

Rules for the Movement of Loads Using Overhead Handling Equipment in Nuclear Facilities

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**The American Society of
Mechanical Engineers**

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ASME NML-7024

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The American Society of Mechanical Engineers

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FOREWORD

ASME NML-1, Rules for the Movement of Loads Using Overhead Handling Equipment in Nuclear Facilities, was developed by the ASME Committee on Cranes for Nuclear Facilities (CNF) to define the requirements and guidelines for a safe, effective load-handling program at commercial nuclear facilities using overhead handling equipment.

In July 1980, the Nuclear Regulatory Commission (NRC) issued NUREG-0612, Control of Heavy Loads at Nuclear Power Plants. Since then, this report has been used to define and control load-handling programs at commercial nuclear power plants.

In 1981, the NRC issued Generic Letter 81-07 asking utilities with nuclear power plants to demonstrate that they were in compliance with the requirements of NUREG-0612, Section 5.1. The nuclear power plants were asked to respond in two phases. For Phase I, nuclear power plants were asked to demonstrate their compliance to the seven guidelines in Section 5.1.1. For Phase II, nuclear power plants were asked to demonstrate their compliance with Sections 5.1.2 through 5.1.6. The Phase II demonstration of compliance required a description of all overhead handling systems used at a nuclear facility; a comparison of the facility's overhead cranes to those described in NUREG-0554, Single-Failure-Proof Cranes for Nuclear Power Plants; and identification of all hazards within the facility and potential methods for eliminating those identified hazards. Generic Letter 85-11 cancelled Phase II requirements (except for any licensing commitments made by a facility) for most nuclear power plants.

One of the seven guidelines of NUREG-0612, Section 5.1, states that facilities shall have administrative controls in place to control the movement of heavy loads. The NRC defines a heavy load as "any load, carried in a given area after a plant becomes operational, that weighs more than the combined weight of a single spent fuel assembly and its associated handling tool for the specific plant in question." Thus, facilities developed procedures to control the movement of loads in excess of the heavy-load limit. The procedures defined crane operator qualifications, specified the locations of safe load paths, and identified special lifting devices.

NUREG-0612, Section 5.1, invokes ANSI N14.6-1978 for guidelines on the design, construction, fabrication, and testing of special lifting devices, and ANSI B30.9-1971 for guidelines on slings used for the movement of heavy loads. ANSI N14.6-1978 was superseded by revised editions in 1986 and 1993 and has since been withdrawn. Since 1971, ASME has issued numerous revisions to ANSI B30.9, and it redesignated the standard as ASME B30.9 in 1990.

Given the age of NUREG-0612, the ASME CNF Committee recognized the need for a new standard to address the control of heavy loads in nuclear power plants. This Standard has been written to maintain consistency with principles found in NUREG-0612. Thus, lifting evolutions with potential radiological consequences greater than a fuel-handling accident are still considered critical, and the seven guidelines have been incorporated into this Standard. However, ASME NML-1 invokes newer standards for requirements specific to overhead handling equipment, below-the-hook lifting devices, slings, and rigging hardware.

As its title indicates, this Standard includes requirements for the movement of all loads using overhead handling equipment within a nuclear facility. It applies a graded approach to the level of controls required for the variety of lifts performed in a nuclear facility, separating lifts into three classifications: standard, special, and critical.

The risk of performing a lift determines the classification of the lift. The risk is quantified based on an evaluation of the factors that may increase the probability of a malfunction or load-handling event and an evaluation of the potential consequences of such an occurrence.

The lift classifications represent increasing levels of risk: a standard lift has the lowest risk, a special lift has a moderate risk, and a critical lift has the highest risk. Special lifts may be appropriate for managing material-handling activities having moderate levels of risk. Within the critical lift classification, this Standard includes a distinct classification, nuclear safety critical lifts, for lifts similar to those characterized in NUREG-0612. Because of the safety-related risks inherent to nuclear safety critical lifts, these lifts require more stringent safety measures than do the other lift classifications.

This Standard also provides requirements for crane design, inspection, and testing and for personnel involved in lifting operations. It also includes three Nonmandatory Appendices. [Nonmandatory Appendix A](#) provides a matrix showing conformance of ASME NML-1 to NUREG-0612. [Nonmandatory Appendix B](#) provides guidance on adopting ASME NML-1 to operating nuclear power plants or other nuclear facilities licensed under the Code of Federal Regulations, Title 10, Part 50. And [Nonmandatory Appendix C](#) provides examples of lift classifications based on the risk associated with the evolution. The lift planner may use these examples as guidance to ensure the correct classification of the lift and the appropriate level of rigor and oversight.

This Standard or portions thereof may be applied to load handling, operations, and maintenance at facilities other than nuclear where enhanced safety may be required.

ASME NML-1-2024 has been updated to clarify requirements, to better align with NRC Regulatory Guide 1.244, and to add more flexibility to load classification. Revisions include adding a definition for load block and changing the use of lower block to load block; clarifying requirements on the use of shelf rigging used for critical lifts; clarifying requirements for continuing compliance testing; adding a nuclear safety critical lift category to [para. 4-1.1](#); providing requirements that allow a nuclear safety critical lift to be classified as a special lift; removing references to ASME NUM-1 Type III Cranes (now CMAA 74); and correcting the use of single-failure-proof to single-failure-proof features.

Following approval by the ASME CNF Committee and ASME, and after public review, ASME NML-1 was approved by the American National Standards Institute on July 29, 2024.

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(1) to permit early implementation of a revision based on an urgent need

(2) to provide alternative requirements

(3) to allow users to gain experience with alternative or potential additional requirements prior to incorporation directly into the Standard

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SUMMARY OF CHANGES

Following approval by the ASME NML-1 Standards Committee and ASME, and after public review, ASME NML-1-2024 was approved by the American National Standards Institute on July 29, 2024.

ASME NML-1-2024 includes the following changes identified by a margin note, **(24)**.

<i>Page</i>	<i>Location</i>	<i>Change</i>
1	1-5	Definition of <i>load block</i> added
3	1-6	Updated
9	2-5.3	Subparagraph (a) revised
9	2-6.1	New subparagraph (c) added and subsequent paragraph redesignated
15	4-1.1	Revised in its entirety
18	5-1.2.2	Revised in its entirety
18	5-1.2.3	Revised in its entirety
19	5-2	Revised
21	Table A-1-1	Under ASME NML-1, para. 4-1.1(a), Requirement or Recommendation revised

Section 1

Introduction

1-1 GENERAL

Movement of loads covered by this Standard shall be 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.

1-2 SCOPE

This Standard specifies requirements for the movement of loads using overhead handling systems at commercial nuclear facilities.

(a) For the purposes of this Standard, overhead handling systems are limited to the following:

(1) those types covered by the following standards:

(-a) ASME B30.1, Chapter 1-6, Telescopic Hydraulic Gantry Systems; and Chapter 1-7, Strand Jack Systems

(-b) ASME B30.2

(-c) ASME B30.5

(-d) ASME B30.16

(-e) ASME B30.17

(-f) ASME B30.21

(-g) ASME NOG-1

(-h) ASME NUM-1

(2) those defined as engineered temporary lift assemblies per [subsection 1-5](#)

(3) those qualified as special designed equipment per ASME HRT-1

(b) This Standard does not cover the individual movement of irradiated fuel assemblies that are bounded by a facility accident analysis.

(c) Lifts licensed under 10 C.F.R. 72 are within the scope of this Standard.

1-3 APPLICABILITY

This Standard applies to all lifting and handling operations at nuclear facilities, including the training and certification of personnel, and the maintenance, inspection, testing, and rework and modification of overhead handling systems and other lifting devices.

The application of this Standard shall begin at the point of initial fuel load at the affected unit under construction.

1-4 RESPONSIBILITY

Compliance with this Standard is the responsibility of the owner.

1-5 DEFINITIONS

(24)

cascading failures: a process in a system of interconnected parts in which the failure of one or a few parts can trigger the failure of other parts and so on.

design rated torque: the torque required to hold the design rated load of the hoist at the point of brake application.

double-rigging arrangement: a system in which two independent sets of load-carrying elements, each capable of carrying the load, are used to connect the load to the overhead handling equipment.

emergency response plan: a set of actions necessary to mitigate the consequences of the worst possible outcomes of a load-handling accident.

engineered temporary lift assembly (ETLA): specially designed lifting equipment that is not general purpose but has a special temporary intended purpose. These assemblies are not standard design items and are not available from a commercial source, and there is no generally accepted consensus standard applicable to the equipment. Examples of ETLAs include special gin poles and derricks; special crane supports such as runways or overhead gantry columns and frames; and special load-handling equipment such as up-end and down-end devices and jacking towers (unless used with the guidance of the applicable volume of ASME B30). ETLAs are required for lifts that cannot be accomplished with standard lifting devices.

essential safety function (ESF): a function performed by a plant system, structure, or component that is necessary to remove decay heat from irradiated fuel, provide shielding, contain radioactive material, or control nuclear reactivity. For the purposes of this Standard, ESFs are defined as follows:

(a) maintaining adequate decay heat removal.

(b) maintaining reactor coolant system and spent fuel pool inventory necessary for adequate shielding, removal of decay heat, and containment of radioactive material. This may be accomplished by preventing leakage from the reactor vessel (during refueling) and spent fuel pool in excess of safety-related makeup capability.

(c) preventing damage to irradiated fuel or to components that function to prevent a substantial release of radioactivity. As used here, a substantial release of radioactivity means the potential for radiation exposures comparable in magnitude to those specified in 10 C.F.R. § 50.34(a)(1), § 50.67(b)(2), or § 100.11.

