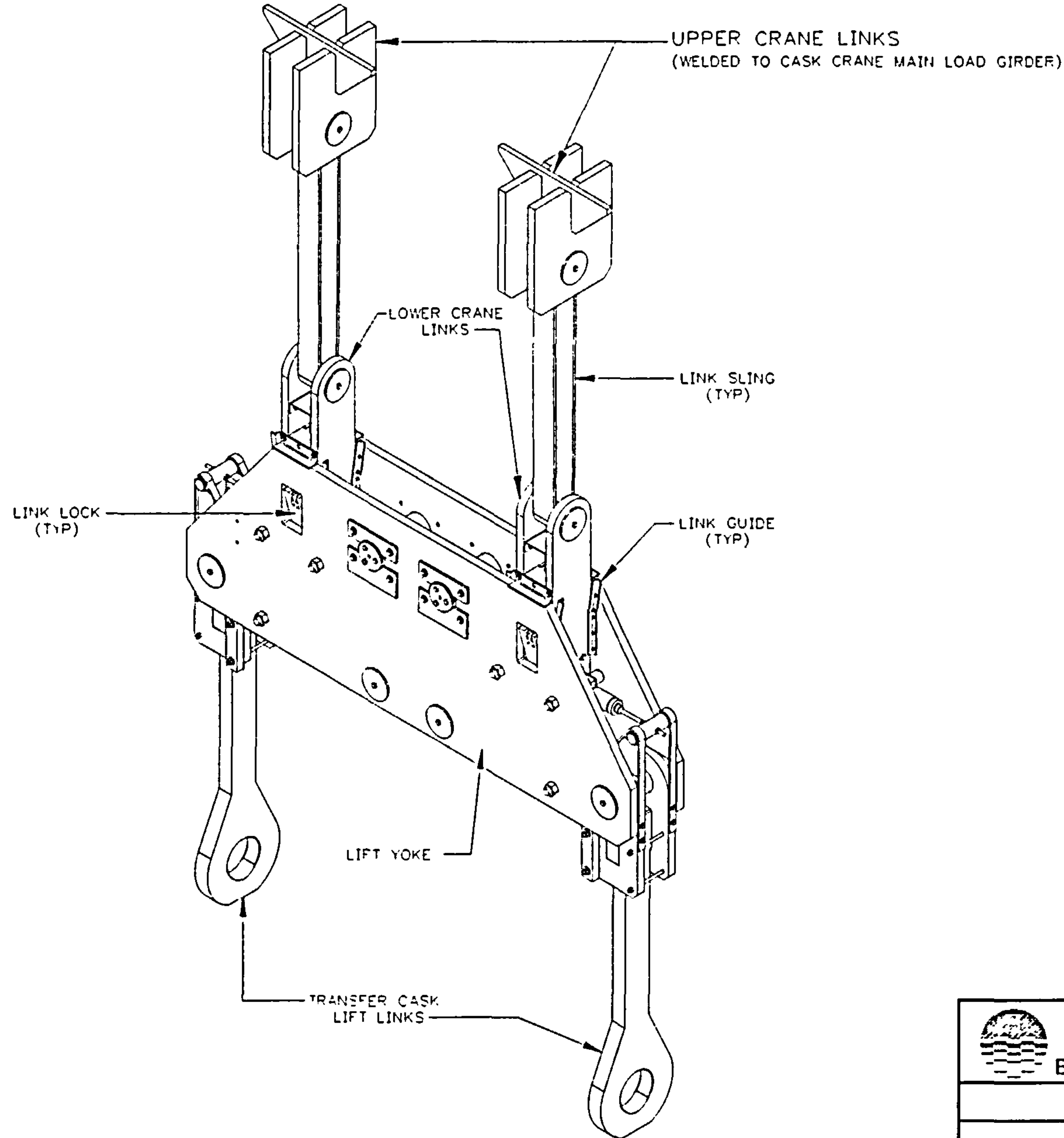
ELEVATION OF RBS FUEL BUILDING AND TRUCK BAY FOR SPENT FUEL STORAGE CASK LOADING



Entergy Operations, Inc.

FIGURE 2

DRY & WET
IMPACT LIMITER
ASSEMBLY



Entergy Operations, Inc.

FIGURE 3

REDUNDANT CRANE RIGGING AND LIFT YOKE ASSEMBLY

Attachment 3

RBG-46478

List of Regulatory Commitments

List of Regulatory Commitments

This table identifies actions discussed in this letter for which Entergy commits to perform. Any other actions discussed in this submittal are described for the NRC's information and are not commitments.

COMMITMENT	TYPE (Check One)		SCHEDULED COMPLETION DATE (If Required)
	ONE-TIME ACTION	CONTINUING COMPLIANCE	
Continuing inspection is in accordance with the RBS Preventative Maintenance Program for slings and special lifting devices. This will be accomplished on a frequency in accordance with ASME B30.9 and ANSI N14.6.		X	Prior to first cask loading campaign
All critical lifts of the MPC, MPC Lid, HI-TRAC, HI-TRAC Top and Pool Lids, containing nuclear fuel or over nuclear fuel, will be made using the Main Hook.		X	Prior to first cask loading campaign
Ensure appropriately designed impact limiters are installed on the cask pool lower shelf and cask washdown area prior to cask lifts in these areas		X	Prior to first cask loading campaign
Ensure cask loading procedures match cask loading evolutions described in this LAR		X	Prior to first cask loading campaign
RBS will retest and qualify the crane for use in temperatures below 70°F as warranted to support cask loading plans. The results from successful retesting will be incorporated into site procedures in the form of revised minimum temperature limitations.		X	Prior to use in temperatures below 70°F
Ensure cask loading procedures include instructions to check for severe weather prior to commencing outdoor cask handling operations. Evaluation and modify, as necessary, severe weather procedures to address cask handling operations per this LAR, particularly operations when the loaded cask is suspended from the outdoor cask handling crane superstructure		X	Prior to first cask loading campaign
We will ensure that cask loading procedures include visual confirmation that redundant rigging is properly engaged and slack is removed from redundant rigging slings prior to horizontal movement whenever a loaded cask is moved horizontally at its maximum suspended elevation.		X	Prior to first cask loading campaign

We will ensure cask loading procedures restrict loaded transfer cask lift height over cask pool lower shelf, cask pool upper shelf, cask washdown area, and mating device to values less than or equal to the values used in the drop analyses.		X	Prior to first cask loading campaign
Provide appropriate personnel training to reflect operating procedures and limits per this LAR		X	Prior to first cask loading campaign
Personnel performing the engagement of redundant rigging will be trained to perform this evolution. These visual verifications will be documented in the controlling procedure(s).		X	Prior to first cask loading campaign
New Dry Fuel Storage (DFS) Procedures, which control activities involving FBCHC operation, that will be written include: 1. DFS-0002, Dry Fuel Cask Loading 2. DFS-0003, Dry Cask Transport and Storage 3. DFS-0004, MPC Unload Procedure 4. DFS-0005, DFS Rigging Plan 5. DFS-0100, FB 113-04 Door (this is the door opening to the outside Cask Crane Structure)	X		Prior to first cask loading campaign
The trained Person In Charge (PIC), with responsibility for the lift, and the trained Cask Crane Operator, with responsibility for crane operation, will establish the crane hoist and travel speeds for loaded cask lifts within the following procedural constraints: • Use Crane "inching speed" at 0.5 fpm where appropriate. "Inching speed may be used, at the flagman's (as the PIC's designee) discretion or at the PIC's discretion, for lift phases where precise load positioning is appropriate. Do not cycle the cask crane by "jogging" or "plugging". The PIC and the crane operator have been trained to use the crane's "inching speed" and not use "jogging" or "plugging" of the crane.		X	Prior to first cask loading campaign

Attachment 4

RBG-46478

Responses to RAIs for LAR 2004-26

**Responses to
RAIs for LAR 2004-26**

RAI from Plant Systems Group

1. The Fuel Building Cask Handling Crane (FBCHC) is described in Section 3.1 of the license amendment request, dated March 8, 2005, as a "non-safety-related, commercial grade crane, " and "a bridge-and-trolley design that is not single-failure-proof." NUREG-0612 section 5.1.4 states that to provide assurance that the evaluation criteria of Section 5.1 are met one of two options should be met in addition to satisfying the guidelines of section 5.1.1. Please indicate which of the two options apply to the use of the FBCHC during Dry Spent Fuel Cask Loading Operations, and discuss in detail how the requirements set forth in the option chosen are met.

Response:

As part of cask loading operations at RBS, only one heavy load is ever suspended above irradiated fuel in the canister in the cask pool – the MPC lid. LAR Attachment 1, Section 4.7.3 provides the reasoning for choosing NUREG-0612 Section 5.1.4, "Reactor Building – BWR," as the applicable section for evaluating the MPC lid handling activity.

Section 5.1.4 of NUREG-0612 offers two options to provide assurance that the evaluation criteria of Section 5.1 are met. Option 2, which requires evaluation of the effects of heavy load drops, was chosen for use in the LAR, as discussed in LAR Attachment 1, Section 4.7.3. Drop evaluations performed in accordance with Option 2 of Section 5.1.4 are required to be performed using the evaluation criteria of NUREG-0612, Section 5.1 and the guidance in NUREG-0612, Appendix A.

LAR Attachment 1, Sections 4.7.4 through 4.7.6 provide detailed discussions of the hypothetical drops of the MPC lid into the fuel-loaded canister and drops the loaded HI-TRAC transfer cask in several different locations in the Fuel Building. The guidance of NUREG-0612, Appendix A was considered, as applicable, in each of the drop analyses as detailed in the LAR. The specific comparison of the results of the drop analyses against the criteria in NUREG-0612 Section 5.1 is provided below.

NUREG-0612, Section 5.1, Criterion I

Releases of radioactive material that may result from damage to spent fuel based on calculations involving accidental dropping of a postulated heavy load produce doses that are well within 10 CFR Part 100 limits of 300 rem thyroid, 25 rem whole body (analyses should show that doses are equal to or less than ¼ of Part 100 limits).

LAR Attachment 1, Section 4.7.4.3 describes how the design basis fuel handling accident described in RBS USAR Section 15.7.4 bounds the potential dose from a drop of the MPC lid into the fuel-loaded MPC, based on a acceptance criterion of 25% of the Part 100 dose limits. Based on the potential damage of up to four fuel assemblies due to an MPC lid drop, a factor of safety of 170 is calculated.

LAR Attachment 1, Section 4.7.6 describes the results of the various postulated drops of the fuel-loaded transfer cask. In every case, no radiological consequences result, either from plant structures, systems, and components, or from the material inside the transfer cask.

Therefore, this criterion is met.

<u>NUREG-0612, Section 5.1, Criterion II</u>

Damage to fuel and fuel storage racks based on calculations involving accidental dropping of a postulated heavy load does not result in a configuration of the fuel such that k_{eff} is larger than 0.95.

As described in LAR Attachment A, Sections 4.7.4 and 4.7.6, neither the MPC lid drop nor the various transfer cask drops result in damage to the fuel assemblies such that re-configuration of the fuel into an unanalyzed geometry and potential criticality are a concern. The fuel remains in an analyzed geometry in all cases, with k_{eff} less than 0.95 as described in Chapter 6 of the HI-STORM 100 FSAR.

Therefore, this criterion is met.

<u>NUREG-0612, Section 5.1, Criterion III</u>

Damage to the reactor vessel or the spent fuel pool based on calculations of damage following an accidental dropping of a postulated heavy load is limited so as not to result in water leakage that could uncover the fuel (makeup water provided to overcome leakage should be from a borated source of adequate concentration if the water lost is being borated).

The drops evaluated in the scope of the LAR occur in the Fuel Building cask pool after fuel loading into the MPC has been completed. The cask pool does not contain spent fuel racks and is not connected to the spent fuel pool once the MPC is loaded and the gate between the cask pool and spent fuel pool is installed. Lifts of heavy loads during cask loading operations do not occur in the vicinity of the reactor vessel.

Therefore, this criterion is met.

<u>NUREG-0612, Section 5.1, Criterion IV</u>

Damage to equipment in redundant or dual safe shutdown paths, based on calculations assuming the accidental dropping of a postulated heavy load, will be limited so as not to result in loss of required safe shutdown functions.

Heavy load lifts required for cask loading operations occur only in the cask pool and outdoor crane structure areas. The only safety-related equipment over which heavy loads are suspended is cables and piping located in a pipe tunnel beneath the cask pit. The RBS current licensing basis (described in USAR Section 9.1.4.3) includes an evaluation of the dropping of a bounding heavy load into the cask pit. No damage to the safety-related cable or piping in the pipe tunnel occurs as a result of this drop.

Therefore, this criterion is met.

2. In Section 4.0 of attachment 1 of the LAR it is stated that the classification of the FBCHC is being upgraded to "Quality Assurance Program Applicable" in the RBS configuration management control systems. Please identify the difference in the requirements for equipment that is designated safety-related as opposed to "Quality Assurance Program Applicable."

Response:

There is no difference in QA requirements between Quality Assurance Program Applicable (QAPA) and Safety Related designations for changes to the FBCHC including recent seismic analysis and required modifications. The use of the QAPA designation in lieu of Safety Related is appropriate because the crane and outside supporting structure were purchased/fabricated/constructed as non-safety related. The FBCHC is currently designated as QAPA, and will be treated as safety related in all respects.

3. In section 4.4 of attachment 1 of the LAR submittal it is stated that the load test performed included testing of the redundant rigging appurtenance design modification, which is relied upon to preclude having to postulate load drops during lateral moves of the crane. Describe how testing of the redundant rigging appurtenance was performed to verify the load carrying capability of the redundant crane links, and discuss in detail the inspection that will be performed, and criteria to be met to assure proper application of the redundant rigging prior to its use.

Response:

The upper crane links were load tested to the same intensity (125% of the rated load) and under the same conditions as the crane. Following the load test, NDE surface examination was performed on welds made under the modification that installed the links, as well as parts of the link plates below the tops of the pins and the pins themselves.

The redundant link components were shop tested in accordance with the Holtec purchase specification. Requirements for shop testing and re-certifications are consistent with ANSI N14.6. Slings were shop tested at the sling fabrication/ test facility in accordance with ASME B30.9.

Continuing inspection is in accordance with the RBS Preventative Maintenance Program for slings and special lifting devices. This will be accomplished on a frequency in accordance with ASME B30.9 and ANSI N14.6.

The redundant link slings are inspected for damage and wear prior to use.

4. In section 4.4 of attachment 1 of the LAR submittal it is stated that load testing of the indoor portion of the FBCHC were performed during initial construction, and because the load-bearing components of the inside portion of the crane structure have not been modified since original installation, another 125% load test is not required. In the NUREG-0612 and NUREG-0554 comparison matrix provided by the applicant it is stated that the actual indoor test lift was

performed in September 1983, and the FBCHC outdoor test lift was performed at a minimum temperature of 74.5°F. The applicant then states, in the notes, that cask loading procedures will require an ambient temperature ≥ 70 °F.

a) In NUREG-0554, Section 2.4 it is stated that in regards to the cold proof testing that "If the desired minimum operating temperature cannot be achieved during the test, the minimum operating temperature should be that of the test until the crane is retested at a lower temperature." Please provide the basis for selection of the minimum ambient temperature of 70 °F to be used in the procedures.

Response:

The use of a minimum operating temperature of 70°F is based on the discussion of NUREG-0554 requirements given in Appendix C of NUREG-0612. The section titled "*Implementation of NUREG-0554 for Operating Plants*" on page C-2, lists alternatives that may be applied when upgrading an existing crane (in lieu of complying with certain recommendations of the NUREG-0554). Item (2) states that the upgrade requirement for coldproof testing was omitted because the minimum ambient temperatures in operating plants was 70°F, which is greater than the nil ductility transition temperature (NDTT) listed in (ASME III, Subsections) NC-2300 and ND-2300.

