ZIONSOLUTIONS LLC
An EnergySolutions Company

10 CFR 50.59
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May 16, 2013 ZS-2013-0194

U.S. Regulatory Commission
ATTN: Document Control Desk
Washington, DC 20555-0001

Zion Nuclear Power Station, Units 1and 2
Facility Operating License Nos. DPR-39 and DPR-48
NRC Docket Nos. 50-295 and 50-304

Subject: Updated Request for Amendment to Approve Methods of Analysis, use of the Upgraded Fuel Handling Building Crane System as a Single-Failure Proof Crane and Approval of a NUREG 0612 Compliant Heavy Loads Handling Program

Reference: 1. Zion*Solutions*, LLC Letter, Daly to NRC, "Submittal of an ASME NOG-1 Exception Request and Update to the Amendment to Approve Methods of Analysis, use of the Upgraded Fuel Handling Building Crane System as a Single-Failure Proof Crane and Approval of a NUREG 0612 Compliant Heavy Loads Handling Program," dated April 4, 2013

Reference: 2. Zion*Solutions*, LLC Letter, Daly to NRC, "Apparent Cause Evaluation for Analysis Errors Associated with the Request for License Amendment for an Upgraded Fuel Handling Building Crane System," dated April 4, 2013

Reference: 3. Zion*Solutions*, LLC Letter, Daly to NRC, "Update to the Rail Clip Analysis Supplementing the Request for Amendment to Approve Methods of Analysis, use of the Upgraded Fuel Handling Building Crane System as a Single-Failure Proof Crane and Approval of a NUREG 0612 Compliant Heavy Loads Handling Program," dated March 4, 2013

Reference: 4. Zion*Solutions*, LLC Letter, Daly to NRC, "Response to Requests for Additional Information for Questions 1, 2, 4 and 5," dated February 21, 2013

Reference: 5. Zion*Solutions*, LLC Letter, Daly to NRC, "Response to Requests for Additional Information for Questions 3 and 6 and Schedule for Submittal of Remaining Responses," dated January 22, 2013

Reference: 6. Zion*Solutions*, LLC Letter, Daly to NRC, "Update to the Supplement for the Request for Amendment to Approve Methods of Analysis, use of the Upgraded Fuel Handling Building Crane System as a Single-Failure Proof Crane and Approval of a NUREG 0612 Compliant Heavy Loads Handling Program," dated January 17, 2013

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Reference: 7. Zion*Solutions*, LLC Letter, Daly to NRC, "Additional Information Supplementing the Request for Amendment to Approve Methods of Analysis, use of the Upgraded Fuel Handling Building Crane System as a Single-Failure Proof Crane and Approval of a NUREG 0612 Compliant Heavy Loads Handling Program," dated December 20, 2012

Reference: 8. Zion*Solutions*, LLC Letter, Daly to NRC, "Request for Amendment to Approve Methods of Analysis, use of the Upgraded Fuel Handling Building Crane System as a Single-Failure Proof Crane and Approval of a NUREG 0612 Compliant Heavy Loads Handling Program," dated October 25, 2012

Reference: 9. Zion*Solutions*, LLC Letter, Daly to NRC, "Request for Amendment to Approve Methods of Analysis, use of the Upgraded Fuel Handling Building Crane System as a Single-Failure Proof Crane and Approval of a NUREG 0612 Compliant Heavy Loads Handling Program," dated May 31, 2012

Zion*Solutions,* LLC (ZS) is in the process of decommissioning the Zion Nuclear Power Station. One of the major activities to complete decommissioning is to place the spent fuel into spent fuel storage casks which must be moved from the Spent Fuel Pool area to a new on-site Independent Spent Fuel Storage Installation (ISFSI) in order to allow timely decommissioning and dismantlement of the Fuel Handling Building. A total of 61 transportable storage canisters (TSCs) will be loaded with spent fuel and moved to the ISFSI. In order to perform this activity, the existing Fuel Handling Building overhead crane will be upgraded to a single-failure proof lifting system to ensure the canister loading and preparation activities are performed safely and without the need to postulate a cask handling accident during any part of the cask movement by the Fuel Handling Building lifting system.

Reference 9, superseded by Reference 8, contained the information to support the initial NRC Review of the License Amendment Request. In the course of that review, analyses supporting the seismic design of the crane and Fuel Handling Building structure were found to require correction. One of those errors led to a modification to the bridge runway clip connections and a supporting calculation as described in Reference 3. Another of the errors led to a reanalysis of the runway girder splice connection to the Fuel Handling Building structure and a description of that analysis is included as well. As a result of these errors, ZS performed an apparent cause evaluation (ACE) and common cause evaluation (CCE) for deficiencies identified in analyses and in design output documents (drawings, specifications, etc.) respectively, (Reference 2) and determined that correction of the errors and additional reviews by both ZS and the contractor were necessary prior to the final reporting of seismic analysis results. The calculations have been updated and finalized, additional reviews have been performed as required by the corrective actions prescribed by the ACE and CCE; this LAR contains the summaries of the final analyses. The NRC in the course of its review, provided requests for additional information (RAIs), which ZS responded to in References 1, 4 and 5. The RAI responses included a request for exception from ASME NOG-1 requirements on wind loading, which has also been incorporated into this submittal. The salient portions of the remaining responses to those RAIs have also been incorporated into the text of this LAR. In addition, the results from Appendix B of ZION001-

CALC-002 describing the Crane Runway Girder Runway Plate, End Support, and Interior Support Evaluation Summary and calculation (ZION001-CALC-037) that includes a summary of the Crane Runway Girder Support at Column. Line X are provided, since these calculations have been completed since the last ZS stratus letter was submitted.

The attached License Amendment request provides information that summarizes the calculations supporting the new single failure proof crane. The information is drawn from analyses revised from the submittal of Reference 2, and incorporates the findings of analyses already reported to the NRC in Reference 1 – 7. In some cases additional analyses have been performed since the cited references were provided to the NRC. As a result, some previously reported values may have changed. In no case, is there an interaction ratio greater than 1.0 reported.

This submittal supersedes our earlier request of Reference 8 with the information described above. Changes from Reference 8 are identified by change bars in the margin for ease of review. The drawings provided in Reference 8, however, have not been reproduced for this submittal and should still be considered as part of this request for amendment.

In accordance with 10 CFR 50.90 "Applications for amendment of license or construction permit" and 10 CFR 50.59 "Changes, tests, and experiments," ZS, is requesting a change to Facility Operating Licenses Nos. DPR-39 and DPR-48 for Zion Nuclear Power Station, Units 1 and 2 (ZNPS). The proposed changes revise the Defueled Safety Analysis Report (DSAR) to include a description of the new single failure proof Fuel Handling Building lifting system and the methodology associated with that design; describe the NUREG 0612 program commitments; and, describe fuel handling operations using the Fuel Handling Building crane. The analyzed event for a spent fuel cask drop in the cask handling area of the Spent Fuel Pool will be deleted from the DSAR (Section 3.9.5) based on use of the single-failure proof system coupled with implementation of the Heavy Loads Program. These measures will sufficiently preclude spent fuel cask drops and the need to explicitly analyze for such an event in or near the Spent Fuel Pool by reducing the probability of a drop event to an acceptably low value, as described in NUREG 0612. No portion of the Fuel Handling Building structure will be adversely affected by the replacement of the Fuel Handling Building Crane. Accordingly no analysis is required or provided for failures of the FHB, its roof or associated structure over the spent fuel pool nor does any effect of building failure on the crane need to be analyzed.

The FHB overhead bridge crane was manufactured by Harnischfeger/P&H as original equipment at ZNPS. It has a 125-ton rated main hoist and a 15-ton rated auxiliary hoist, both of which operate from the same trolley. The FHB overhead crane is characterized as Important-to-the-Defueled-Condition (ITDC) in the DSAR. An ITDC structure, system or component functions and/or supports a spent fuel or radiation protection safety function in the defueled condition.

The lifting system modifications include replacement of the existing trolley on the overhead crane with a new trolley and single-failure proof main hoist and new crane controls. The existing trolley and hoists have been replaced with a new trolley and hoists manufactured by Konecranes Nuclear Equipment & Services, LLC. The new trolley has a new 125-ton rated single-failure proof main hoist and a new 15-ton rated non-single-failure proof auxiliary hoist.

It was necessary to make a structural modification to the existing runway. Rail clips have been added to the runway rails to assure proper anchoring of the rails during a seismic event with a suspended critical load as described in Reference 3.

Associated lifting devices and interfacing lift points will also conform to the guidance in NUREG-0612, Section 5.1.6 in order to ensure that the entire Fuel Handling Building lifting system is single-failure proof for each heavy load lift made in or around the Spent Fuel Pool or in or around a cask loaded with spent fuel or a lift of a cask loaded with spent fuel. The heavy loads safe load paths are identified and additional staging areas in the Fuel Handling Building to facilitate spent fuel transfer are identified as part of this license amendment request. Operator training and procedures will also conform to the recommendations of the regulatory guidance.

A seismic analysis was performed in accordance with ASME NOG-1 "Rules for Construction of Overhead and Gantry Cranes (Top Running Bridge, Multiple Girder)" (ASME NOG-1) for the new trolley. Analysis was also performed to include the existing bridge and new trolley, coupled with the supporting FHB structure that confirmed the overhead crane system will be able to safely control the Maximum Critical Load during a seismic event (SSE).

This License Amendment Request is arranged as follows:

- Attachment 1 provides a description and an evaluation of the proposed change;
- Attachment 2 provides a list of Regulatory Commitments, Proposed Operating License Page Markups, Proposed DSAR Page Markups;
- Attachment 3 provides a copy of the Draft ZS Heavy Loads Program;
- Attachment 4 provides a matrix identifying compliance with NUREG 0612;
- Attachment 5 provides a matrix identifying compliance with ASME NOG-1;
- Attachment 6 provides a matrix identifying compliance with NUREG 0554;
- Attachment 7 provides drawings associated with the runway rail clip modifications which had been originally provided in Reference 3. The remaining drawings included in Attachment 7 to Reference 8 remain applicable.

The proposed change has been reviewed by the ZNPS Station Review Committee in accordance with the requirements of the ZNPS Technical Specifications.

ZS is notifying the State of Illinois of this request for change to the operating license by transmitting a copy of this letter and its attachments to the designated State Official.

Respectfully,

Patrick Daly
Senior Vice President and General Manager
Zion*Solutions*, LLC

cc: John Hickman, USNRC Senior Project Manager
Service List

Attachments: Affidavit
Attachment 1: Description and Safety Analyses for the Proposed Change
Attachment 2: Regulatory Commitments, Proposed Operating License Changes and Proposed DSAR Changes
Attachment 3: Copy of the Draft ZS Heavy Loads Program
Attachment 4: NUREG 0612 Compliance Matrix
Attachment 5: ASME NOG-1Compliance Matrix
Attachment 6: NUREG 0554 Compliance Matrix
Attachment 7: Drawings associated with the Design Change

STATE OF ILLINOIS)
) SS
COUNTY OF LAKE)

Patrick T. Daly, being duly sworn according to law deposes and says:

I am Senior Vice President and General Manager of Zion*Solutions*, LLC, and as such, I am familiar with the contents of this correspondence and the attachments thereto, concerning the Zion Nuclear Power Station, Units 1 and 2, and the matters set forth therein are true and correct to the best of my knowledge, information, and belief.

Subscribed and Sworn to before me
this 16TH day of MAY, 2013

Notary Public of Illinois

LINDA CHOU
OFFICIAL SEAL
Notary Public, State of Illinois
My Commission Expires
December 07, 2015

Zion Nuclear Power Station, Unit 1 and 2 License Transfer Service List

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Attachment 1:

Description and Safety Analyses for the Proposed Change

1.0 SUMMARY DESCRIPTION

Zion*Solutions*, LLC (ZS), is decommissioning the Zion Nuclear Power Station. One of the major activities is to transfer the spent fuel from the Spent Fuel Pool to a new on-site Independent Spent Fuel Storage Installation (ISFSI) in order to allow decommissioning and dismantlement of the Fuel Handling Building. A total of 2,226 spent fuel assemblies and fuel assembly pieces and parts will be loaded into 61 MAGNASTOR transportable storage canisters (TSCs) in the Spent Fuel Pool. When filled, each canister will be moved in a transfer cask to the canister preparation area inside the Fuel Handling Building where it will be drained, dried, backfilled with inert gas and welded shut before it is moved to a storage cask and placed on a low profile cask rail transporter inside the Fuel Handling Building truck bay in preparation for transport to the ISFSI. In preparation for this activity, the existing 125-ton capacity, non-single-failure proof Fuel Handling Building overhead crane will be upgraded to be single-failure proof and heavy load handling will be performed in accordance with a new Heavy Loads Program. These actions will improve the assurance that the canister loading and preparation activities are performed safely and to achieve a very low probability of occurrence for a canister drop event thus effectively precluding the need to postulate a heavy load handling accident in or around the Spent Fuel Pool, or in or around a cask loaded with spent fuel, or a lift of a cask loaded with spent fuel.

The existing trolley on the overhead crane will be replaced with a new trolley with a single-failure proof main hoist and upgraded crane controls. No structural modifications are required for the existing bridge or the support structure with one exception regarding the runway rail clips described below. The design rated load and maximum critical load for the main hoist will remain at 125 tons.

A detailed description of the trolley and hoist replacement and runway modifications are provided below. The proposed changes to the Defueled Safety Analysis Report (DSAR) along with the Heavy Loads Program are also discussed. The DSAR page markups and draft ZS Heavy Loads Program are provided in Attachments 2 and 3, respectively to this submittal.

A technical evaluation discussing the existing plant condition and existing cask drop analysis is provided. The single-failure proof Fuel Handling Building lift system upgrade is consistent with NUREG-0554 "Single-Failure-Proof Cranes for Nuclear Power Plants (NUREG-0554) and Rules for Construction of Overhead and Gantry Cranes (Top Running Bridge, Multiple Girder)" (ASME NOG-1). One exception to the NOG-1 code is identified with respect to wind loads. This lift system and the associated implementation of heavy load procedures will substantially lower the probability of a cask drop event (as described in NUREG-0612 "Control of Heavy Loads at Nuclear Power Plants: Resolution of Generic Technical Activity A-36" (NUREG-0612) and eliminates the need for discrete analysis of a drop of a heavy load in or around the Spent Fuel Pool, or in or around a cask loaded with spent fuel, or a lift of a cask loaded with spent fuel. The Zion Station Defueled Safety Analysis Report (DSAR) defines only a Design Basis Earthquake (DBE) for the facility which is equivalent to the Safe Shutdown Earthquake (SSE) response used as the original design basis for the facility. The current licensing basis does not identify an Operating Basis Earthquake (OBE) or Safe Shutdown (SSE) although the seismic response information that was used in the original facility design is available and used in some

analyses where the OBE response is necessary to conform to the design code. The upgraded crane system meets the ZNPS design basis earthquake (response spectra for the Fuel Handling Building and the crane lift system. However, an evaluation of existing clips on the runway rails during DBE with the crane loaded to its maximum critical load showed the clips to be overloaded. Accordingly, modification of the clip arrangement has been performed. A description of the analyses is included in this Attachment in the section on Seismic Requirements and Analysis, subsection h. The summary is described under "Calculation ZION001-CALC-034, Fuel Handling Building (FHB) 125 Ton Crane Rail Clip Modification and Rail Evaluation" which was previously submitted (Reference 3). The drawings associated with this change are included in Attachment 7. A discussion of any impacts to the remaining accident analyses for a plant undergoing decommissioning is also provided.

A regulatory evaluation discusses how the modifications meet the guidance provided in ASME NOG-1, NUREG-0554, and NUREG-0612. Detailed compliance matrices are provided for each of these guidance documents. The proposed addition of a new license condition to the Unit 1 and Unit 2 licenses and proposed changes to the DSAR are discussed. Also included are a basis for a "no significant hazards consideration" declaration, a statement of environmental considerations and a list of commitments needed to implement the modifications.

2.0 DETAILED DESCRIPTION

2.1 Introduction

Background

The existing trolley on the overhead crane will be replaced with a new trolley with a single-failure proof main hoist and upgraded crane controls compliant with NUREG-0554, ASME-NOG-1 with one exception), and NUREG-0612 as applicable. No structural modifications will be required for the existing bridge or support structure except for the modification of the clip arrangement for the runway rails. The description of the supporting analysis and design is included in this Attachment in the section on Seismic Requirements and Analysis. The drawings associated with this change are included in Attachment 7. Associated lifting devices and interfacing lift points will also meet the guidance in NUREG-0612, Section 5.1.6 in order to ensure that the entire Fuel Handling Building lift system is single-failure proof for each heavy load lift in or around the Spent Fuel Pool, or in or around a cask loaded with spent fuel, or a lift of a cask loaded with spent fuel. The design rated load and maximum critical load for the main hoist will remain at 125-tons. The heavy lifts will use safe load paths including any additional staging areas needed in the Fuel Handling Building to facilitate spent fuel transfer. Operator training and procedures will also conform to the recommendations of the regulatory guidance.

Fuel Handling Building

The Fuel Handling Building (FHB) at the Zion Nuclear Power Station is located between the Unit 1 and Unit 2 Reactor Containment Buildings. The Fuel Handling Building, as described in the DSAR, is a Seismic Class I structure and is characterized as Important-to-the-Defueled-Condition (ITDC). A structure, system or component that supports a fuel safety or radiation protection safety function is designated as Important to the Defueled Condition (ITDC). The seismic qualification of this structure ensures that a structural failure in the building will not result in an increase in the severity of any accident postulated to occur in the defueled condition, thus the entire structure is classified as Seismic Class I. As such, the FHB complies with Section C.2 of Regulatory Guide 1.29, "Seismic Design Classification," and Paragraph II.8 of NUREG-0800, "Standard Review Plan," Section 3.7.2. The west end of the FHB has a Truck Bay at grade that also provides railway access. Shield doors at the north end of the Truck Bay open into an extension with a roll-up door at the north end opening to the outside.

Spent Fuel Pool

The Spent Fuel Pool (SFP) has space in the storage racks for 3,012 assemblies. A total of 2,226 spent fuel assemblies, one failed spent fuel rod storage basket, and one damaged fuel assembly skeleton containing 15 spent fuel rods in the guide tubes are stored in the SFP. A cask load pit, a discrete area in the SFP, has plan view dimensions of 9.5 feet by 9.5 feet with a floor that is approximately 39 feet below the nominal water level of the SFP. The SFP and storage racks are characterized as Important-to-the-Defueled-Condition (ITDC) in the DSAR. The spent fuel will be characterized as damaged or undamaged fuel in accordance with the NRC approved loading

requirements for the NAC MAGNASTOR contents. Damaged fuel assemblies as well as the failed rod storage basket and the damaged fuel assembly skeleton will be placed inside damaged fuel cans and loaded into the NAC MAGNASTOR Transportable Storage Canisters (TSC). Each canister holds up to 37 fuel assemblies.

Overhead Crane

The existing FHB overhead bridge crane was manufactured by Harnischfeger/P&H as original plant equipment. It has a 125-ton rated main hoist and a 15-ton rated auxiliary hoist, both of which operate from the same trolley. The FHB overhead crane is characterized as ITDC in the DSAR.

As demonstrated in the attached compliance matrices, the crane upgrade generally conforms to the applicable criteria as listed in NUREG-0554 and NUREG-0612 Appendix C. ASME NOG-1-2004 (NOG-1) is used as the design and construction standard to satisfy NUREG-0554 requirements. Any deviations are explained in the compliance matrix, including any requests for exceptions, alternative approaches or justifications as appropriate.

2.2 Bridge Modifications

The following modifications will be made to the bridge:

1. Replacement of control panels.
2. Addition of a bridge mounted load cell readout visible from the refueling floor and also a readout in the crane cab and on the radio receiver.
3. Addition of an isolation transformer for the new flux vector and frequency controls.
4. Addition of new radio controls with load cell readout. The existing cab master switches which will remain as an alternate means of crane control.
5. New festoon electrification for the trolley and an additional ground conductor bar for bridge electrification.
6. Modifications to interface with the crane existing main disconnect, crane lighting systems, and crane warning systems.
7. Addition of a cutoff switch that removes power from the crane in the event of a Safe Shutdown Earthquake.
8. Modifications of the bridge limit switch arrangement to enforce end of travel and restricted zone travel and eliminate the existing retractable bridge and trolley stops.
9. Modification of the runway rail clip arrangement that, without considering friction, assure that the clips will not be overstressed during SSE with the crane loaded to its maximum with the hook up.

The bridge has been evaluated with regard to the ASME NOG-1 structural design criteria for use as part of the single failure proof crane system, with one exception, and no structural modifications to the bridge have been determined to be required.

2.3 Trolley and Hoist Replacement

The existing trolley and hoists will be replaced with a new trolley and hoists manufactured by Morris Material Handling/P&H. The new trolley will have a new 125-ton rated single-failure proof main hoist and a new 15-ton rated non-single-failure proof auxiliary hoist. The ASME NOG-1 Type I main hoist unit with Type I main hoist components is designed and arranged to prevent a "two-blocked" condition consistent with the NRC and industry guidance. Also included are new hoist hooks, new carbon steel wire rope, lower block and other components affixed to the trolley. The 125-ton hook will attach directly to the specially-designed yoke for the MAGNASTOR Transfer Cask (MTC). Means and equipment are provided for manually positioning the new upgraded trolley in case of loss of all external AC power.

The existing crane motor controls will be replaced with new alternating current (AC) flux vector main and auxiliary hoist controls and new AC adjustable frequency bridge and trolley controls. New motor controllers and radio controls interface with the existing main line disconnect and magnetic contactor, existing cab master switches, existing crane lighting systems, existing crane warning systems, and existing travel limit switches.

The replacement trolley generally conforms to the applicable design requirements of ASME NOG-1. The main hoist and trolley unit is a NOG Type I design, with the auxiliary hoist being a NOG Type III design. Any deviations or exceptions from ASME NOG-1 are explained in the ASME NOG-1 compliance matrix (Attachment 5). A summary of the upgraded crane performance requirements is provided in Table 1. Table 1 also provides a listing of the key components and dimensions of the new trolley and hoist assemblies. Operating procedures and training will provide operating instructions and limitations for crane operations to assure design limitations are met. Further details of the design are provided as follows:

Travel Length -

1. The north/south (N/S) and east/west (E/W) end of travel limits of the 125-ton hook are the same as the existing end of travel limits and lift lengths are the same or greater than those for the existing hoist.

2. The size of the existing load path restricted zone will be reduced to exclude the new fuel vault. The revised restricted zone will incorporate the Spent Fuel Pool and Transfer Canal plus margin to prevent the MTC from travelling over those areas.

Reeving -

In addition to the requirements of NOG-l, the main hoist is provided with a balanced redundant reeving system such that the load block does not twist in the un-loaded or loaded condition. Reverse bends are not used in the main hoist.

1. The main hoist reeving and arrangement of mechanical components are such to permit lifting at an angle of three degrees in either direction along the centerline of the hoist, parallel with the girders. This off-angle pulling is required for the possible upending of the dry cask storage system components, which will require alternate operations of hoisting and trolley traversing. The arrangement ensures that the hoisting ropes do not rub against the trolley frame when lifting at this angle. Hoist drums are provided with a means to ensure that the ropes are in the drum grooves. A monitoring system shuts down the main hoist crane drive if a wire rope becomes dislodged from its proper groove.

2. The main hoist wire ropes are selected to provide a 10-to-1 design factor when supporting the maximum critical load (MCL) plus the weight of the load block, including an increase to accommodate for degradation due to wear (5%).

3. The auxiliary hoist has a standard double-reeved system providing a true vertical lift.

4. All rope parts of both the main and auxiliary hoist reeving systems are provided with equalizer sheaves or bars to ensure equal rope load.

5. Main hoist fleet angles do not exceed 3½ degrees except for the last three feet of maximum lift elevation.

Hooks -

1. The main hoist dual prong (sister) hook is made of forged alloy steel (similar to SAE 4340) designed for a safety factor of 10-to-1, static plus dynamic, including margin for wear, such that this design margin is maintained when lifting from either the hook prongs or center pin hole. The design of the lower center pin hole requires that the sides of the hook at the pin hole are parallel with a flush face surface. Safety latches bridge the two hook prong openings. To ensure hook mating with the fuel transfer lifting devices, all latch components are narrower than the hook width and do not interfere with pins sized to rest in the valley of the hook prongs.

2. The auxiliary hoist single-prong (fishhook) hook is made of forged carbon steel with a safety latch to bridge the hook prong opening.

3. All hooks rotate 360 degrees and have punch marks to measure the hook prong throat openings. All safety latch components are of a non-corrosive material.

Load Blocks -

1. Critical components of the main hoist upper and lower blocks are designed for a safety factor of 10-to-1, static plus dynamic loading.

2. The main hoist load block is expected to be immersed in the SFP, and is designed accordingly.

Drip Pans -

1. All oil-lubricated components of the main hoist, auxiliary hoist, and trolley are provided with drip pans. Grease-lubricated components which do not have a structure beneath them (such as the trolley deck) also are provided with drip pans to retain any excess lubricant. Drip pans are sized to hold 1.1 times the total quantity of lubricant that could leak.

Lubricants -

1. Lubricants for components immersed in the Spent Fuel Pool are selected to be non-water soluble and free of halogenated compounds, halogens, mercury, and other deleterious materials to ensure compatibility with the pool chemistry.

Hoist Controllers -

1. New main and auxiliary hoist controllers are of the AC "Flux Vector" closed loop variable frequency type, specifically meeting the criteria of NOG-1 Paragraph 6417 and Item 6417.1.

Bridge and Trolley Controllers -

1. New bridge and trolley controllers are of the AC open loop variable frequency type. These controllers meet the criteria of ASME NOG-1Paragraph 6417.

Motors -

1. Motor features are:

    a. The hoist motors are 460v, 3ph, 60 Hz AC vector duty induction motors. Each motor is in accordance with National Electrical Manufacturers Association (NEMA) MG1 Part 31 as applicable for vector duty.

    b. The bridge and trolley drive motors are 460v, 3 phases, 60 Hz AC inverter duty motors. Each traverse motor is in accordance with NEMA MG1 Part 31 as applicable for inverter duty.

c. Maximum motor revolutions per minute (RPM) for any motor is 1800, with bridge motors being selected to interface with the existing bridge drive gear case and shafting.

d. External Motor Branch-Circuit Overload Protection
Each new motor is provided with an automatic resetting three phase bi-metallic thermal overload relay.

e. Motor Branch-Circuit Short-Circuit Protection
Each new motion controller is provided with a separate 3-pole molded case thermal magnetic (inverse-time) circuit breaker.

Hoist Holding Brakes and Emergency Brakes -

1. The brake features are:

a. The main hoist is provided with two shoe-type holding brakes, one on each of the redundant gear trains. Each brake is sized to hold 150% of the rated load hoisting torque.

b. An eddy current brake (Magnetorque) is provided on the common motor drive shaft. This brake allows the load to be lowered at a controlled speed under emergency conditions.

c. Each main hoist holding brake is provided with a means for manual releasing to provide emergency lowering of the load controlled by the Magnetorque eddy current brake in case of loss of all external AC power.

d. The auxiliary hoist is provided with two holding brakes. Each brake is sized for 100% of the rated load hoisting torque.

e. All holding brakes for normal operating modes engage upon returning the motion controller to the neutral ("off") position, upon opening the mainline magnetic contactor, or upon loss of power. An emergency brake (and as appropriate, the normal operating brakes), engage upon the predetermined emergency conditions, such as rope failure.

Bridge and Trolley Brakes -

Each new traverse motion controller motor is furnished with a motor mounted disc brake. Brakes are sized for 100% of the drive torque that can be developed at the point of application and are field adjustable to be capable of stopping the drive within the distances specified in NOG-1. Each brake is furnished with a means for manual brake release. The disc brake of each new traverse motor serves as the emergency brake and as the holding (parking) brake. Each brake engages upon returning the motion controller to the neutral

("off") position, upon opening the mainline magnetic contactor (as can be accomplished by pressing the emergency stop button), upon loss of power, or upon any emergency or faulted condition as detected by the traverse motion controller. Controlled braking for each traverse motion is furnished as a function of the AC variable frequency control.

Hoist Limit Switches -

Each hoist is provided with an upper and lower geared limit switch wired to the hoist control circuit and with a second back-up upper limit switch of the block actuated type. For each hoist, a second back-up lower limit switch is provided based on the load weighing system detecting a slack rope condition. Upon tripping an initial hoist limit switch, only motion in the reverse direction is permitted. Actuation of a second limit switch requires operator action to reset the control system before the control system will allow further motion.

Overload Limiting Device & Load Cell Readout -

Each new hoist controller is furnished with a field adjustable overload limiting device which senses the lifted load (independent of any electronic sensing features of a flux vector hoist control) to prevent lifting overloads which could cause permanent damage. The set point is adjustable, with the high setting approximately 120% of the heaviest lifted load (i.e., loaded and flooded TSC with a lid inside a Transfer Cask and including the Lifting Yoke) to provide a margin for acceleration of the lifted load. A means for bypassing the overload limiting device is furnished in order to perform the field load tests. A digital readout is furnished for the crane cab and a large readout on the bridge will be visible from the refueling floor. The display permits load readout of either the main or auxiliary hoist. A readout is also provided on the radio control system. Operating procedures and training will implement administrative control of the load limit controls.

Radio Controls -

1. The radio control features are as follows:

    a. A new radio control system is furnished as the primary means for controlling the crane. A selector switch is furnished in one of the bridge mounted control enclosures to select either radio or cab operation. The cab master switches have the same control functions as the radio.

    b. The Magnatek/Telemotive radio system has Electromagnetic Compatibility (EMC) such that it does not produce electromagnetic emissions that will interfere with other devices and will not be interfered with by the electromagnetic emissions of other devices.

c. The radio system has a receiver within its own RFI shielded NEMA 12 enclosure, Magnetek SLTX lever type belly box transmitter, receiving antenna, three rechargeable NiCad battery packs, and 120v AC battery charger. The system is digitally encoded and is failsafe upon loss of power or low battery. The system meets Federal Communications Commission (FCC) regulations for a Part 90 licensed system.

d. The Magnetek SLTX transmitter with internal antenna has a transmitter "on" and low-battery LED, key lock transmitter-on switch (removable in the "off" position only), emergency stop button (operating the mainline magnetic contactor), warning horn button, switch for the existing crane lights, main or auxiliary hoist load cell readout, and four (4) separate motion master switches (one for each crane function). Each crane motion master switch has 5 speed steps in each direction. The transmitter is capable of transmitting the master command, all motion commands, and all auxiliary function commands simultaneously. Energizing the transmitter and closing the mainline magnetic contactor illuminates a new "red" under-walkway "power on" light.

e. All radio master switches for motion controllers spring return to the "off" (neutral) position.

Welding Requirements -

Welding is performed in accordance with American Welding Society (AWS) D14.1. The vendors welding procedures comply with both AWS D.1.1 and D.14.1, where applicable.

Load Testing -

The trolley was load tested at the factory. Based on the factory load test of the trolley and the original load test of the bridge, the crane will be put back into service on an interim basis after installation and functional testing but prior to approval of this license amendment. Travel restrictions will be in place during the interim period consistent with the 50.59 screening for the modification. This will limit operations of the crane to be consistent with the exiting DSAR requirements until the license amendment is approved.

During the interim period a 'cold proof' load test will be performed to determine the lower operating temperature limitation for the existing bridge in accordance with NUREG-0554. This load test will be limited to the truck bay and mezzanine area.

Seismic Requirements and Analysis -

A seismic analysis performed in accordance with NOG-1 (with one exception described below), including the existing bridge and new trolley, coupled with the supporting FHB structure confirmed that the overhead crane system can safely control the Maximum

Critical Load during a design basis seismic event ZS is taking exception to the wind loading requirements of Section 4140. That exception request is described below.

The results confirmed that the existing bridge and FHB support structure are adequate. Drawings associated with this design change are included in Attachment 7. Details of the seismic requirements and assumptions are summarized below.

1. General

   A seismic qualification was performed of the new trolley unit, existing bridge, and new components that are mounted on the bridge and trolley. The building structure, up to and including the runway rails was qualified, using a seismic model including the new trolley. The following seismic features are included in the design and analysis:

   a. The trolley is provided with suitable restraints so that it remains on the bridge rails during an earthquake.

   b. The rail clips attaching the runway rail to the runway girder have been analyzed and modifications have been installed and no part of the bridge or trolley will become detached or fall during or after an SSE earthquake.

   c. The main hoist will remain in place and support the maximum critical load during or after a seismic event.

   d. The auxiliary hoist will remain in place with or without a load during a seismic event, but is not required to support that load, because procedural controls will restrict placing a load on the auxiliary hook that could impact stored fuel or a loaded cask.

   e. The design does not provide for the hoists to remain operational during or after an earthquake consistent with the provisions of NUREG-0554.

   f. The seismic analysis of the crane and building does not include the effect of the maximum credible tornado combined with a lift at the full rated capacity of the crane. (An exception to ASME NOG-1, identified above has been requested.) The FHB is designed to withstand the effects of the design basis tornado and associated missiles. Procedural provisions shall be made to prevent FHB Overhead Crane operations during a tornado watch or warning. This procedure revision to AOP-8.4 has already been issued.

2. Seismic Analysis Summary

   The trolley and bridge are qualified to the existing Zion seismic environment described in the DSAR by utilizing dynamic analysis techniques in accordance with the recommendations contained in ASME NOG-1 Paragraph 4150.

The seismic analytical work was performed using computer codes that are commercial off the shelf (COTS) products used in the NRC licensed nuclear industry and controlled by the individual vendors QA programs. Note that there are two different programs used for the main seismic calculations (ANSYS & STAAD). This is because the evaluation of the existing bridge and new trolley was performed by a separate vendor than the evaluation of the FHB. As such there is no overlap in the evaluations. The list of software used in the calculations includes:

a. Seismic analysis of the miscellaneous bolted connections on the trolley was performed with MathCad 14 and some section properties were calculated using AutoCad 2007.

b. Seismic analysis of the Main Hoist Reeving System was performed with MathCad 14 and some section properties were calculated using AutoCad 2007.

c. MathCAD 14 software was used to calculate the trolley frame critical weld stresses.

d. The structural analysis of the bridge and trolley was performed with ANSYS 12 software. The analysis was performed for the crane operational load combinations required by ASME NOG-1 Section 4140 and seismic load cases (three trolley positions with hook up, hook down and no load on the hook configurations) in accordance with ASME NOG-1 Section 4150.

e. The Fuel Handling Building crane and crane supporting structure are modeled as a coupled system using a combination of common finite element practices and a stick model of the crane and analyzed using STAAD. Pro V8i. The seismic loads on the Fuel Handling Building are generated from a dynamic, artificial time history analysis and are used to evaluate the structural integrity of the building.

f. The time history analysis is also used to generate response spectra at the runway rail (crane wheels) using the computer code Spectrum V2.0. The response spectra are used by the crane manufacturer as input to the bridge calculation and to verify input values used for the trolley calculations are bounded.

3. The licensing and design basis for the Fuel Handling Building in the ZNPS DSAR do not require (nor provide for) combining operating or design wind loads nor tornado wind loads with the earthquake loads or crane live loads. The building design however is analyzed for the dead load, live load, thermal loading, and design wind loads. It is also analyzed for dead load, thermal loading, and tornado wind loads. In no case do the required analyses include the design basis earthquake combined with design or tornado wind loads.

   Section 4140 of ASME NOG-1, 2004, "Rules for Construction of Overhead and Gantry Cranes," identifies the loads and load combinations applicable to the analysis performed for Type 1 cranes (which includes the proposed FHB crane modification).

The Operating Wind Load (designated as P_{wo} in NOG-1 and which is not included in DSAR Table 3-5), Design Wind Load (designated as P_{wd} in NOG-1 and is stipulated to be W in the DSAR Table 3-5) and Tornado Wind Load (designated as P_{wt} in NOG-1 and is stipulated to be W′ in the DSAR Table 3-5) are not combined with earthquake loads or crane live loads in DSAR Table 3-5 or proposed Table 3-5A load cases, which reflects the design basis of the Zion Station.

The calculations performed for the proposed crane modification are consistent with the above stated station load combinations. Therefore, since the calculations provided for acceptance of this crane to NOG-1 standards do not contain the full set of load combinations, ZS requests NRC approval of an exception to ASME NOG-1 Section 4140 consistent with the existing NRC approved licensing basis to not include the wind loads as part of the analysis of the crane. Note that the original design basis of the building includes design and tornado wind loads as described above and this exception does not affect the analysis of the crane itself since it is an indoor crane. Proposed updates to Page 23 of 44 of the License Amendment Request and NOG Compliance Matrix sections 4134 and 4140 are provided herewith.

ZS has proposed administrative controls and established procedures to limit the likelihood of having a load suspended from the hook during a tornado.

4. Allowable Stress Criteria

   Allowable stresses for the trolley are in accordance with NOG-l Paragraph 4300 with mechanical component stresses in accordance with ASME NOG-1 Section 5000. Allowable stresses for the existing bridge were also evaluated in accordance with ASME NOG-1 Paragraph 4300 requirements.

5. Detailed Analysis Descriptions

   The following descriptions provide a summary of the calculations that include modeling of existing plant configurations coupled with the new trolley design that documents compliance with the requirements of ASME NOG-1 2004, (primarily Section 4000) with one exception, NUREG 0612, and NUREG 0554 requirements.

   a. KNES Calculation No. 36675-01: Simplified Crane Model for Coupled Analysis

      Summary: This calculation provides the data required to build a stick model of the ZS overhead bridge crane.

      Model Description: The crane mathematical model meets the requirements of NOG -1 para. 4153.3 and 4154.1. The boundary conditions meet the requirements of NOG-1 para. 4153.6 and Table 4154.3-1. The model includes the following elements:

Ropes: Spring stiffness is calculated to represent the ropes and simulate the pendulum effect. Hook up and hook down positions are included.

Bridge: The bridge is modeled with beam elements. The density of the beam elements is adjusted to arrive at the overall weight of the bridge. Girder dimensions and end tie dimensions along with the sections that correspond to each segment are used.

Trolley: The trolley is modeled as a lumped mass with the mass moment of inertia at the center of gravity (CG) of the trolley, connected with the bridge using rigid beam elements. The trolley CG and mass moment of inertia details are modeled. The South and North end positions are identified as well as the mid position, and the two quarter positions.

Boundary Conditions: Bridge boundary conditions and trolley-bridge interface boundary conditions are applied per ASME NOG-1 Table 4154.3-1.

Assumptions: The trolley center of gravity is in-line with the main hook, since the difference between them is only 0.5 inches. This assumption will not adversely affect the results.

Results: The model is used to determine results found in ZION001-CALC-002.

b. Enercon Calculation ZION001-CALC-002 Fuel Handling Building (FHB) 125 Ton Crane Upgrade Evaluation

Summary: This calculation demonstrates that the FHB will continue to perform its safety function of supporting the new 125 ton single failure proof loaded crane following SSE and will meet the requirements of criteria as specified in Section C.2 of Regulatory Guide 1.29. This is accomplished by evaluating the static and dynamic analysis along with the subsequent code check of all primary structural members of the Fuel Handling Building superstructure. A modification was required to the FHB to support crane operations. This modification involved installation of crane runway rail clips. The design description of these clips is included in this Attachment in the description of ZION001-CALC-034.

Model/Methodology Description: The mathematical model of the FHB is coupled with the crane model. This combined model has been analyzed for different loading conditions, which include the Operating Basis Earthquake (OBE, also referred to as the Design Earthquake in the Zion seismic design criteria) and the Safe Shutdown Earthquake (SSE, also referred to as the Design Basis Earthquake or DBE in the DSAR and the Maximum Credible Earthquake or MCE in the Zion seismic design criteria).

The seismic loads are generated from artificial linear time history analysis per ASME NOG-1-2004 (Section 4153.2). In addition to the self weight, in accordance with NUREG 0800, SRP 3.7.2, the mass equivalent to a floor load of 50 pounds per square foot to account for miscellaneous dead loads, 25% of floor design live load and 75% of roof design snow load is included in the dynamic model.

Load cases and load combinations for the Fuel Handling Building structural components, excluding crane components above the runway rail, are in accordance with the Zion DSAR Table 3-5. All applicable combinations are modified to include the rated capacity of the crane, including impact, and live load occurring simultaneously with earthquake. The load combinations are also modified to conform to NUREG-800, which invokes the combinations provided in ACI 349-97 for reinforced concrete and AISC N690-1994 for steel design. The load cases and load combinations for the crane, including all components above the runway rails, are in accordance with ASME NOG-1-2004 (Section 4140 for Type 1 Crane). Note that tornado load is not combined with a loaded crane, resulting in controls over crane operations discussed elsewhere in this document.

Zion DSAR Table 3-5 lists the seismic Class I load combinations for the Fuel Handling Building (FHB). The design wind load (W) and maximum credible tornado wind load (W′) are not combined with earthquake loads in DSAR Table 3-5 or proposed Table 3-5A load cases. Since the wind loads are not included in seismic load cases, calculation ZION001-CALC-002 does not analyze the wind loading. The original FHB calculations continue to be the design basis for the SAR required building wind load evaluations. Calculation ZION001-CALC-002 Revision 2 evaluated the effect of the additional new trolley weight (approximately 3600 lb.) on the original wind load analyses and determined the extra mass to be negligible compared to the combined mass of the bridge, trolley, and live load. The resulting change to the building members is therefore insignificant. In addition, ZS recognizes this limitation of the evaluation and has committed to control heavy load movements if a tornado watch or warning has been declared for the site by the National Weather Service.

The Fuel Handling Building superstructure is analyzed with the crane bridge at the most critical locations along the runway girder to maximize shear and moments. Additional locations are also considered for maximum axial load delivered to the columns, or for an increase in torsional effects on the superstructure. A total of seven bridge locations are modeled including a position to maximize accelerations for evaluation of the crane itself.

Seven bridge positions were evaluated to provide either the most limiting or representative loads as follows:

Position #1, Maximum Moment:

Bridge centered between column lines R and P (east end of Fuel Handling Building (FHB)). This position provides the maximum positive and negative moment. This center position coincides approximately with the western most crane wheel positioned at 0.2L east of column line R corresponding to the maximum moment influence provided in the original FHB design calculations.

Position #2, Maximum Shear Load:

Center of the western most end truck positioned over column line R with the end truck wheels centered equidistant from the column. This location corresponds to the maximum shear influence provided in the original FHB design calculations.

Position #3, Maximum Axial Load:

Crane centerline (and corresponding hook centerline) positioned over column line R with the end trucks centered equidistant from the column. This location corresponds to the maximum of the combined shears on either side of the column as provided in the original FHB design calculations. This position is bounding for axial loads on the column because the cross sectional area for compressive stress and section modulus for bending stress is smaller than the other built up column section comprised of plate girders.

Position #4, Maximum Load Effects to Column Line W:

Centerline of the western most bridge girder 6'-3 1/2" from column line W, as indicated in P&H drawing 105A3002, Sheet 2, that corresponds to the travel limit for the crane, will provide the maximum force effect to column line W, as well as at the wall along column line 17 at the shield door discontinuity between column lines W and V.

Position #5, Maximum Crane Response:

For the purposes of determining the seismic response of the crane, the bridge located with the crane and hook centered directly over column line V, with both end trucks equidistant from the column line is the bounding response scenario. This is scenario judged bounding because the bridge is positioned over the center of the column and located near the stiffer shear wall boundary condition, the crane will see maximum accelerations based on axial stiffness of the column and lateral stiffness adjacent to Wall W. Stiffer locations of the structure take more energy to dissipate inertial forces causing higher accelerations. This is evident in typical response spectra where there tends to exist a plateau of maximum response correlating to elements or structures that behave in a more rigid fashion (high

frequencies and low periods of vibration), such as concrete and masonry structures, as opposed to steel framing systems which vibrate at much longer periods.

Position #6, Maximum Load Effects to Column Line X-17:

For the purposes of determining maximum load to the concrete columns at column line X-17 and S-17 that support the steel columns, the crane will be centered over column line X-17 similar to the way the crane was centered for position 3. This position (Position 6) will be bounding for load effects to both column line X-17 and S-17 since these concrete columns are identical.

Position # 7, Maximum Load Effects to Column Line U-23:

For the purposes of determining maximum load to the concrete column at column line U-23 that supports the steel column, the crane will be centered over column line U-23 similar to the way the crane was centered at Position 3. In addition, longitudinal impact loads will be mirrored since the trolley is positioned along the South extreme end as will the ASME NOG-1 specified boundary conditions. This will fix the North-South translation along column line 23 delivering the maximum force to the column.

Trolley positions considered include both extreme ends, both quarter points, and the mid-point on the bridge girders. For the purposes of analyzing the superstructure, the bounding trolley position is determined to be the north extreme end with the hook loaded in the up position, except where noted above. This position provides the largest center of mass shift from the building center of rigidity. The mid-point, south quarter point, and south extreme end trolley positions are considered bounding for determining the seismic response of the crane. Placing the trolley closer to the stiffer wall (south wall at Column Line 23) provides higher response accelerations. These three positions are modeled with the hook up loaded and unloaded and the hook down loaded and unloaded per the requirements of NOG-1 Section 4153.7.

The crane interface with the FHB and crane support structure is in accordance with the boundary conditions provided in ASME NOG-1-2004 Figure 4154.3-1 and Table 4154.3-1. The crane wheels are modeled as rigid members connected to the runway girder rail and the boundary conditions are applied at the base of the wheels. The girder rail is also modeled as a rigid member offset and positioned from the runway girder by the height of the rail to obtain force effects to the runway structure due to the load at the base of the wheels to the top of the rail. The runway girder, connections and associated framing along the remaining load path are as provided in site drawings.

Both crane support structure and FHB structure are composed of reinforced concrete, bolted, riveted and welded steel members. Structures constructed of reinforced concrete and welded steel have damping equal to 2% and 5% of critical for the Design Earthquake and Maximum Credible Earthquake (MCE), respectively, as provided in the ZS Seismic Design Criteria. The bolted connections between the steel beams and the floor are rigid components designed to transfer significant loads to the concrete and as such do not have damping that is significantly higher than that for welded steel. Any bolted connections associated with the crane are local to the crane and do not impact the dynamic response of the structure. Therefore, the use of 2% and 5% damping for the purposes of evaluating the structure at all modes is appropriate.

The structural steel member code check is performed in accordance with AISC 9th Edition. The design methodology, parameters, and allowable stresses provided within the AISC 9th Edition are identical, or have been expanded upon due to advancements in research, to those provided in the original code of record for the Fuel Handling Building, AISC 6th Edition. Independent steel connection evaluations are performed in accordance with the original code of record, AISC 6th Edition.

Concrete member stresses are checked for enveloped SSE loads (conservative) in accordance with ACI 318-63, which is the original reinforced concrete code used for design of the structure. Anchor bolt analysis is performed utilizing Concrete Capacity Design (CCD) methodology per ACI 349-97, which is supplemented by USNRC Reg. Guides 1.142 and 1.199.

Based on the time histories developed in CALC-002, response spectra at the crane bridge wheels are developed in Enercon Calculation ZION001-CALC-025 using the computer code SPECTRUM and provided to the crane manufacturer (Konecranes) to evaluate the crane and new trolley system. The response spectra curves provided to the crane vendor use a damping value of 4% of critical damping for MCE, which is lower than 7% required per ASME NOG-1-2004, Section 4153.8.

<u>Assumptions</u>:

- The Spent Fuel Pool walls per Zion site drawing B-113 and floor slab per drawing B-118 are considered rigid and will resist any deflections which would cause P-Delta effects at the base of the columns. Rotational and translation springs are not included for foundation effects to provide conservatism in the internal member stresses and to reduce damping effects providing higher accelerations.
- The response effect of sloshing in the spent fuel pool is not considered to affect the response of the steel frames at the level of the crane rail supports.
- It is considered that the values provided in Zion's original seismic analysis are accurate for contribution of building systems not modeled in full detail. Since the plant is not operating, mass values are assumed to have decreased relative

to live loads used in the original design bases thereby providing values that are conservative.

Results: The highest loads and stress values of different components along with allowable values are listed below:

Steel Members and Connections: (Ref. Section 7.2 and Appendix A of CALC-002)

Main Body of Calculation (Section 7.2): The code check for the majority of the steel members was performed as part of the STAAD dynamic evaluation. All of these members pass the code check with the exception of six IRs that were greater than 1.0 which were individually evaluated. These six cases are described below:

- The AMG girder along column line P, STAAD member 55, had interaction ratios (IR's) for shear capacity of 1.038 and 1.048, for two of the models in the initial code check. This member is the segment between the crane runway beam and the column line as shown in drawing B-402. This segment has 1/2" thick gusset plates either side of the AMG girder that extend for 8'-8" in the direction of the governing shear force as shown in drawing B-403, Detail E. The gussets were not included in the model and are shown in the calculation to contribute an additional 1064 kips of shear capacity. The IR with additional shear capacity included is 0.204 for the worst case (previously 1.048) with the other case (previously 1.038) determined to be less than 0.204 by comparison.
- The other four cases are for two W14x43 bracing members along column line 23 at the crane girder elevation as shown on drawings B-402 and B-403. In two load cases, the code check of these two members resulted in IR's of 1.041, 1.108, 1.197, and 1.274. The two load cases are for OBE forces. The Zion DSAR requires allowable stresses for OBE to be in accordance with the AISC specification. A 1/3 allowable stress increase is permitted for earthquake forces per the specification. The allowable stress increase is applied in the calculation and the resultant IR's are shown to be 0.78, 0.83, 0.90, and 0.96 respectively.

Appendix A: Plate girders with web depth to thickness ratio greater than $960/\sqrt{Fy}$ and various other components are not directly checked in STAAD and are evaluated independently in Appendix A. A summary of these items is tabulated below including the forces or stresses and allowables for the highest interaction ratios:

Horizontal Bracing	**Max. enveloped force at connection**	**Allowable**
OBE	55.15 kips	72.16 kips
SSE	58.67 kips	72.16 kips

Beam Members	Max. resultant load at connection	Allowable
OBE	53.04 kips	66 kips
SSE	82.16 kips	90 kips

Girder Connections	Max. resultant load at connection	Allowable
OBE	269.9 kips	282 kips
SSE	275.96 kips	282 kips

Column Connections	Max. Weld Stress	Allowable
OBE	13.839 ksi	14.847 ksi
SSE	16.306 ksi	20.786 ksi

Vertical Bracing	Max. enveloped force at connection	Allowable
OBE	269.02 kips	270.6 kips
SSE	190.62 kips	207 kips

Plate Girders*	Max. Interaction Ratio - Bending	Max. Interaction Ratio - Shear
OBE	0.602	0.637
SSE	0.663	0.667

*For plate girders the interaction ratios are presented as formulas that combine stresses per AISC requirements. This is also true for some other components in Appendix A. However, given the complexity of the formulas for the plate girders, in this case it is simpler to present the IR in lieu of extracting values to present vs. allowables.

Column Base Plates*	Provided Base Plate Thickness	Required
Thickness Required to Resist Flexure due to Compression	2.25"	1.664"

*Base plates are analyzed for the net forces and moments from all members framing into them using SSE loads with OBE allowable stresses and this methodology is considered bounding for both OBE and SSE load combinations.

<u>Crane Runway, Rail and Connections</u>: (Ref. Appendix B of CALC-002)

The purpose of this appendix is to check the crane runway connections which could not be checked with the STAAD.Pro V8i code check in section 7.2 of the main calculation. For evaluation of the rails and the rail clips, see ZION001-CALC-034. For the evaluation of the spliced connection between the crane girders (G8B) at column line X, see ZION001-CALC-037. Connections for members adjacent to the crane rails and girders are checked in Appendix A. A crane Runway Girder Runway Plate, End Support, and Interior Support Evaluation summary is tabulated below:
The member and connections were evaluated using member end forces and moments from STAAD.Pro V8i output from either the maximum envelope of

forces and moments from all of the load combinations or the critical resultant forces and moments from each of the load combinations. The allowable for the loads and moments are calculated in accordance with the DSAR (Ref. 3.1.1) and subsequently the AISC 6th edition for all connections excluding bolts and rivets in extreme (SSE) load cases. The allowable stress for bolts and rivets in the SSE cases is obtained from Ref. 3.1.7. Member section allowable stresses are in accordance with the AISC 9th edition to remain consistent with the main calculation.

SSE loads are used in combination with OBE allowable stresses to provide conservative bounding results for both the SSE and OBE load combinations unless otherwise stated.

Crane Girder Runway Plate		**Allowable**
Maximum Plate Shear Stress O.B.E.	14.2 ksi	14.4 ksi
Maximum Plate Shear Stress S.S.E.	14.84 ksi	20.16 ksi

Crane Runway Girder End Support (Member G7)		**Allowable**
Maximum Combined Shear	214 kips	410 kips

Crane Runway Girder Interior Support (Member G8A)		**Allowable**
Maximum Combined Bolt Shear (Girder Support Col. Cap Plate)	33.45 kips	54.12 kips
T-Beam Stem Bolt Shear (2 Bolts)	7.757 kips	23.56 kips
T-Beam Flg. Bolt Tension	7.757 kips	62.84 kips
Web Angles to Web Stiffener Plate Bolt Shear (13 Bolts Double Shear)	81.24 kips	234.52 kips
Web Angle to Bldg. Col. Tension per Rivet	3.787 kips	15.71 kips
Maximum Fastener I.R.	0.618	1
Girder Web Stiffener Plate to Girder Web Weld Combined Shear	131.13 kips	317. 35 kips
T-Beam Stem (Top Connection) Tension	7.757 kips	33.75 kips
T-Beam Stem (Top Connection) Compression	7.757 kips	59.51 kips
Bearing Stiffener Compression	567.68 kips	659.37 kips

<u>Anchor Bolts, Concrete Columns and Shear Walls</u>: (Ref. Appendix C of CALC-002)

The Zion Station Defueled Safety Analysis Report (DSAR) defines only a Design Basis Earthquake for the facility that is currently undergoing decommissioning and the seismic response curves for the facility provided in the DSAR are equivalent to the Safe Shutdown Earthquake (SSE) response used as the original design basis for the facility. There is no Operating Basis Earthquake (OBE) or Safe Shutdown (SSE) identified.

Although only one calculation is needed to conform to the DSAR, for the purpose of performing calculations on the building structure, the contractor for Zion*Solutions*, LLC (ZS) has used the SSE and OBE responses from the Updated Final Safety Analysis Report (UFSAR) and in most cases, the SSE and OBE have been analyzed in accordance with the SRP. However, in some cases, the SSE loads have been evaluated against the OBE working stress allowables, rather than perform both calculations (conservative). If the interaction ratio (IR) for this case was 1.0 or less, then no further analysis was performed. If the IR of the SSE loads vs. OBE working stress allowables was greater than 1.0, then the SSE and OBE cases were both evaluated.

Additional results that differentiate between OBE and SSE load cases related to the building structural analysis are provided below.

In the case of the crane analysis, per ASME NOG-1-2004 Section 4140, both operating basis earthquake and safe shut down earthquake are defined as extreme environment conditions and for this reason they have the same allowable values. Since operating basis earthquake response spectra are enveloped by safe shut down earthquake response spectra and both events have the same allowable values, OBE event is enveloped by SSE event and no further evaluation is carried out for an OBE event.

<u>Anchor Bolts</u>:

The capacity of the anchor bolts was evaluated for tension and shear as identified in the first two columns. Reactions were calculated at the column baseplates for both OBE and SSE loads using both working stress and ultimate strength load combinations. The anchor bolts were evaluated against the resultant worst case tension and shear loads.

Anchor Bolts			**Allowable**
Tension	Max. Tension in Single Anchor OBE (Type R Base Plate configuration)	89.45 kips	129.41 kips
	Max. Tension in Single Anchor SSE (Type R)	104.70 kips	129.41 kips
	Max. Tension in Group of Anchors OBE. (Type R)	178.81 kips	229.11 kips
	Max. Tension in Group of Anchors SSE (Type R)	209.28 kips	229.11 kips
Shear	Max. Shear in Single Anchor OBE (Type R)	7.99 kips	68.45 kips

Anchor Bolts			Allowable
	Max. Shear in Single Anchor SSE (Type T)	51.95-kips	68.45 kips
	Max. Shear in Group of Anchors OBE (Type R)	15.93 kips	161.20 kips
	Max. Shear in Group of Anchors SSE (Type T)	100.41 kips	137.50 kips
Maximum Interaction, Combined Tension and Shear OBE (Type R)		0.897	1.0
Maximum Interaction, Combined Tension and Shear SSE (Type R)		0.95	1.0

Concrete Columns:

The capacity of the concrete columns was evaluated in accordance with the original code for the design, ACI 318-63. Enveloped forces from the SSE load combinations were used and verified using working stress design (OBE allowable forces and stresses) as opposed to ultimate strength (SSE allowable forces and stresses). The results are bounding for the OBE case.
Axial and moment interaction diagrams from the, "Reinforced Concrete Design Handbook, Working Stress Method", Third Edition, ACI Publication SP-3 were used to compare forces to capacity.

Concrete Columns		Allowable
Max. Axial Load	711.49 kips	3617 kips
Max. Shear Stress	21.9 psi	70 psi
Max. Bearing Stress	207.3 psi	1000 psi
Max. Moment	18351 kip-in	18951 kip-in

Shear Walls:

The capacity of the concrete shear walls was evaluated for shears, moments, and axial loads as identified in the first column. The most limiting cases of evaluations of SSE Loads compared to working stress allowables are identified in the second and third column. The working stress method of ACI 318-63, the original design code of record, was used to evaluate the walls for the enveloped SSE loads. Where acceptable, this bounds the OBE load case. Isolated cases exist where SSE loads were evaluated using ultimate strength design allowables. In all but one case (described in the note to the table below), where SSE loads are evaluated using ultimate strength allowables, OBE loads were evaluated using working stress allowables.

Shear Walls						
Item	**SSE**	**OBE Allowable (Working Stress)**	**SSE**	**SSE Allowable (Ultimate Strength)**	**OBE**	**OBE Allowable (Working Stress)**
Maximum Out of Plane Conc. Shear Stress	70 psi Shear Wall P7	70 psi	77 psi Shear Wall P4	108 psi	64.8 psi Shear Wall P4	70 psi
Maximum Out of Plane Moment Per 1" Width	28.578 k-in. Shear Wall P8A	34 k-in.	30 k-in. Shear Wall P3	66.15 k-in.	Shear Wall P3*	27 k-in.
Maximum In-Plane Shear Stress	68 psi Shear Wall P10C	70 psi	SSE vs. SSE enveloped by SSE vs. OBE		OBE vs. OBE enveloped by SSE vs. OBE	
Maximum In-Plane Moment	1,073,150 k-in. Shear Wall P3	1,097,317 k-in.	SSE vs. SSE enveloped by SSE vs. OBE		OBE Vs. OBE enveloped by SSE vs. OBE	
Maximum Axial Load Per Ft. of Wall	68.86 kips Shear Wall P4	96 kips	314 kips Shear Wall P11	345 kips	230 kips Shear Wall P11	255.36 kips

*SSE Max. Moment - 30 k-in per in./OBE Working Stress Allowable Moment – 27 k-in. per in. (IR= 1.111). The SSE load case was subsequently evaluated independently and the satisfactory results are tabulated above. Based on the analysis and the results tabulated in Attachment 51 of the ZION001-CALC-002, SSE forces and stresses are larger than OBE; therefore by comparison, the wall is acceptable under OBE conditions.

c. KNES Calculation No. 36675-05 (Rev.01): Zion Bridge Structural Calculations

Summary: This analysis evaluates the crane structural steel member stresses and deflections and demonstrates that they meet the NOG-1-2004 Section 4300 design criteria, along with the buckling requirements.

Model/Methodology Description: Although not required for the existing bridge, NOG-1-2004 design criteria are followed for the bridge structural evaluation as it has more stringent rules than EOCI/CMAA and to be consistent with the other calculations.

A finite element model of the crane is developed using ANSYS 13.0 to solve for the applicable load cases. The bridge and end trucks are represented by beam elements and the trolley is represented by shell elements.

With respect to NOG-1-2004 paragraph 4140, the crane model is analyzed for crane operational loads and extreme environmental loads. SSE is considered for extreme loading conditions as it envelopes OBE. For the operational load case, the bridge girders are evaluated with the trolley at mid-span and the end trucks are evaluated with the trolley at the end of the span. 12 combinations of trolley location, hoist position, and load are evaluated for the extreme environmental case. A set of load cases is run at the mid-height hook position in addition to the nine cases required by NOG-1 Table 4153.7-2 (trolley at end, ¼, and mid-span for hook unloaded, hook up with load, and hook down with load). Boundary conditions are in accordance with NOG-1 Figure 4154.3-1 and Table 4154.3-1.

Assumptions:

- End tie bolts take only shear load. The bridge end truck connection is assumed to consist of bolts at the location only where the girder rests on the end truck.
- Conservatively, the bridge end truck connection is assumed to consist of bolts at the location only where the girder rests on the end truck.

Compliance to Section 4300 of NOG-1: The following paragraphs from NOG-1-2004 design criteria (paragraph 4300) are applicable to the analysis:

NOG -1 Section 4311: Calculations per Section 4330 show that the members are not controlled by buckling. Therefore the allowable values from Table 4311-1 are applicable.

NOG -1 Section 4313: The girders conform to the dimensional criteria outlined in Section 4333 of NOG-1, therefore bending stress allowables need not be altered.

NOG -1 Section 4321: This paragraph addresses the combined axial compression and bending. When there is a combination of axial compression (P) and bending (M), the interaction between them increases the bending stress. If a transverse load causing bending (M) produces a deflection d, then the axial compression (P) results in an additional moment P_d. A common practice in the codes is to include the contribution of axial compression to bending through an amplification factor. Since the bridge has a camber, which brings the bridge close to flat during normal operation, the deflection of the bridge with respect to horizontal level will be close to zero and therefore, the P_d moment will be close to zero. Bending stress on the

plates about the minor axis will be insignificant, as the transverse load causing bending about the minor axis does not include the live load. Since the bending is less, the P_d effects will be insignificant in this case, too. Therefore, the stress values are combined per equation (3). This equation is used in ANSYS to compute the axial stress. Therefore, the finite element analysis results are compliant with paragraph 4321.

NOG -1 Section 4322: Allowable bending stress and allowable axial stress are taken as 0.5 times the yield strength according to Table 4311-1. With this data, the denominator of equation (3) in paragraph 4321 of NOG-1 becomes $0.5S_y$. Equation (3) computes the resultant normal stress as the sum of axial stress and bending stress due to bending in two orthogonal directions. This interpretation suggests that comparing the normal stress output from the finite element analysis with $0.5S_y$ allowable is equivalent to using equation (3).

NOG -1 Section 4323: Bolts are evaluated per this Section.

NOG -1 Section 4324: Shear stress is computed by including the effect of direct bending, and shear stress and compared with 0.4 times the yield strength. This is equivalent to comparing the shear stress output from the finite element analysis with $0.4S_y$ allowable.

NOG -1 Section 4330: Buckling is checked in accordance with this Section.

NOG -1 Section 4341: The girder deflection from the finite element analysis is compared with the requirements of this Section.

Conclusion: The stresses and deflections of the structural steel members of the crane bridge were evaluated and it was demonstrated that they meet the NOG-1-2004 design criteria (paragraph 4300) including buckling requirements. Stress and deflection values are tabulated below against their respective allowables.

Operational Load Case

Bridge Girder		**Allowable**
Normal Stress	16.565 ksi	18 ksi
Shear Stress	2.728 ksi	14.4 ksi
Deflection	0.881 in	0.981 in
End Truck		**Allowable**
Normal Stress	4.518 ksi	18 ksi
Shear Stress	2.866 ksi	14.4 ksi

Connections		Allowable
End Tie Bolt Shear Stress	1.35 ksi	17.85 ksi
End Truck Bolt Normal Stress	2.08 ksi	39.6 ksi
End Truck Bolt Shear Stress	6.01 ksi	20.4 ksi

Extreme Environmental (SSE) Load Case

Bridge Girder		**Allowable**
Normal Stress (Hook up, Trolley @ mid)	17.378 ksi	32.4 ksi
Shear Stress (Hook up, Trolley @ ¼)	4.901 ksi	18 ksi
End Truck		**Allowable**
Normal Stress (Hook up, Trolley @ mid)	6.228 ksi	32.4 ksi
Shear Stress (Hook up, Trolley @ ¼)	3.379 ksi	18 ksi
Connections		**Allowable**
End Tie Bolt Shear Stress (Hook up, Trolley @ ¼)	6.79 ksi	27.3 ksi
End Truck Bolt Normal Stress (Hook up, Trolley @ end)	4.0 ksi	60 ksi
End Truck Bolt Shear Stress (Hook up, Trolley @ mid)	23.0 ksi	31.2 ksi

d. KNES Calculation No. 036675-09 NOG-1 2004 Single Failure Proof Trolley Structural Analysis

Summary: This calculation analyzes the stress distribution of the trolley per the load cases presented in NOG-1 2004 and the existing Zion Station design.

Model/Methodology Description: An ANSYS 13 software package, which has been qualified by Konecranes Nuclear Equipment and Services QA program, is used to build and analyze the model. The shell model of the trolley is built in ANSYS 12 and meshed with the SHELL63 elements. Since the trolley is a plate structure, it was decided that the 3D shell model would be the most accurate and efficient finite element model to build and analyze. Mid surfaces of the plates are used to create the shell model. The beam elements are used to model the drum and gear cases. Motor and platform weights are included as lumped masses at their locations. Beam 188 elements are used to model the bridge. Spring elements are used to represent the ropes which are also capable of providing the pendulum frequencies. Applied rope stiffness values for various hook positions are calculated.

Constraint equations (rigid regions) are created to tie the components such as drum, motors and gear cases to trolley and trolley wheels to the bridge.

Finite element models are generated for three trolley positions on the bridge (mid span, quarter span and end span) in combination with hook up, hook down, hook mid and no load on the hook configurations. The set of load cases run at the mid-

height hook position is in addition to the nine cases required by NOG-1 Table 4153.7-2. Boundary conditions are in accordance with NOG-1 Figure 4154.3-1 and Table 4154.3-1.

The response spectrum method is used for qualification of the trolley during the seismic event. From the coupled building crane evaluation, 24 response spectra at crane rail level are generated from ZION001-CALC-002 Rev 0. Enveloping response spectra for each direction are regenerated from the 24 broadened spectra provided. Results of the seismic analysis are combined per ASME NOG-1 Table 4153.7-2 by using SRSS method for all three directional responses along with an absolute value of 1 G static load. All three directional combined normal and shear stresses are determined and compared with NOG-1 allowable values. von Mises stresses are also plotted to show the critical regions. von Mises stress (also called equivalent stress) is used in design work because it allows any arbitrary three-dimensional stress state to be represented as a single positive stress value. Equivalent stress is part of the maximum equivalent stress failure theory. The purpose of providing the von Mises stress is to show the combined stresses and critical regions in one plot, instead of 6 different plots for normal and shear stresses.

Crane operational load cases in section 4140 of the ASME NOG-1

P_{C1}: $P_{db} + P_{dt} + P_{lc}$: enveloped by P_{C2}.
P_{C2}: $P_{db} + P_{dt} + P_{lc} + P_{v}$: analyzed under section 5.1 of this report.
P_{C3}: $P_{db} + P_{dt} + P_{lc} + P_{ht}$: analyzed under section 5.1 of this report.
P_{C4}: $P_{db} + P_{dt} + P_{lc} + P_{hl}$: analyzed under section 5.1 of this report.
P_{C5}: Plant operation induced loads and static test pressure loads. Not applicable

The trolley positions are addressed in Table 4153.7-2 for extreme environment conditions and all the applicable extreme environment conditions are addressed in the report. Impact loads in section 4133 are defined for operating condition loads and they are not required during seismic application as described in section 4140. For this reason, impact loads are applied only on the mid position, which is the most critical case for operational load case.

Load cases P_{C6}, P_{C7}, P_{C8} and P_{C9} are not performed in this analysis, since construction loads are not applicable for this crane. ZS requests an exception to the Operating Wind Pwo, Design Wind Load Pwd, and Tornado Wind Load Pwt, since this crane is used indoors and these loads are not part of the facility design basis for the crane itself. Since the tornado wind load is not evaluated in combination with the crane live load in the original plant design basis, procedural provisions have been made to lower the likelihood of fuel transfer operations during a tornado watch or warning.

Crane seismic event loads in section 4140 of the ASME NOG-1

P_{C10}: $P_{db}+P_{dt}+P_{cs}+P_{e'}$
P_{C11}: $P_{db}+P_{dt}+P_{e'}$
P_{cs}: Credible critical load for SSE = 250,000 lbs.
$P_{e'}$: SSE loads

Per NOG-1 Section 4140, both operating basis earthquake and safe shut down earthquake are defined as extreme environmental conditions; and for this reason, they have the same allowable values. Since operating basis earthquake response spectra are enveloped by safe shut down earthquake response spectra (and both events have the same allowable values), the OBE event is enveloped by the SSE event and no further evaluation is carried out for OBE event.

Compliance to Section 4300 of NOG-1

NOG -1 Section 4311 - Members Not Controlled by Buckling. It is shown that the members are not controlled by buckling. Therefore, the allowable values in Table 4311-1 are used.

NOG -1 Section 4313 - Bending Stress: Section 4313 states that: "The allowable bending stress for members other than those girders conforming to the dimensional criteria outlined in paragraph 4333 shall conform to AISC "Specification for Structural Steel Buildings, Allowable Stress Design and Plastic Design" Chapter F divided by 1.12N for the different loading conditions."

This section reduces the flexural strength to avoid lateral torsional buckling due to bending. However, if the member is a compact section, the plastic moment corresponding to the plastic section modulus can be used as the limit state. This is the same as the tension and compression allowable stress provided in NOG-1. Since the trolley plates are compact sections with several lateral stiffeners supporting them to avoid lateral torsional buckling, section 4313 is not applicable to the compact trolley plates.

NOG -1 Section 4321 - Section 4321 addresses the combined axial compression and bending. When there is a combination of axial compression (P) and bending (M), the interaction between them increases the bending stress. If a transverse load causing bending (M) produces a deflection δ, then the axial compression (P) results in an additional moment Pδ. The common practice in the codes is to include the contribution of axial compression to bending through an amplification factor. The trolley is built using plates that are short (taking credit for the presence of stiffeners), wide and thick. The only significant bending stress present in the trolley is about the major axis and this bending is caused by the application of live load. Because the plates are wide, the moment of inertia about the major axis is usually a large number resulting in a large bending stiffness for a short plate. Therefore, any

deflection caused by bending will be insignificant resulting in negligible increase in bending stress due to the Pδ effects. Bending stress on the plates about the minor axis will be insignificant, since the transverse load causing bending about the minor axis does not include the live load. Since the bending stress is insignificant, the Pδ effects will be insignificant in this case as well. Therefore, the stress values are combined per equation 3 of section 4321.

NOG -1 Section 4322 - Members subjected to Axial Tension and Bending: Allowable bending stress and allowable axial stress are taken as 0.5 times the yield strength according to Table 4311-1 and Section 4322. With this data, the denominator of equation (3) in section 4321 becomes $0.5S_y$. A closer look at the equation (3) shows that it computes the resultant normal stress as the sum of axial stress and bending stress due to bending in two orthogonal directions. From this interpretation it is concluded that comparing the normal stress output from ANSYS with $0.5S_y$ is identical with equation (3).

NOG -1 Section 4323 - Members subjected to Shear and Tension: Section 4323 addresses computing the combined stresses on bolts. Bolts are evaluated in miscellaneous item calculation 36675-14.

NOG -1 Section 4324 - Members subjected to Shear and Bending: As per section 4324, shear stress is computed by including the effects of direct, bending, and shear stress and compared with 0.4 times the yield strength. This is identical to comparing the shear stress output from ANSYS with $0.4S_y$.

NOG -1 Section 4330 - Buckling: Buckling is evaluated in accordance with this section.

Results: Seismic responses are computed by taking the square root of the sum of the squares of the maximum representative values of the co-directional responses caused by each of the three components of earthquake motion at each node, plus an additional 1 G static load.

All three directional normal and shear stresses are within the allowable limits defined in Table 4311-1 for all trolley and hook positions during seismic conditions and operating conditions. The stresses resulting from the hook up position are higher than the stresses in the hook down position, hook mid position and no load on the hook condition.

The table below shows the summary of combined maximum normal and shear stresses that are observed on the trolley for the governing hook up position.

	Max. Normal Stress	Allowable	Max. Shear Stress	Allowable
Operating Case				
Trolley at Mid Span	16.8	25	8	20
Seismic Cases				
Trolley at Mid Span	19.2	45	7.9	25
Trolley at ¼ Span	21.5	45	7.5	25
Trolley at End Span	19.2	45	7.8	25

e. KNES Calculation No. 036675-10 Trolley Critical Weld Stress Calculation

Summary: This calculation determines the trolley frame critical weld stresses in order to demonstrate that those stresses are within allowable stress values.

Model/Methodology Description:
Analysis of welds is performed per NOG-1 Section 4314, which states that the allowable stresses in welds shall be as specified in AWS D1.1, and may be increased by a factor of 1.50 for extreme environmental load combinations.

The trolley frame (per NOG-1 Section 4432.1) shall be designed to resist all loading imposed by the lifted load and the load combinations specified in NOG-1 Section 4140. For this analysis, the worst case load combinations are conservatively used.

Many welds in the calculation are evaluated by symmetry or by comparison to identical welds with higher loading. The welds for the 'drum catcher' support plates are considered to be acceptable by engineering evaluation. These welds will be subjected to compressive loading in the event of a drum shaft failure, but the stress on the welds will be minimal due to the presence of the top plate and the stiffeners underneath. Some girt plate welds were also considered acceptable by engineering evaluation. These welds were not considered in the evaluation of the primary girt plate welds leading to a conservative analysis.

Assumptions:

- The live load will not participate in the horizontal direction seismic calculations. Due to the low frequency of the ropes only the vertical seismic loads are considered for the live load.
- The forces transmitted to the welds due to seismic horizontal accelerations are negligible. The dead loads of the members are small.
- Net vertical seismic acceleration of 2.0g (including 1g for earth's gravity) was conservatively assumed in this calculation.

Results: The calculated weld stresses are within the allowable values. The table below presents the maximum stresses versus the allowable stresses.

	Maximum Weld Stress	Allowable Weld Stress
Operating Load Case	12.47 ksi	15.79 ksi
Seismic Load Case	21.696 ksi	23.69 ksi

f. KNES Calculation No. 036675-14 Seismic Analysis of Miscellaneous Items

Summary: This calculation evaluated the miscellaneous trolley connections to ensure their integrity during a seismic event

Model/Methodology Description: Material properties are given as a minimum and meet the ASTM or referenced standard.

Seismic stresses are calculated by applying a force equivalent to the component weight multiplied by a directional seismic factor at the estimated center of gravity of the component

Tensile forces on bolts due to moments were conservatively calculated at the point in the connection furthest away from the component center of gravity (e.g. at the location of the nut instead of the shear plane location).

NOG-1 allowable bolt stresses are based upon AISC specifications, which are based upon the nominal diameter of the bolt. Therefore, in this calculation the bolt nominal diameter is used in calculating bolt stresses.

The analysis of bridge mounted components is limited to those weighing above 300 lbs. This assumption limits the analysis to the electrical panel assemblies, electrical enclosures, and isolation transformer.

Assumptions:

- Seismic acceleration values (vertical and horizontal) are from Zion DSAR seismic response curves. These values are then multiplied by a 1.5 multimodal factor. Vertical down net acceleration has 1g added for gravity, and vertical uplift net acceleration has 1g subtracted. These seismic values were verified to envelope the accelerations determined in the new seismic analysis.
- All bolted connections are considered to be bearing type connections.
- The weld and bolt stresses are combined directly, which is conservative.
- The centers of gravity of the enclosures and enclosure assemblies are assumed to be at half of their height.
- In the calculations for the electrical platform assemblies only the welds at the bottom of the platform are considered to be holding the platform in place. The

connections on the rear of the assembly are conservatively ignored in order to simplify the calculation process.

- Similarly, in the enclosure bolt stress calculations, only the bolts at the bottom of the enclosure are considered to be holding the enclosure in place. The connections at the rear of the enclosures are conservatively ignored in order to simplify the calculation process.

Results: All analyzed components meet the allowable stress values of the applicable NOG-1 Section. The maximum stresses versus allowable values are presented in the table below. This calculation was only performed for the Extreme Environmental Load Case (SSE).

All values are in ksi	Calculated Stress	Allowable Stress
Max. Weldment Shear Stress	7.17	25
Max. Weldment Tensile Stress	39.48	45
Max. Bolt Shear Stress	38.21	42
Max. Bolt Tensile Stress	47.07	58.73
Max. Combined Weld Stress	26.6	31.5

g. KNES Calculation No. 036675-23 Main Hoist Reeving Stress

Summary: The hoist reeving system is evaluated for normal operation, broken rope and safe shutdown conditions. The components are designed for three times normal load along with 15% impact factor. The equalizer load pin is rated for five times specified lifted load.

Methodology: The components in the main hoist load path are evaluated against applicable NUREG-0612 and NOG-1 requirements. A 15% wear factor is added where applicable per NUREG-0554 requirements. A 5% wear factor is used for the main hoist wire rope due to limited anticipated wear (refer to NUREG-0554 Compliance Matrix).

The main hook is evaluated using straight beam theory in accordance with NOG-1 Section 5477(b). Equations from ASME BTH-1-2005 are used for the pinhole.

Material properties are given as a minimum and meet the ASTM or referenced standard.

Assumptions:

- Net vertical seismic acceleration of 2.0g (including 1g for earth's gravity) was conservatively assumed in this calculation.
- Design is for a minimum of three times the load with a 15% impact factor. This results in an allowable stress of 0.2898 x yield strength for the operational load case. The allowable stress in the seismic load case would be

0.9 x yield. With a vertical equivalent seismic acceleration factor of 2 the effective allowable yield stress is 0.45 x yield. Therefore the operational load case envelopes the seismic case. Critical components were designed for 6:1 on yield, which further envelopes the seismic load case.

- Similarly, for emergency conditions (i.e., broken rope), the allowable stress for mechanical components per NOG-1 Section 5321.2 is 75% of the yield strength. When one rope fails, the maximum increase in load would be 3x (2x normal load with 1.5x impact). Critical components were designed to take 6x the actual load with permanent deformation. Therefore the induced stress is less than 16.67% of the yield strength. Hence, if the load triples and the load path does not change, the induced stress will be less than 50% (3x 16.67%=50%) of the yield strength, which is less than the 75% allowed for the emergency condition. Therefore critical components that do not get into a different load path need not be checked for a single rope failure.

Results: All hoist reeving components including bearings meet the applicable NOG-1 and NUREG-0612/0554 requirements.

Individual evaluations include:

Hook Assembly	Meets NUREG-0612 & NOG-1-2004 (5428.1(b)) requirements	
Max. Normal or Tensile Stress (Tensile Through Shank)	11.27 ksi	< 15.83 ksi per NOG-1
	11.27 ksi	< 11.50 ksi per NUREG 0612
Max. Shear Stress (Tearout at Pinhole)	5.13 ksi	< 9.14 ksi per NOG-1
	5.13 ksi	< 6.64 ksi per NUREG 0612

Rope	Rope is selected based on the most stringent of NOG-Para. 15425.1 requirements. 5% degradation is applied to account for wear.	
Max. Operational Load	33.99 kip	< 38.52 kip per 5425(b)(2) (more limiting than (b)(1)
Max. Impact Load	100.36 kip	< 154.8 kip per 5425(b)(3)
Max. Seismic Load	69.61 kip	< 154.8 per 5425(b)(4)
Max. displacement was also calculated to be 1.69" during a single rope break.		

Bottom Block	Allowable stresses are per NOG-1 Table 4311-1 or NUREG-0612/0554.	
	Calculated Stress	**Allowable Stress**
Max. Bending Stress (Sheave Pin)	13.73 ksi	15 ksi
Max. Shear Stress (Crosshead)	2.59 ksi	3.75 ksi
Max. Bearing Stress(Sheave Pin/Plate)	13.33 ksi	37.50 ksi
Max. Weld Stress (Crosshead)	8.46 ksi	18.90 ksi

Upper Block	Allowable stresses are per NOG-1 Table 4311-1 or NUREG-0612/0554. The limiting values listed below are from the broken rope load case.	
	Calculated Stress	**Allowable Stress**
Max. Bending or Normal Stress (Equalizer Frame Plate 2)	34.25 ksi	37.50 ksi
Max. Shear Stress (Tearout at Equalizer Frame Plate 2 Hole)	14.94 ksi	21.65 ksi
Max. Weld Stress (Equalizer Frame Plate 2)	15.27 ksi	28.35 ksi

Drum	The Drum Shell is designed per NOG-1 Para 5411.5 with allowable stresses per Figure 5474-1 & 2.The Drum Shaft is designed per NOG-1 Para.5415.1with allowable stresses and load combinations per NOG-1 Table 5415.1-1.	
	Calculated Stress	**Allowable Stress**
Max. Drum Stress vs. Allowable: Combined Crushing and Bending Stress in Shell	8.51 ksi	8.91 ksi
Max. Drum Shaft Stress: Combined Bending and Shear (Load Combination 1)	18.65 ksi	40.85 ksi
Max. Drum Weld Combined Stress	6.49 ksi	18.90 ksi

h. Calculation ZION001-CALC-034, Fuel Handling Building (FHB) 125 Ton Crane Rail Clip Modification and Rail Evaluation

<u>Summary</u>: Calculations performed in calculation ZION001-002, Appendix B, demonstrated that the original runway rail and rail clip design were not adequate for the new design basis load case for a seismic event with a load on the hook. This new calculation evaluates the rail clips and the runway rail with the modification installed.