(d) maintaining the geometric configuration of multiple fuel assemblies such that nuclear reactivity cannot increase.

facility acceptable excursion limit (FAEL): the distance a load can move where its movement remains safe. This limit applies to any hoist or travel motion when uncommanded load movement occurs. It is intended to assume a mechanical or a control system failure has occurred and manual or automatic systems must be used to stop the load.

infrequently performed test and evolution (IPTE): infrequently performed test or evolution that has the potential to significantly degrade the plant's margin of safety and therefore warrants additional management oversight and control.

intermediate hoist: an additional hoist that is used as part of the rigging below the primary hoist. It could be used as a means of leveling the load or as a more precise means of lifting the load.

lift, critical: any lift that carries a high risk of a load-handling event, as determined by the presence of certain probability factors and the severity of the possible consequences of such an event.

lift, nuclear safety critical: any lift, performed in a given area after a plant becomes operational, in which the load weighs more than the combined weight of a single spent fuel assembly and its associated handling tool for the specific plant in question that, as a result of uncontrolled motion exceeding the movement safety envelope, can result in the loss of an essential safety function. Nuclear safety critical lifts are a subset of critical lifts.

lift, special: any lift that carries a moderate risk of a load-handling event, as determined by the presence of certain probability factors and the severity of the possible consequences of such an event.

lift, standard: any lift that carries a low risk of a load-handling event, as determined by the presence of certain probability factors and the severity of the possible consequences of such an event.

lifting evolution: the lifting, transporting, and setting down of any load. Lifting and setting down the load in the same location for a rigging adjustment does not constitute a lifting evolution.

load block: the assembly of hook or shackle, swivel, bearing, sheaves, pins, and frames suspended by the hoisting rope; the load block shall include any items reeved in the hoisting ropes.

load-handling event: an unplanned and undesirable occurrence during the movement of a crane or its load that may have a negative effect on operations.

load test, return-to-service: a test that proves the adequacy of the equipment being tested to lift and hold a load.

may: word used to denote permission, which is neither a requirement nor a recommendation.

minimum lift height: the smallest distance that a load must be lifted above a surface in order for the crane's safety features to engage and stop the load should the hoist fail to hold the load. This calculation shall evaluate factors such as wire rope stretch, time to detect uncommanded lowering, brake response time, energy dissipation, and additional distance needed as a safety margin.

Mitigating Systems Performance Index: performance indicator for five nuclear power plant emergency systems: emergency AC power, high-pressure injection, heat removal, residual heat removal, and support cooling.

movement safety envelope: the additional volume around a given crane, load, and rigging configuration that accounts for the detection and mitigation of unintended movement. This envelope is less than or equal to the facility acceptable excursion limit (FAEL) established for the crane design.

OEM: original equipment manufacturer.

overhead handling equipment: permanent cranes, temporary cranes, mobile cranes, and manually operated hoisting equipment that are used to hoist a load or to hoist and move a load from one location to another.

owner: the organization legally responsible for the construction and/or operation of a nuclear facility, including but not limited to one who has applied for or been granted a construction permit or operating license by the regulatory authority having lawful jurisdiction.

planned engineered lifts: lifts in excess of the rated load that are required from time to time on a limited basis for specific purposes such as new construction or major repairs.

predictive maintenance: the use of techniques such as thermal, vibration, and lubrication analyses to predict the service life of a component or system.

preventive maintenance: maintenance techniques implemented to ensure safe and reliable operation of overhead handling equipment.

qualified person: a person who by possession of a recognized degree in an applicable field or a certificate of professional standing, or by extensive knowledge, training, and experience, has successfully demonstrated the ability to solve problems related to the subject matter and work.

redundant lifting device: a lifting device that provides two independent lifting paths, each capable of carrying the load.

risk: the combination of the probability of an occurrence of an undesirable event and the severity of the consequence of that event.

safer load path: the path a load is to be moved, both horizontally and vertically, to minimize the associated risk of a load-handling event.

safe shutdown equipment: equipment required to shut down a reactor and maintain it in a shutdown condition.

shall: word used to denote a requirement.

should: word used to denote a recommendation.

special structure, system, or component (SSSC): any nuclear power plant structure, system, or component that a risk-informed evaluation process has shown to be significant to public health and safety.

supplemental personnel: contractors and vendors who perform work on-site.

test, operational: a test that proves the adequacy of the equipment being operated to properly respond to operator and installed-component inputs.

(24) 1-6 REFERENCES

The following is a list of codes and standards referenced in this Standard. These codes and standards apply to the extent invoked at the point of reference.

- 10 C.F.R. 50 (2018). Domestic Licensing of Production and Utilization Facilities. U.S. Government Publishing Office.
- 10 C.F.R. 72 (2018). Licensing Requirements for the Independent Stage of Spent Nuclear Fuel, High-Level Radioactive Waste, and Reactor-Related Greater Than Class C Waste. U.S. Government Publishing Office.
- 10 C.F.R. 100 (2018). Reactor Site Criteria. U.S. Government Publishing Office.
- AISC 325. Steel Construction Manual, 15th edition. American Institute of Steel Construction.
- ANSI B30.2-1976. Overhead and Gantry Cranes. American National Standards Institute.
- ANSI N14.6-1978. Standard for Special Lifting Devices for Shipping Containers Weighing 10,000 pounds (4500 kg) or More for Nuclear Materials (Withdrawn). American National Standards Institute.
- ASME B30.1-2015. Jacks, Industrial Rollers, Air Casters, and Hydraulic Gantries. The American Society of Mechanical Engineers.
- ASME B30.2-2016. Overhead and Gantry Cranes (Top Running Bridge, Single or Multiple Girder, Top Running Trolley Hoist). The American Society of Mechanical Engineers.
- ASME B30.5-2018. Mobile and Locomotive Cranes. The American Society of Mechanical Engineers.
- ASME B30.9-2018. Slings. The American Society of Mechanical Engineers.
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- ASME B30.20-2018. Below-the-Hook Lifting Devices. The American Society of Mechanical Engineers.
- ASME B30.21-2014. Lever Hoists. The American Society of Mechanical Engineers.
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- CMAA 74-2015. Specifications for Top Running and Under Running Single Girder Electric Overhead Cranes Utilizing Under Running Trolley Hoist. Crane Manufacturers Association of America.
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- NEI 08-05 (2008, July). Industry Initiative on Control of Heavy Loads. Nuclear Energy Institute.
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Section 2 Lifts

2-1 GENERAL

Each facility that uses this Standard shall have a program that controls the movement of loads by overhead handling equipment.

2-2 CLASSIFICATION OF LIFTS

2-2.1 Preliminary Lift Plan

For each lift, a preliminary lift plan should be developed for the purposes of lift classification, with consideration given to the proposed handling equipment, the proposed load, and the environment surrounding the proposed lift path. Lifts shall be classified as standard, special, or critical based on the risk associated with the lift (see [Figure 2-2.1-1](#)).

(a) By definition, nuclear safety critical lifts are a subset of critical lifts. However, a critical lift is not a nuclear safety critical lift unless that lift meets the definition of a nuclear safety critical lift.

(b) Lifts with High probability factors shall not be performed until actions are taken to mitigate those factors. For other lifts that approach a High probability, consideration should be given to mitigating multiple Medium probability factors to reduce the risk of the lift. High probability factors include but are not limited to the following:

- (1) The weight of load has not been calculated or measured.
- (2) The lift involves a mobile crane setup on terrain that has not been evaluated and determined suitable for expected loading.
- (3) The load has an unknown or shifting center of gravity.
- (4) The lift involves lifting devices, rigging hardware, or slings without safe-working-load markings.
- (5) The lift is performed with the crane working clearances to adjacent electrical power lines within +10% of minimum clearances specified in the ASME standard for the respective crane.
- (6) Sling angles are less than 30 deg above horizontal.
- (7) The load is submerged in liquid and is not visible.

(8) The center of gravity of the load is or could potentially shift above the load attachments points, and rigging is arranged such that the load can be influenced by factors that result in the load overturning.

(c) Following any mitigation activities, the preliminary lift plan shall be reevaluated to validate that all High probability factors have been mitigated.

2-2.2 Quantification of Risk

The risk associated with a lift is determined by the probability and consequences of a malfunction or accident. [Tables 2-2.2-1](#) and [2-2.2-2](#) contain examples of the probability factors and consequence factors, respectively, used in the determination.

(a) *Probability*. Probability is a measure of the difficulty of performing a lift. [Table 2-2.2-1](#) contains factors that affect the probability of a malfunction or accident. The user shall review the table and determine which factors apply to the lift being performed. The rating of Low, Moderate, or Medium for any applicable factors provides a probability level. If more than one factor applies to a lift, then the user shall, within the probability category, move the probability rating closer to, but not into, the next higher risk category.

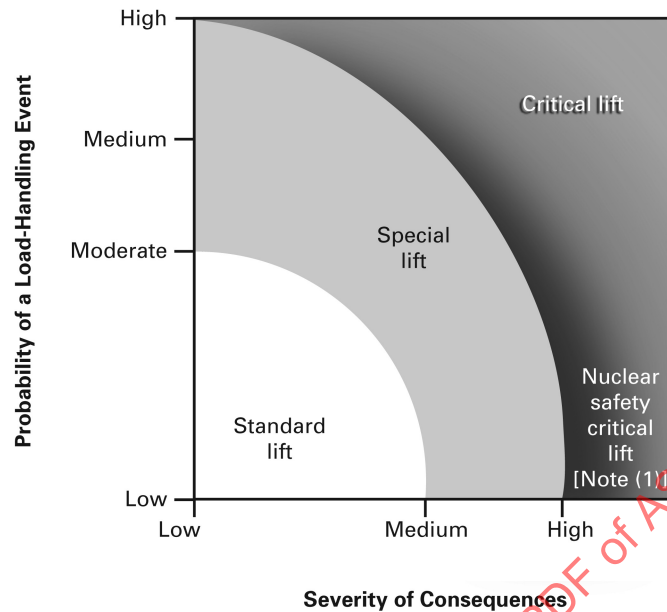
(b) *Consequences*. Consequences are the result of a load-handling event. [Table 2-2.2-2](#) lists possible consequences of a load-handling event. The user shall review the table and determine which consequences could apply should a malfunction or accident occur during a particular lift. The rating of Low, Medium, or High for any applicable consequences provides a consequence severity level from a malfunction or accident. If more than one possible consequence applies to a lift, then the user shall, within the severity category, move the severity rating closer to, but not into, the next higher severity category.

