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E-61399

U. S. Nuclear Regulatory Commission
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Subject: Application for Amendment 3 to NUHOMS® EOS Certificate of Compliance No. 1042, Revision 8 (Docket 72-1042, CAC No. 001028, EPID: L-2021-LLA-0055) – ASME NOG-1 Compliance and the Matrix Loading Crane (MX-LC)

Reference: [1] Letter E-58329 from Prakash Narayanan, Application for Amendment 3 to NUHOMS® EOS Certificate of Compliance No. 1042, Revision 0 (Docket 72-1042), dated March 31, 2021

Based on recent interaction with the NRC, this submittal provides additional detail to demonstrate the single failure proof capability of the Matrix Loading Crane (MX-LC). This information is provided to demonstrate compliance with CoC 1042 Amendment 3 Condition 5 for lifts of the dry shielded canister (DSC) and transfer cask (TC) above heights not analyzed for an accidental drop, and to comply with CoC 1042 Amendment 3 Technical Specification 5.2.1 for TC/DSC lifting height limits.

Specifically, updated final safety analysis report (UFSAR) Section A.2.1.4.2.1 is added to provide details associated with the design of the MX-LC relative to the single failure proof provisions of ASME NOG-1, “Rules for Construction of Overhead and Gantry Cranes (Top Running Bridge, Multiple Girder).”

Enclosure 1 provides a listing of changed UFSAR pages resulting from this Revision 8 to the application for Amendment 3.

Enclosure 2 provides the UFSAR changed pages associated with this Revision 8 to the application for Amendment 3. The changed pages include a footer annotated as “72-1042 Amendment 3, Revision 8, September 2022,” with changes indicated by italicized text and revision bars. The changes are further annotated with gray shading or a gray box enclosing an added section, as well as a footer to distinguish the Amendment 3, Revision 8 changes from previous Amendment 3 changes.

In order to support a scheduled loading campaign in the third quarter of 2023, TN requests that this licensing action be given a priority to have the amendment become effective before the end of the second quarter of 2023.

Should the NRC staff require additional information to support review of this application, please do not hesitate to contact Mr. Glenn Mathues at 410-910-6538, or by email at Glenn.Mathues@orano.group.

Sincerely,

A. Prakash

Prakash Narayanan
Chief Technical Officer

cc: Chris Jacobs (NRC), Senior Project Manager, Storage and Transportation Licensing Branch Division of Fuel Management

Enclosures:

1. List of UFSAR Pages Involved in CoC 1042 Amendment 3, Revision 8
2. CoC 1042 Amendment 3, Revision 8 UFSAR Changed Pages

List of UFSAR Pages
Involved in CoC 1042 Amendment 3, Revision 8

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Enclosure 2 to E-61399

CoC 1042 Amendment 3, Revision 8

UFSAR Changed Pages

A.2.1.4.2 Other Transfer Equipment

The NUHOMS® EOS HSM-MX transfer equipment (i.e., ram, skid, transfer trailer, MATRIX loading crane (MX-LC), MATRIX retractable rolling tray (MX-RRT) and MX-RRT handling device (RHD)) are necessary for the successful loading of the DSCs into the HSM-MX.

A.2.1.4.2.1 MX-LC

A.2.1.4.2.1.1 Introduction

The NUHOMS® MX-LC is the device used as part of the NUHOMS® transfer equipment, designed and built to assist in loading the DSC into the HSM-MX. The MX-LC is a Part 72 [A.2-6] ITS piece of transfer equipment. The MX-LC is designed, fabricated, installed, tested, inspected, and qualified in accordance with *the applicable portions of* ASME NOG-1 [A.2-7], as a Type I gantry crane. In addition, the MX-LC is engineered as "single-failure-proof" per NUREG-0612 [A.2-9]. The MX-LC is considered ITS since it supports the loaded TC/DSC during the DSC's insertion and extraction both into and out of the HSM-MX, respectively, thus providing both a structural and retrieval function.

The MX-LC is a Type I gantry crane as defined in ASME NOG-1, which provides rules for the design, manufacture, testing, inspection, shipment, storage, and erection of electric overhead and gantry multiple girder cranes with top running bridge and trolley used at nuclear facilities. ASME NOG-1 covers three types of cranes (Type I, II and III), where the Type I crane has the most stringent design requirements, and applies to a crane used to handle a critical load, in this case the loaded EOS-TC.

The Type I crane is required to be designed and constructed so that it will remain in place and support the critical load during and after a seismic event, but does not need to be operational after that event. Single- failure-proof features are specified in ASME NOG-1 in such a way that any credible failure of a single component will not result in the loss of capability to stop and hold the critical load.

The MX-LC is comprised of the following subcomponents: a lower boom consisting of four towers with gantry boxes that ride on crane rails in the horizontal x-direction parallel to the face of the HSM; an upper boom, which is installed over the lower boom towers and extends in the vertical z-direction via four jacking screws; and two lift links, which attach the upper boom to the TC skid and ride along the upper boom in the horizontal y-direction in the axial direction of the HSM-MX compartment.

All Indicated Changes are MX-LC details.

The MX-LC is used to position the TC skid in the proper position to dock the TC to the HSM-MX at the designated compartment (either upper or lower compartment) of the HSM-MX for the purpose of inserting the DSC into the HSM-MX or withdrawing it from the HSM-MX. The TC skid (TS) with the attached TC is transferred from the transfer trailer (TT) or self-propelled modular transporter (SPMT) to the MX-LC, where the lift links are connected to the TC skid and the TC skid is subsequently detached from and lifted off the transfer trailer/SPMT. Operationally, the MX-LC travels along the face of the HSM-MX on rails positioned on the ISFSI apron, lifts the TC skid to the proper height, and docks the TC to the HSM-MX. Refer to Figure A.2-2 for details of the MX-LC component.

