UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D.C. 20555-0001

February 28, 2022

Ms. Jean A. Fleming
Vice President, Regulatory and
Environmental Affairs
Holtec Decommissioning International, LLC
Krishna P. Singh Technology Campus
1 Holtec Blvd.
Camden NJ 08104

SUBJECT: INDIAN POINT NUCLEAR GENERATING UNIT NO. 3 − ISSUANCE OF AMENDMENT NO. 272 RE: REVISION TO LICENSING BASIS TO INCORPORATE THE INSTALLATION AND USE OF A NEW AUXILIARY LIFTING DEVICE (EPID L-2020-LLA-0051)

Dear Ms. Fleming:

The U.S. Nuclear Regulatory Commission (NRC, the Commission) has issued the enclosed Amendment No. 272 to Renewed Facility License No. DPR-64 for the Indian Point Nuclear Generating Unit No. 3 (Indian Point 3). The amendment is in response to the application from Entergy Nuclear Operations, Inc., the licensee at the time, dated March 24, 2020, as supplemented by letters dated October 2, 2020, November 9, 2020, February 26, 2021, May 20, 2021, and January 3, 2022. On May 28, 2021, Holtec Decommissioning International, LLC (HDI) became the licensee for Indian Point 3.

The amendment consists of changes to the current licensing basis in the Updated Final Safety Analysis Report regarding the installation and use of a new single-failure-proof auxiliary lifting device in the Indian Point 3 Fuel Storage Building.

The NRC has determined that the related safety evaluation (SE) contains proprietary information pursuant to Title 10 of the *Code of Federal Regulations,* Section 2.390, "Public inspections, exemptions, requests for withholding." The proprietary information is indicated by text enclosed within double brackets. Accordingly, the NRC staff has also prepared a non-proprietary publicly available version of the SE, which is provided as Enclosure 2. The proprietary version of the SE is provided as Enclosure 3.

A Notice of Issuance will be included in the Commission's monthly *Federal Register* notice.

Enclosure 3 to this letter contains proprietary information. When separated from Enclosure 3, this letter is DECONTROLLED.

If you have any questions, please contact me at (301) 415-1030 or by e-mail at Richard.Guzman@nrc.gov.

Sincerely,

/RA/

Richard V. Guzman, Senior Project Manager
Plant Licensing Branch I
Division of Operating Reactor Licensing
Office of Nuclear Reactor Regulation

Docket No. 50-286

Enclosures:
1. Amendment No. 272 to DPR-64
2. Safety Evaluation (non-proprietary)
3. Safety Evaluation (proprietary)

cc: w/Enclosures 1 and 2: Listserv

HOLTEC DECOMMISSIONING INTERNATIONAL, LLC AND

HOLTEC INDIAN POINT 3, LLC

DOCKET NO. 50-286

INDIAN POINT NUCLEAR GENERATING UNIT NO. 3

AMENDMENT TO RENEWED FACILITY LICENSE

Amendment No. 272
License No. DPR-64

1. The U.S. Nuclear Regulatory Commission (the Commission) has found that:

   A. The application for amendment by Entergy Nuclear Operations, Inc. (ENO, the licensee) dated March 24, 2020, as supplemented by letters dated October 2, 2020, November 9, 2020, February 26, 2021, May 20, 2021, and January 3, 2022, complies with the standards and requirements of the Atomic Energy Act of 1954, as amended (the Act), and the Commission's rules and regulations set forth in 10 CFR Chapter I;

   B. The facility will operate in conformity with the application, the provisions of the Act, and the rules and regulations of the Commission;

   C. There is reasonable assurance (i) that the activities authorized by this amendment can be conducted without endangering the health and safety of the public, and (ii) that such activities will be conducted in compliance with the Commission's regulations;

   D. The issuance of this amendment will not be inimical to the common defense and security or to the health and safety of the public; and

   E. The issuance of this amendment is in accordance with 10 CFR Part 51 of the Commission's regulations, and all applicable requirements have been satisfied.

2. Accordingly, by Amendment No. 272, Renewed Facility License No. DPR-64 is hereby amended to authorize revision to the Updated Final Safety Analysis Report (UFSAR), as set forth in the application dated March 24, 2020, as supplemented by letters dated October 2, 2020, November 9, 2020, February 26, 2021, May 20, 2021, and January 3, 2022. The licensee shall update the UFSAR to incorporate the changes as described in the application, supplements, and the NRC staff's safety evaluation attached to this amendment and shall submit the revised description authorized by this amendment in accordance with 10 CFR 50.71(e).

3. This license amendment is effective as of the date of its issuance and shall be implemented within 90 days of the date of issuance. The UFSAR changes shall be implemented in accordance with 10 CFR 50.71(e).

FOR THE NUCLEAR REGULATORY COMMISSION

James G. Danna

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Date: 2022.02.28 12:32:42 -05'00'

James G. Danna, Chief
Plant Licensing Branch I
Division of Operating Reactor Licensing
Office of Nuclear Reactor Regulation

Date of Issuance: February 28, 2022

ENCLOSURE 2

NON-PROPRIETARY SAFETY EVALUATION FOR

AMENDMENT NO. 272 TO RENEWED FACILITY LICENSE NO. DPR-64

HOLTEC DECOMMISSIONING INTERNATIONAL, LLC AND

HOLTEC INDIAN POINT 3, LLC

INDIAN POINT NUCLEAR GENERATING UNIT NO. 3

DOCKET NO. 50-286

Proprietary information pursuant to Section 2.390 of Title 10 of
the *Code of Federal Regulations* has been redacted from this document.

Redacted information is identified by blank space enclosed within [[double brackets]].

UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D.C. 20555-0001

SAFETY EVALUATION BY THE OFFICE OF NUCLEAR REACTOR REGULATION

RELATED TO AMENDMENT NO. 272

TO RENEWED FACILITY LICENSE NO. DPR-64

HOLTEC DECOMMISSIONING INTERNATIONAL, LLC

AND HOLTEC INDIAN POINT 3, LLC

INDIAN POINT NUCLEAR GENERATING UNIT NO. 3

DOCKET NO. 50-286

1.0 INTRODUCTION

By letter dated March 24, 2020 (Reference 1), as supplemented by letters dated October 2, 2020 (Reference 2), November 9, 2020 (Reference 3), February 26, 2021 (Reference 4), and May 20, 2021 (Reference 5), Entergy Nuclear Operations Inc. (the licensee at the time) submitted a license amendment request (LAR or the application) to revise the Updated Final Safety Analysis Report (UFSAR) for Indian Point Nuclear Generating Unit No. 3 (Indian Point 3 or IP3). The amendment would revise the current licensing basis in the UFSAR with regard to the design, installation and use of a new single-failure-proof auxiliary lifting device, termed HI-LIFT, in the Indian Point 3 Fuel Storage Building. On May 28, 2021, Holtec Decommissioning International, LLC (HDI) became the licensee for Indian Point 3. In its letter dated January 3, 2022 (Reference 6), HDI submitted an updated supplement that included a complete HI-LIFT failure modes and effects analysis, a revised design specification for the HI-LIFT, and a revised HI-LIFT structural analysis, all considered proprietary.

The supplemental letters dated October 2, 2020, November 9, 2020, February 26, 2021, May 20, 2021, and January 3, 2022, provided additional information that clarified the application, did not expand the scope of the application as originally noticed, and did not change the U.S. Nuclear Regulatory Commission (NRC or the Commission) staff's original proposed no significant hazards consideration determination as published in the *Federal Register* on May 5, 2020 (85 FR 26729).

2.0 REGULATORY EVALUATION

2.1 System Design and Operation

Section 9.5.2, "System Design and Operation," of the IP3 UFSAR (Reference 7) includes a description of the major structures associated with reactor refueling, including the cask handling system in the IP3 Fuel Storage Building (FSB). The spent fuel pit (SFP) located in the FSB is constructed of reinforced concrete with thick walls and is designed to be seismically robust. The

entire face of the spent fuel pit and transfer canal is lined with stainless steel plate to form a structure with a low probability of significant leakage or rupture. The cask handling area is in one corner of the SFP adjacent to a high, thick, reinforced concrete wall that separates the SFP from the cask washdown area. The truck bay (TB) used for cask transfer is located on the opposite side of the cask washdown area. The TB is adjacent to an internal fuel building wall parallel to and about 25 feet away from the thick IP3 SFP wall.

Section 9.12, "Control of Heavy Loads," of the IP3 UFSAR (Reference 7) includes a description of the existing FSB crane. In 2010, the licensee at the time, Entergy, upgraded a commercial 40-ton crane to a single-failure-proof crane with a 40-ton critical load rating. The crane incorporated electrical limit switches along the bridge and trolley rails to prevent inadvertent movement of the trolley over areas of the spent fuel storage pit that contain stored irradiated fuel.

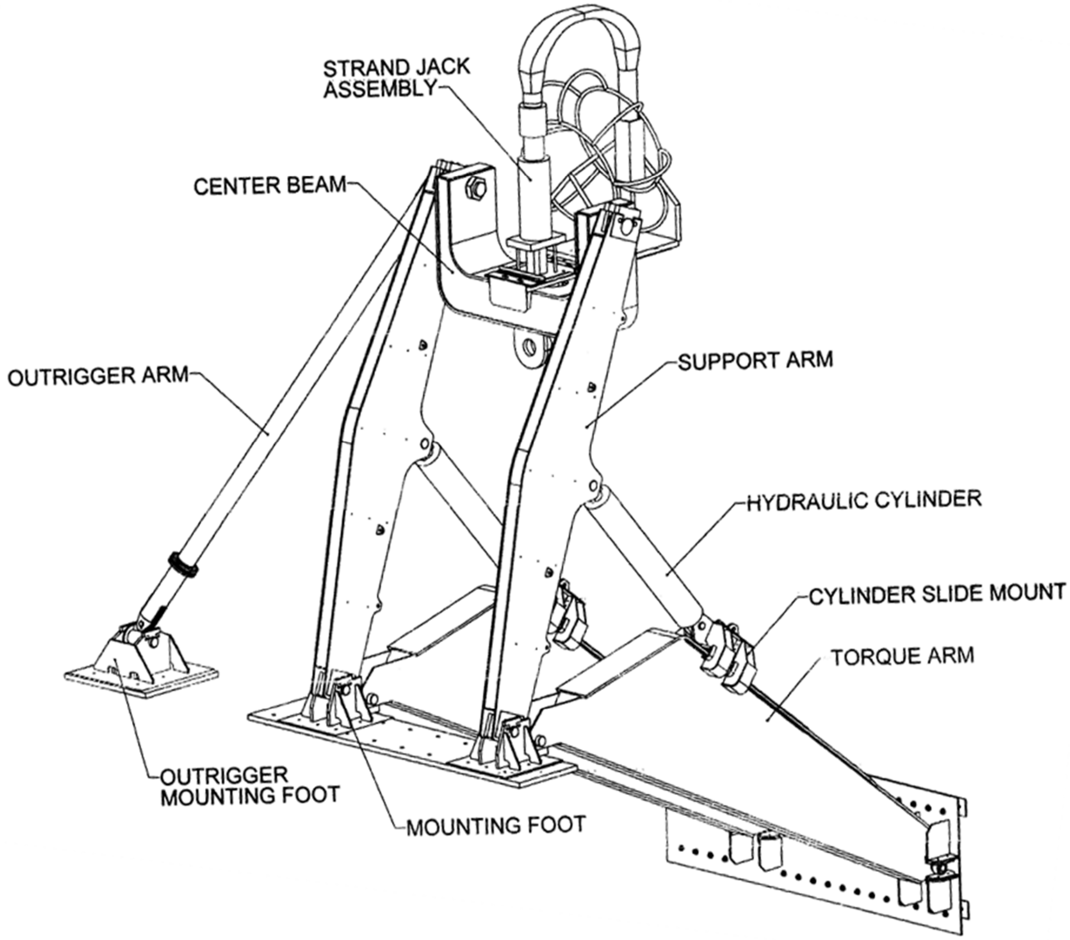
Entergy determined that the design of the fuel storage building would not support a rating adequate for handling of the intended dry cask storage (DCS) transfer cask without significant modifications. As described in IP3 UFSAR Section 9.5.2 (Reference 7), Entergy requested and received a license amendment permitting wet transfer of irradiated fuel from IP3 to the Indian Point Nuclear Generating, Unit No.2 (IP2), SFP for subsequent transfer into the DCS transfer cask. The wet transfer process uses a shielded transfer canister that, when loaded, is within the capacity of the 40-ton FSB crane at IP3.