2-3 ALL LIFTS

2-3.1 General

A lifting and rigging program shall be established to govern all lifts performed using overhead handling equipment at a facility.

**Figure 2-2.1-1
Risk Classification of Lifts**



NOTE: (1) Area of darkest shading indicates nuclear safety critical lift.

2-3.2 Requirements for All Lifts

A facility's lifting and rigging program shall include each of the following components:

(a) policies and procedures to ensure the expectations for rigging and lifting of loads are defined. Elements shall include

(1) clearly defined standards, roles, and responsibilities for personnel involved with rigging and lifting of loads

(2) facility procedure or handbook providing workers with a reference on technical information and safety expectations

(3) written or verbal lift plans consistent with the complexity or uniqueness of the task performed for all lifts

(4) independent reviews verifying the safety of below-the-hook lifting devices brought on-site by contract personnel

(b) training to ensure that all personnel have appropriate knowledge and skills before they perform lifting and rigging activities. Elements shall include

(1) initial and continuing training provided to facility personnel who perform rigging and lifting, develop lift plans, or inspect rigging equipment

(2) hazard awareness training provided to facility personnel to ensure their understanding of the general risks and hazards associated with lifting and rigging

(3) verification that training standards for supplemental personnel are equivalent to those for facility personnel performing similar rigging and lifting activities and moving loads

(4) proficiency verification of all personnel before they perform rigging and lifting tasks

(c) control, storage, and inspection of equipment to ensure that all rigging and lifting equipment, including special or nonstandard site-specific or vendor-fabricated lifting devices, is safe and suitable for service when issued. Elements shall include

(1) clearly defined storage and inspection standards for rigging and lifting equipment

(2) periodic inspection of rigging and lifting equipment for improper storage and damage

(3) removal of damaged rigging and lifting hardware from service by segregation, tagging, or destruction upon discovery of damage

(4) verification that rigging equipment brought on-site by supplemental personnel meets applicable certifications and facility standards

(d) fundamental rigging and lifting practices to ensure safe implementation and operations by all personnel. Elements shall include

(1) the load-handling activity considerations of ASME P30.1

(2) use of load-binding indicators or binding-release devices with stop-work criteria when a load has the potential to bind or drag

**Table 2-2.2-1
Probability of a Load-Handling Event**

Probability Rating	Factors That May Cause a Load-Handling Event
Medium	Weight of load is estimated. Lift involves guides or other alignment methods. Load is submerged in liquid and is visible. Lift uses more than one hook. Lift uses more than one crane. Center of gravity of the load is or could potentially shift above the load attachments points, and rigging is arranged such that the load cannot be influenced by factors that result in the load overturning. Load is drifted between one or more overhead attachment points. Load is greater than 90% capacity for any crane with a radius-based capacity or requires a planned engineered lift for an overhead crane. When two radius-based cranes are being used, load imposed on either crane is greater than 70% of its capacity. Lift is performed with rigging, attachments, lifting devices, or methods that are not covered by OSHA, ASME, or industry rigging handbook requirements. Lift is performed in a switchyard near energized electrical equipment. Lift is performed with ETLAs. Lift is performed with a floating crane. Lift requires access into a confined space or tight area limiting movement of personnel or overhead handling equipment. Lift involves rolling, up-ending, or down-ending components. Lift requires side-loading outside the plane of sheave rotation. Lift is performed in severe weather conditions (as defined by plant-specific processes). Lift is performed when the signalperson does not have direct line-of-sight with the crane operator. Center of gravity of the load is greater than 12 in. from geometric center.
Moderate	Sling angles for the load are greater than 30 deg and less than 45 deg above horizontal. Lift is performed with the load secured at more than two attachment points. Lift is performed in emergency conditions (as defined by plant-specific processes). Lift is performed with snatch blocks or base-mounted drum hoist (tugger). Lift requires side-loading inside the plane of sheave rotation. Lift is performed with a below-the-hook lifting device. Lift is performed with a potential for binding. Lift is performed with the use of an intermediate hoist.
Low	None of the Moderate or Medium factors nor any unique facility factors are present in the lift.

GENERAL NOTES:

- (a) [Table 2-2.2-1](#) is provided as a guide only and is not all-inclusive. Each facility may have unique load-handling requirements that create additional factors not listed, and these factors shall be considered in the probability rating determination.
- (b) OSHA = Occupational Safety and Health Administration.

(e) supervision and oversight by line managers and supervisors who possess the appropriate level of knowledge to review lift plans and conduct field oversight. Elements shall include the following:

(1) The requirements for supervisory oversight of rigging and lifting are defined and communicated.

(2) The oversight of rigging and lifting activities is performed by line managers and supervisors who are sufficiently knowledgeable to recognize and correct fundamental deficiencies and hazardous situations.

(3) Prejob briefings are conducted prior to rigging and lifting activities to identify potential hazards and compensatory actions required to prevent equipment damage and personnel injuries.

2-4 SPECIAL LIFTS

2-4.1 General

Special lifts performed with overhead handling equipment have a greater level of risk than do standard lifts and thus require that the facility establish additional controls to identify, minimize, and manage that risk.

**Table 2-2.2-2
Severity of Consequences**

Severity Rating	Possible Consequences of a Load-Handling Event
High	Breach of a high-energy system, such as steam, electrical, or hydraulic system Injury or death to personnel located on or under the load Destruction of a high-value item Destruction of a long-lead procurement item Loss of availability of safe shutdown equipment Release of hazardous chemical Loss of a heat sink Loss of all three fission product barriers Release of radioactive material exceeding the limits of 10 C.F.R. 100 Reconfiguration of the fuel such that the coefficient of criticality, k_{eff} , is larger than 0.95, which is near the point of nuclear fuel criticality Compromising of a volatile load Water leakage that uncovers irradiated fuel or causes a dilution event
Medium	Damage to a special (risk-significant) system, structure, or component Breach of a medium energy system, such as steam, electrical, or hydraulic system Damage to a high-value item Damage to a long-lead procurement item Unplanned shutdown Damage that would prevent any non-nuclear emergency system, such as fire protection, from fulfilling its function Loss of any single fission product barrier Decrease in the Mitigating Systems Performance Index Derating of plant electrical output Reportable environmental spill that is not contained on-site Contamination of groundwater Critical path delay of a unit outage of more than 24 hr Physical or consequential damage in excess of the insurance deductible Forced outage longer than 10 weeks
Low	None of the Medium or High consequences nor any unique facility consequences

GENERAL NOTE: Table 2-2.2-2 is provided as a guide only and is not all-inclusive. Each facility may have unique consequences resulting from a load-handling event that create additional factors not listed, and these factors shall be considered in the consequence rating determination.

2-4.2 Requirements for Special Lifts

Each facility performing special lifts shall include the following additional requirements in its lifting and rigging programs:

(a) written lift plans that have been prepared by a Rigger I and reviewed by a Rigger II (see [subsection 3-2](#) for descriptions of Rigger I and Rigger II). A written lift plan is not required if owner-approved procedures or drawings that detail the lift are provided.

(b) consideration of cascading failures during the risk evaluation.

(c) use of safer load paths as described in [para. 2-4.3](#).

(d) requirements as provided by one of the following for management or mitigation of the risk identified in (b):

(1) designation of the lift as an infrequently performed test or evolution (IPTE)

(2) implementation of risk mitigation measures such as the use of enhanced safety handling systems [see [para. 2-6.1\(c\)\(2\)](#)], placement of cribbing or impact-softening materials under the load path to protect high-value loads from damage if they are dropped, exclusion of unnecessary personnel from hazardous load-handling areas, or controls on the loading of combustible material near volatile or flammable load paths

(e) management oversight and engagement during the execution of a special lift, including, at minimum, reviewing the lift plan, attending the prejob briefing, and observing the lift.

2-4.3 Safer Load Paths

Safer load paths shall be determined for special and critical lifts to minimize the risk to essential safety functions (ESFs).

(a) Clearances along the load path shall account for the movement safety envelope. This envelope shall be less than or equal to the FAEL established for the crane design.

(b) The flexibility of structural elements shall be considered in the selection of a safer load path and may limit the height a load can be lifted as it is being moved along the path.

(c) Safer load paths shall be clearly defined in facility procedures or shown on facility drawings.

Deviations from defined safer load paths shall require written alternative procedures approved by the appropriate management review committee for the facility.

2-5 CRITICAL LIFTS

2-5.1 General

Critical lifts performed with overhead handling equipment have the highest risk level of all the lift classifications and therefore require that the facility establish controls to identify, minimize, and manage the risk associated with making the lift.

2-5.2 Requirements for Critical Lifts (Excluding Nuclear Safety Critical Lifts)

Each facility performing critical lifts shall include the following additional requirements in their lifting and rigging programs:

(a) rigging plans prepared by a Rigger II, reviewed by a second Rigger II, and then reviewed independently by a third Rigger II or a qualified third party. A written lift plan is not required if owner-approved procedures or drawings that detail the lift are provided.

(b) consideration of cascading failures during the risk evaluation.