<u>Model/Methodology Description</u>: Simplified hand calculations are used to design a new crane rail clip assembly using MathCad 15. Governing crane wheel forces at the top of the crane rail for all crane and trolley positions for each of the load combinations from Attachment 56 of Ref. 3.7 are considered in the calculation for the new rail clip design.

As-built survey data of the crane runway rail determined the maximum existing clip center to center spacing to be 2ft.-7in. The majority of the existing clips are 2 ft.-0 in. center to center spacing. The new rail clips are installed between two existing rail clips providing generally the same center to center spacing (2 ft. -0 in.) as the existing design.

Conservatively, the new clips are designed for full wheel forces applied to a single rail clip without relying on the distribution of forces to the adjacent existing clips providing unanalyzed margin.

When a horizontal seismic load from the crane wheel is applied to the head of the crane rail, the force is decoupled into a bearing force on one edge of the crane rail base (bottom flange) along with the corresponding shear force and an uplift force on the opposite edge of the crane rail base (bottom flange). There are rail clips on each edge of the base (bottom flange) of the crane rail. Therefore each clip will either see force from shear with corresponding bearing or force from uplift. No credit is taken for friction between the bottom flange of the rail and the girder. On the bearing side, clips and bolts are designed for the applied shear force. On the uplift side rail clips and bolts are designed for the bending moment due to the rail bearing on the rail clip support.

The crane rail is checked for the applied forces for web shear, web bending and local rail base (bottom flange) bending.

The rail clip is connected to the top flange of the bridge runway girder. A local stress check of the crane runway girder flange for the applied rail clip forces is also performed. Crane girder global analysis for the applied new rail clip forces is not within the scope of this calculation. Calculation ZION001-CALC-002 describes the crane runway girder analysis.

Assumptions: None

Results: The highest loads and stress values along with allowable values are listed below. Note there are two clip styles; Clip 1 is the standard clip, Clip 2 is located at column tie-backs. The values below are for the limiting clip style for each load type.

Component/Load Description	Load/Stress	Allowable
Bending in clip due to uplift (Clip 2)	34.516 ksi	37.5 ksi
Shear in clip due to uplift at reduced section (Clip 1)	7.055 ksi	20 ksi
Bearing in clip at bolt location (Clip 1)	23.383 ksi	45 ksi
Block shear in clip (Clip 1)	72.34 kip	122.891 kip
Bolt Tension (Clip 1)	17.515 kip	53.7 kip
Bolt Shear (Clip 1)	36.17 kip	39.8 kip
Girder flange local bending due to tension in clip	5.015 ksi	27 ksi
Girder flange local bending due to compression	25.973 ksi	27 ksi

Component/Load Description	Load/Stress	Allowable
Girder flange local bearing	14.289 ksi	32.4 ksi
Girder flange local block shear	72.34 kip	299.334 kip
Crane rail local web shear	9.114 ksi	20 ksi
Crane rail local web bending	32.427 ksi	37.5 ksi
Crane rail minor axis bending	31.325 ksi	37.5 ksi
Crane rail bottom flange local bending	20.094 ksi	37.5 ksi

i. Enercon Calculation ZION001-CALC-037 Fuel Handling Building and Crane Runway Girder Connection at Col. Line X Evaluation

Summary: The Fuel Handling Bldg. Model Files, described in ZION001-CALC-002 (CALC-002), are updated in this calculation, to reflect the crane runway girder splice at Col. Line X, by adding a member end release for My & Mz at this location. The connection was modeled as fixed in the CALC-002 analysis. The effects of the modeling change to the results from the original design analysis in calculation CALC- 002 are shown to be insignificant, therefore, the results of calculation CALC-002 remain valid. The building members, connections, and crane response from the original calculation, CALC-002, are bounding and do not change. The evaluation of the connection of runway girder G8B at Col. Line X contained in this calculation supersedes the evaluation of this connection in calculation CALC-002. The connection for Girder G8B at Col. Line X is acceptable for the loads provided in this calculation with the joint pinned.

Model/Methodology Description: The STAAD Models from CALC-002 were re-run with the crane girder member ends released at Col. Line X to determine the adverse effects this may have on the results of the other sections of the original design calculation, CALC-002. Two more crane bridge locations were added to the STAAD Models to address the full positive moment on the runway girders in the spans adjacent to Col. Line X resulting from releasing the moments at the end connection.

STAAD structural software was utilized to verify the I.R.'s of the structural members for the code check are in accordance with the AISC 9th Edition Manual of Steel Construction. This code check will verify that the moment released due to the new boundary condition will not overstress the crane runway girders in the spans adjacent to Col. Line X.

Hand calculations were performed to evaluate the girder splice connection at Col. Line X in accordance with the AISC 6th Edition Manual of Steel Construction. AISC N690-1994 is used, as required, in accordance with NUREG-0800, to provide allowable overstress factors for bolts. The design loads for evaluation of the girder splice are the maximum envelope end forces for girder member G8B from worst

case SSE results. SSE loads are used in combination with OBE allowable stresses to provide conservative bounding results for both the SSE and OBE load combinations unless stated otherwise.

The time history acceleration response of the crane at the wheels was compared to the original model of CALC-002 to determine any affects on the spectral accelerations used for the crane analysis.

Assumptions: Reference assumptions description for CALC-002.

Results: All the structural members pass the Allowable Code Check with the exception of members 55, 15291, and 2864 which are the same members originally identified in calculation, CALC-002, with IRs higher than 1.0. The IRs, as calculated are equal to or lower than the IRs in the original model. Additional evaluation of the members in the original calculation (CALC-002), has been performed and shows the members with I.R.'s greater than 1.0 to be less than 1.0. Accordingly, The IRs analyzed in this calculation are similarly acceptable.

The highest loads and stresses for the crane runway girder horizontal web stiffener and the components of the girder splice at Col. Line X are reported below:

Crane Girder Runway Plate @ Col. Line X		**Allowable**
Maximum Plate Shear O.B.E.	76.824 kips	88.94 kips
Maximum Plate Shear S.S.E.	92.406 kips	124.52 kips

Crane Runway Girder Interior Support @ Col. Line X (Member G8B)		**Allowable**
Maximum Combined Bolt Shear with Reduction of the Shear Allowable for Bolt Tension (Girder Support Col. Cap Plate)	10.85 kips	52.99 kips
T-Beam Stem Bolt Shear (2 Bolts)	8.23 kips	23.56 kips
T-Beam Flg. Bolt Tension (2 Bolts)	8.23 kips	62.84 kips
Web Angle to Col. Connection Plate Bolt Shear with Reduction of the Shear Allowable for bolt Tension (26 Bolts Single Shear)	37.21 kips	211.05 kips
Web Angle to Girder Bolt Shear based on Compression in Girder and Girder Bearing (13 Bolts Double Shear)	234.17 kips	234.52 kips
Girder End Plate to Col. Flg. Connection Bolt Tension (2 Rows of 13 - 7/8 in. Dia. Bolts)	74.42 kips	625.3 kips
Girder Stiffener Plate to End Plate Weld Connection	74.42 kips	389.47 kips
Girder Stiffener Plate Horiz. Tension	74.42 kips	372.6 kips
Girder Stiffener Plate Horiz. Compression	74.42 kips	517.87 kips

Crane Runway Girder Interior Support @ Col. Line X (Member G8B)		Allowable
T-Beam Stem (Top Connection) Tension T-Beam Stem (Top Connection) Compression	8.23 kips 8.23 kips	33.75 kips 59.51 kips
Girder Web Clip Angle Leg Tension Girder Web Clip Angle Leg Compression Bending Stress of One Angle Leg Against Girder Due to Forces in Z-Direction	39.91 kips 101.67 kips 24.8 ksi	248.4 kips 380.54 kips 27.0 ksi
Girder Support Col. Cap Plate Weld Combined Shear	23.5 kips	201.35 kips
Girder Bearing Stiffener Compression Girder Bearing Stiffener Bearing	229.75 kips 229.75 kips	296.44 kips 360.45 kips

Changing the boundary condition at the two isolated girder splice locations at Col. Line X has no significant impact to evaluations of all the remaining structural elements and connections performed in ZION-CALC-002 aside for the connection of the crane girder at Col. Line X evaluated here. Therefore the evaluations for the other structural elements in calculation CALC-002 are bounding and remain valid.

The time history accelerations at the crane wheels from the CALC-037 model file, are similar when compared with the time history file of the same model of CALC-002 for all three component directions (X,Y, and Z). The maximum delta between the two models is 0.004g in the Z-direction or 1.6%. This change is negligible.

The location of the crane in this model is centered over column line V. As justified in CALC-002, this position is bounding for seismic input response to the crane. The primary mode of vibrations and frequencies do not change with respect to crane/trolley location, loading condition, and hook position as described in CALC-002, therefore the file selected is bounding for all model files and there is no adverse impact to the seismic accelerations provided to the crane vendor in calculation CALC-025.

2.4 Heavy Loads Program

Zion*Solutions*, LLC has developed a heavy loads program that satisfies the guidelines provided in NUREG-0612, Control of Heavy Loads at Nuclear Power Plants." In NUREG-0612, the guidelines for control of heavy load lifts provide assurance for the safe handling of heavy loads in areas where a load drop could impact on stored spent fuel, fuel in the reactor core, or equipment required to achieve safe shutdown or permit continued decay heat removal. Based on the permanently defueled state of the ZNPS, and the length of time the spent fuel has been stored in the Spent Fuel Pool, the areas applicable to NUREG-0612 guidelines are in or around the Spent Fuel Pool, or in or around a cask loaded with spent fuel, or a lift of a cask loaded with spent fuel There is no safe shutdown equipment associated with the handling of heavy loads.. The heavy loads program will prohibit travel with a heavy load over the Spent Fuel Pool, exclusive of the

cask loading area, without the appropriate administrative controls. To further reduce the probability of a load handling accident, ZS will use a single-failure proof crane to improve reliability through increased factors of safety and through redundancy in certain active components for activities near the fuel pool and the handling of spent fuel casks. ZS has followed the guidance for designing single-failure proof cranes provided in NUREG-0554, "Single-Failure-Proof Cranes for Nuclear Power Plants" as supplemented by NUREG-0612 Appendix C and NRC Regulatory Information Summary (RIS) 2005-25 (including Supplement 1).

In NRC Bulletin 96-02, Movement of Heavy Loads over Spent Fuel, Over Fuel in the Reactor Core, or Over Safety-Related Equipment, dated April 1996, the NRC Staff requested licensees to provide specific information detailing the extent of their compliance with the guidelines and their licensing basis. In response to NRC Bulletin 96-02, Exelon provided confirmation that all heavy load handling activities that were planned at that time were within existing regulatory guidelines. Existing plant crane procedures implement the heavy load activities. Furthermore, the response indicated that if any subsequent activities identified an unreviewed safety question per the provisions of 10 CFR 50.59, a license amendment request would be submitted. This proposed license amendment request and the associated heavy loads program, as revised, are intended to satisfy that commitment.

ZS has chosen to satisfy the guidance in Sections 5.1.1, 5.1.2 and 5.1.6 as detailed in the attached NUREG 0612 compliance matrix (Attachment 3). This matrix includes a discussion on meeting the additional guidance provided in Regulatory Issue Summary (RIS) 2005-25, "Clarification of NRC Guidelines on Control of Heavy Loads," issued in October 2005 and as supplemented in May 2007.

The draft Heavy Loads Program is attached to this document and will be approved and implemented by ZS prior to handling heavy loads and revised as needed in accordance with station procedures.

Required Load Lifts -

Each transportable storage canister (TSC) will be placed in the Spent Fuel Pool (SFP) and removed from the pool using a transfer cask. Once a TSC has been loaded with spent fuel and processed it is lowered into a Vertical Concrete Cask (VCC) for transport to the ISFSI. The general steps to fill and process each TSC inside the Fuel Handling Building (FHB) are as follows:

1. Place an empty MAGNASTOR Transfer Cask (MTC) in the FHB Truck Bay or Cask Decontamination Pit (CDP).
2. Place an empty TSC inside the MTC.
3. Transfer the empty MTC/TSC to a staging area on the north side of the SFP.
4. Fill the TSC with water.
5. Lift the flooded MTC/TSC assembly from the staging area to the cask loading pit in the SFP.
6. Fill the TSC with spent fuel.

7. Place the TSC lid on the loaded TSC.
8. Lift the loaded MTC/TSC assembly from the SFP to the CDP.
9. The TSC's internal volume is dewatered, vacuum-dried, lid closure-welded, and filled with inert gas.
10. Lift the MTC/TSC assembly over to the Truck Bay.
11. Place the loaded MTC/TSC assembly on top of an associated Vertical Concrete Cask (VCC)/Transfer Adaptor.
12. Lower the loaded TSC from the MTC into the VCC.
13. Remove the empty MTC from the top of the VCC and place it in the FHB Truck Bay or CDP.
14. Remove the Transfer Adaptor from the VCC and install the VCC Lid.

The Transfer Cask weighs 108,500 lbs. and a fully loaded TSC with a lid weighs 102,000 lbs. The combined weight of the loaded and flooded TSC with a lid inside a Transfer Cask and including the Lifting Yoke is 228,000 lbs. The Fuel Building Crane is rated at 125 tons.

The safe load path for handling the loaded cask will be shown in revised DSAR Figure 3-34. Handling of the MTC will be performed using a specially designed yoke as specified by NAC and described in the MAGNASTOR Safety Analysis Report. Safe load paths for other lifts listed above will be controlled as required by the Heavy Loads Program attached.

This sequence of cask lifts/movements will be performed during both dry run and normal spent fuel transfer operations until all the spent fuel assemblies are removed from the SFP, placed into TSCs lowered into their associated VCCs and transported to the ISFSI.

The FHB overhead crane will also be used to lift/move auxiliary equipment and components (e.g., welding system, vacuum drying system, shielding devices, lifting yokes, etc.) throughout the FHB in preparation for and during spent fuel transfer operations.

2.5 Installation

The crane has been designed, assembled and will be installed using processes compliant with a 10 CFR 50, Appendix B, Quality Assurance Program. The installation of the single failure proof crane will be performed during the summer months of calendar year 2012 which is prior to receipt of NRC approval for use of the crane crediting its single failure proof features. Crane installation will be restricted to areas removed from the spent fuel, such that a failure of the crane or its lifting mechanism will not affect stored spent fuel. Once installed, the heavy loads program will be utilized for heavy load lifts in the FHB, however, administrative and physical prohibitions will remain in effect until approval for use as a single failure proof crane is obtained from the NRC.

2.6 DSAR Changes

In addition to proposing a new license condition for upgrading the Fuel Handling Building overhead bridge crane, DSAR changes are proposed to reflect the design changes to the crane and the implementation of the NUREG-0612 heavy loads program. These proposed changes also remove the existing cask drop event analysis and update the safe load path in the DSAR. Any postulated drops of radioactive components outside of the Fuel Handling Building are compared against the radioactive waste handling accident in the DSAR. The DSAR changes are provided in Attachment 2 and will be implemented upon approval of the proposed license amendment in compliance with 10 CFR 50.71(e).

TABLE 1 - UPGRADED FUEL HANDLING BUILDING OVERHEAD BRIDGE CRANE SYSTEM PERFORMANCE REQUIREMENTS

Bridge Capacity (MCL & Design Rated Load)	125 Tons
Auxiliary Hoist Capacity	15 Tons
Main Hoist Speed (Maximum with MCL)	5 fpm
Main Hoist Speed (Maximum with no Load)	7.5 fpm
Auxiliary Hoist Speed (Maximum with Rated Load)	20-24 fpm
Auxiliary Hoist Speed (Maximum with No Load)	30-36 fpm
Trolley Speed (Maximum with MCL Rating)	50 fpm
Bridge Speed (Maximum with MCL Rating)	50 fpm
Main Hoist Lift	52'-0"
Auxiliary Hoist Lift	74'-1"
Trolley Height	5'-4"
Trolley Gage	13'
Trolley Wheel Base	8'

3.0 TECHNICAL EVALUATION

3.1 Existing Design Bases

The general design criteria followed in the initial design of ZNPS were developed as performance criteria which define or describe safety objectives and procedures. Along with these performance criteria, the Station was designed to comply with Commonwealth Edison's understanding of the intent of the Atomic Energy Commission's (AEC) proposed General Design Criteria, as published for comment by the AEC in July 1967. The Zion Construction Permit, which established many of the ZNPS safety-related design criteria, was issued in December 1968. The ZNPS FSAR, which presented the detailed design of the plant, was submitted in December 1970. Subsequent to this submittal, the AEC's final General Design Criteria was published as Appendix A to 10CFR50 in July 1971.

The performance criteria used in the design of ZNPS that remain applicable in the defueled condition are specifically addressed in the Defueled Safety Analysis Report (DSAR). There, the performance criteria are quoted and are followed by a brief summary of the resulting design or procedures. These performance criteria provide compliance with the intent of the AEC's proposed General Design Criteria, as published in July 1967. The following GDCs are currently applicable to the Fuel Handling Building overhead crane.

GDC 2, Design Bases for Protection Against Natural Phenomena

The Fuel Handling Building and the structures used to protect and handle the spent fuel, such as the Spent Fuel Pool and overhead bridge crane are designed to withstand the effects of natural phenomena such as an earthquake and tornado winds.

GDC 61 - Protection Against Radioactivity Release From Spent Fuel and Waste Storage

Containment of fuel and waste storage is provided if an accident could lead to release of undue amounts of radioactivity to the public environs.

All fuel storage and spent fuel handling activities are performed within the Fuel Handling building and the facility design is such that accidental releases of radioactivity directly to the atmosphere will not exceed the limits of 10CFR100. All operations with the spent fuel are conducted underwater. This provides visual control of the operation at all times and also maintains low radiation levels. The storage pool is filled with borated water which assures sub-criticality at all times, though maintenance of boron in the pool is not required by the ZNPS Technical Specifications. This water also provides adequate cooling for the spent fuel. The spent fuel storage pool is supplied with a cooling system for the removal of the decay heat of the spent fuel. Racks are provided to accommodate the storage of up to 3012 fuel assemblies in a vertical array ensuring appropriate geometry (spacing of assemblies) to maintain subcritical conditions even with unborated water for fuel with for fuel having a maximum loading of 57.4 grams U-235 per axial centimeter of fuel assembly length. The water level maintained in the pool will provide sufficient shielding to permit normal occupancy of the area by operating personnel. Postulated

accidents involving the release of radioactivity from the fuel and waste storage and handling facilities are shown in Chapter 5 of the DSAR to result in exposures well within the limits of 10CFR100. The spent fuel storage pool is a reinforced concrete structure with a corrosion resistant liner. This structure is designed to withstand the anticipated earthquake loadings. The liner will prevent leakage even in the event the reinforced concrete develops cracks.

The following GDC is frequently considered applicable to evaluation of heavy loads handling systems is no longer considered applicable at ZNPS and accordingly not to the Fuel Handling Building Crane for the stated reasons.

GDC 4 - Dynamic Effects Design Bases

No high energy systems remain at ZNPS, thus dynamic events need not be considered with respect to the Fuel Handling Building crane.

The following GDC are frequently considered applicable to evaluation of heavy loads handling systems but are no longer considered applicable at ZNPS. The design and installation of the crane system however satisfies the bases of these GDC.

GDC-1 - Quality Standards and Records

No SSCs are designated as safety related at ZNPS and both reactors are permanently defueled. A designation of Important to the Defueled Condition (ITDC) as opposed to safety related is described by the DSAR for system, structures or components (SSCs) that require additional quality controls based on the current ZNPS conditions. The ITDC quality program is discussed in the Quality Assurance Program Plan. However, the crane design, fabrication and installation have been contracted with KoneCranes Nuclear Equipment & Services LLC who will apply an approved a 10CFR50 compliant QA program equivalent to the ASME NQA-1 program to the crane.

GDC-5 - Sharing of Equipment and Components Important to Safety

There is no requirement for safe shutdown of the units since the units are permanently defueled and no SSCs are designated as safety related. Accordingly, there is no requirement associated with shared equipment to assure safe shutdown. The Fuel Handling Building and Spent Fuel Pool are designed to prevent the release of undue amounts of radioactivity to the public. The accidents currently applicable in the defueled condition are a loss of Spent Fuel Pool cooling, a loss of Spent Fuel Pool inventory, a fuel handling accident, and a radioactive waste handling accident. The DSAR also contains an analysis that shows for a cask drop handling event in the Fuel Handling Building that the spent fuel pool is not damaged. Although GDC 5 is not directly applicable, no single failure of the new lifting system that will be installed will impact the capability of the spent fuel pool to perform its function in its current condition since no new event is credible that affects the existing analyses.

3.2 Existing Safety Analysis

The accidents and events that remain applicable to ZNPS in its permanently defueled condition as currently described in the DSAR are:

- Fuel Handling Accident in the Fuel Building
- Spent Fuel Pool Events/Operational Occurrences
- Radioactive Waste Handling Accident
- Spent Fuel Cask Drop

Those associated uniquely with the Fuel Building are:

Fuel Handling Accident in the Fuel Building

An analysis has been performed for the Fuel Handling Accident in the Fuel Building (involving the drop of a single, irradiated fuel assembly into the pool). This analysis indicates that off-site doses (without mitigation) are much lower than previously evaluated and, thus, well within the 10 CFR 50.34(a)(1) and 10 CFR 100.11 exposure guidelines. The dose to Control Room personnel remains within the limits specified in 10 CFR5 0, Appendix A, GDC-19 under these same conditions. These results are primarily due to the fact that the spent fuel assemblies in the Spent Fuel Pool have undergone more than ten years of radioactive decay and there is an insignificant amount of radioactive iodine left in the fuel assemblies. This accident is discussed in Chapter 5 of the DSAR.

Spent Fuel Pool Events/Operational Occurrences

Potential events associated with the Spent Fuel Pool while in the defueled condition are limited to those related to the loss of pool cooling or the loss of pool water inventory. An analysis for the loss of Spent Fuel Pool cooling concludes that a loss of forced Spent Fuel Pool cooling does not constitute an excessive risk for ZNPS. Analysis of a loss of spent fuel inventory concluded that a rupture in the Spent Fuel Pool cooling return line (the limiting break) does not constitute an unacceptable risk for ZNPS. In both cases this is due to the extremely slow rate of Spent Fuel Pool water boil off. Adequate time is available to initiate corrective measures for restoration of malfunctioning components, or to institute an alternative method of cooling using onsite or offsite water supplies without significant radiological consequences for plant workers in the fuel handling building. This accident is discussed in Chapter 5 of the DSAR.

Spent Fuel Cask Drop

The Spent Fuel Cask Drop analysis is used only for structural considerations to demonstrate that impact of a swinging spent fuel cask that is dropped from the maximum allowed height will not result in damage to the Spent Fuel Pool such that uncontrolled water loss occurs. The permanently defueled condition of the plant does not change this analysis or its conclusions. This event is discussed in section 3.9.5 of the DSAR.

The DSAR does not identify a failure of any portion of the Fuel Handling Building. The absence of this discussion demonstrates that the Fuel Handling Building structure does not result in an adverse consequence in the event of a seismic occurrence. As such the FHB complies with Section C.2 of Regulatory Guide 1.29, "Seismic Design Classification," and Paragraph II.8 of NUREG-0800, "Standard Review Plan," Section 3.7.2.

3.3 Accident Analysis Impacts

Upgrading the Fuel Handling Building overhead crane to a single-failure proof crane and performing operations in accordance with a the proposed heavy loads program will permit elimination of the postulated spent fuel cask drop event analysis from the ZNPS safety analysis (DSAR Section 3.9.5) since the probability of occurrence of a drop will be very low as described in NUREG 0612. The existing cask drop event analysis, as described in DSAR Section 3.9.5, does not envelope the MAGNASTOR cask and yoke which will be used to load the spent fuel from the pool for transport to the ISFSI. A fully loaded MAGNASTOR cask, filled with water, including the transfer cask and the lifting yoke weighs approximately 115 tons under the hook. The existing DSAR cask drop event analysis is for a cask which weighs 110 tons including the yoke and lifting cables.

The existing fuel handling accident, Spent Fuel Pool loss of cooling or pool drain down, and the radioactive waste handling accident as presently described in the DSAR are not affected by the crane upgrade. The fuel handling accident will remain applicable until all spent fuel has been removed from the pool and transported to the ISFSI. The Spent fuel Pool Events and the radioactive waste handling accident will remain applicable until the pool components and low level radioactive waste respectively have been removed from the site during decommissioning.

3.4 Upgraded Crane Safety Analysis

ZS will no longer consider a cask drop to be credible because the use of a single failure proof crane and associated handling programs as described in NUREG 0612 reduces the probability of a canister or cask drop event to acceptably low levels as to effectively preclude the event. ZS specifically commits to meet the guidance of Section 5.1., 5.1.2 and 5.1.6 of NUREG-0612 as discussed in the NUREG 0612 Compliance Matrix (Attachment 4) which is a part of this submittal. This matrix includes a discussion on meeting the additional guidance provided in RIS 2005-25 and clarification of NRC Guidelines on Control of Heavy Loads, issued in October 2005 and as supplemented in May 2007. A list of commitments is also provided in Attachment 1. ZS is upgrading the Fuel Handling Building overhead bridge crane to a single-failure proof crane, which minimizes the probability of a heavy load handling accident in or near the Spent Fuel Pool by improving crane reliability through increased factors of safety and through redundancy in certain active components. ZS has followed the guidance for designing single-failure proof cranes located in NUREG-0554, *Single-Failure Proof Cranes for Nuclear Power Plants*, ASME NOG-1, and NUREG-0612 Appendix C. The Fuel Handling Building and the upgraded crane will withstand the safe shutdown earthquake as described in the DSAR by safely holding the maximum critical load during and after an earthquake. The FHB, as a result of the design basis earthquake, will not adversely impact ITDC structures, systems or components,

such as the fuel pool and stored fuel, and the upgraded crane will have the ability to safely lower the heavy load either with or without power to an area on the safe load path.

The DSAR will be revised to remove the existing cask drop analysis (DSAR Section 3.9.5) and add a discussion to reflect the design changes to the crane and the implementation of the NUREG-0612 heavy loads program. The DSAR changes are provided in Attachment 2.

4.0 REGULATORY EVALUATION

4.1 Applicable Regulatory Requirements/Criteria

The DSAR and plant procedure changes required to implement dry spent fuel storage at the Zion Nuclear Power Station have been evaluated to determine whether applicable requirements and regulations continue to be met with this proposed modification. ZS has determined that the proposed amendment does not require any exemptions or relief from regulatory requirements and does not affect conformance with any 10 CFR 50, Appendix A General Design Criterion (GDC) differently than described in the DSAR.

NRC regulatory guidance applicable to this proposed amendment includes NUREG-0612, "Control of Heavy Loads at Nuclear Power Plants" Sections 5.1.1, 5.1.2, 5.1.6 and Appendix C, NUREG-0554, 'Single-failure Proof Cranes'(Reference 2), ASME NOG-1-2004, which has been endorsed by the NRC in RIS 2005-25, Supplement 1 (Ref.7) as an acceptable means of meeting the criteria in NUREG-0554 "Single-failure Proof Cranes", and ANSI N14.6- 1993, "American National Standard for Radioactive Material - Lifting Devices for Shipping Containers Weighing 10,000 lbs (4500 kg) or More".

The current DSAR licensing basis includes an analysis of the handling of a spent fuel shipping cask in the cask area of the Spent Fuel Pool. Additionally, the movement of the shipping cask from the cask area to the transport area is currently provided in plan view. The licensing basis for the handling of the shipping cask in the cask area of the Spent Fuel Pool will be replaced by use of the single-failure proof crane handling system and the associated heavy loads program. Accordingly, the prevention of a drop and the handling methods identified in the DSAR remain bounding for the handling of the loaded MAGNASTOR Transfer Cask since the single-failure proof design of the crane precludes events in the cask area of the Spent Fuel Pool, due to the very low probability of occurrence of such drops, and on the movement path to the transportation loading area. Because the Fuel Building Crane is integral to the Fuel Building, this amendment request is governed by the regulations in 10 CFR Part 50.

NUREG 0612 Compliance Matrix (Attachment 4)

As a means of demonstrating conformance to the NUREG-0612 criteria for operations, maintenance, testing and administrative procedures, ZS has compiled a point by point evaluation of the heavy load handling controls with the provisions of NUREG-0612 and presents it in Attachment 4 to this Amendment Request. The basis for the individual evaluation is provided and referenced to a specific procedure or administrative control or technical document that provides or will provide demonstration of that basis when completed.

ASME NOG-1 Compliance Matrix (Attachment 5)

Since the NRC has endorsed ASME NOG-1 2004 as an acceptable means of satisfying the Guidelines of NUREG-0554, ZS has compiled a point by point evaluation of the design of the replacement trolley with the provisions of ASME NOG-1 and presents it in Attachment 5 to this

Amendment Request. The basis for the individual evaluation is referenced to a technical document that provides demonstration of that basis. If a specific deviation or an exception is taken relative to a provision, a basis for that deviation is provided.

NUREG-0554 Compliance Matrix (Attachment 6)

The replacement trolley has been designed to ASME NOG-1 criteria, with one exception, which satisfies the NUREG-0554 criteria. To demonstrate that the entire crane system, bridge, bridge rails and supporting building structure meet the guidelines of NUREG-0554, ZS has compiled a point by point evaluation of the design of the crane system with the provisions of NUREG-0554 and presents it in Attachment 6 to this Amendment Request. The basis for the individual evaluation is referenced to a technical document that provides demonstration of that basis. If a specific deviation is taken relative to a provision, a basis for that deviation is provided.

The above references contain appropriate commitments to ANSI N14.6, "American National Standard for Radioactive Material - Lifting Devices for Shipping Containers Weighing 10,000 lbs (4500 kg) or More," and B30.9 2003 "Slings" to ensure compliance with the associated recommendations.

The NRC staff has endorsed (RIS 2005-05 as supplemented) the application of the criteria for Type 1 cranes from ASME NOG-1-2004, "Rules for Construction of Overhead and Gantry Cranes," to the design of new overhead heavy load handling systems as an acceptable method for satisfying the guidelines of NUREG-0554, "Single-Failure-Proof Cranes for Nuclear Power Plants. Further, rigging that conforms with the guidance of N14.6-1993, "Radioactive Materials - Special Lifting Devices for Shipping Containers Weighing 10,000 Pounds (4500 kg) or More," will be used for recurrent load movements of spent fuel casks. The lifting device will have a single load path with twice the design safety factor specified by ANSI 14.6 for the load. ZS has provided information showing conformance with these standards as well as developing administrative controls (Heavy Loads Program) consistent with NUREG-0612 to control the operations, maintenance, testing and administrative controls of handling heavy loads. Accordingly, the use of the single-failure proof crane with the application of the Heavy Load Program procedures provides the basis for approval of use of the crane and precluding the possibility of a drop due to the low probability afforded by these actions.

4.3 No Significant Hazards Consideration Determination

The subject License Amendment Request seeks NRC approval for the methods of analyses, installation of a new trolley on the existing bridge rails in the Fuel Building, approval of the administrative controls to be used for control of heavy loads and certification of the crane and its supporting structure as a single-failure proof crane for use in spent fuel packaging operations. The License Amendment Request further requests that the Defueled Safety Analysis Report (DSAR) be changed to include a description of the crane and its supporting structure and to delete the spent fuel dropped cask event analysis (DSAR Section 3.9.5), which is no longer applicable and to add a section on the control of heavy loads.

Specifically Zion*Solutions*, LLC requests the following:

- Approval of the analyses and methods used to design the new ASME NOG-1 trolley and evaluation of the existing bridge and supporting structures including the existing runway rails and Fuel Building structure as being acceptable for qualification of the Fuel Building Crane as single-failure proof as described by ASME-NOG-1 as endorsed by Regulatory Issue Summary (RIS) 2005-25, Supplement 1, "Clarification of NRC Guidelines for Control of Heavy Loads," (RIS 2005-25) as a means of satisfying the requirements of NUREG-0554.

- Approval that operations, maintenance, testing and administrative procedures developed in accordance with NUREG-0612 provide the necessary controls for the handling of heavy loads at the Zion Nuclear Power Station.

- Approval to revise the DSAR to include: a description of the Fuel Building Crane; a section to describe the Control of Heavy Loads; and deletion of the spent fuel dropped cask analysis.

The use of the new single-failure crane in the Fuel building has been evaluated and the analysis has concluded:

This change does not involve a significant increase in the probability or consequences of an accident previously evaluated.

The existing DSAR analysis assumes that a spent fuel cask drop occurs. In this analysis, the physics of the drop, coupled with concrete bumpers on the cask loading pit and pool edge were used to demonstrate that a postulated drop of the spent fuel cask near the Spent Fuel Pool neither impacted the spent fuel directly nor damaged the pool structure in a manner that adversely affected the spent fuel, when a cask was to be handled in the cask loading pit.

The proposed License Amendment Request to operate a single-failure proof Fuel Building Crane demonstrates that no analysis is required for the cask drop event based on the design and the associated programmatic controls. A drop of the spent fuel cask handled with a single-failure proof crane (designed to ASME NOG-1and compliant with NUREG 0554), operated in accordance with the administrative controls of NUREG 0612, has an acceptably low probability so as to effectively preclude consideration of the event. No aspect of the Fuel Handling Building seismic design adversely affects the ability of the crane to support the load and the cask drop is therefore not considered. The risk of such a drop event using the new single-failure proof crane operated in accordance with the Heavy Loads Program procedures, qualitatively, is lower than the event previously analyzed which postulate the event without evaluation of its likelihood.

Therefore, the proposed change does not involve a significant increase in the probability or consequences of an accident previously evaluated.

This change does not create the possibility of a new or different kind of accident previously evaluated.

The location and design functions of the Fuel Building crane are not changed from those currently described in the DSAR. Because the new crane has a single-failure proof design the uncontrolled lowering, or drop, of a heavy load will not be considered credible. Evaluations show that individual malfunctions or component failures of the crane will not result in load drop. The new single-failure proof crane primary use will be used to move a loaded or unloaded MAGNASTOR transfer cask between the cask loading pit, the decontamination pit, and transfer to the low profile cart rail transport in the Fuel Handling Building. No components that are classified as Important to the Defueled Condition, other than the Fuel Building crane, will be affected by these movements. Based on the design and programmatic controls on the crane no load will lower uncontrollably or drop in or around the spent fuel pool or near an open cask containing spent fuel nor will a cask containing spent fuel drop or be lowered uncontrollably during operation of the crane. Hence no new accidents will be initiated.

Therefore, the proposed change will not create the possibility of a new or different kind of accident from any accident previously evaluated.

Does not involve a significant reduction in a margin of safety.

This proposed License Amendment Request involves the replacement of the existing non-single-failure proof Fuel Building Crane with a new single-failure proof crane. The new crane has been designed to meet the specifications found in ASME NOG-1-2004, which has been endorsed by the NRC in RIS 2005-25, as supplemented, as an acceptable means of meeting the criteria in NUREG-0554, "Single-failure Proof Cranes for Nuclear Power Plants." to provide adequate protection and safety margin against the uncontrolled lowering of the lifted load. The occurrence of a cask load drop accident is considered not credible when the load is lifted with a single-failure proof lifting system meeting the guidance in NUREG-0612, "Control of Heavy Loads at Nuclear Power Plants," Section 5.1.6, "Single-Failure-Proof Handling Systems." As a result, the proposed change, replacing the existing non-single-failure proof crane, has no adverse impact on stored spent fuel, or structural integrity of the pool.

The configuration of the crane and the primary load, a spent fuel cask containing spent fuel, is changed from that of the DSAR. The specific analysis dealing with a drop of the cask will no longer be applicable and removed from the DSAR, since the new single-proof crane makes that event of low enough probability to not be considered credible. The maximum critical lift capacity of the crane has not been changed, though the load to be lifted is larger. The structural analyses of the crane and its support structure, show acceptable margin under the acceptance criteria of NOG-1 for operation of the crane.

Therefore, the proposed change does not involve a significant reduction in the margin of safety. Based on the above, ZS concludes that the proposed License Amendment Request presents no significant hazards considerations under the standards set forth in 10 CFR 50.92(c) and, accordingly, a finding of "no significant hazards consideration" is warranted.

4.4 Environmental Assessment

ZS has evaluated the proposed change against the criteria for identification of licensing and regulatory actions requiring environmental assessment in accordance with10 CFR 51.21, "Criteria for and identification of licensing and regulatory actions requiring environmental assessments." ZS has determined that the proposed change meets the criteria for a categorical exclusion set forth in 10 CFR 51.22, "Criterion for categorical exclusion; identification of licensing and regulatory actions eligible for categorical exclusion or otherwise not requiring environmental review," paragraph (c)(9), and as such, has determined that no irreversible consequences exist in accordance with 10 CFR 50.92, "Issuance of amendment," paragraph (b). This determination is based on the fact that this change is being proposed as an amendment to a license issued pursuant to 10 CFR 50, "Domestic Licensing of Production and Utilization Facilities," which changes a requirement with respect to installation or use of a facility component located within the restricted area, and the amendment meets the following specific criteria:

(i) The proposed change involves no significant hazards consideration.

As demonstrated in Section 5.1, the proposed change does not involve a significant hazards consideration.

(ii) There is no significant change in the types or significant increase in the amount of any effluent that may be released offsite.

The proposed change will allow use of a single-failure proof methodology that includes hardware and operational procedures and processes to replace an existing drop analysis approach. As a result of this approach no changes in consequences occur because of the change. As a result there will be no significant increase in the amounts of any effluents released offsite since no event need be postulated to occur. The proposed change does not increase the production, nor alter the flow path or method of disposal of radioactive waste or byproducts. Therefore, the proposed change will not affect the types or increase the amounts of any effluents released offsite.

(iii) There is no significant increase in individual or cumulative occupational radiation exposure.

The proposed change will not result in changes in the configuration of the facility. There will be no change in the level of controls or methodology used for processing of radioactive effluents or handling of solid radioactive waste, nor will the proposal result in any change in the normal radiation levels within the plant. Therefore, there will be no increase in individual or cumulative occupational radiation exposure resulting from this change.

5.0 References

1. NUREG-0612, Control of Heavy Loads at Nuclear Power Plants: Resolution of Generic Technical Activity A-36

2. NUREG-0554 Single-Failure-Proof Cranes for Nuclear Power Plants

3. ASME NOG-1-2004 Rules for Construction of Overhead and Gantry Cranes (Top Running Bridge, Multiple Girder)

4. Crane Manufacturer's Association of American (CMAA) Specification No. 70-1975

5. American Welding Society (AWS) D14.1 Industrial Mill Crane Welding

6. NRC Regulatory Information Summary (RIS) 2005-25, Clarification of NRC Guidelines for Control Of Heavy Loads , October 31, 2005

7. NRC Regulatory Information Summary (RIS) 2005-25 Supplement 1, Clarification of NRC Guidelines for Control Of Heavy Loads

8. NRC Bulletin 96-02, Movement of Heavy Loads over Spent Fuel, Over Fuel in the Reactor Core, or Over Safety-Related Equipment, dated April 1996

9. John B. Hosmer (ComEd) letter to U.S. NRC, ComEd Response to NRC Bulletin 96-02, "Movement of Heavy Loads Over Spent Fuel, Over Fuel in the Reactor Core, or Over Safety-Related Equipment," dated May 13, 1996

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

Attachment 2:

Regulatory Commitments, Proposed Operating License Changes and Proposed DSAR Changes

List of Regulatory Commitments

This table identifies actions discussed in this letter that Zion*Solutions*, LLC commits to perform.

Any other actions discussed in this submittal are described for the NRC's information and are not commitments.

COMMITMENT	TYPE	
	ONE-TIME ACTION	CONTINUING COMPLIANCE
Notify the NRC when the single-failure proof modifications to the Fuel Handling Building overhead crane are complete	X	
All heavy load lifts in or around the Spent Fuel Pool or in or around a cask loaded with spent fuel or a lift of a cask loaded with spent fuel the Spent Fuel Pool made using the upgraded Fuel Handling Building crane lifting system will meet the guidance in NUREG-0612, Section 5.1.6, as follows: • Special lifting devices, as defined in ANSI N14.6 will meet the guidance in NUREG-0612, Section 5.1.6(1)(a) and ANSI N14.6-1993, as clarified in the NUREG 0612 Compliance Matrix attached to this License Amendment Request (LAR). • Lifting devices not specially designed for the MAGNASTOR casks will meet the guidance in NUREG 0612, Section 5.1.6(1)(b) and ASME B30.9-2003, as clarified in the NUREG 0612 Compliance Matrix attached to this LAR. • The Fuel Handling Building overhead crane will meet the guidance in NUREG 0612, Section 5.1.6(2) and Appendix C and NUREG-0554 as clarified in the NUREG 0612 Compliance Matrix and NUREG-0554 compliance matrix attached to this LAR. • Interfacing lift points will meet the guidance in NUREG 0612, Section 5.1.6(3), as clarified in the NUREG 0612 Compliance Matrix attached to this LAR.		X
Crane operator training will meet the guidance in ASME B30.2-1976.		X
Crane maintenance and inspections will meet the guidance in ASME B30.2-1967.		X
Lift height limits consistent with the crane single failure analysis and NAC MAGNASTOR technical specifications will be included in the crane operating procedures.		X
Revise DSAR Sections 3.2.4.1, 3.9.2.2, 3.9.3.2.3, 3.9.3.2.4, 3.9.5, and 3.9.12 to replace the dropped cask analysis and travel restrictions over the Spent Fuel Pool with a description of the single-failure proof crane modifications to the Fuel Handling Building overhead crane.	X	

COMMITMENT	TYPE	
	ONE-TIME ACTION	CONTINUING COMPLIANCE
Heavy load movements using the Fuel Handling Building (FHB) Overhead Bridge Crane are not permitted if a tornado watch or warning has been declared for the site by the National Weather Service. If heavy load handling with the OBC is in progress when any of these criteria are met, the load will be placed in a safe location as soon as possible and the crane secured.		X
The auxiliary hoist will be administratively controlled to prevent placing a load on the auxiliary hook that could impact stored fuel or a cask containing spent nuclear fuel.		X

Unit 1 Proposed Operating License Change

(e) The appropriate section of the decommissioning trust agreement shall state that the trustee, investment advisor, or anyone else directing the investments made in the trust shall adhere to a "prudent investor" standard, as specified in 18 CFR 35.32(a)(3) of the Federal Energy Regulatory Commission's regulations.

(15) ZS shall take all necessary steps to ensure that the decommissioning trust is maintained in accordance with the application for approval of the transfer of the Zion, Unit 1, license and the requirements of the Order approving the transfer, and consistent with the safety evaluation approving the Order.

(16) ZS is authorized to revise the Defueled Safety Analysis Report (DSAR) as set forth in the application for amendment by the licensee, dated October 25, 2012 and May 16, 2013 . ZS shall update the DSAR to include a description of the single-failure proof Fuel Building crane as authorized by Amendment xxx and in accordance with 10 CFR 50.71(e). This license amendment is effective on the date of issuance and shall be implemented prior to the start of spent fuel transfer operations to the Zion Independent Spent Fuel Storage Installation.

3. This amended license is issued without prejudice to subsequent licensing action which may be taken by the Commission.
4. This license is effective as of the date of issuance and shall expire at midnight on April 6, 2013.

FOR THE ATOMIC ENERGY COMMISSION
Original signed by Roger S. Boyd
A. Giambusso, Deputy Director
For Reactor Projects
Directorate of Licensing

Date of Issuance: October 19, 1973

Amendment xxx

Unit 2 Proposed Operating License Change

(e) The appropriate section of the decommissioning trust agreement shall state that the trustee, investment advisor, or anyone else directing the investments made in the trust shall adhere to a "prudent investor" standard, as specified in 18 CFR 35.32(a)(3) of the Federal Energy Regulatory Commission's regulations.

(15) ZS shall take all necessary steps to ensure that the decommissioning trust is maintained in accordance with the application for approval of the transfer of the Zion, Unit 1, license and the requirements of the Order approving the transfer, and consistent with the safety evaluation approving the Order.

(16) ZS is authorized to revise the Defueled Safety Analysis Report (DSAR) as set forth in the application for amendment by the licensee, dated October 25, 2012 and May 16, 2013. ZS shall update the DSAR to include a description of the single-failure proof Fuel Building crane as authorized by Amendment xxx and in accordance with 10 CFR 50.71(e). This license amendment is effective on the date of issuance and shall be implemented prior to the start of spent fuel transfer operations to the Zion Independent Spent Fuel Storage Installation.

3. This amended license is issued without prejudice to subsequent licensing action which may be taken by the Commission.
4. This license is effective as of the date of issuance and shall expire at midnight on Nov 14, 2013.

FOR THE ATOMIC ENERGY COMMISSION
Original signed by Roger S. Boyd
A. Giambusso, Deputy Director
For Reactor Projects
Directorate of Licensing

Date of Issuance: October 19, 1973

Amendment xxx

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3.2.4 Structures, Systems and Components Important to the Defueled Condition (ITDC)

3.2.4.1 General

SSC classification involves a determination that an SSC is, or is, not safety related[1]. SSCs classified as safety-related are treated differently by regulation than other SSCs[2].

SSC's were originally classified according to the safety function they performed during power operation. Clearly, the first two parts of the safety-related definition in 10 CFR 50.2 (ensuring integrity of the reactor coolant pressure boundary, and the capability to achieve and maintain safe shutdown) are not applicable to a permanently defueled plant. The third part of the safety-related definition (prevent or mitigate consequences of accidents comparable to 10 CFR 50.34(a)(1) or 10 CFR 100.11 guidelines) is also not applicable. This is primarily due to the fact that the present day source terms are significantly reduced.

The accidents and events that remain applicable to Zion Station in its permanently defueled condition are:

- Fuel Handling Accident in the Fuel Building
- Spent Fuel Pool Events/Operational Occurrences
- Radioactive Waste Handling Accident
- ~~Spent Fuel Cask Drop~~

A new analysis has been performed for the Fuel Handling Accident in the Fuel Building. This analysis indicates that off-site doses (without mitigation) are much lower than previously evaluated and, thus, well within the 10 CFR 50.34(a)(1) and 10 CFR 100.11 exposure guidelines. The dose to Control Room personnel remains within the limits specified in 10 CFR 50, Appendix A, GDC-19. These results are primarily due to the fact that the spent fuel assemblies in the Spent Fuel Pool have undergone in excess of a year of radioactive decay and there is an insignificant amount of radioactive iodine left in the fuel assemblies. This accident is discussed in Chapter 5.

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1. Safety related SSCs are those relied upon to remain functional during and following design basis events to ensure: a). the integrity of the reactor coolant pressure boundary; b). the capability to shut down the reactor and maintain it in a safe shutdown condition, and c). the capability to prevent or mitigate the consequences of accidents that could result in potential offsite exposures comparable to guidelines of 10 CFR 100.

2. 10C FR 50, Appendix B notes that "The pertinent requirements of this appendix apply to all activities affecting the safety-related functions of..." SSCs.

The Spent Fuel Pool Events are a loss of forced cooling and a loss of water level. Both cases result in a loss of forced cooling and a loss of inventory such that boiling in the pool eventually occurs. Based on the reduced heat load in the Spent Fuel Pool (due to the elapsed time since both reactors were shutdown), the evaluations of these events demonstrate that, in both cases, the loss of inventory is very slow. For both the loss of Spent Fuel Pool forced cooling and the loss of Spent Fuel Pool inventory, a significant period of time will elapse from the loss of forced cooling until boiling and boiloff of the pool occurs until the water level drops to approximately 3.9 feet above the stored fuel assemblies. At this water level, the resultant radiological dose at the edge of the Spent Fuel Pool is approximately 3.6 R/hr. In either of the above cases, adequate time is available to initiate corrective measures for restoration of malfunctioning components, or to initiate an alternative method of cooling using onsite or offsite water supplies, without significant radiological consequences to plant workers in the Fuel Handling Building or to members of the general public. These events are discussed in Chapter 5.

An evaluation of an accident associated with a container of radioactive resins generated during decontamination activities has been performed. This evaluation indicated that, based upon a curie content of waste significantly higher than would be allowed in a shipping container, an accident that results in the airborne release of dewatered resin will not result in a dose at the EAB in excess of the USEPA Protective Action Guidelines or 10 CFR 100 limits. This accident is described in Chapter 5 (Radioactive Waste Handling Accident).

~~The Spent Fuel Cask Drop analysis is used only for structural considerations to demonstrate that impact of a swinging spent fuel cask that is dropped from the maximum allowed height will not result in damage to the Spent Fuel Pool such that uncontrolled water loss occurs. The permanently defueled condition of the plant does not change this analysis or its conclusions. This event is discussed in section 3.9.5~~

The drop of a spent fuel cask during handling is not considered credible due to the use of a single failure proof Fuel Building crane, the use of special lifting devices that satisfy ANSI 14.6, slings that conform to ANSI B30.9-2003 and implementation of the controls of NUREG-0612, which reduces the probability of a heavy load handling accident in or near the Spent Fuel Pool such that it need not be considered.

Based on the above, it is concluded that no SSC's are required to be classified as safety-related at Zion in its permanently defueled condition. This results in two areas of interest:

1. Zion's "nuclear grade" processes are based largely upon quality assurance (10 CFR 50, Appendix B) requirements. Reclassifying all SSCs as non-safety related could lead to the elimination of most management controls in situations where maintaining management controls is desired.

2. Zion recognizes that certain functions remain important to safety in the defueled condition.

The Cask Loading Pit is a ~~A~~ separate, walled off area ~~is~~ provided at the northwest corner ~~end~~ of the pool ~~for the storage of the spent fuel cask~~ for loading used fuel into a Transportable Storage Canister (TSC). ~~The walls prevent the cask from falling into the spent fuel storage area. The base mat of the fuel storage pool in the cask storage area has been designed so that structural integrity will not be lost in the event of a cask drop.~~ The TSC is handled using a MAGNASTOR Transfer Cask (MTC). The empty MTC and TSC may be staged on the north side of the pool prior to placement in the loading pit. After the TSC is loaded with used fuel, it is moved from the spent fuel pool to the Cask Decontamination Pit for canister processing. The TSC lid is welded and the canister is vacuum dried and back filled with helium in the decontamination pit. When canister processing is complete, the MTC is placed on top of the Vertical Concrete Cask (VCC) and the TSC is lowered into the cask. The VCC with the loaded TSC is then removed from the FHB on a Low Profile Cask Rail Transporter.

In the unlikely event that some leakage from the spent fuel pool were to occur, protective features have been provided to prevent radioactive material release to the environs from either loss of water from the storage pool or mechanical damage to the irradiated fuel.

The below listed features were incorporated in the design of the spent fuel pool to meet the design intent of AEC Safety Guide 13:

1. All spent fuel storage facilities are located in a Seismic Class I structure. In addition, the spent fuel racks within the fuel pool are Seismic Class I.

2. Although no longer required to be functional or credited in any accident analysis, the ventilation system provided in the Fuel Handling Building is equipped with filtration devices to limit the potential release of radioactive materials.

3. All piping connections to or from the spent fuel pool are above the level of the spent fuel racks.

4. Level instrumentation, with alarms, and radiation monitoring devices have been provided for the spent fuel pool.

5. Makeup water for the pool is available from a tank onsite. Backup sources are available from additional water supplies.

6. Interlocks are provided to prevent the main hoist from ~~capable of~~ carrying heavy loads ~~from entering~~ over the area of the spent fuel pool where fuel is stored unless specific procedural requirements are met to bypass the interlocks. These interlocks are described in detail in Section 3.9.3.2.4.1. Figure 3-34 shows the general arrangement of the Fuel Handling Building and the route for the spent fuel transfer cask to move from the pool to the truck bay.

3.9.3.2.3 Fuel Building Crane

The ~~f~~Fuel Handling ~~b~~Building crane is an ~~125-ton electric~~ overhead top-running traveling bridge crane and is equipped with a 125-ton design rated load (DRL) main hoist and a 15-ton auxiliary hoist. The overhead crane is used for lifting and transporting the MAGNASTOR Transfer Cask (MTC) from the Spent Fuel Pool cask loading area to the cask decontamination area and to the Fuel Handling Building truck bay. It is also used to lift and move other equipment located or stored in the Fuel Handling Building and items associated with loading and handling spent fuel casks. The maximum critical load (MCL) rating on the overhead crane is 125 tons.

The overhead crane meets the single-failure proof criteria of ASME NOG-1-2004, NUREG-0554, and NUREG-0612, Appendix C. The main hoist is classified as a Type I main hoist per ASME NOG-1-2004 (single-failure proof for loads up to 125 tons). The auxiliary hoist is not single-failure proof (Type III).

The Fuel Handling Building crane is classified as Important-To-Defueled-Condition (ITDC) equipment and is seismically analyzed. The crane is seismically designed such that it will maintain control of the MCL during a design basis Safe Shutdown Earthquake (SSE) event.

The single-failure proof trolley for the overhead crane meets the structural and mechanical requirements of ASME NOG-1-2004, with one exception, tornado wind loads are not considered in the new analyses and are instead referred back to the original design basis.

~~, designed to allow for lifting and carrying a load 25% above the rated capacity. This is a specification design consideration and does not affect the crane rating.~~ The structural design of the existing bridge and support structure conforms to the applicable requirements of the Electrical Overhead Crane Institute, Inc. (EOCI) Specification and applicable portions of the American Institute of Steel Construction (AISC) Specification for all design provisions not covered by the EOCI Specification. ~~An additional design consideration allows for lifting and carrying a 230-ton load nine feet from the centerline of the north crane rail. This requirement resulted in crane and building runways capable of taking a load far in excess of the rated capacity at that particular location.~~ - The crane has been designed to withstand seismic conditions. The main hook is a "sister hook" type with pin hole and is fitted with safety ~~clamps~~ latches. The hook is forged steel and has been ~~radiographed~~ ultrasonic and magnetic particle inspected. ~~The lifting tackle and gearing was designed with a factor of safety not less than five. The load holding capability for the main hoist cable has a factor of safety of 6.2. Each of the 14 cables has a breaking strength of 48.3 tons.~~ The load on the wire rope does not exceed 10% of the published breaking strength. The load does not exceed 40% of the published breaking strength in a seismic event or broken rope scenario.

The crane is provided with three brakes, an eddy current ~~speed control~~ brake and two ~~motor~~ shoe-type holding brakes. Each ~~motor~~ mechanical brake is ~~rated at 550 ft-lbs and is~~ capable of holding 150% of full ~~the~~ load drive torque. ~~Electrical power is required to unload the motor brakes.~~ Loss of power results in setting the mechanical holding brakes~~locking the load in position~~. ~~The stall-out torque of the motor (275% of full load~~

~~running torque) is 750 ft-lbs. The two motor brakes together are capable of holding the load at the stall-out torque condition~~. Load control is provided by electrically controlled

dynamic braking. The eddy current brake is used for emergency lowering of the load and does not require external power.

3.9.3.2.4 Fuel Building Crane Interlocks

The fuel building crane has been designed with safety interlocks and limit switches, which, together with end stops, guard against any over-travel of both the bridge and trolley~~,~~. ~~and~~ Additional limit switches limit both the upper and lower travel of the hoist. These switches are activated whenever the crane apparatus goes beyond these limits and whenever a high radioactivity signal is transmitted by the radiation monitor. Interlocks are also provided to prevent main hoist travel over the spent fuel racks containing spent fuel. Other interlocks are also provided as safety features for the main hoist. ~~No load and a fully raised main hoist are further requirements for travel over the spent fuel storage pool. These restrictions ensure that no accidental load will be carried over the pool.~~ The interlocks provided are further described below.

3.9.3.2.4.1 Travel Limit Switches

The bridge and trolley are provided with limit switches of the automatic-reset type to slow down the bridge or trolley prior to contact with the end stops. Limit switches are also provided for the bridge and trolley that define a restricted zone around the Spent Fuel Pool (SFP). The zone is based on main hook location such that a spent fuel transfer cask could not be brought over the SFP exclusive of the cask loading pit. In the event that the crane must be brought over the spent fuel pool, where spent fuel is stored, administrative controls performed in accordance with the heavy load program will be used to control bypass of these limit switches.

3.9.3.2.4.2 Hoist Limit Switches

The main and auxiliary hoists are provided with two limit switches in both the raise and lower directions. Both hoists have a geared limit switch for the first limit in each direction. The geared limits remove control power in the direction of motion, but will allow the reverse motion after being actuated. Both hoists also have a weighted limit switch for the second upper limit. The upper weighted limit switches de-energize the respective safety stop circuits, removing power from the hoist motion contactor and setting the brakes. Both hoists utilize the load weighing system to provide a second lower limit. When an underweight (slack rope) condition is detected, the respective safety stop circuits are de-energized, removing power from the hoist motion contactor and setting the brakes.

The following conditions also stop main hoist motion by de-energizing the main hoist motion contactor:

- Mis-reeving detected by a bar over the drum.
- Overweight condition detected by the load weighing system.
- Unbalanced load detected by the load weighing system.
- Overspeed switch.
- Main Hoist Drive fault.

The following condition interrupts the up motion control for the main hoist:

- High radioactivity signal transmitted by Fuel Building overhead crane radiation monitor

~~3.9.3.2.4.1 Interlock/Limit Switch Function~~

~~The bridge and trolley are provided with limit switches of the automatic-reset type to prevent over-travel in either direction. The main hoist has limit switches to stop the hook in its highest and lowest safe positions. Each limit switch is wired so that the drive motor can be energized in the reverse direction after its limit switch has opened. Two limit switches serve to restrict the upward travel of the hoist hooks, while a block-type switch is used on the cable, and screw type on the drum. These switches are adjusted so that if one fails to operate the remaining one will shut off the current.~~

~~Electrical limit switches backed up by fail-safe mechanical stops located on all four rails will not permit any trolley movement over the restricted pool area. If operation over this area is necessary, the operator must override the above mentioned limits with controls located on the bridge. Trolley movement is interlocked through the use of a load cell on the main hook and a position sensor. When the main hook is in its uppermost position and unloaded, the trolley can pass over the restricted area with the auxiliary hoist in operation.~~

~~A mechanical system of stops to prevent crane movement over the fuel pool area consists of a system of bumpers and limit switches. Targets will be provided on the crane bridge to contact special bumpers mounted on the building. Electrical limits are provided on the hoist to sense position and loading. The only time the target can be hoisted out of the way is when the main hoist is in its highest position with an empty hook. Additional limit switches are provided on the target hoists which will not allow operation of the main hoist until the targets are in position. A similar target bumper arrangement is provided for the trolley. The sensing of the hoist position and the load on the hook is done with electric limit switches. An override switch box with red warning lights is located on the bridge.~~

~~In addition, an auxiliary relay with contacts in the raising control circuit of both hoists is provided such that, when it is energized by a fuel radiation monitor, it will prevent further raising of the hoists.~~

~~3.9.3.2.4.2 Hoist Limit Switches - Operation~~

~~The hoist limit switch is a safety device which prevents the bottom block from coming in contact with any part of the trolley. All limit switches are similar in that they open circuits to stop the hoisting motion when the bottom block is raised above a preset upper limit.~~

~~The hoist limit switches automatically reset when the bottom block is lowered below the preset upper limit. Two types of limit switches are used on crane applications. They are the weight-operated limit switch and the geared limit switch.~~

~~The basic operation of any weight-operated limit switch is as follows:~~

1. ~~When the bottom block is below the preset upper limit, the reset counterweight or bar maintains the limit switch in its normal operating~~

position.

2. When the bottom block approaches its preset upper limit, it contacts the reset counterweight or bar. Further upper movement at the bottom block lifts the reset counterweight or bar, allowing the operating lever or sheave to rotate. As the operating lever or sheave rotates it turns a shaft on which the actuating cams are mounted. Therefore, as the shaft rotates, the cams rotate until they open the normally closed contacts of the limit switch. This stops the hoist motor and applies the motor brake.

3. If the bottom block drifts beyond the preset upper limit, the reset counterweight or bar continues to rise and the actuating cams rotate still further. Eventually, the plugging cams close the plugging circuit contacts. This reverses the hoist drum and lowers the bottom block below the preset upper limit.

The adjustable geared limit switch opens the HOIST circuit when the bottom block reaches the preset upper limit and opens the LOWER circuit when the bottom block reaches a preset lower limit. The limit switch is driven by the hoist drum and is actuated after a predetermined number of drum revolutions.

Both the HOIST and LOWER circuits are connected through sets of normally closed contacts in the limit switch. Both the upper and lower limits of bottom block travel are preset at the factory.

3.9.5 Control of Heavy Loads

3.9.5.1 Introduction/ Licensing Background

In response to NRC Bulletin 96-02 (Ref. 13), Exelon provided confirmation (Ref. 14) that all heavy load handling activities that were planned at that time were within existing regulatory guidelines. Furthermore, the response indicated that if any subsequent activities identified an unreviewed safety question per the provisions of 10 CFR 50.59, a license amendment request would be submitted.

In order to move the spent fuel from the spent fuel pool to the Independent Spent Fuel Storage Installation (ISFSI), Zion has upgraded the Fuel Handling Building overhead crane to a single-failure-proof capability. The change in methodology for analyzing a cask drop, from a non-single-failure-proof crane and load drop analysis to a single-failure-proof crane with no assumed load drop, required a license amendment request per 10 CFR 50.90 (Ref.15). The license amendment (Ref. 16) allows the transfer of spent fuel to a transportable storage canister located in the cask loading area of the spent fuel pool without having to assume a cask drop accident.

Operations, maintenance, testing and administrative station procedures provide the necessary controls for the handling of heavy loads over the spent fuel pool such that the requirements of NUREG-0612 are met.

3.9.5.2 Safety Basis

The risk associated with handling of heavy loads at the Zion Nuclear Power Station is acceptably low based on compliance with the NUREG 0612 Section 5.1.1, 5.1 2 and 5.1.6 requirements. For movement of the of the transportable storage canisters in the Fuel Handling Building using the overhead crane, the safety evaluation report concluded that a cask drop accident is unlikely based on the use of the single-failure-proof crane, handling equipment certification and administrative controls.

3.9.5.3 Scope and Control of Heavy Load Handling Systems

The Fuel Handling Building overhead and load handling equipment has been determined to be within the scope of NUREG 0612. The sections that follow provide details of the aspects of the Zion Nuclear Power Station Heavy Loads Program.

3.9.5.4 NUREG 0612 Elements

The Fuel Handling Building overhead crane is within the scope of NUREG 0612. Seven elements must be met as described in NUREG 0612, Section 5.1.1 commonly known as Phase I ["...Accordingly, all plants should satisfy each of the following for handling heavy loads that could be brought in proximity to or over safe shutdown equipment or irradiated fuel in the spent fuel pool area or containment (PWRs), in the reactor building (BWRs), and in other plant areas."] Due to the present state of decommissioning the Zion Nuclear Power Station, the only area still applicable to NUREG-0612 is the spent fuel pool area.

These seven elements of Phase I have been implemented at the Zion Nuclear Power Station as follows:

3.9.5.4.1 Safe Load Paths

Safe load paths have been defined at the Zion Nuclear Power Station for the handling of heavy loads utilizing load handling equipment, which, if dropped could impact irradiated fuel. Deviations from defined load paths will require alternative approved procedures. Load paths are not defined for loads less than 1,800 lbs., however, they typically follow the safest and shortest route with the load as close to the floor as practical. A heavy load is defined as a load greater than or equal to 1,800 lbs.

Existing Fuel Handling Building overhead crane procedures and the fuel transfer procedures describe the job responsibility of the person directing the heavy load movement.

3.9.5.4.2 Load Handling Procedures

Procedures have been developed to cover load handling operations for the heavy loads identified in Table 3.1-1 of NUREG 0612 at the Zion Nuclear Power Station. These procedures identify the required equipment, the inspections and acceptance criteria prior to initiating load movement, the steps and sequence in handling the load and define the safe load path and other special precautions. Because the maximum credible tornado and the fully loaded crane have not been analyzed together, heavy load movements using the Fuel Building overhead bridge crane are not permitted if a tornado watch or warning has been declared for the site.

3.9.5.4.3 Qualifications, Training, and Conduct of Crane Operators

The Zion Nuclear Power Station complies with ANSI B30.2-1976 with respect to operator training, qualification and conduct.

3.9.5.4.4 Special Lifting Devices

The special lifting devices employed at the Zion Nuclear Power Station have been designed in accordance with industrial standards using good engineering practices. The special lifting devices for the MAGNASTOR transfer cask have been provided by NAC. The fabrication of these lifting devices used standard quality control procedures. The lift yoke special lifting devices have been designed and tested in accordance with ANSI N14.6-1993 requirements.

Prior to use of specially designed lifting devices, visual inspection is performed, in some cases, certain critical and accessible parts or members, such as hooks and pins, are non-destructively examined at appropriate time intervals.

Should an incident occur in which a special lifting device is overloaded, damaged or distorted, an engineering assessment is performed. This assessment addresses ANSI NI4.6 and includes consideration of the load test up to the original procurement load test value or I50%, whichever is less.

3.9.5.4.5 Lifting Devices Not Specially Designed

For heavy load handling in the Fuel Handling Building, Zion Nuclear Power Station procures and inspects slings to ANSI B30.9-2003. Inspections are conducted annually and examined visually prior to use. Slings are installed and used in accordance with ANSI B30.9-2003. All lifting devices were designed according to industrial standards using good engineering practices. The dynamic loads generated by the Fuel Handling Building crane at the Zion Nuclear Power Station are added to the static load when selecting slings.

3.9.5.4.6 Inspection and Testing of Cranes

The Fuel Handling Building crane at the Zion Nuclear Power Station is inspected, tested, and maintained in accordance with Chapter 2-2 of ANSI B30.2-1976, with the exception that testing and inspections are performed prior to use where it is not practical to meet the frequencies of ANSI B30.2.

3.9.5.4.7 Crane Design

The Fuel Handling Building crane bridge was originally designed in accordance with the EOCI specification for Electric Overhead Travelling Cranes and runways in accordance with the AISC specifications for the design, fabrication and erection of structural steel for buildings. Welding was performed in accordance with AWS specifications. The trolley and 125-ton main hoist meet the single-failure proof requirements of NUREG-0554 and ASME NOG-1-2004 with one exception. The bridge has been evaluated against ASME NOG-1 criteria for use as part of the single failure proof crane.

3.9.5.5 <u>Safety Evaluation</u>

The overhead handling of heavy loads at the Zion Nuclear Power Station is conducted in a safe manner through the use of safe load paths, qualified operators and adequately designed and maintained load handling equipment.

These controls as implemented by NUREG 0612 “Control of Heavy Loads at Nuclear Power Plants,” Section 5.1.1 (Phase I) and single failure-proof features per Section 5.1.6, ensure that the risk of a load drop accident is low.

Restrictions for load height and weight are procedurally controlled for this activity to ensure the design basis and seismic analysis remain valid. Requirements to ensure that the handling of heavy loads is performed in a safe manner and that the risk associated with these activities is adequately evaluated are provided in station procedures that control these activities.

3.9.5 Spent Fuel Cask Drop Analysis

The design of the spent fuel storage area precludes damage from occurring as a result of a dropped spent fuel shipping cask. Figure 1-8 shows the arrangement of structures and components for the storage and handling of new and spent fuel assemblies. Figure 3-33 provides a sketch which shows the movement of the spent fuel cask from the cask area in the spent fuel storage pool to the transport loading area. An elevation drawing is shown in Figure 3-34. Guard walls are provided in the spent fuel storage pool. These walls, which surround the cask area, rise the full height of the pool and are structurally designed to withstand the impact from a falling spent fuel cask, including the mass of the wire rope, load block, hook, and lifting device. If the cask is positioned over the cask area and tips and falls, it will land on the guard walls. Since the center of gravity of the cask is within the guard walls, as noted on Figure 3-33 the cask cannot tip over into the spent fuel storage pool. If the cask should roll, the slot between the wall will stop the cask since the opening is smaller than the cask dimensions. Therefore, if the cask does not fall straight down, either because the drop occurs over a pool edge and the cask is deflected, or the trunnion or a yoke on one side of the cask fails and produces a lateral force, the spent fuel cask cannot damage any spent fuel. In addition, the fuel building crane is restricted from operation over the spent fuel storage pool by electrical and mechanical interlocks.

An analysis was performed on the integrity of the fuel pool floor. The analysis took into account the highest elevation from which the cask could be dropped. The drag effects of the water were taken into account to determine the energy at impact with the floor. A 9-foot 0-inch-deep slab was provided to distribute the impact force to the foundation. Through-the-slab cracking will not occur and therefore the possibility of leakage is eliminated.

The details of this specific spent fuel cask drop analysis are presented here.

3.9.5.1 Objective of Analysis

Investigation of cask displacement in a plane along the axis of lower block (East West) when unfavorable (West) end of cable breaks. A similar analysis was performed for lateral displacement in the north-south direction that resulted in a 7 inch displacement. This analysis is for the NLI 10/24 cask which weighs 110 Tons including yoke and lifting cables.

3.9.5.2 Statement of Physical Problem

The analysis was done on the assumption that the cask will swing about the most unfavorable cable when the cable on the other extreme end breaks. Since inclusion of downward movement of cask will result in smaller lateral displacement above the pool (the maximum lateral displacement will remain above the cask storage area), the downward movement of the cask was neglected for lateral displacement computations. The system consisting of upper and lower blocks; and cask and yoke will have two kinds of motion:

1. Pendulum swinging about the intersection between the horizontal plane through the center line of the upper block and the vertical plane through the two most eastern cables.

2. Rotational motion of cask and yoke system about its own center of gravity. This motion occurs due to the fact that center of pendulum motion and center of gravity of cask and yoke assembly are not in one vertical line.

Figure 3-35 shows the elevation of the cask along the axis of lower block. The cask is 6" above the pool wall. 00_1 is the axis of upper block. A B is the axis of the lower block. C is the center of gravity of yoke and cask assembly. Other dimensions for the cask position just before lowering in cask area also are shown in the figure.

For analysis, cable 0_1A is assumed to have broken. This results in the swinging of cask about point 0 which is at the other extreme (East) end of upper block. Since point 0 and C are not in the same vertical line, rotation of yoke and cask assembly about C also will occur. Extreme position of two motions are combined to get the maximum lateral displacement.

3.9.5.3 Calculational Methods and Other Assumptions

1. Details Of Impact:

The impact of the cask with guard wall has been assumed to be plastic. Impact energy calculations are made on the basis of approximately 1/4 weight of the guard wall participating in the plastic impact. The impact is essentially vertical (in the plane of guard wall), and the guard wall will act as a column.

The impacted mass of the wall is 14.84 kips/ft/$Sec.^2$

The impact of cask takes place at an angle of 6 – 12' and results into a vertical force of 7750 kips and a horizontal force of 842 kips.

2. Punching Shear:

The punching shear stress value at distance d/2 away from impacted area is 400 psi where "d" is the thickness of wall at the point under consideration.

The vertical compressive stress at the section is approximately 2.13 ksi. The maximum allowable shear based on shear friction is 750 psi. Thus, the actual punching shear stress is within the allowable stress.

Although the impact of cask with guard wall occurs as indicated in Figure 3-36, for conservative calculations of strain energy capacity of guard wall, it is assumed to occur at the corner of the wall as shown in Figure 3-37.

3 Reaction Shear:

Reaction shear along the negative yield line is computed on the basis of the ultimate load capacity of the panel for given yield line pattern. Actual shear stress along the yield line is 116 psi, while allowable shear is 122.5 psi which does not include any credit for the compressive force acting at the section. The resistance function of the wall in the horizontal direction is shown in Figure 3-38. The ultimate load capacity of the wall (258.8 kips) was computed on the basis of the yield line pattern, shown in Figure 3-37, which corresponds to the most critical point of impact.

4. Yield Line Pattern:

Reference is made to Page 277 of "Yield Line Analysis of Slabs" by Jones and Wood. Ultimate load capacity of the slab for point load is 2m when resisting moment capacity of the slab is the same for positive yield lines as well as negative yield lines and is equal to m. If positive moment capacity of the slab is ignored as was done here, the ultimate load capacity reduces to 1.57m. Thus, the more conservative approach of not specifying any moment capacity to positive yield lines is followed.

5. Overall Behavior Of The Structure:

Structural members supporting the guard wall need be checked for the reaction and its dynamic effect due to impact loading of the guard wall. To be conservative, a Dynamic Load Factor of 2.0 can be assumed for the design of these supporting members (base slab and north wall of the pool). Since, by inspection, base slab as well as the north wall of the pool have moment capacities of more than twice that of the guard wall, there is no need for detailed design. It should be noted that these members resist the moments on the two sides of the junction with the guard wall.

3.9.5.4 Results

Calculations indicate that the time required for the pendulum system to swing from dead center to its extreme end (or one-quarter of its period of swinging) is 1.37 seconds. These calculations also show that the time required for the cask to hit the bottom of the pool, which is equivalent to falling a distance of 41.33 feet, is 1.6 seconds; whereas it only takes 0.89 seconds for the center of gravity of the cask and yoke assembly to drop below the top of the guard wall, which is equivalent to a drop of 12.79 feet. Therefore, the center of gravity of the cask and yoke assembly will be below the top of the guard wall before it reaches its extreme horizontal displacement during its first swing. Also, the calculations show that keeping the cask centerline 4 1/2 inches farther away from the guard wall will preclude the dropping cask from hitting the guard wall.

In addition to this analysis, an analysis was performed on the integrity of the fuel pool floor. The analysis took into account the highest elevation from which the cask could be dropped. The drag effects of the water were taken into account to determine the energy at impact with the floor. A 9-foot 0-inch-deep slab was provided to distribute the impact force to the foundation. Through-the-slab cracking will not occur and therefore the possibility of leakage is eliminated.

3.12 References, Section 3.0

1. Spent Fuel Pool Modification for Increased Storage Capacity, Revision 0, dated November 15, 1991.

2. Zion Station Calculation No. 22S-0-110S-0060, "Evaluation of the Zion Spent Fuel Pool for an Accident Temperature of 212 Degrees F."

3. November 18, 1996 ComEd Response to NRC Final Report on Spent Fuel Storage Pool Safety Issues.

4. Gould Co. Calculation SO 7-0432124-EQ dated 1-8-71.

5. Power Conversion Inc. letter dated 5-25-71 and Gaynes Testing Lab report on Job #7115, dated 3-11-71.

6. General Electric Co. letter dated 2-26-71.

7. General Electric Co. Report #70ICS101, dated 2-18-71.

8. Gould Co. Calculation SO 7-043123-EQS, dated 1-8-71.

9. Gould Co. letter dated June 14, 1971 summarizing results of test performed by TII Testing Lab, Inc., College Point, NY.

10. Gaynes Testing Lab Report #71448A dated November 9, 1971.

11. AIEE/IPCEA Power Cable Ampacities, Volume I – Copper Conductors, (AIEE Publication No. S-135-1, IPCEA Publication No. P-46-426) – 1962.

12. Zion Station Calculation No. 22S-B-123M-0080, "SFNI Cooling Tower and HVAC Lightning Evaluation."

13. NRC Bulletin 96-02, "Movement of Heavy Loads Over Spent Fuel, Over Fuel In The Reactor Core Or Over Safety-Related Equipment."

14. John B. Hosmer (ComEd) letter to U.S. NRC, ComEd Response to NRC Bulletin 96-02, "Movement of Heavy Loads Over Spent Fuel, Over Fuel in the Reactor Core, or Over Safety-Related Equipment," dated May 13, 1996.

15. Zion*Solutions*, LLC license amendment requests dated October 25, 2012 and May 16, 2013.

16. NRC License Amendments xxx and xxx, dated ______, 2013.

TABLE 3-5A

Fuel Handling Building Load Combinations including Single-Failure-Proof Crane

Original design of the Fuel Handling Building was in accordance with Table 3-5. The support structure for the Fuel Handling Building overhead crane was reevaluated as part of the single failure proof handling system upgrade described in Section 3.9.2.3. All applicable combinations provided in Table 3-5 were modified to include the rated capacity of the crane, including impact, and live load occurring simultaneously with earthquake and conform to ACI 349-97 for reinforced concrete design and AISC N690-1994 for steel design.

The effect of W' (maximum credible tornado) combined with the full rated capacity of the crane shall not be considered applicable since provisions shall be made to prevent fuel transfer operations during a tornado watch.

For this evaluation, the load combinations of Table 3-5 have been determined to be as follows, which include crane impact loads per AISC N690-1994, Table Q1.5.7.1 and ACI 349-97, Section 9.2.1:

Load Combination		
$D + L + S + C + I_V \pm I_H \pm I_L \pm E_O$	(Severe)	AISC N690-1994
$D + C + I_V \pm I_H \pm I_L \pm E_O$	(Severe - no live load condition)	AISC N690-1994
$D + L + S + C + I_V \pm I_H \pm I_L \pm E_{SS}$	(Extreme)	AISC N690-1994, ACI 349-97
$D + C + I_V \pm I_H \pm I_L \pm E_{SS}$	(Extreme - no live load condition)	AISC N690-1994, ACI 349-97

Member stress limits are in accordance with Table 3-5.

The following additional ultimate strength combinations are applicable to reinforced concrete components, such as anchor bolts, which are evaluated in accordance with ACI349-97 (Ref. 3.1.9):

$1.4D + 1.7(L + S + C + I_V \pm I_H \pm I_L \pm E_O)$	(Severe)	ACI 349-97
$0.9D + 1.7(C + I_V \pm I_H \pm I_L \pm E_O)$	(Severe - no live load condition)	ACI 349-97
$D + L + S + C + I_V \pm I_H \pm I_L \pm E_{SS}$	(Extreme)	ACI 349-97
$0.9D + C + I_V \pm I_H \pm I_L \pm E_{SS}$	(Extreme - no live load condition)	ACI 349-97

Member resistance factors are in accordance with ACI349-97, (Ref. 3.1.9).

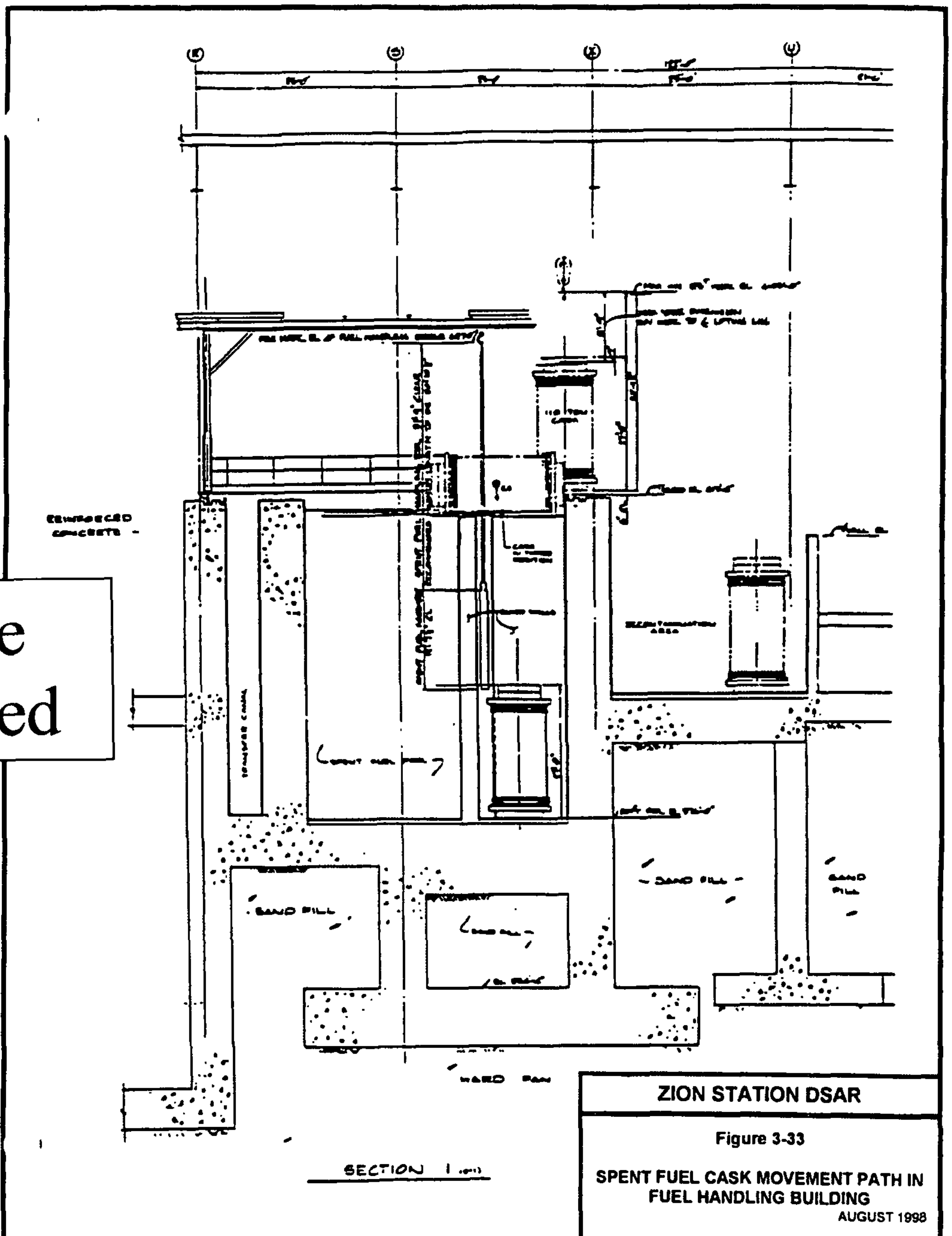
Where:
D = Dead Load including Crane Bridge and Trolley
L = Live Load
S = Snow Load
C = Crane Rated Load including Load Block and Rigging
I_V = Vertical impact load per AISC 6th Edition

I_H = Transverse Crane Impact Load per AISC 6th Edition (perpendicular to building runway girder)
I_L = Longitudinal Crane Impact Load per AISC 6th Edition (parallel to building runway girder)
E_O = OBE Earthquake
E_{SS} = SSE Earthquake

Load combinations for evaluation of the crane are from ASME NOG-1-2004, Section 4140 for a Type I crane with one exception. Tornado wind loads are not considered in the new analyses and are instead referred back to the original design basis. The only credible load combinations to consider which will have an impact on the building evaluation are consolidated into the following load combination. This combination may vary from the previous combinations since it applies impact loads that may, or may not be, different than those required for the building evaluation.