Although Entergy upgraded the FSB crane to single-failure-proof such that a load drop within the crane's rated load need not be postulated, Entergy retained a discussion of a cask drop accident in Section 9.5.3 of the IP3 UFSAR (Reference 7) because the accident bounds other potential load drops in the cask handling area of the IP3 SFP. The results of this analysis indicated that the loaded 40-ton cask dropped from 5 feet above the water surface in the cask handling area of the IP3 SFP could puncture the 1-inch thick stainless steel wear plate and the SFP liner. However, the concrete below the liner is founded on solid rock and much of the bottom of the SFP is below grade, so the licensee concluded that water would be lost from the IP3 SFP at a rate below available makeup water supply rates.

2.2 Licensee's Proposed Changes

The licensee proposed incorporation of the installation and use of a new single-failure-proof auxiliary lifting device (i.e., the HI-LIFT) into the IP3 licensing basis. Installation of the HI-LIFT will eliminate the need to perform wet fuel transfer between IP3 and IP2 and does not require a change to the technical specifications. The wet transfer loading method, as currently approved for IP2 and IP3 in Appendix C to the IP2 and IP3 facility licenses, will remain available in the event it is needed in the future.

The proposed HI-LIFT would be credited as a single-failure-proof lifting device with a critical load rating of 100-tons. The lifting device would be a strand jack assembly pivoting on support arms mounted to the top of the south wall of the IP3 SFP and positioned by hydraulic cylinders acting against a torque arm. The following diagram provides an isometric view of the lifting device:



Licensee's Proposed UFSAR Changes

The licensee proposed an insert to the UFSAR that included, in part, the following information about the HI-LIFT design and operation:

> The HI-LIFT is a wall mounted, removable device that is rated for 100 tons. The HI-LIFT will only be used to lift the HI-TRAC / MPC-32 within the IP3 spent fuel building. The HI-LIFT is designed to meet the single-failure-proof criteria of NUREG-0554 ["Single-Failure-Proof Cranes for Nuclear Power Plants,". May 1979 (Reference 8)], and NUREG-0612 ["Control of Heavy Loads at Nuclear Power Plants," July 1980 (Reference 9)] through compliance with ASME [American Society of Mechanical Engineers] NOG-1, 2004 ["Rules for Construction for Overhead and Gantry Cranes (Top Running Bridge, Multiple Girder)" (Reference 10)]. Associated lifting devices and interfacing lift points also satisfy the guidance of NUREG-0612 in order to ensure the entire fuel handling lift system complies with the single-failure-proof guidance of NUREG-0612 for

each heavy load lift in or around the SFP, or in or around a cask loaded with spent fuel, or a lift of a cask loaded with spent fuel. All heavy lifts will use safe load paths in compliance with NUREG-0612, and operator training will also conform to the recommendations of the regulatory guidance.

The HI-LIFT provides the required hoisting capability through the use of a strand jack to lift and lower the load. The strand jack is a commercial component used worldwide in the construction industry with proven reliability. The HI-LIFT strand jack uses 48 strands to support the HI-TRAC and lift yoke. The strands are much thicker than cable and will not lead to a slack rope condition. A cable management system (i.e., a recoiler), maintains cable alignments as the load is raised and lowered. The strand jack uses two sets of wedge locks and a reciprocating hydraulic cylinder to lift and lower the load. While the load is raised, the lower wedge lock set holds the load in place until the load is taken by the upper wedge lock set. The reverse occurs during load lowering.

The strand jack is supported by a center beam that transfers the load outwards to two support arms, forming an inverted U-shaped frame. The U-frame is supported with a pinned connection to steel base frames (mounting feet) mounted to the top surface of the structural SFP wall. Pivoting the U-frame about the bottom pins provides a translation motion with a range sufficient enough to reach a canister processing location ("washdown area") adjacent to the truck bay, and a cask loading position in the SFP.

Translational motion is provided by the HI-LIFT frame and support arms. The HI-LIFT frame moves the strand jack unit horizontally by pivoting through a defined travel path via the bottom pins attached to the support arms. The travel path encompasses the truck bay washdown area and the cask loading area of the SFP. The length of the support arms limits the travel path of the HI-LIFT and prevents cask movement over spent fuel stored in the SFP racks.

2.3 Regulatory Standards

The regulations established by the NRC in Title 10, Part 50, of the *Code of Federal Regulations* (10 CFR Part 50), "Domestic Licensing of Production and Utilization Facilities," require, among other things, that structures, systems, and components (SSCs) that are important to safety in a nuclear power plant must be designed, operated, tested, and maintained to provide reasonable assurance that safety functions will be accomplished considering the effects of postulated accidents. To that end, the following regulations apply:

In determining whether the proposed amendment to a license should be granted pursuant to 10 CFR 50.92, the Commission will apply the "reasonable assurance" standards of 10 CFR 50.40(a) and 50.57(a)(3), which are among the considerations applied to issuance of initial operating licenses. The regulation at 10 CFR 50.40(a) states that in determining whether to grant the licensing request, the Commission will be guided by, among other things, consideration about whether "the processes to be performed, the operating procedures, the facility and equipment, the use of the facility, and other technical specifications, or the proposals, in regard to any of the foregoing collectively provide reasonable assurance that the applicant will comply with the regulations in this chapter, including the regulations in part 20 of this chapter, and that the health and safety of the public will not be endangered."

In accordance with 10 CFR 50.34(b)(2), the final safety analysis report shall include a description and analysis of, among other things, auxiliary and fuel handling SSCs to show that safety functions will be accomplished. The description shall be sufficient to permit understanding of the system designs and their relationship to safety evaluations.

In accordance with 10 CFR 50.34(b)(6)(iii), the final safety analysis report shall include a description of plans for conduct of pre-operational testing of SSCs.

In accordance with 10 CFR 50.34(b)(6)(iv), the final safety analysis report shall include a description of plans for conduct of normal operations, including maintenance, surveillance, and periodic testing of SSCs.

In accordance with 10 CFR 50.34(a)(3), the preliminary safety analysis report shall consist of, among other things, the preliminary design of the facility including, but not limited to the principal design criteria, the design bases, and the relation of the design bases to the principal design criteria. Appendix A, "General Design Criteria for Nuclear Power Plants," to 10 CFR Part 50 establishes minimum requirements for the principal design criteria for nuclear power plants. The general design criteria (GDC) in 10 CFR Part 50, Appendix A, applicable to this amendment include, in part, the following:

- GDC 1, "Quality standards and records," requires, in part, that structures, systems, and components (SSCs) important to safety be designed, fabricated, erected, and tested to quality standards commensurate with the importance of the safety functions to be performed. Where generally recognized codes and standards are used, they shall be identified and evaluated to determine their applicability, adequacy, and sufficiency and shall be supplemented or modified as necessary to assure a quality product in keeping with the required safety function. A quality assurance program shall be established and implemented in order to provide adequate assurance that these structures, systems, and components will satisfactorily perform their safety functions.

- GDC 2, "Design bases for protection against natural phenomena," requires that SSCs important to safety be designed to withstand the effects of natural phenomena such as earthquakes, tornadoes, hurricanes, floods, tsunami, and seiches without loss of capability to perform their safety functions, with appropriate consideration in the design basis of (1) the most severe natural phenomena historically reported for the site and surrounding area, with sufficient margin, (2) appropriate combinations of normal and accident conditions with the effects of the natural phenomena, and (3) the importance of the safety functions to be performed.

- GDC 4, "Environmental and dynamic effects design bases," requires, in part, that SSCs important to safety be designed to accommodate the effects of postulated accidents, and that they be appropriately protected against dynamic effects, including, but not limited to, the effects of missiles (e.g., falling heavy loads) that may result from equipment failures.

Section 9.1.5, "Overhead Heavy Load Handling Systems," of NUREG-0800, "NRC Standard Review Plan," (Reference 11) references the guidelines of NUREG-0612 (Reference 9), and NUREG-0554 (Reference 8) for implementation of these GDCs in the design of overhead heavy load handling systems. NUREG-0800 notes that compliance with ASME NOG-1-2004, "Rules

for Construction of Overhead and Gantry Cranes," (Reference 10) criteria for Type 1 cranes is an acceptable method for compliance with the NUREG-0554 guidelines.[1]

In NUREG-0612, "Control of Heavy Loads at Nuclear Power Plants" (Reference 9), the NRC staff provided regulatory guidelines for control of heavy loads to assure safe handling of heavy loads in areas where a load drop could impact stored spent fuel, fuel in the reactor core, or equipment that may be required to achieve safe or permit continued decay heat removal. In a letter dated December 22, 1980 (Reference 12), as supplemented by Generic Letter (GL) 81-07, "Control of Heavy Loads," dated February 3, 1981 (Reference 13), the NRC requested that all licensees describe the extent to which the guidelines of NUREG-0612 were satisfied at their facility and what additional modifications would be necessary to fully satisfy the guidelines. This request was divided into two phases (Phase I and Phase II) for implementation by licensees. Phase I guidelines address measures for reducing the likelihood of dropping heavy loads and provide criteria for establishing safe load paths; procedures for load handling operations; training of crane operators; design, testing, inspection, and maintenance of cranes and lifting devices; and analyses of the impact of heavy load drops. Phase II guidelines address alternatives to either further reduce the probability of a load handling accident or mitigate the consequences of heavy load drops to provide reasonable assurance that safety functions would be accomplished in the event of handling system failures. These alternatives include using a single-failure-proof crane for increased handling system reliability, employing electrical interlocks and mechanical stops for restricting crane travel to safe areas, or performing load drops and consequence analyses for assessing the impact of dropped loads on plant safety and operations. Criteria for design of single-failure-proof cranes were included in NUREG-0554. The guidelines of NUREG-0612 also specify that single-failure-proof handling systems include lifting devices providing either redundant full capacity load paths or a single load path with enhanced factors of safety. The guidance specified that special lifting devices be designed to the criteria of American National Standards Institute (ANSI) N14.6, "Special Lifting Devices for Shipping Containers Weighing 10,000 Pounds (4500 kg) or More (Reference 14)."

Appendix C, "Modification of Existing Cranes," to NUREG-0612 provides guidance for upgrading cranes at existing operating plants. This guidance specifies alternatives to NUREG-0554 criteria that continue to satisfy the intent of the criteria when space limitations or other factors preclude full conformance with NUREG-0554 criteria.

Section 9.12, "Control of Heavy Loads," of the IP3 UFSAR (Reference 7) describes the program elements for safe handling of heavy loads. This section states that, in addition to the Phase I guidelines of Section 5.1.1 of NUREG-0612, two basic approaches apply to control of heavy loads: demonstration of adequate handling system reliability or demonstration of acceptable

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[1] The NRC staff has previously licensed lifting devices with designs that deviate from the criteria in NUREG-0554 and ASME NOG-1-2004, which apply to overhead multiple girder bridge cranes with wire rope hoists. For example, in its safety evaluation regarding the Dresden cask transfer facility (CTF), dated June 15, 2001 (Reference 16), the staff recognized that the Dresden CTF was neither a single-failure-proof crane per NUREG-0554 nor entirely a special lifting device per ANSI N14.6. The staff noted that the Dresden CTF was a heavy load/jacking system allowed by the flexibility built into Section 3.5, Appendix B to the 10 CFR Part 72 "Certificate of Compliance for HI-STORM 100 System Dry Cask Storage System," Docket No. 72-1014, Holtec International, Rev. 0, May 2000 (Reference 17), and as such, may be designed and tested in accordance with the intent of NUREG-0612 to achieve the intended improvement in handling system reliability. The staff also noted that the Dresden CTF had components that were equivalent to that of a bridge girder and that such components should be conservatively designed but need not be considered single-failure-proof in accordance with NUREG-0554.

load drop consequences.[2] Section 9.12.4.3, "Single Failure Proof Cranes for Spent Fuel Casks," of the IP3 UFSAR provided the following licensing basis information for cask handling:

> To support spent fuel cask handling activities without the necessity of having to postulate the drop of a spent fuel cask, the Whiting crane was replaced in 2010 with a single-failure-proof Morris Material Handling crane. The replacement crane has a main hook rated at 40 tons that complies with current guidelines for designation as single-failure-proof, including the applicable guidelines of NRC NUREG-0554 and the applicable requirements of American Society of Mechanical Engineers ASME NOG-1-2004, Rules for Construction of Overhead and Gantry Cranes (Top Running Bridge, Multiple Girder).