The MX-LC is a unique telescopic gantry crane with jacking towers, and not an electric overhead traveling crane, as described in ASME NOG-1 [A.2-7], and as such, there are multiple sections of ASME NOG-1 [A.2-7] that do not apply to the MX-LC. Those portions of ASME NOG-1 that are not applicable to the design of the MX-LC involve features for a typical gantry crane with a top running wire rope hoist and trolley unit that do not exist on a telescoping gantry crane with self-locking screw mechanisms. Therefore, the MX-LC component parts must be addressed individually, with regards to applicable criteria located within U.S. NRC regulatory guides and nuclear and non-nuclear industry standards, for the purpose of confirming its single-failure-proof handling capability. The following sections outline the integration of the standards and substantiate the safety of the described systems.

The MX-LC is designed and analyzed to meet the intent of NUREG-0612 [A.2-9], "Control of Heavy Loads at Nuclear Power Plants,"

> *"To provide adequate measures to minimize the occurrence of the principal causes of load handling accidents and to provide an adequate level of defense-in-depth for handling heavy loads near spent fuel and safe shutdown systems."*

Understanding the ISFSI does not have 10 CFR Part 50 safe shut down equipment or a spent fuel pool, it is recognized that the DSCs loaded with fuel must be safely and securely handled, thereby protecting the fuel from damage and protecting the site and surrounding areas from any potential radiological impacts. Even though the potential for a radiological release is very low, the design objective of the MX-LC is to prevent the occurrence of load handling accidents. Therefore, the licensing basis for the MX-LC is to provide a lifting and handling system that is highly reliable, which makes the likelihood of a load drop event extremely small.

All Indicated Changes are MX-LC details.

NUREG-0612, Section 5 provides the general guidelines for controlling heavy loads and, specifically, paragraph 5.1.6 provides guidance in establishing the criteria for single-failure-proof handling through the use of redundant load paths or the implementation of increased factors of safety. NUREG-0612 also points to NUREG-0554, "Single-Failure-Proof Cranes for Nuclear Power Plants", to provide guidance on design, fabrication, installation, and testing of new cranes that are of a highly reliable design. The limitation of NUREG-0612 and its associated reference to NUREG-0554 is that it provides guidance only for cranes and hoisting systems that are "single-failure-proof" electric wire rope hoists, and it does not provide specific guidance for other types of cranes and hoisting systems that may be better suited for a specific application.

As stated in Regulatory Issue Summary (RIS) 2005-25, Supplement 1, "…the application of the criteria for Type 1 cranes from ASME NOG-1, "Rules for Construction of Overhead and Gantry Cranes," to the design of new overhead heavy load handling systems is an acceptable method for satisfying the guidelines of NUREG-0554, "Single-Failure-Proof Cranes for Nuclear Power Plants".

Additionally, from NUREG-0800, Section 9.1.5, "Overhead Heavy Load Handling Systems", Section I.4.C, "The probability for a load drop is minimized by an overhead handling system designed to comply with the guidelines of NUREG-0554 and lifting devices that comply with American National Standards Institute (ANSI) N14.6 or an alternative based on American Society of Mechanical Engineers (ASME) B30.9. An overhead handling system that complies with ASME NOG-1 criteria for Type 1 cranes is an acceptable method for compliance with the NUREG-0554 guidelines."

For the MX-LC design, applicable portions of ASME NOG-1 are used as guidance for the design of the gantry system. Although referred to above from a regulatory perspective, the requirements of NUREG-0554 do not apply to the MX-LC. MX-LC components that are not within the scope of ASME NOG-1 invoke applicable ANSI or ASME B30 Standards and are designed with increased factors of safety and/or implemented redundancy. Special lifting devices per ANSI N14.6 have factors of safety of six on material yield strength and ten on material ultimate strength. All the components and their standards work together to provide a lifting system that is designed for the specific and limited purpose of safely lifting the loaded TC and then transferring the DSC from the EOS Transfer Cask (EOS-TC) to the HSM-MX.

The loaded TC being handled by the MX-LC when above the lift height restriction of TS 5.2.1 is classified as a critical load, per NUREG-0612. Safe handling of this critical load is accomplished by ensuring, through the use of redundancy in active components or load paths and through the use of increased factors of safety, that failure of the heavy load system is highly unlikely and therefore provides adequate defense-in-depth for the MX-LC heavy loads.

All Indicated Changes are MX-LC details.

The MX-LC has a rated lifting capacity of 162 tons. The maximum weight of the loaded TC is approximately 139 tons. The rated lifting capacity of the MX-LC is adequate to support the safe lifting and handling of the combined weights of the loaded TC, transfer skid and hydraulic ram of approximately 162 tons.

The MX-LC major design data is tabulated in Table A.2-3. Design parameters for the major components are presented in Table A.2-4.

