An Approach for Evaluating Heavy Load Lifts and Related Maintenance Tasks in Maintenance Rule (a)(4) Risk Evaluations

EPRI Configuration Risk Management Forum – 2008 Research Task

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PRODUCT DESCRIPTION

This report describes research that addresses the configuration risk assessment and management of risk associated with the lifting of heavy loads. A graded analysis methodology is presented in which nuclear plant operators can assess the potential impacts of heavy load lifts to meet requirements of Section (a)(4) of the Maintenance Rule (10CFR50.65).

Results and Findings

This report describes an integrated, graded approach to evaluate the risk impact of heavy load activities within plant Maintenance Rule (a)(4) configuration risk management programs. The process was developed using input from utility risk assessment managers and validated through tabletop evaluations conducted at several operating nuclear power plants.

Challenges and Objectives

This report provides guidance concerning the consideration of lift and movement activities as part of a plant's Maintenance Rule (a)(4) program. The approach assumes that the heavy load lifts and movements will be assessed as part of the existing plant Maintenance Rule (a)(4) program, using similar processes as are used for other plant configuration changes. In most instances, it should be possible to use a screening approach to focus detailed risk assessment activities only on those planned lifts that could cause a transient if a load drop were to occur. This screening approach should limit the burden for Maintenance Rule (a)(4) risk assessment personnel so that load drop-specific assessments would be performed on only the small fraction of lift activities with the potential for significant impact on nuclear safety risk.

Application, Value, and Use

The process to evaluate the risk impact of heavy load lifts specified in this report will provide nuclear power plant operators with a structured, graded approach to assess these risks in a manner that meets regulatory expectations with minimal resource burden. The graded approach described also supports enhanced configuration risk management and nuclear safety by focusing resources on those relatively few lift activities that could lead to significant effects should a drop event occur.

EPRI Perspective

Configuration risk management is a cornerstone in ensuring both safe and economical operation of commercial nuclear power plants. The potential for large loads to cause damage to plant equipment as a result of incidents during the lifting and movement process has been recognized for many years. However, at many plants, activities to manage the safety risks associated with heavy loads have been considered to be separate from the plant configuration risk management program. This report provides an approach that can be used by utilities to evaluate the risk impact of heavy load activities and to integrate these evaluations into their plant Maintenance Rule (a)(4) configuration risk management programs.

Approach

The process described in this report uses the existing plant Maintenance Rule (a)(4) program to evaluate the potential risk impact of heavy load lifts and movements on nuclear power plant safety risk. The approach uses a screening methodology to identify those heavy load lifts and

movements that require further risk assessment; those lifts and movements that screen out can be handled under the plant's normal work practices and existing administrative controls, and no further risk assessment is necessary. For those lifts and movements that require additional evaluation, guidance is provided for assessing the conditional risk associated with a potential drop event.

Keywords

Configuration risk management
Heavy loads
Maintenance Rule

ABSTRACT

The lifting and movement of plant equipment, materials, and other items occurs frequently at nuclear power plants, particular during refueling outages. The potential for large loads to cause damage to plant equipment as a result of incidents during the lifting and movement process has been recognized for many years. At many plants, the required activities to manage risk due to heavy loads has been considered to be separate from the plant configuration risk management program used to address section (a)(4) of the Maintenance Rule. Recent NRC / industry discussions have highlighted the fact that heavy load lifts need to be considered as a potential source of risk during maintenance activities. This report provides an approach that may be used by utilities to evaluate the risk impact of heavy loads activities within their plant (a)(4) configuration risk management program. The process was developed using input from utility risk assessment managers and validated via tabletop evaluations conducted at several operating nuclear power plants.

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1
INTRODUCTION

1.1 Background

The lifting and movement of plant equipment, materials, and other items occurs frequently at nuclear power plants, particular during refueling outages. The potential for large loads to cause damage to plant equipment as a result of incidents during the lifting and movement process has been recognized for many years. NUREG-0612 [1] was published in 1980 and provides specific recommendations to reduce the risk of an incident due to "heavy loads" activities. NUREG-0612 defines a "heavy load" as one that is equal to or greater than the weight of a single fuel assembly plus its handling tool. For most plants, this corresponds to a load greater than 1000 to 2000 pounds.

NUREG-0612 particularly focuses on lifts associated with outage activities, such as reactor head and reactor vessel internals lifts, fuel movements, etc. Risk-reducing measures considered include the use of single failure-proof lifting devices, the performance of load drop analyses to determine the consequences of a potential load drop, and the development of load lifting procedures that provide checks of the lift device and rigging, limit lift heights and specify safe load paths to minimize the potential for damage.

Since the time of NUREG-0612's publication, the nuclear power industry has greatly expanded the use of on-line maintenance. As a result, the number of heavy load lifts / movements (as well as lifts / movements of other loads that do not qualify as "heavy loads") during plant operating ("at power") conditions has greatly increased. The Maintenance Rule (10CFR50.65) paragraph (a)(4) [2] became effective in 2000, requiring performance of a risk assessment and implementation of appropriate risk management actions prior to conduct of maintenance activities. At many plants, the NUREG-0612 required activities have been considered to be separate from the Maintenance Rule (i.e., the Heavy Loads program is considered to separately manage the risk of load drops such that explicit consideration in the Maintenance Rule processes has not been required).

