NEI Reactor Head Lift Single Failure Proof Crane Equivalence

Introduction

The industry initiative on Control of Heavy Load Lifts provides the alternative of having a “single failure proof crane” in performing reactor vessel head lifts and spent fuel cask lifts over the spent fuel pool. This section of NEI 08-05 provides industry guidance for determining single failure proof equivalence for cranes for the limited purpose of lifting the reactor vessel head. It does not apply to the lifting or movement of spent fuel casks over the spent fuel pool. It also does not apply to new cranes being ordered for new construction plants.

Purpose and Historical Background

Generic Letter 80-113 (supplemented later by Generic Letter 81-07) provided the methodology for addressing Single Failure Proof Handling Systems; see Attachment 1 of enclosure 3. Item 2 of Attachment 1 asked for a detailed point-by-point comparison of the crane in question to NUREG 0554, Single Failure Proof Cranes for Nuclear Power Plants. Some utilities submitted Phase II responses that included this comparison. For any gaps found in those NUREG 0554 comparisons, the equivalence measures provided by this guidance document can be used to fill those gaps and allow for a reactor head lift in accordance with the Heavy Loads Initiative.

For those utilities that did not pursue the Single-Failure-Proof option with their Phase II responses or were licensed after Generic Letter 85-11, the equivalence measures provided by this guidance document may be applied to a reactor head lift if the crane used to make the lift is equipped with certain safety features and also has key supporting documentation. The minimum safety features are as follows:

- Master Switches with Spring Return to Off Feature
- Cab Mounted Emergency Stop Button
- Two Holding Brakes
- Two Upper Limit Switches (Second Upper Limit shall be a Power Disconnect)
- Overspeed Sensor/Circuit

The key supporting documentation includes the following:

- Calculation to show the crane is capable of holding the load during a Safe Shutdown Earthquake or an Event Frequency Calculation to show that the frequency, based on return period of SSE and time the load is over the reactor vessel, is <1E-6
- Calculation to show the Crane meets the CMAA #70-1975 allowable stresses for the bridge, end trucks, and trolley structural components

- Calculation which shows the Design Rated Load of the crane is approximately 15% higher than the Maximum Critical Load (in this case, the head lift) lifted by the crane
- For cranes with a single-hoist drive unit (ASME NOG-1, Figure 5416.1-1), a calculation that documents the gearing meets the design standards of the American Gear Manufacturers Association (AGMA) as referenced in CMAA #70-1975, including the Crane Service Factors therein
- Calculation that determines the Factor of Safety on the Wire Rope for the head lift. Factor is determined by multiplying catalog breaking strength of rope by the number of parts of line and dividing by MCL rating plus weight of block:

$$\mathrm{FS} = \frac{\text{Rope Breaking Strength} \times \text{Parts of Line}}{\text{MCL Rating} + \text{Weight of Load Block}}$$

With these minimum features, the supporting documentation, and the inclusion of the additional control measures described in this guidance document, **the lifting of the reactor head can be made in accordance with the Heavy Loads Initiative**.

The lifting devices used below the hook to make the reactor head lift are required to meet the Phase I requirements as delineated in NUREG 0612, Section 5.1.1.(4).

Guideline Methodology

The NEI Single Failure Proof Crane Equivalence subgroup reviewed Appendix C of NUREG-0612, Modification of Existing Cranes. This appendix references NUREG-0554 and summarizes the single failure proof guidelines in ten specific areas. The appendix states that, “In the case of a new crane, all the recommendations contained in NUREG-0554 should be followed; however, in the case of an existing crane that is to be upgraded to the guidelines of Section 5.1.6, space economies for the crane may not allow ready application of all the safety features to the crane. Additionally application of certain other features may not be practical since they would require replacement of certain components whose adequacy can be verified by alternative measures. Thus, certain adjustments may be necessary to compensate for those features that will not be included.” The appendix then provides some examples of alternative approaches.

The subgroup reviewed section 5.1.6, Single-Failure-Proof Handling Systems of NUREG-0612 which states that the purpose of a crane upgrade is “to improve the reliability of the handling system through increased factors of safety and through redundancy or duality in certain active components.”