3.0 TECHNICAL EVALUATION

The licensee proposed a specially designed lifting assembly that uses a strand jack as the hoisting mechanism and hydraulic cylinders to provide the motive force for translation of the load between a location over the cask loading area of the IP3 SFP and a location over the cask washdown area. The licensee stated that the lifting assembly would be designed, manufactured, installed, and tested to meet the intent of guidelines in NUREG-0612 and NUREG-0554, as appropriate, to preclude cask drops or other events during transient fuel transfer and transport activities within the 10 CFR Part 50 facility. The lifting assembly is specifically designed for use at IP3. The lifting assembly would be mounted to the top of the south wall of the IP3 SFP. The hydraulic cylinders act through the torque arms, which in turn act vertically on the TB wall to counteract the moment when the load is not directly over the SFP wall. The support arms with the U-shaped center beam form the HI-LIFT hoisting frame, and this hoisting frame can only travel along the one axis of motion. The HI-LIFT load path does not travel directly over the spent fuel in the IP3 SFP storage racks. Therefore, by design, the stored spent fuel is reasonably protected from credible equipment failures during cask movements.

The NRC staff considers the HI-LIFT to be an important-to-safety system because it contributes to the protection from the effects of equipment failures that is provided for the irradiated fuel in the IP3 SFP near the cask loading area and the irradiated fuel that would be present in loaded HI-TRAC casks being removed from the IP3 SFP. In addition to the design of HI-LIFT, operational considerations prescribed by the existing IP3 heavy load handling licensing basis described in Section 9.12 of the IP3 UFSAR (e.g., load handling procedures, design of special lifting devices, selection of lifting devices that are not specially designed, and maintenance, inspection, and testing of heavy load handling equipment) contribute to the protection of the irradiated fuel. As specified in GDC-1, the quality standards applicable to the HI-LIFT design, fabrication, construction, and testing should be established commensurate with the importance to safety of the HI-LIFT. The importance to safety of the safety function to be performed is explicitly considered in the protection provided against the effects of natural phenomena. Consideration of the importance to safety is also implicitly present in GDC-2 in the selection of appropriate combinations of normal and accident loads with the effects of natural phenomena and in GDC-4 in the level of protection found to be appropriate.

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[2] In the NRC staff's safety evaluation report transmitted by letter dated February 13, 1985 (Reference 15), the staff concluded that the IP3 licensee's responses to the staff's information requests satisfied the guidelines of NUREG-0612, Sections 5.1.1 and 5.3, and that the licensee's Phase I implementation at IP3 was acceptable.

In order to reasonably consider the effect of importance to safety on acceptance criteria for GDC-1, GDC-2, and GDC-4, the staff explicitly considered the importance of the safety function performed by the HI-LIFT. The guidance of NUREG-0554 specifies a scope of quality assurance that is narrower than the full quality assurance program elements applied to nuclear power plants as specified in Appendix B to 10 CFR Part 50. The proposed HI-LIFT was designed to be supported by existing plant reinforced concrete structures, and its design includes (a) steel structural components fabricated by Holtec under its own NRC-approved quality assurance program and (b) commercial components (i.e., the structural steel material for the HI-LIFT and complex assemblies including the hydraulic cylinders, the counterbalance valves, and the strand jack assembly) that the licensee proposed to qualify using a commercial grade dedication process under the Holtec quality assurance program. The licensee justified the level of quality assurance related to commercial grade dedication of base material, commercial procurement and dedication of complex assemblies, inspections during fabrication, and testing of components, and the complete HI-LIFT system, using the information contained in national consensus standards and NRC guidance documents. Load combinations, including those related to the effects of natural phenomena, were also developed by Holtec using national consensus standards.

3.1 Safety Insights

Consistent with GDC 4, SSCs important to safety should be appropriately protected against dynamic effects (such as the dropping of heavy loads) that may result from equipment failure. In its review, the NRC staff assessed the appropriateness of the protection from equipment failures based on the likelihood and consequences of damage to SSCs important to safety in the IP3 FSB.

The licensee has proposed the use of a new handling system considered to be sufficiently reliable such that an equipment failure resulting in loss of control of the suspended load is not considered within the design basis. This specifically relates to the likelihood of an initiating event with the potential for radiological consequences such as a heavy load drop. In considering the safety impact or risk associated with a licensing action, the NRC staff considers three risk components: (1) what can go wrong?; (2) how likely is it?; and (3) what are the consequences? Therefore, although the focus of the staff's review is on the first two elements, the potential consequences are a consideration in assessing the acceptability of the proposed change.

The proposed license amendment would change the design of the handling system and permit movement of a heavier transfer cask with a greater number of fuel assemblies located within the transfer cask at one time than is permitted currently at IP3. The total inventory of fuel to be removed from the IP3 SFP is not affected by the license amendment. By letter dated May 11, 2021 (Reference 18), Entergy certified in accordance with 10 CFR 50.82(a)(1)(i)-(ii) that: (1) IP3 power operations permanently ceased in on April 30, 2021; and (2) IP3 fuel was permanently removed from the reactor vessel and placed in the IP3 SFP on May 11, 2021. Therefore, no more irradiated fuel would be added to the IP3 SFP. The loading of transfer casks with more assemblies would reduce the total number of lifts at IP3 because three fully loaded heavy transfer casks could transfer approximately the same amount of fuel as eight fully loaded lighter weight transfer casks. Because the current licensed wet transfer process also involves loading the lighter weight transfer casks into the IP2 SFP and transferring the fuel into a heavier transfer cask within the IP2 SFP that is subsequently removed from that SFP, the net effect of directly loading heavier casks in the IP3 SFP is to avoid several wet transfer operations and the

attendant risk, including the occupational dose associated with packaging the fuel for the wet transfer operations. Another consideration is the change in risk associated with use of the proposed HI-LIFT at IP3 instead of using the IP2 cask handling crane for movement of the HI-TRAC transfer casks loaded with fuel from the IP3 SFP.

3.2 HI-LIFT Design

The HI-LIFT design consists of structural, mechanical, and hydraulic control systems. The structural components interface with the IP3 fuel building and include the U-shaped central beam, the two support arms, the support arm mounting feet anchored to the pool wall, the torque arms, the torque arm mounting brackets attached to the TB wall, and an outrigger arm for stability and bracing against lateral loads. The mechanical components provide for translation of the HI-LIFT from over the TB to over the fuel pool and the hoisting and lowering of the HI-TRAC transfer cask using the strand jack system. The hydraulic control system provides hydraulic pressure for the translation of the HI-LIFT using hydraulic cylinders and sequential actuation of hydraulic jacks for the hoisting and lowering actions of the strand jack.

3.2.1 Structural

Consistent with the guidance of NUREG-0554 and the ASME NOG-1-2004 standard, the structural components of a single-failure-proof crane should be conservatively designed in a manner that precludes sudden structural failure. As a product of a conservative design to established nuclear construction standards, structural components are expected to have a sufficiently low likelihood of failure that structural failures are not considered credible. Therefore, structural components of a single-failure-proof crane do not incorporate redundancy in the design.

Unlike a standard overhead crane with multiple bridge girders that operate on rails, the licensee proposed to anchor the HI-LIFT to reinforced concrete structures in the IP3 SFP area. The licensee proposed to anchor the base of the HI-LIFT to the wide SFP wall and attach vertical motion restraints to the thinner TB wall to permit development of a moment with hydraulic cylinders to pivot the HI-LIFT support arms around pin connections mounted to the base anchor plate. The TB wall mount design permits horizontal motion of the torque arms, thereby limiting the horizontal force acting on the TB wall.

The licensee stated that the HI-LIFT design was based on NUREG-0554 and ASME NOG-1-2004 criteria where applicable. Because the design differs from a typical overhead crane, many of the guidance design criteria are not applicable. For example, NUREG-0554 guidelines address protection against lamellar tearing, which is applicable to thick steel plate used for bridge structures spanning long distances. However, the structural steel components of the HI-LIFT are constructed from relatively thin steel plate, which is acceptable because of the design of support arms and their shorter length, that is not subject to lamellar tearing. Furthermore, the licensee stated that all structural steel used in the HI-LIFT is selected to meet the specifications of ASME NOG-1-2004, which ensures appropriate quality. Therefore, the HI-LIFT design is not subject to certain criteria related to the bridge structure of overhead cranes.

3.2.1.1 Concrete Structures

Attachment 4 of the LAR (Reference 1) includes the Holtec International proprietary report titled "Structural Evaluation of HI-LIFT Device and Fuel Storage Building Walls at Indian Point Unit 3," HI-2188625, Revision 1. This report provides the structural qualifications of the IP3 SFP wall, the TB wall and the anchoring system used to connect the HI-LIFT device to the SFP and TB reinforced concrete walls.

3.2.1.1.1 Spent Fuel Pool Wall and Truck Bay Wall Structural Qualifications

LAR Section 3.1.2, "SFP Wall and Truck Bay Wall Structural Evaluation," notes that the HI-LIFT is supported entirely on the IP3 south SFP wall and is balanced by imparting vertical reactions into the south TB wall via a roller support on the TB wall. The impacted walls were evaluated under the three loading orientation cases in accordance with IP3 design code of record, which is the American Concrete Institute (ACI) 318-63, "Building Code Requirements for Reinforced Concrete." Details of the evaluation, including the results, are described in Attachment 4 of the LAR. Attachment 4 states that the SFP and TB walls are evaluated using the finite element program ANSYS, Version # 17.1. The reaction loads were taken from the ANSYS analyses of the HI-LIFT device under three loading orientations cases. Table 5 of Attachment 4 lists the calculated safety factors for the walls and shows that all the factors are greater than the limit of 1.0. Appendix D of Attachment 4 provides a detailed summary of the evaluations of the SFP and TB walls.

The NRC staff reviewed the information provided in the LAR and in Attachment 4 related to the evaluation of the IP3 SFP and TB walls. The staff noted that the system was analyzed for three limiting load cases in Section 3.0 of Attachment 4. However, the staff noted a discrepancy of the angles of rotation for the support arms between descriptions in Section 3.0 of Attachment 4 and in LAR Attachment 3, proprietary Holtec Drawing No. 11654, Revision 1, sheet 11 of 12. It was unclear to the staff which of these correctly captured the HI-LIFT's range of motion and if the analysis used the most limiting value. Therefore, the NRC staff issued RAI-1 on August 20, 2020 (Reference 20), requesting the licensee to address this discrepancy concerning the HI-LIFT device support arm luffing motion angle and incorporate the operating range of the HI-LIFT device support arm in the UFSAR. The licensee submitted a response in a letter dated October 2, 2020 (Reference 2). In its response, the licensee explained that the analysis results presented in HI-2188625 (Reference 21) are conservative since the maximum reaches of the HI-LIFT support arms, over the SFP and over the TB, were converted and rounded to whole numbers such that the angles intentionally bounded the maximum reach distances.

The NRC staff reviewed the licensee's response and agreed the analysis results presented in HI-2188625 are conservative since the bounding angles used in the analysis bound the maximum reach distances of the HI-LIFT support arms. Furthermore, the licensee proposed changes to the associated UFSAR section which makes it clear that the allowable angles used in the analysis are derived from, and bound the maximum reach of support arms over the IP3 SFP and the TB.

While reviewing Appendix D of Attachment 4, specifically subsections D.4.2 and D.5.2 related to the ANSYS model description for the IP3 SFP and TB walls, the NRC staff noted that the concrete wall is modeled primarily with SOLSH190 solid shell elements. These elements can be extremely stiff in bending and it is normally recommended that at least three elements be used through the thickness of a member to provide reasonable results. It was unclear to the

NRC staff whether the effects of concrete cracking could be properly represented using these elements. Therefore, the NRC staff issued RAI-2 on August 20, 2020 (Reference 20), requesting the licensee explain how its analysis of the SOLSH190 elements can properly capture the behavior of the reinforced concrete structures. RAI-2 also requested justification for using one layer of the SOLSH190 element through the thickness of the SFP and TB walls.