$P = D + C + P_v \pm P_{hl} \pm P_{ht}$

Where:
D = Dead Load including Crane Bridge, Trolley and Load Block
C = Crane Rated Load including rigging
P_v = Vertical Impact Load per ASME NOG-1-2004 (Ref. 3.1.10)
P_{ht} = Transverse Horizontal Load per ASME NOG-1-2004 (Ref. 3.1.10) (parallel to building runway girder, perpendicular to crane bridge)
P_{hl} = Longitudinal Horizontal Load per ASME NOG-1-2004 (Ref. 3.1.10) (perpendicular to building runway girder, parallel to crane bridge)



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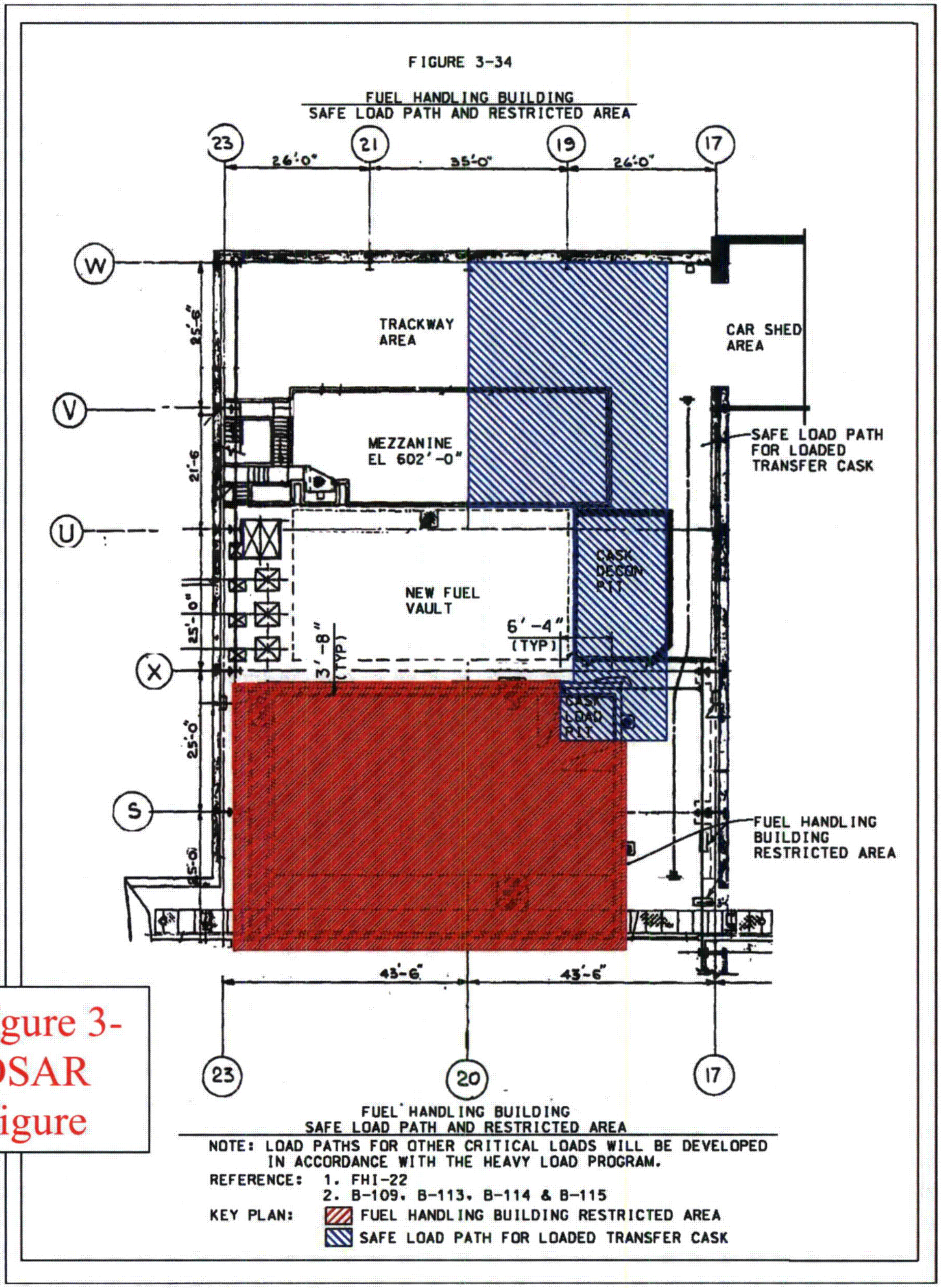
ZION STATION DSAR

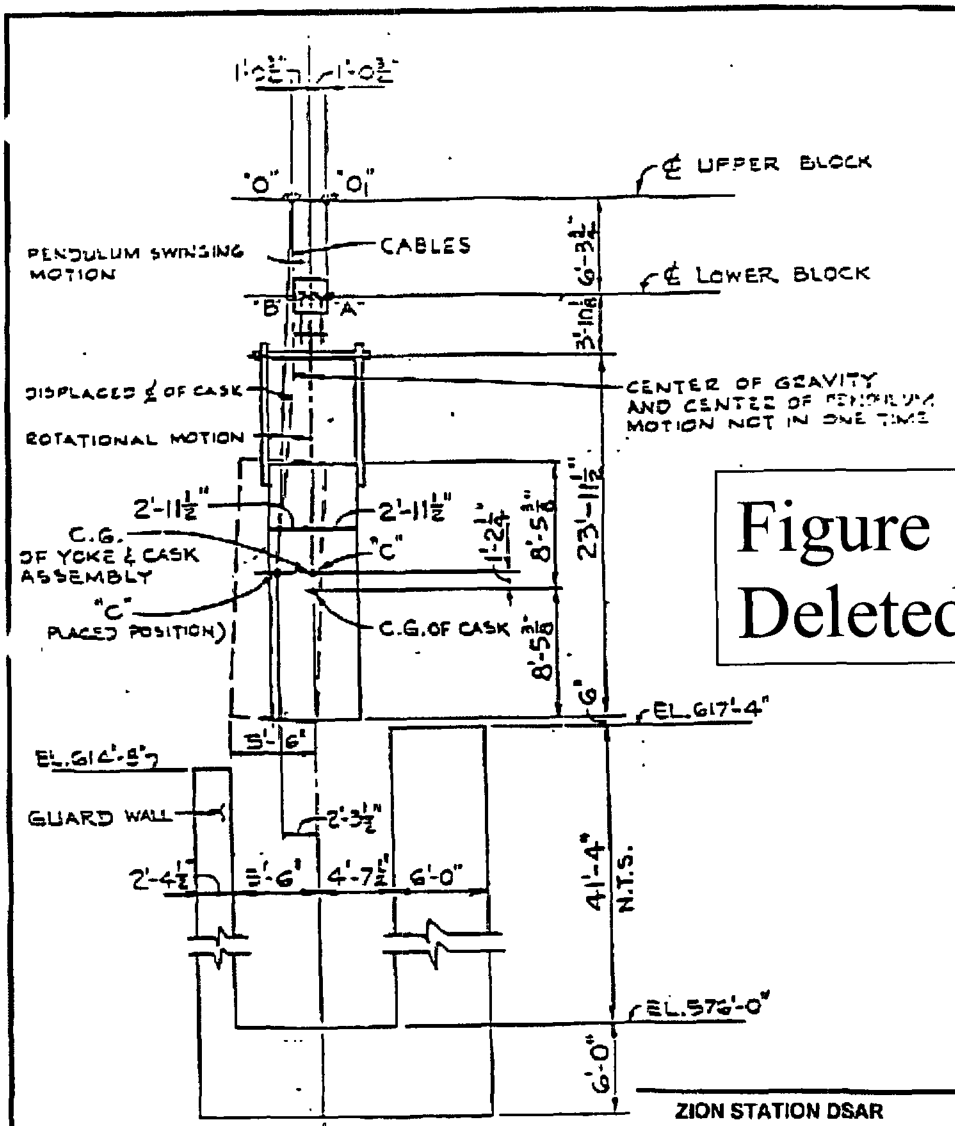
Figure 3-33

SPENT FUEL CASK MOVEMENT PATH IN FUEL HANDLING BUILDING

AUGUST 1998



Replace Figure 3-34 in the DSAR with this Figure



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ZION STATION DSAR

Figure 3-35

CASK OVER STORAGE AREA – LOOKING SOUTH

AUGUST 1960

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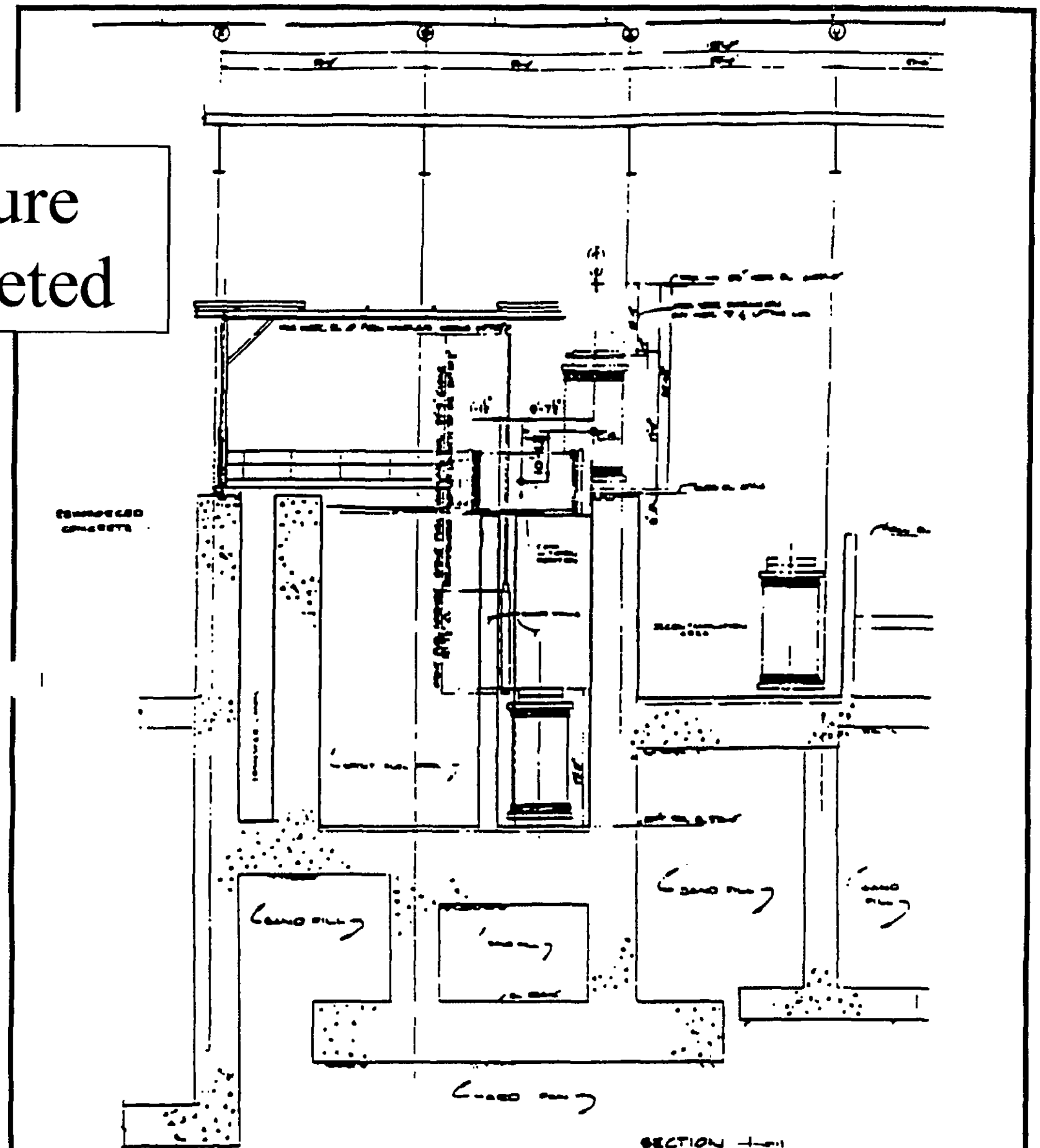
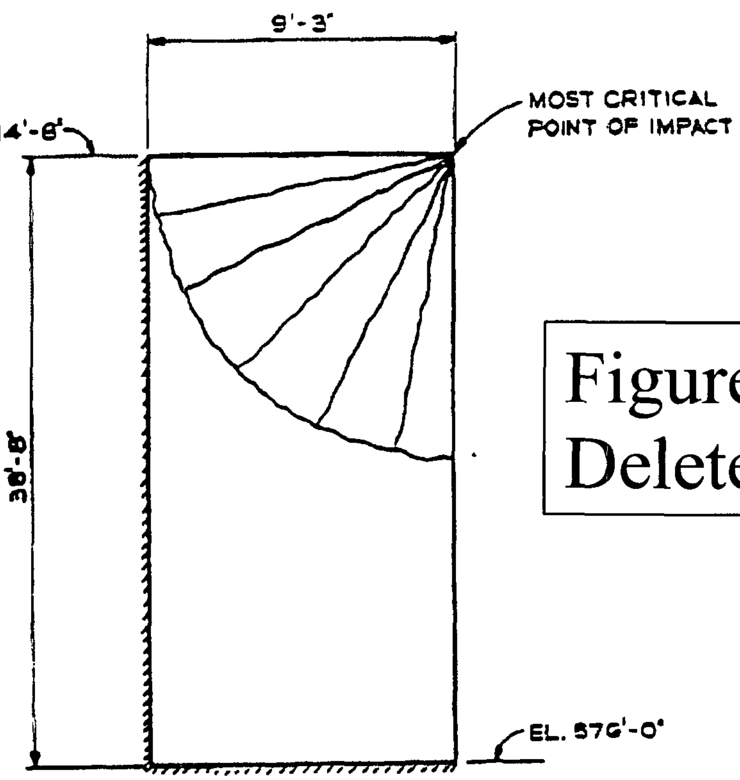


ZION STATION DSAR

Figure 3-36

ELEVATION OF FUEL HANDLING BUILDING – LOOKING SOUTH

AUGUST 1998



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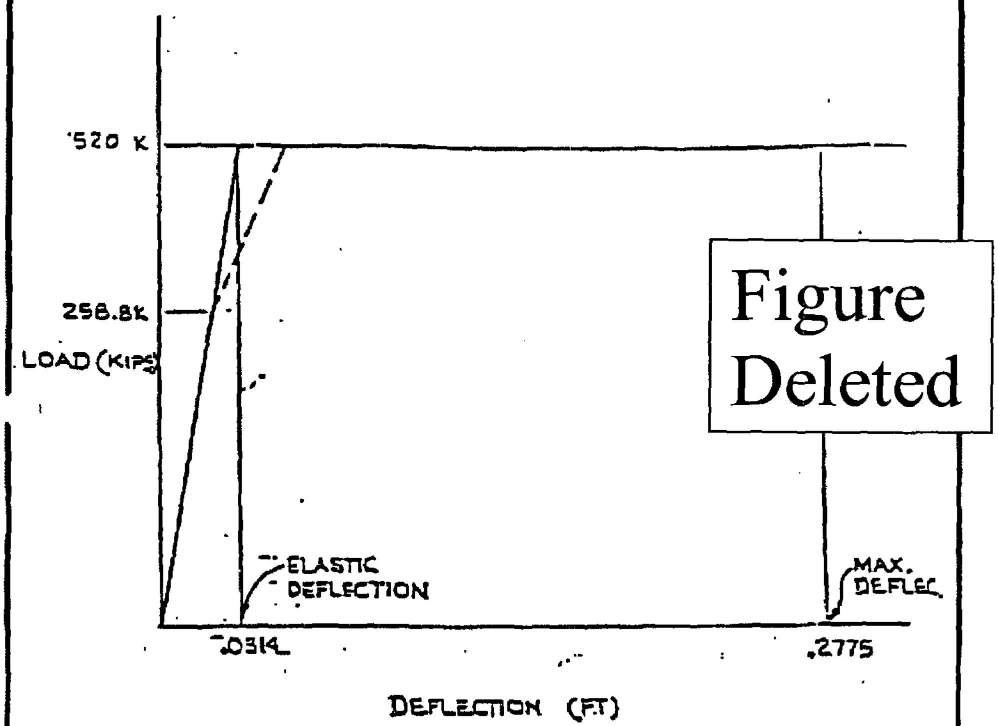
ZION STATION DSAR

Figure 3-37

YEILD LINE PATTERN FOR FLEXURAL FAILURE IN GUARD WALL

AUGUST 1998



ZION STATION DSAR

Figure 3-38
LOAD VS. DEFLECTION CURVE FOR GUARD WALL (FOR MOST CRITICAL POSITION)

AUGUST 1990

Attachment 3

ZionSolutions Draft Heavy Loads Program

Heavy Loads Program

Draft – September 6, 2012

Zion*Solutions* Project

STOP THINK ACT REVIEW

Summary of Changes in this Revision:

- Rev. 0 – This is initial issuance of this procedure.

1. PURPOSE AND SCOPE

1.1. PURPOSE

The purpose of this procedure is to provide administrative controls for safely handling heavy loads in, around and over the spent fuel pool or a loaded spent fuel canister. It is intended to be used in conjunction with approved site procedures, FHI-22, Fuel Building Overhead Crane Procedure/Checklist, and ZAP 510-13 Safe Rigging Practices.

1.2. SCOPE

The scope of this procedure applies only to the Fuel Handling Building Overhead Crane. This procedure is applicable to all personnel involved with moving heavy loads in the Fuel Handling Building using the Fuel Handling Building overhead crane.

2. RESPONSIBILITIES

2.1. ZionSolutions Fuel Transfer & Dry Cask Storage Engineers – are responsible for:

- Generating and controlling Safe Load Paths for fuel transfer within Fuel Handling Building.
- Qualifying heavy load handling personnel in accordance with requirements of ANSI/ASME B30.2-1976, with the support of the Training Department.

2.2. Heavy Load Handling Personnel (Supervisor, Craft and Contractors) – are responsible for:

- Performing heavy load handling operations
- Maintaining, controlling, and inspecting heavy load equipment.
- Identifying/validating heavy loads lifts, assuring heavy load lifts activities are planned and scheduled to ensure risk may be evaluated and communicated.
- Requesting assistance from Fuel Transfer and Dry Fuel Storage Engineering as necessary.
- Following the Heavy Load Lift procedure and work package requirements.
- Ensuring appropriate work order is approved for work to be performed.
- Notify Shift Supervisor or designee approval prior to the lift.

2.3. Planners – are responsible for:

- Identifying heavy load lifts.
- Requesting assistance from Fuel Transfer and Dry Fuel Storage Engineering as necessary.
- Assuring heavy load lifts activities are planned and scheduled so that risk may be evaluated and communicated
- Following Heavy Load Lift procedural and work package requirements.
- Developing an appropriate work order.

2.4. Work Control – is responsible for:

- Based on the results of the risk evaluation, identifying the redundant/diverse equipment important to the defueled condition to be relied upon, should a load drop occur.
- Scheduling the heavy load lift such that diverse equipment will be available at the time of the lift.

2.5. Shift Supervisor – is responsible for:

- Approving Work Orders.
- Overall safety of work activities performed.

2.6. Fuel Transfer Operations – is responsible for:

- Ensuring that any required diverse equipment is "available" at the time of the lift.

2.7. Fuel Transfer & Dry Fuel Storage Maintenance Supervisor – is responsible for:

- Performing a risk evaluation for conditions that do not screen out per Section 5, Spent Fuel Pool and High Risk Activity Management of the Work Management Manual Guide (Ref. 8.1.1). High Risk will screen out if the following conditions occur:
  - Single Failure Proof Crane or hoist, and Rigging are used, or
  - The Work Management Manual Guide, Section 5, Spent Fuel Pool and High Risk Activity Management, does not indicate a high risk.

2.8. Occupational Health Services – are responsible for:

- Certifying the medical qualifications of personnel in accordance with ANSI/ASME B30.2 and ZNPS Policies.

3. DEFINITIONS

3.1. Dedicated Rigging

Rigging that is certified for handling a specific load or loads.

3.2. Restricted Area

An area below a suspended heavy load where, if the heavy load were dropped or lowered, unacceptable damage would occur to irradiated fuel.

3.3. Handling Equipment

All load bearing components used to lift a load, including the crane, hoist, the lifting device, and interfacing load lift points.

3.4. Heavy Load Handler

A person that has successfully completed heavy loads training for the fuel transfer project.

3.5. Heavy Load

A load carried in the Fuel Handling Building that contains irradiated fuel that weighs more than the combined weight of a spent fuel assembly and its associated handling tool (NUREG 0612). A load that weighs more than 1800 pounds over or near the spent fuel pool is considered a heavy load.

3.6. Rigging

Chain, hooks, shackles, links, wire rope, slings, eye bolts, chain blocks and other such portable items.

3.7. Safe Load Path

A path defined for transport of a heavy load that will minimize adverse effects, if the load is dropped, in terms of releases of radioactive material and damage to spent fuel. The path follows, to the extent practical, structural floor members, beams, etc, such that if the load is dropped, the structure is more likely to withstand the impact. Safe Load Paths are indicated on safe load path drawings or by other approved drawings/ methods.

3.8. Single–Failure-Proof

A single failure-proof lifting system consists of:

1.) Cranes, meeting the requirements of NUREG 0554.
2.) Special lifting devices, meeting the requirements of ANSI N14.6-1993 (Section Titled "Special Lifting devices for Critical Loads").
3.) Slings and rigging components use redundant rigging or use rigging that has double the factor of safety and meets the requirements of ASME B30.9-1971.

3.9. Special Lifting Device

A lifting device that is designed specifically for handling a certain load or loads, such as the lifting device for the spent fuel cask. Special lifting devices shall be used when normal rigging is not adequate. Special lifting devices shall be designed, tested and maintained in accordance with ANSI N14.6.

4. MATERIALS, SPECIAL EQUIPMENT AND SUPPORT SERVICES

4.1. Materials:

- The following are some of the materials needed to keep the Fuel Handling Building overhead crane in good working order:
  - Wire rope lubricant (per vendor recommendation)
  - Hydraulic brake fluid (per vendor recommendation)
  - Bearing grease (per vendor recommendation)
  - Gear case lubricant (per vendor recommendation)

4.2. Tools and Equipment:

- Special tools and rigging devices will be provided by NAC to lift the Transportable Storage Cask, Transfer Cask and Concrete Cask during fuel transfer.

4.3. Support Services

- Vendor will provide support services for the Fuel Handling Building crane upgrade including load testing, maintenance and operating procedures and training to the crane operators.
- NAC will provide support services for using the special tools and rigging devices for spent fuel transfer including guidance on operating procedures and cask fuel handling training.

5. PRECAUTIONS, LIMITATIONS, AND PREREQUISITES

5.1. Precautions:

None

5.2. Limitations:

- This procedure only applies to moving heavy loads in the Fuel Handling Building using the Fuel Handling Building overhead crane.

5.3. Prerequisites:

- Personnel Qualification and Certification:

1.) Crane Operators shall successfully complete a medical evaluation or equivalent per ES-SH-PR-602, Operation and Inspection of Overhead Cranes (Ref. 8.1.7) and ZS-SA-01, Zion Restoration Project Health and Safety Plan (Ref. 8.1.12).

A. Crane Operators whose medical certification is not current shall not operate heavy load handling equipment until re-certification is completed.

B. Physical restrictions, such as the need to wear corrective lenses, shall be strictly adhered to and is the responsibility of the crane operator to ensure compliance.

C. Occupational Health Services personnel shall maintain records of crane operator medical qualifications for the period of qualification.

2.) Crane operators shall attend and successfully complete Crane Operator Training for the new Fuel Handling Building overhead crane per Zion*Solutions* training program requirements.

A. The training status of each crane operator shall be maintained by the Zion*Solutions* Training Department.

3.) Heavy Load Handling Personnel other than crane operators shall attend and successfully complete a training brief that contains the job performance measures for heavy load handling.

A. The training status of each qualified person shall be maintained by the Training Department.

- Crane maintenance records are up-to-date and previous inspections completed and documented.

- Handling Equipment Certification:

  1.) Heavy load handling equipment should be identified with unique identification numbers.

    A. Identification for permanent and portable heavy load handling equipment for spent fuel transfer shall be controlled and issued by the Fuel Transfer & Dry Cask Storage Engineers.

    B. Identification shall be traceable to the vendor supplied equipment's Certificate of Test, including other information relevant to certification.

  2.) A vendor supplied "Certificate of Test" shall be available and traceable to each piece of heavy load handling equipment and rigging to verify compliance with applicable ANSI standards.

    A. Heavy load handling equipment shall be certified in accordance with applicable ANSI standard as listed on Attachment 1.
    B. Special lifting devices shall be certified in accordance with ANSI N14.6 or alternate inspection and load test criteria approved by the Fuel Transfer & Dry Cask Storage Engineers.
    C. Completion of a Load Test Procedure may be used in lieu of a Certificate of Test for portable or manually operated heavy load handling equipment and rigging.
    D. Designated Fuel Transfer & Dry Cask Storage Engineers shall be responsible for control and certification of rigging and special lifting devices.
    E. Certificates of Test (or Alternate Test Procedures) and the Test Reports shall be maintained.

- Safe Load Path:

1.) Safe Load Paths shall be established to designate avenues for movement of heavy loads by handling equipment to minimize the potential for damage from those heavy loads, if dropped, to impact irradiated fuel. Safe Load Paths shall be developed in accordance with NUREG-0612. The current safe load paths for the loaded transfer cask are shown in DSAR Figure 3-33 (vertical view) and in the attached figure, Fuel Handling Building Restricted Area (top down view) (Attachment 2). Safe load paths for other heavy lifts shall be shown on applicable drawings and/or procedures.

2.) Changes to Safe Load Paths shall be identified by drawings and available for general facility use.

A. Safe Load Path drawings shall be approved by Fuel Transfer and Dry Fuel Storage Engineering.

B. Safe Load Path drawings shall be in approved spent fuel transfer procedures.

3.) In situations where a Safe Load Path does not exist, cannot be followed, or the transient load will depart from the Safe Load Path, an alternate Safe Load Path shall be established.

A. Alternate Safe Load Paths shall be determined in accordance with NUREG 0612, Section 5.1.1 (1).

B. Alternate Safe Load Paths shall be evaluated and approved by Fuel Transfer and Dry Fuel Storage Engineering before use.

C. Alternate Safe Load Paths shall be documented and included with the Work Package.

D. Heavy load handling operations requiring deviation from Alternate Safe Load Paths shall be rigged Single-Failure-Proof or a load drop analysis shall be performed.

E. Perform 10CFR50.59 Screening/Evaluation per ZAP 100-06, 10 CFR 50.59 Review Process.

6. MAIN BODY

6.1. Handling Equipment Inspection

6.1.1 Inspections of heavy load handling equipment shall be controlled by designated Fuel Transfer and Dry Fuel Storage Engineering personnel and performed in accordance with Fuel Handling Building overhead crane inspection procedures (Ref. 8.1.2 to 8.1.5).

6.1.2 Inspection frequency for heavy load handling equipment shall be in accordance with approved Fuel Handling Building overhead crane and rigging procedures for fuel transfer.

6.1.3 Pre-Operational Inspections of slings, rigging, and hooks performed in accordance with Fuel Handling Building overhead crane and rigging procedures for fuel transfer shall satisfy periodic inspection requirements.

6.1.4 A schedule for inspections of heavy load handling equipment including rigging and special lifting devices shall be maintained by the Fuel Transfer and Dry Fuel Storage Department to ensure timeliness of inspection.

6.1.5 Inspection records shall be maintained electronically or by hard copy.

6.2. Handling Equipment Maintenance

6.2.1 Maintenance shall be performed by ZNPS personnel or an approved service vendor.

6.2.2 Permanent heavy load handling equipment shall be maintained in accordance with the applicable ANSI standard as identified on Attachment 1.

6.2.3 Load bearing components of heavy load handling equipment which have been extensively repaired, repaired by welding, or otherwise modified shall be re-certified before being placed into service in accordance with applicable ANSI criteria.

1.) Test criteria used for re-certification shall be the same criteria used for the original certification unless otherwise stated by Fuel Transfer and Dry Fuel Storage Engineering.

6.2.4 Non-permanent heavy load handling equipment shall be stored in areas to protect it from damage or adverse environments either in the Fuel Handling Building or an enclosed building onsite.

6.3. General Handling Requirements

6.3.1 Heavy load lifts shall be assessed by the Fuel Transfer and Dry Fuel Storage Department for impact to components important to the defueled condition following the guidance in the Work Management Manual Guide (Ref. 8.1.1).

6.3.2 Heavy load handling operations shall be performed in accordance with approved load handling procedures (Ref. 8.1.2 to 8.1.5).

6.3.3 Heavy load handling operations shall be performed by qualified crane operators and qualified persons assigned by the responsible Supervisor.

1.) Operators of heavy load handling equipment shall be familiar with the procedures, height / weight restrictions, and Safe Load Path applicable to the handling operations.

6.3.4 Heavy load handling operations shall be conducted in accordance with the height / weight restrictions at the lowest height practicable defined in approved procedures.

1.) Heavy load handling operations requiring deviation from height / weight restrictions shall be evaluated by Fuel Transfer and Dry Fuel Storage Engineering prior to starting the heavy load handling operation.

2.) Single-Failure-Proof Rigging shall be required for all heavy load handling over the Spent Fuel Pool with spent fuel in the racks.

6.3.5 Heavy load rigging used shall be determined by Fuel Transfer and Dry Fuel Storage Engineering to be adequate for the weight of the item to be handled based upon the weight of the item with allowance for dynamic loading for non-single-failure-proof configurations.

6.3.6 For all configurations, lifting devices that are not specially designed should be installed and used in accordance with station procedure ZAP 510-13, Safe Rigging Practices. In selecting the proper sling, the load should be the sum of the static and maximum dynamic load. The rating on the sling should be greater than the combined maximum static and dynamic load. For purposes of selecting the proper sling, loads imposed by the Design Basis Earthquake (DBE) need not be included in the dynamic loads imposed on the sling or lifting device.

6.3.7 Refer to station procedure, ZAP 510-13, Safe Rigging Practices, for the proper method used in selecting a sling with the appropriate rating for the static and dynamic load lift to be performed.

6.3.8 Handling equipment attachments to permanent station equipment (beams, etc.) shall not be made until evaluation and approval of the attachment is completed by the Engineering Director.

6.3.9 Verification of heavy load handling equipment inspection shall be made before each use.

6.3.10 Heavy loads handling operations, where no load drop analysis has been performed, that are bounded by an existing load drop analysis, require the same accident mitigators as the analyzed load drop.

6.3.11 Handling of heavy loads over irradiated fuel within the scope of NRC Bulletin 96-02, and not previously evaluated, shall be evaluated on a case-by-case basis. Based on the results of these evaluations, the appropriate actions shall be taken as required by NRC Bulletin 96-02. This would only apply if a non-single-failure-proof crane was used to handle heavy loads over the spent fuel pool.

6.3.12 Procedures for heavy load handling operations shall include the following Precaution/Limitation:

"Heavy load movements using the Fuel Handling Building (FHB) Overhead Bridge Crane (OBC) are not permitted if a tornado watch or warning has been declared for the site by the National Weather Service. If heavy load handling with the OBC is in progress when any of these criteria are met, then the load will be immediately lowered to a safe location and the crane secured." (Ref. 8.2.6)

7. RETURN TO NORMAL

None

8. REFERENCES

8.1 Procedures

8.1.1 ZAP 400-16, Work Management Manual Guide

8.1.2 ZAP 510-13, Safe Rigging Practices

8.1.3 MDAI 10-51-1, Crane Inspections

8.1.4 ZAP 510-02, Fuel Transfer and Dry Fuel Storage Plant Modifications

8.1.5 FHI-22, Fuel Building Overhead Crane Procedure/Checklist

8.1.6 ES-SH-PG-600, Hoisting and Rigging Programs

8.1.7 ES-SH-PR-602, Operation and Inspection of Overhead Cranes

8.1.8 ES-SH-PR-603, Operation and Inspection of Mobile Cranes

8.1.9 ES-SH-PR-604, Operation and Inspection of Hoists

8.1.10 ES-SH-PR-605, Non-Standard Lift Plans

8.1.11 ES-SH-PR-606, Safe Use and Inspection of Rigging Equipment

8.1.12 ZS-SA-01, Zion Restoration Project Health and Safety Plan

8.2 Commitments

8.2.1 DSAR Sections 3.9 and 5.2

8.2.2 NRC Bulletin 96-02, "Movement of Heavy Loads Over Spent Fuel, Over Fuel In The Reactor Core Or Over Safety-Related Equipment"

8.2.3 GL 85-11, "Completion of Phase II of Control of Heavy Loads at Nuclear Power Plants, NUREG-0612"

8.2.4 John B. Hosmer (Comed) letter to U.S. NRC, "ComEd Response to NRC Bulletin 96-02, "Movement of Heavy Loads Over Spent Fuel, Over Fuel in the Reactor Core, or Over Safety-Related Equipment," dated May 13, 1996.

8.2.5 Patrick Daly (ZS) letter to U.S. NRC, "Request for Amendment to Approve Methods of Analysis, Use of a Single-failure Proof Crane and Approval of a NUREG 0612 Compliant Heavy Loads Handling Program," dated May xx, 2012.

8.2.6 NOG-1 Compliance Matrix, P&H ***SUPERSAFE***TM Single Failure Proof Upgrade for Zion Fuel Handling Crane, February 2012.

8.3 NRC Guidance

8.3.1 NUREG 0554, "Single Failure Proof Cranes For Nuclear Power Plants"

8.3.2 NUREG 0612, "Control of Heavy Loads at Nuclear Power Plants"

9. RECORDS

The following documents shall be maintained electronically or by a hard copy for the retention period identified in document control:

9.1. Vendor Supplied Certificates of Test

9.2. Handling equipment inspection records

9.3. Crane operator and qualified person(s) qualification records

9.4. Crane operator medical evaluations

10. ATTACHMENTS

10.1. Attachment 1 - Table, Heavy Loads Equipment Certification

10.2 Attachment 2 - Figure, Fuel Handling Building Restricted Area (top down view)

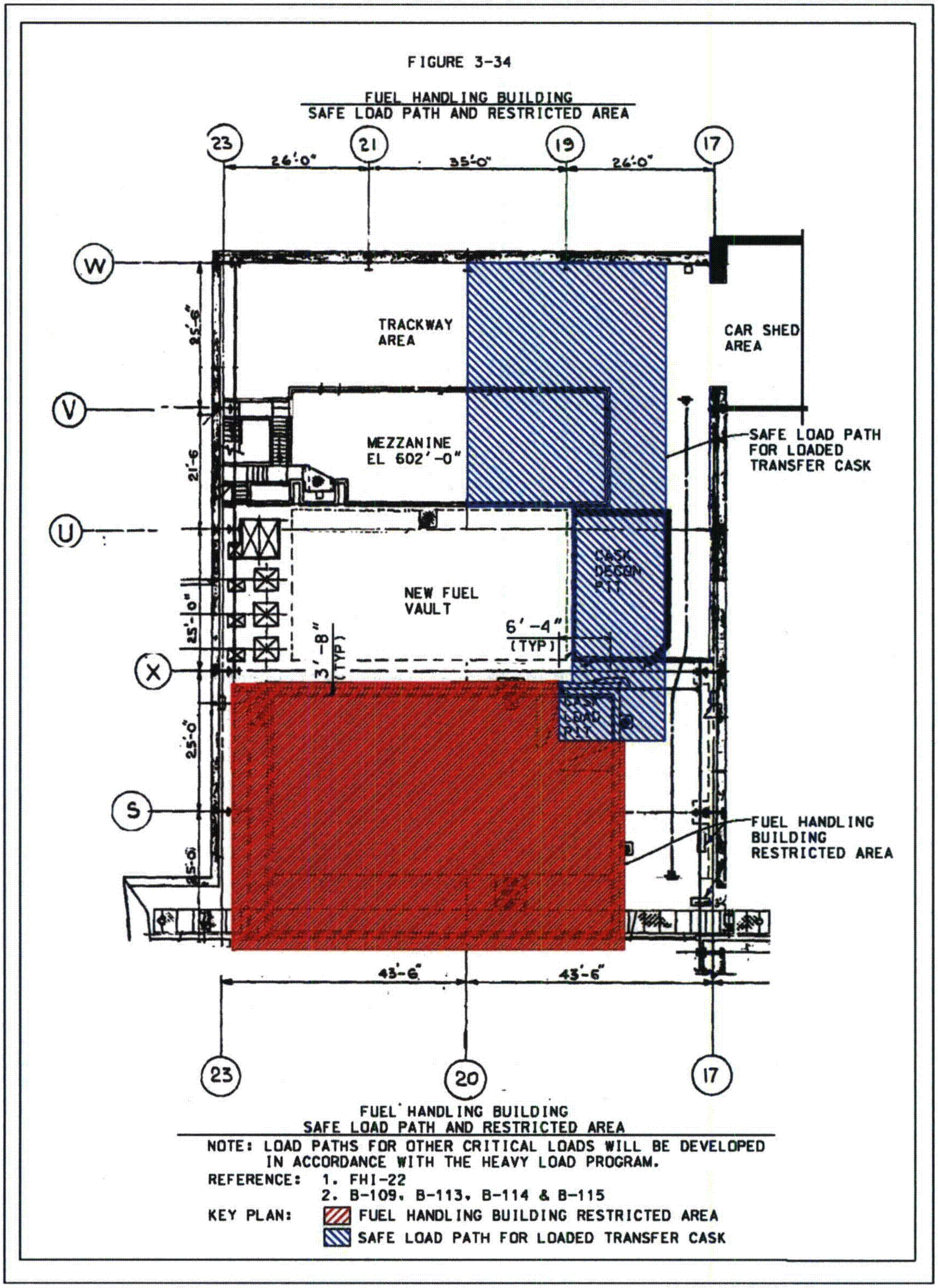
11. FORMS

None

Attachment 1
Heavy Loads Equipment Certification

Handling Equipment Type	**ANSI/ ASME Inspection Standard**
Overhead and Gantry Cranes	B30.2-1976
Slings and Rigging	B30.9-1971
Hooks	B30.10-2001 Edition with 2003 Addenda
Below-the-Hook Lifting Devices	B30.20-2001 Edition with 2003 Addenda
Rigging Hardware	B30.26-2001 Edition with 2003 Addenda
Special Lifting Devices	N14.6-1993

Attachment 2
Figure - Fuel Handling Building Restricted Area



Attachment 4

NUREG 0612 Compliance Matrix

Section	Guidance	Evaluation	Notes
NUREG-0612 Section 5.1.1(1)	Safe load paths should be defined for the movement of heavy loads to minimize the potential for heavy loads, if dropped, to impact irradiated fuel in the reactor vessel and in the spent fuel pool, or to impact safe shutdown equipment.	Safe load paths for heavy loads have been defined at the Zion Nuclear Power Station (ZNPS). Spent fuel cask handling will not require the transfer cask containing the Transportable Storage Cask (TSC) to be suspended over irradiated fuel. The TSC lid is the sole heavy load handled by the Fuel Handling Building overhead crane single-failure-proof lifting system that must be suspended over exposed spent fuel in the loaded canister to properly conduct spent fuel loading operations. The transfer cask, TSC and TSC lid will be handled with the single-failure proof Fuel Building overhead crane single-failure-proof lifting system, including lifting devices and lift points.	The safe load path for the loaded cask in the Fuel Handling Building overhead crane as defined in the draft Heavy Loads Program ZAP-510-19 will be included in Section 5.2 of Zion procedure FHI-22, Fuel Building Overhead Crane Procedure/ Checklist. Other safe load paths will be developed in accordance with the Heavy Loads Program NAC MAGNASTOR Technical Specification 4.3.1.h (MAGNASTOR draft Certificate of Compliance Amendment 3) limits the height for a loaded concrete cask to less than or equal to 24 inches.
NUREG-0612 Section 5.1.1(2)	Procedures should be developed to cover load handling operations for heavy loads that are, or could be handled over, or in proximity to irradiated fuel or safe shutdown equipment.	The ZNPS heavy loads control program includes procedures to address load handling operations for heavy loads handled by the Fuel Handling Building overhead crane single-failure-proof lifting system.	Lift height limits consistent with the single failure analysis and NAC MAGNASTOR FSAR draft Certificate of Compliance amendment 3) (FSAR) will be included in the operating procedures, as appropriate.

Section	Guidance	Evaluation	Notes
NUREG-0612 Section 5.1.1(3)	Crane operators should be trained, qualified, and conduct themselves in accordance with Chapter 2-3 of ANSI B30.2-1976.	Crane operators are trained in the area of heavy load handling, safe load paths, and the potential consequences of load drops over the spent fuel pool. Training will meet the guidance of Chapter 2-3 of ANSI B30.2-1976.	ZNPS currently meets ANSI B30.2-1967. The training program will be upgraded to meet the guidance in Chapter 2-3 of ANSI B30.2-1976.
NUREG-0612 Section 5.1.1(4)	Special lifting devices should satisfy the guidelines of ANSI N14.6-1978.	The special lifting devices used to lift and handle the spent fuel transfer cask and other heavy load components are part of the Fuel Handling Building overhead crane single-failure-proof lifting system. The evaluation of these devices is discussed under NUREG-0612, Section 5.1.6(1)(a) in this matrix.	The transfer cask lifting yoke and crane hook extension meets the requirements of ANSI N14.6-1993 per MAGNASTOR FSAR Sections 2.4.4, 2.6.6, 3.1.2 and 3.1.3.
NUREG-0612 Section 5.1.1(5)	Lifting devices that are not specially designed should be installed and used in accordance with the guidelines of ANSI B30.9-1971.	The lifting devices used to lift and handle the spent fuel transfer cask and other heavy load components that are not specially designed are part of the Fuel Handling Building overhead crane single-failure-proof lifting system. The evaluation of these devices is discussed under NUREG-0612, Section 5.1.6(1)(b) in this matrix.	ZNPS Procedures will be prepared and include the guidance of ANSI B30.9-2003 for slings as requirements for heavy load lifts in the Fuel Handling Building.

Section	Guidance	Evaluation	Notes
NUREG-0612 Section 5.1.1(6)	The crane should be inspected, tested and maintained in accordance with Chapter 2-2 of ANSI B30.2-1976.	The Fuel Handling Building overhead crane is inspected, tested, and maintained in accordance with Chapter 2-2 of ANSI B30.2-1967. The crane trolley and controls are being upgraded and will meet the inspection, testing and maintenance guidance in ANSI B30.2.	ZNPS currently meets ANSI B30.2-1967. The inspection, test and maintenance program will continue to meet the guidance in Chapter 2-2 of ANSI B30.2-1967.
NUREG-0612 Section 5.1.1(7)	The crane should be designed to meet the applicable criteria and guidelines of Chapter 2-1 of ANSI B30.2-1976 and CMAA-70 or suitable alternative provided the intent of ANSI B30.2 and CMAA-70 is satisfied.	The Fuel Handling Building overhead crane is being upgraded to a single-failure-proof design through replacement of the crane trolley and an upgrade of the crane controls. The existing crane bridge will be used as is. The design codes and standards used for the upgraded crane trolley, bridge and controls are a combination of CMAA-70-1975, ASME NOG-1-2004, and original plant design codes as discussed in more detail under NUREG-0612, Section 5.1.6(2) in this matrix. Compliance with these codes and standards will ensure the crane, as a whole, meets the intent or the applicable criteria and guidelines of ANSI B30.2-1976and CMAA-70-1975.	The NOG-1 and NUREG-0554 Compliance Matrices also discusses compliance with applicable portions of CMAA-70.

Section	Guidance	Evaluation	Notes
NUREG-0612 Section 5.1.2(1)	For the spent fuel pool area of a PWR plant, the overhead crane and associated lifting devices used for handling heavy loads in the spent fuel pool area should satisfy the single-failure-proof guidelines in Section 5.1.6 of this report.	The Fuel Handling Building overhead crane and associated lifting devices used to lift and handle the spent fuel transfer cask and other heavy loads associated with spent fuel cask handling operations are designed to be a single-failure-proof lifting system. See the discussion of compliance with NUREG-0612, Section 5.1.6 in this matrix.	
NUREG-0612 Sections 5.1.2(2) through 5.1.2(4)	These sections provide acceptable alternatives to meeting the single-failure-proof guidance in Section 5.1.2(1) for the overhead crane and associated lifting devices.	The upgraded Fuel Handling Building overhead crane and associated lifting devices will meet the guidance in Section 5.1.2(1). The guidance in these sections is not applicable.	
NUREG-0612 Section 5.1.3	For the containment building of a PWR plant, this section provides guidance on heavy load control.	The upgraded Fuel Handling Building overhead crane and associated lifting devices do not have access to the ZNPS Unit 1 or Unit 2 containment buildings. The guidance in this section is not applicable.	
NUREG-0612 Section 5.1.4	For the reactor building of a BWR plant, this section provides guidance on heavy load control.	ZNPS is a PWR plant so the guidance in this section is not applicable.	

Section	Guidance	Evaluation	Notes
NUREG-0612 Section 5.1.5(1)	This section provides guidance on protecting safe shutdown equipment.	Spent fuel cask handling operations occur in the Fuel Handling Building. There is no safe shutdown equipment in the Fuel Handling Building or in the heavy load transport path to the ISFSI. Therefore, this section is not applicable.	The heavy load transport path will also avoid, to the extent possible, traversing over the spent fuel racks in the pool.
NUREG-0612 Section 5.1.5(2)	This section provides guidance on protecting safe shutdown equipment.	Spent fuel cask handling operations occur in the Fuel Handling Building. There is no safe shutdown equipment in the Fuel Handling Building. Therefore, this section is not applicable.	
NUREG-0612 Section 5.1.6(1)(a)	Special lifting devices that are used for heavy loads in the area where the crane is to be upgraded should meet ANSI N14.6-1978, including Section 6 of that document. If only a single lifting device is provided instead of dual devices, the special lifting device should have twice the design safety factor as required to satisfy the guidelines of NUREG-0612, Section 5.1.1(4)	The lifting yoke used to lift the transfer cask is a special lifting device and is designed and fabricated in accordance with ANSI N14.6-1993. The rated load of the lift yoke is 117 tons. The design and safety factors for the lifting yoke are based on a static plus dynamic load of 110% of the rated load. The safety factors for the lifting yoke are 6:1 against the yield strength of the material and 10:1 against the ultimate strength of the material. These safety factors are appropriate for a lifting device designed with increased stress design factors instead of a dual load path in accordance with ANSI N14.6-1993,	The NAC MAGNASTOR FSAR, Sections 3.1.2, 3.1.3, and 3.4.3 states that the hook assembly is designed with a safety factor of 10:1. The NOG-1 Compliance Matrix, The safe load path for the Fuel Handling Building overhead crane as defined in the draft Heavy Loads Program ZAP-510-19 will be included in Section 5.2 of Zion procedure FHI-22, Fuel Building Overhead Crane Procedure/

Section	Guidance	Evaluation	Notes
	From RIS 2005-25, Supplement 1: A special lifting device that satisfies ANSI N14.6-1993, "Radioactive Materials – Special Lifting Devices for Shipping Containers Weighing 10,000 Pounds (4,500 kg) or More," should be used for recurrent load movements in critical areas (i.e., reactor heads, reactor vessel internals, and spent fuel casks). The lifting device should have either dual, independent load paths or a single load path with twice the design safety factor specified by ANSI N14.6 for the load.	Section 7.2.1. There are no other intervening lift devices between the crane hook and the transfer cask lifting trunnions for these lifts. NAC MAGNASTOR FSAR, Section 10.1.2.1, Load Testing of Transfer Casks, states that the lifting and handling of the transfer cask and loaded TSC are the critical lifting loads. The transfer cask lifting trunnions, shield doors and door rails are designed to higher safety factors and are load tested to 300% of the maximum service load for each component.	Checklist.

Section	Guidance	Evaluation	Notes
NUREG-0612 Section 5.1.6(1)(b)	Lifting devices that are not specifically designed and that are used for handling heavy loads in the area where the crane is to be upgraded should meet ANSI B30.9-1971, "Slings" as specified in NUREG-0612, Section 5.1.1(5), except that one of the following should also be satisfied unless the effects of the drop of the particular load have been analyzed and shown to satisfy the evaluation criteria of NUREG-0612, Section 5.1: (i) Provide dual or redundant slings or lifting devices such that the failure of a single component failure or malfunction in the sling will not result in uncontrolled lowering of the load;	Other lifting devices not specifically designed, such as slings, wire ropes, etc., that will be used for heavy load handling (e.g., spent fuel storage racks) with the Fuel Handling Building overhead crane system will meet the guidance in ANSI B30.9-2003 for the particular load being lifted. This is controlled through the ZNPS heavy load control program and procedures. ZNPS may use slings made of metallic or synthetic material in making heavy load lifts with the Fuel Handling Building overhead crane system, based on the nature of the lift and the lifting location. When synthetic slings are used, the rigging of those slings is controlled by procedure to avoid the types of sling failure modes described in RIS 2005-25 (Supplement 1).	ZNPS procedures will be prepared and include the guidance of ANSI B30.9-2003. NAC MAGNASTOR FSAR Table 9.1-1, Major Auxiliary Equipment, states redundant sling systems (two 3-legged slings) are used to transfer a TSC into a concrete cask or a transfer cask and meets the guidance of ANSI N14.6. Alternative TSC handling systems will comply with the ZNPS heavy loads program developed per NUREG-0612.

Section	Guidance	Evaluation	Notes
	OR (ii) In selecting the proper sling, the load used should be twice what is called for in meeting NUREG-0612, Section 5.1.1(5). From RIS 2005-25, Supplement 1: Slings should satisfy the criteria of ASME B30.9-2003, "Slings" and be constructed of metallic material (chain or wire rope). The slings should be either (a) configured to provide dual or redundant load paths or (b) selected to support a load twice the weight of the handled load.		

Section	Guidance	Evaluation	Notes
NUREG-0612 Section 5.1.6(2)	New cranes should be designed to meet NUREG-0554.	The Fuel Handling Building crane is being upgraded to a single-failure-proof design through replacement of the crane trolley and controls. See the NUREG-0554 compliance matrix for a point-by-point compliance discussion of each guideline in NUREG-0554 as it pertains to the upgraded Fuel Handling Building crane.	
NUREG-0612 Section 5.1.6(3)	Interfacing lifting points, such as lifting lugs or cask trunnions should also meet one of the following for heavy loads handled in the area where the crane is to be upgraded unless the effects of the drop of the particular load have been analyzed and shown to satisfy the evaluation criteria of NUREG-0612, Section 5.1: (a) Provide redundancy or duality such that a single lift point failure will not result in uncontrolled lowering of the load; lift point	When the empty or loaded TSC is inside the transfer cask, the transfer cask is lifted and handled with a lifting yoke attached to the transfer cask upper lifting trunnions. The transfer cask upper lifting trunnions are considered a non-redundant, dual lift point system. The upper lifting trunnions and trunnion sleeves are designed and fabricated in accordance with the ANSI N14.6-1993 guidance for non-redundant interfacing lift points. The safety factors for the transfer cask upper lifting trunnions are 6:1 against the yield strength of the material and 10:1 against the ultimate strength of the material. This safety factor meets the safety factor specified in NUREG-0612 for a non-redundant lift point system. The loaded transfer cask to be used at ZNPS weighs a maximum	

Section	Guidance	Evaluation	Notes
	should have a design safety factor with respect to ultimate strength of five (5) times the maximum combined concurrent static and dynamic load after taking the single lift point failure. OR (b) A non-redundant or non-dual lift point system should have a design safety factor of ten (10) times the maximum combined concurrent static and dynamic load.	of 125 tons in its heaviest configuration. When the empty TSC is lifted for initial insertion into the transfer cask, it is lifted by lifting lugs attached to the inside of the canister shell. These lifting lugs are considered interfacing lift points for these lifts. The TSC lifting lugs are not designed with the safety factors specified in NUREG-0612. However, these lifts occur only with no fuel in the TSC and in the truck bay in the Fuel Handling Building. There is no safe shutdown equipment on site. Therefore, a drop of the empty TSC will have no unacceptable consequences.	

Attachment 5

ASME NOG-1 Compliance Matrix

Single Failure Proof Upgrade for Zion Fuel Handling Crane

Crane Serial Number: CN-36675

NOG-1 Compliance Matrix

TABLE OF CONTENTS

Purpose of the NOG-1 Compliance Matrix

The purpose of this report is to verify that the design of the new single failure proof crane upgrade meets the requirements of ASME NOG-1, 2004. This report meets the intent of the matrix for reconciling the trolley design to single failure proof criteria per NOG-1, 2004.

Compliance with the requirements of NOG-1, 2004 is provided for the new trolley and associated upgrades in this document. All other components of the crane are addressed in the NUREG-0554 Compliance Matrix, which demonstrates the crane system as single failure proof by evaluation to the requirements of NUREG 0554.

References

ASME NOG-1, 2004 (Rules for Construction of Overhead and Gantry Cranes (Top Running Bridge, Multiple Girder))

Zion Specification SP-ZS-FH-003

P&H Drawing 28A11377 (Welded Box Girder)
P&H Drawing 29E5235 (Earthquake Restraint & End Stop)
P&H Drawing 29E5236 (Earthquake Restraint & End Stop)
P&H Drawing 105A3002 (Bridge Layout)
P&H Drawing 10F8569 (Trolley Wheel Idler Axle)
P&H Drawing 10F7747F1 (Bridge Wheel Drive Axle)
P&H Drawing 10F7748 (Bridge Wheel Idler Axle)

MMH Document 36675-02 (B22 Painting Specification)
MMH Document 36675-05 (Bridge Stress Calculations)
MMH Document 36675-06 (Electrical Calculations)
MMH Document 36675-07 (Factory Acceptance Test Procedure)
MMH Document 36675-09 (Seismic Analysis)
MMH Document 36675-10 (Trolley Weld Calculation)
MMH Document 36675-11 (Critical List)
MMH Document 36675-13 (Site Acceptance Test Procedure)
MMH Document 36675-14 (Seismic Analysis of Misc. Items)
MMH Document 36675-15 (Crane Installation Procedure)
MMH Document 36675-17 (QA Document Binder)
MMH Document 36675-18 (Main Hoist Gearing Analysis)
MMH Document 36675-20 (Operation & Maintenance Manual)
MMH Document 36675-22 (NUREG-0554 Compliance Matrix)
MMH Document 36675-23 (Main Hoist Reeving Stress Report)
MMH Document MOP 18.1 (Preservation and Packaging)

MMH Drawing QR82460 (Main Hoist Hook Assembly)
MMH Drawing QR89592 (Main Hoist Gear Case Assembly)
MMH Drawing R94424 (Top Level Crane Assembly)

MMH Drawing R94603 (Main Hoist Drum Assembly)
MMH Drawing QR94604 (Main Hoist Drum Machining)
MMH Drawing QR94709 (Main Hoist Motor)
MMH Drawing R94779 (Trolley Assembly)
MMH Drawing R94780 (Main Hoist Machinery Assembly)
MMH Drawing QR94824 (Main Hoist Wire Rope Assembly)
MMH Drawing R94965 (Aux Hoist Assembly)
MMH Drawing R95005 (Main Hoist Bottom Block Assembly)
MMH Drawing R95253 (Trolley Wheel Assembly - Drive)
MMH Drawing QR95370 (Trolley Frame Weldment)
MMH Drawing 54214604 (Interconnection Wiring Diagram)
MMH Drawing R95399 (Electrical Schematic)
MMH Drawing R95797 (Conduit Layout)

NOG-1 Single Failure Proof Requirements	Zion Station FHB *Crane Trolley* Compliance
1000 Introduction	
1100 GENERAL Cranes covered under this Standard shall be designed in accordance with the Standard's requirements, but not necessarily with its recommendations. The word shall is used to denote a requirement, the word should is used to denote a recommendation, and the word may is used to denote permission, which is neither a requirement nor a recommendation.	The crane is designed in accordance with this Standard's requirements.
1110 Scope This Standard covers electric overhead and gantry multiple girder cranes with top running bridge and trolley used at nuclear facilities and components of cranes at nuclear facilities.	The crane is an electric overhead, multiple-girder crane with a top running bridge and trolley for use in a nuclear facility and is covered by this Standard.
1120 Applications This Standard applies to the design, manufacture, testing, inspection, shipment, storage, and erection of the cranes covered by this Standard.	This standard is applied to the design, manufacture, testing, inspection, shipment, storage, and erection of the crane.
1130 Responsibility The cranes covered by this Standard are classified into three types (see para. 1150, Definitions, *crane types*) depending upon crane location and usage of the crane at a nuclear facility. The owner shall be responsible for determining and specifying the crane type. The owner shall also be responsible for determining and specifying the environmental conditions of service, performance requirements, type and service level of coatings and finishes, and degree of Quality Assurance. Determining the extent to which this Standard can be used, either in part or in its entirety, at other than nuclear facilities, shall be the responsibility of those referencing the use of this Standard.	Crane type, environmental conditions of service, performance requirements, type and service level of coatings and finishes, and degree of Quality Assurance are detailed in Zion Specification SP-ZS-FH-003. The equipment design is in accordance with the specific needs of the end user, yet still employs the highest quality standards and engineering evaluations to determine that all safety systems are maintained.
1140 Environmental Conditions (Types I, II, and III Cranes) **1141 Radiation** ***(a)*** The purchase specification shall specify the accumulated	***(a)*** Zion Specification SP-ZS-FH-003 details the accumulated radiation

NOG-1 Single Failure Proof Requirements	Zion Station FHB *Crane Trolley* Compliance
radiation dosage expected to be seen by the crane in the life of the nuclear facility. ***(b)*** Components whose normal life could be reduced by the effects of the specified radiation shall be tabulated and submitted to the crane purchaser. ***(c)*** Components whose failure, due to radiation, could result in loss of one of the single failure-proof features which hold the load either shall be designed to withstand the specified radiation or shall have a specific replacement period. Where state-of-the-art is such that sufficient data are not available, periodic inspections shall be made by the purchaser to determine when replacement should be made.	dosage expected to be seen by the crane in the life of the nuclear facility. ***(b)*** Components whose normal life could be reduced by the effects of the specified radiation will be inspected and replaced as necessary per the recommendations in MMH Document 36675-20 (Operation & Maintenance Manual). ***(c)*** Components whose failure, due to radiation, could result in loss of one of the single failure-proof features which hold the load either are either designed to withstand the specified radiation or will have specific inspection and replacement procedures detailed in MMH Document 36675-20 (Operation & Maintenance Manual). See Note 1.
1142 Temperature ***(a)*** The purchase specification shall specify the following temperature requirements in the area where the crane operates: *(1)* maximum operating temperature, *(2)* minimum operating temperature, *(3)* ambient temperature for motors, *(4)* maximum construction temperature, and *(5)* minimum construction temperature. ***(b)*** The crane shall be designed to withstand the effects of the specified temperatures, or the limitations of the crane's design concerning these temperature conditions shall be specified by the crane designer.	***(a)*** Zion Specification SP-ZS-FH-003 details the maximum and minimum operating temperatures in the area where the crane operates. Construction temperatures are not provided since the crane is not used for construction ***(b)*** The trolley is designed to withstand the effects of the specified temperatures. Any limitations of the trolley design due to the specified temperature conditions will be provided in MMH Document 36675-20 (Operation & Maintenance Manual). See Note 1.
1143 Pressure ***(a)*** The purchase specification shall specify the following pressure requirements in the area where the crane operates: *(1)* normal operating pressure and *(2)* any test or abnormal event of these pressures including the rate of change. ***(b)*** The crane shall be designed to withstand the effects of the specified pressures, or the limitations of the crane's design concerning these pressure conditions shall be specified by the	***(a)*** Zion Specification SP-ZS-FH-003 details the normal operating pressure conditions in the area where the crane operates. ***(b)*** The trolley is designed to withstand the effects of the specified pressures. Any limitations of the trolley design due to the specified pressure conditions will be provided in MMH Document 36675-20 (Operation & Maintenance Manual). Enclosed components that are exposed to changes in pressure are vented.

NOG-1 Single Failure Proof Requirements	Zion Station FHB *Crane Trolley* Compliance
manufacturer. Specifically where there are changes in pressure, enclosures shall be vented.	See Note 1.
1144 Humidity ***(a)*** The purchase specification shall specify the humidity conditions in the area where the crane operates. ***(b)*** The crane shall be designed to withstand the effects of the specified humidity, or the limitations of the crane's design concerning the humidity condition shall be specified by the manufacturer.	***(a)*** Zion Specification SP-ZS-FH-003 details the normal operating humidity conditions in the area where the crane operates. ***(b)*** The trolley is designed to withstand the effects of the specified humidity. Any limitations of the trolley design due to the specified humidity conditions are provided in MMH Document 36675-20 (Operation & Maintenance Manual). See Note 1.
1145 Chemical ***(a)*** *Spray Systems* *(1)* If the crane may be subject to any spray systems, then the chemistry of the spray shall be specified in the purchase specification. Any restrictions on the use of materials due to the effects of the spray shall also be specified. Specifically, where a corrosive spray is present the possibility of H_2 generation exists and, therefore, the use of exposed aluminum, magnesium, galvanized steel, and zinc is to be minimized. *(2)* The crane shall be designed to withstand the effects of the specified spray and shall not use the specified restricted materials. Any limitations of the crane's design concerning the spray condition and the use of any restricted materials shall be specified by the manufacturer prior to the manufacture of the crane. ***(b)*** *Pools* *(1)* If the crane's load block and wire rope are to be immersed, then the chemistry of the pool shall be specified in the purchase specification. Requirements for the materials and lubricants of the load block and wire rope shall also be specified to insure compatibility with the pool	***(a)*** N/A - The crane is not subject to any spray systems ***(b)*** Zion Specification SP-ZS-FH-003 details the Zion spent fuel pool chemistry. The load block and wire rope are immersed in the pool and associated lubricants are selected to be non-water soluble and free of halogenated compounds, halogens, mercury, and other deleterious materials to ensure compatibility with the pool chemistry. MSDS will be provided for all chemicals used, including coatings and lubricants. Any limitations of the crane design due to the pool chemistry and lubrication requirements will be provided in MMH Document 36675-20 (Operation & Maintenance Manual).

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chemistry. In reactor and fuel pools, the lubricants shall basically be nonwater-soluble and shall be free of halogenated compounds, halogens, mercury, and other deleterious materials. *(2)* Load blocks and wire ropes that are to be immersed shall be lubricated with a lubricant that meets the specified lubrication requirements. Any limitations of the crane design concerning the pool chemistry and lubrication requirements shall be specified by the manufacturer.	
1150 Definitions [Text and/or equations omitted]	Specified definitions are used to properly describe the equipment or process.
1160 References The following is a list of codes and standards referenced in NOG-1. These codes and standards apply to the extent invoked at the point of reference. [Text and/or equations omitted]	The *Zion Station FHB Crane Trolley* system complies with the codes and standards to the extent invoked at the point of reference.
1170 Nomenclature The nomenclature used in this Standard is listed and defined in the Section in which it is used.	Specified nomenclature is used for applicable design parameters.
1180 Conversion Factors Conversion factors, including metric equivalents, are provided in the Mandatory Appendix I.	All calculations take unit systems and conversion factors into consideration.
2000 Quality Assurance	
2100 REQUIREMENTS ***(a)*** The quality assurance program of the Manufacturer of Types I and II cranes shall meet the Basic and Supplemental Requirements of ASME NQA-1, or shall meet the Quality Assurance Requirements specified by the owner. ***(b)*** A specific quality assurance program for manufacturers of Type III cranes is not required unless specified in the procurement documents. ***(c)*** A specific quality assurance program for mechanical components	***(a)*** The quality assurance program used for the manufacture of Type I Cranes is a 10 CFR 50 compliant QA program equivalent to the ASME NQA-1 program. This program is audited for compliance. Ref. MMH Document 36675-11 (Critical List) for items covered under this program. ***(b)*** N/A - This is a Type I Crane ***(c)*** N/A - This is a Type I Crane ***(d)*** A quality assurance program for electrical components is not specified per Zion Specification SP-ZS-FH-003.

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for Type II cranes is not required unless specified in the procurement documents. ***(d)*** A specific quality assurance program for suppliers of electrical components for Types I and II cranes is not required unless specified in the procurement documents. ***(e)*** A specific quality assurance program for suppliers of Type I crane structural and mechanical components which are not listed in Table 7200-1, and for Type II crane structural components which are not listed in Table 7200-2, is not required unless specified in the procurement documents. ***(f)*** The quality assurance program for packaging, shipping, receiving, storage, and handling of Types I and II cranes shall be in conformance with Section 8000.	***(e)*** Specific quality assurance requirements for Type I structural and mechanical components not listed in Table 7200-1 are not specified per Zion Specification SP-ZS-FH-003. This is not a Type II crane. ***(f)*** The quality assurance program for packaging, shipping, receiving, storage, and handling of the crane upgrade components is in conformance with Section 8000.
3000 Coatings and Finishes	
3100 COATING SERVICE LEVELS The owner shall specify either coating service level I or II as defined below. ***(a)*** *Coating Service Level I.* For use in areas where coating failure could adversely affect the operation of post-accident fluid systems and, thereby, impair safe shutdown. With few exceptions, coating service level I applies to coatings inside a nuclear power plant's primary containment. ***(b)*** *Coating Service Level II.* For use in areas where coating failure could impair, but not prevent, normal operating performance. The function of coating service level II coatings is to provide corrosion protection and decontaminability in those areas outside primary containment subject to radiation exposure and radionuclide contamination. Coating service level II also applies to coatings in nonradiation areas.	A coating service is not specified per Zion Specification SP-ZS-FH-003, so a service level II coating is used. ***(a)*** N/A - A service level II coating is applied to the trolley. ***(b)*** A service level II coating is applied to the trolley to provide corrosion protection and decontaminability in those areas outside primary containment subject to radiation exposure and radionuclide contamination. Ref. MMH Document 36675-02 (B22 Painting Specification). See Note 1.
3200 SPECIFIC REQUIREMENTS FOR COATING SERVICE LEVELS **3210 Requirements for Coating Service Level I** ***(a)*** Coating requirements for coating service level I shall be in accordance with ASTM D 5144, Standard Guide for Use of	***(a-c)*** N/A - A service level II coating is applied to the trolley.

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Protective Coating Standards in Nuclear Power Plants. ***(b)*** In accordance with ASTM D 5144, coating service level I requires a quality assurance program. ***(c)*** Inspection and testing of coatings for coating service level I shall be in accordance with para. 7700. Specific coating inspections shall be specified by the owner, dependent upon the coating system being used. See ASTM D 5161, Standard Guide for Specifying Inspection Requirements for Coating and Lining Work (Metal Substrates), for selecting and specifying the appropriate inspection requirements.	See Note 1.
3220 Requirements for Coating Service Level II ***(a)*** Coating requirements for coating service level II shall be as specified by the owner. The owner may invoke applicable sections of ASTM D 5144, Standard Guide for Use of Protective Coating Standards in Nuclear Power Plants. ***(b)*** Quality assurance requirements for coating service level II shall only apply as specified by the owner. ***(c)*** Inspection and testing requirements for coating service level II shall be in accordance with para. 7700.	***(a)*** N/A - Coating requirements are specified per Zion Specification SP-ZS-FH-003 ***(b)*** N/A - Quality assurance requirements for coating service level II are not specified per Zion Specification SP-ZS-FH-003 ***(c)*** Inspection and testing requirements for coating service level II are in accordance with this standard. See Note 1.
3230 Additional Requirements Applicable to All Coatings Additional requirements for coatings and finishes are listed in (a) through (o) below. Further information for coatings and finishes is provided in Nonmandatory Appendix A, Section A3240. ***(a)*** If not specified by the owner, the type of coating will be determined by the manufacturer to meet the specified environmental conditions of service and coating service level. Specifically, the selected coatings shall be suitable for any specified radiation, temperature, and chemical immersion or chemical spray environment. ***(b)*** Welding through coatings shall not be allowed unless the coating system is specifically designed and formulated as a weldable system and documentation can be provided by the coating manufacturer to attest to this capability. The use of these	Ref. MMH Document 36675-02 (B22 Painting Specification) for the following items. ***(a)*** A service level II coating is applied to the trolley, which exceeds the requirements of Zion Specification SP-ZS-FH-003. ***(b)*** Welding through coatings is prohibited. ***(c)*** Surfaces exposed to the environment, but inaccessible after assembly are coated prior to assembly. ***(d)*** Interior or enclosed surfaces of the equipment are, at a minimum, primed or coated with appropriate preservatives. ***(e)*** Contact surfaces of friction-type joints to be joined by high-strength bolts are prepared in accordance with AISC "Specifications for Structural Joints Using ASTM A325 or A490 Bolts." Coating systems prohibited by para. 1145 are not used.

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coatings shall be approved by the owner. ***(c)*** Surfaces exposed to the environment, but inaccessible after assembly, such as wheel wells and hubs, shall be coated prior to assembly. ***(d)*** Coating of interior or enclosed surfaces of the equipment, such as inside a welded box section, is not required by this Standard. ***(e)*** Contact surfaces of friction-type joints to be joined by high-strength bolts shall not be coated with specified coating system except for organic or inorganic zinc coating systems not prohibited by para. 1145. ***(f)*** Machined mating surfaces and other surfaces not normally protected by the specified coating system, such as hooks, hook nuts, wheel treads, rails, gears, shafts, pinions, couplings, drum grooves, sheave grooves, and brake wheels, shall be protected by means of an appropriate preservative for shipment and/or storage. The manufacturer shall specify which preservatives must be removed by the owner for proper operation of the equipment. Other preservatives may be removed by the owner after installation of the equipment. ***(g)*** Forced curing or drying of the coating system shall not be performed unless recommended by the coating manufacturer. ***(h)*** Fillers, sealants, and caulking compounds shall be compatible with the coating system. ***(i)*** Finished components, such as motors, brakes, gear reducers, limit switches, electrical dials and gauges, control enclosures, brake rectifier cabinets, control masters, safety switches, auxiliary heaters, push-button stations, transformers, manual magnetic disconnects, light fixtures, reactors, resistor banks, protective guards, cross-shaft bearing blocks, unitized hoists, interior of control cabinets, festoon trolley cable spacer systems cab interiors, and radio control equipment, may be furnished with conventional coatings unless otherwise specified by the owner. ***(j)*** For coating service level I applications, the equipment	***(f)*** Machined mating surfaces and other surfaces not normally protected by the specified coating system are protected by means of appropriate preservative for shipment and storage. Any preservatives that must be removed prior to operation are identified. ***(g)*** Forced curing or drying is not used unless recommended by manufacturer. ***(h)*** Fillers, sealants, and caulking compounds are compatible with the coating system. ***(i)*** Finished components are furnished with conventional coatings unless otherwise specified by the owner. ***(j)*** N/A - A service level II coating is applied to the trolley. ***(k)*** Nameplates and warning labels of factory finished components that are recoated are masked to preserve legibility. ***(l)*** Items such as fasteners and conduit are coated, galvanized or plated and comply with the chemical requirements of para. 1145. A list of galvanized and plated items can be provided upon request. ***(m)*** Any surface contaminants detected are removed after surface preparation to comply with the requirements of the Steel Structures Paining Council (SSPC) Painting Manual. ***(n)*** Any surfaces with visible deterioration beyond the specified SSPC preparation are re-prepared. ***(o)*** When touchup is required on small surfaces where conventional blasting is not desirable, vacuum blasting, power tool cleaning, or hand sanding is used as specified. See Note 1.

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manufacturer shall supply the estimated surface area of exposed parts provided with conventional coatings. ***(k)*** Nameplates and warning labels of factory finished components that are recoated shall be masked to preserve legibility. ***(l)*** Items such as fasteners and conduits shall be supplied with the specified coating system, galvanized, or plating. Galvanizing or plating shall be subject to the requirements of para. 1145. When specifically requested by the owner, a list of galvanized or plated parts shall be provided by the equipment manufacturer. ***(m)*** Surface contaminants, such as grease and oil, detected after blasting shall be removed to produce the surface conditions required by the appropriate Steel Structures Painting Council (SSPC) surface preparation requirement. ***(n)*** If there is visible deterioration of the surface beyond the specified SSPC preparation, repreparation of the surface shall be required. ***(o)*** Preparation of surface shall be accomplished by the methods originally used, except that small areas requiring repair or touchup where conventional blasting is not desirable may be reprepared by one of the following methods. These methods are listed in descending order of effectiveness. *(1)* Vacuum blasting to clean an abrasive finish with a minimum 2.0 mil profile; the minimum blasting air pressure shall be 50 psi at the blasting nozzle. *(2)* Power tool cleaning using grinding wheels, sanding discs, or other devices to provide a minimum 2 mil profile in accordance with SSPC SP-3; the use of a needle gun to roughen the surface after grinding is recommended. *(3)* Hand sanding to obtain as clean a surface as possible in accordance with SSPC SP-2; or wire brushing in accordance with SSPC SP-2.	
4000 Requirements for Structural Components	
4100 GENERAL	

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4110 Scope Section 4000 specifies the design criteria, design, materials, and fabrication procedures for the structural components of Types I, II, and III cranes. The structural components of the crane are identified in para. 4400.	The structural components are designed, procured and manufactured per the requirements of Section 4000.
4120 Nomenclature The nomenclature listed herein is used in the equations in 4000. For further information on nomenclature, application, and units of measurement, see the Section 4000 references noted in parentheses. [Text and/or equations omitted]	Calculation documentation adheres to the nomenclature used in Section 4000 to the extent practical. Any alternative nomenclature used in calculations is accompanied by complete descriptions.
4130 Description of Loads The loads described herein are the loads to be used for the analysis and design of the structural components of the crane. The loads are to be combined as outlined in para. 4140. All loads described, except the crane dead loads, shall be stated by the purchaser in the purchase specification.	All loads used for the analysis and design of the structural components of the crane are detailed in Zion Specification SP-ZS-FH-003 except for the trolley dead load, which is provided in MMH Drawing R94779 (Trolley Assembly). The loads are combined as outlined in para. 4140 for applicable calculations.
4131 Dead Loads ***(a)*** *Trolley* P_{dt} : the total weight of the trolley including all machinery and equipment attached thereto. ***(b)*** *Bridge or Gantry Frame* P_{db} : the total weight of the bridge or gantry frame structure including all machinery and equipment attached thereto, trucks, wheels, and end ties.	***(a)*** The total weight of the trolley is provided in MMH Drawing R94779 (Trolley Assembly) and is used in applicable calculations. ***(b)*** The total weight of the bridge structure is determined from documentation provided by the customer and is used in applicable calculations. Ref. MMH Document 36675-05 (Bridge Stress Calculations).
4132 Live Loads ***(a)*** *Rated Load* P_{lr}. The design rated load to be lifted and transported by the crane which by definition is not considered as the critical load. An allowance for lifting accessories which are not part of the crane, such as yokes, spreader beams, etc., is to be included in the design rated load. ***(b)*** *Critical Load* P_{lc}. For the definition of critical load, see para. 1150. In addition to listing each critical load, the purchaser shall furnish the duration in hours per year that each critical load is expected to be on the crane hook. An allowance for lifting	Ref. Zion Specification SP-ZS-FH-003 for the following items: ***(a)*** The design rated load to be lifted and transported by the crane is provided. Allowance for lifting accessories which are not part of the crane are included in the design rated load. ***(b)*** Critical loads and lifting accessory weights are provided The duration the critical load is expected to be on the hook was not included in Zion Specification SP-ZS-FH-003, however is expected to be less than 150 hours per year, which is well under usage assumed in NOG-1 Section 4350.

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accessories is to be included in each critical load. ***(c)*** *Construction Load P_{cn}.* The maximum expected construction load to be lifted and transported by the crane during the plant construction phase, prior to its use as a plant operating crane. ***(d)*** *Credible Critical Load P_{co}, P_{cs}.* P_{co} is the weight of lifted load which may be considered in combination with the operating basis earthquake (OBE). P_{cs} is the weight of lifted load which may be considered in combination with the safe shutdown earthquake (SSE). Alternatively, P_{co} and P_{cs} may be defined to be lifted loads in credible combinations with seismic events other than OBE and SSE. If this alternative method is used, the appropriate substitution for P_e and $P_{e'}$ shall be made in load combinations P_{c10} and P_{c12}. The loads and seismic events shall be specified by the Purchaser.	***(c)*** N/A - This crane is not used for construction ***(d)*** The credible critical load is specified as the maximum critical load (MCL), which is equivalent to the design rated load. This load is used in combination with the spectra provided for the safe shutdown earthquake (SSE), which envelopes the operating basis earthquake (OBE).
4133 Impact Loads ***(a)*** *Vertical Impact Load P_v.* Shall be taken as 15% of the maximum lifted load. ***(b)*** *Transverse Horizontal Load P_{ht}.* The horizontal load transverse to the bridge is induced by the acceleration or deceleration of the bridge crane or gantry crane along its runway and shall be taken as 5% each of the bridge or gantry frame dead load, the trolley dead load, and the maximum lifted load. ***(c)*** *Longitudinal Horizontal Load P_{hl}.* The horizontal load longitudinal to the bridge is induced by the acceleration or deceleration of the trolley on the crane bridge girder rails and shall be taken as 10% of the trolley dead load and the maximum lifted load.	Ref. MMH Document 36675-09 (Seismic Analysis) and MMH Document 36675-23 (Main Hoist Reeving Stress Report) for the following items:***(a)*** 15% of the maximum lifted load is used for vertical impact loads. ***(b)*** The horizontal load transverse to the bridge is taken as 5% of the combined bridge dead load, the trolley dead load, and the maximum lifted load. ***(c)*** The horizontal load longitudinal to the bridge is taken as 10% of the trolley dead load and the maximum lifted load.
4134 Wind Loads The following wind loads are to be considered to act in any direction. ***(a)*** *Operating Wind P_{wo}.* The maximum wind load under which the crane will be permitted to operate. If none is stipulated by the purchaser, then the nominal wind load specified in CMAA 70 shall be used.	***(a)*** N ZS requests an exception to Section 4140 for inclusion of *Operating Wind P_{wo}* in the load combinations since this crane is used indoors and *Operating Wind P_{wo}* is not part of the facility design basis. ***(b)*** ZS requests an exception to Section 4140 for inclusion of *Design Wind P_{wd}* in the load combinations for the crane analysis since this crane is used indoors.