The subgroup also reviewed Generic Letter 85-11, Completion of Phase II of “Control of Heavy Loads at Nuclear Power Plants” NUREG-0612, dated June 28, 1985. The team noted the NRC determined that upgrading cranes to single failure proof was not cost beneficial, and that the Phase I activities had significantly reduced the risk of drops of heavy loads such that Phase II actions were not required.

Given the regulatory bases described above, the subgroup evaluated the ten specific areas listed in Appendix C of NUREG-0612 to determine **what reasonable measures could be taken by plants to achieve an equivalent single failure proof crane.**

Table 1 summarizes the ten key crane design and hardware equivalency guidelines. The "Bases" column designates whether equivalent measures are permitted under the industry initiative. An "E" indicates the equivalency measure is acceptable; an "MR" indicates the crane must meet the Design/Hardware requirement. The hardware requirements of Table 1 are the minimum safety features needed to achieve single-failure-proof equivalence.

Table 1 Crane Equivalency Guidelines - Design/Hardware Requirements

Equivalency Guideline	Design/Hardware Requirement	Bases
(9) Operator Error	Master Switches with Spring Return to Off Feature Cab Mounted Emergency Stop Button	MR MR
(6) Load Hang-Up Overspeed	Overload Sensor/Circuit Overspeed Sensor/Circuit	E MR
(7) Two-Block	Two Upper Limit Switches (Second Upper Limit shall be a Power Disconnect)	MR
(5) Wire Rope	Dual Wire Ropes	E
(4) Control Design	Master Switches with Spring Return to Off Feature Cab Mounted Emergency Stop Button Two Holding Brakes	MR MR MR
(1) Stress Limits	CMAA 70-1975 Stress Limits	MR
(3) Earthquake	Calculation for SSE with MCL	E
(2) Material	Toughness Properties Known and T_{min} Established	E
(10) Material	Cold-Proof Test	E
(8) Drum	Drum Safety Plates	E

Equivalence

Table 1 indicates whether equivalent measures are available for **the crane lifting the reactor vessel head.** Implementation of the equivalent measures is described in Table 2, which lists the Equivalency Guideline, the key safety issue being addressed, and the equivalent measures required to satisfy the industry initiative. Table 2 lists the safety issues in order of significance, where significance means the most likely cause of crane failure, and the area of greatest gain in reducing the risk of crane failure and load drop. The three most significant safety issues are operator errors, load hang-up, and two-blocking. These "operational" safety issues are also the likely cause of structural challenges to the crane. The remaining seven safety issues require additional safety measures or higher factors of safety which are designed to mitigate the destructive effects of an operational safety event. These seven safety issues are areas of lower probability of failure and are not listed in any order of significance.

The subgroup believes that the objective of the single failure proof crane equivalence can be achieved by reasonable, cost-effective preventive measures for the first three safety issues. These are the first barrier to failure and can be considered preventive measures because if successful, they prevent the high levels of stress that the next seven safety issues are designed to mitigate.

Table 2 Crane Equivalency Matrix

Equivalency Guideline	Safety Issue	Equivalence Measures	Significance
(9) Safety devices such as limit switches provided to reduce the likelihood of a malfunction should be in addition to those normally provided for control of maloperation or operator error.	Prevention of Operator Based Errors	**Crane used to lift Reactor Head:** • Shall be equipped with Master Switches with Spring Return to Off Feature and • Shall be equipped with a Cab Mounted Emergency Stop Button (ESB) within reach of a Crane Operator. This ESB must be separate or unique from a radio or cab operated control switch and • Performance of a Pre-Operational Check[1] **Lifting of Reactor Head shall have the following administrative controls in place:** • 3-Way Direct Communications established between Crane Operator, Person-in-Charge, and Signal Person via headsets and • Second Crane Operator placed in cab of crane, or the most effective location, to act as an observer/ spotter unless the crane is equipped with floor mounted ESBs that are manned during lift performance and • Backup Emergency Stop Signal such as an air horn (pre-tested) provided in case of loss of direct communication and • Pre-Job Brief performed that includes identification of Supervisory Oversight, Establishment of Lift Management Protocol, Acceptable Travel Limits of Crane, Verification of ESB Locations, and Manning of ESBs. and • Maintenance Rule (a)(4) Measures addressed in Outage Safety Plan	High - 1