(c) use of safer load paths as described in [para. 2-4.3](#).

(d) requirements as provided by one of the following for management or mitigation of the risk identified in (b):

(1) designation of the lift as an IPTE

(2) implementation of risk mitigation measures such as the use of enhanced safety handling systems [see [para. 2-6.1\(c\)\(2\)](#)], placement of cribbing or impact-softening materials under the load path to protect high-value loads from damage if they are dropped, exclusion of unnecessary personnel from hazardous load-handling areas, or controls on the loading of combustible material near load paths used for volatile or flammable materials.

(e) management oversight and engagement during the execution of a critical lift, including, at minimum, reviewing the handling plan, attending the IPTE meeting and prejob briefing, and observing the lift.

(f) if deemed necessary, emergency response plans that specify the actions required to mitigate the consequences of the worst possible outcomes identified in (b).

2-5.3 Other Considerations for Critical Lifts

(24)

(a) The running rope and load block of an overhead crane are considered part of the overhead crane. Thus, the movement of an empty load block is not considered a critical lift.

(b) Movement safety envelopes shall be established for overhead cranes used for critical lifts. These envelopes shall include minimum lift heights to ensure that emergency braking systems engage and stop load movement.

2-6 NUCLEAR SAFETY CRITICAL LIFTS

2-6.1 General

(24)

Nuclear safety critical lifts are a subset of critical lifts. Because of the inherent safety-related risks, these lifts require the most stringent safety measures.

(a) The requirements of [paras. 2-4.2](#) and [2-5.2](#) shall not apply to nuclear safety critical lifts.

(b) A facility with a control of heavy loads program described in the facility safety analysis report may continue to handle nuclear safety critical lifts in a manner consistent with the control of heavy loads program.

(c) A lift may be classified as a special lift rather than a nuclear safety critical lift if all of the following conditions are met:

(1) The facility system that performs an ESF is equipped with multiple trains.

(2) Each train of that system is capable of performing the required safety function independently.

(3) A load drop would impact only a single train of that system.

(d) New handling activities or changes to existing handling activities should be evaluated in accordance with applicable regulatory change processes, and the new or changed activities should require use of at least one of the following measures during nuclear safety critical lifts:

(1) *Controlled Ranges of Motion*. Interlocks or physical stops shall be used to prevent the movement of loads to positions where a drop could threaten the performance of an ESF. Interlocks may be mechanical, electrical, or software based.

(2) *Enhanced Safety Handling Systems*. Enhanced safety handling systems shall be designed to have an extremely low likelihood of system failure through use of designs incorporating single-failure-proof features and/or significantly increased margins of safety. Enhanced safety handling systems shall consist of the following two elements:

(-a) cranes or hoists that meet the requirements of [para. 4-1.1](#)

(-b) lift devices that either satisfy the critical lift requirements of [Table 5-1-1](#) or use commercially procured rigging that satisfies the criteria of [subsection 5-2](#)

(3) *Engineering Controls.* Bounds for safe handling shall be based on analysis of the consequences of a postulated load drop, equipment failure, and/or unintended load motion, with respect to a critical load-handling evaluation. These bounds shall define the safer load path, maximum safe load height, maximum safe load weight, and other critical parameters as applicable. These bounds shall be specified in load-handling procedures.

(-a) Analyses of a postulated load drop, equipment failure, and/or unintended load motion shall, as a minimum, include the considerations listed below. Other considerations (e.g., reactor vessel head assembly, spent fuel cask) may be appropriate for the particular load drop being analyzed.

(-1) The load is dropped in a credible orientation, considering single failure points in the rigging, reeving system, and crane hoist drive system, that results in the most severe consequences.

(-2) The load may be dropped at any location in the crane travel area.

(-3) Analyses shall be based on an elastic-plastic curve that represents a true stress-strain relationship of the materials.

(-4) The analyses shall determine realistic damage states with appropriate margin for uncertainty. Analyses shall consider minimal damping to ensure that the calculated energy absorbed by the dropped load and the impacted structure and/or equipment bounds the actual energy absorption.

(-5) Postulated load drops need not be analyzed if the drop energy per unit impact area and total drop energy are bounded by the analysis of another load drop.

(-6) The analysis shall include evaluation of unintended motion, caused by human error or equipment failure, resulting in a load height that may cause a two-blocking condition.

(-7) Evaluation of radiation dose consequences shall consider the maximum effective release of radioactive material based on decay and potential damage state, available filtering and confinement systems, and credible atmospheric dispersion of the release.

(-8) Equipment that is reliable, regularly operated, and well maintained may be credited to mitigate the effects of the load drop, provided the equipment is available at the time of the lift, a procedure governs use of the equipment in the manner necessary to mitigate the load-drop consequences, and operators are trained in the implementation of the procedure.

(-b) The following criteria define acceptable consequences of the postulated load drop:

(-1) Release of radioactive material that may result from damage to spent fuel based on calculations involving accidental dropping of a postulated load produces doses that are equal to or less than one-quarter of 10 C.F.R. 100 limits. 10 C.F.R. 100 limits are 300 rem¹ thyroid and 25 rem whole body.

(-2) Damage to fuel and fuel storage racks based on calculations involving accidental dropping of a postulated load does not result in a configuration of the fuel such that the coefficient of criticality, k_{eff} , is larger than 0.95.

(-3) Damage to the reactor vessel or the spent fuel pool based on calculations of damage following accidental dropping of a postulated load is limited so as not to result in water leakage that could uncover the fuel. Makeup water provided to overcome leakage should be from a borated source of adequate concentration if the water being lost is borated.

(-4) Damage to equipment in redundant or dual safe shutdown paths based on calculations assuming a postulated load drop will be limited so as not to result in loss of required safe shutdown functions.

2-6.2 Movement of Loads Over Irradiated Fuel

Table 2-6.2-1 lists those loads that must be moved over irradiated fuel in the reactor core. All critical lifts that travel directly over or consist of irradiated fuel shall be handled only with hoisting equipment that meets the critical lift requirements of subsection 4-1 and lifting devices that meet the critical lift requirements of Table 5-1-1, unless the requirements of para. 2-6.1(c)(3) can be met.

2-6.3 Other Considerations for Nuclear Safety Critical Lifts

(a) When an empty load block of an ASME NOG-1, Type II crane or an ASME NUM-1, Type II crane is traveling over special structures, systems, or components (SSSCs), administrative or engineering controls shall be in place to prevent the hoist from functioning.

(b) Movement safety envelopes shall be established for overhead cranes used for nuclear safety critical lifts. These envelopes shall include minimum lift heights to ensure that emergency braking systems engage and stop load movement.

¹rem = roentgen equivalent man (as defined by the U. S. Nuclear Regulatory Commission).

Table 2-6.2-1
Loads Moved Over Irradiated Fuel

Load	Reactor Type [Note (1)]
Reactor vessel head	PWR or BWR
Refueling bridge or platform	PWR or BWR
Shield plugs	PWR or BWR
Upper vessel internals	PWR
Drywell head	BWR
Refueling canal plugs and gates	BWR
Moisture separator	BWR
Steam dryer	BWR

NOTE: (1) BWR = boiling water reactor; PWR = pressurized water reactor.

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Section 3

Personnel Requirements

3-1 CRANE-OPERATING PERSONNEL

3-1.1 Crane Operator Training

Crane operators handling loads shall be trained in accordance with the applicable volume of ASME B30. If the crane has any features not addressed in ASME B30, the operator shall be trained in the operation of those features.

3-1.2 Crane Operator Conduct

(a) While operating the crane, the crane operator shall not engage in any practice that will divert his or her attention from the operation of the equipment.

(b) When physically or otherwise unfit, a crane operator shall not engage in the operation of the equipment.

(c) The crane operator shall

(1) be familiar with and understand hand signals

(2) respond to signals from the person who is directing the lift or from an appointed signalperson

(3) obey a stop signal at all times, no matter who gives it

(d) Each crane operator shall be responsible for those operations under the crane operator's direct control. Whenever there is doubt as to safety, the crane operator shall consult with the individual in charge of the lift before handling the load.

(e) The crane operator shall activate the warning device on cab- and remote-operated cranes and, if a warning device is provided, on floor-operated cranes

(1) before starting the bridge or trolley motion of the crane

(2) intermittently during travel of the crane when the crane is approaching persons in the path of the load

(f) Before leaving a crane unattended, the crane operator shall land any attached load, place control master switches in the off position, and turn the crane off if possible.

(g) If the crane is being serviced or inspected, the crane operator shall not apply power to the crane until all service or inspection personnel are known to be clear of the crane or in a safe position.

(h) If power goes off during operation, the crane operator shall immediately place or verify all control master switches are in the off position.

(i) The crane operator shall be familiar with the equipment and its proper care. If adjustments or repairs are necessary or any defects are known, the crane operator shall report them in accordance with the program described in [subsection 4-3](#).

(j) Contacts with runway stops or other cranes shall be made with extreme caution. The crane operator shall do so with particular care for the safety of persons on or below the crane, and only after making certain that any persons on the other cranes are aware of what is being done.

(k) When the wind-indicating device of a cab-operated outdoor crane gives a wind excessive alarm, crane operation shall be discontinued at first opportunity, any suspended loads shall be landed, and the crane shall be prepared and stored for excessive wind conditions.

(l) Prior to the performance of any maintenance work on the crane, the crane shall be locked and tagged out (crane disconnect) in the de-energized position in accordance with facility procedures unless maintenance or troubleshooting activity cannot be performed without power. Additional caution should be used when additional personnel are present on the crane.

(m) Before beginning a new shift or at the earliest opportunity if a mid-evolution turnover is made between the new and leaving operators and it is impractical to perform the tests due to the crane configuration, the crane operator shall test control master switches, push buttons, and, if provided and scheduled for use, radio controls.