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(b) *Design Wind* P_{wd}. The plant design basis wind load resulting from the 100 year recurrence, "fastest mile of wind." Under this loading, the crane will not be operational, but be secured. ***(c)*** *Tornado Wind* P_{wt}. The plant design basis tornado loads. Tornado pressure differentials associated with the plant design basis tornado shall be included in the loading. Tornado-generated missiles shall be considered. The purchaser shall be responsible for the missile parameters and method of evaluation of tornado loads and tornado-generated missiles. Under these loadings, the crane will not be operational, but be secured. Indoor cranes may be subjected to the design basis tornado if the building enclosures have been designed to fail.	***(c)*** ZS requests an exception to Section 4140 for inclusion of *Tornado Wind* P_{wt} in the load combinations for the crane analysis since this crane is used indoors. Procedural provisions shall be made to prevent fuel transfer operations during a tornado watch or warning.
4135 Normal Plant Operating Loads ***(a)*** *Plant Operation Induced Loads* P_p. The loads imposed on the crane through the supporting structure due to normal operation of plant equipment. The crane is not operating. ***(b)*** *Static Test Pressure Load* P_{tp}. The over-pressure imposed on the crane due to the static test pressure load for the structure enclosing the crane. This load applies only to those cranes housed within containments. The crane is not operating.	***(a)*** N/A - Plant operation induced loads are not specified. ***(b)*** N/A Static test pressure loads are not specified.
4136 Seismic and Abnormal Events Loads ***(a)*** *Safe Shutdown Earthquake* $P_{e'}$. The site SSE parameters shall be used in the seismic analysis of the bridge crane or the gantry crane following the procedures outlined in para. 4140. ***(b)*** *Operating Basis Earthquake* P_e. The site OBE parameters shall be used in the seismic analysis of the bridge crane or the gantry crane following the procedures outlined in para. 4140. ***(c)*** *Abnormal Event Loads* P_a. Loads caused by failure of plant equipment which impose jet or missile loads on the crane. The Purchaser shall be responsible for the effects of, and shall establish the criteria for, these loads.	***(a)*** Response spectra for safe shutdown earthquake (SSE) are provided in Zion Specification SP-ZS-FH-003 and ENERCON Calculations ZION001-CALC-002, -025 & 4 and are used for the seismic analysis of the crane following the procedures outlined in para. 4140. Ref. MMH Document 36675-05 (Bridge Stress Calculations) and MMH Document 36675-09 (Seismic Analysis). ***(b)*** N/A - SSE loads are used, which envelope the OBE loads. ***(c)*** N/A - Abnormal event loads are not specified.
4140 Load Combinations The following tabulated loads and their designations are described	ZS requests an exception to this section for inclusion of the *Operating*

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in para. 4120. The various load combinations, using the load designations, are listed herein. All load combinations are applicable to Types I and II cranes, whereas the Crane Operational Loads and the Construction Loads combinations are applicable to the Type III cranes. [Text and/or equations omitted]	*Wind P*, Design *Wind* P_{wd} and *Tornado Wind* P_{wt} for the crane analysis, since this crane is used indoors. Note that wind loads are included in the design basis for the building structure. Procedural provisions shall be made to lower the likelihood of fuel transfer operations during a tornado watch or warning. The various load combinations specified are used for applicable calculations. Ref. MMH Document 36675-05 (Bridge Stress Calculations) and MMH Document 36675-09 (Seismic Analysis).
4150 Seismic Analysis for Types I and II Cranes **4151 Methods of Analysis** A dynamic analysis method (e.g., response spectrum or time-history method) shall be used to establish the response of the crane to a seismic event.	The response spectrum method was used for the dynamic seismic analysis.
4152 Seismic Input Data The seismic input data for the crane seismic analysis shall be provided in the specification for the crane. The seismic input shall be specified as broadened floor response spectra or time histories of acceleration, displacements, or velocities defined at an appropriate level in the structure supporting the crane. For analysis of a crane with a suspended critical load, the specification for the crane shall provide the credible critical load. The basis for determining the credible critical load will be studies of site seismicity and expected crane usage (see para. 4132).	The rail level response spectra are provided by ZionSolutions and applied using the response spectrum method. The credible critical load is specified as the maximum critical load (MCL), which is equivalent to the design rated load. Ref. MMH Document 36675-05 (Bridge Stress Calculations) and MMH Document 36675-09 (Seismic Analysis).
4153 Linear Analysis **4153.1 Response Spectrum Method** The crane shall be considered to respond as a linear elastic system when using the response spectrum method. The undamped natural modes and frequencies shall be computed using a model acceptable under the rules of this Section. These outputs shall serve as the basis for mode-by-mode computation of the response of the crane to each of the three components of seismic input.	The linear response spectrum method is used for seismic evaluation of the crane. Modal solution is performed and un-damped natural modes and frequencies are determined for use in the spectrum analysis. Ref. MMH Document 36675-05 (Bridge Stress Calculations) and MMH Document 36675-09 (Seismic Analysis).

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4153.2 Time-History Analysis Time histories of structural response at the appropriate level may be used for analysis of the crane. The time histories shall be provided by the purchaser, and shall account for parametric variation in the supporting structure. Procedures for assembling the mathematical model shall be in accordance with this Section. The effects of the three components of ground motion shall be combined in accordance with the following requirements. ***(a)*** The representative maximum values of the structural responses to each of the three components of earthquake motion shall be combined by taking the square root of the sum of the squares of the maximum representative values of the co-directional responses caused by each of the three components of earthquake motion at a particular point of the structure or of the mathematical model. ***(b)*** The maximum value of a particular response of interest for design of a given element may be obtained through a step-by-step method. The time-history responses from each of the three components of the earthquake motions may be obtained separately and then combined algebraically at each time step, or the response at each time step may be calculated directly, owing to the simultaneous action of the three components. The maximum response is determined by scanning the combined time-history solution. When this method is used, the earthquake motions specified in the three different directions shall be statistically independent.	N/A - The response spectrum method was used instead of a time-history analysis.
4153.3 Crane Mathematical Model ***(a)*** The crane shall be represented by a generalized three-dimensional system of nodes. The model's geometry shall reflect the overall size, length, connectivity, and stiffnesses of the various structural members. An appropriate element representation of each member shall be used to describe all components which contribute significantly to the stiffness of the crane. The elements shall include, but not necessarily be limited to, the following	Ref. MMH Document 36675-05 (Bridge Stress Calculations) and MMH Document 36675-09 (Seismic Analysis) for the following items: ***(a)*** A detailed finite element representation of the crane structure is generated that represents the overall size, length, connectivity, and stiffness of the various structural members. Shell elements are used to represent the trolley and beam elements are used to represent the bridge structures, including the end ties and end trucks. A combination of beam

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structural members: bridge girders, trolley frame, gantry legs, end ties, end trucks, platform supports, and cab supports; and for cranes required to be analyzed for credible critical loads, drum, upper block supports, and hoist ropes. Line elements emanating from the end truck shall be used to represent the connectivity of the wheels of the crane to the runway rail. ***(b)*** For cranes using bogeyed wheel trucks, pinned connections shall be specified for line elements which represent the attachment of the end trucks to the bridge girders or gantry legs. Where various connected structural members of the crane do not have intersecting centroidal axes, stiff line elements shall be used to represent the offset. These elements shall have stiffnesses which are an order of magnitude higher than the most stiff structural member of the crane. ***(c)*** A simplified finite element representation of the trolley structure using stiff line elements may be used for the crane dynamic model, provided it can be shown by rational analyses that the actual trolley structure responding as an uncoupled system has natural frequencies above 33 Hz. The model used for seismic analysis should be evaluated and revised if required to account for higher frequencies if plant operations induce such frequencies.	and shell elements is used to model the drum. Gear cases, motors, bottom blocks, electrical enclosures, platforms, and wheels are contributed as lumped mass. Line elements emanating from the end trucks are used to represent the connectivity of the wheels of the crane to the runway rail. ***(b)*** End trucks are directly bolted to the bridge girders, so pinned connections are not applicable. Where various connected structural members of the crane do not have intersecting centroidal axes, stiff line elements are used to represent the offset. These elements have stiffnesses an order of magnitude higher than the most stiff structural member of the crane. ***(c)*** A detailed shell model of the trolley structure is used instead of a simplified stiff line model to represent the exact response of the structure.
4153.4 Location and Number of Dynamic Degrees of Freedom Dynamic degrees of freedom shall be assigned to a sufficient number of node points, and in such locations that the real mass and stiffness distribution of the crane are simulated. Structural members subject to concentrated loads shall be provided with additional nodes at the points where a concentrated load or its equivalent mass is positioned. Crane components to be modeled as mass points (concentrated loads) shall include, but not be limited to, upper and lower blocks, gear cases, motors, brakes, heavy electrical control cabinets, cab, wheel assemblies, and trunnion pins. The total number of masses, or degrees of freedom, selected shall be considered adequate when additional degrees of freedom	Ref. MMH Document 36675-05 (Bridge Stress Calculations) and MMH Document 36675-09 (Seismic Analysis) for the following items: A detailed finite element model of the crane is generated using computer software with a significant number of nodes to accurately simulate the real mass and stiffness of the crane. Crane components such as upper and lower blocks, gear cases, motors, brakes, control cabinets, cab, wheels, etc. are modeled as mass points and connected at their respective locations to represent the exact behavior of the crane. Missing mass applications are performed to justify that additional degrees of freedom do not result in more than 10% increase in response. Dynamic coupling is

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do not result in more than a 10% increase in responses. Dynamic coupling shall be accounted for.	accounted for.
4153.5 Decoupling Criteria for the Crane Runway The crane and runway shall be evaluated to determine if the crane can be represented as a separate model or a model coupled with the runway. For the crane to be considered decoupled from the runway, the criteria of (a) or (b) below shall be met. ***(a)*** If $R_m < 0.01$, decoupling can be done for any R_f. ***(b)*** If $0.01 \leq R_m \leq 0.1$, decoupling can be done if $R_f \leq 0.8$ or if $R_f \geq 1.25$. ***(c)*** If $R_m \geq 0.1$, or $0.8 \leq R_f \leq 1.25$, an approximate model of the runway system shall be included with the crane model. R_m and R_f are defined as: R_m = total mass of the crane / mass of the runway system R_f = fundamental frequency of the crane / frequency of the dominant runway motion The purchaser shall determine the mass and frequency characteristics of the crane runway.	***(a-c)*** Coupled building-crane analysis was performed by a ZionSolutions vendor (ENERCON) for evaluation of the building. From the coupled analysis, ENERCON also generated the response spectra at crane rail level for Konecranes to evaluate the trolley and bridge. MMH Document 36675-09 (Seismic Analysis) addresses the new response spectrum data generated from the coupled building-crane model.
4153.6 Boundary Conditions at Trolley and Runway Rails The crane bridge (including gantry legs, if applicable) and trolley shall be provided with devices so that they remain on their respective runways during and after a seismic event. Characteristics of these devices that influence the dynamic behavior of the crane shall be included as boundary conditions in the model of the crane. The restraint devices shall be considered to be in contact with the resisting structure in establishing boundary conditions used in the analysis for the crane. The restraint device and resisting structure shall be designed for the maximum load resulting from the boundary condition considered. The crane shall be modeled with	The bridge and trolley are provided with seismic restraints that prevent them from leaving their respective rails during and after a seismic event as shown in P&H Drawing 29E5235 (Earthquake Restraint & End Stop), P&H Drawing 29E5236 (Earthquake Restraint & End Stop), and MMH Drawing R94779 (Trolley Assembly). The seismic restraints are considered to be in contact with the resisting structure in establishing boundary conditions used in MMH Document 36675-05 (Bridge Stress Calculations) and MMH Document 36675-09 (Seismic Analysis), and the resisting structures are designed for the maximum resulting load. Displacement boundary conditions are applied in the analysis with respect to Figure

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the boundary conditions specified in Fig. 4154.3-1, unless additional restraining, driving, or holding mechanisms exist. Basic boundary conditions for the crane model shall be consistent with the figure and the rational displacements, deformations, and forces in the structure under consideration.	4154.3-1 and Table 4154.3-1.
4153.7 Trolley Locations and Hoist Positions The crane (bridge and trolley) shall be analyzed under two separate loading conditions: ***(a)*** credible critical load on hook ***(b)*** no load on hook The analysis procedure shall use three different trolley positions. These correspond to: the trolley at its extreme end positions on the bridge span; the trolley at the 1/4 point of the span positions; and the trolley at mid-span. In calculating the 1/4 and mid-span positions, a location on the trolley which is approximately equal to the center between the closest trolley wheel to the loaded hook shall be positioned at the appropriate point on the span. Two positions of the loaded hook shall also be analyzed: hook up and hook down. The hook positions shall be specified by the purchaser. Table 4153.7-1 shows 21 independent load cases which are to be considered. The maximum combined structural responses SR_{max} at each node, in terms of displacement, forces, moments, stresses, is SR_{max} = largest of SR_{22}, SR_{23}, . . ., SR_{29}, SR_{30}	The analysis procedures in MMH Document 36675-05 (Bridge Stress Calculations) and MMH Document 36675-09 (Seismic Analysis) use three different trolley positions that correspond to: the trolley at its extreme end positions on the bridge span; the trolley at the 1/4 point of the span positions; and the trolley at mid-span. The hook is also analyzed with ***(b)*** no load and with ***(a)*** the credible critical load at the high hook and low hook positions as specified in Zion Specification SP-ZS-FH-003. The seismic response for each direction and for each node is vector summed and added to the absolute value of the response observed during static loading.
4153.8 Damping **Values** The response of each mode shall be determined from the amplified response spectra for the appropriate values of structural damping. A damping value of 7% of critical damping shall be used for the crane when the SSE is used in the analysis. A damping value of 4% of critical damping shall be used when the OBE is used in the analysis.	The response of each mode is determined from the amplified response spectra provided in Zion Specification SP-ZS-FH-003 for the appropriate values of structural damping. The structure, both crane support structure and SFP building structure, are composed of reinforced concrete, bolted, riveted and welded steel members. Structures constructed of reinforced concrete and welded steel have damping equal to 2% and 5% of critical for the Design

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	Earthquake and Maximum Credible Earthquake (MCE), respectively, as provided in the Zion Seismic Design Criteria, DC-SE-002-ZI. The bolted connections between the steel beams and the floor are rigid components designed to transfer significant loads to the concrete and as such do not have damping that is significantly higher than that for welded steel. Any bolted connections associated with the crane are local to the crane and do not impact the dynamic response of the structure. Therefore, the use of 2% and 5% damping for the purposes of evaluating the structure at all modes is appropriate. Additionally, response spectra curves for time histories at the bridge crane wheels are provided to the crane vendor at 4% damping of critical for MCE, which is lower than 7% required per ASME NOG-1-2004, Section 4153.8, for the crane vendor's evaluation of the Overhead Bridge Crane. A damping value of 7% of critical damping is used for the crane when the SSE is used in the analysis, which envelopes the OBE loading. Ref. MMH Document 36675-05 (Bridge Stress Calculations) and MMH Document 36675-09 (Seismic Analysis).
4153.9 Number of Modes Required for Seismic Analysis It is not generally necessary to include the contributions of all modes to the seismic response of the crane. A modal participation factor shall be used with the modal frequencies to select significant modes. Since high frequency modes may respond strongly in some cases, it is not sufficient to limit the modal analysis to the first several modes computed. Additional modes shall be computed until the inclusion of additional modes does not result in more than a 10% increase in response.	Modal solution is performed up to 33 Hz and all mode shapes are extracted. A 0.001 default threshold value for mode participation is used. Above the 33 Hz value, missing mass method is performed to justify that additional modes do not result in more than 10% increase in response. The missing mass method constitutes the total effect of all system mass that is not included in the modes with frequencies above 33 Hertz. Additional response due to the missing mass is calculated by performing a static analysis for an applied load that is equal to the missing mass multiplied by the highest gravitational acceleration value (ZPA) above 33 Hertz in the provided spectrums. Ref. MMH Document 36675-05 (Bridge Stress Calculations) and MMH Document 36675-09 (Seismic Analysis).
4153.10 Combination of Modal Responses In combining the static and dynamic responses, it shall be assumed that the dynamic responses have the sign which yields the worst	Ref. MMH Document 36675-05 (Bridge Stress Calculations) and MMH Document 36675-09 (Seismic Analysis) for the following items:

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case for the combination being considered. The loading conditions for the static and dynamic load cases which are required to be considered, and the corresponding structural responses (SR_1, SR_2, etc.) are listed in Table 4153.7-1. ***(a)*** *With No Closely Spaced Modes*. When the results of the modal dynamic analysis show that the crane modes are not closely spaced, the crane's response to each of the three components of seismic input shall be combined by taking the square root of the sum of the squares (SRSS). ***(b)*** *With Closely Spaced Modes*. When the results of the modal dynamic analysis show that some or all of the modes are closely spaced (two consecutive modes are defined as closely spaced if their frequencies differ from each other by 10% or less of the lower frequency), modal responses for each of the three components for seismic input shall be combined using one of the following three methods. *(1) Grouping Method*. Closely spaced modes shall be divided into groups that include all modes having frequencies between the lowest frequency in the group and a frequency 10% higher [see Note (1) below]. The representative maximum value of a particular response of interest for the design of a given element of a nuclear power plant structure, system, or the crane attributed to each such group of modes shall first be obtained by taking the sum of the absolute values of the corresponding peak values of the response of the element attributed to individual modes in that group. The representative maximum value of this particular response attributed to all the significant modes of the structure, system, or the crane shall then be obtained by taking the square root of the sum of the squares of corresponding representative maximum values of the response of the element attributed to each closely spaced group of modes and the remaining modal responses for the	Dynamic responses are assumed to have the sign which yields the worst case for the combination being considered. ***(a)*** When the results of the modal dynamic analysis show that the crane modes are not closely spaced, the crane's response to each of the three components of seismic input are combined by taking the square root of the sum of the squares (SRSS). ***(b)*** When the results of the modal dynamic analysis show that some or all of the modes are closely spaced, modal responses for each of the three components for seismic input are combined using the grouping method as described. ***(c)*** The representative maximum values of the structural responses of each of the three directional components of earthquake motion are combined by taking the square root of the sum of the squares of the maximum representative values of the co-directional responses caused by each of the three components of earthquake motion at each node of the crane mathematical model. Maximum values for each of the three-directional components of earthquake motion are calculated per Table 4153.7-2. The maximum combined structural response at each node is determined as specified.

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modes that are not closely spaced. [Text and/or equations omitted] *(2) Ten-Percent Method* [Text and/or equations omitted] *(3) Double-Sum Method* [Text and/or equations omitted] ***(c)*** *Combination of Three Components of Earthquake Motion.* The representative maximum values of the structural responses of each of the three directional components of earthquake motion shall be combined by taking the square root of the sum of the squares of the maximum representative values of the co-directional responses caused by each of the three components of earthquake motion at each node of the crane mathematical model. Table 4153.7-2 lists the representative maximum values (SR_{22}, SR_{23}, etc.) for each of the three-directional components of earthquake motion which are required to be calculated. The maximum combined structural response (SR_{max}) at each node, in terms of displacements, forces, moments, and stresses, is the largest of the representative maximum values of the structural responses of each of the three-directional components of earthquake motion, i.e., SR_{max} = largest of SR_{22}, . . ., SR_{29}, SR_{30}	
4154 Nonlinear Time History for Slack Rope Condition For the case when the credible critical load is being supported by the hoist ropes, and the results of the linear analysis of para. 4153 indicate a slack rope condition, that is, rope going into compression, the nonlinear time-history method of analysis shall be used to determine the maximum rope tension loads resulting from a slack rope condition. These loads shall be used for the sizing of the rope only. Nonlinear analysis concerns the performance of a dynamic analysis of the crane, when subjected to earthquake-induced forces, taking	Slack rope condition is not observed with the provided spectrums. Accordingly, non-linear time history analysis of the ropes is not required. Ref. MMH Document 36675-09 (Seismic Analysis) and MMH Document 36675-23 (Main Hoist Reeving Stress Report).

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into account the nonlinear properties (for example, tension only of the hoist ropes). To perform such an analysis, computer programs are available to solve the equations of motion via direct integration techniques at discrete time intervals over the time history of the earthquake.	
4154.1 Crane Mathematical Mode The crane finite element model shall be similar to the one described in para. 4143.3 for the linear analysis, except that the crane trolley and bridge geometry may be simplified if justification can be provided that the coupling effects of those degrees of freedom that are omitted from the three- dimensional model are not significant. A nonlinear spring (tension member only) shall be used to represent the hoist ropes.	Slack rope condition is not observed with the provided spectrums. Accordingly, non-linear time history analysis of the ropes is not required. Ref. MMH Document 36675-09 (Seismic Analysis) and MMH Document 36675-23 (Main Hoist Reeving Stress Report).
4154.2 Location and Number of Dynamic Degrees of Freedom Dynamic degrees of freedom shall be assigned to a sufficient number of node points and in such locations that the real mass and stiffness distribution of the crane is simulated. An important consideration for modeling the crane for the nonlinear analysis is that the fundamental frequency of the crane system in its unloaded (no load on the hook) configuration approximates that determined by the linear analysis.	Slack rope condition is not observed with the provided spectrums. Accordingly, non-linear time history analysis of the ropes is not required. Ref. MMH Document 36675-09 (Seismic Analysis) and MMH Document 36675-23 (Main Hoist Reeving Stress Report).
4154.3 Boundary Conditions at Trolley and Runway Rails Boundary conditions for the crane model shall be consistent with those specified in para. 4153.6, Fig. 4154.3-1, and Table 4154.3-1.	Slack rope condition is not observed with the provided spectrums. Accordingly, non-linear time history analysis of the ropes is not required. Ref. MMH Document 36675-09 (Seismic Analysis) and MMH Document 36675-23 (Main Hoist Reeving Stress Report).
4154.4 Trolley Locations and Hoist Positions A combined trolley and loaded hook position shall be selected so as to result in a crane system frequency which produces the severest slack rope conditions. Trolley locations and hoist positions specified in para. 4153.7 shall be considered.	Slack rope condition is not observed with the provided spectrums. Accordingly non-linear time history analysis of the ropes is not required. Ref. MMH Document 36675-09 (Seismic Analysis) and MMH Document 36675-23 (Main Hoist Reeving Stress Report).
4154.5 Damping Values A critical damping ratio of 7% shall be used for the rope for	Slack rope condition is not observed with the provided spectrums.

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determining the damping parameters required to form the damping matrix. Higher values may be used with adequate justification.	Accordingly, non-linear time history analysis of the ropes is not required. Ref. MMH Document 36675-09 (Seismic Analysis) and MMH Document 36675-23 (Main Hoist Reeving Stress Report).
4160 Tolerances Dimensions of welded beams, girders, and built-up members shall be within the tolerances specified by AWS D1.1. All measurements shall be based on 70°F ambient temperature and be taken at the manufacturer's plant prior to shipment, unless otherwise specified. A minimum dimensional check of a member will consider straightness, camber, lateral deviation of web to flange center lines, and depth. Overall crane dimensions shall be in accordance with the crane manufacturer's clearance drawing of the crane. Dimensions on the clearance drawings are the maximum dimensions of the crane and shall not be exceeded by the manufacturer. Height and end dimensions shall be shown in relationship to the top of the runway rail center line. Cumulative measurements of crane components are permitted. The accuracy of the runway rail dimensions shall be the responsibility of the purchaser. The runway rails shall be straight, parallel, level, and at the same elevation within the tolerances given in Fig. 4160-1. The crane manufacturer shall design the crane to operate properly within the runway rail tolerances given in Fig. 4160-1.	Welded beams, girders, and built-up members are within the tolerances specified by AWS D14.1. Procedures qualified under AWS D1.1 are acceptable under AWS D14.1 per Section 9.1.4. Measurements are taken during the fabrication process and any deviations from specifications are included in MMH Document 36675-17 (QA Document Binder). Overall crane dimensions are detailed in MMH Drawing R94424 (Top Level Crane Assembly) and are in accordance with the crane manufacturer's clearance drawings. Crane clearances will be verified and documented in MMH Document 36675-13 (Site Acceptance Test Procedure). Height and end dimensions are shown in relationship to the top of the runway rail center line in MMH Drawing R94424 (Top Level Crane Assembly). The accuracy of the runway rail dimensions, including tolerances specified in Fig. 4160-1, will be verified by ZionSolutions. The trolley is designed to properly operate within the rail tolerances given in Fig. 4160-1, as applied to the bridge rails. See Note 1.
4200 MATERIALS AND CONNECTIONS All materials of the structural components of the crane shall be an accepted type, suitable for the purpose for which the materials are to be used, and shall be in compliance with any additional requirements specified herein for the materials.	The materials selected for the trolley are industry specified in accordance with such standards as ASTM and AISC. The specification for each material is available for review and public inspection. Materials are clearly designated on individual component drawings. See Note 1.
4210 Base Materials	

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4211 Material ***(a)*** The base materials listed in Table 4211-1 are considered acceptable for the structural components identified in para. 4400 of Types I and II cranes when they meet the requirements of para. 4212. The manufacturer shall report the materials actually employed to the purchaser. Other suitable materials, which are in compliance with the other provisions for materials specified herein, may be acceptable subject to approval by the purchaser. ***(b)*** The base materials for the components of cranes not included in (a) above shall be in accordance with Specification CMAA 70.	***(a)*** Structural components selected for the trolley are primarily ASTM A36 and A572 materials, which are approved under Table 4211-1. Materials are clearly designated on individual component drawings. ***(b)*** N/A - Structural components for the trolley are selected to be in compliance with Table 4211-1 See Note 1.
4212 Fracture Toughness ***(a)*** Material for the structural components defined in para. 4211(a) for Types I and II cranes shall be impact tested in accordance with (a)(1) below, except as provided in (b) below. Materials for Type III cranes shall be in accordance with Specification CMAA 70. The purchaser shall specify the minimum operating temperature as defined in para. 1150. *(1)* For material greater than 5⁄8 in. thick, Charpy V-notch tests shall be performed in accordance with (a)(3) below, or drop weight tested in accordance with (a)(2) below. *(2)* The drop weight test shall be performed in accordance with ASTM E 208 using specimen type P-1, P-2, or P-3. The sampling shall be in accordance with ASTM A 20 when applicable or ASTM A 673 frequency P except for the type of specimen. The specimen depth shall be at least as far from the material surface as that specified for tensile test specimens in the material specification. The nilductility transition temperature shall be a minimum of 30°F below the minimum operating temperature. *(3)* The Charpy V-notch test shall be performed in accordance with ASTM A 370 using full-size specimens if possible. For Type I, cranes the sampling shall be in accordance with ASTM A 673 frequency P. For Type II	***(a)*** Material for the trolley structural components defined in para. 4211(a) is impact tested in accordance with (a)(1) below, except as provided in (b) below. Minimum operating temperatures are provided in Zion Specification SP-ZS-FH-003. *(1)* Material greater than 5/8 in. thick is Charpy V-notch tested in accordance with (a)(3). *(2)* N/A - Charpy V-notch testing is used instead of drop weight testing. *(3)* Charpy V-notch testing is performed in accordance with the specified requirements. MMH Document 36675-11 (Critical List) details the required components, procedures, and temperatures for testing, and results are provided in MMH Document 36675-17 (QA Document Binder). ***(b)*** Materials are exempted from impact testing as required in (a) above for the following conditions: *(1)* the nominal thickness is 5⁄8 in. or less; *(2)* the nominal cross-sectional area is 1 sq in. or less; *(3)* the maximum tensile stress (including residual stresses if the component is not postweld heat treated) under all conditions of loading required in para. 4100 does not exceed 6000 psi; *(4)* the component is fabricated from an austenitic stainless steel or a nonferrous material not subject to a ductile brittle transition;

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cranes, the sampling shall be in accordance with ASTM A 673 frequency H for specified minimum yields of 55 ksi or less, and frequency P for higher strength steels. The test temperature shall be a minimum of 30°F below the minimum operating temperature. The acceptance criteria shall be as shown in Table 4212-1. The results obtained with sub-size Charpy V-notch specimens shall be converted to full-size specimens in accordance with ASTM A 673 Table 1 before comparison with the acceptance criteria. ***(b)*** The base material shall be exempt from impact testing as required in (a) above provided one of the following is met: *(1)* the nominal thickness is 5⁄8 in. or less; *(2)* the nominal cross-sectional area is 1 sq in. or less; *(3)* the maximum tensile stress (including residual stresses if the component is not postweld heat treated) under all conditions of loading required in para. 4100 does not exceed 6000 psi; *(4)* the component is fabricated from an austenitic stainless steel or a nonferrous material not subject to a ductile brittle transition; *(5)* the component is fabricated from normalized ASTM A 516 Grade 70 steel and the required test temperature or the lowest service temperature is greater than 0°F; *(6)* the component is fabricated from normalized ASTM A 537 Class 1 steel and the required test temperature or the lowest service temperature is greater than −30°F.	*(5)* the component is fabricated from normalized ASTM A 516 Grade 70 steel and the required test temperature or the lowest service temperature is greater than 0°F; *(6)* the component is fabricated from normalized ASTM A 537 Class 1 steel and the required test temperature or the lowest service temperature is greater than −30°F. See Note 1.
4220 Fastener Materials **4221 Material** ***(a)*** The fastener materials in Table 4221-1 are considered acceptable for the structural interconnections of Types I and II cranes. The manufacturer shall report the materials actually employed to the purchaser. ***(b)*** The fastener materials for structural components of cranes not	***(a)*** Structural fasteners for the trolley are selected to be in compliance with Table 4221-1. Materials are designated on assembly drawings. ***(b)*** N/A - Structural fasteners for the trolley are selected to be in compliance with Table 4221-1 ***(c)*** N/A - Structural fasteners for the trolley are selected with plain

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included in (a) above shall be in accordance with Specification CMAA 70. ***(c)*** When not restricted by para. 1145, the fastener materials in Table 4221-2 may be galvanized or coated with zinc-rich paints. Fastener materials with a hardness higher than 320 BHN shall not be galvanized. ***(d)*** The fastener finish and tolerances shall be suitable for the type of connection in which it is employed.	(uncoated) finishes ***(d)*** Structural connections are designed per AISC and take into account the fastener finishes and tolerances where applicable. See Note 1.
4222 Fracture Toughness ***(a)*** Fastener materials for connections defined in 4221(a) shall be impact tested in accordance with (a)(1) below except as provided in (b) below. The purchaser shall provide the minimum operating temperature as defined in para. 1150. *(1)* Charpy V-notch tests shall be performed in accordance with ASTM A 370. For bolts and studs, the sampling shall be in accordance with ASTM A320. For nuts, the sampling shall be in accordance with ASTM A 194. The test temperature shall be equal to or less than 30°F below the minimum operating temperature as defined above. The acceptance criteria shall be as shown in Table 4222-1. ***(b)*** Fastener materials shall be exempt from impact testing as required in (a) above, provided the nominal size of the bolt or stud is 1 in. or less.	***(a)*** N/A - Fastener used on the trolley are exempt from impact testing per (b). ***(b)*** Fasteners used on the trolley are 1 in. diameter or less, exempting them from impact testing. See Note 1.
4230 Welding Materials **4231 Material** All welding materials shall be in compliance with the requirements of AWS D1.1 and the additional requirements specified herein. ***(a)*** Matching filler metal of adequate toughness per para. 4232 shall be used. For the shielded metal arc welding (SMAW) process, low hydrogen type electrodes shall be used for the structural connections of Types I and II cranes per para. 4400. ***(b)*** The filler metal for the structural connections of cranes not included in (a) above shall be as specified.	Welding materials for the trolley are specified in MMH Nuclear Operating Procedure #5.0.1, which complies with both AWS D14.1 and D1.1 where applicable. Procedures qualified under AWS D1.1 are acceptable under AWS D14.1 per Section 9.1.4. Welding materials are specified on individual welding drawings. ***(a)*** Matching filler metal of adequate toughness per para. 4232 is used. SMAW process is not used for this crane ***(b)*** N/A - All filler metal is included in (a) above.

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(c) If the SMAW process is employed for connections per (b) above but one of the base metals is on a component per para. 4211(a) that is over 2-1/2 in. thick, and is subject to applied tensile stresses in excess of 6000 psi, low hydrogen type electrodes shall be used.	***(c)*** N/A - SMAW process is not used for this crane See Note 1.
4232 Fracture Toughness ***(a)*** The filler metal defined in para. 4231(a) shall be impact tested in accordance with (a)(1) below except as provided in (b) below. The purchaser shall provide the minimum operating temperature as defined in para. 1150. *(1)* Charpy V-notch tests shall be performed in accordance with the filler metal specification. The difference between the minimum operating temperature and the test temperature shall be in accordance with Table 4232-1. ***(b)*** The filler metal shall be exempt from impact testing as required in (a) above, provided: *(1)* the base materials are exempt per paras. 4212(b)(1), (2), (3) or (4); or *(2)* the effective throat of the nominal weld is 5/8 in. or less.	***(a)*** Filler material used for critical welds on nuclear cranes is specifically segregated and purchased under a nuclear purchase order. The filler metal is tested to verify the material composition and impact tested as specified. This documentation is maintained by the Quality Department. ***(b)*** N/A - All filler material used for critical welds on nuclear cranes is impact tested per (a). See Note 1.
4240 Welded Studs Welded studs shall not be employed for the connections of the structural components defined in para. 4400. Studs welded to the structural components of the crane shall comply with the requirements for studs specified in AWS D1.1, and shall be compatible with the base material.	N/A - Welded studs are not used in the trolley design See Note 1.
4250 Connections **4251 Welded Connections** Welded connections shall comply with the requirements of AWS D1.1 except as specified herein.	Welding is performed per MMH Nuclear Operating Procedure #5.0.1, which complies with both AWS D14.1 and D1.1 where applicable. Procedures qualified under AWS D1.1 are acceptable under AWS D14.1 per Section 9.1.4. See Note 1.
4251.1 Welding Procedures	

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All welds for Types I and II cranes shall be performed in accordance with written procedures that establish limitations of variables consistent with AWS D1.1. These welds may be either prequalified or qualified in accordance with AWS D1.1.	Welding is performed per MMH Nuclear Operating Procedure #5.0.1, which complies with both AWS D14.1 and D1.1 where applicable. Procedures qualified under AWS D1.1 are acceptable under AWS D14.1 per Section 9.1.4. This document contains both pre-qualified and qualified weld procedures. See Note 1.
4251.2 Qualification Impact Tests The weld procedure qualification shall be exempt from impact testing as required per Mandatory Appendix I, para. I4251.2, provided one of the following is met: ***(a)*** the base materials are exempt per para. 4212(b); or ***(b)*** the base materials are in Material Group 1 of Table 3.1 of AWS D1.1, the weld is made by shielded metal arc welding, submerged arc welding, gas metal arc welding, or flux cored arc welding, and the filler metal is exempt per para. 4232(b); or ***(c)*** the base materials are in Material Group 1 of Table 3.1 of AWS D1.1, the weld is made by shielded metal arc welding, submerged arc welding, gas metal arc welding, or flux cored arc welding, and the weld is postweld heat treated per para. 4251.5.	***(a-c)*** All weld filler metal for the trolley has been impact tested. Test results are included in MMH Document 36675-17 (QA Document Binder). See Note 1.
4251.3 Combination of Weld Types If two or more of the general types of welds (groove, fillet, plug, slot) are combined in a single joint, the allowable capacity of each shall be separately computed with reference to the axis of the group in order to determine the allowable capacity of the combination.	The allowable capacity of each weld group is calculated separately if two or more general types of welds are combined in a single joint. See Note 1.
4251.4 Nondestructive Examination Requirements All welds shall be visually inspected over their entire lengths. Additional inspection and testing of the joints of the three types of cranes shall be as stated below. Examination and acceptance criteria of welds and repairs shall be in accordance with AWS D1.1 unless otherwise stated below. ***(a)*** *Types I and II Cranes.* The following inspections and tests shall be	All welds are visually inspected over their entire length. Additional weld inspections are carried out per MMH Document 36675-11 (Critical List) and as dictated on individual drawings as required. Examination and acceptance criteria of welds and repairs are in accordance with AWS D14.1. Procedures qualified under AWS D1.1 are acceptable under AWS D14.1 per Section 9.1.4.

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applied to welded structural connections. Percents of welds specified for inspection are measured along each face. This doubles the length for fillet welds on both sides of a joint. The length subject to examination of other welds shall be considered as doubled when welds are made from both sides. Areas examined shall be randomly distributed along the weld length. *(1)* Full penetration butt welds: 100% volumetric examination by either radiographic or ultrasonic testing unless the specification for the crane stipulates which method to use. *(2)* Other welds with an effective throat over 3⁄8 in.: dye penetrant or magnetic particle testing as follows unless the specification for the crane stipulates which method to use: *(a)* 100% of each of trolley load girt welds *(b)* 10% of each of the cover plate or flange to web welds of crane girders *(3)* Other welds as stipulated in the crane specification. *(4)* Base materials (greater than 5⁄8 in. thick) with highly restrained welded connections subject to weld shrinkage strains in a through-thickness direction shall be ultrasonically tested per Mandatory Appendix I, para. I4251.4 ***(b)*** *Types III Cranes.* Nondestructive examination requirements for welds and base metal shall be in accordance with Specification CMAA 70 and the manufacturer's standards unless otherwise stated in the specification for the crane.	***(a)*** The following inspections and tests are applied to welded structural connections. Percents of welds specified for inspection are measured along each face. The length subject to examination of other welds is considered as doubled when welds are made from both sides. Areas examined are randomly distributed along the weld length. *(1)* N/A - There are no full penetration butt welds. *(2)* All critical welds are 10% magnetic particle tested. There are no trolley load girt welds with an effective throat over 3/8 in. *(3)* N/A - Additional weld inspections and tests are not specified *(4)* N/A - There are no highly restrained welded connections subject to weld shrinkage strains. ***(b)*** N/A - This is a Type I Crane See Note 1.
4251.5 Postweld Heat Treatment ***(a)*** *Types I and II Cranes.* Welded connections shall be postweld heat treated (stress relieved) in accordance with AWS D1.1 except where exempted by Table 4251.5-1. However, exempted material may be postweld heat treated at the manufacturer's option. Times and temperatures per AWS D1.1 shall be employed. When it is not practical to postweld heat treat an entire assembly,	***(a)*** Welded connections are postweld heat treated (stress relieved) in accordance with AWS D1.1 for welded structures listed in MMH Document 36675-11 (Critical List) and stress relieving is specified on the applicable drawings. Local postweld heat treating and vibratory conditioning are generally not performed. ***(b)*** N/A - This is a Type I Crane

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local postweld heat treatment shall be employed. Local postweld heat treatment shall be accomplished by heating a band of metal that includes the joint. Heating may be obtained by any method that will ensure sufficient uniformity without harming the material. The width of the heated band on each side of the greatest width of the finished weld shall be at least twice the effective throat of the weld. The material outside the heated band shall be protected to avoid harmful temperature gradients. When postweld heat treating is employed, the following shall be observed. *(1)* All required postweld heat treating shall be covered by a written procedure. *(2)* Localized postweld heat treating may be employed as stated above, when approved by the design engineer. A written procedure must address the same seven points outlined in (a)(3) below for furnace postweld heat treating. *(3)* For furnace postweld heat treating, the procedure must address the following: *(a)* temperature at start of thermal cycle; *(b)* rate of heating; *(c)* maximum allowable variation of temperature throughout the portion of the part being treated; *(d)* maximum temperature tolerance at stress relief temperature; *(e)* holding time at stress relief temperature; *(f)* rate of cooling to temperature suitable for removal of work from the furnace; and *(g)* location of thermocouples and the number required. Vibratory conditioning to improve dimensional stability may be used at the option of the Manufacturer. The conditioning shall be done in accordance with the recommendations and procedures established by the manufacturer of the equipment. ***(b)*** *Type III Cranes.* The manufacturer shall determine the need for	See Note 1.

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postweld heat treatment. When used, PWHT shall comply with AWS D1.1.	
4251.6 Stud Welding The welding of studs shall be in accordance with AWS D1.1. The thickness of the base material to which studs are welded shall equal or exceed 20% of the nominal stud diameter to minimize burnthrough.	N/A - Welded studs are not used in the trolley design See Note 1.
4252 Bolted Connections **4252.1 Structural Joints Using ASTM A 325 or A 490 Bolts** Structural joints for structural components identified under para. 4400 using ASTM A 325 or A 490 bolts shall be designed and installed in accordance with the AISC "Specification for Structural Joints Using ASTM A 325 or A 490 Bolts." Bolts holes shall be subpunched and reamed or drilled. Standard holes shall have a diameter nominally 1⁄16 in. in excess of the nominal bolt diameter. Slotted bolt holes shall not be used except for connections which may require field adjustment for fitting the crane to the runway.	Structural joints for the trolley are designed and installed in accordance with the AISC "Specification for Structural Joints Using ASTM A 325 or A 490 Bolts." This includes drilling or reaming holes to 1/16" diameter greater than the nominal bolt size. Slotted bolt holes for structural joints are not used. See Note 1.
4252.2 Structural Joints Using Bolts Other Than ASTM A 325 or A 490 Structural joints using bolts other than ASTM A 325 or A 490 shall be bearing type and shall comply with the requirements for non-high-strength bolts specified in the AISC "Specification for Structural Steel Buildings, Allowable Stress Design and Plastic Design." All bolts shall be torqued to a pre-tension load on the bolt of 60% to 70% of the minimum yield strength of the bolt material. Standard holes shall have a diameter nominally 1⁄16 in. in excess of the nominal bolt diameter, except for bound bolts.	N/A - Only ASTM A 325 or A 490 bolts are used for the trolley structural connections. See Note 1.
4252.3 Pitch and Edge Distances The minimum pitch between centers of bolt holes and minimum edge distances from the center of a bolt hole to any edge shall be as stipulated in the AISC "Specification for Structural Steel Buildings, Allowable Stress Design and Plastic Design."	Hole patterns used for structural bolts meet the minimum pitch requirements as stipulated in the AISC "Specification for Structural Steel Buildings, Allowable Stress Design and Plastic Design." See Note 1.

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4252.4 Bolt Identification The bolting of the structural joints of the Types I and II cranes shall be identifiable. A unique marking system shall be used to identify type and/or grade of bolts and nuts used.	The structural fasteners used for the trolley have industry standard markings as required to identify their specific type and/or grade. These fasteners are also purchased with a certificate of conformance. See Note 1.
4253 Field Connections All field connections of structural components shall be bolted unless otherwise approved by the purchaser. The manufacturer shall provide sufficient information on drawings or in installation manuals on the requirements for all field connections.	All field connections of structural components for the trolley will be bolted. These connections are detailed on the applicable assembly drawings. See Note 1.
4300 DESIGN CRITERIA **4310 Basic Allowable Stresses for Structural Steel Members** **4311 Members Not Controlled by Buckling** For members not controlled by buckling, the basic allowable stresses in structural steel members of the crane shall not exceed values in Table 4311-1.	For members not controlled by buckling, the basic allowable stresses in structural steel members of the crane do not exceed the values specified in Table 4311-1. Ref. MMH Document 36675-05 (Bridge Stress Calculations) and MMH Document 36675-09 (Seismic Analysis).
4312 Compression Members Controlled by Buckling [Text and/or equations omitted]	N/A - There are no structural compression members controlled by buckling. Structural components are fabricated from welded plates, which are covered by paras. 4331 and 4332.
4313 Bending Stress The allowable bending stress for members other than those girders conforming to the dimensional criteria outlined in para. 4333 shall conform to AISC "Specification for Structural Steel Buildings, Allowable Stress Design and Plastic Design" Chapter F divided by 1.12*N* for the different loading conditions.	The allowable bending stress for members other than those girders conforming to the dimensional criteria outlined in para. 4333 conform to AISC "Specification for Structural Steel Buildings, Allowable Stress Design and Plastic Design" Chapter F divided by 1.12*N* for the different loading conditions.
4314 Welds Basic allowable stresses in welds shall be as specified in AWS D1.1. Allowable stresses for all types of welds may be increased for	Trolley weld calculations are provided in MMH Document 36675-10 (Trolley Weld Calculation) using allowable stresses specified in AWS D1.1.

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severe environmental load combinations by a factor of 1.33, and for extreme environmental load combinations by a factor of 1.50.	Allowable stresses for extreme environmental load combinations are increased by a factor of 1.5. See Note 1.
4315 Bolts ***(a)*** *ASTM A 325 or A 490 Bolts.* Allowable working stresses for operational or construction loads shall be in accordance with AISC "Specification for Structural Joints Using ASTM A 325 or A 490 Bolts." Allowable working stresses for other loadings shall be as follows. *(1) Bearing-Type Joints.* Allowable working stresses for bearing-type joints may be increased by a factor of 1.33 for severe environmental loadings, and by a factor of 1.50 for extreme environmental loadings. *(2) Friction-Type Joints.* Allowable working stresses for friction-type joints may not be increased for severe or extreme environmental loadings. ***(b)*** *Bolts Other Than ASTM A 325 or A 490.* Allowable stresses shall be in accordance with Table 4315-1.	Ref. MMH Document 36675-14 (Seismic Analysis of Misc. Items) for the following items: ***(a)*** Allowable working stresses for operational loads are in accordance with AISC "Specification for Structural Joints Using ASTM A 325 or A 490 Bolts." Allowable working stresses for bearing type joints are increased by a factor of 1.50 for extreme environmental loadings. Allowable working stresses for friction type joints are not increased for severe or extreme environmental loadings. ***(b)*** Allowable stresses for bolts other than ASTM A 325 or A 490 are in accordance with Table 4315-1. See Note 1.
4320 Combined Stresses **4321 Axial Compression and Bending** [Text and/or equations omitted]	Discussions are provided in MMH Document 36675-05 (Bridge Stress Calculations) and MMH Document 36675-09 (Seismic Analysis) to demonstrate that the results of the software analysis are in accordance with the requirements of this section.
4322 Axial Tension and Bending Members subject to both axial tension and bending stresses shall satisfy the requirements of Eq. (3). The computed bending tensile stress, taken alone, shall not exceed the applicable value according to para. 4311.	Discussions are provided in MMH Document 36675-05 (Bridge Stress Calculations) and MMH Document 36675-09 (Seismic Analysis) to demonstrate that the results of the software analysis are in accordance with the requirements of this section.
4323 Shear and Tension ***(a)*** Bolts subject to combined shear and tension shall be so proportional that the tension stress, psi, produced by forces applied	***(a)*** N/A - There are no bolts in combined shear and tension. ***(b)*** N/A - There are no friction-type joints.

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to the connected parts, shall not exceed the following. [Text and/or equations omitted] ***(b)*** For bolts used in friction-type joints, the shear stress allowed in para. 4315 shall be reduced so that: [Text and/or equations omitted]	See Note 1.
4324 Shear and Bending The maximum combined shear stress due to shear, bending, and direct stresses shall not exceed the allowable values for shear as given in para. 4311, except that in severe and extreme environmental conditions, the allowable shear stress may be increased by 20%.	Discussions are provided in MMH Document 36675-05 (Bridge Stress Calculations) and MMH Document 36675-09 (Seismic Analysis) to demonstrate that the results of the software analysis are in accordance with the requirements of this section.
4330 Buckling **4331 Local Buckling or Crippling of Flat Plates** The structural design of the crane must guard against local buckling of plates such as webs and coverplates of girders, etc., by limiting the allowable compression stress along opposite edges and the uniformly distributed shear stress assumed to be acting around all edges of the plate or a combination of both. [Text and/or equations omitted]	Calculations for local buckling or crippling of flat plates are performed in MMH Document 36675-05 (Bridge Stress Calculations). The basic allowable stresses in the structural steel members do not exceed the values specified in para. 4332.1. Members are not controlled by buckling.
4332 Combined Compression and Shear Buckling [Text and/or equations omitted]	Combined compression and shear buckling calculations are performed inside the buckling section of MMH Document 36675-05 (Bridge Stress Calculations).
4332.1 Design Factors in Plate Buckling (DFB) [Text and/or equations omitted]	Design factors for plate buckling are applied as required in MMH Document 36675-05 (Bridge Stress Calculations).
4333 Proportion for Fabricated Box Girders [Text and/or equations omitted]	Proportions for fabricated box girders are sufficient and are documented in MMH Document 36675-05 (Bridge Stress Calculations).
4334 Spacing of Transverse Stiffeners [Text and/or equations omitted]	The spacing of transverse stiffeners in the girders is sufficient and is documented in MMH Document 36675-05 (Bridge Stress Calculations).
4335 Stiffness of Longitudinal and Transverse Stiffeners	

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The required stiffness of the longitudinal stiffener and the stiffness of the transverse stiffeners shall be in accordance with Specification CMAA 70.	The required stiffness of the longitudinal and transverse stiffeners is in accordance with Specification CMAA 70 and is documented in MMH Document 36675-05 (Bridge Stress Calculations).
4340 Allowable Deflections and Cambers **4341 Girder Deflection** The total vertical deflection of the girder during operational loading for the rated live load plus trolley (P_{dt} + P_{lr}), and not including impact or dead load of the girder, shall not exceed 1/1000 of the span. The total vertical deflection of the girder during constructional loading for the construction load plus trolley (P_{dt} + P_{cn}), and not including impact or dead load of the girder, shall not exceed 1/600 of the span. The total vertical or lateral deflection of the girder during environmental loading shall be limited such that displacements do not cause the girder or any of its attachments to become dislodged or to leave the crane.	Ref. MMH Document 36675-05 (Bridge Stress Calculations) for the following items: The total vertical deflection of the girder during operational loading for the rated live load plus trolley (P_{dt} + P_{lr}), and not including impact or dead load of the girder, does not exceed 1/1000 of the span. Vertical deflection during constructional loading is not applicable since the crane is not used for construction. Vertical and lateral deflections of the girder during environmental loading are not severe enough to cause the girder or any of its attachments to become dislodged or to leave the crane.
4342 Girder Camber Girders shall be cambered an amount equal to the dead load deflection plus one-half of the deflection caused by the live load plus trolley [camber = Δ (P_{db}) + 0.5 Δ(P_{dt} + P_{lr})].	See Note 1.
4343 Trolley Frame Deflection The trolley frame shall be of rigid construction such that lifted loads do not cause deflections that impair the proper operation of machinery.	The trolley frame is sufficiently rigid such that lifted loads do not cause deflections that impair the proper operation of machinery. Ref. MMH Document 36675-09 (Seismic Analysis).
4344 Miscellaneous Structure Deflection Deflections of components such as end ties, end trucks, saddles, and equalizer beams shall not impair the functions for which they were designed or cause any attachments to the crane to become dislodged or to leave the crane.	Deflections of components such as end ties, end trucks are not severe enough to impair the functions for which they were designed or cause any attachments to the crane to become dislodged or to leave the crane. Ref. MMH Document 36675-05 (Bridge Stress Calculations).

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4345 Gantry Frame Deflection In addition to the preceding criteria, the following criteria shall apply to the gantry frame. ***(a)*** The total vertical deflection of the girder shall not exceed 1/1000 of the span between the gantry legs for the rated live load plus trolley ($P_{dt} + P_{lr}$) when the deflection is calculated as a simply supported beam. ***(b)*** The total vertical deflection of the girder cantilever shall not exceed 1/500 of the cantilever length for the rated live load plus trolley ($P_{dt} + P_{lr}$) when the deflection is calculated as a fixed end cantilever beam. ***(c)*** Side thrust at the runway rail due to gantry leg spreading caused by girder span or cantilever deflection or thermal movement shall be held at an acceptable level by providing adequate clearance between the rail head and the wheel flanges, or by means of other design features incorporated into the gantry structure.	***(a-c)*** N/A - This is not a gantry crane
4350 Fatigue Requirements Cranes used for nuclear power plants are normally used relatively few times during the entire life of the plant, as compared to typical structural fatigue criteria. The number of times a typical crane is cycled from no live load to full capacity load seldom exceeds 20,000 cycles during the entire life of the crane. Because of the combined effect of low full-load cycles and low allowable stresses during normal operation, the allowable stresses for the structural members, as specified in para. 4310, need not be reduced due to fatigue. If the Purchaser determines that greater than 20,000 full-load cycles are required, the Purchaser shall then specify the cycles and load class per Specification CMAA 70. The allowable stresses for the appropriate service level in Specification CMAA 70 shall be used, but shall not exceed the basic operating stress allowables specified in para. 4310.	N/A - There are no additional requirements specified by the purchaser for additional fatigue cycles.
4400 COMPONENT DESIGN **4410 General**	

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4411 Venting Closed sections used in structures which are subject to changes in pressure shall be vented. If used, vent openings shall be sized to equalize the internal closed section (or compartment) pressure with its external environmental pressure. Pressure rate of change tables or graphs may be required to determine maximum flow requirements. Where internal full depth diaphragms extend from the top flange to the bottom flange, the compartment formed by a pair of diaphragms shall be vented.	N/A - Venting is not required since the crane is not subject to pressure changes.
4412 Drainage Box sections when required by environmental conditions shall be drained to prevent moisture from accumulating. Where internal full depth diaphragms extend from the top flange to the bottom flange, the compartment formed by a pair of diaphragms shall be drained. Holes shall be provided in the bottom flange of the box girder for draining the whole box girder or each compartment formed by the diaphragms.	N/A- The environmental conditions do not require that box sections require drainage; however, the bridge girders do have drain holes. Ref. P&H Drawing 28A11377 (Welded Box Girder).
4413 Stress Concentrations Consideration shall be given to points where high stresses might be encountered, such as (but not limited to) at ends of stiffeners, intermittent welds, points of attachment, cut-outs, and reentrant corners. All reentrant corners shall be shaped notch free to a radius of at least 1/2 in. Sharp corner cuts are to be avoided, as are abrupt changes in section properties. Cut-outs, where necessary, shall be made with rounded corners, and their edges shall be analyzed for reinforcement.	All re-entrant corners of the plates are designed to be notch free with a radius greater than 1/2 in. Sharp corner cuts and abrupt changes in section properties are avoided. Cut-outs are made with rounded corners. The analysis of the trolley also envelops these critical stress concentration locations. Ref. MMH Document 36675-09 (Seismic Analysis). See Note 1.
4420 Bridge Girders **4421 General** The crane girders (bridge girders) shall be fabricated of structural steel. Structural steel materials shall comply with the requirements of para. 4210. Construction of the crane girders can be of several types, namely, welded plates to form box sections, box sections fabricated from rolled shapes with or without plates, single-rolled	The crane girders are constructed from welded plates to form a box section using structural steel that complies with para. 4210. Ref. P&H Drawing 28A11377 (Welded Box Girder).

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shapes, or built-up single web plate girders.	
4422 Loading Criteria Bridge girders shall be designed to resist the load combinations specified in para. 4140. When bridge girders and end ties are moment-connected in the horizontal plane, the assembly shall be analyzed as a rigid frame for the transverse horizontal loads.	The bridge girders are designed to resist the load combinations specified in para. 4140 and the assembly is analyzed as a rigid frame for transverse horizontal loads. Ref. MMH Document 36675-05 (Bridge Stress Calculations).
4423 Fabricated Box Girders **4423.1 Proportions** Proportions for fabricated box girders shall be as specified in para. 4333.	Girder proportions are as specified in para. 4333. Ref. MMH Document 36675-05 (Bridge Stress Calculations).
4423.2 Stiffeners The requirements of longitudinal and vertical stiffeners are given in para. 4330. Internal full depth diaphragms are required at machinery attachment points, bridge drive supports, and line shaft bearing supports. The diaphragms may also be considered to meet the requirements of the vertical stiffeners. External stiffeners adjacent to the diaphragms may be required to transmit forces from the attachments into the girder.	Longitudinal and vertical stiffeners for the bridge girders meet the requirements of para. 4330. Internal full depth diaphragms are provided at machinery attachment points, bridge drive supports, and line shaft bearing supports. External stiffeners adjacent to the diaphragms are provided to transmit forces from the attachments into the girder. Ref. MMH Document 36675-05 (Bridge Stress Calculations) and P&H Drawing 28A11377 (Welded Box Girder).
4423.3 Diaphragms All internal diaphragms shall be fitted to bear against the top cover plate to support the trolley rail, and shall be welded to the web plates to transfer the rail load directly to the box girder webs.	All internal diaphragms are fitted to bear against the top cover plate to support the trolley rail, and are welded to the web plates to transfer the rail load directly to the box girder webs. Ref. P&H Drawing 28A11377 (Welded Box Girder).
4423.4 Diaphragm Spacing Short diaphragms shall be placed between full depth diaphragms... [Text and/or equations omitted] The top cover plate of the box girder shall not be considered as contributing to the bending properties of the trolley rail.	Short diaphragms are placed between full depth diaphragms to minimize the bending stress in the girders. The girder top plate is not considered as contributing to the bending properties of the trolley rail. Ref. MMH Document 36675-05 (Bridge Stress Calculations) and P&H Drawing 28A11377 (Welded Box Girder).
4423.5 Diaphragm Thickness The thickness of the diaphragm plate shall be sufficient to resist the trolley wheel load in bearing, on the assumption that the wheel load is distributed over a distance equal to the width of the rail base	The diaphragm thickness is sufficient to resist the trolley wheel load in bearing. Ref. MMH Document 36675-05 (Bridge Stress Calculations).

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plus twice the distance from the rail base to the top of the diaphragm plate.	
4424 Single Web Girders Single web girders may be standard rolled beams or plate girders, reinforced with angles, channels, or plates. Where necessary, auxiliary girders shall be used to support overhanging loads to minimize torsional moments and lateral deflections on the single web girder. The analysis required for single web girders shall be the same as required for the plate box girder in para. 4423. The design shall be in accordance with the AISC Specification for the Design, Fabrication and Erection of Structural Steel for Buildings, but with the allowable stresses set forth in para. 4310.	N/A - This crane uses welded box section girders.
4430 Trolley Frames **4431 Construction** The trolley frame shall be constructed of structural steel. If field assembly of the trolley structure is required, the connections shall be designed to ensure proper alignment of the components.	The trolley frame is constructed from structural steel that complies with para. 4210. Field assembly of the trolley structure is not required. Ref. MMH Drawing QR95370 (Trolley Frame Weldment).
4432 Design **4432.1 Trolley Frame** The trolley frame shall be designed to resist all loading imposed by the motor, gearing, lifted load, and the load combinations specified in para. 4140.	The trolley frame is designed to resist the loading imposed by the motor, gearing, lifted load, and the load combinations specified in para. 4140. Ref. MMH Document 36675-09 (Seismic Analysis).
4432.2 Load Girt The load girt(s) shall be designed to carry the load to the side frames. Care shall be taken that the load girt deflections do not adversely affect the machinery alignment.	The load girts are designed to carry the load to the side frames. The frame has been designed as a welded fixture with low stresses to minimize deflection that would adversely affect machinery alignment. Ref. MMH Document 36675-09 (Seismic Analysis).
4433 Axle Failure Provisions shall be made to prevent a drop of more than 1 in. in case of an axle failure.	The trolley end trucks are designed to prevent a drop of more than 1 in. in case of an axle failure. Ref. MMH Drawing QR95370 (Trolley Frame Weldment).
4440 End Trucks and End Ties	

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4441 End Trucks **4441.1 General** The end truck is the assembly consisting of wheels, bearings, axles, and structural frame that supports the crane bridge.	End trucks consisting of wheels, bearings, axles, and structural frames that support the crane bridge are provided. Ref. P&H Drawing 105A3002 (Bridge Layout).
4441.2 Construction The end trucks shall be constructed of structural steel.	The end trucks are constructed from structural steel that complies with para. 4210 (Ref. P&H Drawing 31A5302/3).
4441.3 Design The end truck shall be designed to support the maximum crane end reactions for the load combinations specified in para. 4140.	The end trucks are designed to support the maximum crane end reactions for the load combinations specified in para. 4140. Ref. MMH Document 36675-05 (Bridge Stress Calculations).
4441.4 Axle Failure Provisions shall be made to prevent a drop of more than 1 in. in case of an axle failure.	The bridge end trucks are designed to prevent a drop of more than 1 in. in case of an axle failure.
4441.5 Wheel Base The wheel base of the end trucks of four-wheel cranes, or center-to-center of outermost wheels of multiple end trucks for cranes with more than four wheels, shall be not less than one-seventh of the girder span.	The wheel base of the outermost bridge wheels is not less than 1/7 of the girder span. Ref. P&H Drawing 105A3002 (Bridge Layout).
4441.6 Rail Sweeps A rail sweep shall be provided in front of each outside wheel. The rail sweep shall project below the top of the bridge runway rail.	Rail sweeps are provided in front of each outside wheel. The rail sweeps project below the top of the bridge runway rail.
4442 End Ties **4442.1 Construction** The end tie shall be constructed of structural steel.	The end ties are constructed from structural steel that complies with para. 4210.
4442.2 Types End ties for cranes with more than four bridge wheels can be either the flexible or rigid type. If equalizer bridge trucks are incorporated into the end carriage design to promote equal sharing of bridge wheel loads, and equalizer pins are provided between the equalizer trucks and equalizer beam and/or the rigid bridge frame structure, a	End ties for this crane are of the rigid type. Equalizer bridge trucks are not used. Ref. P&H Drawing 105A3002 (Bridge Layout)

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rigid type end tie may be used. If equalizer pins are not provided between the equalizer trucks and equalizer beam and/or the rigid bridge frame structure, a flexible end tie must be used.	
4442.3 Design End ties shall be designed to resist the loads due to crane movement and the load combinations specified in para. 4140. A rigid frame analysis shall be used to determine the proportions of the loads resisted by the end ties and by the girders. The flexible end tie shall be designed to accommodate up to 1⁄4 in. difference in elevation of the bridge rail between any wheels or pair of wheels without exceeding allowable stresses.	The end ties are designed to resist the loads due to crane movement and the load combinations specified in para. 4140. A rigid frame analysis is used to determine the proportions of the loads resisted by the end ties and by the girders. Ref. MMH Document 36675-05 (Bridge Stress Calculations). See Note 1.
4450 Gantry Frames **4451 General** Gantry frames shall be fabricated of structural steel. The structural members assembled to form the gantry frame may include, but are not limited to, the following: girders, end ties, legs, trucks, sills, struts, saddles, and equalizer beams. Structural steel materials used in the gantry frame members shall comply with the requirements of para. 4210.	N/A - This is not a gantry crane
4452 Loading Criteria Gantry frames shall be designed to resist the load combinations specified in para. 4140. The gantry frame assembly shall be analyzed as a three-dimensional structure.	N/A - This is not a gantry crane
4453 Gantry Legs Gantry legs shall be designed to withstand the load combinations specified in para. 4140. The legs shall be constructed of structural steel, and their configuration may vary according to the clearance and overall crane geometry required. Gantry legs constructed of box sections shall be provided with diaphragms to maintain the leg geometry. The legs shall be stiffened to meet the requirements of para. 4330.	N/A - This is not a gantry crane
4454 Struts and Sills Struts and sills are used to connect the legs and joining members.	N/A - This is not a gantry crane

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They shall be designed to resist the load combinations specified in para. 4140. Struts and sills shall be constructed of structural steel.	
4455 Saddles and Equalizer Beams Saddles and equalizer beams are used to support the crane structure and are themselves supported by the gantry trucks. Their purpose is to distribute the loading at one corner of the crane equally to the bridge wheels at that corner. They shall be constructed of structural steel. Saddles and equalizer beams shall be designed for the load combinations specified in para. 4140. Plates or hubs used in saddles or equalizer beams to support trunnions and rotating pins shall be designed to meet the bearing stress specified in Section 5000.	N/A - This is not a gantry crane
4456 Gantry Wheel Base The wheel base of the end trucks of four-wheel gantry cranes, or center-to-center of extreme wheels of multiple end trucks for gantry cranes with more than four wheels, may be required to exceed that ratio specified in para. 4441.5. The gantry structure height may necessitate an increased wheelbase in order to gain gantry stability and to reduce gantry skewing.	N/A - This is not a gantry crane
4457 Gantry Stability The gantry crane shall have a safety factor of not less than 1.5 against overturning when used in the unrestrained operating condition and subjected to the load combinations specified in para. 4140. During severe environmental, extreme environmental, or abnormal event loading, the gantry crane shall have a safety factor of not less than 1.1 against overturning. Restraints may be used to prevent overturning.	N/A - This is not a gantry crane
4460 Rails **4461 Requirements** All bridge and trolley rails required to transmit vertical down and horizontal loads due to normal and construction loads only shall conform to the ASCE, ARA, or AREA Specifications. When these rails are used on Types I and II cranes, secondary restraints which are	The bridge and trolley rails conform to the Bethlehem & U.S. Steel standard crane rail specifications as listed in Table 5452.3-1. Seismic restraints are installed on the bridge and trolley and only interact with the rail support structures during a seismic event. Ref. MMH Document

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not necessarily in contact under normal loading conditions shall be provided to resist the vertical up and horizontal loads due to severe environmental and extreme environmental loading conditions. Rails required to transmit vertical up and/or horizontal loads due to severe environmental and extreme environmental loading conditions shall meet all of the requirements of a structural steel member as covered in paras. 4200 and 4300.	36675-14 (Seismic Analysis of Misc. Items). The seismic restraints do not interact directly with the rails.
4462 Fastening Bridge and trolley rails shall be joined by standard joint bars or welded. For other than polar crane runway rails, provision shall be made to prevent creeping of the rails by means of a positive stop at the ends of the rail. Rails shall be securely fastened in place to maintain center-to-center distance of rails. Fastening of rails to the supporting structure shall be appropriate to transfer the calculated horizontal and vertical forces.	The trolley and runway rails are joined by standard joint bars. Trolley rails are provided with positive stops at the ends of the rails to prevent creeping. Rails are securely fastened with rail clips to maintain center-to-center distance. Horizontal and vertical (uplift) forces on the rail and corresponding fasteners are not evaluated since the seismic restraints interact directly with the girder structures. See Note 1.
4470 Footwalks, Handrails, Platforms, Stairs, and Ladders **4471 General** Platforms and footwalks shall be provided as required for access and maintenance. Dimensions and clearances for footwalks, handrails, platforms, stairs, and ladders shall be in accordance with the latest edition of OSHA.	Platforms and foot walks are provided for access and maintenance of the bridge. Platforms and foot walks are not provided for the trolley since it is not a normally accessed location. Platforms and foot walks comply with the latest edition of OSHA.
4472 Materials Materials for construction of footwalks, handrails, platforms, stairs, and ladders shall meet the requirements of para. 4200, except that the requirements of para. 4212 need not be considered. ASTM A 569 is an acceptable material for metal bar grating.	Materials for new construction of foot walks, handrails, platforms, stairs, and ladders meet the requirements of para. 4200, with the exception of para. 4212. See Note 1.
4473 Design Footwalks, handrails, platforms, stairs, and ladders shall be designed for the appropriate dead load and the live loads as specified in the OSHA Standards. Structural design shall be in accordance with para. 4300.	Existing bridge foot walks, handrails, platforms, stairs and ladders will be reused. Design for new construction shall be in accordance with para. 4300.

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	See Note 1.
4480 Operator's Cab **4481 General** ***(a)*** The standard location of the operator's cab shall be at one end of the crane bridge on the driving girder side unless otherwise specified. It shall be so located as not to interfere with the hook approach. The operator's cab shall be open type for indoor service unless otherwise specified. Dimensions and clearances shall be in accordance with the latest edition of OSHA. ***(b)*** Cabs shall be provided with ladder or stairway leading to the bridge footwalk. ***(c)*** The arrangement of equipment in the cab shall be approved by the purchaser. ***(d)*** Cabs shall be designed for maximum operator visibility. A visibility diagram shall be furnished to the purchaser for approval. ***(e)*** If specified by the purchaser, the cab shall be provided with heating, ventilating, and/or air conditioning. ***(f)*** The operator's cab shall have a clear height, with equipment installed, of not less than 7 ft. Provision shall be made in the operator's cab for placement of the necessary equipment, wiring, and fittings. All cabs should be provided with a swiveled seat unless otherwise specified.	Ref. P&H Drawing 105A3002 (Bridge Layout) for the following items: ***(a)*** The cab is located at the end of the crane bridge on the driving girder side and does not interfere with the hook approach. The cab is an open type for indoor service with dimensions that are in accordance with OSHA. ***(b)*** The cab is provided with a ladder leading to the bridge footwalk. ***(c)*** Any new controls furnished for the cab are submitted for approval. ***(d)*** The cab is designed for maximum operator visibility. ***(e)*** N/A - The cab does not have heating, ventilating, and/or air conditioning. ***(f)*** The operator's cab has a clear height, with equipment installed, of more than 7 ft. Existing cab equipment will be reused to the extent possible and any upgrades are submitted to the user for approval. The existing swivel seat is reused.
4482 Materials Materials for construction of the operator's cab shall meet the requirements of para. 4200, except that the requirements of para. 4212 need not be considered.	See Note 1.
4483 Design The operator's cab shall be designed for appropriate dead and live loads. Structural design shall be in accordance with para. 4300.	See Note 1.
4484 Construction **4484.1 Enclosed Cabs** Enclosed cabs shall have watertight plate roofs which slope to the	N/A - An open cab is used instead of an enclosed cab

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rear and shall be provided with sliding, hinged, or drop windows on the three sides, and with sliding or hinged doors. Steel plates for enclosing sides, when used, shall be not less than 1⁄8 in. thick. The window sash shall be equipped with clear shatterproof glass installed from the inside so that if it is dislodged it will fall in the cab. Drop windows shall be protected from breakage by a 1⁄8 in. sheet steel guard, extending to within 2 in. of the floor, and shall be provided with handles and stops which will prevent catching the user's hands or toes when operating the windows. Drop windows shall be counter weighted.	
4484.2 Open Cabs Open cabs shall be enclosed with panels not less than 1⁄8 in. thick or standard railing 42 in. high. Railing enclosures shall be provided with midrail and steel toe plate. Where the top rail, or top of the panel, interferes with the operator's vision, it may be lowered, with the purchaser's approval.	The cab is enclosed with standard hand rails, midrails, and toe plates. Ref. P&H Drawing 105A3002 (Bridge Layout).
5000 Mechanical	
5100 GENERAL **5110 Load Spectrum Crane Classification** **5111 Type I Cranes** ***(a)*** The design of the mechanical components of the crane is based on the loading conditions, the operating frequency, and the operating cycle in respect to the function within the facility. This specific load spectrum information, or a realistic estimate of the anticipated load spectrum, shall be conveyed to the crane manufacturer by the Purchaser. ***(b)*** For a crane having a specific operating cycle such as a typical polar crane, the service condition (load spectrum) can be determined by the number of operating cycles per hour, the type and magnitude of applied loads, the distance of travel motion, and the number of operating hours by given time period. The user shall also establish the service life and reliability requirements for the crane, considering such factors as technical, economic,	***(a)*** The design of the mechanical components of the crane is based on the loading conditions, the operating frequency, and the operating cycle in respect to the function within the facility. The specific load spectrum information and the necessary information to perform a complete seismic analysis are provided in Zion Specification SP-ZS-FH-003. ***(b)*** The service life and usage requirements of the crane are provided in Zion Specification SP-ZS-FH-003. Service and maintenance requirements are provided in MMH Document 36675-20 (Operation & Maintenance Manual). ***(c)*** Design for fatigue is considered for the critical mechanical components of the crane. Ref. MMH Document 36675-23 (Main Hoist Reeving Stress Report). *(1)* Mechanical components in the critical load path are designed

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environmental, and probability of obsolescence. This information is important so that the designer can then provide for the fatigue strength for the components of the crane to meet the requirements of the intended service. The information will provide the basis for the fatigue strength and fatigue life data criteria of the component design, which will require that a numerical documentation of the crane service requirements be in a form that will represent the duty cycle for the crane. This duty cycle or service data for each individual motion of the crane shall be recorded on the Crane Service Data Record Form 1.00 (see Fig. I-5111), and shall become part of the contract between the crane manufacturer and the Purchaser. ***(c)*** The design for fatigue analysis shall be considered for the critical components of the crane mechanical components. The cumulative fatigue usage factors shall reflect the effects of all loads sustained from both the construction and operating periods. In absence of a complete certified crane load cycle or load spectrum, the following criteria shall govern. *(1)* All mechanical components in the critical load path, or whose failure could result in uncontrolled movement of a critical load, shall be designed for infinite fatigue life. *(2)* Travel drives are exempted from infinite fatigue analysis where the maximum excursions due to any postulated failure are facility acceptable. *(3)* Fatigue analysis shall be based on crane maximum rated load. *(4)* Design consideration shall be taken to ensure that the failure of catalog-purchased components during the projected life of the crane will not result in facility unacceptable excursion of the critical load.	per the applicable sections of this standard, which generally provides infinite fatigue life due to high safety factors. *(2)* Travel drives are not considered for infinite fatigue life. *(3)* Fatigue analysis is based on the maximum rated load. *(4)* Failure of catalog-purchased components will not result in facility unacceptable excursion of the critical load.
5112 Types II and III Cranes The load spectrum of Types II and III cranes shall be in accordance with Specification CMAA 70 classifications.	N/A - This is a Type I Crane

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5120 Hoisting Units **5121 Type I Cranes** ***(a)*** The hoist components shall meet the requirements of this Standard, as applicable. ***(b)*** The hoist drive system shall be designed to provide assurance that a failure of a single hoist mechanism component would not result in the uncontrolled movement of the lifted load. This can be accomplished by the application of a single (Fig. 5416.1-1) or dual (Figs. 5416.1-2 and 5416.1-3) hoist drive unit. *(1)* The wire rope drum is exempted from this requirement. *(2)* The hook, hook nut, trunnion, and load block load structure may be exempted from dual load path criteria by doubling the design service factor. ***(c)*** Critical load excursions due to failure in the dual load path shall be determined and certified as to facility acceptability. ***(d)*** Hooks for critical loads shall have dual attaching points.	***(a)*** The hoist components are designed to meet the requirements of this Standard, as applicable. ***(b)*** Assurance that a failure of a single hoist mechanism component would not result in the uncontrolled movement of the lifted load is accomplished by the application of a dual hoist drive system (Fig. 5416.1-2). Load sharing between the gearboxes is assumed to be 75%/25% for normal operation. For single failure overload events, each gearbox is designed to hold 100% load in MMH Document 36675-18 (Main Hoist Gearing Analysis). *(1)* The wire rope drum is exempted from this requirement and is designed according to the applicable sections of this document. *(2)* The hook, hook nut, cross head, and load block are designed according to the applicable sections of this document. ***(c)*** Critical load excursions due to failure in the dual load path are analyzed in the broken rope section of MMH Document 36675-23 (Main Hoist Reeving Stress Report). ***(d)*** The main hoist hook is a sister hook design with dual attaching points. Ref. MMH Drawing QR82460 (Main Hoist Hook Assembly).
5122 Types II and III Cranes Hoist components of Types II and III cranes shall be in accordance with Specification CMAA 70, except as specified herein.	N/A - This is a Type I Crane
5130 Bridge and Trolley Drives **5131 Type I Cranes** ***(a)*** Drive components shall meet the requirements of this Standard, as applicable. ***(b)*** In travel drives, single failure-proof features are generally not required. However, in those cases where a failure in the braking mode could result in a facility unacceptable excursion, the design shall incorporate single failure-proof features to ensure that the crane can be brought to a safe stop.	***(a)*** The drive components are designed to meet the requirements of this Standard, as applicable. ***(b)*** The bridge and trolley travel drive arrangements are not single failure proof and are not required to be single failure proof.
5132 Types II and III Cranes	

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Drive components shall be in accordance with Specification CMAA 70, except as specified herein.	N/A - This is a Type I Crane
5140 General Mechanical Components **5141 Type I Cranes** Couplings, wheels, axles, drive shafts, bearings, fasteners, gear cases, enclosures, guards, bumpers, stops, and limit switches shall meet the requirements of this Standard, as applicable.	Couplings, wheels, axles, drive shafts, bearings, fasteners, gear cases, enclosures, guards, bumpers, stops, and limit switches are designed to meet the requirements of this Standard, as applicable.
5142 Types II and III Cranes General mechanical components shall be in accordance with Specification CMAA 70, except as specified herein.	N/A - This is a Type I Crane
5150 Critical Items **(a)** Critical items for a single failure-proof handling system on a Type I crane are those components which are located between the load and the source of energy holding the load. *(1)* These components require special consideration as to material, design, control of manufacturing processes, and examination of final product. *(2)* Table 7200-1 lists the tests and the inspections that are to be applied to critical items in accordance with the requirements of Section 7000. *(3)* The acceptance criteria for all items listed in Tables 7200-1 and 7200-2 shall be in accordance with para. 7100.	*(a)* MMH Document 36675-11 (Critical List) specifies the critical items, required tests per Table 7200-1, and acceptance criteria per para. 7100.
5160 Nomenclature The following nomenclature is used in Section 5000 and is listed according to the article heading where it appears.	Specified nomenclature is used for applicable design parameters.
5161 Drum Shell Design (Para. 5411.5) [Text and/or equations omitted]	Specified nomenclature is used for applicable design parameters.
5162 Allowable Strength Horsepower — P_{at} (Gearing) [Para. 5413.1(a)] [Text and/or equations omitted]	Specified nomenclature is used for applicable design parameters.
5163 Allowable Durability Horsepower — P_{ac} (Gearing) [Para. 5413.1(b)] [Text and/or equations omitted]	Specified nomenclature is used for applicable design parameters.

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5164 Allowable Momentary Overload — W_{tov} (Gearing) [Paras. 5413.1(c) and 5413.1(d)] [Text and/or equations omitted]	Specified nomenclature is used for applicable design parameters.
5165 Gearing Efficiencies [Para. 5413.1(g)] [Text and/or equations omitted]	Specified nomenclature is used for applicable design parameters.
5166 Reeving Efficiency (Para. 5429) [Text and/or equations omitted]	Specified nomenclature is used for applicable design parameters.
5167 (Table 5452.3-1) [Text and/or equations omitted]	Specified nomenclature is used for applicable design parameters.
5168 Nomenclature (Analytical Procedures; Para. 5472) [Text and/or equations omitted]	Specified nomenclature is used for applicable design parameters.
5169 Analytical Method for Hook of Approximate Trapezoidal Shape (Para. 5477) [Text and/or equations omitted]	Specified nomenclature is used for applicable design parameters.
5200 MATERIALS **5210 Material (Type I Crane)** Materials with less than 15% elongation shall not be used for any mechanical component except electrical motors and hydraulic components.	Materials with less than 15% elongation are not used for any mechanical components other than electrical motors and hydraulic components. See Note 1.
5220 Material (Types II and III Cranes) Materials shall be in accordance with Specification CMAA 70.	N/A - This is a Type I Crane
5300 DESIGN AND PERFORMANCE CRITERIA **5310 Load Combinations** ***(a)*** The individual mechanical components of the overhead or gantry crane shall be designed to provide a design factor specified for that component to resist the forces resulting from the combination of loading specified for the component. The load combinations that must be considered for the individual components vary with the component, and frequently include maximum loadings calculated in the electrical or structural section, i.e., motor torque of a motor or live load including wind and impact.	***(a)*** The individual mechanical components are designed with safety factors to resist the forces resulting from the combination of loading specified. Resultant load combinations determined in the electrical and structural sections are applied to the components as applicable. ***(b)*** Since this is a Type I crane, seismic loading is applied to mechanical components to ensure retention of the load and will prevent any component from becoming a missile. MMH Document 36675-09 (Seismic Analysis) provides the location, magnitude, and direction of the

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(b) Certain components must be designed for seismic loading as a part of the load combinations. If a lump mass approach is used in the seismic design, the methods of structural design calculations within Section 4000 will provide the values of the dynamic analysis which will be determined for location, magnitude, and direction for forces to be used as equivalent static loading. The extent of seismic consideration necessary for the three types of cranes is as follows. *(1) For Type I Cranes.* Seismic loading shall be only to ensure retention of the load and the prevention of any component from becoming a missile that would be detrimental to the facility's safety related equipment. *(2) For Type II Cranes.* Seismic considerations shall be made to ensure that no component of the crane could become a missile that would be detrimental to the facility's safety related equipment. *(3) For Type III Cranes.* Seismic analysis is not required unless specified by the purchaser.	G-forces to be used as equivalent static loading. These loads will be applied to components such as gear cases, drums, reeving systems, etc. in MMH Document 36675-14 (Seismic Analysis of Misc. Items) and MMH Document 36675-23 (Main Hoist Reeving Stress Report).
5311 Design Loads — Hydraulic Components ***(a)*** *For Types I, II, and III Cranes.* The design selection for hydraulic components shall be based on the rated load.	***(a)*** N/A - Hydraulic components are not used on this crane
5320 Allowable Stresses **5321 Type I Cranes** **5321.1 Normal Operating Conditions** All load combinations and factors including stress concentrations shall have a service factor of 1 or more based on the design fatigue allowable stress limit of the material, except as otherwise specified in Section 5000. Service Factor x Design Stress ≤ Allowable Stress	The trolley is designed for all load combinations using a minimum service factor (allowable stress / design stress) of 1 based on the design fatigue allowable stress limits of the materials used. See Note 1.
5321.2 Emergency Conditions For all emergency loads such as load hang-up, seismic loads, using the gross cross-section excluding the stress concentration factors, the service factor shall be not less than 1 based on an allowable	The trolley is designed for emergency loads using a minimum service factor (allowable stress / design stress) of 1 based on an allowable stress equal to 75% of the yield strength.