Equivalency Guideline	Safety Issue	Equivalence Measures	Significance
(6) Sensing devices should be included in the hoisting system to detect such items as overspeed, overload, and overtravel and cause the hoisting action to stop when limits are exceeded.	Elimination of Load Hang-up / Overspeed Type Events	**Crane used to lift Reactor Head:** • Shall Be Equipped with an Overload Sensor/Circuit[2] **OR** • Have a Load Cell / Load Pin provided either on Crane or as part of Lift Rig and • An Individual designated to Observe Load Cell and Confirm Load is less than the weight allowed by plant procedures. Observations shall continue until lift has cleared all potential hang-up points **OR** • Spotters placed at critical locations to monitor lift and observe potential binding and • Spotters equipped with a means of transmitting an emergency stop signal and • Floor mounted ESB's that are manned during lift **Crane used to lift Reactor Head:** • Shall be Equipped with an Overspeed Sensor/Circuit[3] and • Shall have a Pre-Lift Check[1] prior to the lift	High - 2
(7) The reeving system should be designed against the destructive effects of two-blocking.	Elimination of a Two-Block Event	**Crane used to lift Reactor Head:** • Shall be equipped with Two Upper Limit Switches (Second Upper Limit shall be a Power Disconnect)[4] and • Upper Limit Switches must be checked during the station specific crane inspection program in accordance with the requirements of ANSI B30.2-1976. and • Second Crane Operator placed in cab of crane, or the most effective location, to act as an observer/ spotter	High - 3

Equivalency Guideline	Safety Issue	Equivalence Measures	Significance
(5) Design of the wire rope reeving system should include dual wire ropes. Note: Dual wire ropes means the hoist is equipped with redundant reeved wire ropes.	Dual Wire Rope[5]	**Crane used to lift Reactor Head:** • When equipped with a single wire rope, shall have a calculation that shows the wire rope factor of safety for the MCL is 10:1 or greater **OR** • When equipped with dual wire ropes, shall have a calculation that shows the wire rope factor of safety for the MCL is 5:1 or greater on each of the wire ropes **OR** • When equipped with a single wire rope, shall have a calculation that shows the wire rope factor of safety for the MCL is 5:1 and less than 10:1 and • Shall have the wire rope inspected prior to the lift with the maximum allowance for broken wires being - o For running ropes, six randomly distributed broken wires in one lay or two broken wires in one strand in one lay. o For rotation-resistant ropes, two randomly distributed broken wires in twelve rope diameters or four randomly distributed broken wires in sixty rope diameters and • Perform a 5 minute hold of the load after the initial lift is made. (Full expected weight of the head. It is important to get the full weight. Once the lift is made, it may take several more inches to ensure the head is full up.)	Low

Equivalency Guideline	Safety Issue	Equivalence Measures	Significance
(4) Automatic controls and limiting devices should be designed so that component or system malfunction will not prevent the crane from stopping and holding the load safely.	Control Design	**Crane used to lift Reactor Head:** • Shall be equipped with a Cab Mounted Emergency Stop Button within reach of the Crane Operator. This ESB must be separate or unique from a radio or cab operated control switch. and • Shall be equipped with Master Switches with Spring Return to Off Feature and • Shall be equipped with two Holding Brakes[6] and • If equipped with Electric Holding Brakes, ensure the design does not release the brake after restoration of power from the loss of power event	Low
(1) The allowable stress limits should be identified and be conservative enough to prevent permanent deformation of the individual structural members when exposed to maximum load lifts.	Stress Limits	**The crane used to lift Reactor Head shall have:** • A calculation to show the crane meets the CMAA #70-1975 allowable stresses for the bridge, end trucks, and trolley structural components (NUREG 612 Section 5.1.1(7) page 5-4) and • A calculation which shows the design rated load of the crane is approximately 15% higher than the maximum critical load lifted by the crane[7] and • For cranes with a single-hoist drive unit (ASME NOG-1, Figure 5416.1-1), a calculation that documents the gearing meets the design standards of the American Gear Manufacturers Association (AGMA) as referenced in CMAA #70-1975, including the Crane Service Factors therein	Low