In its October 2, 2020, RAI letter (Reference 2), the licensee submitted a response explaining that the ANSYS solid shell element, SOLSH190, is widely used for simulating shell structures with a wide range of thicknesses and the element can better capture the stress distribution than a traditional 8-node brick element since it employs enhanced strain formulations and incorporates transverse shear deformation behavior. The licensee performed a total of **[[ ]]** sensitivity simulations to justify the use of a single layer of SOLSH190 elements through the thickness of the SFP and TB walls in the ANSYS Model. **[[**

]].

The NRC staff reviewed the licensee's response and noted that the results from the sensitivity simulations are within an acceptable percentage and are less than the minimum calculated safety-margin percentage for **[[ ]]** per Table 5.0 of HI-2188625, Revision 2. **[[**

]]. Therefore, based on the results of the licensee's sensitivity study, the NRC staff finds it acceptable for the licensee to model the IP3 SFP and TB walls using a single layer of SOLSH190 elements.

Based on its review, as discussed above, the NRC staff finds that the walls were analyzed for the three limiting load orientations in accordance with the structural design code of record (ACI 318-63) and found to be acceptable with all safety factors greater than 1.0. Accordingly, there is reasonable assurance that the IP3 SFP and TB walls are structurally adequate to support the loads imparted by the HI-LIFT crane.

3.2.1.1.2 Anchor Point Selection and Anchor Evaluation

LAR Subsection 3.1.3 notes that anchor locations on the top of the IP3 SFP wall and through the TB wall will be selected using the as-built condition of the walls, and scans will be performed of the top surface to identify rebar locations where possible. Exploratory drilling will be performed to verify clear locations of concrete where anchors may be installed, and existing

rebar will not be cut or drilled unless it can be positively demonstrated that the rebar is not reinforcement rebar that ensures the structural integrity of the wall. Once a valid anchor pattern and a sufficient number of anchors have been located, the anchor locations will be re-analyzed to verify that the structural capacity of the as-built anchors is sufficient to maintain the safety of the HI-LIFT, and that the structural evaluations of the SFP and TB walls remain valid.

Details regarding the anchor analysis are provided in Appendix E of the LAR Attachment 4 (Reference 1). Appendix E notes that the HI-LIFT will be anchored to the top of the IP3 SFP wall with two sets of anchors, while the attachment to the TB wall will be made by drilling through the wall and using studs with plate washers. **[[**

]].

Appendix E also notes that the anchor embedment depth, spacing, edge distances, etc., may change based on the final as-built configuration; therefore, the aim of the analysis in Appendix E is to present an acceptable methodology for evaluating the anchor bolts. The final analysis will be updated as necessary to account for the final as-built configuration.

The NRC staff reviewed the information provided in the LAR and in Attachment 4 related to the selection and evaluation of the HI-LIFT anchorage. The NRC staff noted that the licensee followed the requirements of ACI 349-85 for analyzing the anchorage system. However, while reviewing the sample calculation provided in Appendix E of Attachment 4, the NRC staff was unable to verify that the licensee addressed the ACI requirements for anchor placement, such as embedment size, edge distance, or prying effects. Therefore, the NRC staff issued RAI-3 in the August 20, 2020, RAI letter (Reference 20), requesting the licensee to describe whether the grouted anchor behavior effects under loads, per the requirements of ACI 349-85, were considered in the calculations. In its October 2, 2020, response (Reference 2), the licensee explained that the grouted anchor group behavior effect of cone-overlapping was appropriately considered in proprietary report HI-2188625, Revision 2, Appendix E, “Structural Qualification of Concrete Anchoring System.” Based on the proposed group anchor patterns, the edge effect did not need to be considered, since the minimum edge distance is greater than or equal to the grouted anchor embedment depth. Using the proposed anchor layout, the licensee determined that the calculated safety factors are greater than 1.0 for tension and shear under normal and seismic load combinations of ACI 318-63. The licensee further stated that the grouted anchor evaluations that were performed are based on the anchor patterns and dimensions from Holtec Drawing 11654 in Appendix G of HI-2188625. The licensee further noted that the grouted anchor evaluations will be revised to account for the final as-built grouted anchor pattern and/or other geometric discrepancies/integration effects in the original calculations.

The NRC staff reviewed the licensee’s response and determined that the effects of multiple cone overlaps were considered in the grouted anchor evaluations and the process was described appropriately with figures in proprietary report HI-2188625. Further, the staff noted that the licensee will reevaluate the anchors to account for the final as-built grouted anchor patterns since the current evaluations are based on the assumed information provided in Holtec Drawing 11654 in Appendix G of HI-2188625. Based on its review, the NRC staff concluded

that the licensee has provided an acceptable methodology for performing the evaluation of grouted anchors.

The NRC staff noted that Section E.6 of Appendix E of LAR Attachment 4 states that the grouted anchors will be tested after installation to verify their design adequacy in accordance with guidance available in the latest ACI code editions. It was not clear to the staff which ACI code edition or provisions would be used for the testing. Therefore, the staff issued RAI-4 in the August 20, 2020, RAI letter, requesting, in part, that the licensee identify the applicable ACI code and its associated provision(s) for testing the grouted anchors and through bolts, if applicable. In its October 2, 2020, RAI response, the licensee stated that the pullout testing methodology for the installed grouted anchors on the SFP wall will accord with the provisions in B.9 "Grouted embedments," of ACI 349-85. Provision B.9.4 in ACI 349-85 requires that randomly selected anchors be tested to a minimum of 100 percent of the strength. The licensee also stated that the through bolts (studs) in the TB wall are not grouted, and they transfer loads into the reinforced concrete TB wall through direct bearing and therefore do not require pull out testing. The NRC staff reviewed the provided information and noted that the SFP anchors will be tested in accordance with Section 6.2 of HI-LIFT specification HI-2188549, which incorporates the guidance of ACI 349-85, and requires testing of all anchors, as opposed to a random sample of anchors. Since the licensee's testing program is in accordance with the applicable provisions of the ACI 349-85 code, including Section B.9, the NRC staff finds it acceptable.

Based on its review, as discussed above, the NRC staff finds that the licensee has provided reasonable assurance that the HI-LIFT crane will be properly anchored to the IP3 SFP and TB walls. The anchorage design follows the requirements of ACI 349-85 and will be field tested for adequacy after installation.

3.2.1.2 HI-LIFT Device Structural Evaluation

According to the LAR, the HI-LIFT device is classified as single-failure-proof by meeting the relevant requirements defined in ASME NOG-1-2004 for a Type I crane as described in NUREG-0554 and NUREG-0612. ASME NOG-1-2004 provides assurance that "any credible failure of a single component will not result in the loss of capability to stop and hold the critical load within facility acceptable excursion limits," and provides this assurance through redundant mechanical features or increased mechanical safety factors to render failure of those components non-credible.

LAR Section 2.1 (Reference 1) describes the system design and operation of the HI-LIFT device, and LAR Section 3.1.1 summarizes the structural evaluation and qualification of the HI-LIFT device, which is documented in more detail in Attachments 2 and 4 of the enclosure. In the LAR, Attachment 2 of the enclosure contains Proprietary Holtec Report HI-2188549, "HI-LIFT Design Specifications for IPEC Unit 3", and Attachment 4 of the enclosure contains Proprietary Holtec Report HI-2188625, "Structural Evaluation of HI-LIFT Device and [FSB] Walls at Indian Point Unit 3." Appendices B and C of Attachment 4 document the structural qualification of the HI-LIFT device for normal loading and seismic loading, respectively.

3.2.1.2.1 Load Combinations for the HI-LIFT Device

The licensee stated in the LAR that the HI-LIFT device was analyzed to satisfy all applicable load combinations in Section 4140 of ASME NOG-1-2004 (Reference 10), which was

demonstrated through the analysis of three bounding load combinations, a normal load case and two bounding seismic load cases. In its review of LAR Attachment 4 of the enclosure, the NRC staff noted that the normal load case accounts for an additional 15 percent maximum lifted load as required by Section 4133 to account for vertical impact loading. The NRC staff also noted that for each load case the system was analyzed for three limiting loading orientations: **[[**

]]. The NRC staff agrees that the three orientations represent limiting loading orientations for assessing the structural qualification of the HI-LIFT Device for the normal and seismic load cases. Furthermore, the NRC staff has reviewed the details and assumptions provided regarding the load cases used to assess the HI-LIFT device and finds them acceptable.

As discussed in more detail in Section 3.2.2.1 of this safety evaluation, leakage from the high-pressure rod-side of one of the two hydraulic cylinders could challenge the structural integrity of the originally proposed HI-LIFT frame design. As part of a defense-in-depth approach described in the failure modes and effects analysis provided in HI-2210873, the licensee proposed to modify the HI-LIFT frame design as necessary to establish that the HI-LIFT could hold the full rated critical load with one of two cylinders unable to retain hydraulic pressure at increased allowable stress limits consistent with extreme environmental conditions. Appendix I of LAR Attachment 4, of the enclosure, demonstrates this ability by providing a conservative bounding analysis of an additional accident load case that models the failure of one of the two hydraulic cylinders. This assessment demonstrates the HI-LIFT frame's resilience against catastrophic single failures affecting a single cylinder, including the failure of a cylinder seal or counterbalance valve. The NRC staff agrees with the licensee's treatment of this case as an accident load case which means its occurrence is not deemed credible before the occurrence of other failures, and thus does not need to be considered with other accident loading, including seismic or impact loads. Similarly, as an accident load case, it can be qualified using the allowable stresses for an extreme environmental event under ASME NOG-1-2004, which were taken as equivalent to the allowables used in the seismic load case. The NRC staff notes that the licensee still conservatively includes an additional 15 percent maximum lifted load as required by Section 4133, as before. This assessment was performed for two of the three limiting loading orientations described above, **[[**

]]. The NRC staff agrees that the two limiting cases are appropriate and remain conservative and limiting for this accident load case assessment.

3.2.1.2.2 Seismic Inputs for HI-LIFT Device

The licensee stated in the LAR that the seismic load case was evaluated using a response spectrum analysis in ANSYS, using the Square Root of the Sum of the Squares (SRSS) method, in accordance with NRC guidance provided in Regulatory Guide 1.92 (Reference 22). The NRC staff notes that the licensee used a **[[ ]]** damped Design Basis Earthquake (DBE) amplified response spectra to perform the seismic evaluation analyses, which is significantly lower in the IP3 UFSAR which permits higher damped spectra curves, or the **[[**

]]. The NRC staff acknowledges that the use of this **[[ ]]** damping assumption is conservative. The staff also notes that the site-specific DBE input, as defined in the IP3 operating basis, was used in

the licensee's structural analysis for the two seismic loading cases. The NRC staff noted in its review that this site-specific DBE input consists of response spectra for the two horizontal directions, which corresponds to a DBE zero period acceleration (ZPA) value of **[[ ]]** in the horizontal direction. The response spectra for the vertical direction is taken as **[[ ]]** and corresponds to a ZPA value of **[[ ]]** in the vertical direction. The NRC staff notes that since the **[[ ]]**. The NRC staff also notes that the analyses used the SRSS results from the **[[ ]]**. The NRC staff reviewed the methodology, assumptions, and inputs used to perform the seismic evaluation of the HI-LIFT device and finds them to be appropriate and acceptable.

3.2.1.2.3 Stress Acceptance Criteria and Stress Evaluation for HI-LIFT Device

The licensee provided the maximum allowable stresses for structural steel members that were used as the stress acceptance criteria for the HI-LIFT device design in Appendices B and C of Attachment 4, of the enclosure of the LAR. The NRC staff reviewed the maximum allowable stresses and agrees that they were obtained in accordance with Section 4300 of the ASME NOG-1-2004 Code (Reference 10) and are thus acceptable to be used as the stress acceptance criteria for the HI-LIFT stress evaluation.

The NRC staff notes that to meet the single-failure-proof criteria in ASME NOG-1-2004 and NUREG-0554 for non-redundant components such as the load block, the safety factor under normal load condition must be above 2.0 to render mechanical failure non-credible. In its review, the NRC staff noted that this required additional safety factor applies only to **[[ ]]**. All other mechanical components are commercially procured and dedicated under the Holtec quality assurance program for their safety functions, with appropriately enhanced factors of safety to render mechanical failure non-credible, and are deemed capable of handling the specified load based on their rated capacities. All safety factors for non-mechanical structural members must be above 1.0.