(n) If at any time controls do not operate properly, the crane operator shall report the malfunction in accordance with the program described in [subsection 4-3](#).

(o) The crane operator shall enter and exit overhead cranes only at authorized locations and designated boarding entrances except in emergency situations.

(p) If the crane has more than one hoisting unit, the operator shall lift only loads that are within the rated load capacity of the hoist and crane structure.

3-1.3 Crane Operator Physical Requirements

Crane operators and crane operator trainees shall meet the following physical qualifications:

(a) vision of at least 20/30 Snellen in one eye and 20/50 Snellen in the other, with or without corrective lenses.

(b) normal depth perception, field of vision, reaction time, manual dexterity, and coordination, and no tendencies to dizziness or similar undesirable conditions.

(c) ability to distinguish colors, regardless of position of colors, if color differentiation is required for operation of the equipment.

(d) adequate hearing, with or without hearing aid, for the specific operation.

(e) sufficient strength, endurance, agility, coordination, and speed of reaction to meet the demands of equipment operation.

(f) no evidence of physical defects or emotional instability that could render a hazard to the operator or others, or that, in the opinion of the examiner, could interfere with the operator's performance. Evidence of such conditions may be cause for disqualification. In such cases, specialized clinical or medical judgments and tests may be required.

(g) no evidence of being subject to seizures or loss of physical control. Evidence of such conditions shall be reason for disqualification. Specialized medical tests may be required to determine these conditions.

3-1.4 Crane Operator Certification

(a) Certification

(1) Crane operators shall be certified by an accredited crane operator testing organization, or by an employer-administered certification program that includes written and practical testing procedures to ensure operators meet the technical knowledge and skills listed in [para. 3-1.1](#).

(2) Crane operators shall also meet the physical requirements outlined in [para. 3-1.3](#).

(3) Crane operator certification is valid for 5 yr.

(b) Recertification

(1) Crane operators shall be recertified by an accredited crane operator testing organization, or by an employer-administered certification program that includes written and practical testing procedures to ensure operators continue to meet technical knowledge and skill requirements of the original certification.

(2) Crane operators shall also meet the physical requirements outlined in [para. 3-1.3](#)

3-2 RIGGING PERSONNEL

Riggers who perform lifts within nuclear facilities shall meet either of two categories of qualifications, Rigger I or Rigger II.

3-2.1 Rigger I Requirements

(a) Individuals qualified to Rigger I shall be able to select the rigging methods and necessary rigging equipment for production load-handling activities.

(b) A qualified Rigger I shall be able to identify the means, e.g., motors, gearboxes, pumps, and similar items, and methods needed to handle unique loads during maintenance events.

(c) A Rigger I shall be able to calculate and interpret weights, centers of gravity, and sling tensions.

3-2.2 Rigger II Requirements

(a) Individuals qualified to Rigger II shall first be qualified to Rigger I.

(b) In addition to having all the abilities of a Rigger I, a qualified Rigger II shall be able to develop the rigging methods and use specialized rigging equipment for unique load-handling activities.

(c) A qualified Rigger II shall be able to assist in the planning and execution of the rigging events that may occur within the facility.

3-2.3 Rigger Qualification

(a) *Qualification.* Individuals qualified to Rigger I and Rigger II shall be trained by an American National Standards Institute (ANSI) accredited rigger-training organization or by an employer-administered rigger-training program that ensures riggers understand and are able to employ safe rigging solutions. Rigger I and Rigger II qualifications shall be valid for a maximum of 5 yr.

(b) *Requalification.* Riggers shall be requalified in accordance with an ANSI-accredited or employer-administered rigger-training program.

3-3 LIFT-SIGNALING PERSONNEL

(a) Personnel performing signaling of lifts shall have knowledge of the type and characteristics of the crane being used for the lift.

(b) Personnel performing signaling of lifts shall be qualified to Rigger I and shall be qualified in signaling.

3-4 LIFT-DIRECTING PERSONNEL

(a) Every lift performed in a nuclear facility shall have a single individual in charge of the lift. This individual shall be qualified at least to Rigger I and shall be a member of the rigging crew.

(b) Special and critical lifts shall have a lift director who provides independent oversight of the lift but who is not involved in the performance of the lift. The lift director shall

(1) be capable and competent to oversee and manage critical lift activities

(2) hold a Rigger II qualification

(3) have the training, experience, knowledge, skill, and ability to perform nearly any standard, special, or critical lift activity

(4) be designated by the site maintenance director or equivalent

3-5 CRANE-INSPECTING PERSONNEL

(a) Crane-inspecting personnel shall have knowledge about

(1) the type and characteristics of the crane being inspected

(2) the applicable volumes of ASME B30

(b) Crane-inspecting personnel shall meet the definition of a qualified person with respect to the equipment and inspection tasks performed.

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Section 4

Overhead Handling Equipment

4-1 CRANE DESIGN

(24) 4-1.1 Overhead Crane

The minimum crane designs for the lift categories are provided in (a) through (d). Table 4-1.1-1 provides examples of where enhanced safety crane designs are used in various nuclear power plant applications.

(a) *For Nuclear Safety Critical Lifts.* Overhead cranes used for nuclear safety critical lifts shall be designed to meet the requirements of ASME NOG-1, Type I; ASME NUM-1, Type I; or other crane designs with single-failure-proof features previously accepted by the applicable regulatory agency.

(b) *For Critical Lifts.* Overhead cranes used for critical lifts should be designed to meet the requirements ASME NOG-1, Type I; ASME NUM-1, Type I; or other crane designs with single-failure-proof features previously accepted by the applicable regulatory agency. At a minimum, overhead cranes used for critical lifts shall meet the requirements of (c).

(c) *For Special Lifts.* Overhead cranes used for special lifts shall be designed to meet, as a minimum, the requirements of ASME NOG-1, Type III or CMAA 74. If the crane itself is located over an SSSC, then the crane shall meet the design requirements of ASME NOG-1, Type II; or ASME NUM-1, Type II.

(d) *For Standard Lifts.* Overhead cranes used for standard lifts shall be designed to meet, as a minimum, the requirements of CMAA 70 or CMAA 74.

As applicable, the criteria stated in (a) through (d) shall also apply to jib cranes and monorail cranes.

4-1.2 Mobile Crane

(a) Design of mobile cranes shall meet the requirements of ASME B30.5.

(b) Mobile cranes shall be used only for standard and special lifts unless

(1) the possible effects of a load drop are evaluated and mitigated as defined in para. 2-6.1(c)(3)

(2) the possible effects of an overturning crane or boom collapse on adjacent SSSCs are evaluated and mitigated as defined in para. 2-6.1(c)(3)

4-1.3 Engineered Temporary Lift Assemblies

(a) Engineered temporary lift assemblies (ETLAs) shall be designed by a qualified person.

For all vendor-supplied designs and calculations of an ETLA, an independent review shall be performed to ensure that the design is adequate to lift and transport the required component and that all requirements of applicable codes are met.

(b) ETLAs shall be used only for standard and special lifts unless

(1) the possible effects of a load drop are evaluated and mitigated as defined in para. 2-6.1(c)(3)

Table 4-1.1-1
Typical Applications of Enhanced Safety Crane Designs

Crane Design	Crane Application	Reactor Type [Note (1)]	Comments
ASME NOG-1, Type I	Reactor crane	BWR, PWR	Designs to NUREG-0554 and supplemented by ASME NOG-1 have been used in lieu of ASME NOG-1, Type I.
	Fuel-building crane	BWR, PWR	This application is typical when spent fuel storage casks (dry storage, transfer, shipping, etc.) are lifted above their licensing basis.
ASME NOG-1, Type II	Turbine crane	BWR	Type II may be used in other reactor designs for economic reasons.
	Pump house crane	BWR, PWR	Optionally, the crane can be located so that a seismic event does not result in the collapse of the crane.
	Rad waste crane	BWR, PWR	These cranes may also be provided with recovery features.

NOTE: (1) BWR = boiler water reactor; PWR = pressurized water reactor.

(2) the possible effects of an overturning crane, crane support structure failure, or gantry jack system collapse on adjacent SSCs are evaluated and mitigated as defined in [para. 2-6.1\(c\)\(3\)](#)

(c) ETLAs shall be load tested. The test load shall be a minimum of 100% but not more than 125% of the ETLA's rated load. The test shall be performed along the full range of motions for the ETLA.

(d) If load testing of an ETLA cannot be performed in place, then the following shall be performed:

(1) The ETLA shall be assembled in the configuration that will be used to perform the lift at the facility.

(2) The ETLA shall be fully load tested across the entire assembly.

(3) Prior to disassembly, the components of the ETLA shall be match-marked and documented.

(4) After transportation to the facility, the ETLA shall be reassembled to the exact same tested configuration and with differences in foundation supports accounted for.

(5) Replacement of fasteners for reassembly shall be in accordance with AISC 325.

4-2 PERIODIC CRANE INSPECTION AND BRAKE TESTING

(a) Overhead handling equipment shall be periodically inspected in accordance with the requirements of the applicable volume of ASME B30.

(b) Each hoist brake shall be statically tested to its design rated torque to prove brake holding capability. This may be accomplished by external means in lieu of test weights.

(c) The results of the inspections shall be documented in the equipment history records.

4-3 CRANE MAINTENANCE

4-3.1 General

(a) A program shall be established to report and document crane deficiencies. The program shall ensure notification of affected parties.

(b) Maintenance affecting the safe operation of overhead handling equipment shall be based on OEM recommendations, requirements of the applicable volumes of ASME B30, operating experience, and applicable facility requirements to provide greater crane reliability.