A.2.1.4.2.1.2 Code Applicability

NUREG-0612 Criteria:

- *Scope is control of heavy loads over the spent fuel pool, fuel in the core, or equipment that is credited to achieve safe shutdown (Section 1.1).*
- *Special lifting devices should satisfy ANSI N14.6 [A.2-14] (paragraph 5.1.1(4)).*
- *Twice the design safety factor is required for lifting devices (paragraph 5.1.6(1)(a)).*
- *New cranes shall be designed to meet NUREG-0554 (paragraph 5.1.6(2)).*

NUREG-0800, 9.1.5, Criteria:

- *An overhead handling system that complies with ASME NOG-1 criteria for Type 1 cranes is an acceptable method for compliance with the NUREG-0554 guidelines (Section I.4.C).*

ASME NOG-1 Criteria:

- *NRC position, as documented in RIS 2005-25 and NUREG-0800, 9.1.5, [A.2-10] is that ASME NOG-1 is an acceptable method for satisfying the guidelines of NUREG-0554.*
- *The Type I crane is used to handle a critical load. It is designed and constructed so that it will remain in place and support the critical load during and after a seismic event, and shall include single-failure-proof features so that any credible failure of a single component will not result in the loss of capability to stop and hold the critical load (Section 1150).*
- *Load combinations are provided in Section 4140.*
- *Operating load allowable stress is 0.5 of yield and extreme environmental load allowable stress is 0.9 of yield (Table 4311-1).*
- *Gantry overturning shall have a safety factor of 1.5, unrestrained, for operational loading, and 1.1 under extreme environmental, with restraints (paragraph 4457).*
- *Components whose failure, due to radiation, could result in loss of the single-failure-proof features that hold the load either shall be designed to withstand the specified radiation or shall have a specific replacement period (paragraph 1141(c)).*

ANSI N14.6 Criteria:

- *Does not apply to cranes.*

All Indicated Changes are MX-LC details.

- *Scope is special lifting device that transmits the load from structural parts of the container to the hook of an overhead hoisting system (paragraph 1.3).*
- *Load bearing members shall have a factor of safety of 3 to yield and 5 to ultimate (para.4.2.1.1).*
- *For critical loads, load bearing members shall have twice the normal stress design factor (paragraph 7.2.1).*

A.2.1.4.2.1.3 Component Design Basis for MX-LC

Gantry Crane Upper and Lower Booms including Gantry Boxes, Header Beams and Cross Beams

ASME NOG-1 for operating loads and seismic. Refer to NOG-1, paragraph 4140 for load combinations and Section 4300 for allowable stress criteria.

Lift Links Connecting the Transfer Skid to the Cross Beams

ANSI N14.6 for special lift device for operating loads and seismic with factors of safety of 6 and 10. Load shared equally between two lift links.

Transfer Skid

ANSI N14.6 for special lift device for operating loads and seismic with factors of safety of 6 and 10: Design load of 139 ton for loaded TC.

A.2.1.4.2.1.4 Functional Specification and Design Criteria

The operational period is limited to loading campaigns at nuclear power plant sites. A typical loading campaign for an operating site involves 6 to 12 cycles, where loading campaigns at decommissioned sites can be up to 100 cycles. The MX-LC is conservatively designed for 150 load cycles per year over a 50-year operating period for a total of 7,500 full-load cycles. At this demand, a metal fatigue analysis is not required, due to the combined effect of the low number of full-load cycles and the very low allowable stresses of ASME NOG-1.

Lifting and lowering speeds for the upper boom of the MX-LC raising the TC to the selected HSM-MX compartment are limited to a maximum of 12 inches/minute. Travel speed of the gantry lower boom along the track rails with the TC loaded in the MX-LC is 72 inches/minute. Axial travel of the lift links along the trolley cross beams for docking and undocking the TC to the HSM-MX under load is controlled to a maximum of a 2 inches/minute. Table A.2-5 summarizes the component speed limits.

All Indicated Changes are MX-LC details.

The design criteria used for the MX-LC is specified in ASME NOG-1, Section 4000. The load combinations identified in paragraph 4140 have been evaluated using the loads that are applicable to the MX-LC in the specific configurations where such loads apply. Controlling load combinations have been used to determine component stresses and then are compared to applicable allowable stresses. The sum of simultaneously applied loads (static and dynamic) do not result in stress levels which would cause any permanent deformation, and thus, the MX-LC fully meets this requirement of ASME NOG-1.

Critical Load

The MX-LC critical load is defined as 200% of the rated load to account for single-failure-proof design requirements. The rated load is equal to the credible critical load and is based on the maximum weight of the EOS-TC containing a DSC including the Transfer Skid with the hydraulic ram, which is 162 tons. Therefore, the resulting critical load for design purposes is 324 tons for the MX-LC system.

Operating Environment

The MX-LC is located outdoors at the ISFSI pad and, as such, is designed for an outdoor environment (i.e., not located in a controlled environment). The design basis normal operating temperature range is 0 °F to 100 °F with relative humidity of 5% to 100%.

Radiation doses from the loaded transfer cask are extremely low, and there are no identified hazardous chemical conditions for the MX-LC.

The MX-LC is not in a reactor containment application, thus considerations for containment pressure or pressure fluctuation for closed box beam girders are not applicable.

Material Properties

ASME NOG-1 addresses the concern for material brittle fracture. Therefore, material testing for the MX-LC follows the criteria specified in ASME NOG-1. The MX-LC is primarily constructed from ASTM A572 Grade 50 plate material, where ASTM A514 plate material is specified where a higher strength plate is needed. Material Properties can be found in Chapter 8.

In accordance with the requirements of ASME NOG-1 and ASME Section III, carbon steel materials exceeding 5/8 inch are impact tested in accordance with ASTM A370. Weld filler materials for welds with an effective throat exceeding 5/8 inch are also impact tested.

ASME NOG-1 requires that the impact test temperature be at least 30 °F below the minimum operating temperature. Acceptance values shall be per ASTM A370 Section 26.1 with the lowest service temperature of 0 °F in such a way that the impact testing temperature shall be at least -30 °F.