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stress equal to 75% of the yield strength, unless specifically exempted elsewhere in Section 5000.	See Note 1.
5322 Type II Cranes **5322.1 Normal Operating Conditions** All load combinations and factors including stress concentrations shall have service factors as stated for the design of specific mechanical components.	N/A - This is a Type I Crane
5322.2 Emergency Conditions (if Applicable) All emergency loads such as load hang-up shall have specific factors as stated for the design of specific mechanical components.	N/A - This is a Type I Crane
5323 Type III Cranes **5323.1 Normal Operating Conditions** Allowable stresses shall be in accordance with the provisions of Specification CMAA 70.	N/A - This is a Type I Crane
5323.2 Emergency Conditions Not applicable for this type of crane.	N/A - This is a Type I Crane
5324 Hydraulic Components — Allowable Stresses **5324.1 Types I, II, and III Cranes** Stresses imposed by the maximum rated load shall not exceed 20% of the average ultimate strength of the material or components.	N/A - Hydraulic components are not used on this crane
5330 Motion Speeds Rated load speeds for hoist, bridge, and trolley shall be such as to allow controlled handling of those loads for which the crane is designed. These speeds depend on the nature of the load, load clearances, position of operator, weight of load, positioning accuracy required, and type of drive. Design rated load speeds recommended in paras. 5331, 5332, and 5333 have been established based on typical operator reaction time and drive performance which will allow the load to be stopped and held.	Rated load speeds for hoist, bridge, and trolley are selected to allow controlled handling of those loads for which the crane is designed. See paras. 5331, 5332, 5333 for individual requirements.
5331 Hoist Speeds **5331.1 Type I Hoists** ***(a)*** The performance speed and speed tolerance of the hoist with rated load shall be specified by the purchaser. The rated load test	Ref. the variable frequency drive parameters specified in MMH Drawing R95399 (Electrical Schematic) for the following items:

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(125% rated load or as specified by purchaser) speed criteria shall be as specified by the manufacturer. ***(b)*** Rated load recommended hoisting speeds are given in Table 5331.1-1 for slow, medium, or fast service for various capacities. The design tolerance for rated load hoisting speed is ±10%. ***(c)*** Hoisting speed for a critical load less than the rated load shall be limited to 125% of the rated load hoisting speed. ***(d)*** Empty hook and light load speed-up controls are permitted. Refer to para. 6320(e). ***(e)*** When precise positioning capability is required, and the principal control system is incapable of providing lowering speed control of 0.5 ft/min with the load as specified by the purchaser, the hoist system shall be equipped with an auxiliary system. The positioning capability speed should be 0.5 ft/min. for a distance of 2 ft within the final position. ***(f)*** The lowering speed for any critical load shall be limited to 125% of the rated load hoisting speed.	***(a)*** The performance speed of the main hoist with 100% rated load is 5 ft/min per Zion Specification SP-ZS-FH-003. Since a speed tolerance is not specified, +/-10% is selected per (b). The 125% rated load test speed is limited to the 100% rated load speed by the variable frequency drive. ***(b)*** The rated load main hoist speed is equivalent to the recommended value for slow service given in Table 5331.1-1. The design tolerance for rated load hoisting speed is ±10%. ***(c)*** The variable frequency drive for the main hoist limits hoisting speed to within ±10% of the rated load hoisting speed for all loads. ***(d)*** Speed-up controls are provided for both hoists per Zion Specification SP-ZS-FH-003 to allow 150% of the rated load hoisting speed for unloaded and light loads. The unloaded/light load speeds are 7.5 ft/min for the main hoist and 30 ft/min for the aux hoist. ***(e)*** N/A - The variable frequency drive for the main hoist has 5 speed steps per Zion Specification SP-ZS-FH-003 and is capable of lowering at 0.5 ft/min with the load as specified. ***(f)*** An over speed protection device on the main hoist ensures the lowering speed of any critical load is limited to 125% of the rated load hoisting speed.
5331.2 Types II and III Hoists Recommended rated load speeds should be as specified in either Table 5331.1-1 or the Speed Table given in Specification CMAA 70.	The performance speed of the aux hoist with 100% rated load is 20 ft/min per Zion Specification SP-ZS-FH-003. This speed is equivalent to the recommended value for slow service given in Table 5331.1-1.
5332 Trolley Speeds **5332.1 Type 1 Cranes** ***(a)*** The performance speed and speed tolerance of the trolley with rated load shall be specified by the purchaser. Rated load test speed (125% rated load) criteria shall be specified by the manufacturer. ***(b)*** Rated load recommended trolley speeds are given in Table 5332.1-1 for various capacities. The design tolerance for a design rated load speed shall be ±10%. ***(c)*** The trolley control shall provide an operating speed range of at least 10 to 1 under all loading conditions or be equipped with an	Ref. the variable frequency drive parameters specified in MMH Drawing R95399 (Electrical Schematic) for the following items: ***(a)*** The performance speed of the trolley with 100% rated load is 50 ft/min per Zion Specification SP-ZS-FH-003. Since a speed tolerance is not specified, +/-10% is selected per (b). The 125% rated load test speed is limited to the 100% rated load speed by the variable frequency drive. ***(b)*** The rated load trolley speed is equivalent to the recommended value for slow service given in Table 5331.1-1. The design tolerance for rated

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auxiliary system to provide precise positioning capabilities. ***(d)*** Trolley speed for a critical load less than rated load shall be limited to 125% of the rated load trolley speed. ***(e)*** Empty hook and light load speed-up controls are permitted. Refer to para. 6340(c).	load trolley speed is ±10%. ***(c)*** The speed control with the variable frequency drive is better than 10:1 under all loading conditions. ***(d)*** The variable frequency drive for the trolley limits travel speed to within ±10% of the rated load trolley speed for all loads. ***(e)*** Empty hook and light load speed-up controls are not provided for the trolley and are not required.
5332.2 Types II and III Cranes Recommended rated load speeds should be as specified in either Table 5332.1-1 or the Speed Table given in Specification CMAA 70.	N/A - This is a Type I Crane
5333 Bridge Speeds **5333.1 Type I Cranes** ***(a)*** The performance speed and speed tolerance of the bridge with rated load shall be specified by the purchaser. Rated load test speed (125% rated load) criteria shall be specified by the Manufacturer. ***(b)*** Rated load recommended bridge speeds are given in Table 5333.1-1 for various capacities. The design tolerance for a design rated load speed shall be ±10%. ***(c)*** The bridge control shall provide an operating speed range of at least 10 to 1 under all loading conditions, or be equipped with an auxiliary system to provide precise positioning capabilities. ***(d)*** Bridge speed for a critical load less than rated load shall be limited to 125% of the rated load bridge speed. ***(e)*** Empty hook and light load speed-up controls are permitted. Refer to para. 6320(c). ***(f)*** For cranes with circular polar-type bridges, the recommended speeds shall be the tangential speeds at the runway rail.	Ref. the variable frequency drive parameters specified in MMH Drawing R95399 (Electrical Schematic) for the following items: ***(a)*** The performance speed of the bridge with 100% rated load is 50 ft/min per Zion Specification SP-ZS-FH-003. Since a speed tolerance is not specified, +/-10% is selected per (b). The 125% rated load test speed is limited to the 100% rated load speed by the variable frequency drive. ***(b)*** The rated load bridge speed is less than the recommended value for slow service given in Table 5331.1-1, and therefore more conservative. The design tolerance for rated load bridge speed is ±10%. ***(c)*** The speed control with the variable frequency drive is better than 10:1 under all loading conditions. ***(d)*** The variable frequency drive for the bridge limits travel speed to within ±10% of the rated load bridge speed for all loads. ***(e)*** Empty hook and light load speed-up controls are not provided for the bridge and are not required. ***(f)*** N/A - This is not a polar crane
5333.2 Types II and III Cranes Recommended rated bridge speeds should be as specified in either Table 5332.1-1 or the Speed Table given in Specification CMAA 70.	N/A - This is a Type I Crane
5334 Pendant Hoist and Travel Speeds **5334.1 Traversing**	

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Motorized travel speed for this motion should be 30 ft/min.	N/A - Radio controls are specified instead of a pendant
5334.2 Vertical Travel of Control Pendant Motorized travel speed for this motion should be 30 ft/min.	N/A - Radio controls are specified instead of a pendant
5335 Powered Hook Rotation (Types I, II, and III Cranes) ***(a)*** Speed of rotation shall be specified by Purchaser. ***(b)*** Rotation limit shall be specified by Purchaser. ***(c)*** Single failure-proof features are not required.	***(a-c)*** N/A - This crane does not have powered hook rotation
5400 COMPONENT DESIGN **5410 Hoist System** **5411 Drum** **5411.1 Description (Type I Cranes)** The drum shall be of cylindrical type, varying in length and diameter, and shall be so designed as to ensure the accumulation of the entire length of rope in one single layer.	The main hoist drum is of cylindrical type and is designed as to ensure the accumulation of the entire length of rope in one single layer. Ref. MMH Drawing R94603 (Main Hoist Drum Assembly)
5411.2 Size (Type I Cranes) The pitch diameter of the drum shall be not less than 24 times the hoist rope diameter for 6 x 37 rope construction, or not less than 30 times the hoist rope diameter for 6 x 19 rope construction.	The main hoist uses high strength wire rope that is 8 x 25 construction and has a manufacturer's minimum recommended ratio for drum groove minor diameter to rope diameter of 20:1. The actual main hoist ratio for drum pitch diameter to rope diameter is 26:1, which is more conservative than the manufacturer's recommendations, as well as the requirements specified for 6 x 37 rope construction. Ref. MMH Drawing QR94604 (Main Hoist Drum Machining)
5411.3 Construction (Type I Cranes) The drum shell shall be of rolled or centrifugal cast steel construction with flanged ends. It shall be designed to withstand combined crushing and bending loads. Equations (1), (2), and (3) may be used to determine the stress in the drum shell. The drum gear shall be pressed on and keyed to the periphery of the shell, hub, or shaft of the drum, or be bolted with close fitting bolts (para. 5456) to the flange on the drum, in which case the bolts transmit only torque.	The main hoist drum shell is a rolled steel structure with flanged ends. It is designed to withstand combined crushing and bending loads as specified. Ref. MMH Document 36675-23 (Main Hoist Reeving Stress Report). The drum gear is pressed on and keyed to the periphery of the drum shell. Ref. MMH Drawing R94603 (Main Hoist Drum Assembly)
5411.4 Grooves (Type I Cranes) Drum grooves shall be machined to a minimum depth equal to	The minimum drum groove depth, the groove radius, and the pitch for

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three-eighths of the diameter of the hoist rope, and a pitch equal to 1.14 x rope diameter or rope diameter + 1⁄8 in., whichever is smaller. The groove radius shall be 1⁄32 in. larger than the radius of the rope. Rope shall be secured to the drum as follows: No less than two wraps of the rope shall remain on the drum at each anchorage to the hoisting drum when the hook is in its extreme low position. Rope end shall be anchored by a minimum of two clamps attached to the drum, or by a socket arrangement specified by the crane or rope manufacturer. The rope clamp bolts shall be tightened evenly to the manufacturer's recommended torque.	the main hoist drum are within the requirements of this section. Ref. MMH Drawing QR94604 (Main Hoist Drum Machining) With the hook at its lowest position, there are no less than 2 wraps on the main hoist drum at each anchorage point. There are two clamps on each rope that are tightened per the manufacturer's recommend torque. Ref. MMH Drawing R94603 (Main Hoist Drum Assembly)
5411.5 Drum Shell Design (Type I Cranes) [Text and/or equations omitted]	The main hoist drum shell is designed in accordance with this section. Ref. MMH Document 36675-23 (Main Hoist Reeving Stress Report).
5411.6 Drum (Types II and III Cranes) The size, construction, and grooving for Types II and III crane drums shall be established in accordance with the provisions of Specification CMAA 70.	The size, construction, and grooving for the aux hoist drum is in accordance with the provisions of Specification CMAA 70. Ref. MMH Drawing R94965 (Aux Hoist Assembly).
5411.7 Single Failure-Proof Features (Type I Cranes) ***(a)*** Single failure-proof features are not required for the drum shell. ***(b)*** In the event of failure of a drum shaft or bearing, the drum must be retained on the trolley in a manner which precludes disengagement of any gearing or brake acting on the drum and precludes disablement of the load-retaining function of these components. ***(c)*** In the event of failure of a drum shaft or bearing, the drum must be retained on the trolley in a manner which precludes disengagement of any gearing or brake acting on the drum and precludes disablement of the load-retaining function of these components.	***(a)*** Single failure proof features are not provided for the main hoist drum shell and are not required. ***(b)*** A drum retainer is installed on both ends of drum to prevent disengagement or load retaining function of any gearing or brake acting on the drum. Ref. MMH Drawing QR95370 (Trolley Frame Weldment). ***(c)*** N/A - This item is identical to (b)
5411.8 Single Failure-Proof Features (Types II and III Cranes) Single failure-proof features are not required for the drum.	Single failure proof features are not provided for the aux hoist drum shell and are not required.

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5412 Drive Motors **5412.1 Type I Cranes** Each hoist drive system, such as those indicated in Figs. 5416.1-1 through 5416.1-3, shall be provided with a hoist drive motor(s) for lifting and lowering loads. Motors shall be selected per para. 6470. Motor fasteners shall be per para. 5456.	The main hoist drive system, similar to Figure 5416.1-2, is provided with a hoist motor for lifting and lowering loads. The motor is selected to comply with para. 6470. Motor fasteners are selected to comply with para. 5456. Ref. MMH Drawing QR94709 (Main Hoist Motor).
5412.2 Types II and III Cranes Motors shall be selected per para. 6470.	The aux hoist motor is selected to comply with para. 6470. Ref. MMH Drawing R94965 (Aux Hoist Assembly).
5413 Gearing **5413.1 Type I Cranes** Gearing shall be designed and manufactured in accordance with the procedures presented by the American Gear Manufacturers Association (AGMA) as modified by this Section. The gearing shall be designed for strength, durability, and momentary overload which includes the loads imposed during a seismic excursion. Unless positive control of accurate alignment under varying loads can be ensured, parallel shaft gearing, both enclosed and open, shall be straddle mounted; that is, each shaft shall be supported by two outboard bearings. (The intent is to preclude inadequately supported or inaccurately aligned overhung gears or pinions, shafts with three bearing supports, and combination gear reducer/wire rope drum shafts.) ***(a)*** *Allowable Strength Horsepower P_{at}.* [Text and/or equations omitted] ***(b)*** *Allowable Durability Horsepower P_{ac}.* [Text and/or equations omitted] ***(c)*** *Allowable Momentary Overload Tooth Load W_{tov}.* [Text and/or equations omitted] ***(d)*** *Crane Class Factor S_{fd} (durability)* [Text and/or equations omitted] ***(e)*** *Allowable Stresses S_{at}, S_{ac}, S_{ay}* [Text and/or equations omitted]	***(a-i)*** Gearing for the main hoist is designed and manufactured in accordance with the procedures presented in AGMA as modified by this Section. The gearing is designed for strength, durability, and momentary overloads, including Increased vertical loads imposed during a seismic excursion. Parallel shaft gearing is straddle mounted with two outboard bearings to provide adequate support. Ref. MMH Document 36675-18 (Main Hoist Gearing Analysis).

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(f) *Load Distribution Factors* K_m, C_m. [Text and/or equations omitted] ***(g)*** *Gear Efficiencies.* [Text and/or equations omitted] ***(h)*** *Gearing Forms and Quality.* [Text and/or equations omitted] ***(i)*** *Lubrication.* [Text and/or equations omitted]	
5413.2 Types II and III Cranes Gearing for Types II and III cranes shall be established in accordance with provisions in Specification CMAA 70.	Gearing for the aux hoist is in accordance with provisions in Specification CMAA 70. Ref. MMH Drawing R94965 (Aux Hoist Assembly).
5414 Brakes — Load and Holding **5414.1 Hoist Control Braking Means (Types I, II, and III Hoists)** An electrical control braking means or a mechanical braking means capable of maintaining controlled lowering speeds shall be provided. Electrically controlled braking means include regenerative, dynamic, countertorque, and eddy current. Brake sizing and design are specified in para.6400. Mechanical load brakes, if used as the control braking means, shall be provided with sufficient thermal capacity to accommodate lowering of the rated load at full speed through the expected operating distance.	Electrically controlled dynamic braking is provided for the main and aux hoists and is designed per para. 6400. Mechanical control braking is not provided and is not required. Ref. MMH Drawing R95399 (Electrical Schematic).
5414.2 Hoist Holding Brakes (Type I Hoists) Two holding brakes shall be provided, mounted such that the failure of any hoist shaft or coupling will not disengage both of the hoist holding brakes. Under normal operating conditions, the brakes will be automatically applied on power removal with the application of one brake delayed to minimize shock to the hoist drive train. Brake sizing and design is specified in para. 6400.	Similar to Fig. 5416.1-2, two mechanical holding brakes are provided for the main hoist and are mounted directly to the gearbox input shafts. Ref. MMH Drawing R94780 (Main Hoist Machinery Assembly). Failure of any hoist shaft or coupling will not disengage both of the hoist holding brakes. Under normal operating conditions, the brakes are automatically applied on power removal with the application of one brake delayed to minimize shock to the hoist drive train. Brake sizing and design is per para. 6400.
5414.3 Hoist Holding Brakes (Types II and III Hoists) Hoist holding brakes shall be selected in accordance with para. 6420.	Holding brakes for the aux hoist are selected in accordance with para. 6420. Ref. MMH Drawing R94965 (Aux Hoist Assembly).

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5415 Load Combinations — Hoist Drive Shafting (Types I, II, and III Cranes) **5415.1 Load Combinations, Allowable Stresses, and Service Factors** The hoist drive machinery shafting shall be designed to resist the following load combinations with corresponding values of allowable stresses and service factors. Combinations of the various types of loading are shown in Table 5415.1-1.	The main and aux hoist drive machinery shafting is selected to resist the load combinations specified in Table 5415.1-1 with corresponding values of allowable stresses and service factors. This conclusion is based on existing, proven designs for similar applications.
5415.2 Computation — Analysis Analytical stress computations shall be performed according to procedures in para. 5470.	Stress calculations are performed according to procedures in para. 5470 based on the load cases specified in Table 5415.1-1.
5416 Single Failure-Proof Features **5416.1 Type I Cranes** The hoist drive system shall be designed to provide assurance that a failure of a single-hoist mechanism component would not result in the loss of the lifted load. This can be accomplished in several ways. Typical applications of single- and dual-hoist drive units are shown in Figs. 5416.1-1 and 5416.1-2, respectively, and are defined below. ***(a)*** *Single-Hoist Drive.* The single-hoist drive may have one gear train with a single drive motor and two holding brakes. One holding brake may be located at the drive motor shaft or any intermediate shaft (including the drum shaft axis), and the second brake may be located at the drum with the drum brake to act as a back-up with a delayed setting or in cases of malfunction. The torque setting of each holding brake shall not be less than 125% of the required full-load drive torque at brake location in normal operation. ***(b)*** *Dual-Hoist Drive.* The dual-hoist drive may have two gear trains with drive motor(s) and at least two holding brakes located on the cross shaft external or between the gear trains, with one of the holding brakes to act as a back-up with a delayed setting. The torque rating of each holding brake shall not be less than 125% of the full-load drive torque required at the brake location in normal operation. Each gear train shall be sized for the total full-load drive	The main hoist drive system is designed to provide assurance that a failure of a single-hoist mechanism component does not result in the loss of the lifted load. This is accomplished by using a dual-hoist drive as shown in Figure 5416.1-2. ***(a)*** N/A A dual-hoist drive is used. ***(b)*** The dual-hoist drive for the main hoist has two gear trains with a single drive motor and two mechanical holding brakes located on the cross shaft between the gear trains, with one of the holding brakes acting as a back-up with a delayed setting. The torque rating of each holding brake is 150% of the required full-load drive torque at the brake location in normal operation per Zion Specification SP-ZS-FH-003, which is more conservative than the requirements of this para. Each gear train is sized for the total full-load drive torque of the motor.

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torque of the motor.	
5416.2 Types II and III Cranes Single failure proof features are not required.	Single failure proof features are not provided for the aux hoist drive system and are not required.
5420 Reeving System ***(a)*** *Type I Cranes.* The design of the rope reeving system shall be such that a single rope failure will not result in the loss of the lifted load. A load balance shall be provided on each rope system. In the event of a hook over travel, where the lower block contacts the crane structure, the ropes shall not be cut or crushed. The wire rope and fleet angle requirements shall be in accordance with paras. 5425.1 and 5426, respectively. *(1) Single Failure-Proof Features.* Single failure proof mechanical features for the reeving system shall consist of the following. *(a)* Reeving system shall be divided into two separate load paths so that either path will support the load and maintain vertical alignment in the event of rope breakage or failure in the rope system. Figure 5420-1 shows one such reeving system. Other reeving systems that meet the above requirements are acceptable. *(b)* Upper blocks and load blocks shall be designed such that each attaching point will be able to support a load of three times the load (static and dynamic) being handled without permanent deformation of any part of the block assembly. These assemblies shall be designed so that the sheaves will be contained in the event of failure of the sheave support pin. ***(b)*** *Types II and III Cranes.* Reeving system components for Types II and III cranes shall be in accordance with Specification CMAA 70. Hoist reeving may be either single or double and may be one or	***(a)*** The design of the main hoist rope reeving system is such that a single rope failure will not result in the loss of the lifted load. A load balance is provided on each rope system and the ropes are guided by the weight-operated limit switch so that ropes are not cut or crushed in the event of a hook over travel. The wire rope and fleet angle requirements are in accordance with paras. 5425.1 and 5426, respectively. Ref. MMH Drawing R94779 (Trolley Assembly). *(1)* Single failure proof mechanical features are provided for the main hoist reeving system and include the following: (a) The reeving system is divided into two separate load paths so that either path will support the load and maintain vertical alignment in the event of rope breakage or failure in the rope system. (b) Upper blocks and load blocks are designed such that each attaching point is able to support a load of three times the load (static and dynamic) being handled without permanent deformation of any part of the block assembly. Components in the lower block that do not provide a dual load path will be designed with double the service factor in accordance with 5121(b)(2). These assemblies are designed so that the sheaves are contained in the event a sheave support pin fails. ***(b)*** Reeving system components for the aux hoist are in accordance with Specification CMAA 70. The aux hoist is double-reeved with multiple parts. Ref. MMH Drawing R94965 (Aux Hoist Assembly). *(1)* N/A - The aux hoist is double-reeved. *(2)* The aux hoist is double-reeved with both ends of the rope attached to the drum in accordance with Fig. 5420-2(b). The drum

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multiple parts. *(1)* On single-reeved hoists, one end of the rope is attached to the drum and the other end is dead ended on a stationary portion of the hoist. Continuous drum grooving runs in one direction. The load block moves laterally in the direction of the axis of the drum as the rope winds onto or off of the drum. Refer to Fig. 5420-2, sketch (a). *(2)* On double-reeved hoists, both ends of the rope are attached to the drum. The drum is grooved with left and right grooves beginning at both ends of the drum, then grooving toward the center of the drum. The load block will follow a true vertical path (true vertical lift) as the ropes wind toward or away from each other onto or off the drum. Refer to Fig. 5420-2, sketch (b). *(3)* Single failure-proof features are not required for Type II and III cranes.	is grooved with left and right grooves beginning at both ends of the drum, then grooving toward the center of the drum. The load block follows a true vertical path as the ropes wind toward or away from each other onto or off the drum. *(3)* Single failure proof features are not provided for the aux hoist and are not required.
5421 Upper Block **5421.1 Type I Cranes** ***(a)*** The upper block, in conjunction with the load block, shall be designed to maintain a vertical load balance about the center of the lifted load and shall have a reeving system of dual design. ***(b)*** All design loads and allowable stresses for mechanical and structural components of the upper block shall be in accordance with paras. 5300 and 4310, respectively. The upper block shall be accessible from above the trolley floor.	***(a)*** The main hoist upper block, in conjunction with the load block, is designed to maintain a vertical load balance about the center of the lifted load and has a reeving system of dual design. Ref. MMH Drawing R94779 (Trolley Assembly). ***(b)*** All design loads and allowable stresses for mechanical and structural components of the main hoist upper block are in accordance with paras. 5300 and 4310, respectively. Ref. MMH Document 36675-23 (Main Hoist Reeving Stress Report).
5421.2 Types II and III Cranes Upper blocks for Types II and III cranes shall be established in accordance with the provisions of Specification CMAA 70.	The aux hoist upper block is designed in accordance with the provisions of Specification CMAA 70. Ref. MMH Drawing R94965 (Aux Hoist Assembly).
5422 Load Block **5422.1 Type I Cranes** ***(a)*** The load block frame shall be constructed of rolled steel and shall be entirely enclosed except for the rope openings. The hook(s)	Ref. MMH Drawing R95005 (Main Hoist Bottom Block Assembly) for the following items:

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shall be free to swivel on antifriction or sleeve bearing so constructed as to exclude dirt and also shall be provided with a means for lubrication. Refer to para. 5460 for data relating to lubrication. ***(b)*** Welding of trunnions for critical load handling load blocks shall not be permitted.	***(a)*** The main hoist load block frame is constructed of rolled steel and is entirely enclosed except at the top for the rope openings. The hook swivels on an antifriction thrust bearing that excludes dirt and provides easy access for re-lubrication per para. 5460. ***(b)*** N/A - The main hoist load block does not use trunnions. A cross head, fabricated from structural steel, is welded directly to the load block
5422.2 Types II and III Cranes Load blocks for Types II and III cranes shall be established in accordance with the provisions of Specification CMAA 70.	The aux hoist load block is designed in accordance with the provisions of Specification CMAA 70. Ref. MMH Drawing R94965 (Aux Hoist Assembly).
5423 Equalizer Systems **5423.1 Type I Cranes** ***(a)*** Where separate rope equalizing is required, either an equalizer bar or a sheave will be acceptable. In either case, two separate and complete reeving systems shall be provided. The equalizer, where possible, should be designed to be accessible from the floor of the trolley and be made in such a manner that it can turn or swivel to align itself with the pull of the ropes. ***(b)*** Equalizer sheaves, when used, shall have a pitch diameter not less than one-half of the diameter of the running sheaves. ***(c)*** Rope equalizer systems shall be designed to meet the criteria as delineated herein. *(1)* Reeving equalization shall not be restricted under normal operating conditions. *(2)* Adequate free movement to compensate for operational block swing and/or normal rope stretch shall be provided. *(3)* Sensing and automatic signaling of excessive rope displacement to either side shall be provided. *(4)* Sensing and automatic signaling of a broken reeving shall be provided. *(5)* In the event of a broken rope, the remaining intact reeving system shall not be loaded to more than 40% of the breaking strength of the wire rope, including the dynamic	***(a)*** The main hoist reeving system consists of two separate and complete reeving systems, each with an equalizer bar assembly accessible from the trolley floor and capable of swiveling to align with the pull of the ropes. Ref. MMH Drawing R94779 (Trolley Assembly). ***(b)*** N/A - Equalizer bars are used instead of sheaves. ***(c)*** The main hoist rope equalizer system is designed to meet the required criteria. Ref. MMH Document 36675-23 (Main Hoist Reeving Stress Report) and MMH Drawing R94779 (Trolley Assembly) for the following items: *(1)* Reeving equalization is not restricted under normal operating conditions. *(2)* Adequate free movement to compensate for operational block swing and/or normal rope stretch is provided. *(3)* Sensing and automatic signaling of excessive rope displacement to either side is provided with the weigh system, which monitors the individual loads on the equalizer trunnions using strain gages. Excessive rope displacement to one side causes an unbalanced load fault, which disables hoisting and applies the brakes. *(4)* Sensing and automatic signaling of a broken rope is provided with the weigh system, which monitors the individual loads on the equalizer trunnions using strain gages. A broken rope causes

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effects of the load transfer. *(6)* The vertical displacement of the load following a rope failure shall be minimized. *(7)* The vertical displacement of the load following a rope failure shall be calculated and reported to the purchaser. *(8)* The effects of a broken rope on the entire system including the equalizer assembly shall be analyzed.	an unbalanced load or underweight fault, which disables hoisting and applies the brakes. *(5)* I n the event of a broken rope,, the remaining intact reeving system is not loaded to more than 40% of the breaking strength of the wire rope, including the dynamic effects of the load transfer *(6)* The vertical displacement of the load following a rope failure is minimized. *(7)* The vertical displacement of the load following a rope failure is calculated and reported to the purchaser. *(8)* The effects of a broken rope on the entire system including the equalizer assembly are analyzed.
5423.2 Types II and III Cranes Equalizer bars or sheaves of Types II and III cranes shall be established in accordance with the provisions of Specification CMAA 70.	The aux hoist equalizers are designed in accordance with the provisions of Specification CMAA 70. Ref. MMH Drawing R94965 (Aux Hoist Assembly).
5424 Sheave Pins **5424.1 Type I Cranes** ***(a)*** Sheave pins for the upper block and load block shall be designed to withstand the combined line pull of the live load, plus the dead load of the load block. ***(b)*** Seismic effects shall be included in the analysis. ***(c)*** Analytical stress computation shall be performed in accordance with para. 5470. ***(d)*** Service factors shall be applied in accordance with para. 5320. ***(e)*** Grease lubricated sheave bearings should be provided with individual lubrication fittings if the pin size is sufficiently large to provide the space for these fittings.	Ref. MMH Document 36675-23 (Main Hoist Reeving Stress Report) for the following items: (a) Main hoist sheave pins are designed to withstand the combined line pull of the live load, plus the dead load of the load block. (b) Seismic effects are enveloped by the broken rope condition since the increased load due to a rope break condition is significantly higher than the seismic loading. (c) Analytical stress computation is performed in accordance with para. 5470. (d) Service factors will be applied in accordance with para. 5320. Load block sheave pins will have the design service factor doubled since they do not provide a dual load path. (e) Individual lubrication fittings are provided in the main hoist sheave pins for grease lubricated sheave bearings.
5424.2 Types II and III Cranes	

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Sheave pins for Types II and III cranes shall be in accordance with the provisions of Specification CMAA 70.	The aux hoist sheave pins are designed in accordance with the provisions of Specification CMAA 70. Ref. MMH Drawing R94965 (Aux Hoist Assembly).
5425 Rope Construction, Loads, and Design Factors **5425.1 Type I Cranes** ***(a)*** *Rope Construction.* The hoist rope shall be of a construction for crane service, such as improved or extra-improved plow steel grades, 6 x 37 class construction (6 strand, 27 to 49 wires per strand), right regular lay with independent wire rope core. Other materials, strength grades, rope constructions, type of cores, and lay may be used where application or future development in wire rope technology indicates. ***(b)*** *Selection of Ropes.* Hoisting ropes shall be selected based on the more stringent of the following requirements. *(1)* The rated load (without impact), plus the weight of the load block divided by the total number of parts of rope per system, shall not exceed 20% of the manufacturer's published breaking strength. *(2)* The maximum critical load (without impact), plus the weight of the load block divided by the total number of parts of rope, shall not exceed 10% of the manufacturer's published breaking strength on the total system or 20% on each of the dual systems. *(3)* The impact load in the transfer of the maximum critical load from one of the dual hoisting rope systems to the other, in the event of rope failure, shall not exceed 40% of the manufacturer's published breaking strength. *(4)* The seismic load (para. 4130) with all parts of rope intact shall not exceed 40% of the manufacturer's published breaking strength. ***(c)*** *Breaking Strength of Ropes.* The breaking strength of rope shall conform to the manufacturer's published values based upon the minimum values determined by actual tensile tests performed on	Ref. MMH Document 36675-23 (Main Hoist Reeving Stress Report) and MMH Drawing QR94824 (Main Hoist Wire Rope Assembly) for the following items: ***(a)*** The main hoist uses high strength EEIPS wire rope of 8 x 25 construction specifically designed for crane service. Right and left regular lay are used per the manufacturer's recommendations. ***(b)*** *(1)* The rated load (without impact), plus the weight of the load block divided by the total number of parts of rope per system, does not exceed 10% of the manufacturer's published breaking strength. *(2)* The maximum critical load is equivalent to the rated load, which does not exceed 10% of the manufacturer's published breaking strength on the total system or 20% on each of the dual systems. *(3)* The impact load in the transfer of the maximum critical load from one of the dual hoisting rope systems to the other, in the event of rope failure, does not exceed 40% of the manufacturer's published breaking strength. *(4)* The seismic load (para. 4130) with all parts of rope intact does not exceed 40% of the manufacturer's published breaking strength. ***(c)*** The breaking strength of rope conforms to the manufacturer's published values based upon the minimum values determined by actual tensile tests performed on new ropes. The theoretical strengths based upon material properties and net metal cross-section are not used.

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new ropes. The theoretical strengths based upon material properties and net metal cross-section shall not be used.	
5425.2 Types II and III Cranes Rope construction, loads, and design factors for Types II and III cranes shall be established in accordance with the provisions of Specification CMAA 70.	The aux hoist wire rope construction, loads, and design factors are in accordance with the provisions of Specification CMAA 70. Ref. MMH Drawing R94965 (Aux Hoist Assembly).
5426 Fleet Angles **5426.1 Type I Cranes** ***(a)*** The rope fleet angle to the drum grooves shall be limited to 3-1⁄2 deg, except at the last 3 ft of the maximum lift elevation it shall be limited to 4 deg. Refer to Fig. 5426-1 for fleet angle measurement to the drum groove. ***(b)*** The rope fleet angle for sheaves shall be limited to 3-1⁄2 deg, except at the last 3 ft of the maximum lift elevation it shall be limited to 4-1⁄2 deg. Refer to Fig. 5426-2 for fleet angle measurement to the sheaves.	Ref. MMH Drawing R94779 (Trolley Assembly) for the following items: ***(a)*** The maximum fleet angle for the main hoist drum is < 3-1/2° throughout the hoisting range, except at the last 3 ft of maximum lift elevation, where it is < 4°. ***(b)*** The maximum fleet angle for the main hoist sheaves is < 3-1/2° throughout the hoisting range, except at the last 3 ft of maximum lift elevation, where it is < 4-1/2°.
5426.2 Types II and III Cranes The operating fleet angle for Types II and III cranes shall be in accordance with CMAA 70.	The aux hoist wire rope fleet angles are in accordance with Specification CMAA 70. Ref. MMH Drawing R94965 (Aux Hoist Assembly).
5427 Sheaves **5427.1 Type I Cranes** Sheaves shall be of steel and provided with antifriction or sleeve bearings. Proper provision for the effects of thrust shall be made where applicable. Figures 5427.1-1 and 5427.1-2 are recommended for running sheave proportions only. The pitch diameter of all sheaves except equalizer sheaves shall be not less than 24 times the diameter of the hoist rope for 6 x 37 rope construction, or not less than 30 times the hoist rope diameter for 6 x 19 rope construction. Sheave journals requiring external lubrication shall be provided with individual grease lines, with the fittings located such that they will be protected from damage (see para. 5460). Means shall be provided to prevent the wire rope from leaving the sheave grooves.	Ref. MMH Drawing R95005 (Main Hoist Bottom Block Assembly) for the following items: The main hoist sheaves are high-strength, low-weight Nylatron material specifically designed for sheave application. The sheaves are provided with sleeve bearings and are separated using washers to prevent galling and accommodate thrust loads. Sheave dimensions are in accordance with the manufacturer's recommendations, but follow Figures 5427.1-1 and 5427.1-2 whenever possible. The main hoist uses high strength wire rope that is 8 x 25 construction and has a manufacturer's minimum recommended ratio for sheave groove minor diameter to rope diameter of 20:1. The actual main hoist ratio for sheave pitch diameter to rope diameter is 22:1, which is more conservative than the manufacturer's recommendations. The main hoist sheave sleeve bearings are solid with

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	lubricant inserts, so there are no external grease lines. Means are provided to prevent the wire rope from leaving the sheave grooves. The bottom block is designed with metal bars that prevent the rope from leaving the sheave grooves.
5427.2 Types II and III Cranes Sheaves for Types II and III cranes shall be established in accordance with the provisions of Specification CMAA 70.	The aux hoist sheaves are in accordance with the provisions of Specification CMAA 70. Ref. MMH Drawing R94965 (Aux Hoist Assembly).
5428 Hooks **5428.1 Single Failure-Proof Features (Type I Cranes)** Type I cranes shall be provided with (a) hook(s) that either: ***(a)*** provide(s) two load-attaching points designed such that each attaching point will be able to support a load of three times the critical load (static and dynamic) being handled without permanent deformation of the hook, other than localized strain concentration in areas for which additional material has been provided for wear, or ***(b)*** provide(s) one load-attaching point designed such that it will be able to support a load of six times the critical load (static and dynamic) being handled without permanent deformation of the hook, other than localized strain concentration in areas for which additional material has been provided for wear.	***(a)*** The main hoist hook is a sister hook design that provides two load-attaching points designed such that each attaching point can support a load of three times the critical load (static and dynamic) being handled without permanent deformation of the hook, other than localized strain concentration in areas for which additional material has been provided for wear. Ref. MMH Document 36675-23 (Main Hoist Reeving Stress Report). ***(b)*** The main hoist hook also has a pinhole, which is a single attachment point that is able to support a load of six times the critical load (static and dynamic) being handled without permanent deformation of the hook. Ref. MMH Document 36675-23 (Main Hoist Reeving Stress Report).
5428.2 Single Failure-Proof Features (Types II and III Cranes) Single failure-proof mechanical features are not required.	Single failure proof features are not provided for the aux hoist hook and are not required.
5428.3 Analytical Procedure for Curved Beams Hook stresses are calculated using the curved beam method described by A.M. Wahl in The Journal of Applied Mechanics, pp. A-239 to A-242, September 1946. For hook configuration and calculation procedures, see para. 5470.	N/A - Straight beam method is used for the main hoist sister hook in accordance with Section 5477(b). The aux hoist hook is purchased from a manufacturer and has a published load rating and safety factor appropriate for the load.
5429 Reeving Efficiency (Types I, II, and III Cranes) The reeving efficiencies are based on the total number of ropes supporting one load block either double reeved or single reeved. The values of the reeving efficiencies are determined from Eq. (12).	Reeving efficiency is determined as required with additional input from Specification CMAA 70. Section 5.2.9.1.1.1 provides a breakdown of efficiencies based on the use of antifriction vs. sleeve bearings and oil

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[Text and/or equations omitted]	lubrication for internal reductions vs. grease lubrication for external reductions. Ref. MMH Document 36675-18 (Main Hoist Gearing Analysis).
5430 Trolley Drives ***(a)*** *Type I Cranes.* Trolley drives shall consist of one of the following arrangements, which are shown in Fig. 5430(a)-1. Each four-wheel trolley shall use a drive arrangement that provides drive to at least 50% of the wheels. Trolleys having more than four wheels shall have at least 25% of the wheels driven. In trolley travel drives, single failure-proof features are generally not required. However, in those cases where a failure of a component could result in a facility unacceptable excursion, the design shall incorporate single failure-proof features to ensure that the trolley can be brought to a safe stop. *(1) A-1 Drive.* The motor is located near the center of the trolley and is connected by means of a flexible coupling to a self-contained gear reduction unit also located at the center of the trolley, which shall be connected to the line shaft by solid or half-flexible couplings. The line shaft is in turn connected to the trolley wheel axles by means of floating shafts with half-flexible couplings. *(2) A-1A Drive.* Same as A-1 drive, except the self-contained gear reduction unit is located closer to one of the trolley wheel axles. *(3) A-1B Drive.* Same as A-1 drive, except the self-contained gear reduction unit is located outside the trolley frame close to one of the trolley wheel axles. *(4) A-2 Drive.* The motor is connected by means of a flexible coupling to a self-contained gear reduction unit located at the center of the trolley. The trolley wheels shall be driven through gears which are either pressed or keyed to their axles or which are attached directly to the wheel. Floating shaft couplings shall be half-flexible type at wheel and reducer connections. If splicing of floating shafts is	Ref. MMH Drawing R94779 (Trolley Assembly) for the following items: ***(a)*** The trolley drive consists of the A-4 arrangement described in (6) and is approximately shown in Fig. 5430(a)-1. The four-wheel trolley uses a drive arrangement that provides drive to at least 50% of the wheels. The motor and gearbox are purchased as a combination unit from and are located near each end of the trolley without torque shafts. The motors are connected (internally) to self-contained gear reduction units by means of flexible couplings. The gear reduction units slip on to the trolley wheel axles and torque is transmitted by means of a torque arm. Since the gear reduction units are directly supported by the shafts, misalignment is not possible and flexible couplings are not required. Single failure proof features are not provided for the trolley drive system and are not required. ***(b)*** N/A - This is a Type I Crane

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required, couplings shall be of the solid type. *(5) A-3 Drive.* The motor is located at the center of the trolley and is connected directly to the line shaft by half-flexible couplings. Self-contained gear reduction units located near each end of the trolley shall be connected to the trolley wheel axles by means of floating shafts with half-flexible couplings or directly with full-flexible couplings. *(6) A-4 Drive.* The motors are located near each end of the trolley without torque shafts. The motors shall be connected to self-contained gear reduction units by means of flexible couplings. The gear reduction units shall be connected to the trolley wheel axles by means of floating shafts with half-flexible couplings or directly coupled by means of full-flexible couplings. *(7) A-5 Drive.* The motor is located near the center of the trolley and is connected by means of a flexible coupling to a self-contained gear reduction unit located near the center of the trolley. This reduction unit shall be connected by sections of line shaft having solid or half-flexible couplings to self-contained gear reduction units located near each end of the trolley, and these in turn connect to trolley wheel axles by means of floating shafts with half-flexible couplings or directly by means of full-flexible couplings. *(8) A-6 Drive.* The motors are located near each end of the trolley and are connected with a torque shaft. On the drive end, the motors shall be connected to self-contained gear reduction units by means of flexible couplings. Gear reduction units are to be connected to trolley wheel axles by means of floating shafts with half-flexible couplings. High speed shafts between motors shall be connected by means of half-flexible couplings. All other couplings shall be of the solid type. ***(b)** Types II and III Cranes.* Arrangement of trolley drives is the same	

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as for Type I cranes.	
5431 Motors — Trolley **5431.1 Type I Cranes** Each motor in a trolley drive arrangement (refer to para. 5430) shall connect directly or indirectly to two opposite wheels for traversing the trolley, or, if individually driven wheels are used, a motor shall be provided to drive opposite wheels. Motors are to be selected per para. 6400.	The trolley drive is an A-4 arrangement that includes individually driven wheels with motors driving opposite wheels. The motors are selected per para. 6400. Ref. MMH Drawing R94779 (Trolley Assembly).
5431.2 Types II and III Cranes Trolley drive motors shall be selected in accordance with para. 6400.	N/A - This is a Type I Crane
5432 Trolley Travel Gearing **5432.1 General — Type I Cranes** Trolley travel gearing shall be designed in accordance with para. 5413 except for the areas delineated in this Section. The actual horsepower imposed on the gearing shall be considered as the rated motor horsepower at its normal time rating as defined in Section 6000. If 60-minute series wound motors are used, then special consideration shall be given to the short time torque ratings of such motors.	The motor and gearbox are purchased as a combination unit and the gearbox meets or exceeds the applicable requirements of AGMA for the respective size, which complies with Section 5413. The actual horsepower imposed on the gearing is considered as the rated motor horsepower at its normal time rating (60 minute minimum) as defined in Section 6000. Ref. MMH Document 36675-06 (Electrical Calculations). 60-minute series wound motors are only applicable to DC motors. Since this is an AC motor, special considerations for short time torque ratings do not apply.
5432.2 Types II and III Cranes Gearing for trolley travels shall be established in accordance with the provisions of Specification CMAA 70.	N/A - This is a Type I Crane
5433 Trolley Brakes **5433.1 Type I Cranes** ***(a)*** Service Brakes. A trolley drive system shall be provided with a service braking means which may be satisfied by the emergency brake, a separate control brake, or as part of the motor controls. Service brake requirements, brake sizes, and brake designs are specified in Section 6000. ***(b)*** Emergency and Parking Brakes. Each primary trolley drive motor	***(a)*** Dynamic braking through the variable frequency drive is provided for the trolley to satisfy the service brake requirement. Service brake requirements, brake sizes, and brake designs comply with Section 6000. ***(b)*** Friction-type brakes are provided for all trolley motors to satisfy the emergency and parking brake requirement. Brake sizing and design complies with Section 6000.

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shall be provided with an emergency and a parking brake. Brake sizing and design are specified in Section 6000.	
5433.2 Types II and III Cranes Trolley brakes shall be in accordance with Specification CMAA 70.	N/A - This is a Type I Crane
5440 Bridge Drives ***(a)*** *Type I Cranes.* Bridge drives shall consist of one of the following arrangements, which are shown in Fig. 5440(a)-1. Each four-wheel bridge shall use a drive arrangement that has at least 50% of the wheels driven. Bridges having more than four wheels, such as eight-wheel, twelve-wheel, or sixteen-wheel, shall have at least 25% of the wheels driven. In bridge travel drives, single failure-proof features are generally not required. However, in those cases where a failure of a component could result in a facility unacceptable excursion, the design shall incorporate single failure-proof features to ensure that the bridge can be brought to a safe stop. *(1) A-1 Drive.* The motor is located near the center of the bridge and is connected by means of a flexible coupling to a self-contained gear reduction unit also located at the center of the bridge, which shall be connected to the line shaft by solid or half-flexible couplings. The line shaft is in turn connected to the bridge wheel axles by means of floating shafts with half-flexible couplings [see (a)(7) below, Note]. *(2) A-2 Drive.* The motor is connected by means of a flexible coupling to a self-contained gear reduction unit located at the center of the bridge. The bridge wheels shall be driven through gears which either are press fitted or are attached directly to the wheel. Line shaft couplings at the center reducer shall be either solid or half-flexible. Line shaft couplings at the truck reduction pinion shall be of the half-flexible type. All other couplings shall be of the solid type [see (a)(7) below, Note]. *(3) A-3 Drive.* The motor is located at the center of the	***(a)*** The bridge drive consists of the A-2 arrangement described in (2) and is approximately shown in Fig. 5440(a)-1. The eight-wheel bridge uses a drive arrangement that provides drive to at least 25% of the wheels. Ref. P&H Drawing 105A3002 (Bridge Layout). Single failure proof features are not provided for the bridge drive system and are not required. The motor is connected by means of a flexible coupling to a self-contained gear reduction unit located at the center of the bridge. The bridge wheels are driven through gears that are keyed and press fitted. Line shaft couplings at the center reducer are solid. The reduction pinion is pressed onto the end of the drive shaft, which is supported by a bearing and does not require a coupling. All other couplings are of the solid type. ***(b)*** N/A - This is a Type I Crane

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bridge and is connected directly to the line shaft by means of half-flexible couplings. Self-contained gear reduction units located near each end of the bridge shall be connected to the bridge wheel axles by means of floating shafts with half-flexible couplings. All other couplings shall be of the solid type. *(4) A-4 Drive.* The motors are located near each end of the bridge without torque shafts. The motors shall be connected to self-contained gear reduction units by means of flexible couplings. The gear reduction units shall be connected to the bridge wheel axles by means of floating shafts with half-flexible couplings or directly coupled by means of full-flexible couplings. *(5) A-5 Drive.* The motor is located near the center of the bridge and is connected by means of a flexible coupling to a self-contained gear reduction unit located near the center of the bridge. This reduction unit shall be connected by sections of line shaft having solid or half-flexible couplings to self-contained gear reduction units located near each end of the bridge, and these, in turn, shall be connected to bridge wheel axles by means of floating shafts with half-flexible couplings [see (a)(7) below, Note]. *(6) A-6 Drive.* The motors are located near each end of the bridge and are connected with a torque shaft. On the drive end, the motor shall be connected to a self-contained gear reduction unit by means of flexible couplings. Gear reduction units are to be connected to bridge wheel axles by means of floating shafts with half-flexible couplings. High speed shafts between motors shall be connected by half-flexible couplings. All other couplings shall be of the solid type. *(7)* Typical bridge drive arrangements for polar cranes are shown in Fig. 5440(a)-2. These drives use the A-4 drive	

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arrangement with the axis of bridge wheel rotation passing through the center of the crane runway diameter. ***(b)*** *Types II and III Cranes.* Arrangement of bridge drives is the same as for Type I cranes.	
5441 Motors — Bridge **5441.1 Type I Cranes** Each bridge drive arrangement, as described in para. 5440 and shown in Figs. 5440(a)-1 and 5440(a)-2, shall use one or more motors for traversing the bridge. Motor(s) shall be selected in accordance with para. 6400.	The bridge drive is an A-2 arrangement that uses a single motor. The motor is selected per para. 6400. Ref. P&H Drawing 105A3002 (Bridge Layout)
5441.2 Types II and III Cranes Bridge drive motors shall be in accordance with Specification CMAA 70.	N/A - This is a Type I Crane
5441.3 Ratings If 60-min series wound motors are used, then special consideration shall be given to the short time torque ratings of such motors.	N/A - 60-minute series wound motors are only applicable to DC motors. Since this is an AC motor, special considerations for short time torque ratings do not apply.
5442 Bridge Travel Gearing **5442.1 Type I Cranes** Bridge travel gearing shall be designed in accordance with para. 5413, except for the areas delineated in this Section. The actual horsepower imposed on the gearing shall be considered as the rated motor horsepower, at its normal time rating, unless 60-min series wound motors are used (see para. 5441.3).	The existing bridge motor is replaced by a new bridge motor with the same horsepower and dimensions. The actual horsepower imposed on the gearing is considered the rated motor horsepower at its normal time rating (60 minute minimum) as defined in Section 6000. See Note 1.
5442.2 Types II and III Cranes Gearing for bridge travels shall be established in accordance with the provisions of Specification CMAA 70.	N/A - This is a Type I Crane
5443 Bridge Brakes **5443.1 Type I Cranes** ***(a)*** *Service Brakes.* A bridge drive system shall be provided with a service braking means that may be satisfied by the parking brake, a separate control brake, or as part of the motor controls. Service	***(a)*** Dynamic braking through the variable frequency drive is provided for the bridge to satisfy the service brake requirement. Service brake requirements, brake sizes, and brake designs comply with Section 6000.

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brake requirements, brake sizes, and brake designs are specified under Section 6000. ***(b)*** *Emergency and Parking Brakes.* Each primary bridge drive motor shall be provided with an emergency and a parking brake. Brake sizing and design are specified under Section 6000.	***(b)*** Friction-type brakes are provided for all bridge motors to satisfy the emergency and parking brake requirement. Brake sizing and design complies with Section 6000.
5443.2 Types II and III Cranes Bridge brakes shall be in accordance with Specification CMAA 70.	N/A - This is a Type I Crane
5450 General Mechanical Components **5451 Couplings (Types I, II, and III Cranes)** **5451.1 General** ***(a)*** Couplings connecting the motor(s) to the hoist and travel(s) shall be the flexible type. Grease lubricated couplings are preferred with gear types. ***(b)*** Cross-shaft couplings, other than the flexible type, shall be steel as specified by the coupling manufacturer. The coupling (other than flexible) may be compression, sleeve, or flange type. Couplings shall be provided at each end truck and each side of the motor gear reducer. Additional couplings may be installed as necessary.	Ref. MMH Drawing R94779 (Trolley Assembly) and P&H Drawing 105A3002 (Bridge Layout) for the following items: ***(a)*** Grease-lubricated flexible couplings are used between the motors and gear cases for the hoist, trolley drive, and bridge drive. ***(b)*** Solid compression type couplings are used for the bridge drive shafts, including at each end truck and at each side of the motor gear reducer. There are no solid type couplings on the trolley.
5451.2 Selection ***(a)*** Coupling selection shall be based on the manufacturer's rating and applicable service factors for crane motions compared to the applied torque on the coupling, giving consideration to the following: *(1)* motor output *(2)* gear ratio *(3)* efficiency of system *(4)* wheel slippage with maximum operating wheel load (friction = $\mu = 0.2$) *(5)* dynamic effects *(6)* brake torque ***(b)*** In no case do all of the loading conditions occur simultaneously, and consideration should be given to the applicable conditions, such as minimum wheel slippage or motor output torque.	***(a-b)*** Coupling selection for the trolley is based on the manufacturer's rating and applicable service factors for crane motions compared to the applied torque on the coupling with consideration for requirements listed in (a) as applicable. See Note 1.

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5452 Wheels — Bridge and Trolley **5452.1 General** Unless other means of restricting lateral movement are provided, wheels shall be double flanged with treads accurately machined. Wheels may have either straight treads or tapered treads assembled with the large diameter toward the center of the span. Drive wheels shall be matched pairs within 0.001 in./in. of diameter, or a total of 0.010 in. on the diameter, whichever is smaller. When flangeless wheel and side roller assemblies are provided, they shall be of a type and design recommended by the crane manufacturer.	Double flanged wheels with straight machined treads are used for both the bridge and trolley per MMH Drawing R94779 (Trolley Assembly) and P&H Drawing 100A4381-S9 (Truck Assembly). Trolley wheel tread diameter is machined within a minimum of 0.010 in. so that all wheels accurately match. Flangeless wheel and side roller assemblies are not used on this crane. See Note 1.
5452.2 Material Wheels shall be rolled or forged from steel for Type I cranes. Types II and III cranes may have wheels cast of carbon or alloy steel. Wheel treads shall have a minimum surface hardness of 300 BHN.	The trolley wheels are forged from steel and the treads are hardened to 57-62 Rc (58 Rc equals approximately 615 BHN). See Note 1.
5452.3 Loading Wheels shall be designed to carry the maximum wheel load under normal conditions. The allowable maximum wheel load is determined by dividing the allowable wheel load in Table 5452.3-1 by the appropriate speed factor of Table 5452.3-2. The allowable wheel load shown in Table 5452.3-1 is that load produced with trolley handling the rated load in the position to produce the maximum load and shall be used for determining wheel sizes. Impact loading due to handling rated load is not included in the allowable wheel loads.	Wheels are designed to carry the maximum wheel load under normal conditions per the requirements of this section. Maximum wheel loads are determined in MMH Document 36675-05 (Bridge Stress Calculations).
5452.4 Clearances ***(a)*** *Bridge Clearances.* Wheel treads shall be a minimum of 3⁄4 in. wider than the rail head for nontapered wheels. ***(b)*** *Trolley Clearances.* Wheel treads shall be a minimum of 3⁄8 in. wider than the rail head for nontapered wheels. ***(c)*** *Tapered Wheel Clearances.* Tapered tread wheels may have a clearance over the rail head of 150% of the clearance provided for straight tread wheels, or as recommended by the crane	Ref. P&H 100A4381-S9 (Truck Assembly), and MMH Drawing R94779 (Trolley Assembly) for the following items: ***(a)*** Bridge wheel treads are not tapered and are a minimum of 3⁄4 in. wider than the rail head. ***(b)*** Trolley wheel treads are not tapered and are a minimum of 3⁄8 in. wider than the rail head. ***(c)*** N/A - Tapered wheels are not used for this crane.

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manufacturer. ***(d)*** *Special Conditions for Wheel Clearances.* Wheel tread clearances may be greater than those specified in Fig. 5452.4-1, if determined necessary to meet runway expansion requirements caused by excessive temperature and pressure. Refer to Section 1000. For guidance on wheel width and height, refer to Table 5452.4-1.	***(d)*** N/A - There are no special conditions for wheel clearances. See Note 1.
5452.5 Axle Fits When rotating axles are used, wheels shall be mounted on the axle with a press fit alone or press fit and keys. All wheels shall have sufficient hub thickness to permit the use of keys.	Wheels are press fit onto axles with keys. Wheel hubs are thick enough to permit the use of keys.
5452.6 Overhung Wheels Overhung wheels shall not be used.	Overhung wheels are not used on this crane.
5453 Axles — Bridge and Trolley **5453.1 General — Type I Cranes** Axles may be either of the fixed or rotating type. ***(a)*** *Load Combinations, Allowable Stresses, and Service Factors.* The bridge and trolley axles shall be designed to resist the load combinations of Table 5453.1(a)-1 with corresponding values of allowable stresses and service factors. ***(b)*** *Computation — Analysis.* Analytical stress computations shall be performed according to procedures in para. 5470.	Ref. MMH Drawing R95253 (Trolley Wheel Assembly - Drive), P&H Drawing 10F8569 (Trolley Wheel Idler Axle), P&H Drawing 10F7747F1 (Bridge Wheel Drive Axle), and P&H Drawing 10F7748 (Bridge Wheel Idler Axle) for the following items: Rotating axles are used on the bridge and trolley wheels. ***(a)*** Bridge and trolley axles are selected to resist the load combinations of Table 5453.1(a)-1 with corresponding values of allowable stresses and service factors. ***(b)*** Axle sizing is based on existing, proven designs for similar applications.
5453.2 General — Type II Cranes Axles shall be designed according to Specification CMAA 70.	N/A - This is a Type I Crane
5453.3 General — Type III Cranes Axles shall be designed according to Specification CMAA 70.	N/A - This is a Type I Crane
5454 Drive Shafts — Bridge and Trolley **5454.1 General — Type I Cranes**	

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Drive shafting shall be designed for the rated load maximum wheel load in combination with the required torque. The magnitude of the torque shall be based on the drive output torque, skid torque, or braking torque, whichever is limiting. ***(a)*** *Computation — Analysis.* Analytical stress computations shall be performed according to procedures in para. 5470. ***(b)*** *Service Factors.* Service factors shall be applied according to para. 5320. ***(c)*** *Torsional Deflection.* The torsional deflection of the cross-shafts and floating shafts shall not exceed the values, shown in Table 5454.1(c)-1. The types of drives referred to in this table are defined in para. 5440. The percent motor torque is the portion of the full-load torque of the drive motor(s) at its normal time rating for the service involved, increased by any gear reductions between the motor and the shaft. If 60-min series wound motors are used, short time rating torques should be considered. The allowable angular deflection is expressed in degrees per foot (deg/ft).	N/A - Drive shafting is not used for the trolley since the trolley travel drives slip directly onto the trolley wheel axles. See Note 1.
5454.2 General — Types II and III Cranes Drive shafting shall be designed according to Specification CMAA 70.	N/A - This is a Type I Crane
5455 Bearings **5455.1 Antifriction Bearings (Type I Cranes)** ***(a)*** The type, size, and mounting of bearings shall be determined by criteria outlined in this Section. Computations confirming the adequacy of the bearing to meet the criteria shall be included as part of the crane analysis. ***(b)*** Bearings with a calculable predicted life expectancy of a minimum of 5000 hr shall be selected. *(1)* Bearing life expectancy shall be determined from the bearing manufacturer's published data or certified extension of published data. *(2)* Bearing life expectancy shall be expressed as the number of hours of operation in which 90% of the bearings	Antifriction bearings are provided for the trolley wheels, main hoist gear cases, and main hoist hook. Ref. MMH Drawing R95253 (Trolley Wheel Assembly - Drive), MMH Drawing R95005 (Main Hoist Bottom Block Assembly), and MMH Drawing QR89592 (Main Hoist Gear Case Assembly). ***(a)*** Bearings are selected based on existing, proven designs that comply with the requirements of this section. Computations confirming the adequacy of bearings are included in MMH Document 36675-23 (Main Hoist Reeving Stress Report). ***(b)*** Bearings are selected based on existing, proven designs with a minimum life expectancy of 5000 hours in accordance with the

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are expected to operate without failure. *(3)* Analytical procedures may be based on L10 or B10, as defined by the AFBMA. *(4)* Infrequent loads, such as impact or seismic, need not be considered in bearing life computation. *(5)* Bearing life computations shall be based on the full rated speed except as exempted herein. *(a)* Bearing life computations may be based on less than full rated speed only if confirmed by the load spectrum, unless otherwise specified by the purchaser. *(6)* Bearing life computations shall be based on the following minimum percentages of maximum load and load combinations. (a) Bridge drive bearings shall be computed using 75% of the maximum load, and shall be computed with no load acting against the wheel flange. (b) Trolley drive and wheel bearings shall be computed using 65% of the maximum load, and shall be computed with no load acting against the wheel flange. (c) Hoist bearings shall be computed using 65% of the full rated load. ***(c)*** Bearings shall be selected to withstand the maximum forces that may be imposed. *(1)* Bearing capability shall be determined from the manufacturer's published data or certified extension of published data. *(2)* The basic static capacity of the bearing shall not be exceeded by load combinations as outlined herein. *(a)* All bearings shall be sized to resist the maximum operating force which can be imposed by the driving motors.	requirements of this section. ***(c)*** Bearings are selected to withstand the maximum forces imposed with respect to the manufacturer's published static capacities. Ref. MMH Document 36675-23 (Main Hoist Reeving Stress Report). ***(d)*** Mounting fits and internal clearances are designed as recommended by the manufacturer. ***(e)*** Gear case bearings are bathed in oil for lubrication. Wheel bearings and the main hoist hook bearing are pre-lubricated with grease and have fittings for re-lubrication. ***(f)*** Gear case bearings are sealed within the gear case. Wheel bearings are contained inside a machined steel housing to exclude dust and minimize grease leakage. ***(g)*** Deflections in assemblies under load are minimized to prevent abnormal bearing loads. Deflection for major frame components is calculated in MMH Document 36675-09 (Seismic Analysis). ***(h)*** N/A - Bearings are selected to comply with the manufacturer's published speed ratings. ***(i)*** The main hoist hook bearing uses non water-soluble grease and has an easily accessible grease fitting for re-lubrication. See Note 1.

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(b) Wheel bearings shall be designed to resist forces due to the maximum wheel load. *(3)* Loads imposed by the safe shutdown earthquake (SSE) shall not exceed 90% of the bearings' minimum fracture limit. ***(d)*** Mounting fits and internal clearances shall be as recommended by the bearing manufacturer. ***(e)*** All bearings shall be provided with proper lubrication or means of lubrication. ***(f)*** Bearing enclosures shall be designed as far as practical to exclude dirt and prevent leakage of oil or grease. ***(g)*** Assemblies shall be analyzed to confirm that deflection under load does not exceed that which the bearing can accommodate. ***(h)*** Special consideration shall be given to bearings which operate at speeds above or below the manufacturer's published data. Certified confirmation of the bearing's capacity beyond published rating must be obtained from the manufacturer. ***(i)*** For bearings of load blocks that are to be immersed: *(1)* lubricants of these bearings shall be compatible with the chemistry of the liquid (refer to Section 1000 for special environmental conditions); *(2)* provisions shall be made for relubricating the bearings once the block has been removed from the liquid.	
5455.2 Antifriction Bearings (Types II and III Cranes) ***(a)*** Refer to Specification CMAA 70. ***(b)*** For bearings of load blocks that are to be immersed: *(1)* lubricants of these bearings shall be compatible with the chemistry of the liquid (refer to section 1000 for special environmental conditions); *(2)* provisions shall be made for relubricating the bearings once the block has been removed from the liquid.	Ref. MMH Drawing R94965 (Aux Hoist Assembly) for the following items: ***(a)*** Antifriction bearings for the aux hoist are in accordance with Specification CMAA 70. ***(b)*** The aux hoist hook bearing uses non water-soluble grease and has an easily accessible grease fitting for re-lubrication.
5455.3 Sleeve Bearings (Type I Cranes) ***(a)*** Only bearings with published and/or certified properties shall be	Self-lubricating brass alloy sleeve bearings are provided for the bottom

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used. ***(b)*** The PV (pressure velocity) rating of the bearing shall not be exceeded for any combination of operating loads. ***(c)*** Forces induced by the SSE shall not exceed 90% of the allowable compressive strength of the bearing. ***(d)*** All bearings shall be provided with proper lubrication or means of lubrication. ***(e)*** Mounting fits and clearances shall be as recommended by the bearing manufacturer. ***(f)*** Bearing enclosures shall be designed as far as practical to exclude dirt and prevent leakage of oil or grease.	block sheaves per MMH Drawing R95005 (Main Hoist Bottom Block Assembly). ***(a)*** Sleeve bearings with published and/or certified properties are used. ***(b)*** Operating loads for sleeve bearings do not exceed PV ratings. ***(c)*** Forces due to a rope break condition, which envelopes seismic loading, do not exceed 90% of the allowable compressive strength of the bearing. Ref. MMH Document 36675-23 (Main Hoist Reeving Stress Report). ***(e)*** Mounting fits and clearances are designed based on the bearing manufacturer's recommended values and standard design practices. ***(f)*** Sleeve bearings are self-lubricating, so oil and grease leakage is not applicable. Clearances for sleeve bearings are minimized to exclude dirt where practical.
5455.4 Sleeve Bearings (Types II and III Cranes) Refer to Specification CMAA 70.	N/A - Sleeve bearings are not used on the aux hoist.
5456 Fasteners — Mechanical Components **5456.1 Fastener Restraints** ***(a)*** *Types I and II Cranes* *(1)* Fasteners shall not loosen under normal operating loads and vibration. *(2)* Cranes which travel over the reactor pool or fuel pool shall use fasteners which do not depend upon lock washers unless they are so located as to be caught upon removal by drip pans or crane structure. For these cranes, when other than high strength bolts are used, preferred locking methods are thread-upsetting fasteners, plastic insert fasteners, tack welding, cementing, or lock wire. High-strength bolts are considered restrained when torqued in accordance with the AISC method. ***(b)*** *Type III Cranes.* Fasteners shall be in accordance with Specification CMAA 70.	Ref. Applicable assembly drawings, MMH Document 36675-15 (Crane Installation Procedure), and MMH Document 36675-07 (Factory Acceptance Test Procedure) for the following items: ***(a)*** *(1)* Fasteners are provided with chemical locking compound, lock nuts, or lock wires and torqued to prevent loosening under normal operating loads and vibration. These items are specified for applicable fasteners on the respective assembly drawings. *(2)* Lock washers are not used. Fasteners are provided with chemical locking compound, lock nuts, or lock wires and torqued. High strength bolts are torqued in accordance with AISC as required. These items are specified for applicable fasteners on the respective assembly drawings. ***(b)*** N/A - This is a Type I Crane See Note 1.

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5456.2 Allowable Stresses ***(a)*** *Types I and II Cranes.* Maximum combined stresses induced in the fasteners by normal operating loads (but not including pretensioning loads) shall not exceed 20% of the ultimate strength of the fasteners. Limiting loads (such as seismic, stall torque, and load hang-up) shall induce combined stresses (not including pretensioning stresses) which do not exceed 90% of the yield strength of the fasteners. ***(b)*** *Type III Cranes.* Maximum combined stresses induced in the fasteners by normal operating loads (not including pretensioning loads) shall not exceed 20% of the ultimate strength of the fasteners.	***(a)*** Maximum combined stresses induced in the fasteners by normal loads (but not including pretensioning loads) do not exceed 20% of the ultimate strength of the fasteners. Maximum combined stresses induced in the fasteners by limiting loads (such as seismic, stall torque, and load hang-up, but not including pretensioning stresses) do not exceed 90% of the yield strength of the fasteners. Stresses in bolts for the hoisting machinery and seismic restraints are analyzed in MMH Document 36675-14 (Seismic Analysis of Misc. Items). ***(b)*** N/A - This is a Type I Crane See Note 1.
5456.3 Mounting of Machinery ***(a)*** *Types I and II Cranes* *(1)* Mounting surfaces for machinery (except for bridge) shall be machined for direct mounting or with allowance for shimming as dictated by the design. *(2)* Single machinery elements such as motors and gear reducers shall not be mounted on multiple support structures which can deflect relative to each other unless the design specifically allows for this deformation. *(3)* Machinery or machine parts whose alignment is important to its operation shall not depend on friction but shall use positive means such as dowel pins, shear bars, or fitted bolts to maintain alignment. *(4)* Gear engagements shall be protected such that equipment deformation could not cause disengagement and drop the load. *(5)* Machinery weights shall be increased by appropriate dynamic factors and analyzed by the static method to determine fastener mounting loads. Allowable stresses shall be in accordance with para. 5456.2. ***(b)*** *Type III Cranes*	***(a)*** Ref. MMH Drawing QR95370 (Trolley Frame Weldment) for the following items: *(1)* Mounting surfaces on the trolley for machinery are machined with allowance for shimming. *(2)* Supports for machinery elements are welded to the trolley frame and then machined together to create a single rigid support structure for all components. *(3)* Trolley machinery does not depend on friction to maintain alignment, but instead uses different methods including jacking bolts and/or shear bars. Ref. MMH Drawing R94779 (Trolley Assembly). *(4)*Gear cases and the supporting structural framework are sufficiently rigid to prevent gear disengagement that would drop the load. This is verified by the rated load test performed per MMH Document 36675-07 (Factory Acceptance Test Procedure). *(5)* Static analysis for fastener mounting loads, including the increases in machinery weight due to dynamic factors from the seismic analysis results, is provided in MMH Document 36675-14 (Seismic Analysis of Misc. Items). Allowable stresses are in accordance with Section 5456.2

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(1) Mounting surfaces for machinery (except for bridge cross-shafting) shall be machined for direct mounting or with allowable for shimming as dictated by the design. *(2)* Single machinery elements such as motors and gear reducers shall not be mounted on multiple support structures which can deflect relative to each other unless the design specifically allows for this deformation. *(3)* Machinery or machine parts whose alignment is important to its operation shall not depend on friction but shall use positive means such as dowel pins, shear bars, or fitted bolts to maintain alignment. *(4)* Gear engagements shall be protected such that equipment deformation could not cause disengagement and drop the load.	***(b)*** N/A - This is a Type I Crane See Note 1.
5457 Gear Cases, Enclosures, and Guards **5457.1 Gear Cases (Type I Cranes)** ***(a)*** All gears except final reduction gears shall be completely enclosed in gear cases. All gear cases shall be oil-tight and sealed with compound or gaskets. ***(b)*** Unless otherwise approved by the owner, the hoist motion gear case base shall be split in one plane through the bearing center lines above the oil level except in microdrives and worm drives. ***(c)*** Openings when provided shall be provided in the top section for the inspection of gearing at mesh lines. Covers for these inspection holes shall be sealed to prevent leakage. ***(d)*** Splash oil lubrication of bearings may be used unless otherwise specified. ***(e)*** Oil pumps shall be used if vertical gearing exceeds two reductions. The oil level on horizontally arranged gearing shall be high enough to immerse the bottom portion of at least two gears. ***(f)*** Solid oil seals should be selected to allow replacement with split seals, if possible. ***(g)*** Easily accessible drain plugs and breathers shall be provided.	Ref. MMH Drawing QR89592 (Main Hoist Gear Case Assembly) for the following items: ***(a)*** All gears for the main hoist and trolley travel drive except for the final reduction gears are completely enclosed in gear cases. All gear cases are oil-tight and sealed with compound or gaskets. ***(b)*** The main hoist gear cases are split in one horizontal plane through the bearing center line above the oil level. ***(c)*** Openings are provided in the top section of the main hoist gear cases for the inspection of gearing at mesh lines. Covers with seals are provided to prevent leakage. The trolley travel drive does not have inspection ports. ***(d)*** Splash oil lubrication of bearings is used for the main hoist and trolley travel drive gear cases. ***(e)*** Oil pumps are not used in the main hoist gear. Oil levels are high enough to immerse the bottom portion of at least two gears. ***(f)*** Solid oil seals are split to allow replacement, where possible. ***(g)*** Easily accessible drain plugs and breathers are provided for the main

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(h) All hoist gear cases shall be mounted on machined surfaces. ***(i)*** Gear cases shall be provided with lugs or other means of lifting. ***(j)*** Means for checking oil level shall be provided.	hoist and trolley travel drive gear cases. ***(h)*** The main hoist gear cases are mounted on machined surfaces of the trolley frame. ***(i)*** The main hoist and trolley travel drive gear cases are provided with lugs or other means of lifting. ***(j)*** An oil dip stick is provided for each gear case. See Note 1.
5457.2 Gear Cases (Types II and III Cranes) Gear cases shall be in accordance with Specification CMAA 70.	Gear cases for the aux hoist are in accordance with Specification CMAA 70. Ref. MMH Drawing R94965 (Aux Hoist Assembly).
5457.3 Enclosures for Gears (Type I Cranes) ***(a)*** All gears not enclosed in gear cases shall be provided with guarded enclosures. This is primarily for the final gear reduction at the hoist drum and travel motion drive wheels. ***(b)*** All gear enclosures shall be designed to retain lubricant. ***(c)*** Openings shall be provided in the top section for the inspection of the gearing at the mesh lines. Covers for these inspection holes shall be sealed to prevent leakage. ***(d)*** Openings for shafts or other rotating parts such as drums shall be provided with means to retain the lubricant. ***(e)*** Gear enclosures shall be provided with lugs or other means of lifting.	Ref. MMH Drawing R94779 (Trolley Assembly) for the following items: ***(a)*** All gears not enclosed in gear cases, including the gear reductions at the hoist drum, are provided with guarded enclosures. ***(b)*** Gear enclosures are provided with seals to retain lubricant. ***(c)*** Openings with seals and cover plates are provided in the top section to inspect the gearing at the mesh lines. ***(d)*** Openings for shafts or other rotating parts are provided with seals to retain the lubricant. ***(e)*** Gear enclosures are provided with lugs for lifting. See Note 1.
5457.4 Enclosures for Gears (Types II and III Cranes) Gear enclosures shall be in accordance with Specification CMAA 70.	N/A - This is a Type I Crane
5457.5 Guards for Moving Parts (Types I, II, and III Cranes) ***(a)*** Exposed moving parts such as gears, set screws, projecting keys, chains, chain sprockets, and reciprocating components, which may constitute a hazard, shall be guarded. ***(b)*** Guards shall be securely fastened. ***(c)*** Each guard shall be capable of supporting the weight of a 200 lb person without permanent deformation, unless the guard is located where it is impossible for a person to step on it.	Ref. P&H Drawing 105A3002 (Bridge Layout) for the following items: ***(a)*** Guards for exposed moving parts are not provided on the trolley since this is not a normally accessed location for personnel. Guards for bridge components are reused. ***(b)*** All guards are securely fastened. ***(c)*** All guards that can be stepped on are fabricated from heavy gage steel and can handle the weight of a 200 lb person without permanent

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	deformation.
5457.6 Guards for Hoisting Ropes (Types I, II, and III Cranes) *(a)* If hoisting ropes run near enough to other parts to make fouling or chafing possible under normal operating conditions, guards shall be installed to prevent this condition. *(b)* A guard shall be provided to prevent contact between bridge or runway conductors and hoisting ropes if they can come into contact under normal operating conditions.	*(a)* Guards are not provided since hoisting ropes do not run near enough to other parts to make fouling or chafing possible under normal operating conditions. *(b)* A guard is provided on the bridge to prevent contact between the ropes, bottom block, and runway conductor bars.
5458 Bumpers and Stops **5458.1 Bridge Bumpers (Type I Cranes)** *(a)* Bumpers shall be sized to limit impact and critical load excursions to facility acceptable magnitudes. *(b)* A crane shall be provided with bumpers. These bumpers shall have the following minimum characteristics: *(1)* energy absorbing (or dissipating) capacity to stop the crane when traveling with power off in either direction at a speed of at least 40% rated load speed (refer to para. 5459 on limit switches for limiting speed upon bumper impact); *(2)* capable of stopping the crane (not including load block and lifted load unless guided vertically) at a rate of deceleration not to exceed an average of 3 ft/sec2 when traveling with power off in either direction at 20% of rated load speed; *(3)* mounted such that there is no direct shear on bolts upon impact. *(c)* Bumpers shall be designed and installed to minimize parts falling from the crane in case of breakage or loosening of bolted connections. *(d)* When more than one crane is located and operated on the same runway, bumpers shall be provided on their adjacent ends to meet the requirements stated above. *(e)* Bumpers are not required on polar cranes unless limited rotation is desired.	*(a-d)* The existing bridge bumpers and stops are reused. *(e)* N/A - This crane is not a polar crane. See Note 1.

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5458.2 Bridge Bumpers (Types II and III Cranes) Bridge bumpers shall be in accordance with Specification CMAA 70.	N/A - This is a Type I Crane
5458.3 Trolley Bumpers (Type I Cranes) ***(a)*** Bumpers shall be sized to limit impact and critical load excursions to facility acceptable magnitudes. ***(b)*** A trolley shall be provided with bumpers. These bumpers shall have the following minimum characteristics: *(1)* energy absorbing (or dissipating) capacity to stop the trolley when traveling with power off in either direction at a speed of at least 50% rated load speed (refer to para. 5459 on limit switches for limiting speed upon bumper impact); *(2)* capable of stopping the trolley (not including load block and lifted load unless guided vertically) at a rate of deceleration not to exceed an average of 4.7 ft/sec^2 when traveling with power off in either direction at one-third of rated load speed; *(3)* mounted such that there is no direct shear on bolts upon impact. ***(c)*** Bumpers shall be designed and installed to minimize parts falling from the crane in case of breakage or loosening of bolted connections. ***(d)*** When more than one trolley is located and operated on the same bridge, bumpers shall be provided on their adjacent ends to meet the requirements stated above.	Ref. MMH Drawing R94779 (Trolley Assembly) for the following items: ***(a)*** Trolley bumpers are sized to limit impact and critical load excursions to facility acceptable magnitudes. ***(b)*** Trolley bumpers are provided that: *(1)* have the energy absorbing capacity to stop the trolley when traveling with power off in either direction at 50% of the rated load speed. *(2)* are capable of stopping the trolley at a rate of deceleration less than 4.7 ft/sec^2 when traveling with power off in either direction at one-third of rated load speed. *(3)* are mounted such that there is no direct shear on bolts upon impact. ***(c)*** Bumper support structures are welded directly to the trolley frame to eliminate the concerns of bolted connections. Bumpers are thru bolted to the supports with chemical locking means to minimize parts falling due to breakage or loosening. ***(d)*** N/A - There is only one trolley on the runway.
5458.4 Trolley Bumpers (Types II and III Cranes) Trolley bumpers shall be in accordance with Specification CMAA 70.	N/A - This is a Type I Crane
5458.5 Trolley Stops (Type I Cranes) ***(a)*** Stops shall be provided at the limits of travel of the trolley. ***(b)*** Stops shall be designed to withstand the forces applied to the bumpers as specified in para. 5458. ***(c)*** If a stop engages the tread of the wheel, it shall not be of a height less than the radius of the wheel. Stops engaging other parts of the crane are recommended.	Ref. MMH Drawing R94779 (Trolley Assembly) for the following items: ***(a)*** Stops are provided to limit the trolley travel ***(b)*** Stops are designed to withstand the forces applied to the bumpers per para. 5458. ***(c)*** Stops do not engage the tread of the wheel, but instead engage a dedicated bumper that is attached to the trolley.