The NRC further studied heavy load lift experience, as documented in NUREG-1774, "A Survey of Crane Operating Experience at US Nuclear Power Plants from 1968 to 2002" [3]. The conclusions of this report included the following:

- The rate of human-error induced load drops has increased over time. At least 70% of load drop incidents are the result of human error.
- The number of load drop events involving "below the hook" causes is significant and the number of these events has increased over time. It should be noted that "below the hook" failures can occur even if the crane mechanism itself is "single failure proof".
- The number of load drop events per year has increased substantially, even when correcting for the fact that the population of plants increased over the period of the study.

While the number of load drop events has increased, the number of events due to mobile crane activities has remained relatively constant, and has actually decreased slightly.

- The most significant events resulting from load drop incidents have been losses of offsite power. The vast majority of these events were the result of incidents using mobile cranes.
- The drop rate for very heavy loads (i.e., greater than 30 tons in weight) appears to be lower than that for less heavy loads (i.e., loads with weights between roughly 1 and 30 tons). Based on the experience data reviewed, the NUREG estimates a load drop probability of 5.6E-05 per lift for very heavy loads.

Recent NRC / industry discussions highlighted the fact that heavy load lifts need to be considered as a potential source of risk during maintenance activities. NRC issued Regulatory Issue Summary RIS 2005-25 [4] to clarify the regulator's expectations concerning heavy loads issues. Additionally, in its enforcement guidance memorandum (EGM) [5], NRC noted the requirement that all licensees "include the movement of heavy loads as a configuration management activity in administrative controls established to implement 10CFR50.65(a)(4)". An NEI Working Group recently issued a heavy loads guidance document that includes the requirement to "ensure your maintenance rule (a)(4) administrative controls include the movement of heavy loads as a configuration management activity". This guidance currently is undergoing regulatory review. However, the guidance document does not provide details on how to evaluate the risk impact of heavy loads activities within the (a)(4) program. This report provides an approach that may be used by utilities to implement this requirement.

While the most significant risk impacts may be caused by "heavy loads" and recent NRC and industry attention has been focused specifically on these loads, it is important to recognize that the potential exists for other lifting / movement activities to pose specific risks to plant safety. Recent violation notices indicate that NRC inspectors are increasingly focusing on on-line maintenance activities that involve lifting and movement of equipment regardless of weight or size in risk-sensitive areas of the plant.

1.2 Objectives

This report provides guidance concerning the consideration of lift / movement activities as part of the Maintenance Rule (a)(4) program. Load lifts occurring at-power and during shutdown are to be considered. The approaches discussed here should be equally applicable to the consideration of other lifting and movement activities that do not involve "heavy loads" but that have a potential to impact nuclear safety risk.

The focus of this guidance is to use existing processes and tools to help address the Maintenance Rule (a)(4) requirement for heavy load lifts. This guidance will primarily focus on qualitative approaches. However, a plant may choose to adopt quantitative approaches to assess and manage the risk of heavy load lifts (e.g., performing a bounding analysis that provides a quantitative estimate of risk impact or conducting quantification within the PRA model that considers the potential for a load drop incident).

In some instances, plants may have performed detailed load drop analyses to determine the expected consequences of a potential load drop. Based on these analyses, safe load paths, load limit heights, and other restrictions may already be in place for certain lift activities. It should be noted that the “safe load path analyses” performed in response to NUREG-0612 might have a somewhat different focus than the risk evaluations discussed in this document. For example, a “safe” load drop might result in a transient that is not relevant to issues addressed in NUREG-0612, which is focused primarily on events that could cause a loss of decay heat removal and damage to irradiated fuel. In cases where a safe load path analysis previously has been performed, a review of the analysis should be conducted to determine if the existing load path analyses would be adequate to be used as the basis for not requiring further (a)(4) risk evaluation.

For the purposes of this guideline, it is assumed that a plant will make use of any available analyses to help assess and manage the risk of a particular lift / movement activity. It is not required, nor is it expected, that any new load drop analyses would be performed; however, a plant may choose to do selected studies to help reduce conservatism in any risk evaluations that may be required.

1.3 Key Elements of the Technical Approach

In utilizing the guidance that is presented in this document, nuclear power plant personnel should keep in mind the following key elements that form the basis of the analysis approach presented in this report:

- Heavy load lifts / movements represent plant configuration changes that need to be considered in conjunction with other plant configuration changes such as ongoing maintenance activities and changes in system operating status.
- The approach assumes that the heavy load lifts / movements will be assessed as part of the existing plant Maintenance Rule (a)(4) program using similar processes as are used for other plant configuration changes. Typically configuration changes are assessed using Probabilistic Risk Assessment (PRA) or Defense in Depth (DID) models. It also is intended that any changes to plant risk classification (e.g. risk “color” made due to the risk evaluations of heavy load lifts / movements) are in accordance with established plant risk management guidance / practices and are commensurate with similar changes made for evaluations of other risks.
- The approach utilizes a screening methodology to identify those heavy load lifts / movements that require further risk assessment; those lifts / movements that screen out can be handled under the plant’s normal work practices and existing administrative controls and no further risk assessment is necessary.
- Load drops represent conditional risks to plant safety, and the likelihood of a particular load being dropped is very low. As such, a risk evaluation (particularly those using qualitative methods) should avoid the use of overly conservative assumptions that might unnecessarily restrict plant operations or maintenance activities.

2

POTENTIAL RISK SIGNIFICANCE OF A LOAD LIFT / MOVEMENT INCIDENT

The process that is outlined here constitutes an approach to perform a Maintenance Rule (a)(4) risk assessment of heavy load lifts. A multi-phase approach is described in this section (and in more detail in Section 3), which begins with a screening evaluation and progresses, if needed, to more detailed qualitative or quantitative assessments. If a lift activity screens out using the guidance presented here, no further (a)(4) evaluation of that activity needs to be performed (i.e., (a)(4) requirements have been addressed).