All Indicated Changes are MX-LC details.

Structural Design

In accordance with ASME NOG-1, the MX-LC is classified as a Type I crane, since it is used to handle a critical load. It is designed to retain control of and hold the load during and after a design basis seismic event. The design includes the stress analysis of the structural elements of the MX-LC and their connections, as well as a stability analysis to demonstrate that the MX-LC will not experience significant sliding or tipping under seismic loading.

For these seismic analyses, a pair of wheel chocks is provided for each of the four gantry boxes to restrain the gantry lower boom from sliding under seismic loading. Retention brackets are also provided at each gantry box to prevent the wheels from leaving the rails during a seismic event. Connections between the upper boom and face of the HSM-MX are provided when in the raised configuration for loading the upper compartments, and a connection between the transfer skid and HSM-MX is also provided. The MX-LC upper boom assembly has four telescoping sections which are braced with viscous dampers to accommodate earthquake loads.

Seismic loads imposed on the MX-LC consider ground motions due to a safe shutdown earthquake (SSE) applied in all three orthogonal directions. The ground motions correspond to the enhanced RG 1.60 response spectrum [A.2-13] scaled to a ZPA of 0.3g in both the horizontal and vertical directions. The mass considered during a seismic event is the distributed mass of the MX-LC and the credible critical load.

The structural evaluation of the MX-LC during lifting of the loaded transfer cask is performed for the load combinations specified in ASME NOG-1, Subsection 4140. The credible critical load of 162 tons is combined with the crane deadload and SSE load for the most limiting extreme environmental load combination. Four configurations are considered for the MX-LC, with the upper boom both in the lowered and raised positions, and with the lift link assemblies both in the fully extended and fully retracted positions. The raised position governs the design due to the higher center of gravity for the load relative to the MX-LC structure.

The MX-LC structural analysis is performed using a finite element model of the MX-LC. The seismic input is applied using the nonlinear time history method. Use of a linear time history method is not possible due to the non-linear characteristics of the viscous dampers in the structural model. Five different time history motions are considered with all three components of earthquake motion applied simultaneously. The time histories are compatible with the specified horizontal and vertical target spectrum (5% spectral damping). These target spectra are based on Regulatory Guide 1.60 [A.2-13] target spectra scaled to a ZPA value of 1.0g with an enhancement (i.e., increase in spectral amplification) in the spectral acceleration levels for both the horizontal and vertical spectra between the frequencies of 9 and 45 Hz. All five time histories are considered in the dynamic transient analyses in the seismic stability models. These time histories are scaled from 1.0g to 0.3g in the horizontal and vertical directions.

All Indicated Changes are MX-LC details.

The results from the controlling load combination are compared to the applicable allowable stresses to demonstrate the structural qualification of the MX-LC. The results meet the requirements of ASME NOG-1, Section 4300. Table A.2-6 provides a summary of the analysis results for key components for the seismic (extreme environmental) loading condition.

Lamellar Tearing

The primary load bearing members for the upper and lower booms, lift links and trolley cross beams are fabricated from plate steel, not rolled structural members. Primary loads are not applied in the through thickness of the material without adequate stiffening. Joints subject to lamellar tearing are avoided in the design, except for possible low loading conditions not susceptible to lamellar tearing.

All butt welds, as defined by ASME, are radiographed and all other primary welds are magnetic particle or dye penetrant examined in accordance with the requirements of ASME NOG-1, Section 4251.4.

Structural Fatigue

A fatigue analysis is not necessary if the loading cycles are less than 20,000 full-load cycles. The load cycles for the MX-LC are less than 7,500 over a 50-year operating period.

Welding Procedures

All welds and welding procedures are performed and qualified in accordance with the AWS D1.1, including preheat and post-weld heat treatment recommendations.

A.2.1.4.2.1.5 Safety Features

The MX-LC satisfies the single-failure-proof criteria of NUREG-0612 by providing a combination of fail-safe features including self-locking screw spindle drives, increased load design factors, as well as structures designed to the criteria of ASME NOG-1 for compliance with single-failure-proof critical load handling.

Auxiliary Systems

Auxiliary systems are designed in such a way that in the event of a single component failure, the load is retained and held in a stable or immobile safe position. Single-failure-proof features of critical component parts of the MX-LC system are identified below.

The MX-LC upper boom raises the transfer skid with the loaded transfer cask to the selected storage compartment of the HSM-MX. Lifting and lowering the load is accomplished by four screw spindle drives (one per each boom tower) using a variable frequency drive motor with all four drives synchronized together. There is no braking function required to hold the load, in such a way that there is no need for a redundant braking system to stop the movement of the upper boom. Rather, the screw spindle thread and worm drive gear are self-locking, which effectively holds the load in the event of a loss of electrical power or failure of the drive motors. The screw spindle drives are designed to 200% of the design load such that structural failure of these components is not credible.

The travel of the gantry along the track rails (i.e., bridge movement direction) is performed by four gantry drives consisting of an integrated motor and gear drive assembly. Each of the sixteen-wheel gantries has a drive arrangement with 50% of the wheels driven. The gearing is self-locking which effectively stops the movement of the gantry in the event of a loss of electrical power or failure of the drive motor. The gearing is designed to 200% of the design load such that structural failure of these components is not credible. Service braking is provided by the variable frequency drives, and parking/emergency braking is provided on each of the four gantries by a motor brake. Based on this design, there is no need for a redundant braking system to stop the gantry travel in the bridge movement direction.