The structural qualification of the HI-LIFT device is documented in Appendices B, C, and I of Attachment 4 of the enclosure of the LAR. Appendix B describes the structural qualification for the normal load case, Appendix C describes the structural qualification for the seismic load cases, and Appendix I describes the structural qualification for the accident load case that models the failure of one of the two hydraulic cylinders. As described in Section 3.2.1.2.1 of this safety evaluation, each load case was evaluated under three bounding loading orientations, except for the accident load case, which was evaluated under two of the three bounding loading conditions. The structural qualification of the HI-LIFT device was performed using a combination of strength of materials calculations and finite element analysis. Holtec constructed a finite element model of the HI-LIFT device in the structural engineering simulation software ANSYS. The licensee notes that some simplifications were made to the finite element model to ease modeling, but that these simplifications do not affect the global response of the structure, and that the components or members that were simplified or omitted from the ANSYS model are evaluated separately to demonstrate their structural integrity. The NRC staff noted in its review that the licensee's calculations regarding certain buckling evaluations deviate slightly from the methodology prescribed in ASME NOG-1-2004, Section 4313. The NRC staff reviewed the applicable calculations presented in Appendices B and C of Attachment 4 of the LAR and finds

that the results of the methodology used in this calculation package provide reasonable assurance that all applicable buckling modes have been adequately addressed and are bounded by the licensee's evaluation. Furthermore, the NRC staff reviewed the licensee's description of the methodology used to develop the finite element model and reviewed a sampling of the calculations that were performed to supplement the finite element evaluation and agrees that the licensee's assumptions and modeling methodology are sound and sufficiently conservative.

The NRC staff reviewed the resulting safety factors from the stress evaluation for the normal load case and the seismic load cases as listed in Tables 3.0 and 4.0, respectively, in Enclosure, Appendix 4, of the LAR, and a sampling of the supporting calculations presented in Appendices B and C of Attachment 4 of the LAR and finds that they adhere to the methodology of ASME NOG-1-2004 and that they conservatively and comprehensively demonstrate the structural adequacy of the HI-LIFT device. The NRC staff observed that all evaluated safety factors listed in Tables 3.0 and 4.0 in Enclosure, Appendix 4, are greater than 1.0. Additionally, the safety factors for the mechanical components, namely the **[[** **]]**, exceed the additional safety factor of 2.0, rendering their failure non-credible to support the classification of the HI-LIFT device as a Type I single-failure-proof crane.

Similarly, for the additional accident load case that models the failure of one of the two hydraulic cylinders, the resulting safety factors from the stress evaluation are listed in Table I.1 in Appendix I of Attachment 4 of the LAR. The NRC staff observed that all evaluated safety factors listed in Table I.1 are greater than 1.0. These results provide assurance, and further reinforces the defense-in-depth measures discussed in Section 3.2.2.1 of this safety evaluation, that in the unlikely event of extreme asymmetrical loading of the HI-LIFT device that could result from catastrophic seal leakage or failure of a counterbalance valve, or from smaller failures coupled with failures of the HI-LIFT control system, the HI-LIFT device will maintain structural integrity to maintain control of the lifted critical load.

Overall, the NRC staff determined that through the analysis of a normal load case, two seismic load cases, and an accident load case, the HI-LIFT device is structurally adequate to be classified as a single-failure-proof lifting device by meeting the relevant requirements defined in ASME NOG-1-2004 for a Type I crane as described in NUREG-0554 and NUREG-0612. As such, the staff finds that the structural qualification of the HI-LIFT device provides reasonable assurance that the HI-LIFT frame will maintain structural integrity under normal loading and seismic loading, and will be able to withstand asymmetrical loading that could result from failure of one of the two hydraulic cylinders such that the lifted critical load will be maintained and can be translated and safety set down.

3.2.2 Mechanical

Mechanical elements of the proposed HI-LIFT are those elements of the crane that experience numerous stress cycles during each lift or experience wear as a result of motion. Accordingly, these elements should be designed with the capability to withstand the potential effects of fatigue or loss of material. The incorporation of functional redundancy or enhanced safety factors in the design may be credited to mitigate these potential failure modes.

The scope of the mechanical system evaluation includes the components that provide for horizontal translation of the load and hoisting or lowering the load. The specific components

considered in the NRC staff's review include the hydraulic cylinders and attached counterbalance valves that provide the motive force to translate the load in a controlled manner, the pin connections that permit the pivoting motion to translate the load, the strand jack assembly that performs the load hoisting and lowering function, and the strand and load block assembly that connects to the load. The licensee established specific design criteria for these components to enhance reliability of the load handling evolution through redundancy, increased design factors, or other measures. The licensee defined these design criteria through evaluation of the proposed design criteria against applicable guidelines drawn from NUREG-0554, NUREG--0612, ASME NOG-1-2004, and specifically for the hydraulic cylinders and the strand jack assembly, ASME B30.1, "Jacks, Industrial Rollers, Air Casters, and Hydraulic Gantries," (Reference 23).

The licensee evaluated a range of component failure modes related to operation of the HI-LIFT. Specifically, the licensee addressed postulated equipment failures affecting the following components: **[[**
]]. The licensee also considered operational errors including potential two blocking conditions and support system malfunctions. Enclosure 2 to the letter dated January 3, 2022 (Reference 6), included Revision 0 of the proprietary Holtec Report HI-2210873, "Failure Modes and Effects Analysis (FMEA) for IP3 HI-LIFT Mechanical and Control Systems," which described postulated failure modes, mitigating features, and the resultant likelihood and effect of the failure. Enclosure 3 to the letter dated January 3, 2022, included Revision 3 to the proprietary Holtec Report HI-2188549, "HI-LIFT Specification for IPEC Unit 3," which contains a detailed evaluation of the HI-LIFT device to applicable design criteria specified in the referenced technical guidance and national consensus standards.

3.2.2.1 Hydraulic Cylinders, Counterbalance Valves, and HI-LIFT Frame

Design

The licensee provided the following general statement in Section 2.1.9 of the enclosure to the LAR describing safety attributes incorporated in the design of the hydraulic cylinders and the attached counterbalance valves:

> The hydraulic cylinders and hydraulic system, which provide lateral movement of the HI-LIFT, will include specific features for control and use and to ensure high reliability. A system will be used for controlled fluid metering to ensure that the cylinders operate in unison, and position controls will be utilized to monitor and adjust the cylinder travel as necessary. In addition, each cylinder is equipped with counter-balance valves that "lock up" the cylinder in the event of a hydraulic failure or pump malfunction, or cessation of flow resulting from an emergency stop application, limit switch activation, or seismic switch activation. All components will also be selected with rated operating pressures that exceed all normal and extreme operating conditions. In combination, these features ensure safe controlled motion in the lateral direction…

The licensee also provided the following statement in Section 3.6.5 of the enclosure to the LAR addressing potential equipment failures affecting the hydraulic swing cylinders:

> The hydraulic cylinders that operate the swing arms are mechanically load tested and procured with enhanced factors of safety to make a catastrophic mechanical

> failure non-credible. Seal leaks and counterbalance valve failures are possible, but they tend to be gradual failures. In this case (i.e., loss of hydraulic power), as well as swing cylinder control failure, hydraulic fluid can be manually bled from the cylinders, allowing gravitational force to pull the swing arms toward one end of travel. In the event the swing arms are at the apex position, rigging can be manually attached, and used to pull the swing arms sufficiently far for gravitational force to become effective. In either case, operators are able to throttle the fluid that is bled off from the cylinders to maintain a slow, controlled motion, such that the swing arms will be at the end of their travel. At that point, the load can then be lowered and placed in a safe condition.

The NRC staff evaluated the proprietary Holtec Report HI-2188549 related to design standards, design criteria, and evaluated failure modes applicable to the hydraulic swing cylinders.

Consistent with guidance in paragraph 5540, “Hydraulics (Types I, II, and III Cranes),” of ASME NOG-1-2004, hydraulic cylinders are considered acceptably reliable for use for critical load handling applications provided that the analyzed load does not exceed 20 percent of the component material ultimate strength. The licensee provided specific design criteria in HI-2188549. **[[**

]]. The licensee also stated that the hydraulic cylinders would be designed, manufactured, and tested to the ASME B30.1-2015, “Jacks, Industrial Rollers, Air Casters, and Hydraulic Gantries,” which provides specific design and proof load test criteria in Chapter 1-2, “Hydraulic Jacks.”

The NRC staff considered the function and operation of the hydraulic cylinders. The cylinders maintain the structure of the HI-LIFT device in the evaluated configurations **[[**
]]. The cylinders also provide the motive force necessary to pivot the HI-LIFT support arms around the mounting pins between the TB (cylinders fully retracted) and the SFP cask area (cylinders fully extended). The structural analysis discussed in Section 3.2.1 of this safety evaluation addresses the integrity of the overall structure under the specified load conditions. **[[**
]]. Over the arc of travel, the hydraulic cylinders experience a loading roughly proportional to the angle of the support arms from vertical. Therefore, the highest hydraulic loads would occur with the cylinders near the end of travel limits for both extension and retraction. The cylinders would be under compression with higher hydraulic pressure on the piston (extend) side of the cylinder when the support arms are tilted toward the TB. Conversely, the cylinders would be under tension with higher hydraulic pressure on the rod (retract) side of the cylinder when the support arms are tilted toward the SFP.

Counterbalance valves mounted directly to the hydraulic cylinder prevent motion of the cylinder by blocking a change in volume on the rod and piston sides of the cylinder unless pressure from the hydraulic control system is provided to the extend or retract pilot valves to position the counterbalance valves. Therefore, the cylinders maintain position under a loss of hydraulic control system pressure. In the fully extended or fully retracted configuration, the mechanical interface of the piston with the cylinder body maintains the HI-LIFT in a stable configuration without hydraulic pressure. Therefore, the safety function of the hydraulic cylinders is to

maintain the HI-LIFT configuration within the bounds of the structural analysis, which evaluates uniform motion of the support arms to maintain structural alignment for most loading conditions.

The licensee credited the counterbalance valves to perform the safety function. The licensee provided the following statement in Enclosure 1 to the letter dated November 9, 2020:

> The primary function of the counterbalance valve is to retain fluid in the hydraulic cylinder in the event of loss of pressure or emergency stop. The counterbalance valve is designed for direct mounting to the hydraulic cylinder to eliminate the possibility of line break between the retained fluid and the valve.

Thus, the counterbalance valves serve to prevent uncontrolled motion of the hydraulic cylinders following failures affecting the hydraulic system. The counterbalance valves also respond to an emergency stop initiated by the HI-LIFT operators to maintain the position of the hydraulic cylinders in the event of other abnormal conditions. The control system combined with operator ability to stop all motion provides reasonable assurance that the analyzed configuration of the HI-LIFT will be maintained, and the system can safely translate the HI-TRAC load between the position above the cask loading area and the position over the cask washdown area in the TB.

In Revision 2 to the Proprietary Holtec Report HI-2188549 (Reference 19), the licensee described the operation of the cylinders, counterbalance valves, and other components used for translation of the transfer cask. The licensee stated that travel speeds are slow, which is the result of the large volume of high-pressure hydraulic fluid necessary to extend or retract the hydraulic cylinders and the selected pumping capacity. **[[**

]].

The NRC staff evaluated the HI-LIFT steel structural analysis in Section 3.2.1.2 of this safety evaluation. The steel structure consists of the support arms, the torque arms, the center beam, and outrigger in addition to the hydraulic cylinder. The steel structural components perform their function by pivoting around pinned connections. The pinned connections are not redundant, but the licensee designed these connections to add design margin to compensate for the lack of redundancy.

Quality Assurance

The NRC staff endorsed the American Society of Mechanical Engineers (ASME) Standard NQA-1, "Quality Assurance Program Requirements for Nuclear Facility Applications," Parts I and II, in Regulatory Guide 1.28, "Quality Assurance Program Criteria (Design and Construction)," Revision 5. Subpart 2.14, "Quality Assurance Requirements for Commercial Grade Items and Services," of NQA-1 is in Part II and provides for the qualification of commercially procured items that perform safety functions. The licensee at the time (Entergy) stated that, commensurate with the importance of the safety functions of the HI-LIFT, all engineering, procurement, fabrication, testing, installation, training, operation, and maintenance activities would be performed in accordance with Holtec's NQA-1 nuclear quality control program, or the station's NQA-1 nuclear quality control program. The licensee specified the critical characteristics that would be verified in the dedication process and provided the following

description of the qualification and testing of the hydraulic cylinders in Enclosure 4 to the letter dated November 9, 2020:

> The hydraulic swing cylinders are procured as a commercial item and dedicated under the Holtec NQA-1 quality assurance program. Dedication will follow NQA-1, Subpart 2.14, Method 1, and will consist of inspections and tests of the swing cylinders. Critical characteristics for dedication include functional performance, and the ability to extend and retract against sufficient load. Proof load testing requirements, proof load requirements, and post testing inspection shall comply with ASME B30.1-2015 Section 1-2.4. In accordance with ASME B30.1-2015, Paragraph 1-2.4.2(b), the proof load test for each manufactured hydraulic jack must be conducted at a minimum of 100% of the hydraulic jack's rated load. The post-test inspection includes checks for worn, cracked, bent, or broken cylinder barrels, structural components and welds, as well as checks for hydraulic fluid leaks.