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(d) Stops shall be mounted such that there is no direct shear on the bolts upon impact.	***(d)*** Stops are directly welded on to eliminate a bolted connection
5458.6 Trolley Stops (Types II and III Cranes) Trolley stops shall be in accordance with Specification CMAA 70.	N/A - This is a Type I Crane
5459 Limit Switches **5459.1 Limit Switches (Type I Cranes)** ***(a)*** Track type for bridge and trolley travel motion (see Section 6000 for application and function). ***(b)*** Geared type for upper and lower travel hoist motion (see Section 6000 for application and function). ***(c)*** Weight and paddle-operated type for upper travel hoist motion (see Section 6000 for application and function). ***(d)*** A trolley track-type limit switch or other device shall be provided and positioned to ensure that, under operating conditions, the trolley speed cannot exceed 50% of rated load speed on engaging the trolley stops and bumpers. ***(e)*** A bridge track-type limit switch or other device shall be provided and positioned to ensure that, under operating conditions, the bridge speed cannot exceed 40% of rated load speed on engaging the bridge stops and bumpers.	Ref. MMH Drawing R95399 (Electrical Schematic) for the following items: ***(a)*** Proximity and rocker arm type limit switches are provided for bridge and trolley travel motion. ***(b)*** Geared limit switches are provided on the main hoist for upper and lower hoisting limits. ***(c)*** A weighted limit switch is provided on the main hoist for upper travel hoist motion. ***(d)*** The limit switches for trolley travel motion control a relay that stops the trolley and sets the brakes so that the trolley does not contact the bumpers. ***(e)*** The limit switches for bridge travel motion control a relay that stops the bridge and sets the brakes so that the bridge does not contact the bumpers.
5459.2 Limit Switches (Types II and III Cranes) Limit switches shall be in accordance with Specification CMAA 70.	Limit switches for the aux hoist are in accordance with Specification CMAA 70. Ref. MMH Drawing R94965 (Aux Hoist Assembly).
5459.3 Clearances For determining clearances between the trolley structure and the load block in its high position, allowance shall be made for lift, trip, and drift as shown in Figs. 5459.3-1 and 5459.3-2.	Allowances are provided for the lift, trip and drift of the bottom block. Available lift is detailed in MMH Drawing R94779 (Trolley Assembly) and the trip and drift will be adjusted and verified per MMH Document 36675-13 (Site Acceptance Test Procedure).
5460 Lubrication **5461 Type I Cranes** ***(a)*** Sheave bearings shall be individually lubricated and accessible for lubrication from the trolley deck for the head block assembly and the operating floor for the load block assembly. Load blocks	***(a)*** The main hoist sheave bearings are sleeve type with lubrication inserts and do not require additional lubrication. The thrust bearing is provided with water-insoluble grease and is easily accessible for relubrication as

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that are immersed in water shall have special provisions to prevent loss of lubricant to the water (refer to para. 1100). ***(b)*** Hoisting ropes, except for stainless steel ropes (consult manufacturer), shall be lubricated. When ropes are immersed in water, the lubricant type shall be selected to reduce the loss of lubricant to the water. ***(c)*** Lubricants for gears, bearings, and wire ropes shall resist effects of gamma or neutron radiation when such effects are present, or facilities shall be provided for changing of the lubricants. ***(d)*** If lubricants cannot be conveniently changed, but are subjected to neutron or gamma radiation, then lubricants shall be NLGI Grade 0 oil containing molybdenum disulfate or NLGI Grade 11⁄2 grease with sodium aluminate thickener. They shall be oxidation and rust inhibited with the exception of wire rope lubricants. ***(e)*** Provisions shall be made to prevent lubricants falling from the crane. ***(f)*** For all above paragraphs, refer to Section 1000.	required. Ref. MMH Drawing R95005 (Main Hoist Bottom Block Assembly). Ref. MMH Drawing QR94824 (Main Hoist Wire Rope Assembly). ***(b)*** The main hoist wire rope is provided with lubrication that is designed for immersion in water. ***(c)*** Lubricants for gears, bearings, and wire ropes are selected to be compatible with facilities that handle radioactive material. ***(d)*** N/A - Lubricants can be conveniently changed per MMH Document 36675-20 (Operation & Maintenance Manual). ***(e)*** Provisions to prevent lubricants falling from the crane include oil seals for lubricated parts and oil-tight drip pans under gearboxes. Ref. MMH Drawing R94779 (Trolley Assembly). ***(f)*** Lubricants are selected with consideration for the environmental conditions in Section 1000. See Note 1.
5462 Types II and III Cranes Lubrication shall be in accordance with Specification CMAA 70, unless the crane is subjected to radiation. If Types II and III cranes are subjected to radiation, then the provisions of para. 5461 apply.	The aux hoist components are provided with lubrication means in accordance with Specification CMAA 70. Ref. MMH Drawing R94965 (Aux Hoist Assembly).
5470 Analytical Procedures It is the purpose of para. 5470 to apply common language for the terms, symbols, data, and formulas that apply most frequently in the process of mechanical crane engineering. The effects of service and stress concentrations are treated separately from the allowable stresses to conform with actual service conditions and actual design geometry. ***(a)*** The basic stress formulas have been listed to achieve uniformity in recording and combining of design stresses throughout the industry. Where applicable, formulas and symbols shall be used as defined in this Standard. All other formulas and symbols used in	***(a)*** Basic stress formulas and symbols are used as defined in this Standard as applicable. All other formulas and symbols used in design calculations conform as far as possible to the method outlined and shown. The given data is applied to low and medium carbon steel and to heat treated alloy steel. ***(b)*** Material strength properties are treated on the basis of ultimate strength where applicable. ***(c)*** The design criteria of this Standard are applied to the crane to prevent progressive fatigue failure.

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design calculations shall conform as far as possible to the method outlined and shown. The given data apply to low and medium carbon steel (usually used as hot rolled and normalized) and to heat treated alloy steel (usually used as quenched and tempered). ***(b)*** Material strength properties have been treated on the basis of ultimate strength because it has a good relationship to the fatigue strength. No differentiation has been made between various materials because of the wide scatter of fatigue strength for each individual heat or each finished component. Heat treated alloy bar has, on the average, higher fatigue strength than medium carbon steel of the same ultimate tensile strength. ***(c)*** Progressive fatigue failure represents the most common mode of failure in crane machinery. The design criteria of this Standard are, therefore, directed mainly to the prevention of accumulative damage to the material of mechanical crane components.	
5471 Stress Concentration Factors (Type I Cranes) ***(a)*** Stress concentration factors K_{NB}, K_{NS}, K_{NT} for shafting in bending, shear, and torsion may be obtained from Stress Concentration Factors by R. E. Peterson.[1] These factors shall give consideration to the effects on the fatigue strength of fillet radii, as well as keyways, combined with heavy press fits. Stress concentration factors for all other forms of notches (such as lubrication holes, threads, grooves) as well as other modes of stressing must also be considered and may be obtained from Stress Concentration Factors.[1] ***(b)*** A combination of stress concentration factors must take place when two or more stress concentrations superimpose in one location — for example, keyway and/or press fit extending in the critical region of a shaft fillet. The proper stress concentration factors K_{NB} or K_{NN} must be applied in calculating σ_X or σ_Y stresses, depending on whether σ_X or σ_Y are basically bending or tension–compression stresses. Stress concentration factors must be entered into calculation even if equal to 1.0.	***(a)*** Stress concentration factors are factored into the design of the crane components where applicable. ***(b)*** Combinations of stress concentration factors are factored into the design of the crane components where applicable.
5472 Nomenclature	

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[Text and/or equations omitted]	Specified nomenclature is used for applicable design parameters.
5473 Working Stresses The maximum working stresses in Class I crane machinery components shall not exceed the maximum allowable stresses σ_{BA}, σ_{NA}, σ_{XA}, σ_{YA}, τ_A, or τ_{TA} unless otherwise specified by the Purchaser. The working stresses (σ_B, σ_N, σ_{EBN}, σ_{EB}, σ_{EN}, σ_X, σ_Y, σ_{EXY}, σ_{EXYT}, τ_X, τ_T, τ_{ET}, τ_{XY} and σ_{EXYT}) are uniaxial, biaxial, shear, combined, or equivalent stresses, which are induced in a mechanical component by the working (operational) loads. The maximum working loads shall include dead loads, maximum live loads, and acceleration and deceleration forces which result from normal operation of the crane. The maximum calculated working stresses shall include both service and stress concentration factors.	Maximum working stresses for machinery components do not exceed the maximum allowable stresses as specified. Maximum working loads include service and stress concentration factors, dead loads, maximum live loads, and acceleration and deceleration forces which result from normal operation of the crane.
5474 Allowable Stresses The allowable stresses σ_{BA}, σ_{NA}, τ_A, and τ_{TA}, which shall be obtained from Figs. 5474-1 through 5474-3, vary with the minimum ultimate tensile strength σ_{UT} of the material in use, as well as with the fluctuation ratios R_B, R_N, R_S, R_T of the working stresses. σ_{XA} and σ_{YA} shall be selected from Figs. 5474-1 or Fig. 5474-2, depending upon whether σ_X or σ_Y are basically bending or tension–compression stresses. τ_{TA} shall be selected directly from Fig. 5474-3.	Allowable stresses are selected from Figs. 5474-1 through 5474-3 as required with respect to the ultimate tensile strength and fluctuation ratios of the working stresses.
5475 Service Factors Service factors K_{SB}, K_{SN}, K_{SS}, and K_{ST} are to be based on para. 5320. Not all components within a crane drive system are necessarily subjected to the same service. Service factors shall give consideration to the following: ***(a)*** risk and consequences of potential failure; ***(b)*** indeterminate load reactions (for example, trolley with rigid frame supported on four track wheels); ***(c)*** unpredictability of operation conditions — for example, unexpected accidents within the building; ***(d)*** dynamic effects — for example, impacts in hoist mechanisms and seismic effects.	Service factors are based on para. 5320 and give consideration to the following: ***(a)*** risk and consequences of potential failure; ***(b)*** indeterminate load reactions; ***(c)*** unpredictability of operation; ***(d)*** dynamic effects.

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5476 Basic Stress Equations ***(a)*** Where applicable, Eqs. (13) through (27) must be used in determining basic stresses in crane machinery components. For determining size of machinery components, maximum working (operational) moments and shear loads, as well as critical section moduli, must be entered into these formulas. ***(b)*** Sign convention must be observed when entering σ_X and σ_Y in Eqs. (25), (26), and (27). (Tension is positive, compression is negative.) ***(c)*** Only stresses which do occur simultaneously at the location where stress is being calculated should be combined. ***(d)*** In Eqs. (19) through (27), anisotropy and stress fluctuation have been given consideration in a simplified manner for easier use in the design engineering process. ***(e)*** For sample calculation, refer to Nonmandatory Appendix B, para. B5476. ***(f)*** The following are the basic stress equations: [Text and/or equations omitted]	***(a-f)*** The basic stress equations outlined in this para. are applied as applicable to the crane machinery components using the maximum operational load combinations.
5477 Analytical Method for Hook of Approximate Trapezoidal Shape (Types I, II, and III Cranes) ***(a)*** *Method of Analysis.* The analytical method given in this section is intended to apply to hooks with cross-sections having a shape as shown by the full line of Fig. 5477-1, which does not deviate significantly from a trapezoidal form. This includes a large number of practical crane-hook sections, such as shown in Fig. 5477-2. This method, while approximate, is much faster than the numerical integration method, and, in the cases to which it has been applied, it has given close agreement with the latter method. Essentially, the analytical method is based on the assumption of an equivalent trapezoidal section having an area equal to that of the actual section. The stress computed in this way is then corrected for the stress increase in the neutral section resulting from the fact that the fibers nearest the center of curvature are farther from the	***(a)*** N/A - The aux hoist hook is purchased from a manufacturer and has a published load rating and safety factor appropriate for the load. ***(b)*** The method of analysis and design of the main hoist sister hook is made using the straight beam configuration for the hook. Ref. MMH Document 36675-23 (Main Hoist Reeving Stress Report). ***(c)*** References are consulted as necessary.

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neutral axis than in the case of the equivalent trapezoidal section. It is assumed that the resultant load on the hook passes through the center of curvature of the curved part and that the critical section is at 90 deg to the resultant load. [Text and/or equations omitted] ***(b)*** The method of analysis and design of a sister hook shall be made using the straight beam configuration for the hook. *(1)* Figure 5477-4 shows the general outline and a shade of a sister hook without a pin hole. *(2)* Figure 5477-5 shows the general outline and shape of a sister hook with a pin hole. ***(c)*** *References for para. 5477* *(1) Strength of Materials*, S. Timoshenko, Second Edition, Part 2, D. Van Nostrand Co., New York, NY, 1941, p. 65. *(2) Stresses in Curved Bars*, H. C. Perkins, Transactions of ASME, Vol. 53, 1931, p. 201. *(3) Mathematical Methods in Engineering*, Thomas von Karman and M. A. Biot, McGraw-Hill Book Co., 1940, p. 5. *(4) Stress Concentration Factors*, R. E. Peterson, John Wiley & Sons, New York, NY, 1974.	
5480 Seismic Analysis **5481 Type I Cranes** ***(a)*** Analysis confirming that the critical load will not be dropped as a result of the forces generated by seismic events shall be performed (see Section 4000). *(1)* The analysis may be static if it includes loads equivalent to those which would be imposed by the seismic event specified. *(2)* Loads due to vertical and horizontal motions shall act together and shall be combined in accordance with para. 4100.	Ref. MMH Document 36675-05 (Bridge Stress Calculations) and MMH Document 36675-09 (Seismic Analysis) for the following items: ***(a)*** Analysis confirming that the critical load will not be dropped as a result of the forces generated by a seismic event is provided. *(1)* N/A - The analysis is performed dynamically. *(2)* Loads due to vertical and horizontal motions act together and are combined in accordance with para. 4100. *(3)* All elements which support the critical load are analyzed, not including material fatiguing, stress concentration factors, and

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(3) All elements which support the critical load shall be analyzed as follows and should not consider material fatiguing, stress concentration factors, and infinite life criteria. *(a)* The stress level at all critical points shall be determined. *(b)* The gross cross-section shall be used in determining the stress level. *(c)* The maximum stress level shall not exceed 90% of the yield strength of the material. *(4)* All computations are to be based on the bulk cross-section of the material without consideration to any fatiguing effects of stress risers, or to the endurance limits of the material. The seismic forces according to the rules in para. 5300 are to be algebraically added to the forces and torques under normal operation. ***(b)*** Analysis shall be performed to confirm that those components which would damage safety related equipment if dropped will remain in place during the seismic event. ***(c)*** Components whose major resonant frequency is greater than 30 Hz may be analyzed as a lumped mass. *(1)* Analysis shall consist of the determination of the stress level of the mounts when applying maximum dynamic forces to the center of gravity of the item. *(2)* Loads shall be combined as in (a)(2) above. ***(d)*** Components whose major resonant frequency is less than 30 Hz shall be analyzed dynamically.	infinite life criteria. *(a)* The stress level at all critical points is determined. *(b)* The gross cross-section is used to determine the stress levels. *(c)* The maximum stress levels do not exceed 90% of the material yield strength. *(4)* Computations are based on the bulk cross-section of the material and the seismic forces are combined per para. 5300. ***(b)*** An analysis will be provided that confirms that those components which would damage safety related equipment if dropped will remain in place during the seismic event. Ref. MMH Document 36675-14 (Seismic Analysis of Misc. Items). ***(c)*** Components whose major resonant frequencies are greater than 30 Hz are analyzed as a lumped mass. *(1)* Analysis determining the stress level of the mounts when applying maximum dynamic forces to the center of gravity is detailed in Ref. MMH Document 36675-14 (Seismic Analysis of Misc. Items). *(2)* Vertical and horizontal loads are combined in accordance with para. 4100, as in (a)(2) above. ***(d)*** Components whose major resonant frequency is less than 30 Hz are analyzed dynamically.
5482 Type II Cranes ***(a)*** Analysis shall be performed to confirm that those components which would damage safety related equipment if dropped will remain in place during the seismic event. ***(b)*** Such components shall be delineated by the bidding documents. ***(c)*** Analysis shall be as listed in para. 5481.	***(a-c)*** N/A - This is a Type I Crane

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5483 Type III Cranes Seismic analysis is not required unless specified by the purchaser.	N/A - This is a Type I Crane
5500 MISCELLANEOUS **5510 Pendant Hoist and Travel Drives (Types I, II, and III Cranes)** **5511 Crane Pendant Mounting** The crane purchaser shall prescribe whether pendant control stations, if furnished, are to be mounted from the trolley frame, fixed positions on the bridge, or a messenger trace on the bridge. The purchaser shall also prescribe whether the crane is to be pendant controlled from several elevations in the building. Whenever possible, the pendant should be suspended in a manner that minimizes undue strains on the electrical conductor cable. A chain or wire rope strain relief should be provided, unless the pendant is suspended directly from a motorized cable reel.	N/A - Radio controls are specified instead of a pendant
5512 Messenger Track System ***(a)*** The track itself should consist of a commercially available profile section, such as a rolled I-beam or an extrusion. A guide wire arrangement commonly known as a Tag-Line System shall be unacceptable for Type I cranes. ***(b)*** Messenger trolleys shall be compatible with the track and shall be of sufficient load carrying capacity to suspend the combined weights of the pendant, cables, and accessories, as well as the pull which could be developed while maneuvering the control station. Messenger trolley rollers shall be mounted on sealed antifriction bearings and shall be provided with lubrication fittings unless bearings are lubricated for life. Individual messenger trolleys should be interconnected by strain relief chains or cables to reduce strains on the electrical control cables when traversing.	N/A - Radio controls are specified instead of a pendant
5513 Motorized Traversing The crane purchaser shall prescribe whether pendant traversing is required. If furnished, the traversing tractor shall be controlled from the pendant station. If cable reels are suspended from a messenger track, consideration should be given to a motorized traversing	N/A - Radio controls are specified instead of a pendant

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system. Consideration should also be given to ensure that the *pendant station is accessible to the operator after it has been lifted* or lowered by a reel.	
5514 Vertical Travel of Control Pendant In cases where pendant crane control is required from several elevations, the purchaser shall specify such requirements. Methods of raising and lowering the pendant shall be determined and specified by the purchaser, depending on prevailing conditions. Commonly used and readily available lifting and lowering devices consist of spring-operated load balancing reels, or motorized cable reels. In cases where motorized cable reels are used, the pendant shall be suspended directly from the electrical cable, without a strain relief rope.	N/A - Radio controls are specified instead of a pendant
5515 Speeds For pendant hoist and travel speeds, refer to para. 5334.	N/A - Radio controls are specified instead of a pendant
5520 Load Weighing Devices (Types I, II, and III Hoists) ***(a)*** Load weighing devices for a hoist unit shall be provided if requested by the purchaser. ***(b)*** Weighing accuracy, location and type of readout, and increments of the readout shall be specified by the purchaser. ***(c)*** Refer to Section 6000 for overload devices.	***(a)*** A load weighing device is provided for the main and aux hoists. ***(b)*** Requirements for the load weighing system are provided in Zion Specification SP-ZS-FH-003. ***(c)*** Overload devices are in accordance with Section 6000.
5530 Welded Construction **5531 Type I Cranes** All welding design and procedures shall conform to the current issue of AWS D1.1. Where special steels or other materials are used, the manufacturer shall provide welding procedures.	Welding design and procedures for the trolley are specified in MMH Nuclear Operating Procedure #5.0.1, which complies with both AWS D14.1 and D1.1 where applicable. Procedures qualified under AWS D1.1 are acceptable under AWS D14.1 per Section 9.1.4. Procedures for special materials are also contained in this document. See Note 1.
5532 Types II and III Cranes Welding shall be in accordance with Specification CMAA 70.	N/A - This is a Type I Crane
5540 Hydraulics (Types I, II, and III Cranes)	

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(a) Hydraulic components and fluids shall be selected to withstand maximum facility lifetime radiation exposure, unless a detailed maintenance program shall be supplied. ***(b)*** Critical loads or facility equipment shall be protected from leakage. ***(c)*** Commercial industrial hydraulic components in the critical load path shall be selected and rated to not exceed 20% of the average ultimate strength of the material.	***(a-c)*** N/A - Hydraulic components are not used on this crane
5550 Ordering Information Orders for cranes under this Standard shall include the following information. ***(a)*** *Load Spectrum Information.* Refer to para. 5111(a). ***(b)*** *Seismic Consideration for Type III Cranes, If Required.* Refer to para. 5310(b)(3). ***(c)*** *Hoist Speeds.* Refer to para. 5331.1(a). ***(d)*** *Trolley Speeds.* Refer to para. 5332.1(a). ***(e)*** *Bridge Speeds.* Refer to para. 5333.1(a). ***(f)*** *Powered Hook Rotation.* Refer to paras. 5335(a) and (b). ***(g)*** *Bearing Life Computations.* Refer to para. 5455.1(b)(5)(a). ***(h)*** *Seismic Analysis for Type III Cranes, If Required.* Refer to para. 5483. ***(i)*** *Crane Pendant Mounting.* Refer to para. 5511. ***(j)*** *Motorized Traversing.* Refer to para. 5513. ***(k)*** *Vertical Travel of Control Pendant.* Refer to para. 5514. ***(l)*** *Loading Weighing Devices.* Refer to paras. 5520(a) and (b).	The following items are detailed in Zion Specification SP-ZS-FH-003: ***(a)*** Load spectrum information ***(b)*** N/A - This is a Type I Crane ***(c)*** Hoist speeds ***(d)*** Trolley speeds ***(e)*** Bridge speeds ***(f)*** N/A - Powered hook rotation is not required ***(g)*** N/A - Bearing life computation requirements in addition to para. 5455.1 are not specified ***(h)*** N/A - This is a Type I Crane ***(i)*** N/A - Radio controls are specified instead of a pendant ***(j)*** N/A - Radio controls are specified instead of a pendant ***(k)*** N/A - Radio controls are specified instead of a pendant ***(l)*** Loading weighing devices
6000 Electrical Components	
6100 GENERAL ***(a)*** The specification for each crane shall state which crane classification applies (para. 1130). Types are summarized from para. 1150 as follows: *(1) Type I Cranes:* single failure-proof features and seismic considerations;	The following items are detailed in Zion Specification SP-ZS-FH-003: ***(a)*** A Type I Crane is specified ***(b)*** The specification details all requirements for materials, coatings, radiation exposure, environmental conditions, and quality assurance. ***(c)*** Generally available equipment which conforms to industry standards,

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(2) *Type II Cranes:* seismic considerations only; (3) *Type III Cranes:* neither single failure-proof features nor seismic considerations. ***(b)*** The specifications for each crane shall include any special requirements for components in accordance with the following: (1) limiting the use of aluminum, zinc, mercury, and other specified materials (para. 6130); (2) painting (para. 6140); (3) life at specified values of radiation exposure (para. 6150); (4) environmental conditions (para. 6160); (5) quality assurance (para. 6170). ***(c)*** Generally available equipment which conforms to industry standards, such as those of NEMA, shall be used unless special designs are necessary. ***(d)*** The electrical equipment is not required to qualify as IEEE 323 Class 1E. ***(e)*** The specification for each Type III crane shall state whether Section 6000 or CMAA 70 is to be invoked for electrical components.	such as those of NEMA, is used unless special designs are necessary. ***(d)*** Electrical equipment does not qualify as IEEE 323 Class 1E, and is not required to. ***(e)*** N/A - This is a Type I Crane
6110 Single Failure-Proof Features (Type I Cranes) ***(a)*** The electrical system shall be designed so that it is possible for the operator to stop and hold a critical load regardless of the failure of any single component used in normal operation. ***(b)*** There shall be means at the operator's location that will allow him to remove power from all drive motors and brakes by opening or de-energizing a power device that is not required to close and open during normal "run-stop" operations. ***(c)*** Any inadvertent short circuit or ground shall be considered a single component failure. ***(d)*** The avoidance of two-blocking shall be accomplished by the use of single failure-proof features and shall not rely on any action by the operator. The normal hoist limit switch shall be supplemented	Ref. MMH Drawing R95399 (Electrical Schematic) for the following items: ***(a)*** The electrical system is designed to be failsafe so that the load is automatically stopped and held in the event of a single component failure. The operator may also stop and hold the load manually at any time by activating the emergency stop. ***(b)*** A master control relay is provided that opens the power circuit to all motors and sets all brakes when the operator depresses the emergency stop on either the radio or cab controls. Under normal operations, the master control relay does not change state. ***(c)*** Any short circuit or ground causes a fault in the drive or circuit breaker and safely shuts down the system. ***(d)*** Each hoist is equipped with two independent upper limit switches that

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by an independent final hoist limit switch operated by the load block to remove power from the hoist motor and brakes.	do not rely on action by the operator. The first gear-type limit switch is supplemented by a second weigh-operated limit switch that removed hoist power and sets the brakes when contacted by the load block.
6120 Seismic Considerations (Types I, II, and III Cranes) ***(a)*** *Type I Cranes.* The user shall provide the equipment that shall de-energize the crane power supply in the event of either a Safe Shutdown Earthquake (SSE) or an Operational Basis Earthquake (OBE). The hoist brakes shall be capable of holding the credible load during an SSE or OBE event, as determined in accordance with para. 6422.1(b). All electrical equipment shall remain on the crane during these seismic events. ***(b)*** *Type II Cranes.* Requirements are the same as for Type I cranes, except that the brakes need not be capable of holding the load during a seismic event. ***(c)*** *Type III Cranes.* Seismic considerations are not required for Type III cranes.	***(a)*** ZionSolutions is responsible for supplying an appropriate means to disconnect the power supply in case of a seismic event. ZionSolutions will install an automatic system to de-energize the crane power supply in the event of either a safe Shutdown or an Operational Basis Earthquake. The hoist brakes are capable of holding the credible load during a seismic event. New control cabinets, raceway, junction boxes, and conduit will be secured to withstand forces due to the specified seismic events. ***(b)*** N/A - This is a Type I Crane ***(c)*** N/A - This is a Type I Crane
6130 Limiting the Use of Specified Materials (Types I, II, and III Cranes) ***(a)*** If the crane specifications require that the content of certain specified materials for use on a crane be kept at a minimum [para. 1145(a)], but it is not practical to eliminate these specified materials completely, the electrical supplier shall tabulate their weight or surface area or the content of an alloy under the following categories: *(1) exposed,* as in the head of a master switch; *(2) bare, within a ventilated enclosure,* as in the shaft fan and rotor bars of a ventilated squirrel cage motor; *(3) bare, within a nonventilated enclosure,* as in a totally enclosed nonventilated squirrel cage motor; *(4) covered,* as in insulated windings within a nonventilated motor, lighting transformer, reactor, etc. ***(b)*** Galvanized conduit may be used except when specifically	***(a)*** N/A - There are no special requirements for limiting electrical materials per Zion Specification SP-ZS-FH-003. ***(b)*** Galvanized conduit is used on the crane and is not specifically prohibited.

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prohibited by the crane specifications.	
6140 Painting (Types I, II, and III Cranes) When the crane specifications include special painting requirements, the electrical items are exempt from the special painting requirements and shall be furnished with a standard industrial finish [see para. 3230(i)].	There are no special painting requirements per Zion Specification SP-ZS-FH-003. Electrical items are furnished with a standard industrial finish per para. 3230. Ref. MMH Document 36675-02 (B22 Painting Specification).
6150 Radiation Exposure [Types I, II, and III Cranes (para. 1141)] *(a)* If the crane is in a location where radiation levels are likely to be a factor in the life of the electrical equipment, the maximum rate of radiation and the total accumulated exposure at the crane elevation shall be stated in the crane specifications. *(b)* Insulation in rotating machines, brakes, and magnetic device coils may be required to meet an accumulated dosage of 10^7 rad in 40 years. Components, such as regulator cards, that can be removed without disconnecting wiring may be required to meet an accumulated dosage of only 10^4 rad, on the basis that such components can be removed and stored in a location where they will not be exposed to more than normal atmospheric radiation during the long time intervals in which the crane will not operate after the power plant has been placed in service. If the user prefers not to remove the components, it will be permissible to establish a routine maintenance procedure of installing new components after they have accumulated a total exposure of 10^4 rad. *(c)* The electrical equipment supplier shall submit data demonstrating that the type of insulation used in the equipment being supplied meets the radiation requirements in the crane specifications.	Ref. Zion Specification SP-ZS-FH-003 for the following items: *(a)* The total accumulated radiation exposure for the life of the crane is provided. *(b-c)* N/A - The total accumulated radiation exposure for the life of the *crane does not pose a risk for the electrical components.*
6160 Environmental Conditions (Types I, II, and III Cranes) *(a)* The electrical equipment specifications shall state environmental conditions to which that equipment may be subjected, such as: *(1)* high humidity or high or low temperatures during prolonged intervals when the crane is in storage or not in	*(a)* Environmental conditions that are applicable to all crane components, including humidity, temperature, pressure, and chemical sprays, are provided in Zion Specification SP-ZS-FH-003.

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use; (2) outside service: *(a)* temporary — during construction only *(b)* continuous *(3)* pressure (para. 1143): *(a)* maximum pressure *(b)* rate of change in pressure *(4)* spray [para. 1145(a)]; *(5)* ambient temperature (para. 1142): *(a)* rated *(b)* short time exposure to temperatures outside rated ambient range *(6)* humidity (para. 1144).	
6170 Quality Assurance (Types I, II, and III Cranes) There shall be no Quality Assurance Program requirements for activities covered by Section 6000, except for those specifically required in the electrical procurement documents (see para. 2100).	There are no Quality Assurance Program requirements for activities covered by Section 6000 detailed in Zion Specification SP-ZS-FH-003. Quality Assurance for packaging, shipping, receiving, storage, and handling of components is provided in accordance with para. 2100.
6180 Duty Cycle or Duty Class (Types I, II, and III Cranes) The specifications shall state the duty cycle requirements in accordance with para. 6418.2 or the electrical duty class that applies to each motion as determined by Table 6472.3(b)-1. If the crane is to be used for construction purposes, the duty cycles or classes required for that service shall be specified. In addition, any requirements for prolonged operation at reduced speed shall be specified.	Electrical duty class is provided for each motion in Zion Specification SP-ZS-FH-003 per Table 6472.3(b)-1. The crane is not being used for construction or prolonged operation at reduced speed.
6200 WIRING MATERIALS AND METHODS (TYPES I, II, AND III CRANES) **6210 General** ***(a)*** *Applicable Standards:* *(1)* National Electrical Code (NEC, Article 610, "Cranes and Hoists") *(2)* American Society for Testing and Materials (ASTM) B 8	Ref. MMH Document 36675-06 (Electrical Calculations) and MMH Drawing R95399 (Electrical Schematic) for the following items: ***(a)*** Wiring materials and methods meet or exceed NEC Article 610, ASTM B8, ASTM B174, and NEMA ICS-1.

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and B 174 *(3)* National Electrical Manufacturers Association (NEMA), Pub. No. ICS 1 ***(b)*** The provisions of this Section apply to interconnecting wiring both within and external to control panel enclosures. It does not apply to wiring which forms an integral part of equipment such as motors, individual control components — for example, contactors, transformers, and relays — and electronic control subassemblies. ***(c)*** The complete raceway system including wire shall be assembled on the crane at the crane manufacturer's facility. Where disassembly is necessary for shipment, components shall be match-marked for ease of field erection. Where any portion of a raceway run must be disconnected or dismantled to permit shipment, the wire shall not be pulled through that raceway during shop assembly. Wire not pulled shall be cut to approximate length and bound in coils marked for the circuit for which it applies. ***(d)*** The wiring system shall meet the applicable requirements of NEC, Article 610. ***(e)*** For Types I and II cranes, the raceway system shall be secured and braced to withstand forces due to specified seismic events. ***(f)*** For cranes located inside the containment, consideration shall be given to rapid pressure changes as required by the specification. Pressure relief openings in electrical enclosures shall be provided where necessary to equalize these pressures.	***(b)*** N/A - Wiring materials and methods meet the requirements of (a) for all components. ***(c)*** The crane controls are pre-wired and will be tested at the factory per MMH Document 36675-07 (Factory Acceptance Test Procedure). The trolley and controls are shipped with as much of the wiring connected as possible to minimize start up or reconnection errors in the field. Wire that is integrated into existing raceway, junction boxes, or conduit is cut to approximate length and bound in coils marked for the circuit for which it applies. ***(d)*** The wiring system meets or exceeds the requirements of NEC Article 610. ***(e)*** New control cabinets, raceway, junction boxes, and conduit are secured to withstand forces due to the specified seismic events. ***(f)*** N/A - This crane is not inside containment. See Note 1.
6220 Materials **6221 Conductors** ***(a)*** Individual conductors including those in multiconductor cables shall have a maximum operating temperature rating not less than 167°F. ***(b)*** Multiconductor cable shall be permitted in wiring the crane. Uses of the cable shall comply with the National Electrical Code. Multiconductor cable used in flexing service shall be Type SO, Type W, or a purchaser-approved alternative.	 Ref. MMH Document 36675-06 (Electrical Calculations) and MMH Drawing R95399 (Electrical Schematic) for the following items: ***(a)*** The standard wire used for electrical panelboards and in conduit is XHHW-2/SIS, which has a 90° C (194° F) temperature rating. ***(b)*** Multiconductor cable used in the wiring of the crane meets or exceeds the requirements of NEC. Multiconductor cable used in flexing service is Type SO or Type W.

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(c) All control conductors and cables used with AC inverter type controls and having operating voltages less than 110 V shall be of a shielded type. ***(d)*** Minimum sizes of conductors shall be as follows: *(1)* No. 14 AWG for power and lighting circuits *(2)* No. 16 AWG for control circuits *(3)* No. 18 AWG for electronic circuits ***(e)*** Conductors shall be annealed copper with minimum stranding as follows: *(1)* ASTM B 8 Class B for nonflexing service *(2)* ASTM B 174 Class K for flexing service ***(f)*** Color coding, if specified, shall be per NEMA Part ICS 1-112.64.	***(c)*** All control conductors and cables with operating voltages less than 110 V are shielded. ***(d)*** Minimum conductor sizes meet or exceed the requirements as specified. ***(e)*** Conductors are annealed copper with stranding in accordance with ASTM specifications for flexing and nonflexing service. ***(f)*** Color coding, where specified, is per NEMA Part ICS 1-112.64. See Note 1.
6222 Raceways ***(a)*** Wiring external to control panel enclosures or assemblies of control panels with integral raceways shall be installed in rigid metal conduit except as otherwise permitted in this Section or as specifically approved by the purchaser. ***(b)*** Short lengths of open conductors shall be permitted at collectors and within enclosures or guards for resistors, reactors, and transformers. ***(c)*** Conduit smaller than 3/4 in. diameter trade size shall not be used. ***(d)*** An electrically continuous system, either liquid-tight or properly drained, shall be used. For a liquid-tight system, gaskets, bushings and seals shall be used where appropriate. ***(e)*** Flexible metal conduit may be used to enclose conductors to stationary or infrequently moved devices such as motors, brakes, master switches, and limit switches, or to equipment subject to vibration. The length of flexible conduit shall not exceed 3 ft. ***(f)*** Connections to moving parts (e.g., bridge to trolley, bridge or trolley to pendant push-button station) may be made by flexible cable not enclosed in conduit. ***(g)*** Conduit shall be rigidly attached to the crane by conduit	Ref. MMH Drawing R95797 (Conduit Layout) for the following items: ***(a)*** All wiring external to control panel enclosures are installed in rigid galvanized steel conduit. ***(b)*** Short lengths of open conductors are used as required at collectors and within enclosures or guards for resistors, reactors, and transformers. ***(c)*** Conduit smaller than 3/4 in. diameter trade size is not used. ***(d)*** Raceways, including pull boxes and wire troughs, are provided with drain holes or are liquid-tight with gaskets and seals. ***(e)*** Flexible metal conduit is used to enclose conductors to stationary or infrequently moved devices such as motors, brakes, master switches, and limit switches, or to equipment subject to vibration. Length of flexible conduit sections does not exceed 3 ft. ***(f)*** Connections to moving parts are made by flexible cable not enclosed in conduit. ***(g)*** Conduit is rigidly attached to the crane by conduit supports that are bolted or welded in accordance with para. 4230. Conduit is not directly welded. See Note 1.

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supports. Welding of conduit shall not be permitted. Conduit supports may be welded to structural members; welding shall be in accordance with para. 4230.	
6230 Wiring Methods *(a)* All conductors shall be identified at each termination by marking with a number to correspond to the schematic diagram. *(b)* Conductors shall be run from terminal to terminal without splices except at devices with integral leads or within junction boxes where connections shall be made with bolted ring-type pressure connectors. *(c)* Pressure-type connectors shall be provided on all wires connected to terminals not equipped with means for retaining conductor strands. *(d)* All external conductors for control circuits shall be routed through terminal blocks with no more than two conductors terminated at each connection point. *(e)* Panel wiring shall be neatly routed and supported in a manner that will not interfere with inspection and maintenance of devices. *(f)* Control conductors external to AC inverter controls that connect to components subject to detrimental effects, due to electromagnetic interference induced in the conductor from other conductors or electrical equipment, shall be of a design or installed in such a manner that prevents such effects. Examples include the following: *(1)* Use individually shielded twisted pair conductors for tachometer or encoder connections. *(2)* Route such conductors through a separate conduit. *(3)* Refrain from splicing connections.	Ref. MMH Drawing R95399 (Electrical Schematic) and MMH Drawing 54214604 (Interconnection Wiring Diagram) for the following items: *(a)* All conductors are identified at each termination with a number corresponding to the schematic diagram. *(b)* Conductors are run from terminal to terminal without splices except at devices with integral leads or within junction boxes where connections are made with bolted ring-type pressure connectors. *(c)* Pressure-type connectors, such as ferrules, are provided on all wires connected to terminals not equipped with means for retaining conductor strands. *(d)* All external conductors for control circuits are routed through terminals blocks and no more than two conductors are terminated at each connection point. *(e)* All panel wiring is neatly routed and supported in a manner that does not interfere with inspection and maintenance of devices. *(f)* Control conductors that connect components sensitive to EMI are shielded, routed separately from power and high energy sources, and are not spliced. See Note 1.
6300 PERFORMANCE SPECIFICATIONS (TYPES I, II, AND III CRANES) **6310 General** *(a)* The rated load speeds recommended in paras. 5331, 5332, and 5333 are normal speeds based on the rated capacity of the crane. The characteristics of drive systems can vary widely with respect to	*(a)* Rated load speeds for all motions are provided in Zion Specification SP-ZS-FH-003. The variable frequency drives provide constant speed,

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speeds at other than rated load and with respect to lowering speeds at any load. Drive systems shall be chosen to conform to any speed — load constraints stated in the specifications. ***(b)*** If more than one control station is required — for example, cab control and radio remote control — performance criteria for each of the stations shall be specified.	regardless of load. ***(b)*** Performance criteria for the radio control and cab control are provided in Zion Specification SP-ZS-FH-003
6320 Hoist ***(a)*** Hoist design rated load speed and speed load characteristics shall be in accordance with para. 5331. The corresponding rated load lowering speed shall not exceed 125% of the hoisting speed. ***(b)*** The maximum lowering speed with 125% capacity test load shall not exceed the maximum lowering speed with rated load by more than 10%. ***(c)*** Auxiliary hoists on Type I cranes shall meet the requirements of single failure-proof design if they handle critical loads. If, through administrative control or other means, assurance is provided that no critical load will be handled by an auxiliary hoist, it shall meet the performance requirements of hoists for Type II cranes. ***(d)*** The hoist drive characteristics shall be such that the peak acceleration and deceleration of the load does not exceed 5 ft/sec^2. ***(e)*** On Type I crane hoists that handle critical loads, control with a high-speed, light-load feature shall be equipped with a means of locking out this feature when handling a critical load. ***(f)*** The stopping distance for various hoist designs is variable. On Type I crane hoists that handle critical loads, the stopping distance shall not exceed 5 in. while lowering the maximum critical load at its maximum speed unless specified otherwise by the purchaser.	Ref. the variable frequency drive parameters specified in MMH Drawing R95399 (Electrical Schematic) for the following items: ***(a)*** Hoist design rated load speed and speed load characteristics are in accordance with para. 5331. The corresponding rated load lowering speed does not exceed 125% of the hoisting speed. ***(b)*** The variable frequency drives for the main and aux hoists limit hoisting speed to within ±10% of the rated load hoisting speed for all loads. ***(c)*** The auxiliary hoist does not handle critical loads and is not single failure proof. The aux hoist meets the hoist requirements in the applicable sections for Type II cranes. ***(d)*** Peak accelerations and decelerations for the main and aux hoists are set to not exceed 5 ft/sec^2. **(e)** Speed-up controls are provided for the main hoist to allow 150% of the rated load hoisting speed when unloaded. The unloaded speed is 7.5 ft/min. The load weighing system detects when a load is on the hook and disables this feature. ***(f)*** The stopping distance for the main hoist with dynamic braking does not exceed 5 in. while lowering the maximum critical load at its maximum speed.
6330 Bridge ***(a)*** The bridge design rated load speed and speed load characteristics shall be in accordance with para. 5333. ***(b)*** Bridge acceleration rates with rated loads should be limited to the values shown in Table 6472.2(b)-1. The operator should have	Ref. the variable frequency drive parameters specified in MMH Drawing R95399 (Electrical Schematic) for the following items: ***(a)*** The bridge design rated load speed and speed load characteristics are in accordance with para. 5333.

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control of deceleration to minimize load swing and avoid wheel slip. In emergency situations such as emergency stop, overspeed, and limit trips, the deceleration rate may exceed the selected acceleration rate and normal deceleration rates. ***(c)*** Type I crane bridge control with a high-speed, light-load feature shall be equipped with a means of locking out this feature when handling a critical load.	***(b)*** Bridge acceleration rates with rated loads are limited to the values shown in Table 6472.2(b)-1. Deceleration rates are automatically controlled by the variable frequency drives to minimize load swing and avoid wheel slip. In emergency situations, the brakes set immediately and deceleration may exceed the selected acceleration rate and normal deceleration rates as permitted. ***(c)*** N/A - A high-speed, light load feature is not provided for the bridge and is not required.
6340 Trolley ***(a)*** The trolley design rated load speed and speed load characteristics shall be in accordance with para. 5332. ***(b)*** Trolley acceleration rates with rated load should be limited to the values shown in Table 6472.2(b)-1. The operator should have control of deceleration to minimize load swing or wheel slip. In emergency situations such as emergency stop, overspeed, and limit trips, the deceleration rate may exceed the selected acceleration rate and normal deceleration rates. ***(c)*** Type I crane trolley control with a high-speed, light-load feature shall be equipped with a means of locking out this feature when handling a critical load.	Ref. the variable frequency drive parameters specified in MMH Drawing R95399 (Electrical Schematic) for the following items: ***(a)*** The trolley design rated load speed and speed load characteristics are in accordance with para. 5332. ***(b)*** Trolley acceleration rates with rated loads are limited to the values shown in Table 6472.2(b)-1. Deceleration rates are automatically controlled by the variable frequency drives to minimize load swing and avoid wheel slip. In emergency situations, the brakes set immediately and deceleration may exceed the selected acceleration rate and normal deceleration rates as permitted. ***(c)*** N/A - A high-speed, light load feature is not provided for the trolley and is not required.
6400 COMPONENT SELECTION (TYPES I, II, AND III CRANES) **6410 Controllers** **6411 General** **6411.1 Applicable Standards** Controllers shall conform to NEC, ASME B30.2, and NEMA Parts ICS 2-213, 3-442, 3-443, and 6-110.	Controllers conform to the requirements of NEC and ASME B30.2. ICS 2-213 is superseded by ICS 9, Part 2, which is superseded by ICS 8, Part 11. ICS 8, Part 11 deals with resistors and rheostats. Dynamic braking resistors are tested by the manufacturer in accordance with NEMA ICS 8 Part 11, Section 9.3. ICS 3-442 is superseded by ICS 8, Part 1. ICS 8, Part 1 deals with general

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	standards for crane controllers rated 600 volts AC/DC or less. All crane controllers conform to ICS 8, Part 1. ICS 3-443 is superseded by ICS 8, Parts 2 - 5. ICS 8, Part 2 deals with constant-voltage DC magnetic controllers for motors on cranes, which are not applicable. Part 3 deals with adjustable-voltage DC controllers for motors on cranes, which are not applicable. Part 4 deals with magnetic controllers for AC wound-rotor motors on cranes, which are not applicable. AC contactor ratings used on the crane conform to the requirements of Part 4. Part 5 deals with static controllers for AC wound-rotor motors on cranes, which are not applicable. ICS 6-110 is superseded by ICS 6. ICS 6 deals with NEMA enclosure ratings (i.e. 12, 4, 4X, etc.). Required tests to validate NEMA ratings are conducted by the enclosure manufacturer. See Note 1.
6411.2 Voltage Variations At an ambient temperature between 32°F and 100°F, the controller shall be capable of operating at a deviation not more than 10% from rated nameplate value, except that for systems using semiconductor power converters, the deviation may be limited to not more than 10% above or 5% below rated name-plate value.	Variable frequency drives are capable of operating at a deviation of +/- 10% from the rated nameplate value per the vendor manuals provided in MMH Document 36675-20 (Operation & Maintenance Manual). Electrical components are designed for a maximum ambient temperature of 110° F per Zion Specification SP-ZS-FH-003, which exceeds the specified requirements. Ref. MMH Document 36675-06 (Electrical Calculations).
6411.3 Ambient Temperature Ambient temperature shall be above 32°F but shall not exceed 100°F. If the specifications state that the equipment is to be operated at ambient temperatures outside this range, the control manufacturer shall be consulted.	Ambient temperature is specified as between 40° F to 110° F per Zion Specification SP-ZS-FH-003. Controllers are selected to operate within the temperatures specified.
6411.4 Enclosure Requirements The enclosures, if required, shall be in accordance with NEMA, Part ICS 6. Consideration shall be given to high humidity or washdown locations, pressure equalization requirements, and outdoor usage	The enclosures are NEMA Type 12, 4X, 3 or 3R in accordance with NEMA Part ICS 6, which complies with the requirements of this section.

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requirements when enclosures are selected.	See Note 1.
6411.5 Protection Against Condensation Unless otherwise specified, enclosed control panels in high humidity locations shall have space heaters to reduce the possibility of condensation. If heaters are used, they should be energized when the crane is to be out of service for more than 8 hr.	Space heaters are not provided for the control panels and are not specified per Zion Specification SP-ZS-FH-003.
6411.6 Hoists ***(a)*** All hoists shall be provided with controlled lowering capable of meeting the performance specifications in para. 6300. ***(b)*** Hoisting shall take place only when the master switch is in a hoisting position. For all loads up to rated load, lowering shall take place only when the master switch is in a lowering position. ***(c)*** For Type I hoists, the devices necessary to comply with the emergency stop requirements of para. 6110(b) shall be within reach of the operator in any operating position. It shall not be necessary to complete a circuit in order to implement these emergency stop provisions. ***(d)*** In the event of an emergency stop or other emergency conditions, the two brakes required by para. 6422.1(a) shall be de-energized without intentional time delay. ***(e)*** Both sides of shunt brake coil circuits on hoists shall be opened when the brake is de-energized. ***(f)*** Type I hoists shall be provided with an indication at the operator's control location to confirm the selected direction of load movement. This indication shall be taken from the drive train motion and electrically separated from the control circuit.	***(a)*** All hoists use variable frequency drives and dynamic braking resistors to provide controlled lowering capabilities in accordance with para. 6300. ***(b)*** Hoisting and lowering is performed manually and occurs only when the master control switch is moved to the corresponding position. ***(c)*** The emergency stop is directly in front of the operator on both the radio and cab controls. Depressing the pushbutton is the only required action to implement the emergency stop. ***(d)*** In the event of an emergency stop, the brakes are immediately set. ***(e)*** The hoist brakes use AC rectified DC shunt coils. Both AC and DC sides are opened when the brake is de-energized. ***(f)*** The radio and cab controls are provided with nameplates that indicate hoisting direction. The direction of travel indicated on the nameplates is verified in MMH Document 36675-13 (Site Acceptance Test Procedure). Encoders are also provided for the hoist motors to provide directional feedback to the variable frequency drives.
6412 Type Selection The type of control supplied shall result in operation complying with the performance specifications in para. 6300, taking into consideration any supplemental requirements stated in the crane specifications. Any of the following types of control that will meet those requirements shall be supplied.	Variable frequency drives are selected for the controls that comply with the performance specifications in para. 6300 and Zion Specification SP-ZS-FH-003
6413 Constant Potential DC	

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6413.1 Hoist ***(a)*** Series motors and series brake(s) shall be used. Control shall provide dynamic braking lowering and include a spring-closed off position dynamic braking contactor to provide self-excitation of the motor series field in the lowering direction. ***(b)*** For Type I hoists, provision shall be made to comply with the maximum hoisting and lowering speed limitations when handling critical loads, as specified in paras. 5331 and 6320, with the overspeed protection specified in para. 6444. Control shall provide that the series brakes cannot be energized unless there is a path for braking current in the motor armature. These provisions are to include the following. *(1)* A double set of conductors and collectors shall be provided in the part of the armature lowering circuit not connected to the series field series brake circuit. *(2)* Any resistance in the armature circuit when lowering shall have a continuous rating equal to the motor rated current. *(3)* If the dynamic lowering contactor in the armature circuit is not closed when the master switch is in any lowering position, the spring-closed emergency dynamic braking contactor shall remain closed. *(4)* Temperature-sensitive devices in the motor shall warn the operator when the temperature approaches a value that could be injurious to the insulation.	***(a-b)*** N/A - Constant potential DC hoist motors are not used on this crane
6413.2 Travel The travel control shall be the reversing, contactor-resistor type with controlled plugging.	N/A - Constant potential DC travel motors are not used on this crane

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6414 Constant Potential AC **6414.1 Hoist** ***(a)*** Speed control may be achieved by the following: *(1)* contactors and resistance in the secondary of the wound rotor motor; *(2)* static power devices such as saturable reactors or thyristors in the secondary of the wound rotor motor; *(3)* contactor(s), and resistance in the primary of a squirrel cage motor *(4)* an electrical load brake; or *(5)* a combination of these methods. ***(b)*** Type I cranes shall be provided with the following: *(1)* open and reverse phase protection; *(2)* a circuit to ensure that power is applied to the hoist motor(s) before the brakes (para. 6422) are released; *(3)* a circuit to de-energize the hoist motor and to set the brakes if the electrical load brake is not energized sufficiently to limit the speed when the control is in a position requiring electrical load brake torque; *(4)* temperature-sensitive devices in motors and load brakes to warn the operator when the temperature of a motor or load brake approaches a value that could be injurious to the insulation or could interfere with meeting the performance specifications in para. 6300.	***(a-b)*** N/A - Constant potential AC hoist motors are not used on this crane
6414.2 Travel ***(a)*** Speed control may be achieved by the following: *(1)* contactors and resistance in the secondary of the wound rotor motor; *(2)* static power devices such as saturable reactors or thyristors in the secondary of the wound rotor motor; *(3)* contactor(s) and resistance in the primary of a squirrel cage motor;	***(a-b)*** N/A - Constant potential AC travel motors are not used on this crane

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(4) an electrical load brake; or *(5)* a combination of these methods. ***(b)*** Control shall include controlled plugging.	
6415 Adjustable Voltage DC ***(a)*** Control shall include a contactor that will disconnect power to any drive not in use. ***(b)*** Control shall include controlled electrical braking and may include a feature that will keep the electrical braking circuit energized until the motor approaches zero speed when the operator wishes to stop. ***(c)*** A contactor shall be provided in the DC motor armature circuit if a generator is the source of DC power, but the contactor can be in either the AC or DC power circuit if static power conversion is used. ***(d)*** Motor field loss protection shall be provided.	***(a-d)*** N/A - Adjustable voltage DC motors are not used on this crane
6415.1 Hoist ***(a)*** Hoists with static power supplies shall include means to automatically remove power from the motor and to set the brake(s) if the drive does not develop braking torque as required when lowering a load or when the operator attempts to reduce speed. ***(b)*** In addition to (a) above, hoists handling critical loads on Type I cranes shall be provided with the following: *(1)* provisions to maintain proper field excitation to comply with the speed limitation in para. 6300. Activation of this speed-limiting feature shall be the responsibility of the designated person responsible for moving critical loads [see para. 6320(e)]. *(2)* a protective circuit to ensure current flow in motor armature circuit before brakes can be energized (current check circuit or torque proving circuit); *(3)* a temperature-sensitive device in the motor to warn the operator when temperature approaches a value that could be injurious; *(4)* temperature-sensitive devices in or near the resistors	***(a-b)*** N/A - Adjustable voltage DC hoist motors are not used on this crane

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that are required to absorb "pump back energy" to warn the operator when the resistors approach a value that could cause them to fail.	
6415.2 Travel ***(a)*** Field loss protection is not required on travel drives having motor field reversing and designed to permit coasting. ***(b)*** When two or more motors connected in parallel are used, provision shall be made at the control panel to permit isolating any motor and to continue operation with the remaining motor(s) with normal protection features, if agreed to by the user, crane builder, and electrical equipment supplier(s).	***(a-b)*** N/A - Adjustable voltage DC travel motors are not used on this crane
6416 Adjustable Voltage AC ***(a)*** Speed control may be achieved by static power devices such as saturable reactors or thyristors in the primary circuit. ***(b)*** Control shall include controlled electrical braking and may include a feature that will keep the electrical braking circuit energized until the motor approaches zero speed when the operator wishes to stop.	***(a-b)*** N/A - Adjustable voltage AC motors are not used on this crane
6416.1 Hoist ***(a)*** The secondary may have a fixed impedance, although a means may be provided to increase the resistance in the secondary of the wound rotor motor for operation at reduced speeds for prolonged periods or if frequent deceleration is anticipated. ***(b)*** An electrical load brake may be used with the above. ***(c)*** Type I cranes shall have protection as required in para. 6414.	***(a-c)*** N/A - Adjustable voltage AC hoist motors are not used on this crane
6416.2 Travel ***(a)*** The secondary may have a fixed impedance, although a means may be provided to increase the resistance in the secondary to permit prolonged operation at reduced speed or to reduce motor heating when plugging. ***(b)*** When two or more motors are used, provision shall be made at the control panel to permit isolating any motor and to continue operation with the remaining motor(s) with normal protection	***(a-b)*** N/A - Adjustable voltage AC travel motors are not used on this crane

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features if agreed to by the purchaser, crane builder, and electrical equipment supplier(s).	
6417 AC Variable Frequency ***(a)*** Control shall consist of a variable frequency drive (VFD) with a full load ampere (FLA) rating equal to, or greater than, the FLA of the corresponding motor(s). ***(b)*** Control shall include, as a minimum, the following protective features: *(1)* output phase loss, *(2)* under voltage, *(3)* over voltage, *(4)* motor thermal overload, and *(5)* VFD overheat. ***(c)*** Control shall provide a control braking means using dynamic braking or line regeneration. ***(d)*** Control shall have a minimum of 150% overload capability for 1 min. ***(e)*** The cable power supply and electronic equipment shall be protected from detrimental effects due to harmonic and EMI/RFI emissions produced by inverters.	Ref. vendor manuals provided in MMH Document 36675-20 (Operation & Maintenance Manual) for the following items: ***(a)*** Variable frequency drives have a full load ampere rating equal to, or greater than, the FLA of the corresponding motors. Ref. MMH Document MMH Document 36675-06 (Electrical Calculations). ***(b)*** Variable frequency drives have protective features including output phase loss, under voltage, over voltage, motor thermal overload, and VFD overheat. ***(c)*** Variable frequency drives provide dynamic control braking. ***(d)*** Variable frequency drives have a minimum of 150% overload capability for 1 min. ***(e)*** Standard practices and designs, including the use of line reactors, isolation transformers, and shielded cables, are used to prevent detrimental effects due to harmonic and EMI/RFI emissions produced by inverters. Ref. MMH Drawing R95399 (Electrical Schematic).
6417.1 Hoist ***(a)*** The VFD control shall incorporate a speed feedback device to sense loss of speed control during any motor operating condition. Hoists with mechanical load brakes are exempt from this requirement. ***(b)*** Control dynamic braking shall be sized for a minimum of 150% of motor full load torque, but shall not, under any circumstances, be less than the torque (or corresponding current) limit setting of the VFD in the hoisting direction. ***(c)*** Control shall sense sufficient motor torque (or corresponding current) before releasing holding brake(s) (i.e., torque proving). Hoists with mechanical load brakes are exempt from this requirement.	Ref. the variable frequency drive manuals in MMH Document 36675-20 (Operation & Maintenance Manual) for the following items: ***(a)*** Encoders are provided for the main and aux hoist motors and provide speed feedback to the variable frequency drives. ***(b)*** External resistor banks used for hoist dynamic braking are sized in MMH Document 36675-06 (Electrical Calculations) to acquire the necessary motor power to resist 150% of motor full load torque. This torque level is not less than the torque limit setting of the variable frequency drive. ***(c)*** Variable frequency drives used for the hoists have a torque-proving circuit that prevents the release of the holding brakes until sufficient motor torque is generated.

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(d) In lieu of the design tolerance para. 5331.1(b), control shall maintain speed control under all motor operating conditions to within ±5% of the commanded speed. ***(e)*** If specified by the owner, control shall be capable of operating at higher than base speed as a function of load (constant horsepower operation) for loads less than 100% rated load. ***(f)*** Type I cranes shall have controls with the following capabilities: *(1)* A warning device shall be provided to warn the operator of a pending motor overheat condition. *(2)* A warning device shall be provided to warn the operator that the dynamic braking resistors have overheated.	***(d)*** Variable frequency drives used for the hoists maintain speed control under all motor operation conditions within 5% of the commanded speed. ***(e)*** Speed-up controls are provided for both hoists per Zion Specification SP-ZS-FH-003 to allow 150% of the rated load hoisting speed when unloaded. ***(f)*** Warning devices are not provided for the motor or dynamic braking resistors since overheating faults will automatically shut down power to the system and set the brakes. Operator input is not required.
6418 Sizing Procedure Control ratings shall be in accordance with NEMA Standards with the following qualifications.	Control ratings are in accordance with NEMA Standards with the following qualifications.
6418.1 Hoists That Handle Critical Loads on Type I Cranes As a minimum, contactor, resistor, thyristor, and reactor ratings shall have a continuous rating equal to the greater of the steady state currents in those devices when hoisting or lowering rated load at full speed. Accelerating resistors, if used, shall be NEMA Class 90 (see NEMA, Part ICS 2-213). Mechanical load brakes shall not be used as the control braking means.	Contactor, resistor, and reactor ratings have a continuous rating equal to the greater of the steady state currents in those devices when hoisting or lowering rated load at full speed. Accelerating resistors are not used for this crane. Mechanical load brakes are not used as the control braking means.
6418.2 Types I, II, and III Cranes The crane specifications shall state all required repetitive duty cycle operations or prolonged operations in terms of load, distance, speed, time, and frequency of repetition. All the control components (including the control braking means) shall be checked by the supplier to ensure that they are adequate for that specification.	Operational and duty cycle information is provided in Zion Specification SP-ZS-FH-003. Control components are checked to ensure that they comply with the requirements of the specification. Ref. vendor manuals provided in MMH Document 36675-20 (Operation & Maintenance Manual).
6420 Friction Brakes **6421 General (Types I, II, and III Cranes)** This Section covers the requirements for friction-type brakes for purposes of holding, emergency, parking, and service brakes.	Friction-type brakes provided for the crane comply with the requirements of this section.

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6421.1 Applicable Standards The brake selections shall be in accordance with the definitions and brake requirements of ASME B30.2, with further specific requirements as covered by this Section and para. 6100.	Brake selections comply with the requirements of ASME B30.2, this Section, and para. 6100.
6421.2 Brake Operation The brakes shall have a thermal capacity for the frequency and duration of the specified operations to prevent over-heating of the brake wheel, disks, brake linings, and other parts. Brake manual release mechanisms shall be furnished to permit drive movement during power outages, and shall be of the manual-release-self-reset type, operative only when held manually in the release position.	Brakes have sufficient thermal capacity for the frequency and duration of the specified operations to prevent overheating of the brake wheel, disks, brake linings, and other parts. Since friction brakes are only used for holding brakes, heat generation is minimal in these devices. Brakes are provided with manual-release-self-reset mechanisms to permit movement during power outages. Ref. MMH Document 36675-20 (Operation & Maintenance Manual).
6421.3 Electric Brakes ***(a)*** The electrical operating and excitation system shall have a thermal rating for the frequency and duration of the specified operations, and the thermal time rating shall equal or exceed the corresponding drive motor time rating. ***(b)*** Brakes with DC shunt coils shall release at 80% and operate without overheating at 110% of the rated excitation system voltage. Whenever DC shunt coils are used on hoist brakes, the combination of the brake coil and excitation system shall result in a quick response of brake release and set. ***(c)*** Brakes with AC coils shall release at 85% and operate without overheating at 110% of rated excitation system voltage.	Ref. the vendor manuals in MMH Document 36675-20 (Operation & Maintenance Manual) for the following items: ***(a)*** The electrical operating and excitation system are designed to have thermal ratings that meet or exceed the corresponding drive motor time ratings. ***(b)*** The hoist brakes use AC rectified DC shunt coils that release at 80% and can operate without overheating up to 110% of the rated excitation system voltage for a short period of time. The combination of the brake coil and excitation system results in a quick response of brake release and set. ***(c)*** The trolley and bridge travel brakes use AC coils that release at 85% and can operate without overheating up to 110% of the rated excitation system voltage for a short period of time.
6421.4 Brake Lining, Friction Material Brake lining material shall permit brakes to maintain adequate torque for the specified environmental conditions and at the lining temperatures resulting from the frequency and duration of the specified operations. Manual or automatic means shall be provided to adjust the brake operating mechanism to compensate for the effect of lining wear.	Brake lining material allows the brakes to maintain adequate torque for the specified environmental conditions and at the lining temperatures resulting from the frequency and duration of the specified operations. The brakes automatically provide for brake lining wear.

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6422 Hoist Brakes (Types I, II, and III Cranes) **6422.1 Hoists That Handle Critical Loads on Type I Cranes** *(a)* A minimum of two holding brakes shall be provided. These brakes shall comply with AISE TR No. 11 or have an alternative design specifically approved by the Purchaser. Each holding brake shall have a torque rating not less than 125% of the full (rated) load hoisting torque at the point of brake application. *(b)* Determination shall be made that if the holding brakes are mounted and adjusted, and linings run in properly for the torque settings required in (a) above, the brake system shall be capable of stopping and holding the credible critical load during an SSE or OBE event. The values used for this determination shall be based on the maximum acceleration forces at the brake(s) computed for the crane SSE or OBE specifications, and the total torque required on the brake system to hold the credible critical load. *(c)* Provision shall be made for emergency lowering of the critical load by an alternative means of operation of the holding brakes. The alternative release mechanisms shall permit control of the braking torque and shall also provide the ability to restore the "brake set" condition promptly, thereby allowing the operators of the alternative release mechanisms to control the lowering speed. A device for indicating lowering speed shall be located at the emergency release station. Intermittent lowering shall be allowed to provide time for cooling the brake mechanism to obtain adequate heat dissipation and to prevent reduction in braking torque that can occur as the result of excessive heat. *(d)* The detrimental effects of radiation exposure on the brake linings shall be determined and a routine replacement procedure established so as to maintain an adequate torque.	(a) Two shoe-type holding brakes are provided for the main hoist that are each sized to hold 150% of the full rated load hoisting torque. Ref. MMH Document 36675-18 (Main Hoist Gearing Analysis). The main hoist shoe brakes comply with AISE TR-11. *(b)* The main hoist brakes are sized to hold the credible critical load during a seismic event as specified. Ref. MMH Document 36675-18 (Main Hoist Gearing Analysis). *(c)* An eddy current brake (magentorque) is provided on the main hoist for emergency lowering of the critical load at a constant speed. The shoe-type holding brakes must be manually released to lower the load and can be reset as required to hold the load. Lowering speed is determined by using a hand held tachometer. Depending on the height that the load must be manually lowered, intermittent lowering may be required to allow the magnetorque to cool. Ref. MMH Document 36675-20 (Operation & Maintenance Manual) for emergency lowering procedures. *(d)* N/A - The total accumulated radiation exposure for the life of the crane does not pose a risk for the brake lining material.
6422.2 Hoists on Types II and III Cranes and Hoists That Do Not Handle Critical Loads on Type I Cranes At least one holding brake shall be provided. Each brake shall have not less than the following percentage of the rated load hoisting	*(a-c)* The aux hoist is provided with one holding brake on the gear case and one holding brake on the hoist motor, in addition to the dynamic

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torque at the point where the brake(s) is applied: ***(a)*** 125% when used with a control braking means other than mechanical; ***(b)*** 100% when used with a mechanical control braking means; ***(c)*** 100% if two holding brakes are provided.	control braking provided by the variable frequency drive. Each holding brake is sized to a minimum of 100% rated load hoisting torque at the point of application. Ref. MMH Drawing R94965 (Aux Hoist Assembly).
6423 Trolley and Bridge Brakes (Types I, II, and III Cranes) **6423.1 Application** ***(a)*** All travel drives shall have service braking means. ***(b)*** When a friction brake is used for service braking, the brake torque shall be sufficient to stop the drive within a distance in feet equal to 10% of the rated load speed in feet per minute when traveling at full speed with rated load. ***(c)*** Emergency brakes shall be of the friction-type that will set automatically upon power failure and shall be capable of stopping the drive within the distance specified in (b) above. *(1) For Type I Cranes.* Emergency and parking brakes shall be provided for the travel drives. Parking brakes shall be automatically applied and shall be provided with time delay relays, if necessary, to eliminate interference with service brake operation. *(2) For Types II and III Cranes.* Emergency brakes shall be provided when required by the specification. ***(d)*** Any combination of service, emergency, and parking functions may be performed by a single friction brake, provided the emergency and parking functions can be obtained without having power available.	***(a)*** Service braking is provided for all trolley and bridge travel motors. ***(b)*** N/A - Dynamic control brakes are used instead of friction brakes for service braking. ***(c)*** Friction-type emergency brakes are provided for all trolley and bridge travel motors that set automatically upon power failure and are capable of stopping within the distance specified in (b). ***(d)*** N/A - Separate brakes are provided for service and emergency braking.
6423.2 Trolley Brake Sizing Procedures ***(a)*** On cab-operated cranes, trolley service braking shall be provided as required by para. 6423.1(a) with sufficient torque to satisfy the deceleration requirements of para. 6423.1(b). ***(b)*** On floor-, remote-, or pulpit-operated cranes, trolley emergency brakes with torque rating to satisfy the deceleration requirements of para. 6423.1(b) shall be provided.	***(a)*** Trolley travel service brakes are provided as required by para. 6423.1(a) with sufficient torque to satisfy the deceleration requirements of para. 6423.1(b). ***(b)*** Trolley travel emergency brakes are provided with sufficient torque to satisfy the deceleration requirements of para. 6423.1(b).

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6423.3 Bridge Brake Sizing Procedures *(a)* On cab-operated cranes with cab on bridges, bridge service braking shall be provided with sufficient torque to satisfy the deceleration requirements of para. 6423.1(b). *(b)* On cab-operated cranes with cab on trolley, bridge emergency brake(s) with torque rating to satisfy the deceleration requirements of para. 6423.1(b) shall be provided in addition to bridge service braking. *(c)* On floor-, remote-, or pulpit-operated cranes, bridge emergency brake(s) shall be provided with torque rating to satisfy the deceleration requirements of para. 6423.1(b).	*(a)* Bridge travel service brakes are provided as required by para. 6423.1(a) with sufficient torque to satisfy the deceleration requirements of para. 6423.1(b). *(b)* N/A - There is no cab on the trolley. *(c)* Bridge travel emergency brakes are provided with sufficient torque to satisfy the deceleration requirements of para. 6423.1(b).
6430 Disconnecting Means **6431 General (Types I, II, and III Cranes)** **6431.1 Applicable Standards** All crane disconnecting devices shall be selected and installed as required by NEC Article 610; ASME B30.2, Section 2-1.10.5; and NEMA Parts ICS 3-442 and 3-443.	The crane disconnecting devices are selected and installed as required by NEC Article 610; ASME B30.2, Section 2-1.10.5; and NEMA ICS 8, Parts 1-5. NEMA ICS 3-442 is superseded by ICS 8, Part 1 and ICS 3-443 is superseded by ICS 8, Parts 2-5.
6432 Main Disconnects **6432.1 Runway Disconnects (Types I, II, and III Cranes)** A circuit breaker or motor circuit switch selected in accordance with NEC 610-31 shall be provided in the leads to the runway conductors.	A circuit breaker is provided in the leads to the runway conductors in accordance with NEC 610-31. Ref. MMH Drawing R95399 (Electrical Schematic).
6432.2 Crane Disconnect (Types I, II, and III Cranes) All cranes shall have a main line disconnect in accordance with NEC 610-32, and shall be rated in accordance with NEC 610-33 plus any additional continuous load. This disconnect shall be enclosed as required by environmental conditions. Unless overcurrent protection is provided by other means, it shall be incorporated in this main line disconnect and the user shall specify available rms symmetrical short circuit current.	The crane main line disconnect is in accordance with NEC 610-32 and NEC 610-14(E), which envelopes NEC 610-33. The disconnect is enclosed as required by environmental conditions. Over current protection is incorporated into the main line disconnect. Ref. MMH Drawing R95399 (Electrical Schematic).
6432.3 Motor Power Circuit Disconnecting Device (Type I Cranes) A device shall be furnished to open the power circuit to all crane drive motors. This device shall be capable of being opened from all	A master control relay is provided that opens the power circuit to all

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operator stations. The device shall open automatically upon failure and shall be unable to reclose until a reset function is performed. The minimum size of this device shall be not less than that required by NEC 610-33. The opening of this device shall cause the holding and emergency brakes to set.	motors and sets all brakes when the operator depresses the emergency stop on either the radio or cab controls. The master control relay opens automatically upon failure and cannot be reset until the emergency stop is manually repositioned. The master control relay is sized per NEC 610-14(E), which envelopes NEC 610-33. Ref. MMH Document 36675-06 (Electrical Calculations).
6432.4 Motor Power Circuit Disconnecting Device (Types II and III Cranes) Unless a device (para. 6432.3) is supplied, the crane disconnect (para. 6432.2) must be accessible for opening by the operator and must be connected in a way that the functional protection required by para. 6432.3 is provided.	N/A - This is a Type I Crane
6432.5 Motion Power Disconnecting Devices (Type I Cranes) Control shall include a separate disconnecting means for each crane motion.	Controls include a separate disconnecting means for each crane motion as shown in MMH Drawing R95399 (Electrical Schematic).
6433 Auxiliary Disconnects (Types I, II, and III Cranes) The crane manufacturer shall provide disconnecting means in the form of fused safety switches or circuit breakers as required by NEC to protect and disconnect all auxiliary equipment supplied by the manufacturer or specified by the purchaser. Auxiliary equipment may include: ***(a)*** lighting, ***(b)*** signal systems, ***(c)*** heating/ventilating/air conditioning, ***(d)*** convenience outlet, and ***(e)*** special devices when applicable. Ground fault circuit interrupters, if required for convenience outlets, shall be a part of the user's specifications.	Circuit breakers are provided as required by NEC to protect and disconnect all auxiliary equipment, including: ***(a)*** lighting, ***(b)*** signal systems, ***(c)*** heating/ventilating/air conditioning, ***(d)*** convenience outlet, and ***(e)*** special devices when applicable. Ref. MMH Drawing R95399 (Electrical Schematic).
6440 Limit Switches **6441 General (Types I, II, and III Cranes)** A limit switch is defined as a switch that is operated by some part or motion of a power driven machine or equipment to alter the	Limit switches are provided for the following: ***(a)*** hoist overtravel,

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electric circuit associated with the machine or equipment. This Section includes the following limit switch requirements for nuclear power plant cranes: *(a)* hoist overtravel, *(b)* hoist overspeed, *(c)* hoist overload, *(d)* hoist drum rope mis-spooling, and *(e)* bridge and trolley overtravel limits. Limit switch requirements, if any in addition to the above, shall be incorporated in the specifications. AC cranes shall have phase reversal protection.	*(b)* hoist overspeed, *(c)* hoist overload, *(d)* hoist drum rope mis-spooling, and *(e)* bridge and trolley overtravel limits. Limit switch requirements are detailed in Zion Specification SP-ZS-FH-003. Phase reversal protection is provided for the crane. Ref. MMH Drawing R95399 (Electrical Schematic).
6442 High Limits **6442.1 Type I Cranes** Hoists that handle critical loads shall include two separate overhoist limit switch systems as required in paras. 6442.2 and 6442.3.	A geared limit switch and a weighted limit switch are provided as two separate upper limits for the main hoist. Ref. MMH Drawing R95399 (Electrical Schematic).
6442.2 First High Limit (Type I Cranes) The first upper hoisting limit shall be a control circuit device such as a geared-type, weight-operated, or paddle-operated switch. Actuation of this switch shall result in the removal of power from the motor and setting the hoist brakes. The operator may lower or back out of this tripped switch without further assistance.	The first upper hoisting limit switch for the main hoist is a geared-type that relies on a relay set to remove power from the raise control circuit and sets the hoist brakes when tripped. This switch does not affect the lowering control circuit. Ref. MMH Drawing R95399 (Electrical Schematic).
6442.3 Final Overtravel High Limit (Type I Cranes) Hoists that handle critical loads shall include, in addition to the first upper limit switch as specified in para. 6442.2, a final power circuit hoisting limit switch. Actuation of this switch shall remove power from the hoist motor directly without relying on the sequencing of any devices and shall set the hoist brakes. Actuation of this limit switch shall prevent further hoisting or lowering.	The second upper hoisting limit switch for the main hoist is a weight-operated type that physically removes power to the drive contactor and sets the hoist brakes when tripped. Actuation of this limit switch prevents further hoisting or lowering. Ref. MMH Drawing R95399 (Electrical Schematic).
6442.4 High Limits (Hoists on Types II and III Cranes and Hoists That Do Not Handle Critical Loads on Type I Cranes) One high limit switch shall be provided.	The aux hoist is provided with two limit switches. Ref. MMH Drawing R95399 (Electrical Schematic).

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6443 Hoist Low Limits (Type I Cranes) Hoists that handle critical loads shall include two separate low limits, as required in paras. 6443.1 and 6443.2.	A geared limit switch and the load weighing system are provided as two separate low limits for the main hoist. Ref. MMH Drawing R95399 (Electrical Schematic).
6443.1 First Low Limit (Type I Cranes) Each hoist that handles critical loads shall include an overtravel low limit switch. This switch may be of the control circuit type. Actuation of this switch shall stop the lowering motion and set the hoist brakes. The operation of this switch shall not prevent hoisting.	The first lower hoisting limit switch for the main hoist is a geared-type that removes power from the lowering control circuit and sets the hoist brakes when tripped. This switch does not affect the raising control circuit. Ref. MMH Drawing R95399 (Electrical Schematic).
6443.2 Final Overtravel Low Limit (Type I Cranes) Hoists that handle critical loads shall include, in addition to a first low limit as specified in para. 6443.1, a final lowering limit switch of the control circuit type that shall be mechanically and electrically independent of the first low limit. Operation of this limit switch shall de-energize a power device other than the device operated by the first low limit to interrupt all power to the hoist motor and the hoist brakes. Actuation of this limit switch shall prevent further lowering or hoisting. When this occurs, a person knowledgeable in the hoist control system shall determine and correct the cause of tripping of the final low limit switch. That person shall direct the raising out of the final low limit after establishing a back out mode which shall prevent further lowering. The first low limit shall be tested for proper operation before making any additional lifts.	The second lower hoisting limit switch for the main hoist is integrated into the load weighing system and removes power from the lowering control circuit and sets the hoist brakes when an underweight/slack rope condition is met. This system is mechanically and electrically independent from the first limit switch. Actuation of this limit switch prevents further hoisting or lowering. The controls are reset by entering a back out mode in which hoisting is permitted, but lowering is still prevented. Ref. MMH Drawing R95399 (Electrical Schematic).
6443.3 Low Limits (Hoists on Types II and III Cranes and Hoists That Do Not Handle Critical Loads on Type I Cranes) A low limit shall be furnished: ***(a)*** as recommended by ASME B30.2, 2-1.10.5(e), when specified in the crane specifications, or ***(b)*** when required by ASME B30.2, 2-1.11.3(c)(1).	***(a-b)*** The aux hoist is provided with two limit switches identical to the main hoist switches described in paras. 6443.1 and 6443.2, which exceeds the requirements of this section. Ref. MMH Drawing R95399 (Electrical Schematic).
6444 Hoist Overspeed Limits (Type I Cranes) ***(a)*** Hoists that handle critical loads shall include an overspeed limit switch. When handling a critical load, hook speeds over 115% of the design rated load lowering speed for any critical load shall trip this	Ref. MMH Drawing R95399 (Electrical Schematic) for the following items: ***(a)*** An overspeed switch is provided for the main hoist. Hook speeds over 115% of the design rated load speed for any load will trip this switch and

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switch, causing all holding brakes to set without intentional time delay. Operation of this switch may also initiate any control braking means normally used for stopping of the load. It shall be necessary to center the master switch and to manually reset the overspeed limit switch (or the overspeed circuit) before operation can be resumed. ***(b)*** On drives which provide high-speed, lightload features, provisions shall be made to permit override of this overspeed limit switch when handling noncritical loads. ***(c)*** When specified, clutched-in-slow-speed hoist drives may include a bidirectional overspeed switch to shut down hoisting or lowering if drive speed exceeds 115% of the rated full load slow lowering speed.	immediately set all brakes. The operator must center the master switch and depress the start/reset pushbutton to resume operation. ***(b)*** The overspeed limit switch is disabled whenever there is no load on the hoist. ***(c)*** N/A - A clutch is not used for this crane.
6445 Hoist Load Limits **6445.1 Overloading (Types I, II, and III Cranes)** Overloading, including load hang-up, of hoists that handle critical loads on Type I cranes shall be detected by means of a load sensing system, or the equivalent, in accordance with para. 6466. The high-load limit shall be set to prevent sustained lifting of more than rated load, but to permit lowering. Specifications shall designate any load limit requirements for Types II and III cranes.	A load weighing system is provided for the main and aux hoists in accordance with para. 6466 and Zion Specification SP-ZS-FH-003 to detect overloading. The high-load limit prevents lifting more than the rated load, but allows lowering. Ref. MMH Drawing R95399 (Electrical Schematic).
6445.2 Unbalanced Load Limits (Type I Cranes) Dual reeved hoists that handle critical loads on Type I cranes shall include a device to detect excessive movement of the equalizer mechanism. Tripping of this device shall initiate a flashing warning light visible to the crane operator and shall shut down the hoisting motion. Means shall be provided to allow the use of hoist under administrative control. Reeving shall then be corrected before returning hoist to additional service.	The main hoist equalizer system includes separate load cells to detect the load on each rope. Excessive movement of the equalizer presents different loads to each load cell, causing an unbalanced load fault that disables the hoisting circuits. A bypass switch is provided to allow use of the hoist under administrative control. Ref. MMH Drawing R95399 (Electrical Schematic).
6446 Hoist Drum Rope Mis-Spooling Limits **6446.1 Hoist Drum Rope Mis-Spooling Limits (Type I Cranes)** Hoists that handle critical loads shall include a hoist drum rope mis-spooling limit switch to detect improper threading of hoist rope in	Two rope mis-spooling limit switches are provided for the main hoist drum to detect improper threading of rope in the drum grooves. The limit

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hoist drum grooves. Actuation of this switch shall result in removal of power from the hoist motor and setting the hoist holding brakes. Actuation of this limit device shall prevent further hoisting or lowering until a key-operated bypass is used to enable lowering out of the mis-spooled condition, with further hoisting prevented until the mis-spooled condition is corrected. The limit shall be tested for proper operation before making any additional lifts.	switches disable the hoisting circuits and set the holding brakes when tripped. A bypass switch is used to enable lowering out of the mis-spooled condition, and further hoisting is prevented until the mis-spooled condition is corrected. Ref. MMH Drawing R95399 (Electrical Schematic).
6446.2 Hoist Drum Rope Level Wind Limits (Types II and III Cranes) Hoist drum rope misspooling limits shall be furnished in accordance with 6446.1 when so specified in the crane specifications.	N/A - Mis-spooling limit switches are not provided for the aux hoist and are not required.
6447 Bridge and Trolley Overtravel Limits (Types I, II, and III Cranes) Bridge and trolley overtravel limits shall be furnished when specified. Refer to paras. 5131(b) and 5459.1(d) and (e).	Bridge and trolley over travel (end of travel) limits are furnished. Ref. MMH Drawing R95399 (Electrical Schematic).
6448 Restricted Handling Path (Type I Cranes) On some Type I cranes, it may be essential that the hook follow a restricted critical load handling path. The requirements for such paths vary widely with individual nuclear plant designs. The crane specifications shall designate the required accuracy, positions where redundancy is required, and any test and signal system required.	N/A - Restricted critical load handling paths are not required per Zion Specification SP-ZS-FH-003. However the main hook travel over the spent fuel area (exclusive of the Cask Load Pit) will be restricted and will require by-pass in accordance with ZS operational requirements.
6450 Master Switches, Pushbuttons, and Radio Controls (Types I, II, and III Cranes) **6451 General** **6451.1 Applicable Standards** All such devices shall comply with ASME B30.2.	All applicable devices comply with ASME B30.2
6452 Contact Ratings	

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Contacts in master switches, pushbuttons, and radio control interface panels should be heavy duty rated per NEMA ICS 2-125. See Table 1 or 2, for appropriate application. Multispeed pendant pushbuttons shall be rated per NEMA A150 or N300.	ICS 2-125 is superseded by ICS 5, Part 1. ICS 5, Part 1 deals with general standards for control-circuit and pilot devices. Contacts in the master switches, pushbuttons, and radio control interface panels conform to these standards and are tested accordingly by the manufacturer. Multispeed pendant pushbuttons are rated per NEMA A150. Ref. vendor manuals in MMH Document 36675-20 (Operation & Maintenance Manual).
6453 Voltage Ratings The voltages in pushbuttons, master switches, and similar control circuit devices shall not exceed 150 V AC or 300 V DC.	Pushbuttons, master switches, and similar control circuit devices are designed to operate at 120 V AC. Ref. MMH Drawing R95399 (Electrical Schematic).
6454 Radio Controls If radio control of cranes in the containment area has been provided for construction operation, that equipment shall be removed before the crane is certified for service in the operating plant unless the effect of radio transmission on reactor plant instrumentation has been analyzed.	N/A - This crane is not used for construction
6460 Auxiliary Equipment (Types I, II, and III Cranes) **6461 General** Auxiliary electrical equipment shall be provided as specified. All necessary mounting hardware, wiring, disconnecting means, and associated control means shall be included. For Types I and II cranes, all auxiliary equipment shall be mounted and secured so as not to become dislodged or to fall from the crane during a seismic event.	Auxiliary electrical equipment is provided as specified. All necessary mounting hardware, wiring, disconnecting means, and associated control means is included. All auxiliary equipment is mounted and secured so as not to become dislodged or to fall from the crane during a seismic event. Ref. MMH Document 36675-14 (Seismic Analysis of Misc. Items).
6462 Light Fixtures Light fixtures shall be as specified in the crane specifications.	Existing crane lighting is reused per Zion Specification SP-ZS-FH-003
6463 Signal Systems Signal systems shall be as specified in the crane specifications.	Signal systems are designed in accordance with Zion Specification SP-ZS-FH-003
6464 Heating, Ventilating, and Air Conditioning Heating, ventilating, and air conditioning shall be as specified in the crane specifications.	There are no requirements for heating, ventilation, and air conditioning per Zion Specification SP-ZS-FH-003

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6465 Convenience Outlets Convenience outlets shall be as specified in the crane specifications.	Existing convenience outlets on the crane are reused per Zion Specification SP-ZS-FH-003.
6466 Load Sensing Devices Load sensing devices shall be as specified in the crane specifications. When load sensing devices provide control functions such as load limiting, as covered in para. 6445.1, they shall be powered from the control circuit of the associated drive.	A load weighing system is provided for the main and aux hoists per Zion Specification SP-ZS-FH-003 and is powered from the control circuit of the associated drive. Ref. MMH Drawing R95399 (Electrical Schematic).
6467 Power for Auxiliary Equipment Except as stated in para. 6466 or unless otherwise specified, power for all auxiliary equipment shall be from a separate protected branch circuit(s) connected ahead of the main drive motor disconnecting means, so that power is available to auxiliary equipment when the main drives are shut down.	A utility circuit is provided for the crane with a separate disconnect means upstream of the main drives so that power is available to auxiliary equipment when the main drives are shut down. Ref. MMH Drawing R95399 (Electrical Schematic).
6468 Wiring for Auxiliary Equipment All wiring for auxiliary equipment shall be in accordance with NEC. All equipment shall be grounded.	All wiring for auxiliary equipment is in accordance with NEC. All equipment is grounded. Ref. MMH Drawing R95399 (Electrical Schematic).
6470 Motors (Types I, II, and III Cranes) **6471 General** ***(a)*** *Direct Current Motors.* DC motors shall be in accordance with either NEMA MG-1 or AISE TR No. 1. ***(b)*** *Alternating Current Motors* *(1) Definite Purpose Inverter-Fed Motors.* AC squirrel cage motors applied to variable frequency drives (VFDs) shall be specifically designed for inverter duty and shall conform to NEMA MG-1, Part 31, or other standard as approved by the owner. *(2) Definite Purpose Wound Rotor Induction Motors.* AC wound rotor motors shall conform to NEMA MG-1, Part 18.501 through 18.520. *(3) Other AC Motors.* All other AC motors not already described shall conform to NEMA MG-1.	***(a)*** N/A - DC motors are not used on this crane ***(b)*** *(1)* AC squirrel cage motors used on this crane are specifically designed for inverter duty and conform to NEMA MG-1, Part 31. *(2)* N/A - AC wound rotors are not used on this crane. *(3)* N/A - AC squirrel cage motors are used on this crane. ***(c)*** All motors have enclosures and time ratings as required for the duty and environmental conditions per Zion Specification SP-ZS-FH-003.