The travel of the lift links along the trolley rail on the cross beams of the upper boom (i.e., trolley movement direction) is performed by two electro-mechanical actuators, where the speeds of those actuators are synchronized and controlled through variable drive frequency units with acceleration and deceleration limits set in the controller. The screw spindle thread and worm drive gear in the electrical cylinders are self-locking, which effectively stops the movement of the lift links in the event of a loss of electrical power or failure of the drive motor. The gearing is designed to 200% of the design load in such a way that structural failure of these components is not credible. Based on this design, there is no need for a redundant braking system to stop the travel of the lift links in the trolley movement direction.

Special lifting devices associated with the MX-LC including the lift links and transfer skid are sized in accordance with ANSI N14.6 [A.2-14]. In accordance with NUREG-0612 and ANSI N14.6, if a lifting device has twice the minimum required design safety factor, it satisfies the requirements for a single-failure-proof handling system. This is accomplished by designing these components for 200% of the design load.

All Indicated Changes are MX-LC details.

Electrical Control Systems

The MX-LC is designed with automatic controls and limiting devices such that in the event of inadvertent operator action, component malfunction, or failure of subsystem control functions occur during the load handling, these occurrences do not prevent the system from stopping and holding the load. The system is equipped with sensors and instruments that monitor and measure the various conditions of interest to operations, in such a way that the control system provides maximal probability that normal threshold limits will not be exceeded and that undesired operational conditions or events will not occur or are adequately mitigated.

The electrical components of the MX-LC are not credited to support the load. De-energizing the system provides a fail-safe method for holding the load. An emergency stop button, which de-energizes all electrical circuits and motor controls, is provided at the operator control panel.

Hoist and travel motions are procedurally controlled to be very slow. Only one motion can be performed at a given time, as limited by the controller logic. The lifting, lowering and travel speeds have pre-programmed independent controls that limit the crane operator from exceeding predefined speeds. The speed settings are factory set and cannot be changed or adjusted by the crane operator. To ensure that travel distances are not exceeded, travel encoders and sensors are provided with stop limits so that electric cylinders and the jacking screws cannot be run to the end of their stroke which could cause damage.

A load sensing system with limit device to protect against the potential for an overload condition is not necessary for the MX-LC since the potential for a load hang-up is not credible, and the load carried by the MX-LC is highly repeatable (i.e., crane load is limited to the configuration with a loaded transfer cask with the hydraulic ram installed, located on the transfer skid which is connected to the MX-LC lift links). Furthermore, after the DSC is loaded and sealed, and the transfer cask lid is installed, the weight of the loaded transfer cask is confirmed by the plant's cask handling crane load sensing system. The weights of the transfer skid and hydraulic ram are fixed (i.e., known weights). Therefore, the weight of the load on the MX-LC crane is pre-determined prior to lifting the load with the MX-LC, so that a load sensing system with a hoist overload limit device is not required.

The MX-LC control system does not ensure any safety function by itself, as it does not command the handling equipment in an automatic mode, but only in manual control mode with a human-in-the-loop. The MX-LC equipment is operated under administrative controls (i.e., trained operator and procedures) with an engineered electrical control system designed to prevent and/or mitigate the consequence of human error or equipment failure.

A.2.1.4.2.1.6 Emergency Repairs

If the MX-LC is immobilized because of malfunction or failure of controls or components while holding the load, the crane can hold the load indefinitely while repairs or adjustments are made. Repairs may be made at any location along the MX-LC track rail system. If the gantry drive system is inoperable, the MX-LC can be manually pulled to the loading area at the end of the HSM-MX array if required for repairs and/or for installation of the TC lid.

In lieu of a "manual operation" to lower and secure the load, contingency rigging is available to lower the load. Although the MX-LC is designed as single-failure-proof, that does not preclude the possibility of an operational/functional failure (not gross structural failure) of the lifting equipment. The lifting equipment is qualified to fail safe (i.e., stop movement and continue to hold the load), but could lose its operational function to raise or lower the load. In the event the lifting equipment is unable to be repaired, provisions are available in an operating instruction to safely lower the load via alternative means.

The contingency rigging replaces the load path of the lift links and trolley assemblies, which connect the loaded transfer skid to the trolley rails. This rigging consists of synthetic slings connected to the transfer skid and trolley rails with intervening air operated chain hoists to lower the load. The synthetic slings conform to ASME B30.9 and the chain hoists conform to ASME B30.16. The rigging is designed to meet the single-failure-proof design requirements of NUREG-0612, by either use of rigging with double the required capacity, or by the use of redundant rigging with independent load paths, where the secondary rigging picks up the load in the event the primary rigging fails. The rigging is classified as ITS, therefore, the contingency rigging hardware has the same single-failure-proof design requirements and safety classification as the MX-LC components that it replaces.

A.2.1.4.2.1.7 Hoisting Machinery

The MX-LC is designed in accordance with the applicable portions of ASME NOG-1 to lift the 162-ton loaded transfer cask including the transfer skid and hydraulic ram and dock the transfer cask to the HSM-MX. All specified static and dynamic loadings during MX-LC lifting and lowering have been evaluated. Lifting devices are designed for twice the lifted load, in accordance with NUREG-0612 and ANSI N14.6, as applicable.

The primary hoisting component of the MX-LC is the telescoping upper lift boom of the gantry assembly (Figure A.2-2). The upper boom lifts and lowers the load using the lift links that are hung off the upper boom trolley rails and attach to the transfer skid with the loaded transfer cask and ram. Vertical screw spindle drive assemblies (one in each of four lower boom towers) hoist the load using the screw drive motor and gear box, which are located in the gantry boxes.

All Indicated Changes are MX-LC details.