Equivalency Guideline	Safety Issue	Equivalence Measures	Significance
(3) The crane should be capable of stopping and holding the load during a seismic event equal to a Safe Shutdown Earthquake (SSE) applicable to that facility.	Earthquake	**Crane used to lift Reactor Head:** • Shall have a calculation to show the crane is capable of holding the load during an SSE **OR** • Shall have an Event Frequency Calculation to show that the frequency, based on return period of SSE and time the load is over the reactor vessel, is <1E-6.[8]	Low
(2) The minimum operating temperature of the crane should be determined from the toughness properties of the structural material and that are stressed by the lifting of the load.	T_{min} for Operation	**Crane used to lift Reactor Head:** • Shall have a cold-proof load test **OR** • Shall be operated in an environment where the ambient temperature in the vicinity of the crane is at least 70° F or greater (Verify prior to lift)[9]	Low
(10) The crane system should be given a cold proof test if material toughness properties are not known	T_{min} for Operation	**Crane used to lift Reactor Head:** • Shall have a cold-proof load test **Or** • Shall be operated in an environment where the ambient temperature in the vicinity of the crane is at least 70° F or greater (Verify prior to lift)[9]	Low
(8) The hoisting drum(s) should be protected against dropping should its shafts or bearings fail.	Drum Safety Plates[5]	**Crane used to lift Reactor Head:** • Ensure all credible failure modes have been eliminated by the use of measures outlined above[10] and • Inspect drum bearings before lift as part of the station equivalent of an ASME B30.2-1976 Periodic Inspection of the Crane	Low

[1] Crane Inspections are defined as follows:

- Pre-Operational Check - Station specific inspection program in accordance with the requirements of ANSI B30.2-1976 performed at the start of the refueling outage. This inspection must include a detailed inspection of the wire rope (for cranes with a single wire rope and FS between 5:1 and 10:1, see Equivalency Guidance Item 5 for inspection criteria) and drive train. All safety functions included on the crane (limit switches, overspeed, overload, etc) must be verified as functional during this inspection.
- Pre-Lift Check - Prior to the lifting of the reactor head, another functional check of the crane safety features and braking systems shall be performed.

[2] Overload Circuit - If the hoist used to lift the reactor head is equipped with an overload circuit, the overload circuit must meet the following requirements:

- Switch shall trip when the load on the hook exceeds 125% of the design rated load.
- Operation of the overload trip switch shall remove power from the hoisting motor and cause all holding brakes to set.
- Require manual reset.

[3] Overspeed Circuit - The hoist used to lift the reactor head must have an overspeed circuit which meets the following requirements:

- Switch shall trip when the hook lowering speed exceeds 115% to 125% of the design rated load lowering speed.
- Actuation of the overspeed trip switch shall cause all holding brakes to set.
- Require manual reset.

[4] Second Upper Limit Switch - This needs to be done via contactor for Variable Frequency Drive (VFD) equipped cranes. When utilized with VFDs, the utilization of power limit switches must be applied such that the “T” leads are not broken between the drive and the motor. As the “T” leads open, the VFD may fail the internal secondary power devices as the voltage spikes.

[5] Significant modifications may be necessary in order to add redundant reeving or drum restraints to an existing hoist

[6] Holding Brake - The hoist used to lift the reactor head must have a holding brake system which meets the following requirements:

- Two independent holding brakes are required.
- For cranes equipped with a single-hoist drive unit, the holding brakes shall be mounted on opposite sides of the gearbox or so arranged that a single coupling or high-speed shaft failure does not de-couple both brakes from the gearbox.
- For cranes equipped with dual (redundant) hoist drive units (single drum), each gearbox shall be equipped with a holding brake.
- The holding brakes on hoists shall be applied automatically when power is removed from the hoist
- A brake which acts directly on the wire rope drum or its shaft is considered a holding brake.

[7] For cranes with a margin greater than 8% and less than 15%, the design of the crane must be equivalent to CMAA Class C (Moderate Service) or higher (Polar Crane usage is equivalent to CMAA Class A1 or Standby Service). For those cranes with margins of 8% or less, the design of the crane must be equivalent to CMAA Class D or higher.

[8] Event Frequency Calculation: The SSE for the newer plants with RG 1.165 would show that the SSE centers around the 10^{-5} return period and the upper bound is about the 10^{-4}. That was for the 5 Hz and 10 Hz type frequencies. There is currently work underway to evaluate new seismic hazard information relative to high frequency accelerations. This could drive the numbers somewhat higher when completed.