4-3.2 Preventive Maintenance

(a) Equipment shall be evaluated to determine its preventive maintenance requirements. The evaluation shall include the vendor recommendations as delineated in their technical manual and bulletins, applicable industry standards and operational experience, and maintenance experience and equipment history records.

Equipment shall be monitored and evaluated for degradation in performance because of age, as appropriate.

(b) A preventive maintenance schedule shall be established to uniquely identify the equipment and the type and frequency of the preventive maintenance to be performed.

(c) The effectiveness of preventive maintenance actions on equipment should be determined through analysis using predictive maintenance to ensure reliable and safe operation. The results of the effectiveness review should be used to adjust the frequency and extent of the preventive maintenance program.

(d) Where applicable, a program shall be developed and implemented to prevent damage from condensation, corrosion, and adverse environmental conditions during periods of prolonged idleness. Preventive measures may include special lubricants or additives for gearing and hydraulic or pneumatic systems; heaters for electronics; and protective coatings for unpainted surfaces such as sheave grooves, wire rope drums, and wire rope; and start-up of electric drives to ensure dielectric reformation of capacitors.

4-3.3 Corrective Maintenance

(a) An assessment of failure cause and required maintenance shall be made consistent with the type of item failure and the importance of the item. The assessment shall also include, as appropriate, the possibility of similar failure in other items. Assessments shall be performed in accordance with documented procedures and shall be appropriately reviewed.

(b) Identified failures that could have serious effects on safety or operability shall have an engineering evaluation. This evaluation will substantiate or revise the failure assessment and corrective action planning.

(c) Identified failures and the related attributed cause assessments shall be included in the equipment history records.

4-4 CRANE TESTING

All new cranes shall be load tested in accordance with the applicable design standard. When required, operational and return-to-service load testing shall be performed as described in [paras. 4-4.1](#) and [4-4.2](#).

4-4.1 Operational Test

A new or reinstalled crane or a crane out of service for more than 12 months shall be tested by a qualified person prior to its initial use to confirm that it performs in compliance with the provisions of this Standard.

(a) The following functions and devices shall be tested:

- (1) hoist braking [see [para. 4-2\(b\)](#)]
- (2) lifting and lowering
- (3) trolley travel
- (4) bridge travel
- (5) hoist-limit devices

(-a) The final upper limit switch shall be tested to ensure the hoist will not two-block (or otherwise damage wire rope) when the hoist is operated at increasing speeds, up to full speed, with no load.

(-b) Where provided, the initial upper limit switch shall be tested to ensure the final upper limit switch is not actuated when the hoist is operated at increasing speeds, up to full speed, with no load.

(-c) All other provided limit devices should be checked for proper functionality.

(6) travel-limiting devices

(7) locking and indicating devices, if provided

(b) Tests of altered and repaired cranes may be limited to the functions or components affected by the alteration or repair as determined by a qualified person.

(c) Wire rope shall be replaced in accordance with the OEM's instructions, and the replacement shall be followed by an operational test as described in (a)(1), (a)(2), and (a)(5).

4-4.2 Return-to-Service Load Test

A crane taken out of service for the replacement or major modification of any structural load-bearing element shall undergo a return-to-service load test before being returned to service.

(a) The test load shall be greater than 100% but not more than 125% of the crane's rated load. For a rope replacement, a return-to-service load test is not required and only the applicable portions of para. 4-4.1 need to be performed.

(b) Before the return-to-service load test, the repaired or modified portion of the crane equipment, as identified by the OEM or qualified person, shall undergo a periodic inspection in accordance with subsection 4-2.

(c) The return-to-service load test of altered and repaired cranes may be limited to the functions affected by the alteration or repair if such limitation is determined acceptable by a qualified person.

(d) The return-to-service load test shall consist of the following operations as a minimum:

Step 1. Statically test each hoist brake to its design rated torque to prove brake holding capability. This may be accomplished by external means in lieu of test weights.

Step 2. Lift the test load a sufficient distance to ensure that the load is supported by the crane. Each hoist brake should be isolated and individually used to hold the load for a time sufficient to verify no drift occurs.

Step 3. If the trolley requires testing, transport the test load by means of the trolley from one end of the crane bridge to the other. The trolley shall approach the limits of travel as close as would be practical in the event use-area restrictions were imposed.

Step 4. If the bridge requires testing, transport the test load by means of the bridge over the portions of the bridge requiring testing. Transport the load in one direction with the trolley as close to the extreme right end of the crane as would be practical in the event use-area restrictions were imposed, and then in the other direction with the trolley as close to the extreme left end of the crane as would be practical in the event use-area restrictions were imposed.

Step 5. Lower the test load, stop, and hold the load for a time sufficient to verify no drift occurs.

A full range of design basis speeds shall be used during all tested motions with the test weight.

Section 5

Lifting Devices and Other Rigging Equipment

5-1 LIFTING DEVICES

Each lifting device shall meet the requirements of one of the ASME BTH-1 Design Categories. The classification of a lift determines the Category of lifting device required for that lift, as noted in [Table 5-1-1](#).

5-1.1 Lifting Devices for Standard and Special Lifts

Lifting devices for standard and special lifts shall meet the design, fabrication, inspection, and testing guidance in ASME BTH-1 (see [Table 5-1-1](#)) and ASME B30.20.

5-1.2 Lifting Devices for Critical Lifts

Lifting devices for critical lifts shall meet the design, fabrication, and inspection guidance in ASME BTH-1 and ASME B30.20. As shown in [Table 5-1-1](#), these devices shall be designed to ASME BTH-1, Design Category C, unless they are redundant lifting devices. Each independent lifting path of a redundant lifting device shall be designed as ASME BTH-1, Design Category B.

5-1.2.1 Considerations for Critical Lifts

(a) Intermediate hoists shall not be used for critical lifts unless they are ASME NUM-1, Type I underhung hoists.

(b) Synthetic slings may be used only if one of the following applies:

(1) The tensioned slings remain in a straight line between their end bearing points.

(2) The tensioned legs wrap around a curved surface with a minimum D/d ratio of 25:1, where D is the diameter of the curved surface and d is the nominal body diameter of the sling.

(c) Rigging shall either use a double-rigging arrangement or be rated for 2 times the required load. If a double-rigging arrangement is used, each set of load-carrying elements shall account for any dynamic loading caused

by any failure in the opposite set of load-carrying elements. In the event of a failure of one set of load-carrying elements, the redundant set shall minimize load movement.

5-1.2.2 Load Test of Lifting Devices Used for Critical Lifts (24)

(a) Load testing of lifting devices used for critical lifts shall be conducted prior to initial use and prior to use following repairs or alterations on load-bearing components. The test shall be conducted in accordance with one of the following:

(1) An ASME BTH-1, Design Category C lifting device shall be subjected to a test load equal to 150% (+5%/–0%) of the maximum service load. After the device sustains the test load for a period of not less than 10 min, critical areas, including major load-bearing welds, shall be visually inspected for defects and all components inspected for permanent deformation. Nondestructive examination (NDE) of the major load-bearing welds shall be performed in accordance with AWS D14.1/D14.1M, Section 10.8.

(2) A redundant lifting device shall be load tested in accordance with (1) except that each path in the redundant device shall be subjected separately to a test load equal to 125% (+5%/–0%) of the maximum service load.

(b) When the test is performed with a crane, care shall be taken to ensure crane operations remain within allowed tolerances as described in the applicable ASME standard.

(c) When acoustic emissions testing (AET) will be used for continuing compliance of the lifting device, a baseline AET shall be taken at a load test as described in (a)(1) or (a)(2). The AET shall be performed in accordance with ASTM E569/E569M.

5-1.2.3 Continuing Compliance for Lifting Devices Used for Critical Lifts (24)

(a) A lifting device used for critical lifts shall be inspected as described in (1) or shall be tested as described in (2) each time it completes the maximum number of lifting evolutions listed in [Table 5-1.2.3-1](#). Any flaw discovered shall be evaluated and dispositioned by a qualified person. Required repairs should be in accordance with the manufacturer's original design specifications.

Table 5-1-1
Lifting-Device Design Category
for Each Lift Classification

Lift Classification	ASME BTH-1 Design Category
Standard	A or B
Special	B
Critical	C or redundant B

Table 5-1.2.3-1
Maximum Number of Lifting Evolutions
Between Continuing Compliance Tests
for Design Category C Lift Devices

Storage Location of Design Category C Lifting Device	Maximum Number of Lifts Between Compliance Tests
Indoors	
Controlled environment	100
Uncontrolled environment	80
Outdoors	
Covered	20
Uncovered	See 5-1.2.3(c)

(1) Major load-carrying welds and critical areas, as determined by a qualified person, shall be visually examined for cracks in accordance with AWS D14.1/D14.1M, Section 10.

(2) AET shall be performed in accordance with ASTM E569/E569M.

(b) Load testing prescribed in para. 5-1.2.2(a)(1) or para. 5-1.2.2(a)(2) shall be performed following repairs or alterations to load-bearing components.

(c) Any Design Category C lift devices stored outdoors shall meet the requirements of (a) prior to every use.

5-1.3 Quality Assurance Requirements for Lifting Devices Used for Critical Lifts

Design Category C lifting devices shall be designed, procured, fabricated, inspected, tested, and examined in accordance with a Quality Assurance Program conforming to the applicable requirements of ASME NQA-1.

5-2 OTHER RIGGING EQUIPMENT

(24)

(a) For standard lifts, special lifts, and lifts made with redundant load path below-the-hook lifting devices, off-the-shelf rigging hardware shall meet the requirements of ASME B30.9 and ASME B30.26.

(b) For critical lifts, off-the-shelf rigging hardware shall meet the requirements of ASME B30.9 and ASME B30.26 with all safe working loads reduced by 50%.