RBS will retest and qualify the crane for use in temperatures below 70°F as warranted to support cask loading plans because operations of the crane are not limited to areas inside the operating plant structures. The results from successful retesting will be incorporated into site procedures in the form of revised minimum temperature limitations.

b) When the cold proof testing was performed for the indoor portion of the crane during the original installation of the crane, at what temperature was the test performed and what minimum temperature of operation is currently used for the indoor portion of the crane.

Response

The pre-operational testing of the crane was performed prior to turnover of responsibility from the constructor to RBS. Consequently, temperatures from the test are not available. However, RBS dry cask procedures limit the minimum ambient temperature inside the Fuel Building to >70 °F during cask operations. As stated above, RBS will retest and qualify the crane for use in temperatures below 70°F as warranted to support cask loading plans. The results from successful retesting will be incorporated into site procedures in the form of revised minimum temperature limitations. This applies to both inside and outside the building operations.

c) In NUREG-0554, Section 2.4 it is stated that following the proof test "the nondestructive examination of critical areas should be repeated at 4-year intervals or less." Please indicate whether nondestructive tests were performed after the proof test of the indoor portion of the crane during the original installation, and describe at what interval and to what extent nondestructive examinations have been conducted for critical areas.

Response:

Review of the 1983 crane load test records indicates the crane was not used to lift loads during construction. Search of the RBS electronic database (IDEAS) provided historical evidence of inspections, including surface examination, of crane parts ~ every 24 months back to 1999. Earlier records were not readily available, however the regularity of these inspections provides confidence that inspections have been performed.

Note that Attachment 4 to the LAR is a comparison of RBS crane attributes to requirements for upgrading to a single failure proof crane as per NUREG-0554 rather than demonstrating compliance to the NUREG. Also note that the portions of the RBS crane to which the coldproof testing requirements apply are the ferritic load carrying members subject to brittle fracture. Therefore, the parts of the crane tested inside the fuel building in September, 1983, and outside in April, 2004, are the same.

Use of the FBCHC after construction but prior to preparations for loading dry casks has been occasional and limited to the transfer of high integrity (radwaste) containers (HICs). The typical weight of a HIC is ~50,000 lbs which is < 50% of the FBCHC rated capacity (250,000 lbs).

Current requirements include regular, periodic inspections of load bearing members or inspections prior to use as required by governing codes and in accordance with the RBS Preventative Maintenance Program.

5. Section 4.7.2.1 of attachment 1 of the LAR discusses how the redundant crane rigging is used. In this section in reference to the successful engagement of the redundant rigging it is stated that "successful engagement of the redundant rigging is visually confirmed."

   a) Please identify and discuss any other means that are used to confirm the successful engagement of the redundant rigging.

Response:

The successful engagement of the redundant rigging includes both the engagement of the Link Locks of the Lower Links into the windows of the Lift Yoke and achieving tautness in the redundant slings.

Following observation that the Lower Links are properly inserted into the Lift Yoke, the Link Locks are then engaged into the Lift Yoke window openings. The Link Lock engagement in the Lift Yoke window openings is confirmed when the colored marking of the Link Locks are observed against the window opening surface. See attached Photograph #1 showing a Link Lock engaged. There are four such Link Lock engagements in the Lift Yoke, two in the Lift Yoke front strongback and two in the Lift Yoke rear strongback.

Beyond the visual observation of the Link Lock engagement in the Lift Yoke opening window, Link Lock engagement is further confirmed by the ability to remove the slack in the redundant slings when the Main Hook is lowered.

Photograph #2 shows the slings in the slacked condition prior to lowering the Main Hook.

Following lowering the Main Hook, the top plate of the Lower Link raises above the top of the Lift Yoke and the top of the Link Locks are against the inside top of the window in the Lift Yoke as seen in Photograph #3. The redundant slings become taut as shown in Photograph #4.

b) Explain why visual confirmation is considered sufficient.

Response:

The visual indications for Link Lock engagement in the Lift Yoke window opening and achieving tautness in the redundant slings are clear and unambiguous. This is facilitated by the use of different color coatings which clarify visibility. The rigging personnel and their supervision have been trained to recognize the visual indications.

c) Inclusion of the inspection requirement in the cask loading procedures is listed in Attachment 3 to LAR in the list of regulatory commitments. Please describe what criteria will be used to verify that the redundant rigging is properly engaged, and discuss how it has incorporated in the training.

Response:

The criteria for proper engagement is included in the controlling procedures and covered in the training for personnel responsible for making the lift. Specific criteria elements include:

- Visual verification that the Lower Links are properly aligned and seated in the Lift Yoke, see Photograph #1. This includes the position of the painted sides of the Link Locks in the Lift Yoke window and the seating of the Lower Link Top Plate on top of the Lift Yoke.
- Visual verification that the Link Locks have engaged in the Lift Yoke openings as is shown in Photograph #1. Visual verification is to be performed by both a trained rigging worker and by either the person responsible for the lift (Person In Charge or PIC) or the Cask Loading Supervisor.
- Visual verification that the redundant slings are taut.

These visual verifications will be documented in the controlling procedure(s).

Personnel performing the engagement of redundant rigging will be trained to perform this evolution. The method of visually confirming that redundant rigging is "successfully engaged" is an objective in DFS Loading Operations training. The photos described above, or similar, will be used as training aids as well as oral presentations of the engagement process.

The visual indications for the Link Lock engagement in the Lift Yoke window opening and achieving tautness in the redundant slings are discussed in the response to RAI #5 a). The color marking on the upper sides of the link locks and the looseness or sag in the redundant slings are clear and unambiguous. The rigging personnel and their supervision have been trained to recognize the visual indications.

Additionally, qualification of the redundant rigging system considered various values for pre-load and damping in the slings. See the response to question RAI #8 b).

6. In section 4.7.6.5 of attachment 1 of the LAR submittal, a drop is postulated to occur while the loaded transfer cask is suspended above the impact limiter on the pedestal at elevation 98'-1. On FSAR figure 9.1-9, this area is identified as the "spent fuel cask washdown area," and the drawing indicates that a pipe tunnel is located on the elevation directly below the washdown area. The FSAR also states that safety-related electrical cables and one safety-related pipe are among the SSCs contained in the pipe chase area. The discussion in the LAR only discusses the impact the drop would have on the structural integrity of the transfer cask. Please discuss the impact of the postulated drop on the structural integrity of the facility and any potential impact to safety-related pipes and electrical equipment located in the pipe chase on the elevation below.

Response:

An evaluation of the structural integrity of the Fuel Building structure due to a drop of the loaded transfer cask into the cask pit is not included in the LAR because this event is bounded by the 125-ton shipping cask drop already licensed as described in RBS USAR Section 9.1.4.3. A 125-ton shipping cask, assumed to fall 20' onto the concrete pedestal at elevation 95'-0", is analyzed for the effect on the Fuel Building structure as part of the River Bend Station licensing basis.

The analysis concluded that although damaged, the concrete floor of the Cask Washdown Pit (which is also the ceiling of the tunnel under it) would not suffer gross failure or collapse, in part, because the concrete is contained by metal decking. Subsequently, there is no adverse impact to safety related piping and electrical cabling in the tunnel.

7. Appendix A to attachment 1 of the LAR submittal gives a step-by-step list of the operational activities required for spent fuel pool cask handling operations when using the fuel building cask handling crane. Please specify what, if any new procedures will be required, identify what current procedures require updating, what inspections are planned, how operators will be trained and on the new equipment configurations and procedures, and what administrative controls if any will be utilized prior to or during cask handling.

Response:

New Dry Fuel Storage (DFS) Procedures, which control activities involving FBCHC operation, that will be written include:

1. DFS-0002, Dry Fuel Cask Loading
2. DFS-0003, Dry Cask Transport and Storage
3. DFS-0004, MPC Unload Procedure
4. DFS-0005, DFS Rigging Plan
5. DFS-0100, FB 113-04 Door (this is the door opening to the outside Cask Crane Structure)

These procedures also control the sequence of operational activities. The exact sequence may vary slightly from those shown in Attachment 1, Appendix A depending upon plant conditions. This Appendix has been revised for clarity and to reflect further operational experience in the use of the crane. These procedures also control the use of the FBCHC Main Hook and Auxiliary Hook use. The Main Hook is used for critical lifts. All critical lifts of the MPC, MPC Lid, HI-TRAC, HI-TRAC Top and Pool Lids, containing nuclear fuel or over nuclear fuel, will be made using the Main Hook. The Auxiliary Hook is occasionally used to relocate ancillaries. An example is moving the Lift Yoke Extension from its normal storage location (which the Main Hook can not reach) to a location where it can be attached to the Main Hook. Another example is moving tool boxes, and ancillaries into the Fuel Building at the beginning of a loading campaign. The Auxiliary Hook may also be used to move component lids, within its capacity and not over nuclear fuel to position them for other evolutions.

The current procedure that requires updating is MLP-7500, Operation of the Spent Fuel Cask Crane. The trained Person In Charge (PIC), with responsibility for the lift, and the trained Cask Crane Operator, with responsibility for crane operation, will establish the crane hoist and travel speeds for loaded cask lifts within the following procedural constraints:

- Use Crane "inching speed" at 0.5 fpm where appropriate. "Inching speed may be used, at the flagman's (as the PIC's designee) discretion or at the PIC's discretion, for lift phases where precise load positioning is appropriate.
- Do not cycle the cask crane by "jogging" or "plugging". The PIC and the crane operator have been trained to use the crane's "inching speed" and not use "jogging" or "plugging" of the crane.
- The manufacturer's design maximum hoisting speed is 6 fpm. The calculated maximum speed is 5.88 fpm.
- The manufacturer's design maximum trolley travel speed is 50 fpm.

Inspections and Tests, performed by trained personnel, of the FBCHC include:

1. PMID-50035555-01, Periodic Crane Inspection

2. MLP-7500, Operation of the Spent Fuel Cask Crane (Section on Frequent Inspection (those performed prior to daily use))

Training for crane operators and personnel performing Dry Fuel Storage handling will be provided in the DFS Loading Operations training program.

Administrative Controls, included in procedures, to be utilized prior to and during cask handling include:

1. Only trained personnel are permitted to operate the crane or rig or handle loads
2. Prior to FBCHC use in a loading campaign, its inspections and re-certifications must be current
3. Prior to critical lifts, the work supervisor must verify that the ambient temperature requirements are met
4. Prior to critical lifts outside of the Fuel Building, the work supervisor must verify that the current and forecasted meteorological conditions are acceptable
5. All rigging used must be in the site rigging program and inspected per materials handling procedures prior to use
6. All special lifting devices to be used must have current inspections and re-certifications
7. All critical lifts are made with the FBCHC Main Hook
8. Load Lift height limitations within the cask drop analysis basis
9. Loaded HI-TRAC horizontal travel between the Cask Pool and the Cask Pit and between the Cask Pit and the Stack-up area will utilized latched redundant crane links
10. Loaded HI-TRAC vertical lifts over the Cask Pool lower shelf and the Cask Pit will be over appropriately designed and located Impact Limiters.
11. Lifts over spent fuel must meet the surveillance requirements of STP-701-7500, Spent Fuel Cask Crane Travel—Spent and New Fuel Storage and Transfer Pools.

8. In response to the compliance to NUREG-0554 Section 4.1, item 6, given on page 20 of the attachment to the April 19, 2005 supplemental submittal, it is indicated that the crane does not have a dual load path rope reeving system, and that for most horizontal load movements, redundant rigging is engaged to lift the yoke to provide single failure protection against drops. In section 4.7.2.1 it is stated that " After initial engagement of the lift yoke, the slings have some slack in them." In section 4.7.2.2 "Load Transfer during Postulated Failure Scenarios", the load path slings are assumed to have no slack. The assumption is based on the use of operating administrative controls to ensure that the slings in the load path have a minimal amount of slack without carrying any significant portion of the load.

a) Please discuss how balancing and distribution of the load is accomplished with redundant rigging engaged.

Response:

The intent is for the FBCHC main hook to carry the load, with the redundant rigging slings only carrying sufficient load to remove any visible slack in the slings.

This condition is established by:

1. Raising the FBCHC main hook and Lift Yoke (with attached HI-TRAC) sufficiently high so that the redundant rigging Link Locks can be engaged in the lift yoke window openings, which is visually verified as discussed in detail in the response to Plant Systems' RAI #5.

2. Once the redundant rigging Link Locks have been verified as engaged in the window openings in the Lift Yoke, the FBCHC main hook and lift yoke (with attached HI-TRAC) is slowly lowered until the visible slack is removed. The *removal of the sling slack is readily apparent to field personnel.*

b) Since the assumption that load paths sling have no slack is based solely on administrative controls which relies on visual confirmation that all slack has been removed, the possibility that some slack will remain still exist. Please discuss the sensitivity of the redundant links to changes in slackness, including results of analyses which were performed to demonstrate the impact that variation in slack would have on load transfer during postulated failures.

Response:

RBS personnel recognize the importance of the redundant rigging being taut but not carrying a significant load.

Loading depends on the sling pre-load or tautness. Sling pre-load contributes to the load drop distance when the primary load path is removed. The redundant rigging qualification analysis considers various initial pre-loads in the slings; they were assumed to be taut and pre-loaded to varying degrees. Based on manufacturer's input, a mathematical expression was developed relating the stretch of the slings to the load in the slings. From this, a range of pre-loads from a value of taut but with no pre-load (0 lbs) to about half of the full load was considered. Additionally, damping values of the redundant link system were varied to account for uncertainty in the damping introduced by the slings.

This provided the basis to establish a range of peak loads and dynamic amplification factors of the redundant sling system. Using this method, a maximum redundant link system load and a corresponding dynamic amplification factor was developed and used for *qualification.*

RAI from Mechanical and Civil Engineering Branch

1. It is stated that the previous seismic analysis was performed with no load on the crane hook, and a re-analysis was performed, and the analysis results indicated that the crane system is

qualified to hold the maximum critical load during a design basis seismic event, except two welds and the welds were upgraded. Please provide information to the following questions:

(a) Define the boundary of the crane system
(b) Have the beams and columns that support the crane qualified in the re-analysis?
(c) Provide the magnitude of the maximum critical load and the governing load combinations
(d) Describe the re-analysis procedures
(e) Describe the method(s) you used to verify that all components of the crane system are qualified except the two welds.

Response:

(a) and (b) The re-analysis included the Crane Runway Girders and all building structural elements and their connections, lateral braces for the runway girders and connections, trolley main load girt and connections, trolley drive girt and connections and the trolley end trucks.

(c) The crane was evaluated for a load of 250K (125 tons) at various heights and with the trolley at various locations on the runway. The maximum interaction ratio calculated was for the trolley member connections (1.615) and the crane rope (factor of safety of 1.475). These were evaluated for the load combination:

D + SSE + 250 k (lifted)

(d) and (e) A three dimensional finite element computer model of the crane system was developed for elastic analysis for elements discussed in (a) above, and included the SSE seismic response for the subject elevation. Prior to this analysis, the existing crane design bases considered SSE acting on the crane system but without a load on the hook.

The analysis was performed using multiple cases with the lifted load at different heights and trolley locations along the rail. The peak forces in elements, determined using response spectra analysis, were then combined with the static effects due to dead load and the lifted load to develop the maximum forces in elements. The calculation concluded that two welds were overstressed.

The crane qualification calculation identifies unacceptable configurations that require reconciliation. Modifications to the crane (welds) were designed, verified and installed under a separate documentation package.

Acceptance criteria were developed for each evaluated element. The acceptance criteria were selected as 1.5 times AISC allowable stresses, not to exceed the yield strength of the material. The ultimate strength of the crane was used as a basis for its acceptance criteria.

2. It is stated that, if outdoor cask handling is underway and weather conditions unexpectedly deteriorate rapidly, sufficient time exists to move the suspended cask to a safe location in a controlled, deliberate manner. Please provide the basis that support your conclusion of "sufficient time exists."