In the same document, the licensee also provided the following description of the qualification and testing of the counterbalance valves:

> Counterbalance valves will be dedicated for service following NQA-1, Subpart 2.14, Method 1, and will consist of inspections and tests. Critical characteristics for dedication include functional performance, such as shutting flow and retaining fluid in the cylinder upon loss of supply pressure, and opening and closing the main flow port as expected in response to control pressure signals. Critical characteristics to demonstrate integrity include the ability to hold rated pressure. Functional and pressure tests may be performed in a fixture, however, final functional tests must be performed after mounting to the hydraulic swing cylinders. After the pressure test, visible surfaces of the counterbalance valves must be inspected for cracks, deformation, hydraulic fluid leaks, and any evidence of structural damage.

Thus, the licensee has identified a set of critical characteristics for the essential commercially procured items forming the portion of the HI-LIFT that supports translation of the loaded transfer cask.

The licensee also stated in the enclosure to the license amendment request that the design, fabrication, and installation of the HI-LIFT would be subject to quality assurance programs compliant with the requirements of 10 CFR Part 50, Appendix B.

NRC Staff Evaluation

The hydraulic cylinders, counterbalance valves, and attached structural components of the HI-LIFT structural frame perform a function comparable to the bridge and trolley structures of the overhead crane design specified in NUREG-0554 and ASME NOG-1-2004, and that were considered in the criteria included in NUREG-0612. In the overhead crane design with multiple girders, the safety function of supporting the suspended load would be performed by the passive bridge and trolley girders and structural attachments, which are in an inherently stable configuration with the load suspended between the girders. Active components consist of only the bridge and trolley drives and brakes, which do not perform an essential safety function to support the load. The HI-LIFT frame performs its safety function as an essentially passive

structure during hoisting and lowering activities when the hydraulic cylinders are at their limits of travel and are supported by physical interface between the piston and the cylinder body. In these positions, the counterbalance valves lock the cylinders at the respective limit of travel. Conversely, during translation of the HI-LIFT, the hydraulic cylinders, counterbalance valves, and pin connections are performing active functions to maintain the stability of the HI-LIFT frame.

In order to better understand the design margin available in the structure to accommodate deformations that may result from uneven operation of the cylinders, the staff requested that the licensee define threshold bounds of acceptable operation and measures that provide assurance these thresholds would not be reached during operation. The licensee provided the results of the analysis and measures to prevent reaching the threshold bounds of acceptable operation in its letter dated May 20, 2021. The analysis determined that stresses in components of the HI-LIFT frame could be maintained within ASME NOG-1-2004 allowable values for a specific range of uneven operation at the rated load, which the licensee specified **[[**

]]. The staff evaluation of the analysis is presented in Section 3.2.1.2.3 of this safety evaluation. The licensee also established acceptance criteria for periodic hydraulic seal leakage tests and described a primary and backup control system for management of cylinder position.

The reliability of the hydraulic cylinders and the pinned connections between moving components of the HI-LIFT frame is important to safety because these components are not redundant and function to maintain the analyzed configuration of the HI-LIFT device. The licensee proposed to credit substantial margins of safety instead of redundancy to maintain the function of these components. The staff assessed the reliability of these components that perform safety functions through a change in configuration commensurate with the importance to safety of that function. In determining the importance to safety, the staff considered the limited number of load cycles on these components necessary to complete the function of transferring the limited fuel inventory from the IP3 SFP to dry storage. The licensee demonstrated that these components have about twice the normal design factor with respect to maximum normal loading conditions. The NRC staff found that the design margin of the pinned connections provides reasonable assurance that the connections would maintain the HI-LIFT in its design configuration. In addition, the staff found the design margin provided for the hydraulic cylinders sufficient to provide reasonable assurance that these components would perform their function during the limited number of cask movements without catastrophic failure. The staff considered qualification of these components through the Holtec Quality Assurance program directly for the pinned connections, or through commercial grade dedication for the hydraulic cylinders, and found it provided reasonable assurance that the components installed in the HI-LIFT would have the specified design margin.

The licensee noted that the hydraulic cylinders and counterbalance valves contain seals that are intended to prevent movement of the hydraulic fluid from chamber to chamber or to the environment, and thus prevent positional drift. The licensee stated that the seals tend to fail gradually, and, therefore, any seal leakage that develops could be compensated by operation of the hydraulic control system. In the case of a loss of hydraulic power or a failure of the control system affecting operation of the hydraulic cylinders, the licensee stated that hydraulic fluid could be manually bled from the hydraulic cylinders to allow gravitational forces to pull the swing arms to the nearest end of travel position for the cylinders. The licensee also stated that

operators are able to throttle the fluid drained form the cylinders to maintain a slow, controlled motion to the end of travel position where the load would be held in a stable position.

The NRC staff assessed the likelihood of cylinder or counterbalance valve seal failure that could not be readily compensated by operator control of the hydraulic system during the limited number of HI-LIFT operating cycles necessary for fuel transfer from the IP3 SFP. The licensee established selection criteria for these commercial components that ensured the hydraulic cylinders, including the seals, would have ample design margin. The licensee also identified inspection activities that would provide assurance that early seal degradation would be detected, as discussed in Section 3.3.3 of this safety evaluation. However, the staff was concerned that certain minor seal leaks within the proposed leak test acceptance criteria described in the attachment to the letter dated May 20, 2021 (Reference 5), could allow unacceptable deformation of the HI-LIFT frame following a loss of hydraulic pressure or power to the hydraulic system before operator action could reliably mitigate the condition.

In addition, the staff was concerned that other control system failures could result in uneven motion of the hydraulic cylinders through differences in the amount of hydraulic fluid delivered to each cylinder or minor seal leakage that affects one cylinder more than the other. The licensee stated that controlled fluid metering would be used to ensure that the hydraulic cylinders would move slowly in unison, and that motion controls would be available to correct any uneven motion of the cylinders. The licensee included the following description of the motion controls in Enclosure 2 to the letter dated May 20, 2021:

> The hydraulic swing cylinder primary control system will use a flow balancing system with the ability to vary the flow to each cylinder, using variable speed pumps or similar system. Position indication sensors will be installed to detect the positions of each cylinder rod, to provide ongoing feedback to the control system. The primary control system logic constantly compares the relative positions of each cylinder rod, and adjusts the flow to each cylinder accordingly to maintain relative positions of each cylinder rod within a preset limit of approximately **[[ ]]**. If the primary control system reaches its preset limit for relative cylinder position, it will stop motion, and alert the operator at the control console. If the primary controls reach this limit and stop motion, operators will initiate troubleshooting procedures to diagnose and repair components of the system before resuming travel. The manual hydraulic fluid bleed-off procedure (described in HI-2188549, Revision 2, Section 7.1.3) may be employed if needed to reposition the HI-LIFT and lifted load without the use of electronic controls.
>
> To provide protection from primary control system failure, a redundant control system will monitor cylinder rod positions. If rod positions reach a preset limit of approximately **[[ ]]**, the redundant control system will provide an alarm to operators and disconnect electrical power to the hydraulic pumps, which removes hydraulic pressure to the system, causing counterbalance valves to close, and cylinders to stop and hold position. If the redundant controls reach this limit and stop motion, operators will initiate troubleshooting procedures to diagnose and repair components of the system before resuming travel. As stated above, the manual hydraulic fluid bleed-off procedure (described in

HI-2188549, Revision 2, Section 7.1.3) may be employed if needed to reposition the HI-LIFT and lifted load without the use of electronic controls.

In addressing these concerns, the NRC staff evaluated the capability to recover from loss of hydraulic pressure and flow conditions considering: (1) the acceptable range of uneven cylinder operation; (2) the measures the licensee described to recover from such conditions; and (3) the potential for undetected or known-but-acceptable seal leakage to exist within the cylinders or valves. The staff considered minor seal leakage within the specified limit provided by the licensee and the potential for further minor degradation during operation after testing. The staff recognized some redundancy in the hydraulic cylinder and counterbalance valve design that would limit HI-LIFT motion due to seal leakage without hydraulic control system pressure or flow in certain conditions. For example, cylinder drift with leakage by a piston seal when the piston-side of the cylinder is at higher pressure would be self-limiting (with no other seal leakage) because leakage across the piston would reach a new equilibrium after loss of hydraulic power to limit fluid and piston motion. This self-limiting condition develops because rate of volume change with piston motion is smaller on the rod-side than on the piston-side such that the leakage rapidly increases rod-side pressure. Conversely, when the rod-side pressure is higher, such as when the cask is toward the SFP side of the HI-LIFT support pins, cylinder motion with a piston seal leak would not be self-limiting because the weight of the cask would be acting to further extend the rod from the cylinder, which increases the internal cylinder fluid volume as the volume displaced by the portion of the rod inside the cylinder decreases. Thus, leakage from the high-pressure rod-side would continue by the leaking piston seal to the piston side because the volume on the piston side increases as leakage continues. This latter case challenges HI-LIFT stability because minor seal leakage in one cylinder could allow the cylinder to drift beyond the range of uneven cylinder motion established by the licensee's analysis as acceptable.

The licensee addressed this condition in the failure modes and effects analysis provided in HI-2210873. The licensee proposed a defense-in-depth approach to protect the configuration of the HI-LIFT frame to resolve the staff's concerns with seal leakage conditions. First, the licensee proposed a revised leak test methodology that tests both cylinders prior to load translation to verify that any existing minor seal leakage would allow adequate time (a minimum of 30 minutes) for operators to manually restore the HI-LIFT to a stable configuration before exceeding the frame deformation limit at normal operating stress limits. Second, the licensee modified the design of the hydraulic system to provide redundancy for the function of locking the hydraulic cylinders in position, which protects against significant failures affecting the counterbalance valve seals. Finally, the licensee proposed to modify the HI-LIFT frame design as necessary to establish that the HI-LIFT could hold the full rated critical load with one of two cylinders unable to retain hydraulic pressure at increased allowable stress limits consistent with extreme environmental conditions. This third measure provides defense against catastrophic single failures affecting a single cylinder. The staff found that these measures provided reasonable assurance that important to safety equipment would be appropriately protected against seal degradation or failure.

The NRC staff also evaluated the capability to recover from uneven delivery of hydraulic fluid from the hydraulic control system considering: (1) the acceptable range of uneven cylinder operation; (2) the measures the licensee described to recover from such conditions; and (3) the reliability of the proposed mitigation measures. The licensee addressed this condition in the failure modes and effects analysis provided in HI-2210873. The licensee modified the hydraulic control system to include an independent and diverse system to hydraulically lock the HI-LIFT

frame in the unlikely event that the primary hydraulic control system fails to maintain the HI-LIFT frame configuration within established limits. The failure modes and effects analysis in HI-2210873 and Appendix F to HI-2188549, Revision 3, included a conceptual design of this independent supervisory control system. The NRC staff determined that this system provides reasonable assurance that important to safety equipment would be appropriately protected against hydraulic control system failures.

Overall, the NRC staff determined that the design proposed for the HI-LIFT frame, the hydraulic cylinders, and the associated hydraulic control system provides reasonable assurance that equipment important to safety would be appropriately protected from equipment failures affecting the hydraulic cylinders, counterbalance valves, and attached structural components of the HI-LIFT structural frame. The licensee has developed a commercial grade dedication program and identified appropriate pre-operational tests to verify the adequacy of the design and fabrication of the hydraulic cylinders and counterbalance valves. Therefore, the NRC staff has found the design of the hydraulic cylinders, counterbalance valves, and attached structural components of the HI-LIFT structural frame acceptable for the purpose of HI-TRAC transfer cask handling operations at IP3 and in conformance with GDC-1, GDC, 2, and GDC 4.