The upper and lower boom sections are designed and manufactured to match the boom strength to the lifting capacity and stability of the machine. The manufacturing process ensures precise tolerances and straightness for the booms.

The screw spindle drive assemblies are self-locking and provide the primary means to hold the load in a fail-safe manner.

The hoisting function is controlled by four synchronized variable frequency drive (VFD) motors, which provide very precise load movement regardless of any difference in load that may exist in each gantry tower. The system is designed in such a way that all four towers move at the same speed, direction and final distance. Travel encoders are provided to monitor the hoisting height in each gantry tower with such indication provided on the control panel. A complete set of backup encoders is provided in the event of a malfunction of the primary encoder.

Reeving System

The MX-LC does not utilize a wire rope reeving system, so safety issues with rope reeving, rope wear, groove alignment, sheave pitch diameter and fleet angle are not applicable. A single-failure-proof gantry crane lift system is used for raising the loaded transfer cask to the selected compartment of the HSM-MX.

Drum Support

The MX-LC does not utilize a hoisting drum for a wire rope reeving system, so safety issues with support for the load hoisting drums on the trolley and a drum braking system are not applicable. The primary load carrying members are the pair of lift links which are captured on the trolley rails of the cross beams spanning between the two header beams of the upper boom.

Head and Load Blocks

The MX-LC does not utilize head and load blocks. A hoist is not used to lift the loaded transfer cask, so safety issues associated with a traditional block type hoisting system are not applicable.

Hoisting Speed

CMAA Specification #70 recommends that the hoist raising and lowering speed for a 100-ton crane be no more than 48 inches per minute. The lifting and lowering speeds for the MX-LC upper boom are limited to 12 inches per minute, which is also much less than the slow speed restriction of 48 inches per minute allowed by NOG-1 Table 5331.1-1 for a rated load between 150 and 249 tons. This low lifting/lowering speed of the MX-LC provides an extra margin of safety for the hoisting equipment.

All Indicated Changes are MX-LC details.

Designing Against Two-Blocking and Load Hang-up

"Load Hang-Up" is an act in which the load is stopped by a fixed object during hoisting, which can possibly overload the hoisting system. "Two-Blocking" is an act of continued hoisting to the extent that the upper head block and the load block are brought into contact, and unless additional measures are taken to prevent further movement of the load block, excessive loads are created in the reeving system.

ASME NOG-1 defines a load hang-up force as "load hang-up forces at maximum hoisting speed, including inertia," which involves a dangling load on the crane hook that gets hung up causing instability in the crane. In the particular case of the MX-LC, a load hang-up is considered non-credible due to the specific configuration of the crane with limited potential for interferences to the load, the repeatable nature of the crane's travel path and load configuration (i.e., transfer cask on transfer skid connected to MX-LC), and in consideration of the slow lifting speed of the crane and monitoring of the load by the crane operator and dedicated spotter during movement of the load. Furthermore, while the load is being lifted, movement of the gantry in the bridge and trolley directions is precluded by interlocks within the MX-LC controller logic, thereby further reducing the potential for a load hang-up event to occur. NUREG-0612, Appendix C indicates that a system of interlock circuitry preventing movement of the bridge and trolley while lifting the load is an acceptable alternative to designing for load hang-up.

A two-blocking condition is not possible for the MX-LC since it does not utilize load blocks or a load reeving system.

Lifting Devices

Special lifting devices that are associated with the MX-LC are conservatively designed for 200% of their design loads, which effectively applies factors of safety of ten on ultimate and six on yield, and therefore, satisfies the required single-failure-proof criteria of ANSI N14.6. Special lifting devices include the pair of lift links and the transfer skid.

Wire Rope Protection

The MX-LC does not utilize a wire rope reeving system for hoisting, thus wire rope protection against side loads due to hoisting angles departing from a normal vertical lift is not needed. Therefore, the MX-LC is not susceptible to a side load failure mechanism due to hoisting angles departing from a normal vertical lift.

Machinery Alignment

The proper functioning of the MX-LC during load handling is ensured by providing adequate support strength of the individual component parts and their associated welds/connections. Gear trains used to drive the MX-LC hoisting, and travel functions have twice the required capacity.

Hoist Braking System

The MX-LC screw spindle drives are self-locking and will hold the load in the event of a loss of electrical power or failure of the drive motors. Therefore, a redundant hoist braking system is not required.

A.2.1.4.2.1.8 Bridge and Trolley

Braking Capacity

The MX-LC has inherent safety features because the gantry boxes on the track rails and the lift links on the trolley rails do not move unless power is applied to the drive motors. This ensures that the crane motion stops in the bridge and trolley travel directions whenever power is removed. Once the drive motors are de-energized, the self-locking feature of the gearing stops all motion so that traditional braking hardware is not required.

The MX-LC travel speed is limited to 6 feet per minute, which is much less than the travel speed limits from CMAA #70 or NOG-1.

Safety Stops

Limiting devices are provided to control over travel in the bridge and trolley travel directions. In the bridge direction, end stops are provided on the gantry track rails to limit the travel of the gantry boxes. In the trolley direction, the electric cylinder restraint acts as a stop for the retracted trolley position, and the HSM-MX acts as a stop in the extended trolley position when docking the transfer cask to the HSM.

An emergency stop button is provided on the MX-LC control panel.

A.2.1.4.2.1.9 Drivers and Controls

Driver Control Systems

All movements of the MX-LC are performed by electro-mechanical devices using variable frequency drive (VFD) motors.

Malfunction Protection

Means are provided in the control circuits to sense and respond to abnormal conditions.

All Indicated Changes are MX-LC details.