For the purpose of this calculation use either a plant specific SSE frequency, or 1E-3 as default. If this is assumed, the event frequency calculation would be:

(1E-3) X (hours reactor vessel head is above the vessel (lifting and replacing)/ approximate hours between refuelings)

Examples:

Hrs Head is above vessel	Event Frequency	
Months between cycles	18	24
Two	1.52E-7	1.14E-7
Four	3.04E-7	2.28E-7

Note: This is an approximate calculation. It is NOT required to measure actual times the head is above the vessel during actual head movement. The approximate time above the vessel is based on experience and procedures. If procedures or experience changes such that the time above the vessel increases significantly, a recalculation would be appropriate.

[9] Minimum Ambient Temperature - In lieu of a 70° F minimum temperature, test coupons may be taken from the primary load-bearing crane structural members (e.g. bridge girders, trolley structure, upper and lower block frames) to allow for Charpy V-Notch Impact Testing. The results of this testing may allow the establishment of a lower minimum operating temperature. (The Quad Cities Station successfully lowered their minimum operating temperature through such testing.)

[10] Failure modes – The credible failure mode is overload which includes load hang-up and two-block. The load hang-up and two-block events are addressed by other design features or equivalence measures.

Equivalence Examples

Table 3 and Table 4 provide examples of how the equivalence measures can be used to show that a reactor lift meets the intent of the Heavy Loads Initiative.

Crane Originally Evaluated for NUREG 0612 Phase II

The Table 3 example is for a crane that was evaluated as part of the Phase II response to NUREG 0612. This evaluation consisted of a point-by-point comparison to NUREG 0554. The results of the point-by-point comparison indicated the crane did not meet NUREG 0554 in two areas. These were:

1. No fracture toughness properties known or a cold proof test performed
2. Dual wire-rope with a FS less than 10:1

Attachment C of NUREG 0612 provided the utility with an alternative to performing the cold proof test. However, a hardware modification was required to address item 2. With the issuance of GL 85-11, any planned hardware modifications to correct item 2 were deemed as no longer required.

As a result of the Heavy Loads Initiative, the utility has taken another look at the original Phase II point-by-point comparison. This guidance document provides equivalency measures that address both of these areas. Table 3 shows how the point-by-point comparison was revised to take credit for these equivalency measures. After updating the point-by-point comparison using the equivalency measures, the comparison was documented in accordance with station procedures.

Crane Never Evaluated for NUREG 0612 Phase II

The Table 4 example represents a crane that was NOT evaluated as part of the Phase II response to NUREG 0612. Thus, there is not point-by-point comparison to NUREG 0554.

As a result of the Heavy Loads Initiative, the utility has reviewed the crane design and existing documentation. Based upon this review and the equivalency measures provided by this guidance document, the utility has determined that pursuing a single-failure-proof equivalency for this crane is the best approach for the reactor head lift. To show single-failure-proof equivalency, the utility developed a step-by-step plan which describes the crane action being performed, the safety issue(s) that apply to the crane action, and the checks and controls taken to address the safety issue(s). These checks and controls are based upon the equivalence measures provided by Table 2.

In the Table 4 example, the crane used to make the lift has the following design features:

- No fracture toughness properties known or a cold proof test performed
- A single wire-rope with a FS between 5 and 10
- Master Switches with Spring Return to Off Feature
- Two Upper Limit Switches (Second Upper Limit is a Power Disconnect)
- A Cab Mounted Emergency stop button within reach of the operator
- Two holding brakes
- Overspeed Sensor/Circuit
- No floor mounted emergency stop buttons
- No Overload Sensor/Circuit
- Event Probability Calculation used to show the likelihood of an SSE earthquake is sufficiently low while the lift is being performed

A general description of the lift is as follows:

> Initially, in the first several feet of movement, directly above the flange, the major concern is whether the load has hung-up. If there is to be a hang-up, it is most likely to be observed in the first movement of the head. As shown in Table 4 checks are put into place to determine if load hang-up is occurring. Once the initial lift has been completed and it is known that the head is physically off the flange, then the lift continues vertically until the guide studs are cleared. During this stage there is concern over hang-up and binding of the head and the guide studs. After the guide studs are cleared, the head can be raised to an elevation that will allow movement to the head stand. The head could also be moved laterally away from the reactor vessel once the guide studs are cleared and then the raising completed. The final concern is the potential of a two-block event at the high point of the lift. The redundant upper limit switches are in place to prevent this event.
>
> Reinstallation of the head first presents the two-block concern as the head is lifted off the stand. Once the head has been moved back over the vessel, then the potential for load binding develops as the head is lowered to the guide studs. Once again, Table 4 indicates the measures in-place to protect the lift from this event.