Response:

The outdoor handling of a loaded HI-TRAC transfer cask is a periodic, short-duration, transient operation required only during cask loading. As committed in LAR Section 4.6, outdoor cask handling will not be permitted if the weather is expected to be conducive to tornado formation. The weather expected during outdoor cask handling operations will be verified to be acceptable prior to commencing outdoor cask handling using sources such as the National Oceanic and Atmospheric Administration (NOAA) and the National Weather Service (NWS) via the Internet or other appropriate communication tools. There is a NWS radio / alert system in the plant control room. The site procedure for severe weather requires that if a tornado or severe thunderstorm warning is issued by NWS for West Feliciana Parish, or other surrounding parishes, or if a tornado is sighted, then a plant wide announcement of the condition is made and, by procedure, any fuel handling or radioactive material transport activities underway are to be immediately brought to a safe condition and stopped. The Fuel Building door at the FBCHC is also to be closed. Weather conditions will also be monitored continuously while outdoor cask handling operations are ongoing. Therefore, a tornado touching down on site during outdoor cask handling operations with no notice whatsoever would be an unexpected and highly unlikely occurrence.

Both the HI-TRAC transfer cask and HI-STORM overpack are designed to withstand tornado winds and tornado-generated missiles. Once the transfer cask is placed atop the overpack or placed on the ground, it is in an analyzed condition. This reduces the tornado missile threat to an even shorter period of time where the HI-TRAC transfer cask is suspended outdoors from the crane main hook (i.e., in transit from the Fuel Building to a position above the HI-STORM overpack). The tornado-generated missile would also have to make its way through the crane superstructure and hit a relatively small target area in the cask structural load path to be of concern. An evaluation of the time it would take to lower the transfer cask to the ground or move it back into the Fuel Building if a tornado unexpectedly occurs has been performed as discussed below.

The Fuel Building Cask Handling Crane main hoist maximum lowering speed with the rated load on the hook is 5.9 ft/min. The maximum crane main trolley speed with the rated load on the hook is 50 ft/min. The transfer cask bottom is approximately 20 feet above the ground when suspended in the outdoor crane structure. The farthest point out from the Fuel Building that the transfer cask travels in the outdoor crane structure is approximately 40 feet. Using arbitrarily chosen nominal lowering and trolleying speeds (i.e., less than the maximum values), the estimated time it would take to lower the transfer cask to the ground or trolley the cask back into the Fuel Building in the event a tornado is observed in the area during outdoor cask handling operations is illustrated in the table below.

Hoist Lowering Speed (ft/min)	Lowering Distance (ft.)	Time to Lower (min.)	Trolley Speed (ft/min)	Trolley Distance (ft.)	Time to Trolley (min.)
5	20	4	40	40	1

These periods of time, plus any time required for supervisory personnel to decide to execute these maneuvers would result in the cask being placed in a safe location either inside the Fuel Building, on top of the mating device or on the ground in the outdoor crane structure in less than 15 minutes after plant entry into the associated adverse operating procedure. This time is considered sufficient to ensure the transfer cask can be moved to a safe location in a deliberate and controlled manner in the event a tornado unexpectedly occurs.

RAI from Spent Fuel Pool Organization

The following information is needed to complete review of the three reports submitted in the Entergy Letter, dated July 12, 2005.

1. Holtec Report No. HI-2022956, "HI-TRAC Impact Limiter Qualification at River Bend, Rev. 1"

SFPO reviewed structural performance of the impact limiter to ensure that the cask is protected such that the maximum cask deceleration is less than 64.8 g for which the HI-TRAC transfer cask, MPC, and fuel assemblies have been demonstrated to be structurally adequate during a cask vertical drop accident.

1.1 Submit a copy of Reference 11 on relevant crush strength for the General Plastic Last-a-Foam FR-3700 polyurethane foam to demonstrate that appropriate stress-strain curve is considered in evaluating impact limiter lock-up effects.

Basis. The crush strength of the 13 pcf foam, as reported in Reference 11 and Figure 5 of the report, is markedly different from that based on the 9/92 edition of the Last-a-Form FR-3700 data sheet available to the staff. For instance, Figure 5 lists crush strengths of 819 psi and 10,936 psi for strains at 30% and 80%, respectively. However, the corresponding strengths available to the staff are 582 psi and 5,206 psi. Use of the Figure 5 crush strength will underestimate impact limiter vertical deformation, which, in turn, may render the calculation incapable of evaluating impact limiter lock-up effects.

Holtec Response:

Our copy of the last-a-foam catalog is dated 2/97 and includes not only the 9/92 data sheet that is referred to by the staff in the RAI, but also includes data sheets for dynamic crush strength for fr-3700 material. The dynamic crush data that Holtec used in the simulations is attached as requested. Holtec has discussed the issue concerning
The 9/92 data sheet vs the 6/96 data sheet with general plastics (Mr. Glenn Strom) and the difference in the data appears to have its roots in changes in the testing apparatus and measurement technique. In response to a direct question by Holtec to Mr. Strom concerning which data set is appropriate when the user is performing a non-linear dynamic simulation (as opposed to a simple energy balance), the general plastic response was that the use of the 6/96 data was more appropriate.

Having provided the above response, Holtec has rerun two simulations using the 9/92 data as input to provide a comparison of results and assess the effect of the two different data sets for the 13pcf density material. The following table provides the results of the additional analyses and the comparison with the results in the report.

Item **6/96 Data used in report (From Figs. 12 and 16)**	Cask Deceleration (g's)	Impact Limiter Crush (in)	Impact Limiter Strain (%)	**Item** **2/92 Data**	Cask Deceleration (g's)	Impact Limiter Crush (in)	Impact Limiter Strain (%)
Drop into Cask Pit	48	12.84	55.2	**Drop into Cask Pit**	55.44	15.53	66.8
Drop into CWA	32.4	9.67	41.6	**Drop into CWA**	30.61	12.43	53.5

The tabular comparison results above show that for the drop into the cask pit the use of lower crush strength (2/92 data) does cause a greater crush; however the deceleration is still acceptable. For the drop into the CWA, the impact limiter also experiences greater crush with the "2/92" crush data, but the impact limiter does not experience increased g's because the crush does not reach the region where the stiffness begins to increase.

In conclusion, the 6/96 data set is the appropriate data set to use per manufacturer's recommendation; however, the proposed impact limiters continue to perform their function even if the 2/92 data is assumed to apply.

Attachment (2 pages, dated 6/96) from 2/97 last-a-foam catalog + 1 page 2/92 input for additional vn simulations

GENERAL PLASTICS MANUFACTURING CO., P. O. BOX 9097, TACOMA WA 98409 TEL ~~206~~ 253-473-5000

Glenn ~~Strong~~ Strom

LAST-A-FOAM ® FR-3700
DYNAMIC CRUSH STRENGTH
@ 75°F, PARALLEL TO RISE (PSI)

	CRUSH %									
DENSITY	10	20	30	40	50	60	65	70	75	80
3	90	74	73	74	77	85	95	116	143	217
4	129	112	112	116	125	145	168	210	272	438
5	170	153	156	165	183	221	282	335	452	765
6	214	198	205	220	249	312	377	493	688	1219
7	260	247	259	281	325	419	514	686	989	1830
8	308	299	316	348	409	542	674	917	1361	2632
9	358	355	379	420	502	681	859	1188	1816	3667
10	410	413	445	498	603	837	1070	1505	2365	4987
11	547	545	584	649	785	1107	1435	2056	3335	6930
12	644	647	696	779	951	1362	1784	2578	4180	8761
13	749	759	819	922	1137	1652	2188	3189	5173	10938
14	862	881	953	1080	1344	1981	2653	3900	6332	13508
15	984	1013	1099	1253	1574	2353	3184	4724	7679	16524
16	1114	1155	1257	1442	1827	2770	3789	5675	9237	20041
17	1254	1309	1428	1647	2105	3238	4476	6767	11031	24119
18	1402	1473	1613	1869	2410	3760	5253	8017	13089	28823
19	1560	1650	1811	2110	2744	4341	6130	9444	15439	34222
20	1727	1839	2023	2370	3109	4986	7116	11066	18112	40388
21	1905	2040	2251	2650	3505	5701	8222	12904	21144	47398
22	2093	2255	2494	2952	3937	6491	9460	14982	24568	55335
23	2292	2483	2754	3275	4404	7363	10842	17323	28425	64285
24	2501	2726	3031	3623	4911	8323	12381	19954	32753	74337
25	2722	2983	3326	3994	5459	9377	14091	22903	37595	85586
30	4012	4513	5096	6268	8913	16344	25764	43504	71191	163427

6/3/96

GENERAL PLASTICS MANUFACTURING CO., P.O. BOX 9097, TACOMA WA 98409 TEL 206-473-5000

LAST-A-FOAM ® FR-3700
DYNAMIC CRUSH STRENGTH
@ 75°F, PERPENDICULAR TO RISE (PSI)

	CRUSH %									
DENSITY	10	20	30	40	50	60	65	70	75	80
3	54	49	50	55	61	70	80	99	135	216
4	86	81	84	92	103	125	148	189	264	435
5	124	119	125	137	156	197	239	312	448	759
6	167	164	175	191	219	287	354	472	693	1208
7	215	215	232	252	292	395	496	673	1009	1811
8	268	272	296	322	375	522	666	920	1407	2601
9	325	335	368	400	469	668	866	1218	1900	3619
10	387	404	447	486	573	836	1100	1571	2502	4916
11	496	516	554	625	769	1114	1490	2189	3518	7021
12	595	621	668	756	937	1371	1844	2717	4374	8797
13	705	738	795	901	1125	1664	2251	3329	5372	10889
14	825	866	934	1063	1335	1997	2717	4035	6529	13335
15	956	1007	1088	1241	1570	2372	3247	4844	7862	16178
16	1099	1161	1255	1437	1829	2795	3849	5768	9391	19464
17	1254	1329	1438	1652	2116	3268	4529	6820	11139	23240
18	1422	1511	1638	1887	2432	3797	5295	8013	13128	27560
19	1603	1709	1853	2142	2779	4386	6155	0361	15382	32477
20	1797	1922	2087	2419	3159	5040	7119	10880	17929	38049
21	2007	2152	2339	2720	3574	5766	8195	12587	20796	44335
22	2231	2399	2611	3045	4028	6568	9395	14499	24012	51400
23	2472	2665	2904	3397	4521	7454	10729	16634	27608	59309
24	2729	2950	3218	3776	5058	8430	12209	19013	31617	68131
25	3003	3255	3556	4185	5641	9502	13847	21657	36073	77939
30	4666	5122	5630	6727	9354	16600	24891	39662	66382	144476

output[24].y4	Value (psi)
0	0
0.05	300
0.1	535
0.2	542
0.3	582
0.4	651
0.5	791
0.6	1111
0.65	1427

0.65	1427
0.7	1973
0.75	2938
0.8	5206
0.85	7474
0.9	9742

2/92 crush vs. strain data used in additional VN simulations

2. <u>Holtec Report No. HI-2043278, "Evaluation of Postulated HI-TRAC 125D Transfer Cask Drop Accidents at River Bend Station," Rev. 2</u>

2.1 Submit finite element modeling details for the lid-to-shell partial penetration weld joint and the gap interface between the MPC closure lid and the shell body. With respect to the weld, provide justification for using directly the uniaxial stress-strain material properties for evaluating the calculated von Mises stress, which is primarily biaxial in nature.

<u>Basis</u>. In Figure 9 of the report, the lid-to-shell weld is shown to be subject to material yielding while the lower shell near the bottom plate of the MPC remains elastic, for a 7" vertical drop of the loaded transfer cask. In a separate calculation package for the MPC subject to a 25-ft drop, the most critically stressed and strained location, however, is shown to be at a lower shell section near the bottom plate. It's unclear whether any modeling anomalies have been introduced to the weld finite element scheme, such as type, size, number of elements, and order of integration for determining stress/strain performance of the weld. Holtec should provide information to show that the weld details are adequately modeled so as not to invalidate the reported stress/strain results.

<u>Holtec Response:</u>

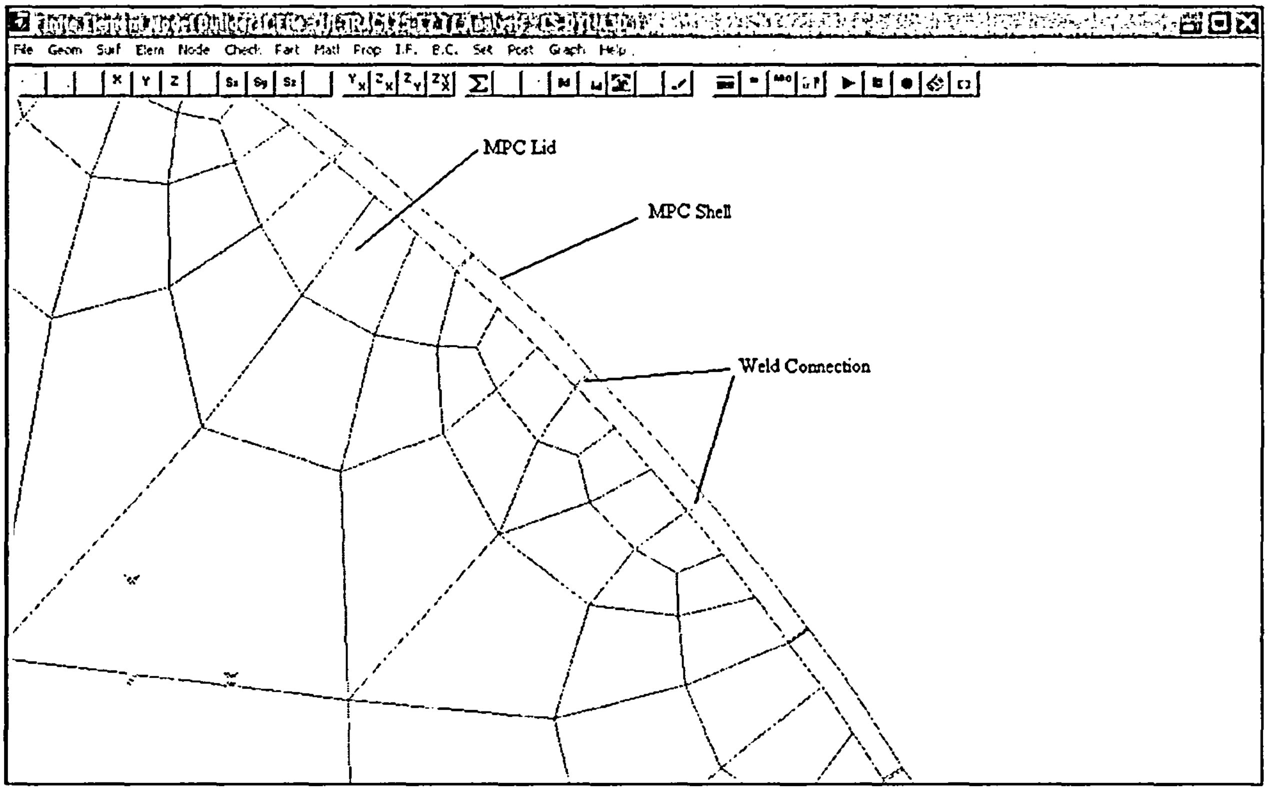
In the HI-TRAC drop analysis, the MPC lid-to-shell weld joint was modeled by using the LS-DYNA command "*CONSTRAINED_SPOTWELD" at 26 locations around the circumferential weld line of the quarter MPC model with full consideration of the 1/16" gap between the lid and the shell body (a constrained spot weld every 2"). Since the ½" thick MPC shell was modeled with shell elements, each pair of constrained shell/lid nodes that represent the local weld connection are distanced 0.625", which is the sum of the lid-to-shell radial gap (1/16") and one half of the shell thickness (1/4"). The following figure shows the weld connection of the LS-DYNA MPC model. The figure shows the top view of the MPC lid (modeled using solid elements), and an end view of the shell (modeled using thin shell elements). It should be pointed out that the HI-STORM FSAR has demonstrated that the MPC lid-to-shell weld joint will not fail as long as the design basis deceleration is not exceeded, which is true for the analyzed 7" drop event.