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(c) All AC or DC motors shall have enclosures and time ratings as required for the duty and environmental conditions.	
6472 Motor Size Selection, AC or DC ***(a)*** The motor size selection is determined by the duty class or duty cycle for each motion, not the Type I, II, or III crane classification. Because of the large variety of crane drives available and the difference in the effects of those drives on the thermal adequacy of the motors under consideration, any attempt to develop a procedure for selecting motor ratings becomes quite involved. Whenever possible, the specifications should indicate the most severe repetitive duty (or duties) that each motor will be required to meet, especially including intervals of slow speed operation, if any. The supplier shall be responsible for selecting ratings that will meet the specified duty with the type of control specified. In the absence of duty cycle requirements, the specifications shall clearly identify the duty class to be used for each motion in the procedure described herein. The rating of auxiliary devices (such as mechanical or electrical load brakes) must also be selected to meet the specified duty or duty class. ***(b)*** For ambient temperatures above 100°F, the motor design (frame size, insulation class, enclosure, and ventilation) shall be selected to compensate for the increased ambient so the total insulation temperature will not exceed the value allowed by NEMA for the selected insulation class. For example, in a 140°F ambient, a motor with Class F insulation rated at Class B rise might be selected.	***(a)*** Zion Specification SP-ZS-FH-003 provides the most severe duty requirements, which are used to design the motors and controls. ***(b)*** Motors are designed with class H insulation and for operation in ambient temperatures of 110° F per Zion Specification SP-ZS-FH-003.
6472.1 Hoists The hoist motor shall be so selected that its nameplate rating will not be less than that given by the following formula: $hp = K_S WV/33{,}000E$ [Text and/or equations omitted]	Hoist motors are sized as specified. Ref. MMH Document 36675-18 (Main Hoist Gearing Analysis).
6472.2 Bridge and Trolley ***(a)*** The force required to drive the bridge or trolley consists of that necessary to overcome rolling friction, and that necessary to	***(a-f)*** The trolley motors are sized to meet the requirements of this section, including all referenced equations and tables, with respect to the

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accelerate the crane. The rolling friction is proportional to the total weight of the crane and is assumed to be constant at all speeds. Unless otherwise specified, a friction factor per Table 6472.2(a)-1 shall be used for anti-friction bearing cranes. Mechanical efficiencies are included in these factors. ***(b)*** Unless otherwise specified, the acceleration rate with rated load for either AC or adjustable voltage (AV) drives is to be selected from the slow values shown in Table 6472.2(b)-1. ***(c)*** The size of the bridge and trolley motor shall not be less than the computed from Eq. (2): [Text and/or equations omitted] ***(d)*** After selecting an approximate motor by Eq. (2), obtain data on the Wk^2 of the motor, brake wheel, couplings, and pinion. The sum of these values is the rotating Wk_R^2. Calculate the equivalent Wk^2 of the load by the following equation. [Text and/or equations omitted] ***(e)*** If the motor is being selected for a duty class rather than a specified duty cycle, the motor rating should not be less than [Text and/or equations omitted] ***(f)*** The speed ratio for bridge and trolley drives will be determined as shown in para. 6473, computing the free-running hp from Eq. (5): [Text and/or equations omitted] ***(g)*** *Polar Cranes:* horsepower for bridge drives [Text and/or equations omitted]	speeds defined in Zion Specification SP-ZS-FH-003. The new bridge motors are sized to meet the performance requirements of the existing motors that are being replaced. ***(g)*** N/A - This is not a polar crane.
6472.3 Service Factors ***(a)*** As stated in para. 6472(a), the most severe requirements should be stated in the specifications whenever possible so the supplier can check the specific motor and control required. ***(b)*** If the crane specifications do not indicate a specific duty but state the duty class for each motion, the K_S values for Eqs. (1), (2), and (4) are listed in Table 6472.3(b)-1. There is no guarantee that these values will result in the optimum motor selection, but they do indicate relative ratings.	***(a)*** Zion Specification SP-ZS-FH-003 provides the most severe duty requirements, which are used to design the motors and controls. ***(b)*** N/A - A specific duty is specified.

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6472.4 Calculation of Motor Heating ***(a)*** When definite operating requirements have been specified, the time, motor torque, and average motor speed can be calculated for each step of acceleration, running, and deceleration. The procedure for checking the thermal adequacy of the motor will vary, depending on the type of motor and motor enclosure. For totally enclosed series wound AISE TR No. 1 DC mill motors used for constant-potential DC control at 230 V, published curves may permit determining whether or not the allowable percent time-on exceeds the actual percent time-on. If the same type of motor is used at more than 230 V, the motor manufacturer shall be consulted to evaluate the effect of the increased core losses and friction and windage losses. ***(b)*** On adjustable voltage DC drives, self- and forced-ventilated shunt motors can be checked by comparing the calculated rms current and average speed against curves of allowable rms current versus average rpm for the motors being checked. In totally enclosed motors, the losses (armature, field, core, brush, friction, windage, and stray load) shall be summarized to see if the total is below the dissipating capability of the selected motor operating over the repetitive cycle. Similarly, in AC motors, losses are divided into fixed and variable. As an approximation, the variable losses can be considered to be proportional to secondary current squared. Also, for a given value of secondary resistance, the secondary current can be calculated by [Text and/or equations omitted] all on a per unit basis. (If the calculated per unit I is less than the corresponding per unit T, use the per unit T value. Also, in order to take into consideration the primary copper losses at very low values of torque, the value of per unit I shall not be less than 0.4.) ***(c)*** The AC motor thermal evaluation could be performed as follows. Establish a duty cycle with the time and torque for each step calculated. Convert torque to per unit current using Eq. (11) or the	***(a-c)*** The motor manufacturer (Name) verifies the thermal adequacy of each motor and determines the appropriate size based on the required application as part of his design documentation.

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torque–current speed characteristics of the type of control to be used. Add the square of the per unit current x time (in seconds) x per unit variable losses to the operating time (in seconds) x per unit fixed losses. If that total is less than the sum of the seconds x the dissipation factors for each step in the cycle, the motor has adequate thermal capacity. The variable losses, fixed losses, and dissipation factors are to be obtained from the selected motor manufacturer, or the cycle summary shall be submitted to the manufacturer. See para. B6472.4 for an example of AC motor heating calculation.	
6472.5 Duty in Excess of Class 4 ***(a)*** Above 50% time-on or more than 45 cycles per hour, the required duty cycle capability shall be stated by the specification writer, who should consider the possible advantages of self-ventilated, forced-ventilated, or air-over-frame motor construction, depending upon the atmospheric conditions at each installation. The acceptable type(s) shall be indicated in the specifications. ***(b)*** If prolonged (over 30 sec) or repetitive operation at reduced speed is required, it shall be specified. Any reduced speed operations which fall below 5% speed for prolonged periods or which are repetitive shall not be evaluated by the procedures in para. 6472.4 without consulting the electrical manufacturer. ***(c)*** Because variations in motors and controls can be appreciable, ratings selected by any duty cycle calculations shall be checked by the electrical manufacturer after an order has been placed.	***(a-b)*** N/A - Duty in excess of class 4 is not specified.
6473 Drive Speed Ratios Drive speed ratios shall be determined as follows: [Text and/or equations omitted] ***(a)*** For 230 V DC series motors, the manufacturer's characteristic curves for 230 V shall be used. At a constant-potential voltage other than 230 V, obtain an equivalent 230 V hp by multiplying the free-running hp by 230 divided by the applied voltage. From the curves, use this equivalent hp to obtain the motor speed at 230 V. Calculate	***(a)*** N/A - 230 V DC series motors are not used on this crane. ***(b)*** N/A - AC wound rotor motors are not used on this crane. ***(c)*** N/A - DC adjustable voltage shunt motors are not used on this crane. ***(d)*** Characteristic curves for AC squirrel cage motors provided by the motor manufacturer are used.

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the approximate N_f by multiplying the rpm so obtained by the applied voltage divided by 230. ***(b)*** For AC wound rotor motors, the typical characteristic curves for wound rotor motors in Fig. 6473(b)-1 shall be used, taking into consideration the total secondary resistance at full speed. The curves are based on motors providing 3% slip at rated torque with rings shorted and with rated voltage applied to the primary, [Text and/or equations omitted] At the calculated per unit hp, read per unit torque from appropriate hp-resistance curve and then read per unit synchronous speed at that torque on the speed curve for the same resistance. The dash line is an example at 0.75 per unit hp and 20% total resistance, resulting in approximately 0.88 per unit torque and 0.82 per unit synchronous speed. ***(c)*** For DC adjustable voltage shunt motors, obtain manufacturer's rated speed for armature voltage and field strength used. ***(d)*** For AC squirrel cage motors, use the motor's specific characteristic curves, to be supplied by the motor manufacturer.	
6480 Conductor Systems (Types I, II, and III Cranes) **6481 General** ***(a)*** Conductor types and sizes shall be in accordance with NEC, taking into consideration the voltage drop limitations affecting the allowable voltage variations at the controller specified in para. 6411.2. ***(b)*** If insulated, the insulation shall be rated for the radiation dose specified, if any. ***(c)*** Each multiconductor control cable shall include spare conductors. The quantity of spares shall be approximately 10% of the total, but not less than two and not more than five being required. ***(d)*** For repeated flexing service, the bending radius for the cable and the cable support system shall be not less than the minimum recommended for the cable by its manufacturer. Means shall be	***(a)*** Conductor types and sizes are in accordance with NEC, taking into consideration the voltage drop limitations affecting the allowable voltage variations at the controller specified in para. 6411.2. Ref. MMH Document 36675-06 (Electrical Calculations). ***(b)*** N/A - The total accumulated radiation exposure for the life of the crane does not pose a risk for conductor insulation. ***(c)*** Each multiconductor control cable is sized to have at least 10% additional spare conductors with a minimum of two extra conductors. ***(d)*** Bending radii for the bridge conductor cables and cable support system are not less than the minimum manufacturer recommendations. The bridge conductor system uses a rigid cable carrier that minimizes stress in the cables during movement.

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provided for supporting, extending, and retracting the cable to allow movement without exceeding the stress limit in the cable as stated by the cable manufacturer.	
6482 Conductor System Categories Conductor systems shall be considered in the following three general categories.	Conductor systems are categorized as either runway systems, bridge systems, or auxiliary systems.
6482.1 Runway Systems Conduct power from the building supply to the crane.	Components that conduct power from the building supply to the crane are categorized as runway systems.
6482.2 Bridge Systems Conduct power and control between the bridge and trolley portions of the crane.	Components that conduct power and control between the bridge and trolley portions of the crane are categorized as bridge systems.
6482.3 Auxiliary Systems Such as pendant pushbutton, communication, remote control, and instrumentation cables.	Components for pendant pushbuttons, communications, remote control, and instrumentation are categorized as auxiliary systems.
6483 Conductor System Types ***(a)*** When AC variable frequency controls are used, the runway and bridge conductor systems shall include a grounding conductor. ***(b)*** The following three general types of conductor systems shall be considered to meet the needs of the three categories in para. 6482. *(1) Contact Conductor.* These systems may consist of either a rigid bar or taut wire with a sliding or rolling collector. To ensure continuous contact on Type I, II, or III systems that use AC variable frequency drives or DC motor drives, there shall be at least two spring-loaded contact shoes per phase on main line systems in the primary circuit of AC motors and in any DC motor armature circuit that does not supply current to a series brake. Adequate expansion means shall be incorporated to allow for building expansions and contractions as specified. Where low-contact resistance is required for low current or low-voltage pilot devices, such as tachometer generators, a combination of conductor and collector materials shall be suitable for that usage.	***(a)*** The runway and bridge conductor systems include grounding conductors. Ref. MMH Drawing R95399 (Electrical Schematic). ***(b)*** *(1)* Rigid conductor bars are provided for the main line runway system and include two spring-loaded contact shoes per phase. Low contact resistance is not required for the main line. *(2)* N/A - Brush-type cable reels are not used for this crane. *(3)* A cable carrier with flexible continuous conductors is used for the bridge system.

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(2) Brush-Type Cable Reel. These systems consist of a cable, which is payed out off of a reel, and uses a slip-ring and brush arrangement to maintain electrical contact. Where low-contact resistance is required for low-current or low-voltage pilot devices, such as tachometer generators, a combination of slip-ring and brush materials shall be suitable for that usage. *(3) Flexible Continuous Conductor.* These systems consist of a continuous flexible cable, either flat or round, that is suspended in a festooned arrangement from a trolley and track system or in a cable carrier.	
6500 ELECTRICAL EQUIPMENT TESTING REQUIREMENTS (TYPES I, II, AND III CRANES) All electrical equipment shall be tested in accordance with Section 7000.	Electrical equipment is tested in accordance with Section 7000 per MMH Document 36675-07 (Factory Acceptance Test Procedure) and MMH Document 36675-13 (Site Acceptance Test Procedure).
7000 Inspection and Testing	
7100 TESTS AND ACCEPTANCE CRITERIA The following list identifies the specific tests and acceptance criteria for the inspections and tests specified by Tables 7200-1 and 7200-2. ***(a)*** Drop weight test per ASTM E 208 or Charpy impact test per ASTM A 370. The owner or the owner's designated representative shall establish the acceptance criteria unless stated otherwise in this Standard. ***(b)*** 100% radiographic test (RT) or ultrasonic test (UT) of buttwelds in accordance with AWS D1.1. Acceptance criteria shall be in accordance with AWS D1.1. ***(c)*** 10% magnetic particle test (MT) or dye penetrant test (PT) of the linear feet of each weld that exceeds 10 in. in length unless stated otherwise in this Standard. Technique and acceptance criteria shall be in accordance with AWS D1.1. ***(d)*** *UT Volumetric Test* *(1)* UT volumetric tests are in accordance with ASTM A	Ref. MMH Document 36675-11 (Critical List) for testing requirements of individual components as specified by Table 7200-1. Testing requirements are also specified on applicable component drawings. Testing results are documented in MMH Document 36675-17 (QA Document Binder) ***(a)*** Charpy impact testing is performed per ASTM A370. Acceptance criteria complies with Zion Specification SP-ZS-FH-003. ***(b)*** Radiographic or ultransonic testing of buttwelds and acceptance criteria are in accordance with AWS D14.1. Procedures qualified under AWS D1.1 are acceptable under AWS D14.1 per Section 9.1.4. ***(c)*** Magnetic particle or dye penetrant testing of welds and acceptance criteria are in accordance with AWS D14.1. Procedures qualified under AWS D1.1 are acceptable under AWS D14.1 per Section 9.1.4. ***(d)*** *(1)* UT volumetric testing and acceptance criteria for plate

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435/A 435M-90 for plate material. Acceptance criteria for plate material shall be in accordance with ASTM A 435/A 435M-90. *(2)* UT volumetric tests are in accordance with ASTM E 114 and ASTM A 388/A 388M-01 for wrought or forged material after forging and before machining. *(a)* Acceptance criteria for forged material shall be in accordance with the following requirements: *(1) Straight Beam.* A forging or bar shall be unacceptable if the results of straight beam examinations show one or more reflectors that produce indications accompanied by a complete loss of back reflection not associated with or attributable to geometric configurations. Complete loss of back reflection is assumed when the back reflection falls below 5% of full calibration screen height. *(2) Angle Beam Rule.* A forging or bar shall be unacceptable if the results of angle beam examinations show one or more reflectors that produce indications exceeding the amplitude reference line from the appropriate calibration notches. *(b)* Acceptance criteria for the tensioned area of Type I crane hooks shall be in accordance with the following: *(1)* Discontinuity indications in excess of the response from a 5/64 in. diameter flat-bottomed hole at the estimated discontinuity depth shall not be acceptable. *(2)* Discontinuity indications in excess of the response from a 5/64 in. diameter flat- bottomed hole at the estimated discontinuity depth shall not	material are in accordance with ASTM A435/A435M-90. *(2)* UT volumetric testing of wrought or forged material is in accordance with ASTM E114 and A338/A338M-01. Acceptance criteria is as specified. ***(e)*** Proof load testing of hooks and acceptance criteria are in accordance with ASME B30.10 ***(f)*** Wire rope breaking strength testing is performed on a sample of the furnished rope by the manufacturer. The breaking strength meets or exceeds the manufacturer's published data. ***(g)*** Magnetic particle or dye penetrant testing is in accordance with ASTM A275/A275M, E709, and/or E165. Acceptance criteria is as specified. See Note 1.

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have their indicated centers closer than 1 in. *(3)* Elongated (stringer) type defects in excess of 1 in. in length shall not be acceptable if at any point along the length the discontinuity indication is equal to or greater than the response from a 5⁄64 in. diameter flat-bottomed hole. *(c)* Acceptance criteria for material without parallel surfaces (such as sheave pins and shafts) shall be in accordance with (d)(2)(b) above. ***(e)*** Proof load test of hooks including dimensional inspection as described in ASME B30.10. Acceptance criteria shall be in accordance with ASME B30.10. ***(f)*** Wire rope breaking strength test. Breaking strength shall meet or exceed published breaking strength in accordance with Federal Specification RR-W-410 or wire rope manufacturer's published data. The sample used for the test shall be taken from the wire rope furnished. ***(g)*** MT or PT *(1)* MT or PT shall be performed in accordance with ASTM A 275/A 275M, E 709, and/or E 165. *(2)* Nonrepairable transverse indications shall be in accordance with the following: *(a)* Indications with any dimension of 1⁄16 in. are unacceptable on material under 2 in. thick; on material 2 in. and over, indications with any dimension over 1⁄8 in. are unacceptable. *(b)* Four or more indications of any size separated by less than 1⁄16 in. edge-to-edge are unacceptable on material under 2 in. thick; on material 2 in. and over, less than 1⁄8 in. edge-to-edge are unacceptable. *(c)* Ten or more indications of any size in any 6 in.2 determined with the major dimension taken in the	

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most unfavorable location relative to the indications but not exceeding 6 in. in length, are unacceptable. *(d)* Indications may be explored to determine if they are the result of material discontinuities, material properties or part geometry. Only indications resulting from material discontinuities shall be considered unacceptable; however, all indications identified that exceed the criteria in (a) through (c) above shall be recorded in the test report. *(3)* Nonrepairable transverse indication shall be unacceptable within the tensioned sections of the hook. Repairs by welding on the hook shall not be acceptable.	
7200 MANUFACTURING Inspections and testing of Types I and II cranes shall conform to this Standard. Assurance of implementation of the requirements of this Subsection for Types I and II cranes shall be in accordance with Section 2000. The manufacturer's standard inspection and testing program shall apply to Type III cranes if not otherwise specified in this Standard or contract document.	Inspection and testing of the crane conforms to this Standard. Implementation of the requirements of this Subsection is in accordance with Section 2000
7210 Receipt and In-Process Inspection and Testing Requirements ***(a)*** Receipt inspection and testing shall be performed for those items listed in Table 7200-1 for Type I cranes and Table 7200-2 for Type II cranes. In-process inspection and testing shall be performed in accordance with Table 7200-1 for Type I cranes and Table 7200-2 for Type II cranes. (See para. 7100 for definitions of inspections and tests required by tables.) ***(b)*** Documentation required by Table 7200-1 or Table 7200-2 shall be reviewed and accepted by the crane manufacturer prior to the assembly of any item listed in these tables. ***(c)*** All structural welds shall be visually inspected over their entire lengths for any type crane. Acceptance criteria of welds and repair shall be in accordance with AWS D1.1.	***(a)*** MMH Document 36675-11 (Critical List) details the inspection and testing required per Table 7200-1. Results are included in MMH Document 36675-17 (QA Document Binder). ***(b)*** Documentation required by Table 7200-1 is listed in MMH Document 36675-11 (Critical List). These items are reviewed and accepted prior to assembly. Results are included in MMH Document 36675-17 (QA Document Binder). ***(c)*** All structural welds are visually inspected per AWS D14.1. Procedures qualified under AWS D1.1 are acceptable under AWS D14.1 per Section 9.1.4. Results are included in MMH Document 36675-17 (QA Document Binder).

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	See Note 1.
7220 Electrical Documentation On Type I cranes, reports of standard NEMA tests shall be furnished by the electrical equipment manufacturer for hoist and travel motors and brakes.	NEMA MG-1 motor reports for all hoist and travel motors, including integrated brakes, are provided in MMH Document 36675-17 (QA Document Binder)
7230 Assembly Inspection Requirements The crane shall be sufficiently assembled to ensure that parts are properly fitted. Permanent wiring, other than that normally done at field erection, shall be complete. Control panels and rigid conduit shall be installed. It is not required to reeve the drum and blocks, to attach the cab, or to erect on gantry legs. Inspections of the work shall be performed by the crane manufacturer. The owner or the owner's designee may verify that crane components are being installed, assembled, or connected in compliance with the latest appropriate drawings, codes, standards, and procedures.	The trolley is completely assembled and wired and will be tested per MMH Document 36675-07 (Factory Acceptance Test Procedure). All control panels and rigid conduit for the trolley are installed. Items that interface with the bridge and building are assembled, wired, and tested to the extent possible prior to installation on site. Inspections are performed as required.
7240 Electrical Inspection Requirements Inspections shall be performed at the crane manufacturer's plant to verify the following: *(a)* terminal connections for tightness; *(b)* panels and resistors are properly placed; *(c)* required fuses are installed; *(d)* panels, switches, resistors, and other parts and materials are in accordance with job drawings and are properly identified; *(e)* raceways are properly installed, and race-ways to be removed for shipment are to be properly fitted for field installation; *(f)* no interferences involving electrical items exist when trolley moves through its full range; *(g)* electrical items do not protrude beyond the confines of the crane as established by the job drawings; *(h)* electrical items requiring routine maintenance are accessible; *(i)* no wiring is touching resistor heating parts;	Inspections will be performed at the factory and on site per MMH Document 36675-07 (Factory Acceptance Test Procedure) and MMH Document 36675-13 (Site Acceptance Test Procedure) to verify the following: *(a)* terminal connections are tight; *(b)* panels and resistors are properly placed; *(c)* required fuses are installed; *(d)* panels, switches, resistors, and other parts and materials are in accordance with job drawings and are properly identified; *(e)* raceways are properly installed, and race-ways to be removed for shipment are properly fitted for field installation; *(f)* no interferences involving electrical items exist when trolley moves through its full range; *(g)* electrical items do not protrude beyond the confines of the crane as established by the job drawings;

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(j) portions of conductor systems which are designed to move in order to accommodate crane motion move freely; *(k)* ancillary electrical items are properly installed; *(l)* pendant cable strain relief is properly installed on pendant push-button station-operated cranes; *(m)* overload relay current sensing elements are in accordance with job drawings; *(n)* motor connections are properly made; *(o)* contactors and electromechanical relays whose armatures are accessible operate freely by hand; *(p)* electrical enclosures are correct NEMA type and panel doors operate properly; *(q)* brushes are properly seated; *(r)* electrical holding brakes are adjusted to correct torque settings; and *(s)* conductors are identified at each termination by being marked to correspond to the schematic diagram.	*(h)* electrical items requiring routine maintenance are accessible; *(i)* no wiring is touching resistor heating parts; *(j)* portions of conductor systems which are designed to move in order to accommodate crane motion move freely; *(k)* ancillary electrical items are properly installed; *(l)* N/A - Radio controls are specified instead of a pendant *(m)* overload relay current sensing elements are in accordance with job drawings; *(n)* motor connections are properly made; *(o)* contactors and electromechanical relays whose armatures are accessible operate freely by hand; *(p)* electrical enclosures are correct NEMA type and panel doors operate properly; *(q)* brushes are properly seated; *(r)* electrical holding brakes are adjusted to correct torque settings; and *(s)* conductors are identified at each termination by being marked to correspond to the schematic diagram.
7250 Shop No-Load Test A shop no-load test shall be performed at the crane manufacturer's facility. Procedure(s) shall be prepared and used by the crane manufacturer in conducting the shop no-load test. If subsequent manufacturing or associated activities affect the validity of this test or portions thereof, the appropriate portion of the test shall be repeated. The crane manufacturer's personnel shall direct the test following the appropriate procedure(s). Nonconformances found during the shop no-load test shall be treated as required by this Standard.	A shop no-load test will be performed for the trolley at the manufacturer's facility under the direction of the manufacturer. Testing is specified in MMH Document 36675-07 (Factory Acceptance Test Procedure) and will not be performed until manufacturing of all items that affect the validity of the test are completed. Nonconformances found during the shop no-load test are treated as required by this Standard.
7251 Prerequisites Prior to conducting the shop no-load test, the crane or applicable portions to be tested shall be assembled and wired subject to the following. *(a)* The crane or its applicable portions need not be completely	Prior to conducting the shop no-load test, the trolley is assembled and wired and will be subject to the following. Ref. MMH Document 36675-07 (Factory Acceptance Test Procedure). *(a)* The trolley is completely assembled, wired, and coated with primer as

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assembled, wired, or painted at time of testing if subsequent work will not influence or alter the results of the test. ***(b)*** Temporary electrical connections for test purposes are acceptable for normally installed field wiring. Where conductor bar systems are used, only enough of the conductor bar lengths need be installed to set collector shoes and check trolley operations. ***(c)*** When testing the operation of mechanical portions of the crane, the use of a temporary controller is acceptable. ***(d)*** When testing electrical portions of the crane, the crane will be tested with the actual crane controls unless specifically excepted by the purchaser.	a minimum for the shop no-load test. ***(b)*** Temporary electrical connections for items that interface with the crane will be used to test the system. ***(c)*** N/A - A temporary controller is not used. ***(d)*** When testing electrical portions of the crane, the crane will be tested with the actual crane controls
7252 Mechanical Requirements As a minimum, the following mechanical functions shall be verified: ***(a)*** traverse of the trolley frame with wheel assemblies and other trolley-to-bridge interface items for tracking and clearances on the bridge (powered operation is preferable if conditions permit); ***(b)*** powered operation of bridge and trolley drive and hoist units; ***(c)*** operation of miscellaneous mechanical components such as brake and rail clamps in accordance with design criteria.	The following mechanical functions will be verified during in MMH Document 36675-07 (Factory Acceptance Test Procedure) and MMH Document 36675-13 (Site Acceptance Test Procedure). ***(a)*** traverse of the trolley frame with wheel assemblies and other trolley-to-bridge interface items for tracking and clearances on the bridge; ***(b)*** powered operation of bridge and trolley drive and hoist units; ***(c)*** operation of miscellaneous mechanical components including the brakes
7253 Electrical Requirements A test of the crane electrical system shall be made to verify proper operation of the controls. For radio controlled cranes, the transmitter-receiver system need not be used for this test. An alternate means of operation of the receiver driven relay panel is acceptable.	The functionality of all electrical crane controls will be tested in MMH Document 36675-07 (Factory Acceptance Test Procedure) and MMH Document 36675-13 (Site Acceptance Test Procedure).
7260 Preparation for Shipment Requirements As a minimum, the preparation for shipment of Types, I, II, and III cranes shall meet the requirements of Section 8000. Coatings shall be inspected in accordance with para. 70.	The preparation for shipment of the crane will meet the requirements of Section 8000. Coatings are inspected in accordance with para. 7700.
7270 Final Verification of Document Requirements The owner or the owner's authorized representative shall verify the documentation which has been compiled by the manufacturer as	The owner or owner's authorized representative will verify the documentation compiled by the manufacturer as required by para. A-

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required by para. A-7613.	7613, that will be contained in MMH Document 36675-17 (QA Document Binder).
7300 RECEIPT AND STORAGE REQUIREMENTS FOR STORAGE FACILITY AND/OR SITE Assurance of implementation of the requirements of this Subsection for Types I and II cranes shall be in accordance with Section 2000.	There is no storage of equipment at Zion Station. Equipment is shipped directly from the factory to the site for immediate installation following delivery and receipt inspection. ZionSolutions will execute the receipt requirements of this section in accordance with the Section 2000 requirements.
7310 Receiving Inspection This Subsection defines requirements for the receipt inspection of cranes to be fulfilled by the organization responsible for performing the handling, storage, and reshipment of the equipment. These requirements outline the criteria involved in the inspection to verify that the crane components have been received in accordance with contractual requirements. The receipt inspection verifies that the quality of the crane has not been reduced due to corrosion, contamination, deterioration, or physical damage resulting from its being shipped.	Storage and reshipment are N/A. ZionSolutions is the organization responsible for performing the handling of the equipment at the site and is therefore responsible for the receiving inspection at the site. Criteria will be established as described in the sections below to verify that the crane components have been received in accordance with contractual requirements and that the quality of the crane has not been reduced due to corrosion, contamination, deterioration, or physical damage resulting from its being shipped.
7311 Requirements The following minimum requirements for receipt inspection apply to Types I, II, and III cranes.	ZionSolutions will prepare requirements for receipt inspections as described in the following sections.
7311.1 Receiving Inspection Plan A Receiving Inspection Plan shall be prepared by the owner or owner's designated representative. The plan shall provide instructions for performing receiving inspection covering the following activities: ***(a)*** documentation, ***(b)*** visual inspection, ***(c)*** marking and tagging, ***(d)*** testing, and	***(a-e)*** ZionSolutions will prepare a Receiving Inspection Plan which will provide receiving instructions for the following activities: ***(a)*** documentation, ***(b)*** visual inspection, ***(c)*** marking and tagging, ***(d)*** testing, and ***(e)*** preparation for storage

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(e) preparation for storage.	
7311.2 Receiving Inspection Plan Implementation Receiving inspection shall be initiated upon notification that the crane has arrived at the designated area. This inspection shall be carried out in accordance with the Receiving Inspection Plan.	ZionSolutions receiving inspection will be initiated once the crane has arrived at the designated area at the Zion Station site and the inspection performed in accordance with the Receiving Inspection Plan..
7312 Conformance to Documentation A review shall be made to ensure that a correlation exists between the item received and its supporting documentation. The review shall include a comparison of the release for shipment documents, equipment identification numbers, purchase order document numbers, and other item identification.	The Receiving Inspection Plan will include criteria to review and ensure that a correlation exists between the item received and its supporting documentation and will include a comparison of the release for shipment documents, equipment identification numbers, purchase order document numbers, and other item identification..
7313 Visual Examination **7313.1 Preliminary Inspection** A preliminary inspection shall be performed prior to unloading to identify damage that may have occurred. Observations for unusual conditions shall include: ***(a)*** *Fire.* Charred paper, wood, or paint, indicating exposure to fire or high temperature. ***(b)*** *Excessive Exposure.* Weather-beaten, frayed, rusted, or stained containers indicating prolonged exposure during transit. ***(c)*** *Environmental Damage.* Water or oil marks, damp conditions, dirty areas, or salt film (indicating exposure to seawater or winter road salt chemicals). ***(d)*** *Tie Down Failure.* Shifted, broken, loose, or twisted shipping ties, and worn material under ties. ***(e)*** *Rough Handling.* Splintered, torn, or crushed containers indicating improper handling; review of impact recording instrument readings, when required.	***(a-e)*** The Receiving Inspection Plan and associated inspection criteria to perform a preliminary inspection prior to unloading to identify damage that may have occurred. Unusual conditions that will be included in the inspection criteria for checking include: (a) Fire (b) Excessive Exposure (c) Environmental Damage (d) Tie Down Failure (e) Rough Handling
7313.2 Item Inspection Item inspection shall be performed at the designated receiving area. Unless the package marking prohibits unpacking, the contents of all shipments shall be visually inspected to ascertain compliance with specified packing and shipping requirements. Items packaged	ZionSolutions will perform item inspection at the designated receiving area. The Receiving Inspection Plan will ensure that the following criteria are met: Unless the package marking prohibits unpacking, the contents of all shipments shall be visually inspected to ascertain compliance with specified packing and shipping requirements. Items packaged in separate,

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in separate, moisture-proof, transparent bags shall be visually inspected without unpacking. Inspections shall be performed in a manner to avoid contamination of the item during inspection.	moisture-proof, transparent bags shall be visually inspected without unpacking. Inspections shall be performed in a manner to avoid contamination of the item during inspection.
7314 Marking and Tagging Items shall be inspected to verify that the markings and tags are affixed in accordance with Section 8000 and the purchase order documents. The Receiving Inspection Plan shall identify these marking and tagging requirements.	ZionSolutions will prepare a Receipt Inspection Plan and associated criteria to inspect items to verify that the markings and tags are affixed in accordance with Section 8000 and the purchase order documents.
7315 Testing In those cases where the purchase order documents and para. 7100 require testing during receiving inspection, the Receiving Inspection Plan shall delineate the test requirements and provide documentation instructions.	Subsequent to receipt inspection, the equipment will be tested in accordance with MMH Document 36675-13 (Site Acceptance Test Procedure) prior to being released for use.
7316 Preparation for Storage When the receiving inspection of an item has been completed, the item should be in satisfactory condition for storage. Assurance should be made that pipe caps or covers removed for receiving inspection are replaced, machined surfaces are protected, and crated items have been recrated in accordance with original purchase order requirements and para. 7260, governing preparation for shipment and storage.	N/A There is no storage of equipment. Equipment is shipped directly from the factory to the site for immediate installation following delivery and receipt inspection.
7320 Handling Inspection This Subsection defines requirements for the handling inspection of cranes to be fulfilled by the organization responsible for performing the handling, storage, and reshipment of the equipment. These requirements outline the criteria involved in the inspection to verify that the crane components have been handled in an acceptable manner. The handling inspection verifies that the quality of the crane has not been reduced due to unacceptable methods and procedures for handling the crane.	Subsequent to receipt inspection, the equipment will be tested in accordance with MMH Document 36675-13 (Site Acceptance Test Procedure) prior to being released for use. This testing will ensure no deleterious effects from site handling.
7321 Requirements An inspection program shall be established by the owner or the owner's designated representative for equipment and rigging in	ZionSolutions will prepare an inspection program for equipment and

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accordance with Section 8000.	rigging in accordance with Section 8000.
7330 Storage Inspection Prior to the commencement of storage activities, the owner or the owner's designated representative shall establish and maintain a storage inspection program consistent with the requirements of this Standard. The program shall specify the inspection surveillance intervals for these requirements.	N/A There is no storage of equipment. Equipment is shipped directly from the factory to the site for immediate installation following delivery and receipt inspection.
7331 Requirements Inspections and examinations shall be performed on a planned and systematic basis consistent with the requirements of Types I, II, and III cranes to verify that the integrity of the stored item and its protective cover, as provided for in para. 7260, are being maintained. Verification during the inspection activity shall be in accordance with Section 8000.	N/A There is no storage of equipment. Equipment is shipped directly from the factory to the site for immediate installation following delivery and receipt inspection.
7340 Preparation for Reshipment This Subsection defines the requirements for preparation for reshipment of cranes to be fulfilled by the owner or the owner's authorized representative.	N/A There is no reshipment of equipment. Equipment is shipped directly from the factory to the site for immediate installation following delivery and receipt inspection.
7341 Requirements The following minimum requirements for reshipment apply to Types I, II, and III cranes. Measures shall be established and documented to ensure that the equipment has been maintained and preserved in accordance with established instructions, procedures, or drawings to prevent damage, deterioration, and loss as per paras. 7320 and 7330. Prior to reshipment, the requirements of para. 7260 shall be verified or reestablished. The owner may waive specific requirements if waiving them is not adverse to quality, and provided the minimum requirements of para. 7310 are met. The documentation generated as requirements of paras. 7310 through 7340 shall be completed prior to reshipment and retained as specified in para. A-7620.	N/A There is no reshipment of equipment. Equipment is shipped directly from the factory to the site for immediate installation following delivery and receipt inspection.
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Assurance of implementation of the requirements of this Section for Types I and II cranes shall be in accordance with Section 2000.	Implementation of the requirements of this Section follows the applicable quality assurance programs specified in Section 2000.
7410 Installation **7411 Preinstallation Verification** **7411.1 General** Prior to the actual installation of Types I, II, and III cranes, there are certain preliminary inspections, checks, and similar activities that shall be completed to verify that the crane and the installation area conform to specified requirements, and that the necessary resources are available to assure that the quality of the crane will be maintained as the installation proceeds. The quality requirements and quality assurance actions that are necessary during installation shall be planned and reviewed so that they are understood by the responsible individuals.	Preliminary walk downs that include inspections, checks and other similar activities are performed on the crane to verify that the crane and the installation area conform to specified requirements, and that the necessary resources are available to assure that the quality of the crane will be maintained as the installation proceeds. The crane will be installed in accordance with MMH Document 36675-15 (Crane Installation Procedure). This procedure will include the quality requirements and quality assurance actions that are necessary during installation , and the procedure will be reviewed with the customer prior to installation so the requirements are understood by the responsible individuals.
7411.2 Identification (for Type I Cranes) Checks shall be made to verify that the identity of received equipment has been maintained and is in accordance with the latest approved-for-construction drawings, equipment lists, specifications, and established procedures. If these checks disclose apparent loss of identification, the identity shall be reaffirmed prior to release for installation. Checks shall be made to verify that a control system for maintaining identification of items throughout installation has been established. Provisions shall be made for an alternative system for equipment identification to drawings, specification, or records when identification or markings must be destroyed, hidden, or removed from an item.	The crane will be installed in accordance with MMH Document 36675-15 (Crane Installation Procedure). This procedure will include the necessary verification of component identification and marking.
7411.3 Processes and Procedures (Types I and II Cranes) Consistent with the construction activities schedule, inspections or checks shall be performed to verify that procedures are ready when	Inspections or checks are performed to verify that procedures are ready when needed during the installation of the crane components. These

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needed for use in the installation of the crane components. These inspections or checks shall include the verification of the following items. *(a)* Approved procedures, drawings, manuals, or other work instructions are provided to the installer at the construction site. *(b)* Special instructions and checklists as required are available at the installation area or attached to the item. *(c)* Approved procedures and instructions for special processes such as coating, welding, and nondestructive examination are available at the site. *(d)* Where applicable, personnel, procedures, and instructions shall have been qualified through the preparation of workmanship standards, samples, or mockups that simulate actual job conditions. *(e)* Installation preparations have been completed, including such tasks as removal of packaging, conditioning, cleaning, and preliminary positioning. *(f)* Jigs, fixtures, and equipment for special processes, if required, are available at the site and conform to specified requirements. *(g)* Equipment for handling and placement of items is available at the site and is adequate to perform the work in accordance with specified requirements. *(h)* Warnings and safety notices, appropriate to the activity, are posted.	inspections or checks include the following items. *(a)* Only approved procedures, drawings, manuals, or other work instructions are used for installation and testing. *(b)* Special instructions and checklists are provided where required. *(c)* Approved procedures and instructions for any special processes such as coating, welding, and nondestructive examination are available at the site. *(d)* All personnel are qualified to perform their assigned tasks. Installation procedures are reviewed and approved by the owner. *(e)* Installation preparations are completed prior to install. *(f)* Special equipment for installation is tested prior to being used. *(g)* Material handling equipment is available at the site and is appropriate for the intended use. *(h)* Warnings and safety notices applicable to the installation will be specified in MMH Document 36675-15 (Crane Installation Procedure). Warnings and safety notices applicable to the facility are the responsibility of the owner.
7411.4 Physical Condition and Record Review (Types I, II, and III Cranes) Inspections or checks, as appropriate, shall be performed to verify that the crane items are in accordance with the specified requirements and that quality has been maintained. These inspections or checks shall include the following verifications. *(a)* Protective measures and physical integrity during storage have been maintained in conformance with paras. 7330, 7430, and Section 8000. *(b)* Nonconformances have been satisfactorily disposed of or	Inspections or checks, as appropriate, will be performed by the owner and manufacturer before and after installation to verify that the crane items are in accordance with the specified requirements and that quality has been maintained. Ref. MMH Document 36675-07 (Factory Acceptance Test Procedure), MMH Document 36675-13 (Site Acceptance Test Procedure), MMH Document 36675-15 (Crane Installation Procedure), and MMH Document 36675-17 (QA Document Binder). These inspections or checks include the following verifications.

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controlled. *(c)* Items have been cleaned in accordance with specified requirements.	*(a)* N/A - There is no storage of equipment. Equipment is shipped directly from the factory to the site for immediate installation. *(b)* Nonconformances are satisfactorily disposed of or controlled. *(c)* Items are cleaned in accordance with specified requirements.
7411.5 Site Conditions (Types I, II, and III Cranes) Inspections or checks, as appropriate, shall be performed to verify that conditions of the installation area conform to specified requirements and precautions have been taken to prevent conditions that will adversely affect the quality of the item during installation. These inspection checks shall verify the following. *(a)* Protection from adjacent construction activities is being provided, including implementation of appropriate exclusion and area cleanness requirements. *(b)* Protection from inclement weather and other ambient conditions adverse to quality is being provided. *(c)* Materials that may be deleterious to the crane items being installed are controlled. *(d)* Installation of the crane will not adversely affect the subsequent installation of other equipment, and repair or rework on any nonconforming items can be performed satisfactorily. *(e)* Permanent crane runway (or approved temporary) supports and mountings that will properly interface with the crane have been installed. *(f)* Servicing or maintenance activity related to installation has been performed.	Inspections or checks, as appropriate, are performed during the crane walk down and during installation per MMH Document 36675-15 (Crane Installation Procedure) to verify that conditions of the installation area conform to specified requirements, and precautions are taken to prevent conditions that will adversely affect the quality of the item during installation. These inspection checks verify the following. *(a)* N/A - There are no construction activities adjacent to the installation area *(b)* Protection from inclement weather and other ambient conditions adverse to quality is being provided. *(c)* Materials that may be deleterious to the crane items being installed are controlled. *(d)* Installation of the crane does not adversely affect the subsequent installation of other equipment, and repair or rework on any nonconforming items can be performed satisfactorily. *(e)* Permanent crane runway supports and mountings that will properly interface with the crane are installed. *(f)* Servicing or maintenance activity related to installation has been performed.
7412 Control During Installation For Types I and II cranes, checking, inspection, examination, or testing activities shall be performed during the installation of crane components to ensure that the crane is being assembled in accordance with prescribed procedures. These activities shall be performed in a systematic manner to ensure surveillance throughout the installation process. A procedure shall be provided for the coordination and sequencing of these activities at	Checking, inspection, examination, or testing activities will be performed during the crane installation to ensure that the crane is assembled in accordance with prescribed procedures. These activities are performed in a systematic manner to ensure surveillance throughout the installation process. MMH Document 36675-15 (Crane Installation Procedure) provides the coordination and sequencing of these activities at established inspection points during successive stages of installation.

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established inspection points in successive stages of installation. A method shall be implemented to ensure that engineering and design changes are documented and controlled during installation.	Engineering and design changes are documented and any new revisions of applicable documents are officially transmitted to the owner.
7413 Process and Procedure Control For Types I and II cranes, checks shall be made to verify that a system of controls has been established and is being maintained at the construction site to assure the following. *(a)* The applicable revisions of approved procedures, drawings, and instructions are being followed. *(b)* Qualified and approved processes, materials, tools, and other equipment are being used by qualified personnel. *(c)* The status of installation, inspections, examinations, or tests is clearly indicated or identified in inspection records. *(d)* The installation, inspection, and testing sequence are being maintained. *(e)* Identification, appropriate segregation, and disposition of nonconforming items are being controlled. *(f)* Inspection and test reports are current, accurate, and complete.	The manufacturer and owner jointly provide quality checks to ensure that installation and start up on site are performed per appropriate procedures for the items listed. Ref. MMH Document 36675-15 (Crane Installation Procedure) and MMH Document 36675-13 (Site Acceptance Test Procedure *(a)* The applicable revisions of approved procedures, drawings, and instructions are controlled separately by both the manufacturer and owner. All new document revisions are officially transmitted to the owner. *(b)* Qualified and approved processes, materials, tools, and other equipment are being used by qualified personnel. *(c)* The status of installation, inspections, examinations, or tests is clearly indicated or identified in inspection records. *(d)* The installation, inspection, and testing sequence are maintained. *(e)* Identification, appropriate segregation, and disposition of non-conforming items are controlled. *(f)* Inspection and test reports are current, accurate, and complete.
7414 Examination Nondestructive examinations, when required, shall be performed in accordance with para. 7100.	Nondestructive examinations, when required, will be specified on applicable drawings, in MMH Document 36675-15 (Crane Installation Procedure) or in MMH Document 36675-13 (Site Acceptance Test Procedure), and will be performed in accordance with para. 7100.
7415 Inspection (Types I, II, and III Cranes) Inspections of the work areas and the work in progress shall be performed to verify that crane components are being located, installed, assembled, or connected in compliance with the latest approved for construction drawings, manufacturer's instructions, codes, installation instructions, and procedures. Inspections performed shall include as appropriate the following:	MMH Document 36675-15 (Crane Installation Procedure) provides assurance that crane components will be located, installed, assembled, or connected in compliance with the latest approved for construction drawings, instructions, codes, installation instructions, and procedures. Inspections performed include the following as applicable:

NOG-1 Single Failure Proof Requirements	Zion Station FHB *Crane Trolley* Compliance
(a) identification; *(b)* location and orientation of components; *(c)* leveling and alignment; *(d)* clearances and tolerances; *(e)* tightness of connections and fasteners; *(f)* fluid levels and pressures; *(g)* cleanness; *(h)* welding operations including materials and process controls; and *(i)* adequacy of housekeeping, barriers, and protective equipment to ensure that items will not be damaged or contaminated as a result of adjacent construction activities.	*(a)* identification based on MMH drawing numbers *(b)* location and orientation of components *(c)* leveling and alignment *(d)* clearances and tolerances *(e)* tightness of connections and fasteners *(f)* fluid levels are proper *(g)* cleanness *(h)* welding is performed per proper procedures *(i)* N/A - The facility is already constructed
7416 Assembled Inspection (Types I, II, and III Cranes) Checks shall be performed to verify that all components have been correctly installed. If construction or associated activities affect the results of these checks, the checks shall be repeated if necessary to assure that the quality has not been adversely affected. Checkout procedures to verify correctness of installation and ability to function shall include the following mechanical elements: *(a)* proper positioning of mating parts, such as couplings; *(b)* completion of proper greasing or lubrication; *(c)* priming, venting, and filling of casings, reservoirs, etc.; *(d)* proper installation of seismic anchors and restraints; *(e)* reeving to conform to manufacturer's instructions; *(f)* recording camber of girders with trolley(s) at midpoint of span; *(g)* control of special bolting method; *(h)* inspection of electrical connections for good contact and conformance with wiring diagram; and *(i)* inspection of bridge conductor-collector system for proper alignment.	The installed system is carefully checked to verify that all components have been correctly installed. Checkout procedures to verify correctness of installation and ability to function will be provided in MMH Document 36675-07 (Factory Acceptance Test Procedure), MMH Document 36675-13 (Site Acceptance Test Procedure), MMH Document 36675-15 (Crane Installation Procedure), and in applicable assembly drawings. These procedures include: *(a)* proper positioning of mating parts, such as couplings; *(b)* completion of proper greasing or lubrication; *(c)* priming, venting, and filling of casings, reservoirs, etc.; *(d)* proper installation of seismic anchors and restraints; *(e)* reeving to conform to manufacturer's instructions; *(f)* recording camber of girders with trolley(s) at midpoint of span; *(g)* control of special bolting method; *(h)* inspection of electrical connections for good contact and conformance with wiring diagram; and *(i)* inspection of bridge conductor-collector system for proper alignment.
7420 Preoperational Testing and Inspection This Subsection defines requirements for pre-op testing and	This crane is not used for construction. Pre-operational testing will be

NOG-1 Single Failure Proof Requirements	Zion Station FHB *Crane Trolley* Compliance
inspection to ensure that the equipment will perform as required for handling of items during construction. A pre-op testing and inspection program shall be established to demonstrate that the crane will perform satisfactorily in service. The preop testing shall be performed in accordance with written test procedures which incorporate the requirements and acceptance criteria contained in applicable documents, which include applicable manufacturer recommendations. The owner or the owner's designated representatives shall conduct and be responsible for the pre-op tests called for in these procedures, shall furnish all facilities necessary for the performance of such tests, and shall ensure that proper communications are established for control of testing. Pre-op testing and inspection requirements discussed in this Subsection shall be applicable to Types I, II, and III cranes; these testing requirements shall be completed after the equipment has been installed and prior to construction-operational use of the crane.	performed per MMH Document 36675-13 (Site Acceptance Test Procedure).
7421 No-Load Test A no-load test will be performed on cranes, after the power supply has been verified to be in conformance with the crane specifications, to verify the following: ***(a)*** motor rotation is correct; ***(b)*** lubrication and cooling systems are in service; ***(c)*** limit switches, interlocks, and stops are properly adjusted and set; ***(d)*** instrumentation is calibrated and in service as required; and ***(e)*** controls are adjusted properly for all drives for hoist, trolley, and bridge through the speed ranges.	No-Load testing will be performed per MMH Document 36675-13 (Site Acceptance Test Procedure) to ensure: ***(a)*** motor rotation is correct ***(b)*** all applicable components are lubricated ***(c)*** limit switches are properly operating ***(d)*** instrumentation is calibrated and in service as required ***(e)*** controls are adjusted properly for all hoist, trolley, and bridge drives
7421.1 Additional Requirements At the same time the no-load testing is being performed, the following information shall be recorded or observed: ***(a)*** *Electrical for (Full-Speed Conditions)* *(1)* motor volts	The following items will be recorded or observed per MMH Document 36675-13 (Site Acceptance Test Procedure): ***(a)*** *Electrical for (Full-Speed Conditions)* *(1)* motor volts

NOG-1 Single Failure Proof Requirements	Zion Station FHB *Crane Trolley* Compliance
(2) motor amps *(3)* motor rpm ***(b)*** *Mechanical* *(1)* noise level *(2)* oil leaks *(3)* excessive vibration *(4)* complete check of crane to certified clearance drawing *(5)* gear alignment and engagement ***(c)*** *Structural* *(1)* overall clearances *(2)* trolley end approaches	*(2)* motor amps *(3)* motor rpm ***(b)*** *Mechanical* *(1)* noise level *(2)* oil leaks *(3)* excessive vibration *(4)* complete check of crane to certified clearance drawing *(5)* gear alignment and engagement ***(c)*** *Structural* *(1)* overall clearances *(2)* trolley end approaches
7422 Full-Load Test The crane shall be statically loaded at mid-span to a maximum of 100% of hoist manufacturer's rating, and the deflection of the bridge at its center shall be measured and recorded. With this load, the crane shall be operated through all drives for hoist, trolley, and bridge, and through all speed ranges to demonstrate speed controls and proper function of limit switches, locking, and safety devices. For Type I cranes, the manual critical load lowering device(s) shall be tested. For Type I cranes, each holding brake shall be tested individually to verify that it will stop and hold the test load.	MMH Document 36675-13 (Site Acceptance Test Procedure) details the static loading of the crane at mid-span to a maximum of 100% of the rated load, and recording the deflection of the bridge at its center. With this load, the crane will be operated through all drives for hoist, trolley, and bridge, and through all speed ranges to demonstrate speed controls and proper function of limit switches, locking, and safety devices. This procedure also includes testing the manual critical load lowering devices and individually testing the holding brakes to verify that each will stop and hold the test load.
7423 Rated Load Test After the no-load test and full-load tests are completed, and prior to use of the crane to handle loads, the crane shall be rated load tested. ***(a)*** The crane shall receive a rated load test of 125% (+5%, -0%) of the manufacturer's rated load. ***(b)*** The rated load test shall consist of the following operations as a minimum requirement. *(1)* Lift the test load a distance to ensure that the load is supported by the crane and held by the hoist brakes. *(2)* Transport the test load by means of the trolley from one	Ref. MMH Document 36675-13 (Site Acceptance Test Procedure) will control testing of the for the following items: ***(a)*** The trolley is load tested to 125% during the factory acceptance test. The crane will be load tested to 125% (+5%, -0%) of the rated load to establish a minimum operating temperature in accordance with NUREG-0554 guidance. ***(b)*** The load test consists of the following operations: *(1)* Lifting the test load a distance to ensure that the load is supported by the crane and held by the hoist brakes. *(2)* Transporting the test load by means of the trolley from one

NOG-1 Single Failure Proof Requirements	Zion Station FHB *Crane Trolley* Compliance
end of the crane bridge to the other. The trolley shall approach the limits of travel as close as is practical in the event use area restrictions are imposed. *(3)* Transport the test load by means of the bridge for the full length of the runway in one direction with the trolley as close to the extreme right-hand end of the crane as is practical, and in the other direction with the trolley as close to the extreme left end of the crane as is practical. *(4)* Lower the test load, stop, and hold the load with the brakes. *(5)* Verify that the nameplate reflects load rating per (a) above.	end of the crane bridge to the other, approaching the limits of travel as close as is practical. *(3)* Transporting the test load by means of the bridge for the full length of the runway in one direction with the trolley as close to the extreme right-hand end of the crane as is practical, and in the other direction with the trolley as close to the extreme left end of the crane as is practical. *(4)* Lowering the test load, stopping, and holding the load with the brakes. *(5)* Verifying that the nameplate reflects the load rating per (a) above.
7424 Certification A written report confirming that the crane has successfully passed the rated load test load rating of the crane shall be furnished. This report shall be signed by representatives of all parties participating in the test.	MMH Document 36675-13 (Site Acceptance Test Procedure) details the load testing procedures. This document will be signed by representatives of all parties participating in the test upon successful completion.
7430 Cranes Used for Construction (Types I, II, and III Cranes) Temporary use of cranes to which this Standard applies that are to become part of the completed project may be desirable. However, authorization for such usage shall be as provided for in the contract or by written approval from the responsible organization. Such use shall not subject the crane to conditions for which it was not designed. The temporary use authorization shall include: ***(a)*** conditions of use; ***(b)*** maintenance requirements; ***(c)*** inspections and test as required to maintain operability and quality during periods of temporary use of the crane; and ***(d)*** requirements for maintaining operating and maintenance logs. When temporary use is completed, conditions of temporary use shall be evaluated to verify that the crane continues to satisfy the specified requirements for its permanent intended use.	***(a-d)*** N/A - This crane is not used for construction
7500 QUALIFICATION FOR PERMANENT PLANT SERVICE	

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Assurance of implementation of the requirements of this Subsection for Types I and II cranes shall be in accordance with Section 2000.	N/A - This crane is not used for construction and, therefore, does not require additional qualification for permanent plant service after construction use.
7510 Construction Use Record Review **7511 Requirements** Measures shall be established and implemented for the reviewing of construction use records for Types I, II, and III cranes. As a minimum, the following construction use records shall be reviewed by qualified personnel: ***(a)*** maintenance log and ***(b)*** operating log.	***(a-b)*** N/A - This crane is not used for construction and, therefore, does not require additional qualification for permanent plant service after construction use.
7512 Documentation Documentation to substantiate that construction use record review has been completed as required by para. 7511 shall be validated. This documentation shall be maintained in accordance with para. A-7630. These records shall be considered valid only if stamped, initialed, signed, or otherwise authenticated and dated by authorized personnel.	N/A - This crane is not used for construction and, therefore, does not require additional qualification for permanent plant service after construction use.
7520 Inspection Prior to Performance Testing This Subsection is intended to outline the inspection requirements necessary to qualify Types I, II, and III cranes for permanent plant service after construction use.	N/A - This crane is not used for construction and, therefore, does not require additional qualification for permanent plant service after construction use.
7521 Requirements Systems and procedures shall be established by the owner or the owner's designee to ensure that the inspection requirements as delineated within this Section are accomplished and documented by qualified personnel. These requirements are minimums and may be added to after review of construction use records if applicable. Discrepancies shall be corrected and reinspected in accordance with this Standard.	N/A - This crane is not used for construction and, therefore, does not require additional qualification for permanent plant service after construction use.
7521.1 General ***(a)*** Prior to making mechanical and electrical inspections, the construction use logs shall be reviewed as required by para. 7510 of	***(a-b)*** N/A - This crane is not used for construction and, therefore, does not require additional qualification for permanent plant service after

NOG-1 Single Failure Proof Requirements	Zion Station FHB *Crane Trolley* Compliance
this Standard. Special attention shall be given to inspection of problem areas as noted in construction use logs. ***(b)*** Cranes shall be checked for cleanness. Dirt and foreign material shall be removed prior to inspection.	construction use.
7521.2 Mechanical Inspection ***(a)*** Inspection covers shall be cleaned and opened, and exposed components shall be inspected for physical damage. ***(b)*** Oil in reservoir shall be visually inspected for cleanness, filling to proper level, and foreign material. ***(c)*** Gears shall be rotated so that all teeth on all gears can be inspected for pitting, featheredges at the tips of teeth, and misalignment. ***(d)*** Bolts shall be inspected for tightness. ***(e)*** Couplings shall be inspected for tight bolts, elongation of bolt holes, and tightness of keys in keyways. ***(f)*** Bridge and trolley drive and idler wheels shall be inspected for excessive flanging and flat spots. See Fig. 7521.2(f)-1. ***(g)*** External welds listed in Tables 7200-1 and 7200-2 shall be visually examined. ***(h)*** All structural members shall be visually inspected by a qualified person for damage resulting from abuse or neglect. ***(i)*** Verify camber and compare with recording made per para. 7416(f). ***(j)*** Sheaves shall be inspected for wear and defects that could damage wire rope. ***(k)*** Bumpers and stops shall be verified as intact and operable. ***(l)*** Bearing housings shall be inspected for integrity, lubrication, and cleanness. ***(m)*** Trolley rail clips and trolley rails shall be inspected for tightness, excessive wear, and alignment. ***(n)*** Cab glass shall be inspected and replaced as necessary. ***(o)*** Wire rope shall be inspected for broken wire, strands, twists, kinks, or signs of wear.	***(a-u)*** N/A - This crane is not used for construction and, therefore, does not require additional qualification for permanent plant service after construction use.

NOG-1 Single Failure Proof Requirements	Zion Station FHB *Crane Trolley* Compliance
(p) Capacity signs shall be inspected for visibility from the operating floor. ***(q)*** Hoist drums shall be inspected for wear and defects that could damage wire rope. If groove root diameter is worn in excess of one-fourth the rope diameter, drum shall be replaced. ***(r)*** Hook shall be inspected in accordance with ASME B30.10. Hook dimensions shall be validated. A record of this validation shall be maintained in accordance with para. A-7630. ***(s)*** Top nut on hook shank shall be verified to be secure and not turned on shank. ***(t)*** Hook shall be inspected to see that it swivels easily and that thrust bearing is lubricated and in good condition. ***(u)*** All hydraulic and pneumatic systems shall be inspected for leaks and damage.	
7521.3 Electrical Inspection (Visual) While Crane Is Immobile A qualified electrician shall be assigned to the electrical inspection. All electrical power to the crane is to be locked out and under the control of the inspector. ***(a)*** *Motors* *(1)* Inspect all brushes for wear, even contact, and damage. *(2)* Inspect springs for tension on brushes. *(3)* Inspect slip rings for pitting and wear. *(4)* Inspect wires and terminals for tightness. *(5)* Inspect insulation on wires for cracks or brittleness. *(6)* Verify that motor bearings are properly lubricated. ***(b)*** *Other Electrical Components* *(1)* Inspect connections for tightness. *(2)* Inspect collector system for physical damage. *(3)* Inspect insulators for cracks. *(4)* Inspect contactor and relay contacts forwear, pitting, and burning (does not apply to sealed relay contacts). *(5)* Verify that timers are functioning and properly set. *(6)* Verify that all panel doors shut properly and door seals	***(a-c)*** N/A - This crane is not used for construction and, therefore, does not require additional qualification for permanent plant service after construction use.

NOG-1 Single Failure Proof Requirements	Zion Station FHB *Crane Trolley* Compliance
are intact. *(7)* Inspect resistors for burned-out sections, breaks, or cracks in insulation. *(8)* Inspect disconnect switches and overload devices. *(9)* Inspect master switch(es) or pendant pushbutton station contacts for operation, tight connections, and wear or pitting (unless contacts are sealed). *(10)* Inspect limit switches for operation, tight connections, and wear or pitting (unless contacts are sealed). *(11)* Inspect electrical enclosures for cleanness. ***(c)*** Verify the integrity of electrical enclosures and conduit systems.	
7530 Testing Requirements The crane shall be tested in accordance with para. 7420.	N/A - This crane is not used for construction and, therefore, does not require additional qualification for permanent plant service after construction use.
7540 Modification and Changes Modifications and changes in design shall be reviewed and approved by the owner or owner's designated representative. These changes in design shall be inspected and tested in accordance with this Standard.	N/A - This crane is not used for construction and, therefore, does not require additional qualification for permanent plant service after construction use.
7550 Recertification **7551 Crane Not Used for Construction** When the crane has not been used for construction and has been certified in accordance with para. 7420, it requires no recertification.	The crane is not used for construction and is certified in accordance with para. 7420. No recertification is required.
7552 Crane Used for Construction When used for construction, the crane, including any components installed subsequent to construction usage, shall be recertified by a qualified individual in accordance with paras. 7420 and 7500. The record of successful completion of these tests shall be signed by all participating parties.	N/A - This crane is not used for construction and, therefore, does not require additional qualification for permanent plant service after construction use.
7600 DOCUMENTATION The owner shall define, in its purchase documents, the requirements for the collection, storage, and maintenance of	The requirements for the collection, storage, and maintenance of documentation applicable to procurement, design, manufacture, shipment, receipt, storage, installation, and startup of cranes covered by

NOG-1 Single Failure Proof Requirements	Zion Station FHB *Crane Trolley* Compliance
documentation applicable to procurement, design, manufacture, shipment, receipt, storage, installation, and startup of cranes covered by this Standard. Guidance for determining documentation requirements to be specified in the owner's purchase documents is provided in Nonmandatory Appendix A. As a minimum, design and manufacturing documentation to be specified in the owner's purchase documents for all cranes shall include assembly and outline drawings; electrical schematics and wiring diagrams; acceptance test plans and procedures; software test plans for controls; operating instructions; maintenance instructions; and software programs. Installation documentation to be specified in the owner's purchase documents for all cranes shall include records of high strength bolt torquing, data sheets or logs on equipment installation inspection and alignment, lubrication records, documentation of testing performed after installation and prior to acceptance, results of end-to-end electrical tests, final system adjustment data, acceptance test procedures and results, and load tests. Additionally, for Type I and II cranes, system calculations and load summary reports shall be included. The owner's quality assurance program shall define which of these quality assurance documents are permanent records. Assurance of the implementation of the quality assurance documentation requirements contained in the owner's purchase documents for Type I and II cranes shall be in accordance with Section 2000.	this Standard are detailed in Zion Specification SP-ZS-FH-003. This specification includes requirements for assembly and outline drawings; electrical schematics and wiring diagrams; acceptance test plans and procedures; software test plans for controls; operating instructions; maintenance instructions; and software programs. Installation documentation will be provided as required in MMH Document 36675-15 (Crane Installation Procedure), and MMH Document 36675-13 (Site Acceptance Test Procedure) details the results of end-to-end electrical tests, final system adjustment data, acceptance test results, and load tests. Various calculations and load summary reports for the electrical and mechanical crane systems are listed in the references section. ZionSolutions will define the permanent quality assurance records in accordance with its Quality Assurance Program
8000 Packaging, Shipping, Receiving, Storage, and Handling	
8100 GENERAL The packaging, shipping, receiving, storage, and handling of Types I and II nuclear facility cranes shall be governed by the applicable Sections of ASME NQA-1, Part II, Subpart 2.2 and the modifications of this Section, as listed in Table 8000-1, or shall meet the quality assurance requirements specified by the owner. Type III cranes shall meet requirements of procurement documents. Receiving, storage, and handling functions, per Table 8000-1, are	The crane is packaged in accordance with ASME NQA-1, Part II, Subpart 2.2 and the modifications listed in Table 8000-1, or meets the quality assurance requirements specified by the owner. Any special instructions are transmitted to the owner prior to arrival. MMH Document MOP 18.1 (Preservation and Packaging) is the local control document.

NOG-1 Single Failure Proof Requirements	Zion Station FHB *Crane Trolley* Compliance
normally applicable to organizations other than crane manufacturers who perform under the requirements of this Standard.	
9000 Planned Engineering Lifts	
[Text and/or equations omitted]	N/A - There are no planned engineering lifts that exceed the rated load of the crane.

Note 1. Compliance with the requirements of NOG-1, 2004 is only provided for the new trolley and associated upgrades in this document. Bridge structural stress evaluation was conservatively performed in accordance with NOG-1 and is addressed where applicable. All other components of the crane are addressed in the NUREG-0554 Compliance Matrix, which demonstrates the crane system as single failure proof by evaluation to the requirements of NUREG 0554.

Attachment 6

NUREG 0554 Compliance Matrix

Safety Analysis Report (NUREG 0554 Compliance Matrix)

For

Single Failure Proof Trolley
Zion Fuel Handling Crane

Crane Serial Number: CN-36675

PURPOSE OF SAFETY ANALYSIS REPORT

The purpose of this report is to verify the design of the new Zion Fuel Handling Building (FHB) Crane meets the requirements of NUREG 0554. This report demonstrates the compliance of the crane design to NUREG 0554.

BACKGROUND

The FHB crane is one of the first tools used in getting the fuel to the pad. The crane handles each cask and accurately positions it underwater in the cask loading area next to the spent fuel racks where it is filled with spent fuel. Once each cask is filled, the crane is used to perform a number of steps to assemble the cask, and then lifts and transports each cask to the cask preparation area where it is drained, backfilled with inert gas, and prepared for transport to the ISFSI. These moves of cask components and the assembled cask require numerous heavy loads that are transported near the spent fuel racks or open canister. Therefore, the spent fuel loading process needs to meet the guidance of NUREG 0612.

NUREG 0612 provided guidance for users to define the requirements of the overhead crane, specifically the Single Failure Proof Criteria, but implemented standards that are approximately 30 years old. NUREG 0612 provided one path for the user to make the crane a Single Failure Proof device per the requirements of NUREG 0554. NUREG 0554 provided the user direction, but was very qualitative in nature, leaving design areas open to interpretation. Two major steps which occurred to help eliminate this ambiguity included the issuance of ASME NOG–1 2004 and the endorsement of NOG–1–2004 by the Nuclear Regulatory Commission in Regulatory Issue Summary (RIS) 2005-25, Supplement 1, "Clarification of NRC Guidelines for Control of Heavy Loads,. For plants with existing cranes, this provided a quantifiable and detailed direction for the implementation of Single Failure Proof Criteria plus a path to use their original design basis to meet the regulator's requirements. The most common solution is to replace the trolley with a NOG–1–2004 compliant assembly, and then qualify the bridge to NUREG 0554. The plant can then bundle the entire crane into a NUREG–0554 compliant assembly to enable them to proceed with Spent Fuel Cask handling.

REFERENCES

Fuel Handling Building Overhead Bridge Crane Upgrade Services, Specification SP-ZS-FH-003, Rev. 01

NUREG 0612, "Control of Heavy Loads at Nuclear Power Plants", published by Nuclear Regulatory Commission, July 1980

ASME NOG–1–2004, "Rules for Construction of Overhead and Gantry Cranes (Top Running Bridge, Multiple Girder," published by The American Society of Mechanical Engineers, Issued May 16, 2005.

NRC Regulatory Issue Summary 2005–25, Supplement 1, Clarification of NRC Guidelines for Control of Heavy Loads, published by Nuclear Regulatory Commission, May 29, 2007.

MMH Calculation #36675-23, ZionSolutions Fuel Handling Building Crane Reeving Stress Calculation.

CMAA-70-2004, Specifications for Top Running Bridge and Gantry Type Multiple Girder Electric Overheat Traveling Cranes

MMH Procedure #36675-07, Factory Acceptance Test Procedure

MMH Procedure #36675-08, Main Hook and Nut Test Procedure

MMH Calculation #36675-10, Trolley Stress CriticalWeld Stress Calculation

MMH Calculation #36675-05, Zion Bridge Structural Calculations

MMH Calculation #36675- 09, Trolley Structural Analysis

MMH Procedure #36675-24, Bridge Inspection Procedure

MMH Document #36675-11, Critical List

MMH Procedure #36675-12, Main Hoist Wire Rope Test Procedure

MMH Procedure #36675-13, Site Acceptance Test

MMH Procedure #36675-16, Magnetorque Emergency Lowering Test Procedure

MMH Drawing R95399 Electrical Schematic

MMH Drawing 54214604 Interconnect Diagram (Electrical)

Section #	NUREG 0554 SINGLE-FAILURE-PROOF CRANES FOR NUCLEAR POWER PLANTS	Compliance Criteria For the ZionSolutions Fuel Building Crane	Licensee Exceptions	Items to be Tested	How it is tested
1.0	INTRODUCTION A general requirement for design and operation of light-water reactors is that fuel storage and handling systems be designed to ensure adequate safety under normal and accident conditions. Overhead cranes are used to lift and transfer heavy component parts such as spent fuel casks and reactor vessel heads. When a load being handled by a crane can be a direct or indirect cause of release of radioactivity, the load is called a critical load.	ZionSolutions single failure proof crane system utilize specially designed equipment that ensures safe and user friendly operation, including the handling of critical loads in nuclear applications. Special design considerations as outlined in NUREG 0554 are incorporated into the design of the Zion Fuel Handling Building single failure proof crane system to insure maximum safety, durability, and trouble free service when handling nuclear materials, including critical loads.	None	None	None
	NRC has licensed reactors on the basis that the safe handling of critical loads can be accomplished by adding safety features to the handling equipment, by adding special features to the structures and areas over which the critical load is carried, or by a combination of the two. When reliance for the safe handling of critical loads is placed on the crane system itself, the system should be designed so that a single failure will not result in the loss of the capability of the system to safely retain the load. This report identifies features of the design, fabrication, installation, inspection, testing, and operation of single-failure-proof overhead crane handling systems that are used for handling critical loads. These features are limited to the hoisting system	ZionSolutions single failure proof crane system utilizes various safety features to handle critical loads in nuclear power generation facilities, and are designed to ensure that a single failure of the crane system will not result in the loss of the capability of the system to safely retain a load. This is achieved through safety enhancements, safety margins, conservative design and redundancies. Controls procedures and processes are utilized during all phases of design, fabrication, installation, inspection, testing, and operation of the single-failure-proof crane system to ensure safe handling of critical loads. ZionSolutions single failure proof crane system complies with all applicable aspects of NUREG 0554 including all referenced codes and standards	None	None	None

Section #	NUREG 0554 SINGLE-FAILURE-PROOF CRANES FOR NUCLEAR POWER PLANTS	Compliance Criteria For the ZionSolutions Fuel Building Crane	Licensee Exceptions	Items to be Tested	How it is tested
	and to braking systems for trolley and bridge. Other load-bearing items such as girders should be conservatively designed but need not be considered single failure proof.	as clarified in this document.			
	The general value of existing standards is recognized in this report, and reliance is placed on quality levels indicated in CMAA Specification #70 and in ANSI B30.2.0-1967 as supplemented by the recommendations in the following sections of this report.	ZionSolutions single failure proof crane system complies with the general standards and quality levels contained in CMAA #70 and ANSI B30.2.0-1967. Other supplemental requirements and enhancements are further outlined in this report. The crane bridge was originally built and tested to EOCI-61 and ANSI B30.2.0-1967. CMAA-70 superseded EOCI-61. The structural design of the new trolley was performed per NOG-1-2004 and is the new Code of record for the trolley. No structural modifications were made to the bridge and therefore no deviation to the original Code of Record has occurred.	None	None	None
	The typical plant layout for pressurized water reactors (PWR's) is such that two different cranes may be required to handle critical loads. One of these cranes is located in the spent fuel storage and transfer area where the largest critical load would be a spent fuel shipping cask. The other crane is	The scope of this work is limited to the Fuel Handling building crane at Zion. There is one crane, which is shared between the two units and traverses the length of the building and over the spent fuel pools on a common runway.	None	None	None

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	located inside the containment structure over the reactor vessel where it is used to lift the reactor vessel head during refueling periods; this crane is called a polar crane because of the circular track for the bridge structure. In the plant layout for the majority of the boiling water reactors (BWR's) designed and built, a single crane handles critical loads near the reactor vessel and at the spent fuel storage area. However, for recent BWR plant designs (BWR Mark 6), two cranes could be needed to handle critical loads.				
2.1	Construction and Operating Periods When an overhead crane handling system will be used during the plant construction phase prior to its intended service in the operating plant, separate performance specifications may be needed to reflect the duty cycles and loading requirements for each service. At the end of the construction period, changes to the crane system may be required to reflect the specifications for the permanent operating plant condition. For example, if the specification for the size of the hoist drive motor differs sufficiently for the two applications, the motor and the	The scope of this modification and upgrade are only for operational performance. Issues dealing with new construction are not applicable. Allowable design stress limits (range) for the crane are based on, and are in compliance with NOG-1-2004 and therefore encompass Table 3.3.3.1.3-1 of CMAA Specification #70, including the appropriate duty cycle. These stress levels are documented in MMH Calculations #36675-23 Reeving Stress Report, 36675-09 Seismic Analysis, 36675-05 Bridge calculation, and 36675-10 Trolley Weld Calculation. The sum of the	None	None	None

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	affected control equipment would have to be replaced or changed for the operating plant phase. Features and functions needed for the cranes during the plant construction period are not considered in this report except where the use of the crane during construction may influence its design and operation for the permanent plant operation. If the load lifts during construction are heavier than those for plant operation, the performance specifications should include design criteria for a permanent crane for construction as well as for operation. The allowable design stress limits for the crane intended for plant operation should be those indicated in Table 3.3.3.1.3-1 of CMAA Specification #70 and reflecting the appropriate duty cycle in CMAA Specification #70. The sum total of simultaneously applied loads (static and dynamic) should not result in stress levels causing permanent deformation, other than localized strain concentration, in any part of the handling system during either the construction or the operating phase. The effects of cyclic loading induced by jogging or plugging[3] an uncompensated	simultaneously applied loads (static and dynamic) is evaluated to ensure that they do not result in stress levels causing permanent deformation, other than localized strain concentration, in any part of the handling system. The control system is a Variable Frequency Control system and therefore reverse plugging and dynamic impact due to jogging are not applicable. The structural design of the new trolley was performed per NOG-1-2004 and is the new Code of record for the trolley. No structural modifications were made to the bridge and therefore no deviation to the original Code of Record has occurred.			

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	hoist control system should be included in the design specification.				
2.2	Maximum Critical Load A single-failure-proof crane should be designed to handle the maximum critical load (MCL) that will be imposed. However, a slightly higher design load should be selected for component parts that are subject to degradation due to wear and exposure. This will provide a margin in the crane's load-handling ability before it drops below its MCL capacity. An increase of approximately 15% of the design load for these component parts would be a reasonable margin. The MCL rating should be clearly marked on the crane. Certain single-failure-proof cranes may be required to handle occasional non-critical loads of magnitude greater than the MCL during plant maintenance periods. For such cases, the maximum non-critical load will be the design rated load (DRL). The design of certain components may be decided to a greater extent by the MCL rating even though standard commercial practice may be used for the DRL rating. The DRL rating should be marked on the crane separately from the MCL marking.	The Maximum critical load (MCL) and the Design Rated Load (DRL) are both 125 tons per the design specification (3.1.3{1}) Since they are the same, only the MCL will be displayed. The crane components have been evaluated for the applicability of the 15% degradation factor and results of the evaluation are identified on Attachment 1. Since the fleet angles for the wire rope are limited, the equipment is indoors, the rope is lubricated, the rope is inspected to a defined criteria per ASME B30.2, and the limited use the crane will see at rated load, a 5% wear factor was used in their sizing (see Attachment 1).	None	None	None

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2.3	Operating Environment The operating environment, including maximum and minimum pressure, maximum rate of pressure increase, temperature, humidity, and emergency corrosive or hazardous conditions, should be specified for the crane and lifting fixtures.	The indoor environmental conditions for the Fuel Handling Building Crane are stated in the Design Technical specification. These parameters have been used in the design of the crane.	None	None	None
	For cranes inside the containment structure, the closed box sections of the crane structure should be vented to avoid collapse during containment pressurization. Drainage should be provided to avoid standing water in the crane structure.	This crane is not in containment and therefore this item is not applicable. Note that the only box section would be the trolley end trucks and they are vented to the atmosphere the Fuel Handling Building.	None	None	None
2.4	Material Properties Cranes are generally fabricated from structural shapes and plate rolled from carbon steel (no alloying elements except for 1% manganese in heavier section) or low-alloy steel (less than 5% total alloy content). Some of these steel parts exceed 12 mm (1/2 in) in thickness and may have brittle-fracture tendencies when exposed to lower operating temperatures so that testing of the material toughness becomes necessary. When low-alloy steels are used, weld metal toughness is of greater concern than the base metal.	The structural components of the trolley are made of A572 Grade 50, which conforms to the requirement of carbon steel. Designated structural materials of thickness 2½ in. to >5/8in. shall be impact tested by the Charpy V-notch test in accordance with Section ND-2300 of the ASME Code or the drop-weight test in accordance with Section NC-2300 of the Code. Materials of thickness greater than 2½ in. shall be impact tested by the drop-weight test in accordance with Section NC-2300 of the ASME Code. The test requirements are documented on the Critical List, #36675-11, plus the drawings that show	None	Those pieces of structural steel designated as critical per the Critical List and the weldment drawings.	These will be tested per ASME Boiler Code and NOG-1.