3.2.2.2 Strand Jack

Design

The licensee provided the following description of the strand jack in the enclosure to the license amendment request dated March 24, 2020 (Reference 1):

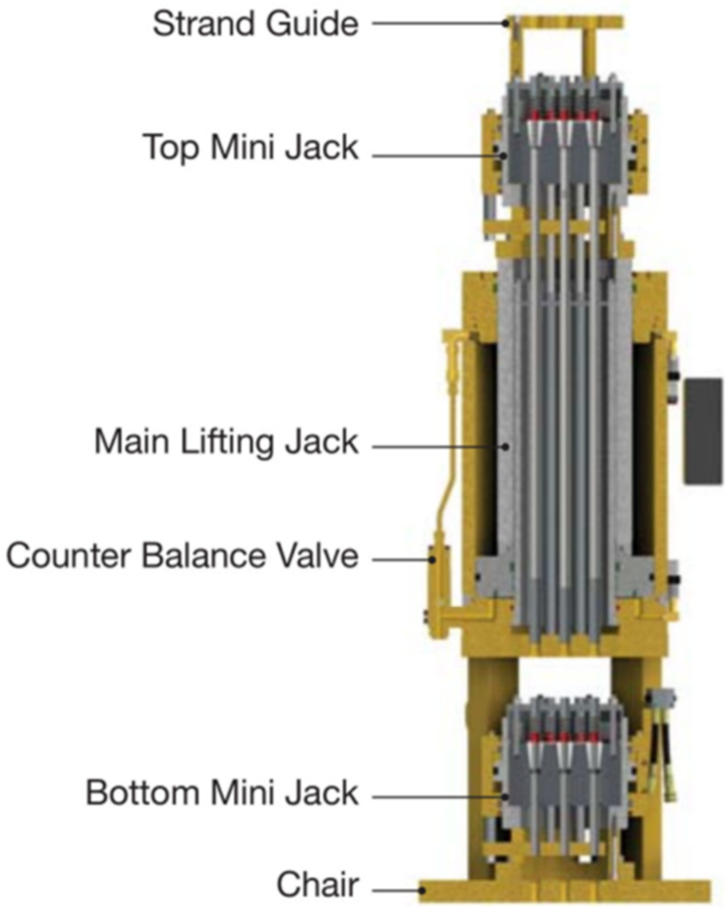
> The HI-LIFT will provide the hoisting capabilities required for DCS loading in the IP3 FSB, utilizing a Strand Jack to lift and lower the load. The Strand Jack is a commercial component used worldwide in the construction industry with proven reliability. The HI-LIFT Strand Jack is used to support the weight of the load and provides the means to raise and lower the load. The HI-LIFT Strand Jack uses a bundle of 48 parallel steel strands to support the HI-TRAC and lift yoke. A strand management system (i.e., recoiler), maintains control of the strands as the load is raised and lowered. The Strand Jack uses two sets of wedge locks and a reciprocating hydraulic cylinder to lift and lower the load. While the load is raised, the upper wedge lock set holds the load in place until the load is taken by the lower wedge lock set. The reverse occurs during load lowering. Strand Jack wedges are only used to impose static friction, and do not provide dynamic energy dissipation equivalent to the mechanical load brake as described under Section 5414.2 of NOG-1. The Strand Jack bundle is designed to meet the requirements of NOG-1 5425.1.(b).2 and the Maximum Critical Load (MCL) does not exceed 10 percent of the total break strength of the strand bundle. The load is shared among all strands and wedges such that the failure of one strand or one wedge does not result in any significant loss of load capacity….

The licensee also provided the following description of strand jack safety features:

> The Strand Jack, which supports the weight of the HI-TRAC and lift yoke, is equipped with multiple safety features. The strand jack control system is equipped with redundant limit switches that limit the upward movement of the HI-TRAC. Two blocking protection is provided by a limit switch that interfaces

> with programmable logic controller (PLC) controls, and a second independent limit switch which removes power from the hydraulic power unit. Features of the PLC-based control system will stop upward motion when either the limit switch or pressure trip setpoint is reached. In addition, hydraulic pressure in the Strand Jack is regulated to limit the upward force that can be exerted in the event of a load hang-up. The Strand Jack has a rated minimum capacity of twice the MCL. The break strength of the bundle strands is greater than ten times the MCL.

The licensee included the following diagram of a strand jack device as Figure 2 in Attachment 1 to the enclosure provided in the license amendment request:



The licensee also provided a description of the load block configuration in Enclosure 4 to its letter dated November 9, 2020. The ends of the strands are captured in an anchor block with a set of anchor wedges. This anchor block utilizes a retainer plate and bolts to ensure the wedges remain engaged and gripped to the strands. The anchor block is integrated into the load block, and the load block includes a fitting that can be directly pinned to a HI-TRAC lifting yoke or other ancillary lifting device.

The licensee established design criteria for the strand jack system to support reliable operation. The licensee included certain design criteria in the HI-LIFT design specification, HI-2188549,

that addressed conformance with applicable guidelines drawn from ASME NOG-1-2004, NUREG-0612, and NUREG-0554. In Enclosure 4 to the letter dated November 9, 2020, the licensee stated that the strand jack would be designed and manufactured consistent with the ASME B30.1 standard. Section 1-7.1.2 of ASME B30.1-2015 states "The strand jack system shall be designed in accordance with the criteria established by the manufacturer or a qualified person." The licensee developed more detailed design criteria for the strand jack based on NUREG-0554 guidelines found to be transferable to the stand jack design. The licensee listed the design criteria important to the safety function of the strand jack in Table 6.2, "Design Criteria Consistent with NUREG-0554," which was provided in Enclosure 1 to the letter dated February 26, 2021. The licensee stated that these design criteria would be incorporated into the HI-LIFT design specification, HI-2188549, "HI-LIFT Specification for IPEC Unit 3."

The licensee evaluated the potential for component failures and provided either justification of a suitably low probability of failure such that it would not be considered credible, or it explained how the failure would be mitigated to maintain control of the load and permit eventual lowering of the load. The licensee provided a failure modes and effects analysis (FMEA) for the strand jack assembly and the associated hydraulic controls in Table 7.1, "FMEA Table for Strand Jack Load Bearing Items," and Table 7.2, "FMEA for Hydraulics and Control System," which were included in the proprietary attachment 1 to Enclosure 1 of the letter dated February 26, 2021 (Reference 4). **[[**

]]. The licensee stated that the strand jack design provides effective load sharing among redundant components, particularly the strands and wedges. The independent capability of each anchor block to support the load, in combination with the design of the strand jack that separates functions, permits a number of components that are essential to lowering the suspended load to be repaired or replaced while the load is suspended from one of the anchor blocks. The licensee addressed these capabilities in detail in the FMEA tables.

Quality Assurance

The licensee provided the following description of the qualification and testing of the hydraulic strand jack in Enclosure 4 to the letter dated November 9, 2020:

> The strand jack is procured as a commercial item and dedicated under the Holtec NQA-1 quality assurance program. Dedication will follow NQA-1, Subpart 2.14, Method 1, and will consist of inspections and tests of the strand jack. Critical characteristics for dedication include functional performance and the ability to lift/lower/hold sufficient load. Functional requirements include the ability to grip and ungrip the strands at each anchor, extend and retract the main cylinder, and sequence these operations to lift and lower the load. Proof load testing requirements, proof load requirements, and post testing inspection shall comply with ASME B30.1-2015, Section 1-7.4. In accordance with ASME B30.1-2015 paragraph 1-7.4.2(b), the proof load test for each manufactured strand jack must be conducted at a minimum of 110% of the strand jack's rated load. The post-test inspection includes checks for worn, cracked, bent, or broken cylinder barrels, structural components and welds, as well as checks for hydraulic fluid leaks.

The licensee provided a list of characteristics associated with the strand jack and how those characteristics identified as critical would be verified in proprietary Table 6.1, "Design Characteristics of the HI-LIFT Strand Jack," which was provided in Enclosure 1 to the letter dated February 26, 2021 (Reference 4). The table identified the verification methods and acceptance criteria for activities related to design, fabrication, and pre-operational testing of the strand jack. These verification methods included inspection of documents, observation of a proof load test, and inspection of components in the primary load path.

Evaluation

The NRC staff evaluated the reliability of the HI-LIFT strand jack in holding the HI-TRAC transfer cask considering the criteria specified in Section 4 of NUREG-0554 for hoisting machinery. The staff focused on the reliability of stopping and holding the load following credible component failures (i.e., those components performing the function of holding brakes in a traditional hoist), the structural capacity of non-redundant components (i.e., those components comparable to a wire rope drum in a traditional hoist), the reliability of the strand system (i.e., those components performing the function of the reeving system in a traditional hoist), and the load block. The NRC staff also evaluated the ability to recover a load stranded by a component failure under the criteria established in Section 3.4, "Emergency Repairs," of NUREG-0554. The NRC staff compared the NUREG-0554 criteria against the design information specified in Revision 2 of the HI-LIFT design specification, HI-2188549, and the information provided by the licensee's letter dated February 26, 2021.

Unlike a wire rope hoist, a strand jack lifting system does not require brakes to stop and hold the load. **[[**

]]. The strand jack uses the reciprocating motion of a jacking cylinder to raise and lower the load suspended from the strands. **[[**

]].

The staff evaluated the effect of potential hydraulic control system failures on the safe operation of the strand jack. Loss of hydraulic power at any time during the strand jack operating cycle would result in a loss of pressure to the counterbalance valves on the main cylinder, thereby locking the main cylinder in position. **[[**

]]. Therefore, a loss of power or hydraulic pressure results in a safe condition with the load supported by the strands held in the anchor blocks. The staff also evaluated a statement from the HI-LIFT design specification, HI-2188549, that no more than one strand could be disengaged by a single mechanical or hydraulic failure. In order to evaluate this statement with respect to hydraulic

system failures, the staff requested the results of a hydraulic system failure modes and effects analysis, which the licensee provided as proprietary Table 7.2, "FMEA Table for Hydraulics and Control System," in Enclosure 1 to the letter dated February 26, 2021. This table included certain failure modes that could challenge the ability to meet the criterion that no more than one strand could be disengaged by a hydraulic control system failure. To resolve this concern, the licensee described a change to the design of the hydraulic control system to ensure that no more than one strand could be disengaged by a single mechanical or hydraulic failure. **[[**

]]. Based upon its review of the licensee's submittals, the NRC staff found the operation of the strand jack hydraulic control system to be acceptably reliable to meet the intent of NUREG-0554 to stop and hold the load following credible equipment failures and loss of power conditions.

The strand jack contains components that perform passive functions and are not redundant. These include the strand jack structure, the main jack hydraulic cylinder, and the two anchor blocks. The licensee has stated these components are designed with at least twice the normal factor of safety and would be subject to additional analyses to ensure the reliability of these components in service. **[[**

]]. Based upon its review of the licensee's statements, the NRC staff found the design criteria applied to structural components of the strand jack to be acceptable.

The strand jack contains hydraulic fluid seals in the main cylinder at the interface between the main jack, which acts as a piston, and the casing of the jack. The counterbalance valves on the main cylinder also contains seals. Although the mini-jacks also contain seals, they do not perform a function related to holding the load because those mini-jacks actuate to release the unloaded collet wedges only. The licensee addressed potential degradation of the seals that resulted in a decreased ability to hold hydraulic pressure. Seal degradation is unlikely to result in a loss of ability to hold the load because excessive leakage by the seals would prevent lifting the main jack from the casing to begin a cask lifting operation and sudden, catastrophic seal failure is also unlikely because the maximum operating pressures are well below the rated design pressure. The licensee stated that degradation would likely be a slowly developing condition. The staff found relatively short stroke length of the main jack, the slow rate of motion providing the ability to monitor the jack, and the periodic inspection of the seals prior to each cask loading evolution provide reasonable assurance that developing seal degradation would be detected before it could challenge the ability of the HI-LIFT to hold the load. The staff found slow degradation of the seals justified because the system operates in a relatively clean environment and seal degradation mechanisms other than those resulting from significantly contaminated hydraulic fluid tend to be slow processes. The staff further found that degradation of the seals would not challenge the HI-LIFT capability to hold the load, based on the licensee's statement that the HI-LIFT structure and strand jack would be qualified to withstand the impact

of the main jack piston reaching the end of travel. **[[**

]].