2.1 Potential Risk Impacts of Load Lifts and Movements

A load drop incident could impact the plant in one of two ways: the drop incident might trigger a plant transient; and / or equipment considered in the plant's PRA or defense-in-depth models might be damaged. In considering the effects of a drop incident, the following is a non-exhaustive list of possible transients that should be considered:

- A plant trip (if at power)
- Loss of offsite power or a major plant transformer
- Loss of coolant accident, LOCA (e.g., due to a drop inside primary containment)
- Loss of spent fuel pool integrity (e.g., due to a drop in the SFP area)
- Loss of heat removal – this could be a loss of the power conversion system while at power (i.e., loss of main feedwater, etc.), loss of decay heat removal while shutdown, or loss of spent fuel pool cooling (at power or while shutdown)
- Loss of key plant support systems (such as specific electrical buses, turbine or reactor building cooling water, service water, component cooling water, instrument air, important HVAC systems, etc.)
- Flooding due to damage to systems with large water inventories (e.g., circulating water, fire protection, damage to large plant tanks, etc.)

"Plant equipment damage" should be considered in the context of the specific available structures, systems, and components (SSCs) that are needed either to support current plant conditions or to mitigate a possible plant event that would be initiated by a drop incident. One example might be a potential drop event that would disable the running train of Residual Heat Removal (RHR) while the plant is in a shutdown state. While it is possible that another train of RHR might be available to provide cooling, defense-in-depth would be degraded in such a situation. As such, this event may need to be further evaluated for its risk impact. On the other hand, consider the case in which a PWR containment spray pump could be damaged by a load drop event. This pump would only be needed to mitigate the consequences of a LOCA inside containment. Assuming a load drop incident in the vicinity of the pump resulted in a transient, the incident would not cause a LOCA. The resulting transient event would not require this pump to function. Therefore, damage to this "PRA-modeled" component (or "DID component") would not impact the consequences of the potential load drop event.

Modern configuration risk management practices at nuclear power plants (NPPs) typically "protect" available trains of plant equipment when other trains or systems are out of service. In considering the potential risk impacts of load drop incidents, the evaluator should consider whether or not "protected equipment" that could be damaged by the load drop would be needed to mitigate the load drop event. In most cases, this equipment would be needed; however, if that equipment is not required for the event which would be triggered by the load drop, then its "protected" status may not be relevant to the risk evaluation.

As a first step in the process of risk assessment of heavy load lifts, it is helpful to identify the types of risk significant scenarios that could be caused by heavy load drops at a nuclear plant. In general, the following four scenarios summarize the spectrum of possible impacts.

Scenario 1 – The incident causes no transient and SSCs modeled in the PRA (or shutdown / power operation DID logic models) are not impacted.

Situations of this type could include a drop for which no damage is expected (e.g., as a result of load drop analysis), situations in which the only equipment threatened by a potential load drop is already inoperable (e.g., the load lift is in support of maintenance of the equipment that could be damaged by the load drop), and situations in which the damage that results occurs in areas of the plant that do not impact core damage risk (e.g., an incident in the radwaste building). For incidents of this type, the core damage risk impacts would be minimal (if any) and specific (a)(4) risk evaluation of a potential load drop need not be considered. As no transient is induced by the incident and no risk-important equipment is damaged, the incremental core damage probability (ICDP) and incremental large early release probability (ILERP) will clearly remain below the risk thresholds for which Risk Management Actions (RMAs) need to be considered.

Scenario 2 – The incident causes no transient, but one or more available SSCs modeled in the PRA (or shutdown / power operation DID logic) is impacted.

Situations of this type could include a drop which damages standby equipment that would be used to mitigate some types of plant transients or accidents; however, the plant does not trip (if at power) and transients that require this equipment to operate do not occur as a result of the lift event. In such situations, the plant should be able to either make repairs while the plant continues to operate, or the plant can conduct an orderly shutdown (if at power) or remain in a safe, stable state (if already shutdown) using other plant equipment. As no transient is induced, the ICDP and ILERP would most likely remain below the risk thresholds for which Risk Management Actions (RMAs) need to be considered. However, in cases where other SSCs not credited in the PRA or DID model that can provide alternate success paths are not available coincident with the heavy load lift, a plant may wish to implement specific RMAs to reduce the likelihood of loss or degradation of SSCs modeled in the PRA/DID logic caused by a heavy load drop.

Scenario 3 – The incident causes a plant transient, but no available SSCs modeled in the PRA (or shutdown / power operation DID logic) are impacted.

Incidents of this type might include events that occur in the turbine building while the plant is at power (i.e., the load drop could result in a plant trip). Another special scenario would be that in which a loss of offsite power could occur as a result of the event (e.g., a load drop incident in the switchyard or near the plant transformers which could result in loss of offsite power). In general, the risk impact of these scenarios would be due to the increased likelihood of the plant transient occurring. A particular subset of these scenarios that might have a greater risk impact would be those situations in which SSCs that are required to mitigate the transient are undergoing maintenance. For example, a load drop incident that could result in a loss of offsite power would have an even greater risk impact if one of the plant's emergency diesel generators was out of service at the time of the event.

Scenario 4 – The incident causes a plant transient and one or more available SSCs modeled in the PRA (or shutdown / power operation DID logic) to mitigate the transient are impacted.