NONMANDATORY APPENDIX A

NUREG-0612/ASME NML-1 CONFORMANCE MATRIX

A-1 INTRODUCTION

This Appendix provides a conformance matrix (see [Table A-1-1](#)) comparing NUREG-0612 guidelines to related ASME NML-1 requirements and recommendations and indicating whether each listed ASME NML-1 requirement or recommendation conforms to the referenced NUREG-0612 guideline. This matrix is not a summary of all the requirements in ASME NML-1 in that ASME NML-1 is a comprehensive standard providing substantial and additional criteria for the movement of loads using overhead handling equipment.

[Table A-1-1](#) is offered for the owner to use as part of any required licensing submittal. It should be noted that certain guidelines in NUREG-0612 are either plant specific or outside the scope of ASME NML-1 and are not included in this matrix; therefore, their applicability and use is the responsibility of the owner. Additional guidance on licensing submittals is provided in this Appendix. It should also be noted that conformance with only the ASME NML-1

paragraphs referenced in the matrix is neither intended nor endorsed by ASME as meeting the criteria for a critical lift program for a nuclear facility.

NOTE: When evaluating ASME NML-1 for conformance with NUREG-0612, refer to the text of ASME NML-1 for the exact wording of the respective requirements.

NUREG-0612 is divided into the following six chapters:

- (a) Chapter 1, Introduction
- (b) Chapter 2, Potential Consequences of a Load Drop on Spent Fuel
- (c) Chapter 3, Survey of Licensee Information
- (d) Chapter 4, Review of Historic Data on Crane Operations
- (e) Chapter 5, Guidelines for Control of Heavy Loads
- (f) Chapter 6, Resolution of Issue

Chapters 1 through 4 and Chapter 6 are information only and provide no guidelines. Therefore, the conformance matrix in [Table A-1-1](#) addresses only Chapter 5.

Table A-1-1
NUREG-0612/ASME NML-1 Conformance Matrix

Section (Paragraph)	NUREG-0612		ASME NML-1		Comments
	Summary of Guidance	Section, Subsection, or Para- graph	Requirement or Recommendation	Conforms to NUREG- 0612 (Yes/No)	
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.	2-4.3	Safer load paths shall be defined for the movement of critical or special lifts to minimize the potential for these loads to impact ESFs.	Yes	...
	The path should follow, 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.		The flexibility of structural elements shall be considered in the selection of a safer load path and may limit the height a load can be lifted as it is being moved along the path.	Yes	...
	These load paths should be defined in procedures, shown on equipment layout drawings, and clearly marked on the floor in the area where the load is to be handled.		Safer load paths shall be clearly defined in facility procedures or shown on facility drawings.	No	The marking of floors is not required by ASME NML-1.
	Deviations from defined load paths should require written alternative procedures approved by the plant safety review committee.		Deviations from defined safer load paths shall require written alternative procedures approved by the appropriate management review committee for the facility.	Yes	...
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.	2-6.1	A facility with a control of heavy loads program described in the facility safety analysis report may continue to handle nuclear safety critical lifts in a manner consistent with the control of heavy loads program. New handling activities or changes to existing handling activities should be evaluated in accordance with applicable regulatory change processes, and the new or changed activities should require use of at least one of the following measures during nuclear safety critical lifts: controlled ranges of motion, enhanced safety handling systems, or engineering controls.	Yes	...
		2-6.2	All critical lifts that travel directly over or consist of irradiated fuel shall be handled only with hoisting equipment that meets the critical lift requirements of subsection 4-1 and lifting devices that meet the critical lift requirements of Table 5-1-1, unless the requirements of para. 2-6.1(c)(3) can be met.	Yes	...
	At a minimum, procedures should cover handling of those loads lifted in Table 3.1-1 of this report.	2-2	Lifts are classified as standard, special, and critical based on the probability and the potential consequences of a load drop. NUREG-0612 lifts are classified as nuclear safety critical lifts, which are a subset of critical lifts, and which require additional measures.	Yes	ASME NML-1 doesn't contain a table prescribing specific loads that must be included in the control of critical lifts. ASME NML-1 contains criteria that ensure that all loads contained in NUREG-0612, Table 3.1-1, are covered by the facility's control of heavy loads procedure.

Table A-1-1
NUREG-0612/ASME NML-1 Conformance Matrix (Cont'd)

Section (Paragraph)	NUREG-0612		ASME NML-1		Comments
	Summary of Guidance	Section, Subsection, or Para- graph	Requirement or Recommendation	Conforms to NUREG- 0612 (Yes/No)	
5.1.1 (2) (cont'd)	These procedures should include: identification of required equipment, inspections and acceptance criteria required before movement of load, the steps and proper sequence to be followed in handling the load; defining the safe load path; and other special precautions.	2	This Section outlines the procedural requirements. The requirements increase in rigor from those for standard lifts to those for critical lifts and those specifically for NUREG-0612 (nuclear safety critical) lifts.	Yes	...
5.1.1 (3)	Crane Operators should be trained, qualified, and conduct themselves in accordance with Chapter 2-3 of ANSI B30.2-1976.	3-1	Crane operators shall be trained and qualified and shall conduct themselves in accordance with paras. 3-1.1 through 3-1.4 .	Yes	The referenced ASME NML-1 paragraphs meet the requirements of ASME B30.2. ASME NML-1 also includes physical requirements for crane operators.
5.1.1 (4)	Special lifting devices should satisfy the guidelines of ANSI N14.6-1978.	5-1.2	Lifting devices for critical lifts shall meet the design, fabrication, and inspection guidance in ASME BTH-1 and ASME B30.20.	Yes	ANSI N14.6 has been withdrawn. ASME NML-1 invokes ASME BTH-1 and ASME B30.20. ASME BTH-1 is a design standard, and ASME B30.20 is a fabrication and inspection standard.
	This standard should apply to all special lifting devices which carry heavy loads in areas as defined above.				
	For operating plants certain inspections and load tests may be accepted in lieu of certain material requirements in the standard.	5-1.2.3	A lifting device used for critical lifts shall undergo inspection as described in 5-1.2.2(a)(1) or testing as described in 5-1.2.2(a)(2) each time it completes the maximum number of lifting evolutions listed in Table 5-1.2.3-1 .	No	This guidance does not apply to new facilities. ASME NML-1 does not allow inspections and testing in lieu of meeting material requirements.
	In addition, the stress design factor stated in Section 3.2.1.1 of ANSI N14.6 should be based on the combined maximum static and dynamic loads that could be imparted on the handling device based on characteristics of the crane which will be used. This is in lieu of the guideline in Section 3.2.1.1 of ANSI N14.6 which bases the stress design factor on only the weight (static load) of the load and of the intervening components of the special handling device.	5-1.2	Lifting devices for critical lifts shall meet the design, fabrication, and inspection guidance in ASME BTH-1 and ASME B30.20.	Yes	ASME BTH-1 requires the inclusion of dynamic loading.

Table A-1-1
NUREG-0612/ASME NML-1 Conformance Matrix (Cont'd)

Section (Paragraph)	NUREG-0612		ASME NML-1		Comments
	Summary of Guidance	Section, Subsection, or Para- graph	Requirement or Recommendation	Conforms to NUREG- 0612 (Yes/No)	
5.1.1 (5)	Lifting devices that are not specially designed should be installed and used in accordance with the guidelines of ANSI B30.9-1976, "Slings".	5-2	Off-the-shelf rigging hardware shall meet the requirements of ASME B30.9 and ASME B30.26.	Yes	ASME NML-1 expands this NUREG-0612 requirement to include the connecting hardware.
	However, in selecting the proper sling, the load used should be the sum of the static and dynamic load.	...	No ASME NML-1 equivalent requirement.	No	ASME NML-1 does not require the consideration of dynamic loading on slings unless the sling uses a double-rigging arrangement.
	The rating identified on the sling should be in terms of the "static load" which produces the maximum static and dynamic load.	...	No ASME NML-1 equivalent requirement.	No	ASME B30.9 requires only the manufacturer's load rating be applied to a sling.
	Where this restricts slings to use on only certain cranes, the slings should be clearly marked as to the cranes with which they may be used.	...	No ASME NML-1 equivalent requirement.	No	The lack of uniquely identified slings negates the need for this NUREG-0612 requirement.
5.1.1 (6)	The crane should be inspected, tested, and maintained in accordance with Chapter 2-2 of ANSI B30.2-1976, "Overhead and Gantry Cranes," ...	4-2	Overhead handling equipment shall be periodically inspected in accordance with the requirements of the applicable volume of the ASME B30 Standard.	Yes	...
		4-4.1	New or reinstalled cranes or cranes out-of-service for more than 12 months shall be tested by a qualified person prior to initial use to confirm that the crane performs in compliance with the provisions of this Standard.	Yes	...
		4-3.1	Maintenance affecting the safe operation of overhead handling equipment shall be based on OEM recommendations, the applicable volume of ASME B30, operating experience, and/or other applicable facility requirements to provide greater crane reliability.	Yes	...
	... with the exception that tests and inspections should be performed prior to use where it is not practical to meet the frequencies of ANSI B30.2 for periodic inspection and test frequency (e.g., the polar crane inside a PWR containment may be only used every 12 to 18 months during refueling operations, and is generally not accessible during power operation. ANSI B30.2, however, calls for certain inspections to be performed daily or monthly. For such cranes having limited usage, the inspections, test, and maintenance should be performed prior to their use.)	4-3.2(d)	Where applicable, a program shall be developed and implemented to prevent damage during prolonged idleness from condensation, corrosion, and adverse environmental conditions. Preventive measures may include special lubricants or additives for gearing and hydraulic or pneumatic systems; heaters for electronics; protective coatings for unpainted surfaces such as sheave grooves, wire rope drums, and wire rope; and start-up of electric drives to ensure dielectric reformation of capacitors.	Yes	Paragraph 4-3.2(d) applies to PWR containment cranes, which are subject to long periods of storage between refueling outages.