Because the weld joint is not explicitly modeled with solid or shell elements in the 7" HI-TRAC drop analysis as described above, the Von Mises stress shown in Figure 9 of the report actually represents the stress status of the MPC shell at the weld connection. The Von Mises stress (i.e., effective stress) combines stresses in two or three dimensions into a single number (a scalar) using the following formula.

$$\sigma_e = \frac{1}{\sqrt{2}}[(\sigma_x - \sigma_y)^2 + (\sigma_y - \sigma_z)^2 + (\sigma_z - \sigma_x)^2 + 6(\tau_{xy}{}^2 + \tau_{yz}{}^2 + \tau_{zx}{}^2)]^{1/2}$$

Once the resulting effective stress reaches the limiting value of an isotropic material determined in the uniaxial tensile test, material yielding begins according to the von Mises yield criterion. Finite element results are typically presented using von Mises stress for ductile material under complex stresses. Since the MPC stainless steel is an isotropic ductile material, the use of uniaxial stress-strain material properties in conjunction with von Mises stress in the finite element drop analysis is considered to be appropriate.

As shown in figure 9 of the report, the MPC shell at the shell-to-lid weld connection yields in the analyzed 7" HI-TRAC drop event as a result of the local bending introduced by the small gap between the MPC lid and the shell; the impact does not result in global deformation in the MPC shell. In a separate analysis (documented in HI-2043276) where the MPC directly drops from 25 ft above a rigid target, however, the impact is so severe that the bottom section of MPC buckles immediately as the impact stress wave starts to propagate upward. Dissipating part of impact energy through deformation, the bottom section of the MPC shell acts like an impact limiter that may significantly diminish the otherwise high stresses in the rest of shell above the buckled section. Moreover, the small gap between the MPC lid and the shell may prevent the top section of the shell from being buckled, although the top of shell does experience much greater stress than the 7" drop case.



3. Holtec Report No. HI-2043276, "Analysis of a Postulated MPC Drop Accident during MPC Transfer Operation," Rev. 0

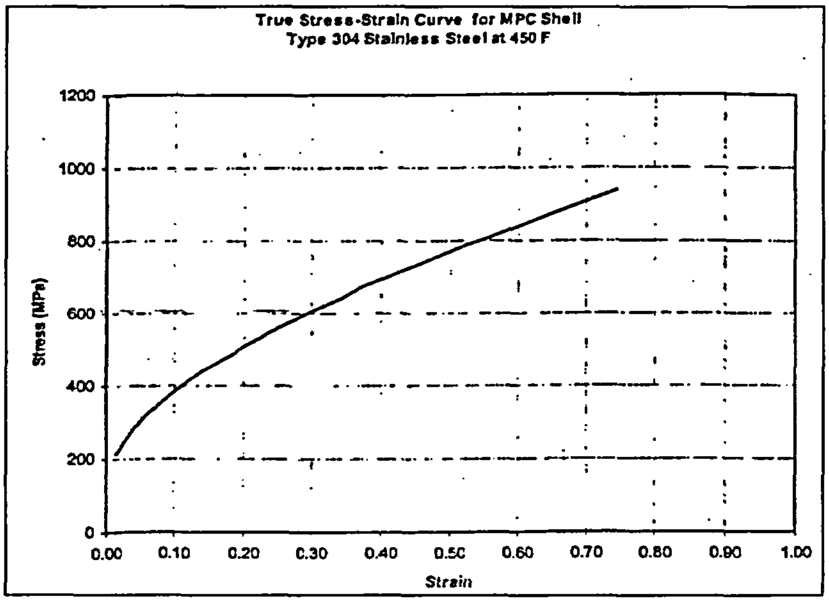
3.1 Considering true stress and true strain, perform a supplemental LS-DYNA analysis of the MPC to demonstrate that the strains at the lid-to-shell weld and the lower shell section near the bottom plate remain to be bounded by the material failure strains.

Basis. Contrary to that required by the LS-DYNA to use true stress and true strain in its large-strain computation algorithm, engineering stress-strain relationship appears to have been considered in modeling the elasto-plastic drop analysis of the MPC. The staff notes that the materials at both the top and bottom parts of the MPC are subject to major yielding and resulting stress relaxation at the lid-to-shell weld may affect appreciably the stress state change for the lower shell. Proper account of stress-strain relationship is essential for evaluating maximum strains at critical locations of the MPC.

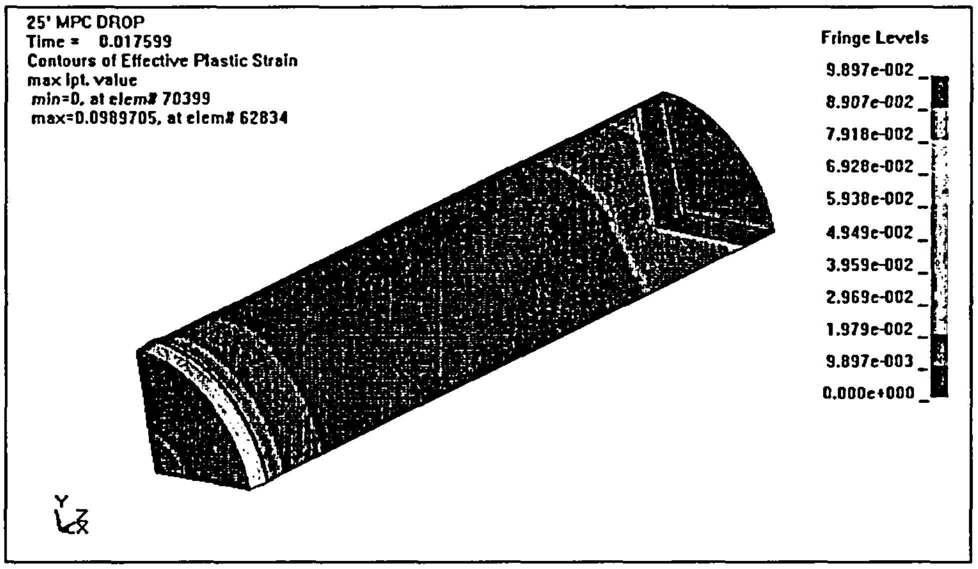
Holtec Response:

The use of engineering stress-strain relationship for the MPC model is conservative, since the true stress-strain relationship for stainless steel, which accounts for the reduction of the loaded area of the specimen in the tensile test, has a much greater material failure true strain. The above statement is consistent with NRC staff's position in the ASLB (safeguards) hearing regarding the aircraft impact evaluation for the PFS ISFSI. Since the mathematical relationship between engineering stress/strain and the true stress/strain (can be derived by assuming both constancy of volume and a homogeneous distribution of strain along the gage length of the tension specimen) breaks down after necking of the tension specimen, the complete true stress-strain curve for a material can only be obtained through actual measurements in the tensile test.

Nevertheless, a supplemental LS-DYNA analysis has been performed by using the true uniaxial stress-strain relationship presented by the NRC staff in the ASLB hearing to demonstrate the conservatism; the true stress-strain curve shown below was originally obtained by the Sandia National Laboratories.



The following figure shows the plastic strain result from the supplemental LS-DYNA analysis. The maximum plastic strain of the MPC shell (0.09897) is smaller than that reported in Figure 5 of HI-2043276 (i.e., 0.2125) where the engineering stress-strain relationship was used. The plastic strain results comparison confirms that the use of engineering stress strain relationship is conservative for the drop analysis.



3.2 Discuss why an irregular stress state in the circumferential direction, as displayed in Figure 4 of the report, should result in an uniform plastic strain state, shown in Figure 5.

Basis. The irregular light green/yellow stress contours near the closure lid end do not suggest that uniform plastic strain state is attainable in the upper MPC shell.

Holtec Response: The plastic strain distribution shown in Figure 5 was obtained at the time instant (0.018103 sec) when all MPC shell finite elements had experienced their peak stresses that determine the final plastic strain state. The stress distribution presented in Figure 4, however, is for a much earlier time instant (0.0087997 sec). The instantaneous stress status in a dynamic problem (such as the MPC impact event) does not reflect the final plastic strain distribution of the structure, which is quite different from a static problem. Therefore, an instantaneous irregular stress distribution in the circumferential direction of the shell, which could be caused by local effects such as the symmetric boundary condition of the model on the stress wave propagation, does not imply that the distribution of the peak stresses experienced by the MPC shell over the impact process is irregular. Because of the symmetry in both geometry and loading, the MPC shell will experience a symmetric (or uniform) distribution of peak stresses in the drop event although the peak stresses occur at different time instants. The obtained steady plastic strain distribution in Figure 5 of the report reflects the distribution of the peak stresses that the MPC shell experiences during the impact process.

Attachment 5

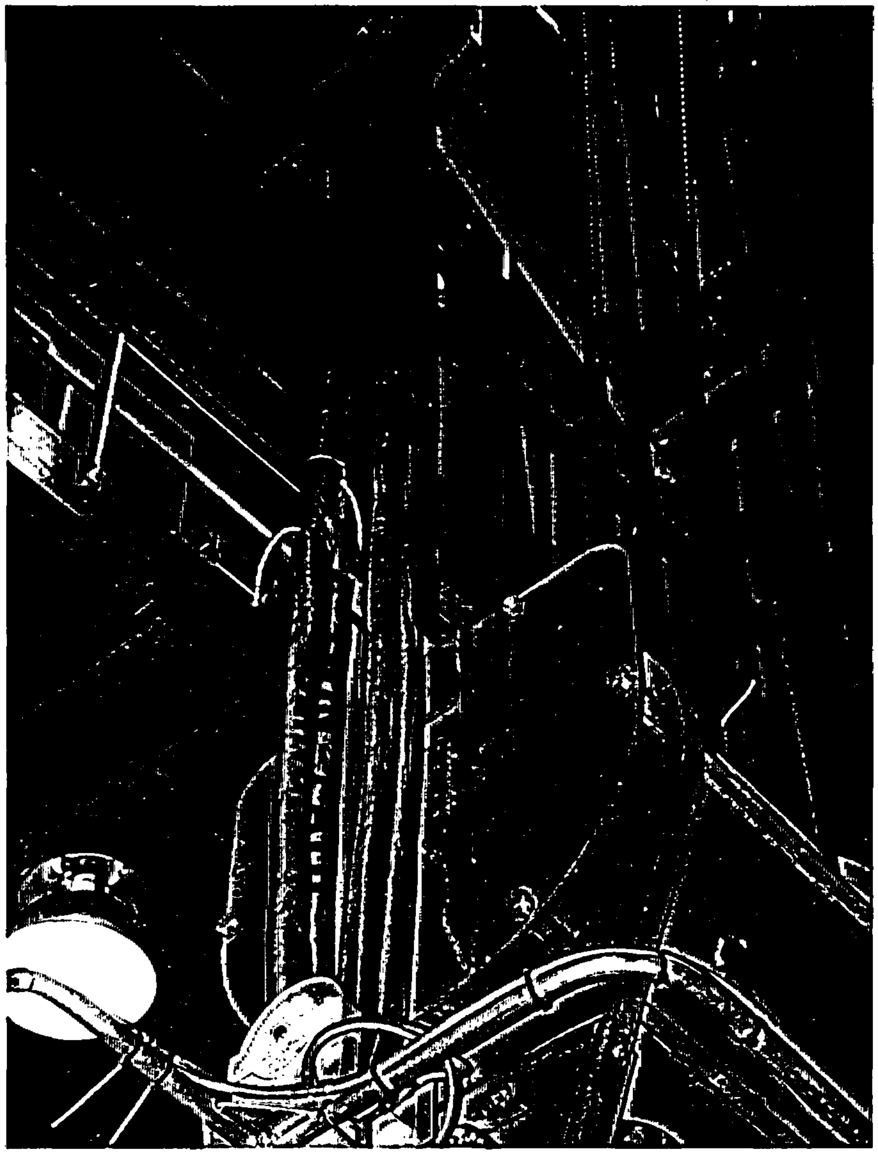
RBG-46478

Photographs of Redundant Rigging

Redundant Rigging Engagement

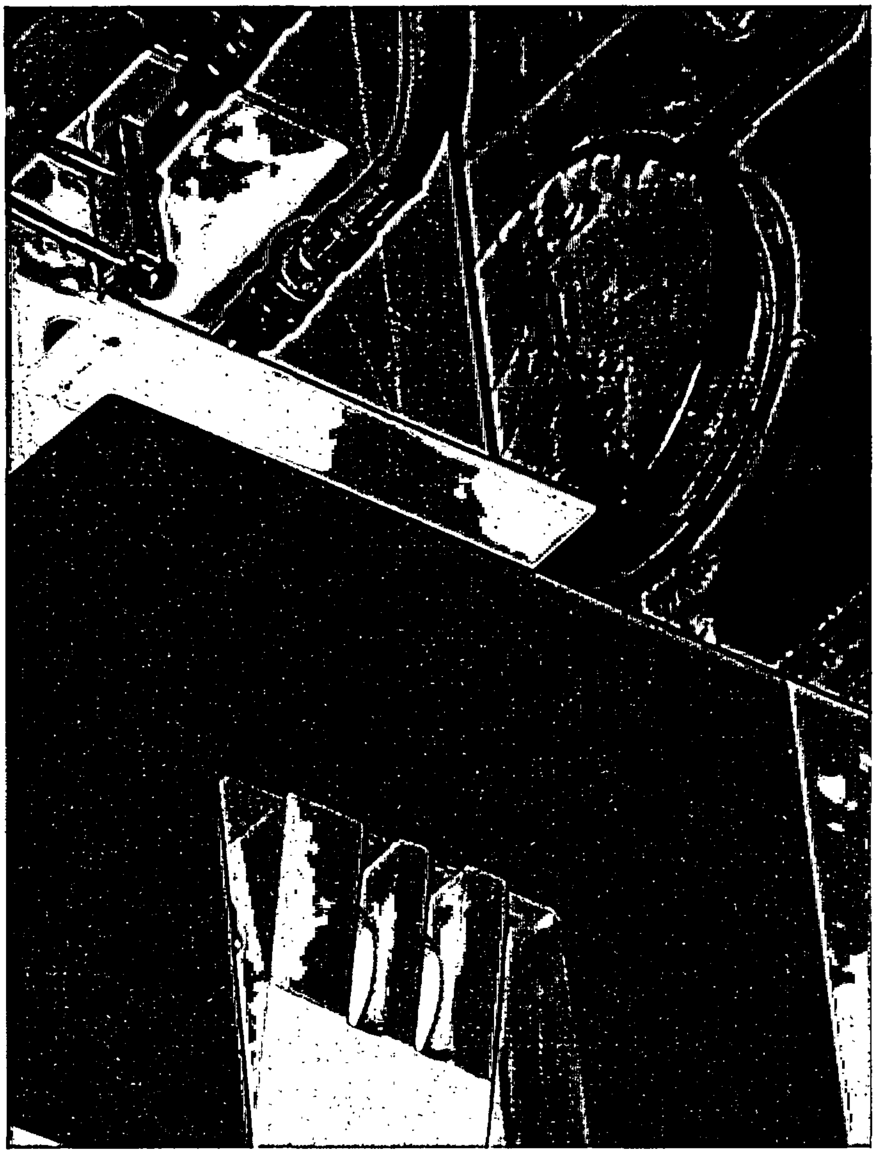
Photograph #1

The FBCHC Main Hook and attached Lift Yoke have been raised to achieve seating of the Lower Link in the Lift Yoke. Visual observation of the Lower Link top plate's seating on the top of the Lift Yoke Strongback is used to verify that proper seating of the Lower Link in the Lift Yoke. The painted top sides of the Link Locks can be fully seen. The Link Lock has been engaged (pivoted outward into the window in the Lift Yoke Strongback).