Incidents of this type would have the greatest potential risk impact on the plant. In these scenarios, a load drop event could cause a plant transient while simultaneously disabling some equipment that might be used to mitigate the event. A particularly risk-significant subset of incidents would be those in which other SSCs credited in the PRA or DID model to mitigate the transient are simultaneously out of service. For example, one train of a mitigating system was out of service due to maintenance while the other train was damaged by the postulated load drop. Another scenario might be one train of one system is out of service and another train of a different required mitigating system is damaged by the load drop. It should be stressed that even if SSCs credited in the PRA or DID model are impacted, there may still be SSCs not credited in the PRA or DID model that can provide alternate success paths to allow for the load drop-induced transient to be mitigated successfully. Commensurate with standard risk management practices, the risk evaluation should consider the integrated impact on all available mitigating systems and specify risk management actions appropriate for the scenario.

In many instances, a load lift / movement may result in different impacts along the path by which the load travels. For example, a plant transient might be initiated only if a drop occurred along one segment of the load path. Damage to available PRA / DID-modeled SSCs might occur only along other segments of the load path. To reduce conservatism, it would be appropriate to sub-divide some lifts / movements so as to properly consider the unique risk impacts that occur along different segments of the path. However, for screening purposes, the evaluator may assume all of the potential impacts of the lift / movement could occur simultaneously; thus obtaining a conservative estimate of risk impact.

2.2 Mitigating Factors to Consider

When evaluating the risk impacts of a potential load drop incident, it is also important to consider those factors that can serve to reduce the risk of the event. In general, these factors could help to reduce the likelihood of the load drop incident occurring (i.e., initiating event frequency reduction). In considering the potential for a load drop event occurring, the following factors should be considered:

- Are the lifting device and the rigging to be used of a single failure-proof design? (Such a design reduces the likelihood that a drop incident could occur; however; human errors can still be contributors to drop risk).

- Have detailed lift-specific procedures been developed (including the independent verification of rigging and appropriate management oversight of the lift process) to ensure that the lift is performed safely? (The use of formal procedures with specific detailed guidance reduces the likelihood of an error that could result in a load drop.)

- If the load to be lifted is relatively "light", are there intervening concrete or metal structures present that would prevent damage to SSCs or limit damage only to those SSCs not protected by these structures? (Note that the determination of which loads and plant structures meet the requirements of this criteria would need to be determined by the utility, e.g., through the performance of conservative generic calculations, etc.)

Compensatory actions and other risk management actions would help keep the risk of a load drop incident to a minimum acceptable level. These most likely would need to be developed on a lift-specific basis (e.g., What type of transient could occur? What SSCs could be affected? What other SSCs are available to perform the functions of the impacted equipment? Could the lift be performed at a different time?, etc.) The development of contingency plans and other Risk Management Actions is further discussed in Section 3.3.

2.3 Considerations for Developing an Initial Screening Process for Lift Activities

The first step in determining if a given activity creates a risk impact is to have potential candidate lifts / movements identified so that personnel responsible for implementing Maintenance Rule (a)(4) requirements can perform the required risk assessments. The same process should apply to all lift activities, whether performed by utility personnel or by contractor personnel. Similarly, the process needs to function in a similar manner both for on-line maintenance activities and for tasks performed during refueling outages.

It is particularly desirable to have a simple qualitative screening process in place that work planning / scheduling personnel can use to identify those items that might require further evaluation. By screening most lifts / movements at the work planner / scheduler level, the evaluation burden for the (a)(4) personnel would be reduced.

As part of their configuration risk management / Maintenance Rule (a)(4) programs, many NPPs already have developed High Risk Evolution (HRE) procedures for various lift events that occur during outages, as well as for key on-line maintenance activities that involve significant lift activities. These HRE procedures would already contain guidance to safely perform the lift activities and would implement specific RMAs. The use of these procedures should be considered as part of the initial screening process and the RMAs that are prescribed should be credited, at least qualitatively, in the risk assessment process.

3
EVALUATION METHODOLOGY

3.1 Initial Screening for Risk-Significant Load Lifts and Movements

Figures 3-1 and 3-2 illustrate a recommended decision process to be used to assess the risk of a specific load lift / movement. Many of these decision questions could be answered by work planning / scheduling personnel, which would minimize the burden on the personnel responsible for (a)(4) evaluations and reduce the need for their involvement to those cases where detailed analysis needs to be performed. As noted in Section 2, in many instances it may be appropriate to consider potential load drop incidents that could occur at different points on the load path as separate independent segments. In such cases, the approach described here would be performed for each individual segment and the results would then be combined to assess the total risk of a potential load lift / movement. (As an alternative, the worst case result from each individual segment could be used for the entire load lift / movement activity and used to develop a conservative risk assessment and subsequent risk management actions.) Figure 3-1 illustrates the risk assessment screening process that would be used to assess potentially risk-significant lifts / movements.

The intent of this decision process is to limit the need for additional lift-specific (a)(4) risk evaluations (described in Figure 3-2) to only those situations that might result in a significant calculated risk increase (as opposed to evaluating the plant configuration without consideration of the potential for a lift-related incident). For most cases, there is no need for further evaluation, alternatively pre-determined Risk Management Actions (RMAs) could be implemented without the need to specifically evaluate the lift-related risk.

In particular, activities that fit the Scenario 1 and Scenario 2 categories described in Section 2 generally would not need to have any further evaluation performed. In the event that additional equipment credited in the PRA or DID logic is out of service at the same time, Risk Management Actions (RMAs) may need to be considered for specific situations.

Activities that fit the Scenario 3 and 4 categories may trigger a more detailed lift-specific (a)(4) risk assessment. RMAs would be implemented, as necessary, based on the results of the assessment.