Table A-1-1
NUREG-0612/ASME NML-1 Conformance Matrix (Cont'd)

NUREG-0612		ASME NML-1			Comments
Section (Paragraph)	Summary of Guidance	Section, Subsection, or Paragraph	Requirement or Recommendation	Conforms to NUREG-0612 (Yes/No)	
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, "Overhead and Gantry Cranes" and CMAA-70, "Specifications for Electric Overhead Travelling Cranes."	4-1.1(a)	Overhead cranes used for nuclear safety critical lifts shall be designed to meet the requirements of ASME NOG-1, Type I; ASME NUM-1, Type I; or other crane designs with single-failure-proof features previously accepted by the applicable regulatory agency.	Yes	ASME NOG-1 requirements are more restrictive than those of ASME B30.2 or CMAA-70.
	An alternative to a specification in ANSI B30.2 or CMAA-70 may be accepted in lieu of specific compliance if the intent of the specification is satisfied.				
5.1.5	In other plant areas, loads may be handled which, if dropped in a certain location, may damage safe shutdown equipment.	2-4	Under ASME NML-1, the consequences of such an event are high, which will drive this lift into either the special or critical classification. Both of these lifts demand greater rigor in the planning, execution, and oversight of the lift.	Yes	...
		5-1	Lifting devices for noncritical lifts shall meet the design, fabrication, inspection, and testing guidance in ASME BTH-1 (as described in Table 5-1-1) and ASME B30.20.	Yes	...
5.1.6	For certain areas, to meet the guidelines of Sections 5.1.2, 5.1.3, 5.1.4, or 5.1.5, the alternative of upgrading the crane and lifting devices may be chosen.	2-6.1(c)(2)	Enhanced safety handling systems shall be designed to have an extremely low likelihood of system failure through use of designs incorporating single-failure-proof features and/or significantly increased margins of safety.	Yes	...

NONMANDATORY APPENDIX B

ADDITIONAL INFORMATION FOR FACILITIES LICENSED UNDER 10 C.F.R. 50

B-1 GENERAL

The information in this Appendix is provided for any facility licensed under 10 C.F.R. 50 desiring to transition its control of heavy loads program from a NUREG-0612-based program to an ASME NML-1-based program.

B-2 REGULATORY COMMITMENTS

Each facility shall review and determine the disposition of all regulatory commitments submitted to show compliance to

(a) NUREG-0612, including NRC GL 80-113, NRC GL 81-07, NRC GL 85-11, and NRC Bulletin 96-02

(b) INPO Significant Operating Experience Report 06-1

(c) NEI 08-05

Disposition of each commitment shall be performed in accordance with the facility's processes.

B-3 FINAL SAFETY ANALYSIS REPORT

Transition from a NUREG-0612-based program to an ASME NML-1-based program shall be performed under 10 C.F.R. § 50.59, "Changes, Tests, and Experiments," in accordance with the applicable facility's process. An update to the facility's Final Safety Analysis Report is necessary to reflect the change in licensing basis. [Figure B-3-1](#) provides a suggested format and structure for the added content.

Figure B-3-1
Suggested Format and Content for Updating a Facility's Final Safety Analysis Report

X Control of Nuclear Safety Critical Lifts

X.1 Introduction/Licensing Background

Summarize the site-specific licensing correspondence to and from the NRC concerning the control of special and critical lifts (e.g., ASME NML-1, NUREG-0612, GL 80-113, GL 81-07, GL 85-11, Bulletin 96-02, RIS 2005-25, RIS 2005-25 Supplement 1). Use General References (see NEI 98-03) to point to licensee-controlled documents that provide detail for the control of critical lifts.

X.2 Safety Basis

Describe the safety basis that ensures that the risk associated with load-handling failures is acceptably low, based on meeting the requirements of ASME NML-1 subsection 2-6.

Describe the safety basis that ensures the risk associated with the performance of reactor vessel head lifts is acceptably low, based on meeting the requirements of NEI 08-05.

X.3 Scope of Nuclear Safety Critical Lift Systems

List or describe the overhead handling systems that are capable of lifting loads that weigh more than the combined weight of a single spent fuel assembly and its associated handling tool, which, as a result of uncontrolled motion exceeding the movement safety envelope, can result in the loss of an essential safety function.

The list can be presented in tabular form, or provide a General Reference to letters and documents that describe the overhead handling systems. The level of detail should be determined by the licensee and be consistent with the rest of the Updated Final Safety Analysis Report.

X.4 Control of Critical Lifts Program

Outline of suggested text for introduction to this paragraph:

The Nuclear Safety Critical Lifts Program consists of the following:

1. Licensee commitments to be continued following the evaluation of ASME NML-1, Nonmandatory Appendix B, subsection B-2.
2. For reactor pressure vessel head lifts
 - i. EITHER a load drop analysis with assumptions (lift height, load weight, medium present) from the head drop analysis incorporated into plant procedures.
 - ii. OR crane equipped with single-failure-proof features (or equivalent with justification).
3. For spent fuel cask lifts, either a load drop analysis OR crane equipped with single-failure-proof features.

X.4.1 [Licensee Name] Commitments in Response to ASME NML-1 Elements

All nuclear facilities with a nuclear safety critical lifts program shall show intent to comply with each of the following program elements:

1. Development of a nuclear safety critical lifts program as described in subsection 2-6.
2. Classification of nuclear safety critical lifts as described in subsection 2-2.
3. Definition of a safer load path as described in para. 2-4.3.
4. Protection of irradiated fuel from load drops as described in para. 2-6.1.
5. Design, fabrication, and testing of special lifting devices as described in para. 5-1.2.

Figure B-3-1
Suggested Format and Content for Updating a Facility's Final Safety Analysis Report (Cont'd)

6. Lifting devices not specially designed are installed and used as described in subsection 5-2.
7. Cranes used for any nuclear safety critical lifts shall be designed as described in para. 4-1.1.
8. Cranes used for any nuclear safety critical lifts shall be inspected, tested, and maintained as described in subsections 4-2, 4-3, and 4-4.
9. Qualification, training, and conduct of crane operators as described in subsection 3-1.
10. Special lifts that may affect safe shutdown equipment are controlled as described in subsections 2-3 and 5-1.

If the requirements of the specified ASME NML-1 sections and paragraphs cannot be met, then justification of the proposed equivalency shall be provided.

X.4.2 Reactor Pressure Vessel Head (RPVH) Lifting Procedures

If a load drop analysis is being used to support lifts of the RPVH, describe the assumptions (restrictions on load height, load weight, and medium present under the load) from the head drop analysis that are incorporated into plant procedures.

Suggested text is shown in italics below. Required additional information is shown in brackets.

To control reactor pressure vessel head lifts, [name of plant] procedures are used to control the lift and replacement of the reactor pressure vessel head. These procedures establish load height, load weight, and medium present under the load. These procedures: (1) use the guidance and acceptance criteria in NEI 08-05 [state references to the analysis]; and (2) provide additional assurance that the core will remain covered and cooled in the event of a postulated reactor pressure vessel head drop.

If a crane equipped with single-failure-proof features or equivalent is being used to support lifts of the RPVH, describe the design elements needed to make the single failure proof crane or equivalent description complete and accurate.

X.4.3 Cranes Equipped With Single-Failure-Proof Features for Spent Fuel Casks

For the spent fuel casks, either describe the design elements needed to make the crane description complete and accurate, or describe the assumptions used in the spent fuel cask drop analysis.

X.5 Safety Evaluation

Provide a clear basis for the site's conclusion that critical lifts are handled safely.

1. Controls implemented by ASME NML-1 make the risk of a load drop very unlikely.

AND

2. In the event of a postulated load drop, the consequences are acceptable, as demonstrated by the load drop analysis. Restrictions on load height, load weight, and medium under the load are reflected in plant procedures.

OR

1. The use of a crane equipped with single-failure-proof features or equivalent makes the risk of a load drop extremely unlikely and acceptably low.

AND

2. The risk associated with critical lifts is evaluated and controlled by facility procedures.

GENERAL NOTE: This suggested format and content is adapted from NEI 08-05, Section 4.3.

NONMANDATORY APPENDIX C

EXAMPLES OF LIFT CLASSIFICATIONS

C-1 INTRODUCTION

The information in this Appendix is provided to aid the user in determining the classification of a lift based on the risk factors and possible consequences listed, respectively, in [Tables 2-2.2-1](#) and [2-2.2-2](#).

C-2 EXAMPLES

C-2.1 Example 1

(a) *Lift Description.* An overhead crane is being used to lift a reactor head weighing 94% of the crane's rated load. The head is connected to the crane hook by means of a vendor-supplied lift device.

(b) *Applicable Factors From [Table 2-2.2-1](#)*

(1) Risk factor: Lift is performed using a below-the-hook lifting device — Moderate.

(2) Probability rating of the lift: Moderate.

(c) *Applicable Factors From [Table 2-2.2-2](#)*

(1) Possible consequences and their related severity ratings

(-a) destruction of a high value item — High

(-b) destruction of a long-lead procurement item — High

(-c) release of radioactive material exceeding the limited specified in 10 C.F.R. Part 100 — High

(-d) reconfiguration of the fuel such that k_{eff} is larger than 0.95 — High

(-e) water leakage that uncovers irradiated fuel — High

(2) Severity rating of the lift: High Plus

(d) *Classification.* This lift is a nuclear safety critical lift (by definition) (see [Figure C-2.1-1](#)). This exercise validates the extreme consequences associated with a nuclear safety critical lift.

Figure C-2.1-1
Example 1: Nuclear Safety Critical Lift