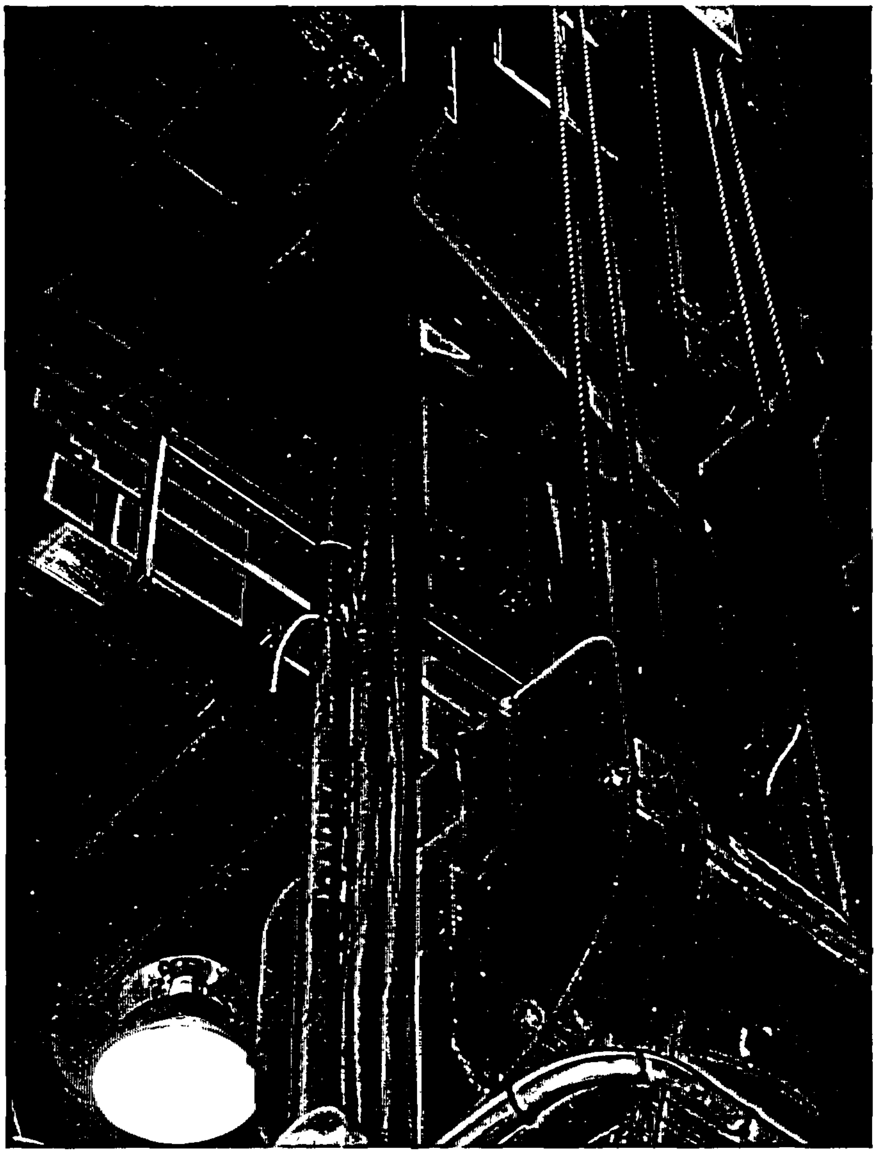
Photograph #2

A view of the redundant link slings, at same conditions as shown in Photograph #1. The slings are visibly slack.



Photograph #3

The FBCHC Main Hook and attached Lift Yoke have been lowered so that the top of the Link Locks are against the inside top of the window in the Lift Yoke. This position permits putting tension on the Redundant Link Slings by lowering of the FBCHC Main Hook.



Photograph #4

The FBCHC Main Hook and attached have been lowered slightly to cause the Redundant Link Slings to become visibly taut.

The tautness of the slings confirms that the Link Locks have been engaged.

Attachment 6

RBG-46478

NUREG-0612 AND NUREG-0554 Comparison Matrix for the RBS Fuel Building Cask Handling Crane

NUREG-0612 AND NUREG-0554 COMPARISON MATRIX FOR THE RBS FUEL BUILDING CASK HANDLING CRANE

Document and Section	Guidance	Evaluation	Notes
NUREG-0612 Section 5.1.1(1)	Safe load paths should be defined for the movement of heavy loads to minimize the potential for heavy loads, if dropped, to impact irradiated fuel in the reactor vessel and in the spent fuel pool, or to impact safe shutdown equipment.	Safe load paths for heavy load movements have been defined at RBS. The FBCHC is prevented, by design, from traveling over the reactor vessel and the spent fuel pool. Loaded spent fuel casks are not handled over irradiated fuel. The MPC lid is the sole heavy load handled by the FBCHC that must be suspended over exposed spent fuel in the loaded canister to properly conduct spent fuel cask loading operations.	The consequences of a postulated drop of the MPC lid into the loaded MPC have been evaluated and found to not result in an unacceptable fuel configuration and the radiological consequences are bounded by the previously evaluated fuel handling accident described in RBS USAR Section 15.7.4.
NUREG-0612 Section 5.1.1(2)	Procedures should be developed to cover load handling operations for heavy loads that are, or could be handled over, or in proximity to irradiated fuel or safe shutdown equipment.	RBS' heavy load control program includes procedures to cover load handling operations for heavy loads, including those handled by the FBCHC.	Lift height limits, consistent with the drop analyses will be included in the operating procedures, as appropriate.
NUREG-0612 Section 5.1.1(3)	Crane operators should be trained, qualified, and conduct themselves in accordance with Chapter 2-3 of ANSI B30.2-1976.	Crane operators are trained in the area of heavy load handling, safe load paths, and the potential consequences of load drops over the reactor vessel, spent fuel pool, and safe shutdown equipment. They conduct themselves appropriately in accordance with this training. The training is based upon ANSI B30.2-1976.	

NUREG-0612 AND NUREG-0554 COMPARISON MATRIX FOR THE RBS FUEL BUILDING CASK HANDLING CRANE

Document and Section	Guidance	Evaluation	Notes
NUREG-0612 Section 5.1.1(4)	Special lifting devices should satisfy the guidelines of ANSI N14.6-1978.	The special lifting devices used with the FBCHC to handle heavy loads required for dry storage cask loading operations (i.e., the lift yoke, lift yoke extension, and MPC lift cleats) satisfy the guidelines of ANSI N14.6-1993.	The redundant rigging system (Figure 3 of Attachment 2 to LAR 2004-26) is comprised of upper links, lower links, and connecting slings. The upper links are attached to the crane structure and are not a special lifting device. The upper links are designed with safety factors of 3 and 5 to yield and ultimate strength, respectively. The lower links also do not meet the definition of a special lifting device. However, Entergy has chosen to design them in accordance with the guidance of ANSI N14.6-1993.
NUREG-0612 Section 5.1.1(5)	Lifting devices that are not specially designed should be installed and used in accordance with the guidelines of ANSI B30.9-1971.	The lifting devices used with the FBCHC to handle heavy loads required for dry storage cask loading operations that are not specially designed (i.e., slings, rigging, connecting devices) satisfy the guidelines of ANSI B30.9-1984.	Slings are used to lift and lower the empty MPC, the MPC lid, and the loaded MPC, and are also part of the redundant load path that is engaged for most horizontal transfer cask movements. The redundant load path slings connect the upper and lower crane links (see Figure 3 in Attachment 2 to LAR 2004-26).
NUREG-0612 Section 5.1.1(6)	The crane should be inspected, tested, and maintained in accordance with Chapter 2-2 of ANSI B30.2-1976.	The FBCHC is inspected, tested, and maintained in accordance with ANSI B30.2-1976. Two periodic inspections are performed, on a 6-month and an 18-month frequency.	

NUREG-0612 AND NUREG-0554 COMPARISON MATRIX FOR THE RBS FUEL BUILDING CASK HANDLING CRANE

Document and Section	Guidance	Evaluation	Notes
NUREG-0612 Section 5.1.1(7)	The crane should be designed to meet the applicable criteria and guidelines of Chapter 2-1 of ANSI B30.2-1976 and CMAA-70 or suitable alternative provided the intent of ANSI B30.2 and CMAA-70 is satisfied.	The FBCHC was designed to meet the applicable criteria and guidelines of CMAA 70-1971 and ANSI B30.2-1967.	NRC Supplemental SER for RBS dated January, 1985, Section 2.3.7 concludes that the FBCHC design complies with CMAA-70-1975 and ANSI B30.2-1976.
NUREG-0612 Section 5.1.6(1)(a)	Special lifting devices that are used for heavy loads in the area where the crane is to be upgraded should meet ANSI N14.6-1978, including Section 6 of that document. If only a single lifting device is provided instead of dual devices, the special lifting device should have twice the design safety factor as required to satisfy the guidelines of NUREG-0612, Section 5.1.1(4).	The FBCHC is being upgraded only to the extent that a redundant rigging feature is being incorporated in the design. The redundant rigging is engaged above the crane hook and, therefore, does not meet the definition of a special lifting device. Below the hook, the lift yoke and MPC lift cleats are designed in accordance with ANSI N14.6 with twice the design safety factor. The lift yoke extension is designed in accordance with ANSI N14.6 but the design safety factors are not doubled.	Load drops have been postulated in the areas where the lift yoke extension is used.

NUREG-0612 AND NUREG-0554 COMPARISON MATRIX FOR THE RBS FUEL BUILDING CASK HANDLING CRANE

Document and Section	Guidance	Evaluation	Notes
NUREG-0612 Section 5.1.6(1)(b)	Lifting devices that are not specifically designed and that are used for handling heavy loads in the area where the crane is to be upgraded should meet ANSI B30.9- 1971, "Slings" as specified in NUREG-0612, Section 5.1.1(5), except that one of the following should also be satisfied unless the effects of the drop of the particular load have been analyzed and shown to satisfy the evaluation criteria of NUREG-0612, Section 5.1: (i) Provide dual or redundant slings or lifting devices such that the failure a single component failure or malfunction in the sling will not result in uncontrolled lowering of the load; OR (ii) In selecting the proper sling, the load used should be twice what is called for in meeting NUREG-0612, Section 5.1.1(5).	The FBCHC is being upgraded only to the extent that a redundant rigging feature is being incorporated in the design. The slings used in the redundant rigging (above the crane hook) are designed in accordance with ANSI B30.9. MPC lift slings, MPC lid lift slings, and other connection devices used below the crane hook are designed in accordance with ANSI B30.9 to twice the load called for in meeting Section 5.1.1(5).	
NUREG-0612 Section 5.1.6(2)	New cranes should be designed to meet NUREG-0554.	This criterion is not applicable because the FBCHC is not a new crane. The FBCHC was designed before the issuance of NUREG-0554.	

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Document and Section	Guidance	Evaluation	Notes
NUREG-0612 Section 5.1.6(3)	Interfacing lifting points, such as lifting lugs or cask trunnions should also meet one of the following for heavy loads handled in the area where the crane is to be upgraded unless the effects of the drop of the particular load have been analyzed and shown to satisfy the evaluation criteria of NUREG-0612, Section 5.1: (a) Provide redundancy or duality such thata single lift point failure will not result in uncontrolled lowering of the load; lift points should have a design safety factor with respect to ultimate strength of five (5) times the maximum combined concurrent static and dynamic load after taking the single lift point failure. OR (b) A non-redundant or non-dual lift point system should have a design safety factor of ten (10) times the maximum combined concurrent static and dynamic load.	The lifting trunnions of the HI-TRAC transfer cask have a design safety factor greater than 10 times the maximum combined static and dynamic load. A dynamic load factor of 1.15 is applied to the mass of the lifted load.	

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NUREG-0554 Section 2.1 (Item 1)	The allowable design stress limits for the crane intended for plant operation should be those indicated in Table 3.3.3.1.3-1 of CMAA 70 reflecting the appropriate duty cycle in CMAA 70.	The design stress limits of the FBCHC structural members are in accordance with CMAA 70-1971. Load-carrying parts other than structural members and hoisting ropes are designed to a maximum stress level of 20% of ultimate strength of the material. The crane was also re-qualified by analysis in 2002 considering a load on the hook using CMAA 70-2000 allowable stresses and loadings.	
NUREG-0554 Section 2.1 (Item 2)	The sum total of simultaneously applied loads (static and dynamic) should not result in stress levels causing permanent deformation, other than localized strain concentration, in any part of the handling system during either the construction or the operation phase.	The FBCHC was designed not to exceed material yield strengths under static and dynamic loading conditions. Dynamic loading is addressed in the design through the use of a 15% impact load factor based on a hoist speed of 30 ft/min or less (ref. CMAA specification No. 70, 1971).	FBCHC main hoist speed is 6 fpm.
NUREG-0554 Section 2.1 (Item 3)	The effects of cyclical loading induced by jogging or plugging an uncompensated hoist control system should be included in the design specification.	The FBCHC main hook hoist is designed for stepped, variable speed operation with a load on the hook ranging from 0.5 fpm (inching speed) to 6 fpm (normal speed). The use of inching speed during cask handling prevents cycling due to jogging or plugging. Therefore, this requirement does not apply.	

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NUREG-0554 Section 2.2 (Item 1)	A single-failure-proof crane should be designed to handle the maximum critical load (MCL) that will be imposed. However, a slightly higher design load should be selected for component parts that are subjected to wear and exposure. An increase of approximately 15% of the design load for these components would be a reasonable margin.	Component parts of the FBCHC are designed for an MCL of 125 tons – the maximum weight of the HI-TRAC transfer cask. The intent of this guideline is met by requiring hoisting ropes and other load-carrying parts (other than structural members) to have a rated-load minimum safety factor of five.	
NUREG-0554 Section 2.2 (Item 2)	The MCL rating should be clearly marked on the crane.	The FBCHC MCL is marked on the crane.	
NUREG-0554 Section 2.2 (Item 3)	Single-failure-proof cranes may be required to handle occasional noncritical loads of magnitude greater than the MCL during plant maintenance periods. For such cases, the maximum noncritical load will be the design rated load (DRL). The design of certain components may be decided to a greater extent by the MCL rating even though standard commercial practice may be used for the DRL rating.	The FBCHC is designed and used to lift spent fuel shipping and storage cask components as well as other waste containers. The heaviest of these lifts is the HI-TRAC 125D spent fuel transfer cask, which has a maximum lifted weight of 125 tons. Therefore, the MCL and the DRL are the same for this crane.	No lifts greater than the MCL (rated capacity) are permitted with the FBCHC.
NUREG-0554 Section 2.2 (Item 4)	The DRL rating should be marked on the crane separately from the MCL marking.	The MCL and DRL are the same for the FBCHC. Therefore, no separate DRL marking is required.	

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NUREG-0554 Section 2.3	The operating environment, including maximum and minimum pressure, maximum rate of pressure increase, temperature, humidity and emergency corrosive or hazardous conditions should be specified for the crane and lifting fixtures.	The FBCHC is located inside the RBS Fuel Building and operates both indoors and outdoors. It is kept indoors when not in use. Because of its Fuel Building location, the FBCHC is not affected by potential containment pressurization events; therefore the rate of pressure increase and the effects of a corrosive environment (i.e., containment spray) are not applicable. Appropriate environmental conditions of service are established in the procurement specification.	
NUREG-0554 Section 2.4 (Item 1)	For cranes already built and operating; such cranes should be tested by subjecting the crane to a test lift at the lowest anticipated operating temperature.	The FBCHC indoor test lift was required to be performed at a temperature of 20°F or higher. The actual indoor test lift was performed in September, 1983. The FBCHC outdoor test lift was performed at a minimum temperature of 74.5°F. Dry spent fuel cask loading operations will not be conducted at temperatures below 70°F.	Cask loading procedures will require an ambient temperature $\geq$ 70°F for all heavy load lifts. This is consistent with NUREG-0612, Appendix C, page C-2, item (2). Entergy may perform a load test in the future if experience dictates a lower operating temperature is desirable.