Table 3-1 summarizes the assessment actions to be taken for each of the above-described scenarios.

It should be noted that a plant may use the screening flowchart presented in Figure 3-1 in an iterative fashion. For example, if a lift / movement is to be performed for which no load drop consequence analysis has been performed, the flowchart could be evaluated assuming that equipment under the load path would be damaged if a load drop were to occur. If this case results in a Scenario 1 or Scenario 2 outcome (i.e., no lift-specific (a)(4) risk evaluation required), then any appropriate RMAs would be implemented as necessary. If, however, the case results in a Scenario 3 or Scenario 4 outcome, then the plant staff could decide whether it would be possible to perform a consequence analysis (or to modify the load path or other characteristics so that an existing consequence analysis is bounding) to determine the actual expected impacts of an incident instead of performing an (a)(4) risk evaluation. The flowchart would then be used again, based on the information obtained from the consequence analysis. If the flowchart logic now indicates that a Scenario 1 or Scenario 2 outcome would result (or another outcome that only requires the application of RMAs), then a detailed (a)(4) risk evaluation would not need to be performed.

Figure 3-2 shows how a detailed (a)(4) risk assessment would be performed, in the event that one is necessary. Because the lift / movement creates only a conditional likelihood of an event, it is important not to assign an overly conservative risk result (e.g., heightened risk colors) solely on the basis of the potential load drop.

3.2 Considerations for Qualitative and Quantitative Risk Analysis

3.2.1 Qualitative Analysis

In some cases, the existing qualitative defense in depth (DID) model used for (a)(4) evaluations may include previously defined High Risk Evolutions (HREs) for the transient events that may be caused by a load drop (e.g., increased risk of loss of offsite power, increased risk of loss of feedwater event, etc.). These HREs might be used as surrogates for a drop-induced transient. Existing DID models for the various Key Safety Functions (KSFs) could be used to determine how many systems / trains might be available for each KSF considering both the SSCs that are out of service and those potentially (i.e., conditionally) damaged by a drop incident. Note that the consideration of potential impacts to a single or to multiple KSFs would be performed in accordance with existing (a)(4) risk assessment procedures. Assessment of each impacted KSF on an individual basis can be performed to determine if any risk color changes are needed. This assessment should consider that the risk of a load drop impacting a KSF is a conditional one, and these conditional impacts should be given a different weighting from that given to SSCs that are known to be unavailable or otherwise out of service. If more than one equipment train remains available to support a specific KSF, then no risk color change may be required. However, if it is impractical for the analyst to perform a detailed evaluation, a conservative approach also is provided in Figure 3-2 that would apply a risk color change to each affected KSF.

3.2.2 Quantitative Analysis

If a quantitative assessment is performed, the two risk measures to be considered are the increase in initiating event probability and the damage to required SSCs following the event. The risk increase that is calculated based on the above measures must be conditionally weighted by the likelihood of the load drop occurring. One approach could be to use the existing quantitative PRA model to determine the conditional core damage / large early release probabilities (e.g., by evaluating the transient caused by the potential load drop assuming that the equipment damaged by the drop is failed, as well as any other out-of-service equipment at the time of the drop, but with all other plant equipment assumed to be available). This conditional probability would then be multiplied by an estimate of the load drop probability (i.e., the load drop frequency multiplied by the estimated duration of the lift activity) to calculate the ICDP and ILERP due to the load drop. The ICDP and ILERP would then be added to the ICDP and ILERP assuming no load drop (i.e., which would be normally calculated as part of the (a)(4) process) to obtain an overall estimate of risk due to the lift / movement. The total risk level would then be used to determine the "risk color" and the need for any RMAs.

3.2.3 Load Drop Frequency Assessment

If a quantitative assessment is performed, a key input to this evaluation will be the expected frequency of a load drop event. While there is some historical information concerning load drop events at nuclear power plants, it may be adequate to use a conservative screening value to bound the risk estimate. As noted in Section 1, NUREG-1774 estimated the average drop rate for very heavy loads at 5.6E-05 per lift. As human errors are a contributing factor to many of the reported drop events and it is not certain that the drop rate for "very heavy loads" would be equally applicable to all load lift events (i.e., the precautions taken prior to such lift events may be greater than that taken for less massive loads), a more conservative estimate of 1.0E-04 per lift could be used. This value provides a reasonable conservative estimate that is near the upper limit of drop rates reported in NUREG-0612 that was based on US Navy data. If the resulting risk estimate using this drop frequency is acceptable, then no further evaluation would be required. On the other hand, if the risk estimate obtained using these estimates is unacceptably high, then the plant could consider either altering the lift / movement activity to reduce risk or performing a more detailed analysis of the expected frequency of a load drop for the specific situation expected to occur.

3.3 Implementation of Risk Management Actions during Heavy Load Lifts and Movements

As indicated in the evaluation methodology discussed in the previous sub-sections, there will be instances in which implementation of RMAs is necessary. The plant will need to determine which specific actions would be most appropriate for the particular activity being performed. In many cases, the types of RMAs that are implemented in response to other risk-significant activities also may be applicable for a lift / movement (e.g., pre-job briefings and training, management oversight, minimization of work in other areas, etc.). Lift-specific RMAs can address one or more of the following risk contributors:

- Reducing the likelihood of a load drop incident.
- Reducing the likelihood of damage given a load drop incident occurs.
- Minimizing the magnitude of the risk increase if load drop induced damage occurs.