The strand system, which consists of 48 strands and the wedges that anchor the strands, performs the function of the redundant reeving system in a crane designed to NUREG-0554 criteria. The number of strands provides substantial redundancy such that a sequential overloading of strands would not be credible. Furthermore, the licensee provided justification that the strands would effectively share loading. **[[**

]]. The licensee stated that the strands are protected against two-blocking and other operational errors by limit switches controlling the maximum lift height and by hydraulic system relief valves that limit the maximum lifting force to values that would not damage the strands. The NRC staff found that the strand configuration and operation provide reasonable assurance that a strand or wedge failure could easily be accommodated by the specified strand jack design. Furthermore, operating experience and the justification provided by the licensee provides reasonable assurance that the strand system would reliably hold the load following postulated equipment failures.

The licensee provided general design details related to the construction of the load block in Enclosure 4 to the letter dated November 9, 2020, and proprietary information relative to the load block design in Enclosure 1 to the letter dated November 9, 2020, and Attachment 2 to Enclosure 1 of the letter dated February 26, 2021. The NRC staff determined that the load block design was consistent with guidance in NUREG-0554, as modified by Appendix C to NUREG-0612 for applications where space is limited. Therefore, the load block design criteria provide reasonable assurance that the strand jack would reliably hold the load following credible equipment failures.

The criteria of NUREG-0554 address the ability to repair a crane with the load suspended or the provision of a capability to lower the load if an equipment failure or malfunction immobilizes the crane. The NRC staff reviewed the information provided by the licensee regarding credible failures that could immobilize the strand jack. The NRC staff determined that affected components could be replaced with the load suspended from the strand jack because the upper and lower anchor blocks effectively provide redundant holding capability for the load and components that could credibly fail are accessible while the load is suspended.

Overall, the NRC staff determined that the design proposed for the strand jack provides reasonable assurance that equipment important to safety would be appropriately protected from equipment failures affecting the strand jack, thereby satisfying GDC-4. The licensee has developed a commercial grade dedication program and identified appropriate pre-operational tests to verify the adequacy of the design and fabrication of the strand jack, which satisfies GDC-1. The structural design satisfies GDC-2. Therefore, the NRC staff found the strand jack design acceptable for the purpose of HI-TRAC transfer cask handling operations at IP3.

3.2.3 Summary of Design Evaluation

The NRC staff has completed its review of the IP3 HI-LIFT device and finds that the licensee has adequately qualified the proposed IP3 HI-LIFT device as structurally adequate for its intended use as a reliable HI-TRAC transfer cask handling system in the IP3 FSB. The licensee has also defined an appropriate commercial grade dedication process for the strand jack and hydraulic cylinders that would be procured as commercial items. Also, the licensee has incorporated design features in the HI-LIFT device that provide appropriate protection from the effects of credible equipment failures, and, as a result, the effects of a postulated load drop need not be evaluated to provide reasonable assurance that essential safety functions would be accomplished. Therefore, the NRC staff finds that the HI-LIFT design and description of quality assurance measures applied to design and fabrication demonstrate that the requirements of 10 CFR 50.34(b)(2) regarding demonstration of reasonable assurance that safety functions would be accomplished, GDC 1 regarding quality assurance, GDC 2 regarding appropriate protection against the effects of natural phenomena, and GDC 4 regarding appropriate protection against the effects of equipment failures would be satisfied.

3.3 <u>Installation, Testing, Maintenance, and Operations</u>

3.3.1 HI-LIFT Installation

The licensee noted the following characteristics related to assembly and installation of the HI-LIFT crane in Attachment 2 (Revision 1 to the Holtec Report HI-2188549, "HI-LIFT Design Specification for IPEC Unit 3") of Reference 1.

> The HI-LIFT will be supported entirely by the six-foot thick south SFP wall. Loads from the torque arms on the south truck bay wall will be limited to vertical reactions, through the use of a roller system.
>
> The loads from the weight of the cask are reacted by forces that act on the SFP wall and translational forces react in the vertical direction only against the truck bay wall. The existing [FSB overhead] crane capacity is not affected [by the installation]. Although the range of motion of the [FSB overhead] crane will be limited while the HI-LIFT is in use, use of mobile or temporary lifting equipment will mitigate the impact.
>
> The fuel service platform maintains full operational capability and is unaffected by the presence of the HI-LIFT [crane]. No supplemental fuel handling measures are needed.
>
> Power for the HI-LIFT is drawn from an electrically-powered hydraulic skid, which can be positioned to best suit the loading operations. The skids may be moved and unplugged so permanent wiring [to the crane] is not needed.
>
> All existing rigging, procedures, personnel qualification, drawings, and systems used with the existing [FSB] cranes remain unaffected.

The NRC staff reviewed the above information. The staff determined that installation of the crane may be performed on the SFP wall and over the cask washdown area and that the individual component weights are such that the existing overhead crane permits assembly and

disassembly. However, if necessary for installation, the staff found that the existing IP3 Heavy Load Handling Program and the 40 ton single-failure-proof overhead FSB crane provide acceptable controls for safe installation activities over the cask handling area of the spent fuel pit. The existing overhead FSB crane incorporates design features to prevent component failures from causing a loss of the capability to control suspended loads. The heavy load handling program provides acceptable administrative controls for development of load handling procedures, training, and selection and use of below-the-hook lifting devices.

3.3.2 Pre-Operational Testing

The licensee specified HI-LIFT pre-operational inspection and testing elements in HI-2188549, Revision 3, and in Enclosure 1 to the letter dated February 26, 2021. The NRC staff reviewed the proposed test plan and found it satisfies the intent of the test program described in ASME NOG-1-2004 for Type 1 cranes. Therefore, the NRC staff concludes that the pre-operational test program is acceptable and consistent with the requirements of 10 CFR 50.34(b)(6)(iii).

3.3.3 Operations, Maintenance, and Inspection

The licensee described operations, maintenance, inspection, and testing that would be applied to the HI-LIFT device throughout its life, in Enclosure 4 to the letter dated November 9, 2020, as follows:

> Holtec will provide a detailed Operations and Maintenance (O&M) manual for the HI-LIFT including requirements for inspection, maintenance, and testing for continued compliance. All personnel involved with operating, inspecting, or maintaining the HI-LIFT must be trained in accordance with relevant Holtec and plant procedures. Testing and maintenance of the system will be in accordance with ASME B30.2-1976, "Overhead and Gantry Cranes (Top Running Bridge, Single or Multiple Girder, Top Running Trolley Hoist)," Section 2-2 [5]. In addition, the strand jack and swing cylinders will be subject to the testing and maintenance provisions in ASME B30.1[17].

The licensee provided a complete listing of proposed maintenance activities, inspections, and tests for the HI-LIFT in Table 6.1, "Maintenance Inspections and Tests Program Schedule," in Revision 3 to HI-2188549. The NRC staff reviewed the described operations, maintenance, testing, and inspection of the HI-LIFT and found that the inspection, testing, and maintenance activities are consistent with national consensus standards where applicable and provide reasonable assurance the HI-LIFT would be maintained consistent with safe operation. Therefore, the staff found the maintenance, inspection, and test program satisfies the requirements of 10 CFR 50.34(b)(6)(iv).

3.4 Conclusion

The NRC staff's review of the proposed HI-LIFT crane determined that the crane meets regulatory requirements for its intended purpose of transferring irradiated fuel and certain radioactive waste in the HI-TRAC transfer cask at IP3. Although the NRC staff found that the proposed crane does not conform with certain criteria specified in NUREG-0612, NUREG-0554, and ASME NOG-1-2004, the staff concluded that the proposed HI-LIFT satisfies the intent of these documents in providing a handling system with a level of safety commensurate with the proposed use of the HI-LIFT for transfer of the limited inventory of spent fuel at IP3 using the

HI-TRAC transfer cask. Specifically, the proposed HI-LIFT provides appropriate protection against potential dynamic effects resulting from equipment failures because it uses enhanced design factors to reduce the probability of failure, provides redundancy in certain key components to prevent challenges to the HI-LIFT, and provides defense in depth measures, including the capability to hold the load in the event of cylinder failure and provide for manual actions to restore the HI-LIFT frame to a safe and stable configuration. Therefore, the protection against dynamic effects is commensurate with the safety significance of the load handling activities in the IP3 FSB and, thus, the HI-LIFT may be classified as single-failure-proof.

4.0 STATE CONSULTATION

In accordance with the Commission's regulations, the New York State official was notified of the proposed issuance of the amendment on March 23, 2021. The State official provided comments and questions by e-mail communication dated July 31, 2020, October 22, 2020, and January 19, 2021 (ADAMS Accession Nos. ML21363A158, ML21363A160, and ML21363A164, respectively). The NRC staff held conference calls on February 4, February 17, and April 6, 2021, with the New York State official, reviewed the comments and considered them in its review of the LAR. The State official provided formal comments by letter dated April 21, 2021 (ADAMS Accession No. ML21111A361), stating, in part:

> …the State is providing several recommendations for the NRC that address concerns identified in our review: balancing of the crane's support arms; the analysis of new stresses to the truck bay wall; and HI-LIFT inspection and testing. It is our hope that the NRC ensures that all calculations, evaluations, and analyses, and inspections are performed in a detailed, thorough and comprehensive manner. Subject to the specific concerns and recommendations outlined below, the State does not oppose Entergy's license amendment request.

Following the NRC staff's receipt of the licensee's updated supplement to the LAR dated January 3, 2022, the New York State official was re-notified of the proposed issuance of the amendment on January 27, 2022. The State official had no further comments.

5.0 ENVIRONMENTAL CONSIDERATION

The amendment changes a requirement with respect to installation or use of a facility component located within the restricted area as defined in 10 CFR Part 20. The NRC staff has determined that the amendment involves no significant increase in the amounts, and no significant change in the types, of any effluents that may be released offsite, and that there is no significant increase in individual or cumulative occupational radiation exposure. The Commission has previously issued a proposed finding that the amendment involves no significant hazards consideration (May 5, 2020, 85 FR 26729), and there has been no public comment on such finding. Accordingly, the amendment meets the eligibility criteria for categorical exclusion set forth in 10 CFR 51.22(c)(9). Pursuant to 10 CFR 51.22(b), no environmental impact statement or environmental assessment need be prepared in connection with the issuance of the amendment.

6.0 CONCLUSION

The Commission has concluded, based on the considerations discussed above, that: (1) there is reasonable assurance that the health and safety of the public will not be endangered by operation in the proposed manner, (2) there is reasonable assurance that such activities will be conducted in compliance with the Commission's regulations, and (3) the issuance of the amendment will not be inimical to the common defense and security or to the health and safety of the public.

7.0 REFERENCES

1. Entergy Nuclear Operations, Inc. letter to U.S. Nuclear Regulatory Commission (NRC), "Proposed License Amendment to Revise the Indian Point Nuclear Generating Unit No. 3 Licensing Basis to Incorporate the Installation and Use of a New Auxiliary Lifting Device," March 24, 2020 (ADAMS Accession No. ML20084U773).

2. Entergy Nuclear Operations, Inc. letter to U.S. Nuclear Regulatory Commission (NRC), "Response to Requests for Additional Information - License Amendment Request to Revise the Indian Point Nuclear Generating Unit No. 3 Licensing Basis to Incorporate the Installation of a New Auxiliary Lifting Device," October 2, 2020 (ADAMS Accession No. ML20276A322).

3. Entergy Nuclear Operations, Inc. letter to U.S. Nuclear Regulatory Commission (NRC), "Response to Requests for Additional Information - License Amendment Request to Revise the Indian Point Nuclear Generating Unit No. 3 Licensing Basis to Incorporate the Installation of a New Auxiliary Lifting Device," November 9, 2020 (ADAMS Accession No. ML20314A355)

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Principal Contributors: S. Jones, NRR
I. Tseng, NRR
A. Istar, NRR
B. Lehman, NRR

Date: February 28, 2022

SUBJECT: INDIAN POINT NUCLEAR GENERATING UNIT NO. 3 − ISSUANCE OF AMENDMENT NO. 272 RE: REVISION TO LICENSING BASIS TO INCORPORATE THE INSTALLATION AND USE OF A NEW AUXILIARY LIFTING DEVICE (EPID L-2020-LLA-0051) DATED FEBRUARY 28, 2022

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