The completed lift plan was documented in accordance with station procedures.

Table 3 Example of a NUREG 0554 Comparison using the NEI Guidance Document

NUREG 0554 REQUIREMENT	RESPONSE	BASIS/ACTIONS REQUIRED
2.4 Material Properties		
2.4.1 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.	Crane was not been cold proof tested and no fracture toughness properties are known. *In lieu of a cold-proof test, a minimum operating temperature of 70° is established per the guidance document for the Heavy Loads Initiative, NEI 08-05. WBN Procedure MI-68.001 will be revised to require verification of ambient air temperature in Upper Containment of above 70°F prior to the performance of the MCL.*	NEI Guidance Document 08-05 MI-68.001
Several sections omitted for simplicity		
4. Hoisting Machinery 4.1 Reeving System		
4.1.1 Design of the rope reeving system(s) should be dual with each system providing separately the load balance on the head and load blocks through the configuration of ropes and rope equalizer(s).	Dual reeving and equalizing systems are used for the main and auxiliary hoists. Load balancing through cross-reeving is achieved for both hoists.	Contract 75K38-86129 TVA Specification 2212, WB-DC-20-4
4.1.2 The maximum load (including static and inertia forces) on each individual wire rope in the dual reeving system with the MCL attached should not exceed 10% of the manufacturer's published breaking strength.	The factor of safety for the wire rope on the main hook is 8.57:1 for the MCL of 160 tons. This does not meet the minimum factor of safety of 10. *Based upon the guidance document for the Heavy Loads Initiative, NEI 08-05, for a hoist equipped with dual wire ropes, the minimum factor of safety must be 5:1. Therefore, 8.57:1 is considered equivalent.*	NEI Guidance Document 08-05 Supplemental Calculations (Attachment B)

Table 4 - Performance of a Reactor Head Lift with an Equivalent Single-Failure-Proof Crane

Crane Action	Safety Issue	Check/Control
Head Removal		
Pre-Lift Activities		• Pre-Operational Inspection Performed at the start of refueling outage • Maintenance Rule (a)(4) measures addressed in Outage Safety Plan • Pre-Job Brief performed that includes identification of Supervisory Oversight, acceptable travel limits of crane, and establishment of Lift Management Protocol for entire lift • Backup Emergency Stop Signal such as an air horn (pre-tested) provided in case of loss of direct communication • Second Crane Operator placed in cab of crane, or the most effective location, to act as an observer/ spotter for the duration of the lift • 3-Way Direct Communications between Crane Operator, Person-in-Charge, and Signal Person via headsets (batteries refreshed in all radios) established and maintained for entire duration of lift • Load Cell check out complete with Individual to monitor load cell in place • Verified ambient air temperature is greater than 70° F • Pre-lift inspection performed just prior to lift
Initial Lift - From Flange to 24" above Flange	• Operator Error • Load Hang-Up	• Load Cell monitored (Person monitoring load cell is equipped with emergency stop signal) • 5 minute hold of the load performed after the initial lift is made to verify brakes and wire rope • Weight of head checked against station procedures • Perform visual inspections once the head is free to ensure only the head is being lifted
Raise Head Until Clear of Guide Studs - 168" to 240" above Flange	• Operator Error • Load Hang-up	• Verify load moving • Continue monitoring of load cell • Raise head at a minimum slow speed[1] • Individuals stationed to observe for head binding on guide studs •
Complete Upward Movement	• Operator Error • Two-Block Event	• Two Upper Limit Switches (Second Upper Limit shall be a Power Disconnect) • Master Switches with Spring Return to Off Feature • Two Holding Brakes
Translate to Stand	• Operator Error • Trolley Brake Failure • Bridge Brake Failure	• Trolley and Bridge movements maintained within safe load paths • Trolley and Bridge speeds minimized to eliminate load swings
Lower to Stand	• Operator Error • Hoist Brake Failure	• Two Holding Brakes