RMAs that can be considered to reduce the likelihood of a load drop incident include many of the items discussed in NUREG-0612 and include the following:

- Use of additional lifting devices (if possible) to provide protection from single failures.
- Use of detailed procedures including independent verification to minimize operator errors during rigging / lifting activities.
- Use of safety chains and other measures to prevent the load from causing damage if dropped by the primary lifting device.
- Walk down of the load path to identify potential obstacles or other issues that could contribute to a load drop event (or impact with other equipment during movement).

- If mobile or temporary lifting devices are used, provide features to ensure that the temporary devices will not tip or fall on other plant equipment.

RMAs that can be considered to reduce the likelihood or magnitude of damage in the event of a load drop include:

- Alteration of the load path to avoid travel over / near sensitive equipment or areas.
- Limiting the height of the lift.

Finally, the risk of load drop-induced damage could be reduced through actions such as the following:

- Implementation of contingency plans to address the potential consequences of a postulated drop (e.g., transients that are expected, mitigating systems that will be needed).
- Establishing alternate success paths for systems that could be damaged by the postulated load drop.
- Minimizing work on systems outside the area where the load is being lifted / moved that could be used to mitigate a drop incident.
- Pre-testing of standby systems that would be needed to respond to the postulated drop event.
- Re-schedule load lifts to avoid periods when risk-significant SSCs are out of service.

Table 3-1: Summary of Assessment Approach for Each Load Drop Scenario

Scenario	Could a Transient Occur If Load Dropped?	Could PRA / DID-Modeled SSCs be Damaged if Load Dropped?	Risk Evaluation Required
1	No	No	No further risk evaluation required.
2	No	Yes	No further (a)(4) risk evaluation required. If SSCs not credited in PRA / DID that can provide alternate success paths if a load dropped occurred are OOS, then consider RMA implementation.
3	Yes	No	No further (a)(4) risk evaluation required if all PRA / DID-modeled SSCs required to mitigate the transient are available (however, consider RMA implementation). If PRA / DID-modeled SSCs needed to mitigate the transient are OOS, then perform further risk assessment of the potential load drop. If SSCs credited in the PRA or DID model are OOS; then SSCs not credited in the PRA or DID model that can provide alternate success paths may be available to allow for the load drop-induced transient to be mitigated successfully. If sufficient alternative mitigating SSCs (or other means to maintain defense in depth) remain available to respond to the drop-induced transient, then the additional risk assessment may be abbreviated in scope.
4	Yes	Yes	Perform further risk assessment of the potential load drop and implement RMAs as indicated by the assessment. If sufficient alternative mitigating SSCs (or other means to maintain defense in depth) remain available to respond to the drop-induced transient, then the additional risk assessment may be abbreviated in scope.

Figure 3-1: Lift / Movement Activity Screening Logic (Page 1 of 2)

(Note: If different impacts occur at various times or in different locations during the lift / movement, then sub-divide the activity based on specific impacts and use this logic to screen each portion of the lift / movement)