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		the critical items have the required test requirements & inspections clearly delineated in the lower right hand corner. All test results are fully documented and provided in the QA documentation package.			
	However, it may be impractical to perform toughness tests for cranes that have progressed too far in the manufacturing sequence or for cranes already built and operating. Such cranes should therefore be tested by subjecting the crane to a test lift at the lowest anticipated operating temperature. It is desirable to include the crane manufacturer in the planning of the test. Minimum operating temperatures should be specified in order to reduce the possibility of brittle fracture of the ferritic load-carrying members of the crane. In order to ensure resistance to brittle fracture, materials for structural members essential to structural integrity should be tested in accordance with the following impact test requirements. Either drop weight test per ASTM E-208 or Charpy tests per ASTM A-370 may be used for impact testing The minimum operating temperature based on the drop weight test should be obtained by following	The trolley will be a new fabrication and conform to the impact testing as defined above. A minimum operating temperature of 40 degrees F was specified for the new trolley. Since toughness test data is not available for the existing bridge, a cold proof load test will be performed to establish the minimum operating temperature for the crane as discussed below.	None	None	None

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	procedures in paragraph NC-2300 of Section III of the ASME Code. The minimum operating temperature based on the Charpy V-notch impact test should be obtained by following the procedures in paragraph ND-2300 of Section III of the ASME Code. Alternative methods of fracture analysis that achieve an equivalent margin of safety against fracture may be used if they include toughness measurements on each heat of steel used in structural members essential to structural integrity. In addition, the fracture analysis that provides the basis for setting minimum operating temperatures should include consideration of stress levels; quality control; the mechanical checking, testing, and preventive maintenance program; and the temperatures at which the DRL test is run relative to operating temperature.				
	These toughness recommendations were developed at a time-when typical material section thickness for crane girders was a maximum of 51 mm (2 in). However, later information indicates that material thicknesses of 102 mm (4 in) or more may be needed for some applications. The rules for ASME Code Class 3 charpy testing do not make any adjustments for thicknesses	Designated trolley structural materials of thickness >5/8in. shall be impact tested by the Charpy V-notch test in accordance with Section ND-2300 of the ASME Code or the drop-weight test in accordance with Section NC-2300 of the Code. Materials of thickness greater than 2½ in. shall be impact tested by the drop-weight test in accordance with Section NC-2300 of the ASME Code.	None	Those pieces of structural steel designated as critical per the Critical List and the weldment drawings.	These will be tested per ASME Boiler Code and the NOG-1.

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	greater than 64 mm (2 1/2 in), and for this reason it is felt that the NC-2300 and ND-2300 requirements give equivalent requirements only for the smaller thicknesses. For thicknesses over 64 mm (2 1/2 in), it is recommended that the NC-2300 requirements be used exclusively.				
	As an alternative to the above recommendations, the crane and lifting fixtures for cranes already fabricated or operating may be subjected to a cold proof test consisting of a single dummy load test as follows: Metal temperature of the structural members essential to the structural integrity of the crane handling system should be at or below the minimum operating temperature. The corresponding dummy load should be equal to 1.25 times the MCL. If the desired minimum operating temperature cannot be achieved during the test, the minimum operating temperature should be that of the test until the crane is retested at a lower temperature. The cold proof test should be followed by a nondestructive examination of welds whose failure could result in the drop of a critical load. The nondestructive examination of critical areas should be repeated at 4-year intervals or less.	This requirement is being addressed for the bridge by performing a cold proof load test after installation. The trolley has been fabricated in accordance with the toughness testing requirements stated above and will be load tested at the factory. If the minimum operating temperature of 40 degrees F is not achieved in the structural steel of the bridge during the cold proof load test, the component temperatures recorded during the test will become the limiting temperature for those components. An inspection of the bridge girders and end trucks will be performed after the cold proof load test. MMH Procedure #36675-24, Bridge Inspection Procedure provides detailed instructions on how to perform the inspection and what welds to visually inspect. ZionSolutions will implement future inspections per their site operating instructions for NDE of the critical areas at < 4	None	Load test the bridge will be performed	A load test procedure will be prepared to load test the crane at low temperature. Bridge inspection after the load test will be performed per P&H Procedure 3675-24.

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		year intervals			
	Cranes and lifting fixtures made of low-alloy steel such as ASTM A514 should be subjected to the cold proof test in any case. Cast iron should not be used for load-bearing components such as rope drums. Cast iron may be used for items such as electric motor frames and brake drums.	The following materials are not used in the construction of ZionSolutions single failure proof crane system: - Low-alloy steels such as ASTM A514 are not used. - Cast iron is not used for load-bearing components	None	None	None
2.5	Seismic Design Overhead cranes may be operating at the time that an earthquake occurs. Therefore, the cranes should be designed to retain control of and hold the load, and the bridge and trolley should be designed to remain in place on their respective runways with their wheels prevented from leaving the tracks during a seismic event. If a seismic event comparable to a safe shutdown earthquake (SSE) occurs, the bridge should remain on the runway with brakes applied, and the trolley should remain on the crane girders with brakes applied. The crane should be designed and constructed in accordance with regulatory	ZionSolutions single failure proof crane systems are designed to retain control of, and hold a critical load during a seismic event. The bridge and trolley wheels are held captive to their respective runways with heavily constructed seismic restraints that are designed to prevent the wheels from leaving the runway. A detailed 3D ANSYS shell model of the trolley is developed in addition with a 3D model of the existing bridge. Crane rail level response spectra which is generated from a coupled crane building analysis is used and response spectrum analysis is performed to calculate the dynamic response of the trolley and bridge to show that they complied with NOG-1 and NUREG 0554. (P&H Documents #36675-09 and 5.)	None	None	None

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	position 2 of Regulatory Guide 1.29, "Seismic Design Classification." The MCL plus operational and seismically induced pendulum and swinging load effects on the crane should be considered in the design of the trolley, and they should be added to the trolley weight for the design of the bridge.	The seismic design criterion for the crane system is position 2 of Regulatory Guide 1.29, "Seismic Design Classification." Seismic analysis of the crane system was in accordance with NOG-1-2004. The MCL plus operational and seismically induced pendulum and swinging load effects on the crane are taken into consideration. During the horizontal direction seismic event, the natural frequencies of the ropes are much smaller than the natural frequencies of the crane. As a result, the motion of the crane with a smaller period does not amplify the motion of the rated load and thus the pendulum effect is insignificant. This condition is also seen in Table 4135.7-1 of NOG-1 as: "Increase in the load due to pendulum effect need not be considered due to the relatively small displacements of the load."			
2.6	Lamellar Tearing Bridge and trolley structures are generally fabricated by welding structural shapes together. Problems have been experienced with weld joints between rolled structural members. Specifically, subsurface lamellar tearing has occurred at the weld joints during fabrication, and the through-thickness strength of the material	ZionSolutions single failure proof trolley is designed to eliminate the potential for problems that could occur with weld joints between rolled structural members, such as subsurface lamellar tearing, resulting in reduced strength of the material. All weld joints are carefully analyzed and designed to limit the possibility of this occurrence. To insure weld adequacy, all welds are	None	Critical welds as designated on the Critical List and the individual drawings.	A Certified Weld Inspector following the requirements of NOG-1 perform weld inspections. These are documented in the Quality Documentation Package.

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	has thus been reduced. When weld joints are carefully designed and fabricated, lamellar tearing is not expected to occur, but for certain weld joints it may be necessary to examine the joint by radiography or ultrasonic inspection, as appropriate, to ensure the absence of lamellar tearing in the base metal and the soundness of the weld metal. All weld joints whose failure could result in the drop of a critical load should be nondestructively examined. If any of these weld joint geometries would be susceptible to lamellar tearing, the base metal at the joints should be nondestructively examined.	visually examined, and all weld joints whose failure could result in the drop of a critical load are nondestructively examined. Any weld joint subject to lamellar tearing is nondestructively tested by ultrasonic means to ensure the absence of lamellar tearing in the base metal and the soundness of the weld metal. In addition, weldments where laminar tearing can occur are stress relieved after welding. The trolley will be stress relieved. For the new trolley, the weld inspection requirements are specified in the Critical List (Document #36675-11.) They are governed by the vendor's (MMH's) approved welding and inspection procedures. The visual weld inspection of the bridge was governed by the Bridge Inspection Procedure (Document #36675-24) and performed by the MMH inspection team.			
2.7	Structural Fatigue Since each crane loading cycle will produce cyclic stress, it may be necessary to investigate the potential for failure of the metal due to fatigue. If a crane will be used during the construction period, it will experience additional cyclic loading, and these loads should be added to the	The crane is designated as a Class A crane per CMAA-70. The trolley weld calculation (MMH Calc #36675-10) takes into account this Class, but applies a more conservative allowable to ensure that the actual usage of the crane is enveloped for fatigue. For mechanical components, the crane was designed to NOG-1 and therefore fatigue has	None	None	None

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	expected cyclic loading for the permanent plant operation when performing the fatigue evaluation. A fatigue analysis should be considered for the critical load-bearing structures and components of the crane handling system. The cumulative fatigue usage factors should reflect effects of the cyclic loading from both the construction and operating periods.	been incorporated where required. One example includes the strength and durability calculations for the gearing.			
2.8	Welding Procedures Problems with welding of low-alloy steels can occur if the base metal temperature is not properly controlled during welding and the post weld heat treatment. Preheat temperatures and post weld heat-treatment (stress relief) temperatures for all weldments should be specified in the weld procedure. Welds described in the recommendations of Section 2.6 should be post weld heat treated in accordance with Sub-article 3.9 of AWS D1.1, "Structural Welding Code."	Low alloy steels have not been used for the ZionSolutions crane as indicated in Paragraph 2.4. All welding on the ZionSolutions single failure proof crane system is completed by AWS certified welders, in compliance with pre-certified weld procedures that conform to AWS D1.1 "Structural Welding Code." To control the possibility of welding problems, preheat temperatures and post weld heat-treatment (stress relief) temperatures for all welds is controlled by the use of weld procedures that define preheat and post weld heat-treatment temperatures. Welds described in the recommendations of Section 2.6 of NUREG 0554 are post weld heat treated in accordance with Sub-article 3.9 of AWS D1.1 for the trolley and similar AWS standards for the bridge. (Zion Specification SP-ZS-FH-003)	None	None	None

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3.0 3.1	SAFETY FEATURES General Numerous applications have been reviewed by the NRC staff, and the need for inclusion of certain safety features and the magnitudes of specific operational limits to provide, adequate safety have been determined. A crane handling system includes all the structural, mechanical, and electrical components that are needed to lift and transfer a load from one location to another. Primary or principal load-bearing components, equipment, and subsystems such as the driving equipment, drum, rope reeving system, hooks, blocks, control systems, and braking systems should receive special attention.	ZionSolutions single failure proof crane system employ safety features to maximize crane safety of all items including structural, mechanical, and electrical components that are needed to lift, hold and transfer a load, including critical nuclear loads. Primary or principal load-bearing components, equipment, and subsystems such as the Hoist drive equipment, drums, rope reeving systems, hooks, blocks, control systems, and braking systems are analyzed and provisions are included in the ZionSolutions single failure proof design to ensure maximum safety such as redundancy, conservative design, enhanced safety margins and other special design considerations. Primary or principal parts are designed to insure that a single failure does not result in the loss of the capability of the system to retain the load. Key safety features are further outlined in this report.	None	None	None
3.2	Auxiliary Systems All auxiliary hoisting systems of the main crane handling system that are employed to lift or assist in handling critical loads should be single failure proof. Auxiliary systems or dual components should be provided for the main hoisting	On this crane, the Auxiliary hoist will not handle critical loads and is a standard commercial hoist.	None	None	None

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	mechanism so that, in case of subsystem or component failure, the load will be retained and held in a stable or immobile safe position.				
3.3	Electric Control Systems It is important to prevent the release of radioactivity in case of failure, malfunction, or loss of load. It may be necessary to include special features and provisions to preclude system incidents that would result in release of radioactivity. The automatic controls and limiting devices should be designed so that, when disorders due to inadvertent operator action, component malfunction, or disarrangement of subsystem control functions occur singly or in combination during the load handling, and assuming no components have failed in any subsystems, these disorders will not prevent the handling system from stopping and holding the load. An emergency stop button should be added at the control station to stop all motion.	ZionSolutions single failure proof crane system is designed to provide safe operation, and prevent the release of radioactivity in case of failure, malfunction, or loss of power. Special features are included in the equipment design to preclude system incidents that would result in release of radioactivity. This is shown in the MMH drawings R95399 (Schematic) and 54214604 (Interconnect.) The first part of the control system is based on the hoisting system and direct inputs to a relay based control system. In the first layer of safety, the system does not depend on a PLC, scanning rates, or programming. All load cells and limit switches are "hard-wired" to activate safety systems. Some of the special controls include: Load Cells – located in series with each wire rope, they are used in a number of safety functions including broken rope detection, over load, load hang-up and "two-blocking." Up limit switches – Stops bottom blocks up travel to prevent "two-blocking."	None	The following items are tested: Load cell Weighted Limit switch Geared upper/lower limit switch Over-speed switch Variable Frequency Drives Mis-spooling detection	All of these items will be checked in the Factory Acceptance Procedure, 36675-07.

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		Geared Limit switch – Stops bottom block from traveling too far in the up or down direction. Over speed switch – ensures that the load is always in control or the brakes are applied. Special Ergonomic controls per CMAA 70 and B30.2 to minimize operator errors. Phase reversal relay – to monitor incoming power and protect in case of a change. Mis-spooling switches - detects overwrap of the wire rope on the drum. In addition, the Smartorque Drive™ has many safety features that provide additional layers of safety: Quick Stop Function - provides an automatic Alternate Deceleration at Stop Command. This feature differs from the normal deceleration time and is applied only when the run command is removed. Travel Limit - this function automatically slows and stops the hoist when it reaches the travel limits. Load Check – this function is a load-limiting feature that ensures the programmed load limit of the hoist is not exceeded. It prevents the lifting (and potential loss) of a load that is overweight. When the drive detects an			

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		overload condition, it prevents any further raising. However, the load can be lowered at a specified speed. Torque Limit – function dynamically controls the torque output of the motor at all times. The Torque Limit Function limits the amount of motor torque on all four quadrants of vector control operation. No-Load Brake Hoist mode provides a special start/stop sequence designed specifically to prevent the movement of the load when initially starting, specifically an overhanging heavy load. Using a series of timers and counters that monitor parameter feedback, the drive begins by building up torque in the motor to a predefined level prior to releasing the brakes. Weight Calculation - weight measurement calculation is based on motor torque at a constant speed. Slack Cable Detection – this condition is detected when the torque output is drastically reduced and has dipped below a set point. Maintenance Timer - a maintenance feature that will alert an operator, for example, when			

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		the bearings need to be greased based on total running time. Emergency Stop buttons – Emergency stop buttons are included on each operators control station. The drive also has many functions to detect problems within the drive and provide a safe method to control the load and inform the operator of the condition. Motor Overload Under Voltage Level Reference Detection Torque Detection Hardware Protection Motor Overheating Phase Loss			
3.4	Emergency Repairs A crane that has been immobilized because of malfunction or failure of controls or components while holding a critical load should be able to hold the load or set the load down while repairs or adjustments are made. This can be accomplished by inclusion of features that will permit manual operation of the hoisting system and the bridge and trolley transfer mechanisms by means of appropriate	The ZionSolutions single failure proof crane system is designed to significantly reduce the possibility of the crane becoming immobilized because of malfunction or failure of controls or components while holding a critical load. Nevertheless, provisions are included to allow the crane to hold the load or set the load down, in a controlled manner, while repairs and/or adjustments are made during the unlikely occurrence of such an immobilization.	None	The emergency lowering of the 100% load using the Magnetorque. Will test the emergency movement of the bridge and trolley during the Site	The Magnetorque will be checked in the Factory Acceptance Procedure, 36675-07. Test will be performed per MMH document #36675-13

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	emergency devices. Means should be provided for using the devices required in repairing, adjusting, or replacing the failed component(s) or subsystem(s) when failure of an active component or subsystem has occurred and the load is supported and retained in the safe (temporary) position with the handling system immobile. As an alternative to repairing the crane in place, means may be provided for safely transferring the immobilized hoisting system with its load to a safe lay down area that has been designed to accept the load while the repairs are being made. The design of the crane and its operating area should include provisions that will not impair the safe operation or safe shutdown of the reactor or cause un-acceptable release of radioactivity when corrective repairs, replacements, and adjustments are being made to place the crane handling system back into service after component failure(s).	The hoisting system includes an emergency lowering system that allows the load to be safely lowered with, or without, power. The emergency lowering system uses an eddy current brake to provide emergency lowering in a controlled and safe manner. The eddy current brake develops a regenerative electrical field during the emergency lowering process to safely control the lowering speed of the hoist. Detailed instructions describing the complete process of safe emergency lowering are located on the hoist near the emergency lowering system. In addition, if there was a problem with the eddy current brake, there are additional procedures that are used to lower the load using just the shoe brakes. The crane bridge and trolley are provided with means to provide emergency transport by using a mechanical driving mechanism. Both the bridge and trolley can be manually moved by spinning the motor shaft or pulling with a come-a-long. To facilitate the use of the emergency hoist lowering system, or bridge and trolley emergency transport system, operators' platforms and/or personnel safety tie offs are located at each device. Detailed instructions describing the emergency bridge & trolley transport process		Acceptance Test.	

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		are located directly on the crane in close proximity to each emergency input drive shaft.			
4.1	Reeving System Component parts of the vertical hoisting mechanism are important. Specifically, the rope reeving system deserves special consideration during design of the system. The load-carrying rope will suffer accelerated wear if it rubs excessively on the sides of the grooves in the drum and sheaves because of improper alignment or large fleet angles between the grooves. The load-carrying rope will furthermore suffer excessive loading if it is partly held by friction on the groove wall and then suddenly released to enter the bottom of the groove. The rope can be protected by the selection of conservative fleet angles. Ropes may also suffer damage due to excessive strain developed if the rope construction and the pitch diameter of the sheaves are not properly selected. Fatigue stress in ropes can be minimized when the pitch diameter of the sheaves is selected large enough to produce only nominal stress levels. The pitch diameter of the sheaves should be larger for ropes moving at the highest velocity near the drum and	The ZionSolutions single failure proof hoist reeving system includes special provision to ensure maximum safety and reliability. To reduce the possibility of accelerated wire rope wear, the load-carrying rope system is carefully designed to assure proper wire rope selection, proper wire rope alignment, conservative sheave pitch diameters, and conservative fleet angles at all times. The wire rope construction is carefully analyzed for each specific application (Reeving Stress Report, MMH #36675-23), in order to provide the most suitable wire rope. The reeving system design carefully evaluates the rope alignment on the wire rope drum to insure that the wire rope properly tracks to the correct position of each drum groove. Correct wire rope alignment is achieved by using conservative sheave pitch diameters, conservative fleet angles, proper alignment of all components, and operational testing to insure proper wire rope tracking using the requirements of B30.2 and NOG-1. Site specific operation, inspection and maintenance procedures are also provided to insure that operations personnel understand all aspects of the reeving system including	None	Mis-reeving detection system	Mis-reeving detection system will be tested per the Factory Acceptance Procedure – P&H document #36675-07

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	can be smaller for sheaves used as equalizers where the rope is stationary. Protection against excessive wire rope wear and fatigue damage can be ensured through scheduled inspection and maintenance.	inspection and maintenance intervals using the guidance of the Wire Rope Manufacturers Guidelines. Misreeving protection is also provided with a sensing system that disables power to the hoist if a misreeved condition is detected (such as an over wrap on the drum). This is shown in the MMH Drawing R95399 (Schematic).			
	Design of the rope reeving system(s) should be dual with each system providing separately the load balance on the head and load blocks through configuration of ropes and rope equalizer(s). Selection of the hoisting rope or running rope should include consideration of the size, construction, lay, and means or type of lubrication, if required, to maintain efficient working of the individual wire strands when each section of rope passes over the individual sheaves during the hoisting operation. The effects of impact loadings, acceleration, and emergency stops should be included in selection of rope reeving systems. The maximum load (including static and inertia forces) on each individual wire rope in the dual reeving system with the MCL attached should not exceed 10% of the manufacturer's	The ZionSolutions single failure proof reeving system utilizes a single drum, dual load path wire rope reeving system to achieve reeving redundancy. Each load path is independent and separately balanced to insure smooth and balanced load transfer in the unlikely event of a wire rope failure. The wire rope used on the trolley is special Python Super 8-CD EEIPS, 1-5/8" diameter rope with a breaking strength of better than 192.6 tons. There are four separate ropes; 2 right lay and 2 left lay. The maximum load (plus a factor for degradation and inertia) on each individual wire rope in the dual reeving system with the MCL attached does not exceed 10% of the manufacturer's published breaking strength (Reeving Stress Report, MMH #36675-23).	None	Rope breaking strength tested	The Python rope breaking strength will be tested during the rope test at the rope vendor and documented in procedure 36675-12, which is the Quality documentation package for the trolley modification. The rope vendor is a qualified nuclear supplier per the crane vendor's (P&H's)10 CFR 50 App. B program.

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	published breaking strength.				
	The ratio of wire rope yield strength to ultimate strength may vary sufficiently for different production runs to influence the wire rope rating in such a manner that the initial safety margin selected would be too small to prevent the critical load from straining the wire rope material beyond the yield point under abnormal conditions. It would, therefore, be prudent to consider the wire rope yield strength as well as the ultimate strength when specifying wire rope in order to ensure the desired margin on rope strength.	It is recognized that the ratio of wire rope yield strength to ultimate strength may vary sufficiently for different production runs to influence the wire rope rating in such a manner that the initial safety margin selected would be too small to prevent the critical load from straining the wire rope material beyond the yield point under abnormal conditions. To preclude the possibility of this occurrence, each lay of wire rope is proof load tested to determine actual properties and to ensure that the desired margin on rope strength are sufficient. The rope vendor is required to document that the cables provided for the crane is from the same reel as the proof test. In addition, each rope assembly with the fitting attached is also tested. The rope drawing specifies the required tests (MMH #QR94824 and all test results are fully documented per MMH Main Hoist Wire Rope Test Procedure (#36675-12.)	None	Rope breaking strength tested	The Python rope breaking strength is tested during the rope test at the rope vendor and documented in procedure 36675-12, which is the Quality documentation package for the trolley modification.
	The maximum fleet angle from drum to lead sheave in the load block or between individual sheaves should not exceed 0.061 rad (3-1/2°) at any one point during hoisting except that for the last 1 m (3 ft) of maximum lift elevation the fleet angle may increase slightly. The use of reverse bends	The ZionSolutions single failure proof wire rope reeving system uses conservative fleet angles. The maximum fleet angle from the drum to trunnions in the upper block does not exceed 3.5° except at the last 1 meter where it approaches 4°. Reverse bends are not present in the reeving system.	None	None	None

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	for running wire ropes should be limited, and the use of larger sheaves should be considered for those applications where a disproportionate reduction in wire rope fatigue life would be expected from the use of standard sheave diameters for reverse bends. The equalizer for stretch and load on the rope reeving system may be of either beam or sheave type or combinations thereof. A dual rope reeving system with individual attaching points and means for balancing or distributing the load between the two operating rope reeving systems will permit either rope system to hold the critical load and transfer the critical load without excessive shock in case of failure of the other rope system.	The ZionSolutions equalizer system uses an equalizer beam design. The dual rope reeving system uses four (4) individual attaching points as a means for balancing or distributing the load between the two operating rope reeving systems of the redundant reeving system. Each independent reeving system is designed to hold the critical load and transfer the critical load without excessive shock in the unlikely occurrence of the failure of one of the other rope systems. Safe load transfer during a wire rope failure is achieved since there are two independent rope systems per side of the beam, resulting in virtually no hook movement during the unlikely occurrence of wire rope transfer, should one of the wire rope systems fail. Hook movement is documented in P&H Document 36675-23.			
	The pitch diameter of running sheaves and drums should be selected in accordance with the recommendations of CMAA Specification #70. The dual reeving system may be a single rope from each end of a drum terminating at one of the blocks or equalizer with provisions for equalizing beam-type load and rope stretch, with each rope designed for the total load. Alternatively, a 2-rope system may be used	The pitch diameter of running sheaves and drums for ZionSolutions single failure proof crane system is selected in accordance with the recommendations of CMAA Specification #70 and the Python rope manufacturer's recommendations. The pitch diameter is 42 inches for the drum and 36 inches for the sheaves in the bottom block which is more conservative than CMAA-70. The ZionSolutions dual reeving system uses four	None	None	None

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	from each drum or separate drums using a sheave equalizer or beam equalizer or any other combination that provides two separate and complete reeving systems.	ropes with independent (redundant) wire rope load paths. The wire ropes are equalized in an upper block equalizer assembly that is designed to allow safe load transfer, with virtually no hook movement, during the unlikely occurrence of a failure of one of the four wire rope systems.			
4.2	Drum Support Proper support of the rope drums is necessary to ensure that they would be prevented from falling or disengaging from their braking and control system. The load hoisting drum on the trolley should be provided with structural and mechanical safety devices to limit the drop of the drum and thereby prevent it from disengaging from its holding brake system if the drum shaft or bearings were to fail or fracture.	ZionSolutions's single failure proof crane system uses captive drum support systems to ensure that the drum is prevented from falling or disengaging from their braking and control system. The drum support system includes a heavily constructed, close fitting cradle that safely limits drop of the drum and thereby prevent it from disengaging from its holding brake system during the unlikely occurrence of a drum shaft or bearing failure or fracture.	None	None	None
4.3	Head and Load Blocks The head and load blocks should be designed to maintain a vertical load balance about the center of lift from load block through head block and have a reeving system of dual design.	The fuel handling cranes' head and load block reeving systems use a symmetrical, dual load path (redundant), designed to maintain vertical load balance about the center of lift from load block through head block. A dual load path redundant reeving system is utilized.	None	Hook Travel is vertical	Will be tested per the Site Acceptance Test (SAT) MMH document #36675-13

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	The load-block assembly should be provided with two load-attaching points (hooks or other means) so designed that each attaching point will be able to support a load of three times the load (static and dynamic) being handled without permanent deformation of any part of the load-block assembly-other than localized strain concentration in areas for which additional material has been provided for wear.	The load-block assembly utilizes (2) two load attached points and is comprised of a sister hook with a 2nd center, pin hole, load attachment point. The load blocks including the individual sister hook prongs are conservatively designed to support a load greater than three times the MCL (static and dynamic) being handled without permanent deformation of any part of the load-block assembly, *other than localized strain* concentration in areas for which additional material has been provided for wear. The hook pinhole has double the above safety factor in accordance with NUREG-0612 App. C and NOG-1 since it is a single attachment point. It is important to note that there are some issues when comparing NOG-1, NUREG 0612 and 0554. Therefore, we will be using a safety factor for those items on the hook that are based on a single failure mode such as the hook throat on Attachment 2. It is important to note that issues exist when comparing NOG-1, NUREG 0612 and NUREG 0554. Therefore, a safety factor is provided for those items that are based on a single failure mode such as the hook throat on	None	None	None

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		Attachment 2 to this matrix factor of 1.30 was conservatively applied to safety factors for both ultimate and yield strengths to account for dynamic load and degradation.			
	The individual component parts of the vertical hoisting system components, which include the head block, rope reeving system, load block, and dual load-attaching device, should each be designed to support a static load of 200% of the MCL. A 200% static-type load test should be performed for each load-attaching hook. Measurements of the geometric configuration of the hooks should be made before and after the test and should be followed by a nondestructive examination that should consist of volumetric and surface examinations to verify the soundness of fabrication and ensure the integrity of the hooks. The load blocks should be nondestructively examined by surface and volumetric techniques. The results of examinations should be documented and recorded.	The individual component parts of the vertical hoisting system components, including the head block, rope reeving system, load block, and dual load-attaching device, are designed to support a static load greater than 200% of the MCL. A 200% static-type load test is performed on each load-attaching hook assembly and measurements of the geometric configuration of the hooks are made before and after load testing per B30.10. After completion of load testing, nondestructive examination of the hook is completed, consisting of volumetric and surface examinations to verify the soundness of fabrication and ensure the integrity of the hooks. The results of all testing are documented. The hook geometry is also checked after load testing to ensure that hook deformation has not occurred. All test results are fully documented per B30.10. Note that the hook and nut (assembly) are tested together to the 200%. This will be documented in Hook and Nut Test, MMH procedure #36675-08.	None	Main Hoist Hook testing	The main hoist hook and nut assembly will be tested to 200% coupled with multiple NDE tests. This is documented in MMH procedure #36675-08 with associated documentation in the Quality Documentation package for the trolley modification.

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4.4	Hoisting Speed Maximum hoisting speed for the critical load should be limited to that given in the "slow" column of Figure 70-6 of CMAA Specification #70.	ZionSolutions's single failure proof crane system utilizes a maximum hoisting speed for critical load handling that is limited to the speed shown in Table 4-1 of the Design Technical specification. These limits are 5 FPM for the main hoist with a load and 7.5 FPM without a load (express speed) and are within the requirements of Figure 70-6 of CMAA-70-1975.	None	Main Hoist speed checks	The Main Hoist speed will be checked in the Site Acceptance Test, #36675-13.
	Selection of hoisting speed is influenced by such items as reaction time for corrective action for the hoisting movement and the potential behavior of a failed rope. To prevent or limit damaging effects that may result from dangerous rope spin-off in case of a rope break, the hoisting speed should be limited. The rope traveling speed at the drum is higher than at other points in the reeving system, and the potential for damage due to rope failing and interference with other parts of the system should be considered. Conservative industry practice limits the rope line speed to 1/4 m/s (50 fpm) at the drum.	Since the ZionSolutions reeving system is a two part system (for each of the 4 individual ropes) the rope traveling speed is only double the hook speed, or 10 fpm. This is well under the requirement of 50 fpm.	None	Main Hoist speed checks	The Main Hoist speed will be checked in the Site Acceptance Test, #36675-13.

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4.5	Design Against Two-Blocking A potential failure of a hoist travel-limit switch could result in a "two-block" incident and in the cutting or crushing of the wire rope. In order to protect the wire rope, the reeving system should be designed to prevent the cutting or crushing of the wire rope if a two-blocking incident were to occur.	ZionSolutions single failure proof crane system provides two-block protection by various redundant methods. Three (3) separate and independent methods of protection are provided, including a control circuit upper limit switch, a weight operated upper limit switch, and an overload limit switch. In addition, the trolley frame and bottom block are designed to prevent the rope from being crushed (and thus weakened) between the two structures.	None	Testing of the: 1. Geared upper limit switch 2. Weighted operated Limit switch 3. Overload (load cell) limit switch.	Two-block prevention will be tested on the system at slow and normal speeds as per the Factory Acceptance Procedure – MMH document #36675-07. The test consists of checking the limit switches.
	The mechanical and structural components of the complete hoisting system should have the required strength to resist failure if the hoisting system should "two-block" or if "load hang-up" should occur during hoisting. The designer should provide means within the reeving system located on the head or on the load-block combinations to absorb or control the kinetic energy of rotating machinery during the incident of two-blocking. As an alternative, the protective control system to prevent the hoisting system from two-blocking should include, as a minimum, two independent travel-limit devices of different designs and activated by separate mechanical means. These devices should de-energize the hoist drive motor and the main power supply. The protective control	The two block protection system exceeds the protection requirements of NUREG 0554 by providing three (3) distinctly different levels of two-block protection. The two block protection system consists of the following levels of protection. **Control Circuit Upper Limit Switch (1st level of defense)** The control circuit upper limit switch is the 1st level of defense. This system uses a rotary control circuit limit switch that is calibrated to disable control circuitry to the hoist motor at a pre-set upper and lower elevation. This system is completely independent of all other two-block protection systems. **Weight Operated Upper Limit Switch (2nd level of defense)**	None	Testing of the: 1. Geared upper limit switch 2. Weighted Operated Limit switch 3. Overload (load cell) limit switch.	Two-blocking will be tested on the system at slow and normal speeds as per the Site Acceptance Procedure – MMH document #36675-13. The test consists of checking the limit switches.

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	system for load hang-up, a part of the overload protection system, should consist of load cell systems in the drive train or motor-current-sensing devices or mechanical load-limiting devices. The location of mechanical holding brakes and their controls should provide positive, reliable, and capable means to stop and hold the hoisting drum(s) for the conditions described in the design specification and in this recommendation. This should include capability to withstand the maximum torque of the driving motor if a malfunction occurs and power to the driving motor cannot be shut off. The auxiliary hoist, if supplied, should be equipped with two independent travel-limit switches to prevent two-blocking.	The weight operated upper limit switch is the 2nd level of defense. This system uses a hook block actuated weight operated limit switch that is calibrated to disable power to the hoist motor at a preset upper elevation that is higher than the control circuit limit switch elevation. This system is completely independent of all other two-block protection systems **Overload (Load Cell) Limit System (3rd level of defense)** Four (4) individual load cells are mounted in series with each of the four individual wire ropes to monitor lifting conditions, and assure that the crane is operating within the operating limits of the MCL. The overload system is present to detect an overload condition at a preset value of the MCL. When an overload condition is detected the load cell sends a signal to the hoist motor control circuit and immediately disables hoisting. This system provides two block and load hang-up protection. Note: P&H recommends the pre-set value be as low as possible, within the band of 105% to 120%, but high enough to prevent inadvertent trips due to dynamic effects.			
4.6	Lifting Devices				

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	Lifting devices that are attached to the load block such as lifting beams, yokes, ladle or trunnion-type hooks, slings, toggles, and clevises should be conservatively designed with a dual or auxiliary device or combinations thereof. Each device should be designed or selected to support a load of three times the load (static and dynamic) being handled without permanent deformation.	Lifting devices used on the ZionSolutions single failure proof crane system that attach to the load block are site specific and will be in accordance with NUREG-0612 and the ZionSolutions Heavy Loads Program.	None	None	None
4.7	Wire Rope Protection Sideloads would be generated to the reeving system if hoisting were done at angles departing from a normal vertical lift and resulting damage could be incurred in the form of excessive wear on sheaves and wire rope. A potential would also exist for the wire rope to be cut by jumping its groove barrier on the drum. If sideloads cannot be avoided, the reeving system should be equipped with a guard that would keep the wire rope properly located in the grooves on the drum.	ZionSolution's single failure proof crane application is carefully analyzed to evaluate the possibility of sideload lifting scenarios. If sideloading occurs, the design of the rope attachment points prevents mis-alignment since the torque arm limits movement. Since side loading can lead to the wire rope double wrapping on the drum, misreeving protection is provided with a sensing system that disables power to the hoist if a misreeved condition is detected. This system is in lieu of guards and is superior since it minimizes wear on the wire rope. Coupled with this protection, rope inspections per ASME B30.2 would be performed in the event of a misreeving to verify no rope damaged had occurred.	None	Mis-reeving detection system	The mis-reeving detection system will be tested in the Factory Acceptance Procedure – MMH document #36675-07

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4.8	Machinery Alignment Power transmission gear trains are often supported by fabricated weldments of structural parts. The proper alignment of shafts and gears depends on the adequacy of bearings and their supports to maintain correct alignment of all components. The proper functioning of the hoisting machinery during load handling can best be ensured by providing adequate support strength of the individual component parts and the welds or bolting that binds them together. Where gear trains are interposed between the holding brakes and the hoisting drum, these gear trains should be single failure proof and should be of dual design.	ZionSolutions's single failure proof crane system is manufactured in accordance with MMH procedures and processes to insure that all quality objectives are achieved. To ensure a robust and stable platform for the hoisting equipment is assured, the trolley is conservatively designed and the trolley weldment is stress relieved after welding and prior to machining. The trolley is then machined including all motor, gearbox and eddy current brake (Magnetorque) mounting pads. Alignment of shafts and gears is controlled by following procedures that define tolerances for all machinery. Alignment is further verified as part of routine checks and inspections that are performed and documented during the entire fabrication and assembly process. All connection hardware and welds are analyzed and inspected to ensure proper strength and durability. Gear trains interposed between the holding brakes and the hoisting drums, are of dual design, each capable of holding the load and therefore are single failure proof. If there is a problem with one side of the drive train, including brake, shafts, gear box, bearings, seals, ect., the other side is fully functional to handle the load and safely	None	None	None

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		lower the load.			
4.9	Hoist Braking System Mechanical holding brakes in the hoisting system (raising and lowering) that are automatically activated when electric power is off or mechanically tripped by over-speed devices or overload devices in the hoisting system will help ensure that a critical load will be safely held or controlled in case of failure in the individual load-bearing parts of the hoisting machinery.	ZionSolutions's single failure proof crane system utilizes dual (redundant) failsafe holding brakes in the hoisting system (raising and lowering) that are automatically activated when electric power is off, or by overload devices in the hoisting system to ensure safe handling of critical loads, including the unlikely occurrence of a single rope failure. Note that this safety system does not go through a PLC and therefore is not susceptible to software errors or scan rates.	None	The shoe brakes are tested a number of ways including: 1. 100% emergency stops. 2. 125% load tests 3. Emergency lowering	The shoe brakes will be tested in the Factory Acceptance Procedure – MMH document #36675-07
	Each holding brake should have more than full-load stopping capacity but should not have excessive capacity that could cause damage through sudden stopping of the hoisting machinery. A minimum brake capacity of 125% of the torque developed during the hoisting operation at the point of brake application has been determined to be acceptable.	Each of the two redundant holding brakes of the ZionSolutions single failure crane system are designed for a minimum of 150% full-load stopping capacity, but has insufficient overcapacity to cause damage through sudden stopping of the hoisting machinery ' A time delay has been included in the control system to activate the first brake and then activate the second brake. Calculations are completed and verified to assure proper brake capacity. The brake torques are factory set and documented on the detail drawing.	None	The shoe brakes are tested a number of ways including: 1. 100% emergency stops. 2. 125% load tests 3. Emergency	The shoe brakes will be tested in the Factory Acceptance Procedure – MMH document #36675-07

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				lowering	
	The minimum hoisting braking system should include one power control braking system (not mechanical or drag brake type) and two holding brakes. The holding brakes should be applied when power is off and should be automatically applied on overspeed to the full holding position if a malfunction occurs. Each holding brake should have a torque rating not less than 125% of the full-load hoisting torque at point of application (location of the brake in the mechanical drive). The minimum number of braking systems that should be operable for emergency lowering after a single brake failure should be two holding brakes for stopping and controlling drum rotation.	Load control braking is accomplished by the variable frequency drive and an associated dynamic braking unit. Two (2) shoe type mechanical hoist holding brakes are included in the hoist braking system each rated at no less than 150% of full load hoisting torque at the point of application. The holding brakes are applied when power is off, or during the unlikely event that an overspeed situation is encountered. In addition, an eddy current brake (Magnetorque) brake is provided that activates on loss of power or when brakes are engaged to slow down the motor. The 3 component braking system is designed to ensure that the minimum number of braking systems that are operable for emergency lowering after a single brake failure is two brakes to stop and control drum rotation. By using the emergency procedure in the Crane Technical Manual, the operator can safely lower the load using the eddy current brake (Magnetorque) and one (1) holding brake.	None	The shoe brakes are tested a number of ways including: 1. 100% emergency stops. 2. 125% load tests 3. Emergency lowering	The shoe brakes will be tested in the Factory Acceptance Procedure – MMH document #36675-07
	The holding brake system should be single failure proof; i.e., any component or gear train should be dual if interposed between the holding brakes and the hoisting drums. The dynamic and static alignment of all	The hoist holding brake system is based on the NOG-1, Figure 5416.1-2 design where independent paths are established so that if one shoe brake fails, the other can fully control the load. The design of the hoisting	None	None	None

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	hoisting machinery\components, including gearing, shafting, couplings, and bearings, should be maintained throughout the range of loads to be lifted, with all components positioned and anchored on the trolley machinery platform.	machinery\components, including gearing, shafting, couplings, and bearings, is conservatively designed with all components anchored to the trolley platform, to maintain alignment throughout the entire range of loads (dynamic and static) that are lifted.			
	Manual operation of the hoisting brakes may be necessary during an emergency condition, and provision for this should be included in the design conditions. Adequate heat dissipation from the brake should be ensured so that damage does not occur if the lowering velocity is permitted to increase excessively. It may be necessary to stop the lowering operation periodically to prevent overheating and permit the brake to dissipate the excess heat. Portable instruments should be used to indicate the lowering speed during emergency operations. If a malfunction of a holding brake were to occur and emergency lowering of the load become necessary, the holding brake should be restored to working condition before any lowering is started.	Provisions are included in the brake system design to allow manual operation of the hoisting brakes during an emergency condition through an emergency brake release lever. After the holding brakes are released the hoisting system utilizes an emergency lowering system that allows the load to be safely lowered with, or without, power. The emergency lowering system uses an eddy current brake (Magnetorque) to provide emergency lowering in a controlled and safe manner. The eddy current brake develops a regenerative electrical field during the emergency lowering process to safely control the lowering speed of the hoist. Detailed instructions describe the complete process of safe emergency lowering and are located on the hoist near the emergency lowering system. The eddy current (Magnetorque) brake system does not generate heat on the main holding brakes during the emergency lowering process. Procedures describing how	None	Test the emergency lowering of the 100% load using the eddy current brake (Magnetorque).	The eddy curent brake (Magnetorque) will be checked in the Factory Acceptance Procedure, 36675-07 using MMH procedure 36675-16.

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		to safely complete the manual lowering process, including monitoring of the lowering speed by use of portable instruments (tachometer) or visually. Detailed instructions describing the emergency lowering process are located in close vicinity to the hoist brake system.			
5.1	Braking Capacity (Bridge & Trolley) Failure of the bridge and trolley travel to stop when power is shut off could result in uncontrolled incidents. This would be prevented if both bridge and trolley drives are provided with control and holding braking systems that would be automatically applied when the power is shut off or if an overspend or overload condition occurs because of malfunction or failure in the drive system.	The bridge and trolley drives utilize SMARTORQUE™ open loop adjustable frequency control systems that continuously monitor the speed and direction of the crane. The drive continuously monitors itself and immediately ceases operation and sets the brakes if a fault is detected. The bridge and trolley brakes are self adjusting AC Disc type and are automatically applied when power is not present or in an over-speed condition. In addition to a disc brake, the drive also utilizes dynamic braking resistor(s) which slows and stops the respective motion. The SMARTORQUE™ system also has the following features: Quick Stop Function - provides an automatic Alternate Deceleration at Stop Command. This feature differs from the normal deceleration time and is applied only when the run command is removed. Torque Limit – function dynamically controls	None	Test brakes of bridge and trolley	Bridge and trolley brakes will be tested in both the Factory Acceptance Procedure – MMH document #36675-07and Site Acceptance Procedure, 36675-13.

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		the torque output of the motor at all times. The Torque Limit Function limits the amount of motor torque on all four quadrants of vector control operation.			
	To avoid the possibility of drive motor over torque within the control system, the maximum torque capability of the driving motor and gear reducer for trolley motion and bridge motion of the overhead bridge crane should not exceed the capability of gear train and brakes to stop the trolley or bridge from the maximum speed with the DRL attached. Incremental or fractional inch movements, when required, should be provided by such items as variable speed controls or inching motor drives. Control and holding brakes should each be rated at 100% of maximum drive torque that can be developed at the point of application. If two mechanical brakes, one for control and one for holding, are provided, they should be adjusted with one brake in each system leading the other and should be activated by release or shutoff of power. This applies to both trolley and bridge. The brakes should also be mechanically tripped to the "on" or "holding" position in the event of a malfunction in the power supply or an overspend condition. Provisions should be made for manual emergency operation of	Drive motor over torque within the control system is avoided by limiting the maximum torque capability of the driving motor and gear reducer for trolley motion and bridge motion of the overhead bridge crane so they do not exceed the capability of gear train and brakes to stop the trolley or bridge from the maximum speed with the DRL (and MCL) attached. Incremental or fractional inch movements are provided by variable speed controls. Control and holding brakes are each rated at 100% of maximum drive torque that can be developed at the point of application. The bridge and trolley brakes are mechanically tripped to the "on" or "holding" position in the event of a malfunction in the power supply. Provisions are included for manual emergency operation of the brakes. The holding brake is designed so that they cannot be used as a foot-operated slowdown brake. Drag brakes are not used in the P&H design.	None	None	None

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	the brakes. The holding brake should be designed so that it cannot be used as a foot-operated slowdown brake. Drag brakes should not be used. Mechanical drag-type brakes are subject to excessive wear, and the need for frequent service and repair tends to make this type of brake less reliable; they should therefore not be used to control movements of the bridge and trolley.				
	Opposite-driven wheels on bridge or trolley that support bridge or trolley on their runways should be matched and should have identical diameters.	Opposite-driven wheels on the bridge and trolley are matched and have identical diameters within manufacturers specified machining tolerances.	None	None	None
	Trolley and bridge speed should be limited. The speed limits indicated for slow operating speeds for trolley and bridge in specification CMAA #70 are recommended for handling MCLs.	ZionSolutions's single failure proof crane system utilizes a maximum bridge and trolley speed for critical load handling that is limited to 50 FPM. These values come from the specification. Note the CMAA-70-1975 speed table gives for the Trolley at 100 tons, 50 FPM, while the 150 tons, 30 FPM; however, 50 fpm is equal to the recommended slow operating speed from NOG-1 Table 5332.1-1. The bridge speed is within the slow guidelines of CMAA-70-1975.	Yes, however, 50 fpm is equal to the recommend ed slow operating speed from NOG-1 Table 5332.1-1. The bridge speed is within the slow	Test Trolley and Bridge speeds	Speeds will be documented per the Site Acceptance Test, MMH Document #36675-13

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			guidelines of CMAA-70-1975.		
5.2	Safety Stop Limiting devices, mechanical and/or electrical, should be provided to control or prevent over travel and over-speed of the trolley and bridge. Buffers for bridge and trolley travel should be included at the end of the rails. Safety devices such as limit-type switches provided for malfunction, inadvertent operator action, or failure should be in addition to and separate from the limiting means or control devices provided for operation.	Bridge and trolley limiting devices are used to control the maximum travel capability of the bridge and trolley on their respective runways. Both the bridge and trolley utilize end stop travel limit switches. These limit switches stop the travel motion of the bridge and/or trolley. As a final limiting device, both the bridge and trolley are mechanically stopped by substantial end travel end stops.	None	Limit switches to test include: Bridge travel Trolley travel	All of these limit switches will be tested per the Site Acceptance Test, MMH Document #36675-13.
6.0 6.1	DRIVERS AND CONTROLS Driver Selection The horsepower rating of the hoist driving motor should be matched with the calculated requirement that includes the design load and acceleration to the design hoisting speed. Overpowering of the hoisting equipment would impose additional strain on the machinery and load-carrying devices by increasing the	The horsepower rating of the hoist driving motor is matched with the calculated requirement that includes the design load and acceleration to the design hoisting speed. Careful consideration is given to the selection of the hoist motor to avoid overpowering of the hoisting equipment as this would impose additional strain on the machinery and load-carrying devices by increasing the hoisting acceleration rate.	None	None	None

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	hoisting acceleration rate.				
	To preclude excessive drive motor torque, the maximum torque capability of the electric motor drive for hoisting should not exceed the rating or capability of the individual components of the hoisting system required to hoist the MCL at the maximum design hoist speed. Overpower and over-speed conditions should be considered an operating hazard as they may increase the hazard of malfunction or inadvertent operation. It is essential that the controls be capable of stopping the hoisting movement within amounts of movement that damage would not occur. A maximum hoisting movement of 8 cm (3 in) would be an acceptable stopping distance. Normally, a crane system is equipped with mechanical and electrical limiting devices to shut off power to driving motors when the crane hook approaches the end of travel or when other parts of the crane system would be damaged if power were not shut off. It is prudent to include safety devices in the control system for the crane, in addition to the limiting devices, for the purpose of ensuring that the controls will return to or maintain a safe holding position-in case of malfunction. Electric	To preclude excessive drive motor torque, the maximum torque capability of the electric motor drive for hoisting does not exceed the rating or capability of the individual components of the hoisting system required to hoist the MCL at the maximum design hoist speed. The controls are designed to stop the hoisting movement within <3in. of movement so that damage would not occur. The crane system is equipped with mechanical and electrical limiting devices to shut off power to the driving motor(s) when the crane hook approaches the end of travel or when other parts of the crane system would be damaged if power were not shut off. These systems are described earlier in other sections of this report. All operators' control systems are designed to operate in the safest possible manner, and are designed to return to or maintain a safe holding position in case of malfunction. Electric circuitry design is carefully considered so that the controls and safety devices ensure safe holding of the critical load when called upon to perform their safety function. An emergency stop button is located at the operator's control station and	None	Hoist Limit switches to test include: Hoist travel up Hoist travel up (back up) Hoist travel down Emergency stop buttons	Each of these limit switches and E-stops will be tested per the Site Acceptance Test, MMH Document #36675-13.

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	circuitry design should be carefully considered so that the controls and safety devices ensure safe holding of the critical load when called upon to perform their safety function. For elaborate control systems, radio control, or ultimate control under unforeseen conditions of distress, an "emergency stop button" should be placed at ground level to remove power from the crane independently of the crane controls. For cranes with a DRL rating much higher than the MCL rating, it may be necessary to provide electrical or mechanical resetting of overload sensing devices when changing from one operation to the other. Such resetting should be made away from the operator cab location and should be included in an administrative control program.	on the radio transmitter. The MCL and the DRL are the same for this crane, so adjustment of set points is not necessary.			
6.2	Driver Control Systems The control systems should be designed as a combination of electrical and mechanical systems and may include such items as contactors, relays, resistors, and thyristors in combination with mechanical devices and mechanical braking systems. The control system(s) provided should include consideration of the hoisting (raising and lowering) of all loads, including the rated	ZionSolutions single failure proof crane system is designed to provide safe operation, and prevent a radioactive release in case of failure, malfunction, or loss of power. Special features are included in the equipment design to preclude system incidents that would result in release of radioactivity. Note the ZionSolutions Fuel Handling Crane will not be lifting individual fuel elements from a reactor vessel or a storage rack.	None	The following items are tested: Load cell Weighted Limit switch Geared upper limit switch	All of these items will checked per the Factory Acceptance Procedure, 36675-7.

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	load, and the effects of the inertia of the rotating hoisting machinery such as motor armature, shafting and coupling, gear reducer, and drum. If the crane is to be used for lifting spent fuel elements, the control system should be adaptable to include interlocks that will prevent trolley and bridge movements while the load is being hoisted free of a reactor vessel or a storage rack, as may be recommended in Regulatory Guide 1.13, "Spent Fuel Storage Facility Design Basis."	The control system is based on the hoisting system and direct inputs to a relay based control system. In the first layer of safety, the system does not depend on a PLC, scanning rates, or programming. All load cells, limit switches, and pressure switches are "hard-wired" to activate safety systems. Some of the special controls include: Load Cells – located in series with each wire rope, they are used in a number of safety functions including broken rope detection, over load, load hang-up and "two-blocking." Up limit switches – Stops bottom blocks up travel to prevent "two-blocking." Geared Limit switch – Stops bottom block from traveling too far in the up or down direction. Over speed switch – ensures that the load is always in control or the brakes are applied. Special Ergonomic controls per CMAA 70 and B30.2 to minimize operator errors. In addition, the Smartorque Drive™ has many safety features that provide additional layers of safety: Quick Stop Function - provides an automatic Alternate Deceleration at Stop Command. This feature differs from the normal deceleration time and is applied only when		Over-speed switch Variable Frequency Drives	

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		the run command is removed. Travel Limit - this function automatically slows and stops the hoist when it reaches the travel limits. Load Check – this function is a load-limiting feature that ensures the programmed load limit of the hoist is not exceeded. It prevents the lifting (and potential loss) of a load that is overweight. When the drive detects an overload condition, it prevents any further rising. However, the load can be lowered at a specified speed. Torque Limit – function dynamically controls the torque output of the motor at all times. The Torque Limit Function limits the amount of motor torque on all four quadrants of vector control operation. No-Load Brake Hoist mode provides a special start/stop sequence designed specifically to prevent the movement of the load when initially starting, specifically an overhanging heavy load. Using a series of timers and counters that monitor parameter feedback, the drive begins by building up torque in the motor to a predefined level prior to releasing the brakes. Weight Calculation - weight measurement calculation is based on motor torque at a constant speed. Slack Cable Detection – this condition is			

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		detected when the torque output is drastically reduced and has dipped below a set point. Maintenance Timer - a maintenance feature that will alert an operator, for example, when the bearings need to be greased based on total running time. The drive also has many functions to detect problems within the drive and provide a safe method to control the load and inform the operator of the condition. Motor Overload Under Voltage Level Reference Detection Torque Detection Hardware Protection			
6.3	Malfunction Protection Means should be provided in the motor control circuits to sense and respond to such items as excessive electric current, excessive motor temperature, over-speed, overload, and over travel. Controls should be provided to absorb the kinetic energy of the rotating machinery and stop the hoisting movement reliably and safely through a combination of electrical power controls and mechanical braking systems	Various devices are installed on the crane system to monitor key motor functions, and to provide a high degree of reliability and safety including the following is a summary of malfunction protections devices. An emergency stop button is provided on each operator's station to allow the crane operator to immediately stop the load in the case of a malfunction.	None	The following items are tested: Load cell Weighted Limit switch Geared upper limit switch	All of these items will be checked per the Factory Acceptance Procedure, 36675-07.

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	and torque controls if one rope or one of the dual reeving systems should fail or if overloading or an overspend condition should occur.	Motor protections are included in the SMARTORQUE closed loop, motor control system which monitors excessive electric current, excessive motor temperature, over-speed, and overload. Over travel protection is provided for all motions of the cranes system. The bridge and trolley over travel protection system includes stop travel limit switches and mechanical end stops. The hoist travel limit system includes redundant upper and lower limit switches and two-block and load hang-up protection. Overload (in excess of MCL) is also detected and prevented by a load cell system that constantly monitors the weight of the lifted load, and limits the overall lifting capacity to maintain safe working conditions. The SMARTORQUE™ control system also constantly monitors the crane to detect and shutdown the hoist if an overcapacity situation is encountered. Over speed protection is provided with the Smartorque™ control system which continuously monitors the crane speed. Uncommanded move protection is provided		Over-speed switch Variable Frequency Drives VFD & Thermal magnetic circuit breaker for excessive currents for each motion (instantaneous trip) Thermal overloads in motor coupled with separate motor overload for high temp protection Trolley and bridge end of travels	

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		with the SMARTORQUE™ control system. If the system detects a move that is inconsistent with the position of the operators control the motion is disabled. Two-Block protection is provide by redundant travel limit switches, and multiple load cells which disables and protects the hoist system if a two-block situation is imminent. Misreeving protection is provided with a sensing system that disables power to the hoist if a misreeved condition is detected.			The trolley and bridge L.S. will be tested per the Site Acceptance Procedure, 36675-13.
6.4	Slow Speed Drives Increment drives for hoisting may be provided by stepless controls or inching motor drive. If jogging or plugging is to be used, the control circuit should include features to prevent abrupt change in motion. Drift point in the electric power system when provided for bridge or trolley movement should be provided only for the lowest operating speeds.	The use of the variable frequency drive has advanced significantly beyond this discussion. The VFD allows a wide range of speed control while continuously monitoring the direction of the load. The integration of the encoder ensures that the VFD compensates or the brakes are engaged if the commanded direction is different than the actual direction detected by the encoder. Plugging or jogging is not used.	None	None	None
6.5	Safety Devices Safety devices such as limit-type switches provided for malfunction, inadvertent	The ZionSolutions single failure proof crane system includes numerous safety devices to protect against malfunction, inadvertent operator action, or failure, which are in	None	See Section 6.3	See Section 6.3

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	operator action, or failure should be in addition to and separate from the limiting means or control devices provided for operation.	addition to and separate from the limiting means or control devices provided for operation. A detailed listing of safety and protection devices is included in paragraph 6.3.			
6.6	Control Stations The complete operating control system and provisions for emergency controls for the overhead crane handling system should preferably be located in a cab on the bridge. When additional operator stations are considered, they should have control systems similar to the main station. Manual controls for hoisting and trolley movement may be provided on the trolley. Manual controls for the bridge may be located on the bridge. Remote control or pendant control for any of these motions should be identical to those provided on the bridge cab control panel. Cranes that use more than one control station should be provided with electrical interlocks that permit only one control station to be operable at any one time. In the design of the control systems, provision for and locations of devices for control during emergency conditions should be provided.	The ZionSolutions crane's primary operation center is the cab control and includes all necessary controls to safely operate the crane and all of its safety features. In addition, a remote radio control is provided that includes the same control functions as the main operators control system. Manual controls for hoisting and trolley emergency and/or maintenance purposes are provided on the trolley. Manual controls for the bridge motion for emergency and/or maintenance purposes are located on the bridge. To preclude the possibility of multiple control stations being operated at the same time electrical interlocks are provided that permit only one control station to be operable at any one time. Emergency stop buttons are included on each operators control station.	None	Test cab and radio control to verify cannot operate at the same time	The test will be performed both per the Factory Acceptance Procedure, 36675-07and in the Site Acceptance Procedure, 36675-13.

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7.1	General Installation instructions should be provided by-the manufacturer. These should include a full explanation of the crane handling system, its controls, and the limitations for the system and should cover the requirements for installation, testing, and preparations for operation.	Complete and easily comprehendible installation instructions are provided for the crane system. Detailed crane installation checklists are also provided to properly check and verify the construction sequence. The installation instructions provide a complete overview of the entire crane system including a full explanation of all items and operating limitations. The installation manuals also provide specific details regarding installation, testing, operation and maintenance details for the entire system.	None	None	None
7.2	Construction and Operating Periods When the permanent plant crane is to be used for construction and the operating requirements for construction are more severe than those required for permanent plant service, the construction operating requirements should be defined separately. The crane should be designed structurally and mechanically for the construction loads, plant service loads, and their functional performance requirements. At the end of the construction period, the crane handling system should be modified as needed for the performance requirements of the nuclear power plant operating service. After construction use,	This crane will not be used for construction and therefore the first part of this section is not applicable. Comprehensive installation procedures are developed to ensure the correct and safe assembly of all items in order to ensure compliance with all design requirements.	None	None	None

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	the crane should be thoroughly inspected by nondestructive examination and load tested for the operating phase. The extent of nondestructive examination, the procedures used, and the acceptance criteria should be defined in the design specification. If allowable design stress limits for the plant operating service are to be exceeded during the construction phase, added inspection supplementing that described in Section 2.6 should be specified and developed. During and after installation of the crane, the proper assembly of electrical and structural components should be verified. The integrity of all control, operating, and safety systems should be verified as to satisfaction of installation and design requirements.				
8.1	General A complete check should be made of all the crane's mechanical and electrical systems to verify the proper installation and to prepare the crane for testing. Information concerning proof testing on components and subsystems that was required and performed at the	Prior to functional testing a complete inspection of the entire crane system is conducted to ensure proper assembly and integrity of all items. The inspection process includes a highly detailed checklist of all items including any adjustments or modifications that are required prior to startup of the crane. All results are documented and retained for future reference.	None	Factory Acceptance Testing performed.	Factory Acceptance Testing will be performed per MMH Procedure #36675-07.

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	manufacturer's plant to verify the ability of components or subsystems to perform should be available for the checking and testing performed at the place of instal-lation of the crane system.	A complete review of all documentation, tests results, proof load test certificates etc., for all components is conducted to ensure that all items are in compliance with relevant codes, standards and requirements. All results are thoroughly documented for future reference.			
8.2	Static and Dynamic Load Tests The crane system should be static load tested at 125% of the MCL. The tests should include all positions generating maximum strain in the bridge and trolley structures and other positions as recommended by the designer and manufacturer. After satisfactory completion of the 125% static test and adjustments required as a result of the test, the crane handling system should be given full performance tests with 100% of the MCL for all speeds and motions for which the system is designed. This should include verifying all limiting and safety control devices. The features provided for manual lowering of the load and manual movement of the bridge and trolley during an emergency should be tested with the MCL attached to demonstrate the ability to function as intended.	The entire ZionSolutions crane system will be subjected to extensive testing in accordance with comprehensive documented test procedures to ensure proper operation of all items at the MCL. All test results are recorded for future reference. Shop Testing at the MMH factory This testing will consist of fully assembling the trolley and: • Cycling all the controls using both an operator station and the radio. • Two block prevention testing of the main hoist by verifying both sets of main hoist limit switches work. Performing a 125% rated load test of both the main and auxiliary hoist. Emergency lowering the main hoist using the Magnetorque with the MCL. Load cell tests for both main and aux hoist.	None	The assembled trolley will be tested in the shop and the assembled trolley and bridge (complete crane system) will be tested at the site	The tests will be performed both per the Factory Acceptance Procedure, 36675-07and per the Site Acceptance Procedure, 36675-13.

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		Testing of all other hoist limit switches and safety systems. Site Testing This testing will occur after the trolley and all modifications have been installed on the existing bridge and will include: • Performing a 125% cold proof load test of the bridge. • Two block testing of the main hoist using the two limit switches. • Load cell tests for both main and aux hoist. • Cycling all the controls using both the operator station and the radio. • Detailed post test inspection to ensure no components have been adversely affected by the testing. 125% load test with manual movement of the bridge and trolley to the extent possible. • Performing a 125% rated load test of both the main and aux hoist. • Emergency lowering the main hoist using the Magnetorque with the MCL. • Load cell tests for both main and aux hoist. • Testing of all other hoist limit			

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		switches and safety systems. Clarification #1: At the Site Acceptance Testing, the bridge and trolley will have very limited travel during the loads tests since there are restrictions on carrying heavy loads. Since the bridge and existing building runway had been load tested when initially installed plus the modifications did not significantly modify the applied loads to the bridge or runway, the original tests are still valid.			
8.3	Two-Block Test When equipped with an energy-controlling device between the load and head blocks, the complete hoisting machinery should be allowed to two-block during the hoisting test (load block limit and safety devices are bypassed). This test, conducted at slow speed without load, should provide assurance of the integrity of the design, the equipment, the controls, and the overload protection devices. The test should demonstrate that the maximum torque that can be developed by the driving system, including the inertia of the rotating parts at the over torque condition, will be absorbed or controlled during two-blocking or load hang-up. The complete hoisting	The crane comes with dual upper limit switch; geared limit switch that trips out the drive, and a weight operated type switch that physically removes power to the drive contactor and sets the hoist brakes when tripped. No energy-absorption system is included in this crane design.	None	The assembled trolley will be tested in the shop and the assembled trolley and bridge (complete crane system) will be tested at the site	The tests will be performed both per the Factory Acceptance Procedure, 36675-07and per the Site Acceptance Procedure, 36675-13

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	machinery should be tested for ability to sustain a load hang-up condition by a test in which the load-block-attaching points are secured to a fixed anchor or an excessive load. The crane manufacturer may suggest additional or substitute test procedures that will ensure the proper functioning of protective overload devices.				
8.4	Operational Tests Operational tests of crane systems should be performed to verify the proper functioning of limit switches and other safety devices and the ability to perform as designed. However, special arrangements may have to be made to test overload and over-speed sensing devices.	Extensive operational tests will be conducted on the entire ZionSolutions single failure proof crane system in order to verify proper functionality of all items including limit switches and safety devices and procedures are implemented to safely test overload and over-speed sensing devices under closely supervised surveillance.	None	The assembled trolley will be tested in the shop and the assembled trolley and bridge (complete crane system) will be tested at the site	The tests will be performed both per the Factory Acceptance Procedure, 36675-07and per the Site Acceptance Procedure, 36675-13
8.5	Maintenance After installation, equipment usually suffers degradation due to use and exposure. A certain degree of wear on such moving parts as wire ropes, gearing, bearings, and brakes will reduce the original design factors and the capacity of the equipment to handle the rated load. With good maintenance practice, degradation is not	To ensure the integrity of each ZionSolutions crane system extensive testing is completed prior to turnover for commercial operation. In the event that any items have sustained wear or exposure, a plan is implemented to return those items to acceptable standards to ensure safe handling of critical loads at the MCL crane capacity. A site specific customized crane maintenance plan, that thoroughly identifies the maintenance	None	None	None

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	expected to exceed 15% of the design load rating, and periodic inspection coupled with a maintenance program should ensure that the crane is restored to the design condition if such degradation is found. Essentially, the MCL rating of the crane should be established as the rated load capacity, and the design rating for the degradable portion of the handling system should be identified to obtain the margin available for the maintenance program. The MCL should be plainly marked on each side of the crane for each hoisting unit. It is recommended that the critical-load--handling cranes should be continuously maintained above MCL capacity.	criteria and maintenance frequency is implemented at the time of crane turnover to operations in order to maintain the crane at the MCL capacity. The MCL and design rating are clearly marked on outboard surfaces of each crane girder.			
9.0	OPERATING MANUAL The crane designer and crane manufacturer should provide a manual of information and procedures for use-in checking, testing, and operating the crane. The manual should also describe a preventive maintenance program based on the approved test results and information obtained during the testing. It should include such items as servicing, repair and replacement requirements, visual examinations, inspections, checking, measurements, problem diagnosis,	The entire ZionSolutions single failure proof crane system is subjected to extensive testing prior to commercial operations. A comprehensive operation and maintenance manual is provided which includes detailed information regarding the entire crane system including operation, startup, testing, maintenance, troubleshooting, parts, diagnostics, and other special instructions pertinent to the crane system. The manual also establishes the MCL margin for degradation of wear-susceptible component parts and the process for evaluating the margin.	None	None	None

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	nondestructive examination, crane performance testing, and special instructions. The operating requirements for all travel movements (vertical and horizontal movements or rotation, singly or in combination) incorporated in the design for permanent plant cranes should be clearly defined in the operating manual for hoisting and for trolley and bridge travel. The designer should establish the MCL rating and the margin for degradation of wear-susceptible component parts.				
10.0	QUALITY ASSURANCE Although crane handling systems for critical loads are not required for the direct operation of a nuclear power plant, the nature of their function makes it necessary to ensure that the desired quality level is attained. A quality assurance program should be established to the extent necessary to include the recommendations of this report for the design, fabrication, installation, testing, and operation of crane handling systems for safe handling of critical loads. In addition to the quality assurance	The ZionSolutions single failure proof crane system is built in compliance with an NQA-1 compliant quality assurance program. The quality assurance program is applicable to all aspects of the ZionSolutions crane including but not limited to design, fabrication, installation, testing, and operation. In addition to the quality assurance program established for site assembly, installation, and testing of the crane, applicable procurement documents are maintained to provide a quality assurance program consistent with, or enveloping, the pertinent provisions of Regulatory Guide 1.28, "Quality Assurance Program Requirements (Design	None	None	None

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	program established for site assembly, installation, and testing of the crane, applicable procurement documents should require the crane manufacturer to provide a quality assurance program consistent with the pertinent provisions of Regulatory Guide 1.28, "Quality Assurance Program Requirements (Design and Construction)," to the extent necessary. The program should address all the recommendations in this report. Also included should be qualification requirements for crane operators.	and Construction)," to the extent necessary. The quality control program also addresses all the recommendations in this report. A certificate of compliance, certifying that all applicable requirements have been met is provided as part of the final quality control documentation package. The ZionSolutions Quality Assurance Plan will be used to formally accept the crane system for operation at ZNPS. Qualification requirements for crane operators are provided in the crane training manual and operator training is provided at the time of crane commissioning.			

Attachment 1
NUREG 0554, SECTION 2.2
15% DEGRADATION FACTOR

Per NUREG 0554, Section 2.2, "a slightly higher design load should be selected for component parts that are subject to degradation due to wear and exposure.... An increase of approximately 15% of the design load for these component parts would be a reasonable margin."

MMH's opinion is that this requirement is applicable to only those components in the load path and only those components that see relative movement between interfacing surfaces. Based on the location of this crane inside the Fuel Handling Building, which is very protected and has a mild atmosphere, the degradation of the equipment due to "exposure" would have a negligible effect on the structural components. Based on this definition, we have evaluated the following components and determined which should have the 15% applied:

Component Name	MMH Drawing #	Is the 15% factor applicable?	Discussion
Sister Hook	QR82460	Yes	Only the seats of the hooks and the pin hole are applicable. In addition to the 15% vertical impact factor per NOG-1, the reeving calculation used an additional 15% applied to the MCL to account for degradation and wear and envelopes the requirements in the Technical Specification, Section 4.1.6.8
Nut	QR83165	No	No relative movement between hook and nut. Wear could only occur at the thrust bearing, and its failure would not drop the load.
Bottom Block Frame	QR95495	No	Relative motion is between the thrust washer and frame, and its failure would not drop the load. There is no relative motion between the sheave pins and the frame since the pins are keyed to the frame.
Sheave Pin	QR95496	No	Sheaves rotate about the sheave pins, but there is a bushing between the sheave and pin. The bushing will wear before the pin and the structural calculations do not take credit for the bushing. Thus, wear can occur, but does not affect the design basis.

Component Name	MMH Drawing #	Is the 15% factor applicable?	Discussion
Sheaves	QR95497	No	Wear of sheave due to rope will not cause a dropped load. The only result will be that the sheave will see higher stresses. In addition, the sheave is not designed based on load, but based on the size of rope used on the sheave.
Wire Rope Assembly (Qty of 4)	QR94824	Yes (partially)	The calculation uses 5% factor to account for wear since the fleet angles are limited, the equipment is indoors, and the ropes lubricated.
Upper Block Trunnion (Qty of 4)	QR95566	Yes, for the interface between the rope assembly pin and the trunnion only.	There are two interfacing items. First, the load cell is keyed to the trunnion, so no wear can occur to the trunnion. Second, the pin between the rope socket and the trunnion can move and wear can occur to the trunnion. This location will have a 15% increase in the design load.
Load Cell (qty of 4)	QR95249	No	The load cell is keyed to the Upper Block Trunnion and rotates in a bushing in the equalizer. No wear can occur between the trunnion and the load cell (no relative movement) since they are keyed. Between the load cell and bushing, the bushing will wear before the pin. Thus, wear can occur, but does not affect the design basis.
Upper Block Equalizers	QR95525 QR95527	No	Both interface locations have bushings in them. Since the bushings will wear first, no negative effect to the design basis will occur.
Upper Block Pin	QR95567	No	This pin is keyed into the upper block frame. Since there is no movement between the pin and the frame, no wear can occur. As discussed above, the interface between the pin and the equalizers is a bushing. Since the bushing will wear first, no negative effect to the design basis will occur.
Upper Block Frame	QR95371	No	As mentioned above in the discussions for "Upper Block Pin", no wear can occur between the pin and the frame since the pin is keyed into the upper block frame.
Gears and Pinions in Gearbox	QR89592	Yes	The gears were designed to operate at 75% loading in each box. Therefore, the increase in loading envelopes the 15% requirement.

Component Name	MMH Drawing #	Is the 15% factor applicable?	Discussion
Couplings	18U100 18U108	No	There is no movement in the couplings since they are bolted & keyed.
Motor Shafts	QR94709 R95583	No	The motor shafts are held in bearings and bushings. Therefore no wear of a structural member will occur.
Shoe Brakes	QR94714 QR76929	No	The brakes are oversized to either 125% or 150% already to account for abnormalities. In addition, the brakes are self-adjusting and will take up for wear of the pads.
Drum	QR94604	No	The wear of a drum is usually limited to the lands (peaks) and the sides of the grooves due to side loading (excessive fleet angles.) The structural analysis of the drum is based on the base of the groove (section of the drum core), and therefore does not see degradation.

Attachment 2
RECONCILE REQUIREMENTS OF ATTACHMENT PATHS

Standard	Single Load Attachment Point	Two Load Attachment Points
NUREG 0554	No discussion	(Section 4.3) "...assembly should be provided with two load attaching points (hooks or other means) so designed that each attaching point will be able to support a load of three times the load (static and dynamic) being handled without permanent deformation of any part of the load block assembly...."
NUREG O612	(Section 5.1.6 {2}) For operating plants, the crane should be upgraded in accordance with the implementation guide lines of Appendix C of this report. (Appendix C, {5}) "... at one installation being upgraded, a single attachment sister hook was accepted. However, the safety factor was increased to 10:1 to compensate for loss of the single failure proof feature and to equal the total safety factor of the wire rope. "	(Section 5.1.6 {2}) Meet the requirements of NUREG 0554
NOG-1	(Section 5428.1) "...provide one load attaching point designed such that it will be able to support a load of six times the critical load (static and dynamic) being handled without permanent deformation of the hook other than localized strain concentration..."	(Section 5428.1) "....provides two load attaching points designed such that each attaching point will be able to support a load of three times the critical load (static and dynamic) being handled without permanent deformation of the hook, other than localized strain concentration ..."
Zion*Solutions* Technical Specification SP-ZS-FH-003	(Section 4.1.6.8) "The main hoist dual prong (sister) hook shall be designed for a safety factor of 10-to-1, static plus dynamic, such that this design margin is maintained when lifting from either the hook prongs or center pin hole."	(Section 4.1.6.3) "Unless specified elsewhere....allowable stresses of individual mechanical components shall be in accordance with the requirements of NOG-1 Section 5000."
Reeving Stress Calculation Report 36675-23	Safety factor of 10-to-1, static plus dynamic and including degradation factor, based on ultimate strength. Safety factor of 6-to-1, static plus dynamic and including degradation factor, based on yield strength.	See "Single Load Attachment Point" response

Example Stress Levels

Hook Material:	34CrNiMo6
Ultimate Strength:	$\sigma_u = 115$ ksi
Yield Strength:	$\sigma_y = 95$ ksi
Vertical Impact Factor:	1.15 (15%)
Degradation Factor:	1.15 (15%)
Impact + Degradation:	1.30

NUREG 0612:

$$\frac{\sigma u}{\text{Safety Factor}} = \frac{\sigma_u}{10} = 11.5\ ksi$$

NOG-1:

$$\frac{\sigma_y}{(\text{Safety Factor})\ \text{x}\ (\text{Impact} + \text{Degradation Factors})} = \frac{\sigma_y}{6\ \text{x}\ 1.30} = 12.18\ ksi$$

Zion*Solutions*:

$$\frac{\sigma_u}{(\text{Safety Factor})\ \text{x}\ (\text{Impact Factor})} = \frac{\sigma_u}{10\ \text{x}\ 1.15} = 10\ ksi$$

MMH Calculation:

$$\frac{\sigma_u}{(\text{Safety Factor})\text{x}\ (\text{Impact} + \text{Degradation Factors})} = \frac{\sigma_u}{10\ \text{x}\ 1.30} = 8.85\ ksi$$

-AND-

$$\frac{\sigma_y}{(\text{Safety Factor})\text{x}\ (\text{Impact} + \text{Degradation Factors})} = \frac{\sigma_y}{6\ \text{x}\ 1.30} = 12.18\ ksi$$

Attachment 7

Fuel Handling Building and Auxiliary Buildings Drawings Associated with the Single Failure Proof Crane Upgrade

Fuel Handling Building and Auxiliary Building Plant Structural Drawings

B-107, Rev. K, Fuel Handling Bldg. Foundation Plan El. 617'-0" West Area
B-108, Rev. P, Fuel Handling Bldg. Foundation Plan El. 617'-0" East Area
B-109, Rev. J, Fuel Handling Bldg. Foundation Plan El. 602'-0" West Area
B-113, Rev. E, Fuel Handling Bldg. Foundation Plan El. 602'-0" East Area
B-114, Rev. AD, Fuel Handling Building Foundation Plan Elevation 592'-0" - West Area
B-115, Rev. N, Fuel Handling Building Foundation Plan Elevation 592'-0" - East Are A
B-116, Rev. D, Fuel Handling Building Foundation Plan
B-117, Rev. G, Fuel Handling Building Foundation Car Shed Plan
B-118, Rev. L, Fuel Handling Bldg. Foundation Section A-A
B-119, Rev. R, Fuel Handling Bldg. Foundation Section B-B
B-120, Rev. N, Fuel Handling Building Foundation-Section C-C
B-121, Rev. H, Fuel Handling Bldg. Foundation Section D-D
B-122, Rev. E, Fuel Handling Building Foundation-Section E-E
B-123, Rev. M, Fuel Handling Bldg. Foundation Section F-F
B-124, Rev. P, Fuel Handling Bldg. Foundation Section G-G
B-125, Rev. K, Fuel Handling Building Foundation-Section H-H
B-126, Rev. M, Fuel Handling Building Fdn. Sections & Details - Sheet 1
B-151, Rev. AB, Auxiliary Bldg. Foundation Plan El. 542'-0" N.W. Area
B-283, Rev. N, Turbine Building & Service Building Column Schedule
B-284, Rev. F, Auxiliary Bldg. & Refueling Bldg. Column Schedule
B-287, Ref. E, Turbine Bldg. & Auxiliary Bldg. Column Details
B-291, Rev. H, Column Bracing Rows 15, 5, P, V, W, Y and 38
B-294, Rev. G, Column Bracing Rows 17 & 23
B-295, Rev. G, Column Bracing Sections & Details
B-335, Rev. J, Turbine Building Floor Framing Sections & Details Sheet 1
B-365, Rev. Y, Auxiliary Building Framing Plan El. 617'-0" Southwest Area
B-366, Rev. Z, Auxiliary Building Framing Plan El. 617'-0" Northwest Area
B-375, Rev. H Auxiliary Building Framing Plan El 642'-0" Southwest Area
B-376, Rev. D, Auxiliary Building Framing Plan El. 642'-0" Northwest Area
B-381, Rev. C, Auxiliary Building Roof Framing Plan El. 668'-0" S.W. Area
B-382, Rev. B, Auxiliary Building Roof Framing Plan El. 668'-0" N.W. Area
B-391, Rev. A, Fuel Handling Bldg. Transfer Canal Winch Details
B-392, Rev. B, Car Shed Roof Framing Plan El. 618'-6"
B-401, Rev. C, Fuel Handling And Aux. Bldg. Girder Schedule
B-402, Rev. H, Fuel Handling Building Crane Girder and Rail Plan
B-403, Rev. F, Fuel Handling Building Crane Girder Sections & Details
B-404, Rev. G, Fuel Handling Building Roof Framing Plan West Area
B-405, Rev. L, Fuel Handling Building Roof Framing Plan East Area

B-406, Rev. C, Fuel Handling Transfer Canal Gate Sect. & Dets.
B-420, Rev A Fuel Handling Building Wall Plan El 617'-0" West Area
B-421, Rev. A, Fuel Handling Building Wall Plan El. 617'-0" East Area
B-422, Rev. B, Car Shed Roof & Wall Plan El. 618'-6"
B-556, Rev. C, Typical Masonry Wall Details
B-634, Rev. N, Auxiliary Building Roof Sections & Details
B-654, Rev. G, Fuel Handling Bldg. Ground Fl. Plan - El. 592'-0"
B-655, Rev. E, Fuel Handling Bldg. Ground Fl. Sections & Details
B-657, Rev. X, Fuel Handling Bldg. Operating Fl. Plan El. 617'-0"
B-658, Rev. J, Fuel Handling Bldg. Removable Wall Modification
B-659, Rev. E, Fuel Handling Bldg. - Equipment Removal Crosstown Platform
B-660, Rev. D, Fuel Handling Bldg. Roof Plan
B-661, Rev. C, Fuel Handling Building Equipment Removal Crosstown Cart
B-662, Rev. A, Fuel Handling Bldg. Stair No. F-1
B-717, Rev. M, Pipe Chase Framing Plans El. 574'-4 3/4", 598'-3 1/4", & El. 607'-0"
B-718, Rev. L, Pipe Chase Framing Plans El. 574'-4 3/4", 598'-3 1/4", & El. 607'-0"
B-719, Rev. J, Pipe Chase Framing Sections & Details
B-721, Rev. L, Auxiliary Building Wall Plan El. 592'-0" S.W. Area
B-722, Rev. J, Auxiliary Building Wall Plan El. 592'-0" N.W. Area
B-723, Rev. PP, Auxiliary Building Wall Plan El. 592'-0" S.E. Area
B-724, Rev. AG, Auxiliary Building Wall Plan El. 592'-0" N.E. Area
B-725, Rev. J, Auxiliary Building Wall Plan El. 601'-3"
B-726, Rev. LN, Auxiliary Building Wall Plan El. 617'-0" S.W. Area
B-727, Rev. JP, Auxiliary Building Wall Plan El. 617'-0" N.W. Area
B-731, Rev. CE, Auxiliary Building Wall Plan El. 642'-0" S.W. Area
B-732, Rev. U, Auxiliary Building Wall Plan El. 642'-0" N.W. Area
B-733, Rev. MM, Auxiliary Building Wall Plan El. 642'-0" S.E. Area
B-734, Rev. YB, Auxiliary Building Wall Plan El. 642'-0" N.E. Area
B-740, Rev. F, Auxiliary Building Sections & Details Sheet 1
B-743, Rev. G, Auxiliary Building Sections & Details Sheet 4
B-744, Rev. K, Auxiliary Building Sections & Details Sheet 5
B-747, Rev. V, Auxiliary Building Sections & Details, Sheet 8
B-751, Rev. J, Auxiliary Building Sections & Details, Sheet 12
B-753, Rev. J, Auxiliary Building Sections & Details, Sheet 12
B-754, Rev. J, Auxiliary Building Sections & Details, Sheet 15
B-811, Rev. C, Floor Loading Diagram Aux. Bldg. El's. 542', 560', 579' & 592'
B-812, Rev. A, Floor Loading Diagram Aux. Bldg. El. 601'-3", 617'-0", 630'-0", 642'
B-819, Rev. A, Floor Loading Diagram Diesel Generator & Fuel Hdlg. Bldg
ZION001-C-028 Sheet 1 Rev 0 FHB Crane Rail Modification Plan View Sooth Rail

ZION001-C-028 Sheet 2 Rev 0 FHB Crane Rail Modification Plan View North Rail
ZION001-C-028 Sheet 1 Rev 2 FHB Crane Rail Modification Details.

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