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NUREG-0554 Section 2.4 (Item 2)	Minimum operating temperatures should be specified in order to reduce the possibility of brittle fracture of the ferritic load-carrying members of the crane.	The FBCHC's minimum design temperature is 2°F. Dry spent fuel cask loading operations will not be conducted at temperatures below 70°F.	Cask loading procedures will require an ambient temperature ≥ 70°F for all heavy load lifts. This is consistent with NUREG-0612, Appendix C, page C-2, item (2). Entergy may perform a load test in the future if experience dictates a lower operating temperature is desirable.
NUREG-0554 Section 2.4 (Item 3)	In order to ensure resistance to brittle fracture, material for structural members essential to structural integrity should be tested in accordance with the following impact test requirements. Either drop weight test per ASTM E-208 or Charpy tests per ASTM A-370 may be used for impact testing.	Structural steel used in the FBCHC is ASTM A36. Material certifications for steel used in construction of the FBCHC do not include impact test results.	Cask loading procedures will require an ambient temperature ≥ 70°F for all heavy load lifts. This is consistent with NUREG-0612, Appendix C, page C-2, item (2). Entergy may perform a load test in the future if experience dictates a lower operating temperature is desirable.

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NUREG-0554 Section 2.4 (Item 4)	The minimum operating temperature based on the drop weight test should be obtained by following procedures in Paragraph NC-2300 of Section III of the ASME Code. The minimum operating temperature based on the Charpy V-notch impact test should be obtained by following procedures in paragraph ND-2300 of Section III of the ASME Code. Alternative methods of fracture analysis that achieve an equivalent margin of safety against fracture may be used if the include toughness measurements on each heat of steel used in structural members essential to structural integrity. In addition, the fracture analysis that provides the basis for setting minimum operating temperatures should include consideration of stress levels; quality control; the mechanical checking, testing, and the temperatures at which the DRL test is run relative to operating temperature. For crane girder material section thickness over 64 mm (2.5 in), it is recommended that the NC-2300 requirements be used exclusively.	Structural steel used in the FBCHC is ASTM A36. Material certifications for steel used in construction of the FBCHC do not include impact test results.	Cask loading procedures will require an ambient temperature $\geq$ 70°F for all heavy load lifts. This is consistent with NUREG-0612, Appendix C, page C-2, item (2). Entergy may perform a load test in the future if experience dictates a lower operating temperature is desirable.

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NUREG-0554 Section 2.4 (Item 4) (continued)	As an alternative to the above recommendations, the crane and lifting fixtures for the cranes already fabricated or operating may be subjected to a coldproof test consisting of a single dummy load test follows: Metal temperature of the structural members essential to the structural integrity of the of the crane handling system should be at or below the minimum operating temperature. The corresponding dummy load should be equal to 1.25 times the MCL. If the desired minimum operating temperature cannot be achieved during the test, the minimum operating temperature should be that of the test until the crane is retested at a lower temperature. The coldproof test should be followed by a nondestructive examination of the welds whose failure could result in the drop of a critical load. The nondestructive examination of critical areas should be repeated at 4-year intervals or less. Cranes and lifting fixtures made of low-alloy steel such as ASTM A514 should be subjected to the coldproof test in any case.		

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NUREG-0554 Section 2.4 (Item 5)	Cast iron should not be used for load-bearing components such as rope drums. Cast iron may be used for items such as electric motor frames and brake drums.	No cast iron is used for any component subject to cyclic stress, except for the main trolley traverse drive gear cases, wheel bearing capsules, brake wheels, and some brake parts.	
NUREG-0554 Section 2.5 (Item 1)	The cranes should be designed to retain control of and hold the load, and the bridge and trolley should be designed to remain in place on their respective runways with their wheels prevented from leaving the tracks during a seismic event.	The FBCHC main trolley, auxiliary trolley, and auxiliary bridge are designed to ensure the bridge and trolleys remain in place and their wheels do not leave their rails and no trolley part falls during a seismic event.	The FBCHC design does not include a main bridge. Seismic calculations show that the main hoist wire rope exceeds its yield strength under SSE loads but maintains a minimum factor of safety of 1.475 against ultimate strength when the load is supported solely by the main hoist. Redundant rigging will be engaged to hold the load in case of failure in the primary load path in areas where load drops have not been analyzed.
NUREG-0554 Section 2.5 (Item 2)	If a seismic event comparable to a safe shutdown earthquake (SSE) occurs, the bridge should remain on the runway with brakes applied, and the trolley should remain on the crane girders with brakes applied.	The FBCHC is designed to ensure the bridge and trolleys will not leave their rails during or after a safe shutdown earthquake.	

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NUREG-0554 Section 2.5 (Item 3)	The crane should be designed and constructed in accordance with regulatory position 2 of Regulatory Guide 1.29, "Seismic Design Classification". The MCL plus operational and seismically induced pendulum and swinging load effects on the crane should be considered in the design of the trolley, and they should be added to the trolley weight for design of the bridge.	The FBCHC was qualified for normal operation assuming a 1.15 dynamic load factor and to remain on its rails and not drop the load during a safe shutdown seismic event.	The seismic analysis evaluated the rated load on the hook with the hoist rope extended to various lengths.
NUREG-0554 Section 2.6	All weld joints whose failure could result in the drop of a critical load should be nondestructively examined. If any of these weld joint geometries would be susceptible to lamellar tearing, the base metal at the joints should be nondestructively examined.	All FBCHC welds were visually examined. All welds of the main hoist gears, pinions, and shaft assemblies were MT inspected.	Load girt and drive girt end connection welds on the FBCHC trolley were non-destructively examined following recent modifications implemented to increase the trolley's seismic capacity. Other welds on the trolley were non-destructively examined on a sampling basis to assure the quality of the component.
NUREG-0554 Section 2.7	A fatigue analysis should be considered for the critical load-bearing structures and components of the crane handling system. The cumulative fatigue usage factors should reflect effects of the cyclic loading from both the construction and operating periods.	The FBCHC is a low duty cycle device. A fatigue analysis is not required.	
NUREG-0554 Section 2.8 (Item 1)	Preheat temperatures and post-weld heat treatment (stress relief) temperatures for all weldments should be specified in the weld procedure.	Preheat temperatures and post-weld heat treatment of weldments were performed and documented as required by AWS D1.1-1972.	

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NUREG-0554 Section 2.8 (Item 2)	Welds described in the recommendations of Section 2.6 should be post-weld heat treated in accordance with Subarticle 3.9 of AWS D1.1, "Structural Welding Code".	All welding was performed and documented in accordance with AWS D1.1-1972. Other than the main and auxiliary hoist reducer weldments, which were thermally stress relieved, welds associated with all other bridge and trolley weldments were not subjected to post-weld heat treatment (stress relief).	Per NUREG-0612, Appendix C, page C-3, item (3), some crane weldments may not have been heat treated per Subarticle 3.9 of AWS D1.1-1972. As a substitute for weld heat treatment, welds whose failure could result in the drop of a critical load should be non-destructively examined to ascertain that the weldments are acceptable. See notes for NUREG-0554, Section 2.6 above.
NUREG-0554 Section 3.2 (Item 1)	All auxiliary hoisting systems of the main crane handling system that are employed to lift or assist in handling critical loads should be single failure proof.	The FBCHC auxiliary hook is not employed to lift or assist in handling heavy loads during cask loading operations.	
NUREG-0554 Section 3.2 (Item 2)	Auxiliary systems or dual components should be provided for the main hoisting mechanism so that, in case of subsystem or component failure, the load will be retained and held in a stable or immobile safe position.	The FBCHC main hoisting mechanism is not single-failure proof by design. Redundant rigging is employed during most horizontal movements of the cask to provide temporary single-failure-proof protection against drops.	A complete review of cask operations, including potential load drops has been performed. Evaluations and analyses of hypothetical drops required to be postulated have been performed. No unacceptable consequences of load drops are predicted.

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NUREG-0554 Section 3.3 (Item 1)	The automatic controls and limiting devices should be designed so that, when disorders due to inadvertent operator action, component malfunction, or disarrangement of subsystem control functions occur singly or in combination during the load handling, and assuming no components have failed in the subsystems, these disorders will not prevent the handling system from stopping and holding the load.	The main and auxiliary hoists have limit switches that stop the hook in its highest and lowest safe positions. Two limit switches, each of a different design and in series, limit upward travel of each hook. A block type switch is used on the cable and a screw type on the drum, which are adjusted such that if one fails the other will shut off power to the motor and set the brakes. The limit switch actuating mechanisms are located so that the switches will trip under all conditions of hoist load and hoist speed, in sufficient time to prevent contact of the load block with the drum, upper sheaves, or any part of the trolley. The main hoist is also provided with a slack cable limit switch to prevent hoisting or lowering against a slack cable. And with a centrifugal limit switch to apply the holding brakes in the event of an overspeed. The centrifugal limit switch is located such that if a shaft or coupling fails and causes disengagement of the main hoist motor and one holding brake, it would still trip upon the ensuing overspeed and engage the remaining holding brake to stop uncontrolled movement of the load. The centrifugal limit switch is also located such that there is no coupling between the switch and the main hoist gears. Each hoist is provided with an overload cutoff that senses an overload on the hoist and stops the hoisting motion, but allows safe lowering of the load to the floor. The load limiting device is adjustable up to 130% of rated load.	The main hoist is equipped with an alternator-excited eddy current lowering control brake system, which is capable of maintaining a controlled lowering speed of the 125-ton rated load, in the event of a loss of all AC power or electrical failure of the hoist's motor controller. Emergency lowering of the main hoist using the eddy current brake requires that the two hoist holding brakes be manually released.

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NUREG-0554 Section 3.3 (Item 2)	An emergency stop button should be added at the control station to stop all motion.	The FBCHC operator cab includes a safety switch to disconnect the main power feed conductors from the motor control stations. The cab also includes a "reset-stop" pushbutton station with a red stop button that opens the main line electrical contactor. Opening this contactor will stop all motion.	
NUREG-0554 Section 3.4 (Item 1)	A crane that has been immobilized because of malfunction or failure of controls or components while holding a critical load should be able to hold the load or set the load down while repairs or adjustments are being made.	The FBCHC main and auxiliary hoists are provided with holding brakes that are automatically applied to the hoist motor shaft when the motor is de-energized. The main hoist is equipped with an alternator-excited eddy current lowering control brake system, which is capable of maintaining a controlled lowering speed of the 125-ton rated load, in the event of a loss of all AC power or electrical failure of the hoist's motor controller. Emergency lowering of the main hoist using the eddy current brake requires that the two hoist holding brakes be manually released.	

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NUREG-0554 Section 3.4 (Item 2)	Means should be provided for using the devices required in repairing, adjusting, or replacing the failed component(s) or subsystem(s) when failure of an active component or subsystem has occurred and the load is supported and retained in the safe (temporary) position with the handling system immobile. As an alternative to repairing the crane in place, means may be provided for safely transferring the immobilized hoisting system with its load to a safe laydown area that has been designed to accept the load while the repairs are being made.	The main hoist is equipped with an alternator-excited eddy current lowering control brake system, which is capable of maintaining a controlled lowering speed of the 125-ton rated load, in the event of a loss of all AC power or electrical failure of the hoist's motor controller. Emergency lowering of the main hoist using the eddy current brake requires that the two hoist holding brakes be manually released.	
NUREG-0554 Section 3.4 (Item 3)	The design of the crane and its operating area should include provisions that will not impair the safe operation or safe shutdown of the reactor or cause unacceptable release of radioactivity when corrective repairs, replacements, and adjustments are being made to place the crane handling system back into service after component failure(s).	The FBCHC operates and is maintained in the Fuel Building. Its operation and maintenance do not affect the ability of the reactor to operate or be shutdown safely.	
NUREG-0554 Section 4.1 (Item 1)	Design of the rope reeving system(s) should be dual with each system providing separately the load balance on the head and load blocks through configuration of ropes and rope equalizer(s).	The FBCHC does not have a dual (redundant) rope reeving system. The reeving arrangement is a multi-part, double reeved system, utilizing one piece of wire rope.	A complete review of cask operations, including potential load drops has been performed. Evaluations and analyses of hypothetical drops required to be postulated have been performed. No unacceptable consequences of load drops are predicted.

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NUREG-0554 Section 4.1 (Item 2)	Selection of the hoisting rope or running rope should include consideration of the size, construction, lay, and means or type of lubrication, if required, to maintain efficient working of the individual wire strands when each section of rope passes over the individual sheaves during the hoisting operation.	The FBCHC sheaves are provided with cable retainers to prevent the cables from leaving the sheave grooves. The hoisting ropes are right regular lay, pre-formed steel with independent wire rope centers. Rope lubricants (including those for pre-lubricating the internal core and rope lays during weaving) are not water soluble.	
NUREG-0554 Section 4.1 (Item 3)	The effects of impact loadings, acceleration, and emergency stops should be included in selection of rope reeving systems. The maximum load (including static and inertia forces) on each individual wire rope in the dual reeving system with the MCL attached should not exceed 10% of the manufacturer's published breaking strength.	The FBCHC wire rope was selected so that the rated hoist load plus the weight of the load block, divided by the number of parts of rope does not exceed 20 percent of the nominal breaking strength of the rope (a safety factor of five).	

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NUREG-0554 Section 4.1 (Item 4)	The ratio of wire rope yield strength to ultimate strength may vary sufficiently for different production runs to influence the wire rope rating in such a manner that the initial safety margin selected would be too small to prevent the critical load from straining the wire rope material beyond the yield point under abnormal conditions. It would, therefore, be prudent to consider the wire rope yield strength as well as the ultimate strength when specifying wire rope in order to ensure the desired margin on rope strength.	The FBCHC hoisting ropes are designed so that the rated hoist load plus the weight of the load block for that hoist, divided by the number of parts of rope for the hoist does not exceed 20 percent of the nominal breaking strength of the rope (a safety factor of five).	

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NUREG-0554 Section 4.1 (Item 5)	The maximum fleet angle from drum to lead sheave in the load block or between individual sheaves should not exceed 0.061 rad (3-1/2") at any one point during hoisting except that for the last 1 m (3 ft) of maximum lift elevation the fleet angle may increase slightly. The use of reverse bends for running wire ropes should be limited, and the use of larger sheaves should be considered for those applications where a disproportionate reduction in wire rope fatigue life would be expected from the use of standard sheave diameters for reverse bends.	The FBCHC is a "stand-by" service crane (used approximately every 18 months), where fatigue failure of the wire rope is highly unlikely. CMAA 70-1971 (the code of record for the RBC FBCHC) did not specify rope reeving fleet angle limitations. The crane manufacturer's internal standard practice for hoist wire rope reeving design was to limit the maximum fleet angle at any point within the reeving system to 4.75 degrees to ensure satisfactory rope life. The reeving arrangement employed on the RBS FBCHC does not expose the wire rope to a reverse bend condition.	Per NUREG-0612, Appendix C, page C-3, item (4), in lieu of meeting this fleet angle recommendation, a "more frequent inspection program" for the wire rope is acceptable for ensuring the integrity of the rope. For this service, the crane manufacturer recommends inspecting the wire rope either prior to, or after use of the crane (i.e., on an 18-month interval). RBS maintenance procedures require inspection of the wire rope every six months, which meets the NUREG-0612 recommendation for more frequent inspections.
NUREG-0554 Section 4.1 (Item 6)	The equalizer for stretch and load on the rope reeving system may be of either beam or sheave type or combinations thereof. A dual rope reeving system with individual attaching points and means for balancing or distributing the load between the two operating rope reeving systems will permit either rope system to hold the critical load and transfer the critical load without excessive shock in case of failure of the other rope system.	The FBCHC hoist is equipped with a sheave-type equalizer, not a bar-type equalizer. The hoist reeving arrangement is a multi-part, double-reeved system, utilizing one piece of wire rope. The crane does not have a dual load path rope reeving system.	For most horizontal load movements, redundant rigging is engaged to the lift yoke to provide single failure protection against drops. A complete review of cask operations, including potential load drops has been performed. Evaluations and analyses of hypothetical drops required to be postulated have been performed. No unacceptable consequences of load drops are predicted.