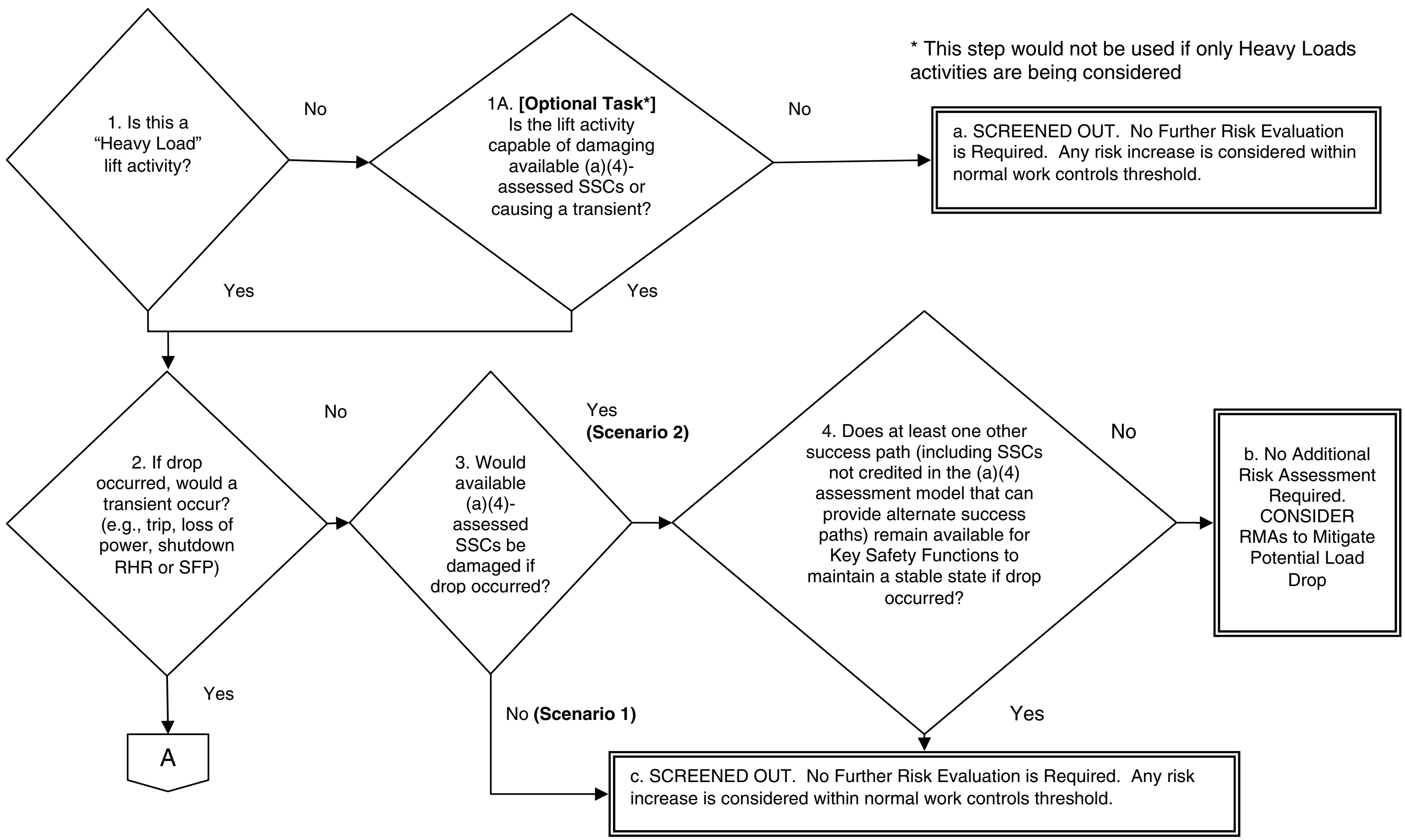


Figure 3-1: Lift / Movement Activity Screening Logic (Page 2 of 2)

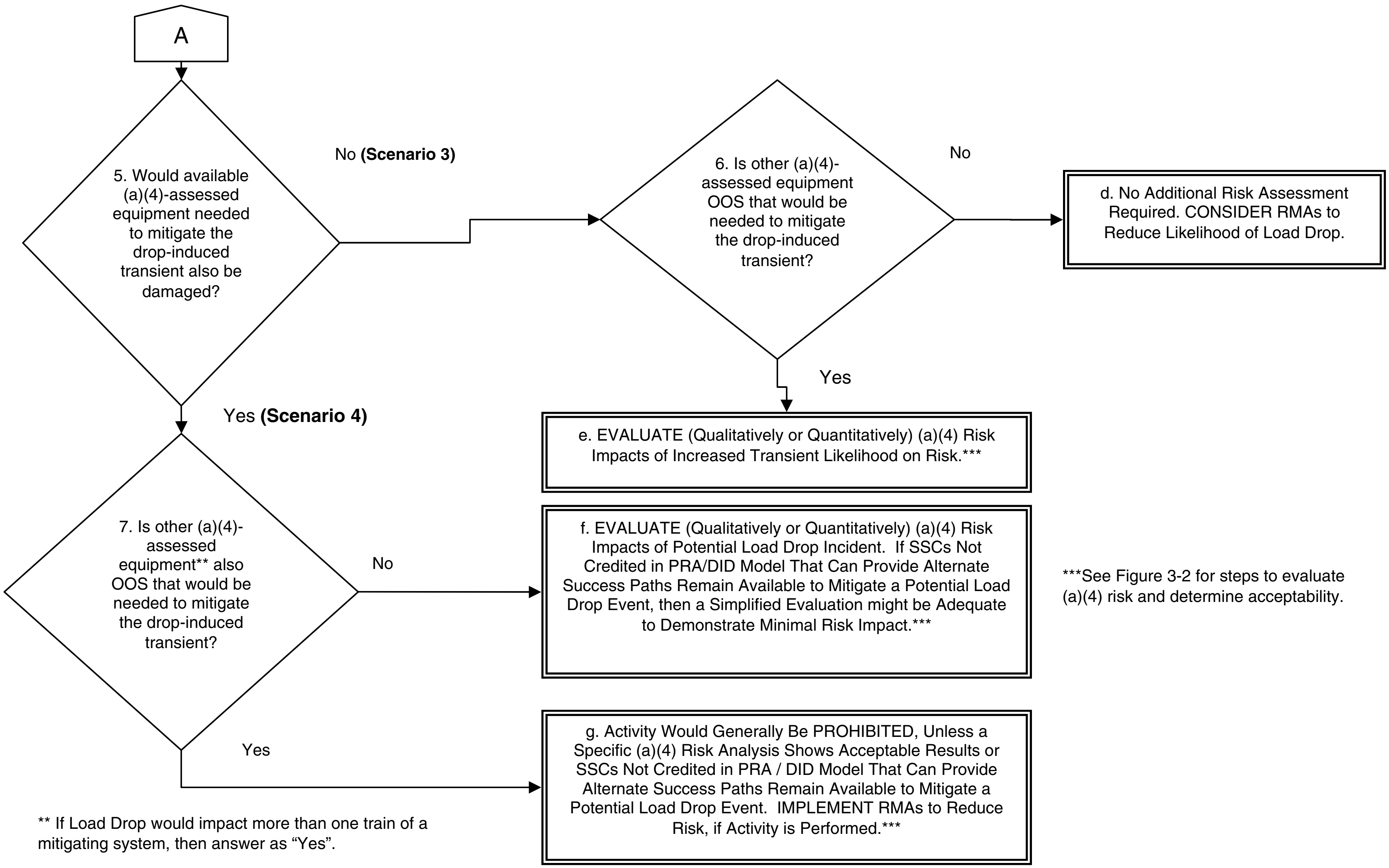
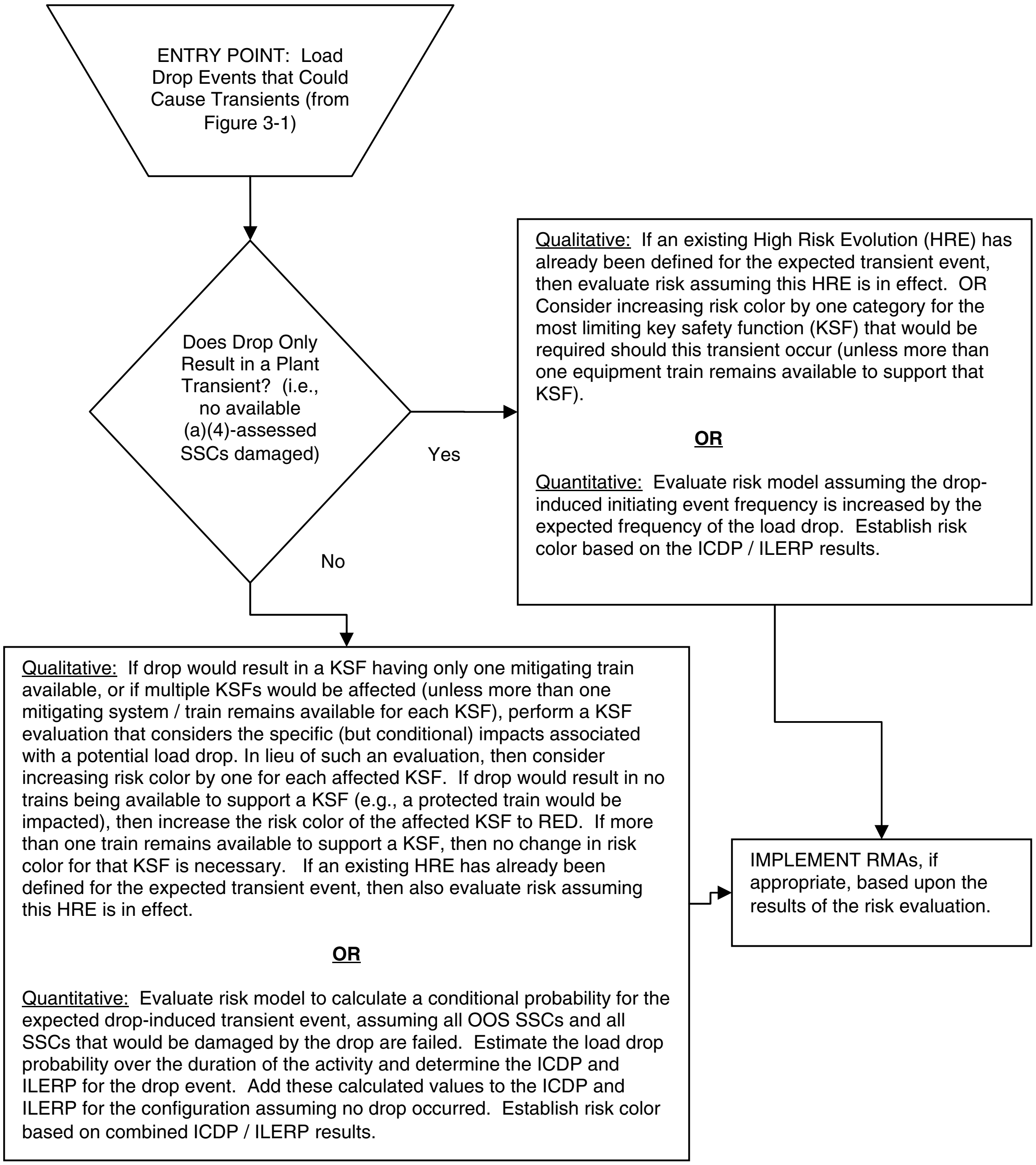