<u>Slow Speed Drives</u>

The hoisting function is controlled by four VFD motors that are synchronized to ensure even travel of the screw drives when lifting/lowering the load. If one gantry tower is running ahead of the others, the slow tower mode is entered so that the other towers can catch up. The system will stop all tower movement if a single tower exceeds the preset limit.

<u>Safety Devices</u>

The lifting, lowering, and travel speeds have independent controls that limit the operator from exceeding predefined factory set speeds. In the event of a malfunction of the drive system or loss of power to the drive motors, the self-locking feature of the gantry screw spindle drives can hold the load indefinitely while repairs or adjustments are made. The load cannot be inadvertently lowered or dropped.

<u>Control Station</u>

The MX-LC is provided with a control station that is manned by the crane operator. All operations for the hoisting and travel functions of the gantry crane are performed at the control station. An E-stop switch is also provided. Cameras located on the MX-LC and transfer skid are provided to assist the crane operator in monitoring the position of the load and aligning the transfer cask to the HSM during the docking process.

A.2.1.4.2.1.10 Installation Instructions

Procedures are provided for the assembly and installation of the MX-LC. Operating procedures and maintenance manuals include a full explanation of the crane handling system, its controls, and the limitations for the system, and include the requirements for installation, testing, operation, and maintenance of the MX-LC.

A.2.1.4.2.1.11 Testing and Preventative Maintenance

Assembly, inspection, and testing of the MX-LC are performed in accordance with ASME NOG-1, Section 7000, under the approved TN Americas LLC (TN) Quality Assurance (QA) program. All required documentation is verified prior to shipment.

A.2.1.4.2.1.12 Static and Dynamic Load Tests

After the initial assembly of the MX-LC, the crane is tested without any load applied in accordance with ASME NOG-1, paragraphs 7250 and 7421 (no-load tests). The crane is taken through the full range of lifting heights, the full range of bridge and trolley travel, and over the full range of lift and travel speeds. Mechanical, electrical and control functions of the MX-LC equipment are verified for proper operation.

All Indicated Changes are MX-LC details.

After the no-load test, the crane is loaded to the maximum capacity of 162 tons in accordance with ASME NOG-1, paragraph 7422 (full load test). Testing is performed over the full range of lifting/lowering speeds (0.5 inches per minute to 12 inches per minute) up to the maximum height of the lift. Proper operation of the screw spindle assemblies and motor drives is verified. Similarly, proper operation of the gantry travel along the track rails and travel of the lift links on the trolley rails is verified.

After the full load test, the crane is rated as load tested at 125% of the maximum capacity of 162 tons in accordance with ASME NOG-1, paragraph 7423 (rated load test). The test load is lifted a sufficient distance to ensure that the load is fully supported by the crane. Proper operation of the screw spindle assemblies and motor drives is verified. Similarly, proper operation of the gantry travel along the full length of the track rails and travel of the lift links on the trolley rails is verified.

Two-Block Tests

A two-block condition is not applicable to the MX-LC because there is no head or load block. Rather, the load is raised/lowered on the upper boom by extending/retracting the screw spindle drive assemblies. Therefore, a two-block test is not required.

Operational Tests

After assembly of the MX-LC at the plant site but prior to performing HSM loading operations, functional tests of the MX-LC are performed using the empty transfer cask to verify the proper functioning of safety devices and performance of the crane as designed.

A.2.1.4.2.1.13 Maintenance

During operations, the crane may be subject to degradation due to use and exposure. Good maintenance practices and pre-operational inspections prior to each cask loading campaign ensure that the crane operates safely and maintains its full rated capacity of 162 tons. The crane will be in service intermittently for up to 50 years, loading as many as 7,500 DSCs. Typical maintenance steps for the MX-LC when in service are similar to those from when the crane was initially placed into service. The MX-LC operation and maintenance manuals include the necessary maintenance activities and pre-operational checks.

A.2.1.4.2.1.14 Operating Manual

Operating procedures and maintenance manuals for the MX-LC have been developed by TN for use at ISFSI sites. These documents provide the necessary information and guidance for use in checking, testing, and operating the MX-LC.

A.2.1.4.2.1.15 Quality Assurance

The TN QA program is implemented to ensure that the requirements of ASME NOG-1 with regards to design, fabrication, installation, testing and operation of crane systems for safe handling of critical loads are implemented. The MX-LC and associated components are procured under the QA program. Detailed quality assurance requirements for suppliers are identified in the supporting QA plan. There are two graded quality categories for the MX-LC, defined as Quality Categories B and C.

ASME NOG-1, Section 2000 requires that the manufacturer of Type I cranes (a crane that is used to handle a critical load) meet the basic and supplemental requirements of ASME NQA-1. The MX-LC is procured under the QA program, which fully complies with ASME NQA-1.

A.2.1.4.2.2 MX-RRT

The MX-RRT is part of the NUHOMS® transfer equipment and is a device used to support the DSC, during transfer operations. There are two MX-RRT beams inserted into opposing channels below the DSC opening on the HSM-MX. Each of the MX-RRT beams are removed upon completion of the loading operation and replaced with the HSM-MX shield door shielding blocks. The MX-RRT is designed in accordance with ASME B30.1 [A.2-15] as a combination power-operated jack with industrial rollers. Structural acceptance criteria of the MX-RRT is in accordance with ASME NOG-1 [A.2-7]. In addition, the MX-RRT is engineered as "single-failure-proof" per NUREG-0612 [A.2-9]. The MX-RRT function is twofold, one to accept the DSC during its insertion and second, to lower the DSC onto its permanent pillow blocks within the HSM-MX. The MX-RRT is a Part 72 ITS piece of transfer equipment. The MX-RRT is considered ITS as it supports the DSC during its insertion and extraction both into and out of the HSM-MX, respectively, thus providing both a structural and retrieval function.