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NUREG-0554 Section 4.1 (Item 7)	The pitch diameter of running sheaves and drums should be selected in accordance with the recommendations of CMAA Specification #70. The dual reeving system may be a single rope from each end of a drum terminating at one of the blocks or equalizer with provisions for equalizing beam-type load and rope stretch, with each rope designed for the total load. Alternatively, a 2-rope system may be used from each drum or separate drums using a sheave equalizer or beam equalizer or any other combination that provides two separate and complete reeving systems.	The pitch diameter of the FBCHC running sheaves is in accordance with CMAA 70-1971. The hoist reeving is a conventional double reeved system, utilizing one piece of wire rope. The crane does not have a dual load path rope reeving system.	For most horizontal load movements, redundant rigging is engaged to the lift yoke to provide single failure protection against drops. A complete review of cask operations, including potential load drops has been performed. Evaluations and analyses of hypothetical drops required to be postulated have been performed. No unacceptable consequences of load drops are predicted.
NUREG-0554 Section 4.2	The load hoisting drum on the trolley should be provided with structural and mechanical safety devices to limit the drop of the drum and thereby prevent it from disengaging from its holding brake system if the drum shaft or bearings were to fail or fracture.	In the event of a failure of either the main hoist drum shaft or drum bearing at the drive end of the drum, no mechanical or structural means are provided to prevent disengagement of the main hoist drum from the hoist's two holding brakes.	For most horizontal load movements, redundant rigging is engaged to the lift yoke to provide single failure protection against drops. A complete review of cask operations, including potential load drops has been performed. Evaluations and analyses of hypothetical drops required to be postulated have been performed. No unacceptable consequences of load drops are predicted.

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NUREG-0554 Section 4.3 (Item 1)	The head and load blocks should be designed to maintain a vertical load balance about the center of lift from load block through head block and have a reeving system of dual design.	The FBCHC is designed to maintain the vertical load balance about the center of lift from the load block through the head block, but does not have a dual (redundant) reeving system design.	For most horizontal load movements, redundant rigging is engaged to the lift yoke to provide single failure protection against drops. A complete review of cask operations, including potential load drops has been performed. Evaluations and analyses of hypothetical drops required to be postulated have been performed. No unacceptable consequences of load drops are predicted.
NUREG-0554 Section 4.3 (Item 2)	The load-bock assembly should be provided with two load-attaching points (hooks or other means) so designed that each attaching point will be able to support a load of three times the load (static and dynamic) being handled without permanent deformation of any part of the load-block assembly other than localized strain concentration in areas for which additional material has been provided for wear.	The FBCHC design does not have redundant load-attaching points. The main hook is of the sister-hook type and has a design factor of safety to ultimate of 5.0. For most horizontal load movements, redundant rigging is engaged to the lift yoke to provide single failure protection against drops (See Section 4.7.2 of Attachment 1 to LAR 2004-26).	NUREG-0612, Appendix C, page C-3, item (5) for operating plants allows for a sister hook in lieu of two attachments points to meet the intent of this guidance.

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NUREG-0554 Section 4.3 (Item 3)	The individual component parts of the vertical hoisting system components, which include the head block, rope reeving system, load block, and dual load-attaching device, should each be designed to support a static load of 200% of the MCL. A 200% static-type load test should be performed for each load-attaching hook. Measurements of the geometric configuration of the hooks should made before and after the test and should be followed by a nondestructive examination that should consist of volumetric and surface examinations to verify the soundness of fabrication an ensure the integrity of the hooks. The load blocks should be nondestructively examined by surface and volumetric techniques. The results of examinations should be documented and recorded.	The FBCHC structural components were designed for 100% static rated load (maximum critical load) and analyzed for a 1.15 dynamic load factor. The crane main hook was factory tested at 1.25 times its rated load. Hoisting ropes and load-carrying parts other than structural members have a design safety factor of five. Structural members are designed with stress allowables in accordance with CMAA 70-1971. The main hook was MT-examined before and after load testing. The main hook forging billet was UT-examined to verify the soundness of the raw material used to fabricate the main hook. Examination results are documented.	The following tests and inspections were not required by the FBCHC procurement specification (1975): • 200% MCL static load test for the hook(s) • Measurements of the geometric configuration of the hook(s) before and after load testing • Volumetric inspection of the hook before and after load testing • NDE of the load block(s)
NUREG-0554 Section 4.4	Maximum hoisting speed for the critical load should be limited to that given in the "slow" column of Figure 70-6 of CMAA Specification #70.	The maximum FBCHC normal hoisting speed for the MCL is 6 fpm and "inching speed" is 0.5 fpm. CMAA 70-1971, Table 70-6 specifies 5 fpm slow speed for this capacity crane.	The calculated maximum main hoist design "rated load" speed is 5.88 fpm, which exceeds the 5 fpm speed recommended in CMAA 70-1971 for the maximum critical load. The 5.88 fpm maximum hoist speed yields a maximum rope line speed at the drum of 35 fpm, which is less than the suggested line speed limit of 50 fpm.

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NUREG-0554 Section 4.5 (Item1)	The reeving system should be designed to prevent the cutting or crushing of the wire rope if a "two-blocking" incident should occur.	No specific provisions for addressing the consequences of two-blocking are included in the FBCHC design. Each hoist includes limit switches to stop the hook at its highest and lowest safe positions. Two differently designed limit switches, used in series, provide redundancy and diversity to limit the upward travel of each hoist hook.	
NUREG-0554 Section 4.5 (Item 2)	The mechanical and structural components of the complete hoisting system should have the required strength to resist failure if the hoisting system should "two-block" or if "load hang-up" should occur during hoisting.	The FBCHC design includes load limiting devices that stop hoisting operations upon indication of an overload condition. No specific provisions for addressing the consequences of two-blocking are included in the FBCHC design. Each hoist includes limit switches to stop the hook at its highest and lowest safe positions. Two differently designed limit switches, used in series, provide redundancy and diversity to limit the upward travel of each hoist hook.	NUREG-0612, Appendix C, page C-3, item (7) suggests interlocking circuitry to preclude bridge and trolley movement while hoisting the load in lieu of load hang-up protection. The FBCHC does not have this interlocking circuitry. Cask loading procedures will prohibit simultaneous FBCHC trolley and hoisting movement.

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NUREG-0554 Section 4.5 (Item 3)	The designer should provide means within the reeving system located on the head or on the load-block combinations to absorb or control the kinetic energy of rotating machinery during the incident of two-blocking. As an alternative, the protective control system to prevent the hoisting system from two-blocking should include, as a minimum, two independent travel-limit devices of different designs and activated by separate mechanical means. These devices should de-energize the hoist drive motor and the main power supply. The protective control system for load hang-up, a part of the overload protection system, should consist of load cell systems in the drive train or motor-current-sensing devices or mechanical load-limiting devices.	Each hoist includes limit switches to stop the hook at its highest and lowest safe positions. Two differently designed limit switches, used in series, provide redundancy and diversity in limiting the upward travel of each hoist hook. A block-type limit switch is used on the cable and a screw-type is used on the drum. They are adjusted such that if one limit switch fails the other shuts off power to the motor and sets the brakes. The actuating mechanisms of the limit switches are located so that they trip the limit switches under all conditions of hoist load and hoist speed in sufficient time to prevent contact of the load block with the drum, upper sheaves, or any part of the trolley. Each hoist includes an overload cutoff that senses the load on the hoist and stops the hoisting motion in an overload condition.	

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NUREG-0554 Section 4.5 (Item 4)	The location of mechanical holding brakes and their controls should provide positive, reliable, and capable means to stop and hold the hoisting drum(s) for the conditions described in the design specification and in this recommendation. This should include capability to withstand the maximum torque of the driving motor if a malfunction occurs and power to the driving motor cannot be shut off.	The load control for the main hoist is provided by an eddy current control brake for hoisting and lowering motions. Accompanying the control brake are two independent shoe-type holding brakes that are automatically applied to the hoist motor shaft when the motor is de-energized. Both of the holding brakes have a minimum rated braking torque of 150% of the motor full load torque.	Although the two main hoist holding brakes are each capable of resisting the maximum hoist motor torque, they cannot be "manually applied" in the event an electrical control malfunction occurs and power to the hoist motor cannot be shut off. In this event, the hoist brakes may be indirectly set by either pressing the crane "power stop" button or by pulling the handle on the main line disconnect switch (mounted in the operator's cab) to the "open/off" position.
NUREG-0554 Section 4.5 (Item 5)	The auxiliary hoist, if supplied, should be equipped with two independent travel-limit switches to prevent two-blocking.	The FBCHC auxiliary hoist is not used in cask handling operations.	
NUREG-0554 Section 4.6	Lifting devices that are attached to the load block such as lifting beams, yokes, ladle or trunnion-type hooks, slings, toggles, and clevises should be conservatively designed with a dual or auxiliary device or combinations thereof. Each device should be designed or selected to support a load of three times the load (static or dynamic) being handled without permanent deformation.	See evaluation for NUREG-0612, Sections 5.1.1(4), 5.1.1(5), 5.1.6(1)(a), and 5.1.6(1)(b).	
NUREG-0554 Section 4.7	If side loads cannot be avoided, the reeving system should be equipped with a guard that would keep the wire rope properly located in the grooves on the drum.	Side loading of the FBCHC is not required or expected during cask handling activities. All lifts are purely vertical.	

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NUREG-0554 Section 4.8 (Item 1)	The proper functioning of the hoisting machinery during load handling can best be ensured by providing adequate support strength of the individual component parts and the welds or bolting that binds them together.	The FBCHC structural members are designed so that the stress in the material does not exceed CMAA 70-1971 limits when lifting the rated load. FBCHC load-carrying parts other than structural members are designed with a safety factor of five against ultimate strength when lifting the rated load.	
NUREG-0554 Section 4.8 (Item 2)	Where gear trains are interposed between the holding brakes and the hoisting drum, these gear trains should be single failure proof and should be of dual design.	The FBCHC is not of the single-failure-proof design. For most horizontal load movements, redundant rigging is engaged to the lift yoke to provide single failure protection against drops (See Section 4.7.2 of Attachment 1 to LAR 2004-26).	A complete review of cask operations, including potential load drops has been performed. Evaluations and analyses of hypothetical drops required to be postulated have been performed. No unacceptable consequences of load drops are predicted.
NUREG-0554 Section 4.9 (Item 1)	Each holding brake should have more than full-load stopping capacity but should not have excessive capacity that could cause damage through sudden stopping of the hoisting machinery. A minimum brake capacity of 125% of the torque developed during the hoisting operation at the point of brake application has been determined to be acceptable.	The FBCHC main and auxiliary hoist holding brakes have a minimum rated braking torque of 150% of the hoist motor full load torque.	

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NUREG-0554 Section 4.9 (Item 2)	The minimum hoisting braking system should include one power control braking system (not mechanical or drag brake type) and two holding brakes. The holding brakes should be applied when power is off and should be automatically applied on overspeed to the full holding position if a malfunction occurs. Each holding brake should have a torque rating not less than 125% of the full-load hoisting torque at point of application (location of the brake in the mechanical drive).	The FBCHC main hoist includes an eddy current control brake and two independent shoe-type holding brakes. The holding brakes are automatically applied to the hoist motor shaft when the motor is de-energized. The holding brakes have a minimum rated braking torque of 150% of the hoist motor full load torque. The holding brakes are designed to retard the load if uncontrolled lowering is sensed.	Normal main hoist motor shaft speed is 1800 RPM. The main hoist lowering control is protected by a centrifugal-type overspeed switch, which is set to open (i.e., cut power to) the lowering circuit, setting the two hoist holding brakes, at an approximate motor shaft speed of 1950 RPM.
NUREG-0554 Section 4.9 (Item 3)	The minimum number of braking systems that should be operable for emergency lowering after a single brake failure should be two holding brakes for stopping and controlling drum rotation.	The FBCHC main hoist includes a control brake and two independent holding brakes, leaving two brakes available in the event of a single brake failure.	
NUREG-0554 Section 4.9 (Item 4)	The holding brake system should be single failure proof, i.e., any component or gear train should be dual if interposed between the holding brakes and the hoisting drums.	One of the two FBCHC main hoist holding brakes is located outboard of the gear case on an extended pinion shaft. There is no coupling between this outboard brake and the gear case.	

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NUREG-0554 Section 4.9 (Item 5)	Manual operation of the hoisting brakes may be necessary during an emergency condition, and provisions for this should be included in the design conditions. Adequate heat dissipation from the brake should be ensured so that damage does not occur if the lowering velocity is permitted to increase excessively. It may be necessary to stop the lowering operation periodically to prevent overheating and permit the brake to dissipate the excess heat. Portable instruments should be used to indicate the lowering speed during emergency operations. If a malfunction of a holding brake were to occur and emergency lowering of the load became necessary, the holding brake should be restored to working condition before any lowering is started.	The main hoist is equipped with an alternator-excited eddy current lowering control brake system, which is capable of maintaining a controlled lowering speed of the hoist's 125-ton rated load in the event of a loss of all AC power or electrical failure of the hoist's motor controller. Emergency (eddy current brake) lowering of the main hoist requires that the two hoist holding brakes, which are spring-set on a loss of power, be manually released.	
NUREG-0554 Section 5.1 (Item 1)	Bridge and trolley drives [should be] provided with control and holding brake systems that would be automatically applied when the power is shut off or if an overspeed or overload condition occurs because of malfunction or failure in the drive system.	The FBCH main trolley includes a hydraulically operated brake, mounted on the main trolley motor extension shaft, to control movement and an electric parking brake that is only engaged when the magnetic main power line disconnect is open (de-energizing the motor).	The auxiliary bridge is not provided with a separate drive. The auxiliary bridge is fixed to the main trolley and movement is controlled by the main trolley drive.

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NUREG-0554 Section 5.1 (Item 2)	To avoid the possibility of drive motor overtorque within the control system, the maximum torque capability of the driving motor and gear reducer for trolley motion and bridge motion of the overhead bridge crane should not exceed the capability of gear train and brakes to stop the trolley or bridge from the maximum speed with the DRL attached.	The FBCHC The main trolley hydraulic control brake has a minimum braking torque of 100% of the main trolley motor full load motor torque. The electric parking brake has a minimum braking torque of 75% of the main trolley motor full load motor torque.	
NUREG-0554 Section 5.1 (Item 3)	[Bridge and trolley] incremental or fractional inch movements, when required, should be provided by such items as variable speed controls or inching motor drives.	Controls for the FBCHC main trolley are full magnetic reversible with five steps of variable speed. The main trolley also includes an inching motor with a maximum speed of 0.5 fpm.	
NUREG-0554 Section 5.1 (Item 4)	[Bridge & trolley] control and holding brakes should each be rated at 100% of maximum drive torque that can be developed at the point of application.	The FBCHC The main trolley hydraulic control brake has a minimum braking torque of 100% of the main trolley motor full load motor torque. The electric parking brake has a minimum braking torque of 75% of the main trolley motor full load motor torque.	
NURE4G-0554 Section 5.1 (Item 5)	If two mechanical brakes, one for control and one for holding, are provided, they should be adjusted with one brake in each system leading the other and should be activated by release or shutoff of power. This applies to both trolley and bridge.	The FBCHC main trolley hydraulic control brake is actuated by a foot lever located in the cab. The electric parking brake only engages when the magnetic main [power] line disconnect is in the open position.	