Figure 3-2: Qualitative/Quantitative (a)(4) Risk Assessment Logic for Activities That Require Specific Evaluation



4
CONCLUSIONS

The risk impacts of heavy load lifts / movements should be explicitly considered as part of the (a)(4) assessment process, as indicated in by recent documents published by both the NRC and NEI. However, in most instances, it should be possible to utilize a screening approach to focus detailed risk assessment activities only on those planned lifts that could cause a transient if a load drop were to occur. This screening approach should limit the burden for (a)(4) risk assessment personnel so that load drop-specific assessments would be performed on only the small fraction of lift activities with the potential for significant impact on nuclear safety risk.

Both qualitative and quantitative approaches are presented in this report that can be used as a starting point for the development of plant-specific (a)(4) assessment processes for heavy lifts. In any assessment performed, it should be recognized that the likelihood of a load drop is small and that any postulated risk impact is contingent on a drop occurring that would result in a plant transient or equipment damage.

The identification of work activities involving heavy lifts / movements is the first step of the process to determine if further evaluation is required. If some activities that involve lifting are not currently considered in the (a)(4) process, then mechanisms need to be established to identify these activities to personnel who can perform the risk screening methodology presented here.

Risk Management Actions can play an important role in maintaining the risk of lift activities at an acceptably low level. Many of these RMAs are already in use at NPPs, and credit should be given to these existing practices in the (a)(4) assessment process.

5
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[1] US Nuclear Regulatory Commission; "Control of Heavy Loads at Nuclear Power Plants", *NUREG-0612*; US Nuclear Regulatory Commission; Washington DC (1980)

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[3] US Nuclear Regulatory Commission; "A Survey of Crane Operating Experience at US Nuclear Power Plants From 1968 through 2002"; *NUREG-1774*; US Nuclear Regulatory Commission; Washington DC (2003)

[4] US Nuclear Regulatory Commission; "Clarification of NRC Guidelines for Control of Heavy Loads", *Regulatory Issue Summary 2005-25 and Supplement 1*; US Nuclear Regulatory Commission; Washington DC (2005, 2007)

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