A.2.1.4.2.3 MX-RRT Handling Device

The MX-RRT handling device is part of the NUHOMS® Transfer Equipment and is a device used to allow insertion and extraction of the MX-RRT and the HSM-MX shield door shielding blocks. This is a NITS piece of equipment since it does not provide a safety function feature for the HSM-MX.

A.2.1.5 Auxiliary Equipment

No change to Section 2.1.5.

All Indicated Changes are MX-LC details.

Table A.2-3
MX-LC Major Design Data

Item	***Quantity/Description***
Gantry Towers	*4 towers integrated with the upper boom assembly*
Design Rated Load	*162 tons*
Gantry Span (bridge direction)	*21'-0"*
Gantry Span (trolley direction)	*17'-0"*
Gantry Boxes	*4 gantry boxes – 68" x 91-1/2"*
Extended Height	*43'-2" from pad to top of cross beam assy*
Stability Devices	*Viscous dampers for seismic loading*

Table A.2-4
MX-LC Design Parameters

Component	***Design Value***
Transfer Cask with Loaded DSC	*139 tons*
MX-LC Lift Boom Capacity	*162 tons*
Loaded DSC	*55 tons*
Transfer Skid	*15 tons*
Hydraulic Ram	*7 tons*

Table A.2-5
MX-LC Component Speeds

Component	***Maximum Speed***
Gantry Along Track Rails (bridge direction)	*72 inches/minute*
Lift Links Along Upper Boom Cross Beams (trolley direction)	*2 inches/minute*
Upper Boom Lift	*12 inches/minute*

Table A.2-6
Stress Ratios for MX-LC Structural Members

Component	***Maximum Stress Ratio for Extreme Environmental Load Case***
Upper Boom	*0.87*
Gantry Cross Beam	*0.93*
Gantry Header Beam	*0.87*
Lower Boom	*0.65*
Lift Link	*0.75*
Screw Spindle Assy	*0.90*
Viscous Dampers	*0.54*

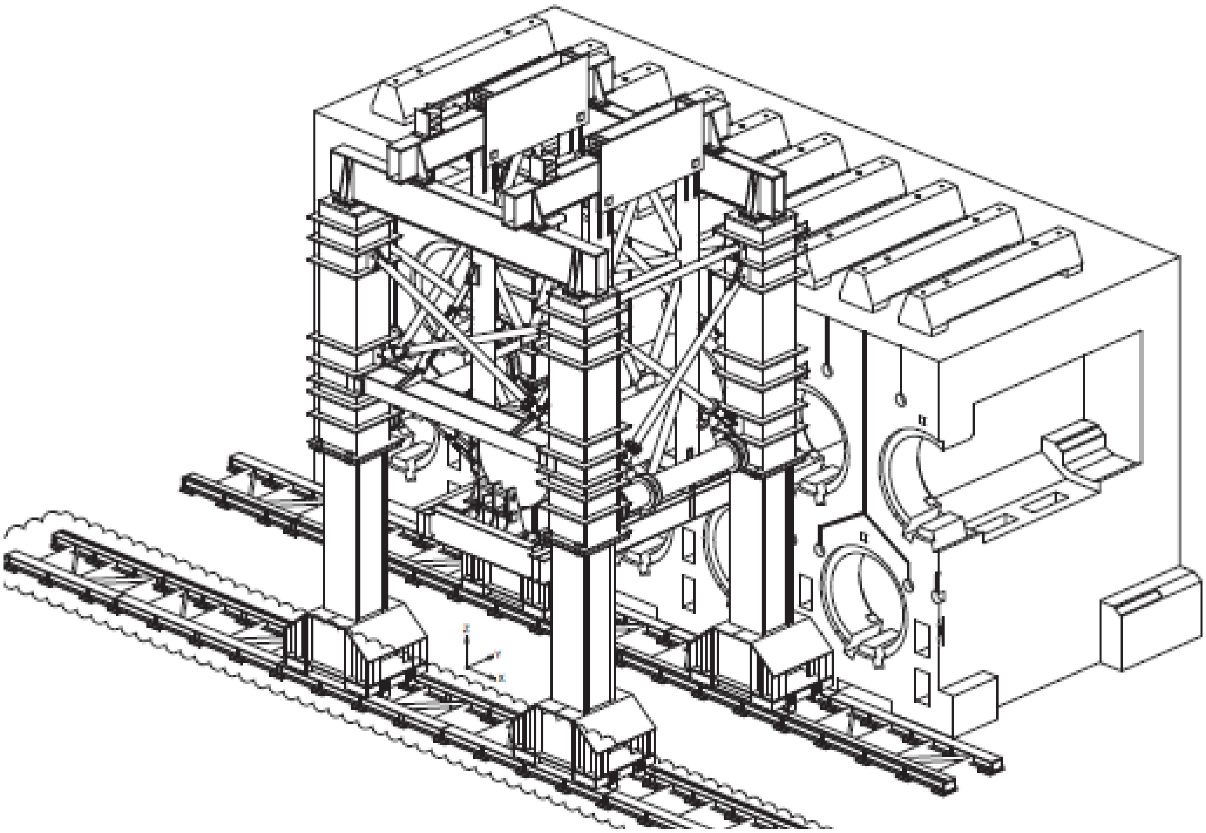

Figure A.2-2
MX-LC MATRIX Loading Crane