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NUREG-0554 Section 5.1 (Item 6)	The [bridge and trolley] brakes should also be mechanically tripped to the "on" or "holding" position in the event of a malfunction in the power supply or an overspeed condition.	The FBCHC trolley brakes have no such feature.	
NUREG-0554 Section 5.1 (Item 7)	Provisions should be made for manual emergency operation of the [bridge and trolley] brakes.	The FBCHC operating cab includes a "reset-stop" control panel that opens the main [power] line magnetic contactor, cutting all power to the trolley and hoist. The electric trolley parking can then be engaged.	
NUREG-0554 Section 5.1 (Item 8)	The [bridge and trolley] holding brake should be designed so that it cannot be used as a foot-operated slowdown brake.	The FBCHC main trolley drive is equipped with a foot-operated, hydraulic shoe-type brake for normal service braking. The shoe-type parking (holding) brake is non-foot-operated and automatically engages in the "power-off" condition.	
NUREG-0554 Section 5.1 (Item 9)	[Bridge and trolley] drag brakes should not be used.	The FBCHC has no drag brakes. A hydraulic brake is used for trolley control. The hydraulic foot-operated brake is not self-adjusting and receives periodic inspection and adjustment in accordance with he manufacturer's recommendations.	

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NUREG-0554 Section 5.1 (Item 10)	Opposite-driven wheels on bridge or trolley that support bridge or trolley on their runways should be matched and should have identical diameters.	The term "opposite driven wheels" refers to the rotation of the drive wheel at each end of a crane bridge or trolley when facing the end of each axle. When originally manufactured, the FBCHC main trolley drive's mechanically shaft connected, "opposite-driven wheels" were matched for diameter in accordance with the manufacturer's specified tolerance limits.	The FBCHC main hoist does not have a bridge.
NUREG-0554 Section 5.1 (Item 11)	Trolley and bridge speed should be limited. The speed limits indicated for slow operating speeds for trolley and bridge in specification CMAA-#70 are recommended for handling MCLs.	The FBCHC main trolley has an inching speed of 0.5 fpm and a maximum normal speed of 50 fpm, which is classified as "slow" in CMAA-70-1971, Table 70-6.	The FBCHC Main Trolley functions as a bridge as used in CMAA-70-1971, Table 70-6.
NUREG-0554 Section 5.2 (Item 1)	Limiting devices, mechanical and/or electrical, should be provided to control or prevent overtravel and overspeed of the trolley and bridge.	The FBCHC bridge and trolley drive motors and electrical controls are not equipped with either overspeed or overtravel protective devices. Overtravel is stopped by contact of the bridge and trolley-mounted bumpers with bridge and runway-mounted end travel stops. The FBCHC is precluded by design from travel outside of the safe load path designated for cask handling operations.	

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NUREG-0554 Section 5.2 (Item 2)	Buffers for bridge and trolley travel should be included at the end of the rails.	The FBCHC trolley is provided with bumpers having sufficient energy absorbing capability to stop the bridge and trolleys when either is traveling at a speed of 40% of rated load speed.	
NUREG-0554 Section 5.2 (Item 3)	Safety devices such as limit-type switches provided for malfunction, inadvertent operator action, or failure should be in addition to and separate from the limiting means or control devices provided for operation.	The FBCHC trolley does not have such limit-type devices. Bumpers are provided at the ends of the rails. The FBCHC is precluded by design from travel outside of the safe load path designated for cask handling operations.	
NUREG-0554 Section 6.1 (Item 1)	The horsepower rating of the hoist driving motor should be matched with the calculated requirement that includes the design load and acceleration to the design hoisting speed. Overpowering of the hoisting equipment would impose additional strain on the machinery and load-carrying devices by increasing the hoisting acceleration rate.	The calculated required 125-ton main hoist horsepower is 55.5, based upon an actual hoist speed of 5.9 fpm. This is 7-1/2% less than the rated motor horsepower of 60 hp. This surplus motor horsepower is within acceptable design limits.	

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NUREG-0554 Section 6.1 (Item 2)	To preclude excessive drive-motor torque, the maximum torque capability of the electric motor drive for hoisting should not exceed the rating or capability of the individual components of the hoisting system required to hoist the MCL at the maximum design hoist speed. Overpower and overspeed conditions should be considered an operating hazard, as they may increase the hazard of malfunction or inadvertent operation. It is essential that the controls be capable of stopping the hoisting movement within amounts of movement that damage would not occur. A maximum hoisting movement of 8 cm (3 in) would be an acceptable stopping distance.	The two main hoist upper limit switches will interrupt the hoisting motion and set the two holding brakes, each of which is capable of stopping the upward movement of the load block the recommended 3 inches, preventing a two-block event.	

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NUREG-0554 Section 6.1 (Item 3)	Electric circuitry design should be carefully considered so that the controls and safety devices ensure safe holding of the critical load when called upon to perform their safety function. For elaborate control systems, radio control, or ultimate control under unforeseen conditions of distress, an "emergency stop button" should be placed at ground level to remove power from the crane independently of the crane controls. For cranes with a DRL rating much higher than the MCL rating, it may be necessary to provide electrical or mechanical resetting of overload sensing devices when changing from one operation to the other. Such resetting should be made away from the operator cab location and should be included in an administrative control program.	The FBCHC design includes a radio remote controller. A transfer switch and interlocking circuitry permits control from only the bridge-mounted control panel or the remote controller at any one time. The radio remote control system has the same operational features for bridge, trolley, and hoist operation as the bridge-mounted control panel, including an emergency stop button.	For the FBCHC, the DRL and MCL are the same.

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NUREG-0554 Section 6.2	The (driver) control systems should be designed as a combination of electrical and mechanical systems and may include such items as contactors, relays, resistors, and thyristors in combination with mechanical devices and mechanical braking systems. The control system(s) provided should include consideration of the hoisting (raising and lowering) of all loads, included the rated load, and the effects of the inertia of the rotating hoisting machinery such as motor armature, shafting and coupling gear reducer, and drum. If the crane is to be used for lifting spent fuel elements, the control system should be adaptable to include interlocks that would prevent trolley and bridge movements while the load is being hoisted free of a storage rack, as may be recommended in Regulatory Guide 1.13, "Spent Fuel Storage Facility Design Basis".	The main hoist controls are designed as a combination of electrical and mechanical systems as described, in accordance with the design standards in place at the time. The mechanical and electrical systems associated with the hoist(s) have been designed with due consideration of the effects of all applicable and significant loads, forces, and moments. The FBCHC is physically unable to access individual spent fuel assemblies in the spent fuel racks.	

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NUREG-0554 Section 6.3	Means should be provided in the motor control circuits to sense and respond to such items as excessive electric current, excessive motor temperature, overspeed, overload, and overtravel. Controls should be provided to absorb the kinetic energy of the rotating machinery and stop the hoisting movement reliably and safely through a combination of electrical power controls and mechanical braking systems and torque controls if one rope or one of the dual reeving systems should fail or if overloading of an overspeed condition should occur.	All motors meet applicable NEMA MG1 standards. The FBCHC main hoist motors are provided with thermal detectors embedded in the stator windings that trip the motors in the event they overheat. The main hoist motor controls also include the following protective devices: current overload protection, undervoltage protection, phase loss protection, overspeed protection, hoist overtravel protection, hoist overload protection, and hoist slack line protection.	
NUREG-0554 Section 6.4	Increment drives for hoisting may be provided by step-less controls or inching motor drive. If jogging or plugging is to be used, the control circuit should include features to prevent abrupt change in motion. Drift point in the electric power system, when provided for bridge or trolley movement, should be provided only for the lowest operating speeds.	The main hoist and trolley are provided with inching motors that travel at 0.5 fpm. Jogging or plugging is not required for cask handling activities.	
NUREG-0554 Section 6.5	Safety devices such as limit-type switches provided for malfunction, inadvertent operator action, or failure should be in addition to and separate from the limiting means or control devices provided for operation.	The FBCHC is provided with limit switches and load-limiting devices. These devices are separate from normal operating controls.	

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NUREG-0554 Section 6.6 (Item 1)	The complete operating control system and provisions for emergency controls for the overhead crane handling system should preferably be located in a cab on the bridge.	The operating control system, including the "stop-reset" panel is located in the operator's cab, located between the main hoist and the auxiliary hoist at the end of the auxiliary bridge facing the centerline of the main trolley.	
NUREG-0554 Section 6.6 (Item 2)	When additional operator stations are considered, they should have control systems similar to the main station.	The radio remote control device emulates all operations of the bridge-mounted control panel. During remote operation, the function of foot operated braking is achieved automatically following bridge motor de-energization.	
NUREG-0554 Section 6.6 (Item 3)	Manual controls for hoisting and trolley movement may be provided on the trolley. Manual controls for the bridge may be located on the bridge. Remote control or pendent control for any of these motions should be identical to those provide on the bridge cab control panel.	The radio remote control device emulates all operations of the bridge-mounted control panel.	
NUREG-0554 Section 6.6 (Item 4)	Cranes that use more than one control station should be provided with electrical interlocks that permit only one control station to be operable at any one time.	The radio remote control station includes a transfer switch and interlocking circuitry to restrict crane control to either the bridge-mounted control station or the remote control station at any time.	

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NUREG-0554 Section 6.6 (Item 5)	In the design of the control system, provision for and locations of devices for control during emergency conditions should be provided.	The bridge-mounted and radio remote control stations include an emergency stop button.	
NUREG-0554 Section 7.1	Installation instructions should be provided by the manufacturer. These should include a full explanation of the crane handling system, its controls, and the limitations for the system and should cover the requirements for installation, testing, and preparations for operation.	The crane operating and maintenance manual was provided by the manufacturer to Entergy and have been translated into plant operating procedures.	
NUREG-0554 Section 7.2	During and after installation of the crane, the proper assembly of electrical and structural components should be verified. The integrity of all control, operating, and safety systems should be verified as to satisfaction of installation and design requirements.	FBCHC functional testing including no-load and full load tests of all motions.	
NUREG-0554 Section 8.1 (Item 1)	A complete check should be made of all the crane's mechanical and electrical systems to verify the proper installation and to prepare the crane for testing.	A complete mechanical and electrical check of the crane was made to prepare the crane for testing.	
NUREG-0554 Section 8.1 (Item 2)	Information concerning proof testing on components and subsystems that was required and performed at the manufacturer's plant to verify the ability of components or subsystems to perform should be available for the checking and testing performed at the place of installation of the crane system.	Documentation of all required factory and field tests was required as part of the procurement documents.	

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NUREG-0554 Section 8.2 (Item 1)	The crane system should be static load tested at 125% of the MCL. The tests should include all positions generating maximum strain in the bridge and trolley structures and other positions as recommended by the designer and manufacturer.	The FBCHC was load-tested both indoors (as part of initial acceptance) and outdoors (as part of post-modification testing of the outdoor crane structure) at 1.25 times the rated load.	
NUREG-0554 Section 8.2 (Item 2)	After satisfactory completion of the 125% static test and adjustments required as a result of the test, the crane handling system should be given full performance tests with 100% of the MCL for all speeds and motions for which the system is designed. This should include verifying all limiting and safety control devices. The features provided for manual lowering of the load and manual movement of the bridge and trolley during an emergency should be tested with the MCL attached to demonstrate the ability to function as intended.	The FBCHC was given a loaded running test of all motions at 1.25 times its rated capacity.	

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NUREG-0554 Section 8.3 (Item 1)	When equipped with an energy-controlling device between the load and head blocks, the complete hoisting machinery should be allowed to two-block during the hoisting test (load block limit and safety devices are bypassed). This test, conducted at slow speed without load, should provide assurance of the integrity of the design, the equipment, the controls, and the overload protection devices. The test should demonstrate that the maximum torque that can be developed by the driving system, including the inertia of the rotating parts at the overtorque condition, will be absorbed or controlled during two-blocking or load hang-up.	A two-blocking test was not performed on the FBCHC.	Per NUREG-0612, Appendix C, Page C-3, item (8), the FBCHC main hoist includes two travel limit switches, each of independent design, used in series, and a load limiting device.
NUREG-0554 Section 8.3 (Item 2)	The complete hoisting machinery should be tested for the ability to sustain a load hang-up condition by a test in which the load-block-attaching points are secured to a fixed anchor or an excessive load. The crane manufacturer may suggest additional or substitute test procedures that will ensure the proper functioning of protective overload devices.	A load hang-up test was not performed on the FBCHC. Each hoist is provided with an overload cutoff that senses an overload on the hoist and stops the hoisting motion, but allows safe lowering of the load to the floor. The load limiting device is adjustable up to 130% of rated load.	The FBCHC does not have the interlock circuitry suggested by NUREG-0612, Appendix C, page C-4, item (9), Cask loading procedures will prohibit simultaneous FBCHC trolley and hoisting movement.

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NUREG-0554 Section 8.4	Operational tests of crane systems should be performed to verify the proper functioning of limit switches and other safety devices and the ability to perform as designed. However, special arrangements may have to be made to test overload and overspeed sensing devices.	A functional test of the FBCHC was performed to verify its complete range of travel and functionality with and without a load on the main and auxiliary hooks.	
NUREG-0554 Section 8.5	Essentially, the MCL rating of the crane should be established as the rated load capacity, and the design rating for the degradable portion of the handling system should be identified to obtain the margin available for the maintenance program. The MCL should be plainly marked on each side of the crane for each hoisting unit. It is recommended that the critical-load-handling cranes should be continuously maintained above MCL capacity.	The rated load for each hoist is clearly marked on the crane. The maximum critical load is the design rated load (125 tons). The crane receives periodic preventive maintenance and inspection to address degradation issues.	

NUREG-0612 AND NUREG-0554 COMPARISON MATRIX FOR THE RBS FUEL BUILDING CASK HANDLING CRANE

Document and Section	Guidance	Evaluation	Notes
NUREG-0554 Section 9 (Item 1)	The crane designer and crane manufacturer should provide a manual of information and procedures for use in checking, testing, and operating the crane. The manual should also describe a preventive maintenance program based on the approved test results and information obtained during the testing. It should include such items as servicing, repair replacement requirements, visual examinations, inspections, checking, measurements, problem diagnosis, nondestructive examination, crane performance testing, and special instructions.	An O&M manual was provided with the FBCHC. The recommendations in this manual have been included in the site operating and maintenance procedures for the crane.	
NUREG-0554 Section 9 (Item 2)	The operating requirements for all travel movements (vertical and horizontal movements or rotation, singly or in combination) incorporated in the design for permanent plant cranes should be clearly defined in the operating manual for hoisting and for trolley and bridge travel. The designer should establish the MCL rating and the margin for degradation of wear-susceptible component parts.	An O&M manual was provided with the FBCHC. The recommendations in this manual have been included in the site operating and maintenance procedures for the crane.	

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Document and Section	Guidance	Evaluation	Notes
NUREG-0554 Section 10 (Item 1)	A quality assurance program should be established to the extent necessary to include the recommendations of this report for the design, fabrication, installation, testing, and operation of crane handling systems for safe handling of critical loads.	While it is a non-safety-related component, The FBCHC will be designated as "Quality Assurance Program Applicable" in the RBS quality assurance program. All modifications, maintenance, testing, and inspections will be performed as safety-related activities.	
NUREG-0554 Section 10 (Item 2)	In addition to the quality assurance program established for site assembly, installation, and testing of the crane, applicable procurement documents should require the crane manufacturer to provide a quality assurance program consistent with the pertinent provisions of Regulatory Guide 1.28, "Quality Assurance Program Requirements (Design and Construction)," to the extent necessary.	The FBCHC was a commercial-grade purchase made in the late-1970s. While 10 CFR 50 Appendix B requirements and R.G. 1.28 QA guidance did not apply, the procurement specification required the supplier to have an inspection, testing, and documentation program to ensure the crane met the requirements of the specification. In addition, certain key fabrication steps were witnessed or verified by the architect/engineer for RBS.	
NUREG-0554 Section 10 (Item 3)	The (quality assurance) program should address all the recommendations in this NUREG. Also included should be qualification requirements for crane operators.	NUREG-0554 did not exist at the time the FBCHC was designed and fabricated. Crane operator qualifications are part of the RBS training program.	