Head Installation		
Pre-Lift Activities		• Pre-Job Brief performed that includes identification of Supervisory Oversight, acceptable travel limits of crane, and establishment of Lift Management Protocol for entire lift • Backup Emergency Stop Signal such as an air horn (pre-tested) provided in case of loss of direct communication • Second Crane Operator placed in cab of crane, or the most effective location, to act as an observer/ spotter for the duration of the lift • 3-Way Direct Communications between Crane Operator, Person-in-Charge, and Signal Person via headsets (batteries refreshed in all radios) established and maintained for entire duration of lift • Load Cell check out complete with Individual to monitor load cell in place • Verified ambient air temperature is greater than 70° F • Pre-lift inspection performed just prior to lift
Initial Lift	• Operator Error • Hoist Brake Failure	• Load Cell monitored (Person monitoring load cell is equipped with emergency stop signal) • 5 minute hold of the load performed after the initial lift is made to verify brakes and wire rope • Two Holding Brakes
Translate to Vessel	• Operator Error • Trolley Brake Failure • Bridge Brake Failure	• Trolley and Bridge movements maintained within safe load paths • Trolley and Bridge speeds minimized to eliminate load swings
Lower to Guide Studs	• Operator Error • Hoist Brake Failure	• Personnel placed in key locations to perform visual observations • Two Holding Brakes • Perform close observation of the head orientation because as the wire rope reeves out, the head may tend to rotate. Slight movements in rotation of the hook, and/or bridge may be needed to compensate • Upon reaching the tapered portion of the guide studs, additional adjustments may be needed before proceeding to the straight portion of the guide stud
Lower to Flange	• Operator Error • Hoist Brake Failure • Load Hang-Up	• Two Holding Brakes to control lowering • Check that a near equal gap exists around all the guide studs • No Trolley or Bridge movements allowed once aligned with the guide studs • Load Cell monitored (Person monitoring load cell is equipped with emergency stop signal)

[1] Minimum slow speed is defined as a speed that does not create overheating of the motors or other challenges to the drive system. The speed should be as slow as is practical.

Use of the Equivalence Methodology

Establishment of a single-failure-proof crane or the equivalent of a single-failure-proof crane can be performed using one of two methods. As described earlier, these methods are:

Point-by-point comparison - This may have been performed as part of a station's Phase II submittal and may have resulted in the identification of several gaps. The station could choose to do modifications to close those gaps or use the equivalence measures outlined in this guidance document as shown in Table 3. In either case, documentation should be developed in accordance with station procedures. This documentation would be available for inspection upon request.

Equivalence Evaluation - If the point-by-point comparison was not made by the station, then the station may choose to perform an equivalence evaluation. This would require the station to review the design of the crane to determine if the minimum hardware requirements and documentation requirements listed earlier have been provided. If the crane does have the minimum hardware and documentation requirements, then the station should develop a Lift Plan similar to Table 4 to describe the additional measures to be taken during the head lift. These additional measures must be based upon the guidance of Table 2. The design features and the Lift Plan must also be documented in accordance with station procedures. This documentation would be available for inspection upon request.

Conclusion

The use of a single-failure-proof or equivalent single-failure-proof crane provides a cost-effective alternative to performing the load drop analysis needed to meet the Heavy Loads Initiative. Most of the measures outlined in the guidance document are already performed by stations when the reactor head lifts are made. Any additional measures or modifications are expected to have minimal cost and schedule impact. The result is a reactor head lift that is performed safely and efficiently.

References

NRC Staff Report NUREG 0554, Single-Failure-Proof Cranes for Nuclear Power Plants

NRC Staff Report NUREG 0612, Control of Heavy Loads at Nuclear Power Plants

NRC Letter Dated December 22, 1980, Control of Heavy Loads (Later identified as GL 80-113)

NRC Generic Letter 81-07, Dated February 3, 1981, Control of Heavy Loads

NRC Generic Letter 85-11, Dated June 28, 1985, Completion of Phase II of "Control of Heavy Loads at Nuclear Power Plants" NUREG-0612

Crane Manufacturers Association of America Specification #70, 1975 Edition

American Society of Mechanical Engineers Specification NOG – 1, Rules for Construction of Overhead and Gantry Cranes (Top Running Bridge, Multiple Girder), 2004 Edition

American Society of Mechanical Engineers Specification B30.2, Overhead and Gantry Cranes (Top Running Bridge, Single or Multiple Girder, Top Running Trolley Hoist), 1976 and 2005 Editions