

April 19, 1999

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MEMORANDUM TO Ashok C. Thadani, Director  
Office of Nuclear Regulatory Research

FROM Brian W. Sheron, Associate Director  
For Projects Licensing and Technical Analysis  
Office of Nuclear Reactor Regulation

SUBJECT: PROPOSED GENERIC SAFETY ISSUE - POTENTIAL RISK AND  
CONSEQUENCES OF HEAVY LOAD DROPS IN NUCLEAR POWER  
PLANTS

In the attachment to this memorandum, the Division of Systems Safety and Analysis in the Office of Nuclear Reactor Regulation has identified a potential generic safety issue (GSI) for evaluation by the Office of Nuclear Regulatory Research (RES). The attachment describes the GSI in accordance with RES Office Letter No. 7, "Procedure for Identification, Prioritization, Resolution, and Tracking of Generic Issues."

The proposed GSI addresses the potential risk and consequences of dropping heavy loads within nuclear power plants. It is similar in nature to Unresolved Safety Issue (USI) A-36, "Control of Heavy Loads Near Spent Fuel," which, in 1986, was reported to Congress as resolved.

In 1985, the staff declared, through Generic Letter (GL) 85-11, "Completion of Phase II of Control of Heavy Loads at Nuclear Power Plants, NUREG-0612," that licensees need not analyze the potential consequences of a heavy load drop. In 1986, the staff reported that USI A-36 was resolved based on the implementation of NUREG-0612, "Control of Heavy Loads at Nuclear Power Plants - Resolution of Generic Technical Activity A-36." Subsequent review of licensees' programs for the handling of heavy loads reveals that there is a substantially greater potential for severe consequences to result from the drop of a heavy load than previously envisioned by the staff.

As a result, the staff is concerned that although licensees may be operating within the regulatory guidelines in GL 85-11, they may not be taking action above and beyond existing regulations to maintain the level of protection necessary to avoid undue risk to public health and safety. In other words, licensees may not be taking adequate measures, if any, to assess and mitigate the consequences of dropped heavy loads. Therefore, the staff is asking that RES evaluate the safety impact of the guidelines provided in GL 85-11. We are also requesting that RES provide, to NRR, a schedule for prioritization of the proposed GSI within one month of receiving this memorandum. The proposed GSI has been coordinated with the Regulatory Effectiveness Assessment and Human Factors Branch in RES.

Attachment: As stated  
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PROPOSED GENERIC SAFETY ISSUE ON  
THE POTENTIAL RISK AND CONSEQUENCES  
OF HEAVY LOAD DROPS IN NUCLEAR POWER PLANTS

DESCRIPTION

Historical Background

NRC's 1986 Annual Report to Congress stated that Unresolved Safety Issue (USI) A-36, "Control of Heavy Loads Near Spent Fuel," was resolved with issuance and implementation of NUREG-0612, "Control of Heavy Loads at Nuclear Power Plants, - Resolution of Generic Technical Activity A-36," July 1980. Subsequent to NUREG-0612, NRC issued two other significant documents related to the control of heavy loads at nuclear power plants: Generic Letter (GL) 80-113, "Control of Heavy Loads," dated December 22, 1980, and GL 85-11, "Completion of Phase II of Control of Heavy Loads at Nuclear Power Plants, NUREG-0612," dated June 28, 1985. Although there are a number of other documents that provide guidance on the control and handling of heavy loads, the above three documents provide the framework for the existing staff position.

NUREG-0612 provides the results of NRC staff review of the handling of heavy loads at nuclear power plants and provides guidelines for licensees to take a defense-in-depth approach to (1) reduce the likelihood of dropping heavy loads, and (2) limit the consequences if a heavy load is dropped. It also provides criteria for acceptable measures of consequences of dropped loads. The criteria is similar to the measures that apply in a fuel handling accident analysis. More specifically, NUREG-0612 provides guidelines and recommendations for licensees to assure safe handling of heavy loads by prohibiting, to the extent practicable, heavy load travel over spent fuel assemblies, over the core, and over safety-related equipment. The NUREG defines a heavy load as any load carried in a given area during the operation of the plant that weighs more than the combined weight of a single spent fuel assembly and its associated handling tool. Phase I of NUREG-0612 provides guidelines for reducing the likelihood of dropping heavy loads and limiting the resulting potential consequences of a load drop and is focused on establishing safe load paths, procedures for load handling operations, training of crane operators, and the design, testing, inspection, and maintenance of cranes and lifting devices. Phase II of NUREG-0612 provides further protection by recommending methods for mitigating the consequences of dropped loads, including the use of a single-failure-proof crane, use of electrical interlocks and mechanical stops to restrict crane travel, and performance of load drop and consequence analyses to assess the impact of dropped loads on plant safety. The guidelines are based on the review of historical data relating to the principle causes of load drops and fault tree analyses and probability estimates.

GL 80-113 (unnumbered at time of issuance) requested that licensees implement the guidelines in NUREG-0612 and identify any problems encountered in the process. This GL also requested that licensees promptly implement some interim actions in accordance with the

NUREG, including establishing safe load paths, verifying crane design, performing inspections and operator training, and establishing load handling procedures. Licensees were to provide a 6-month response regarding implementation of the interim actions and Section 5.1.1 of NUREG-0612. Licensees also were to provide a 9-month response regarding implementation of Sections 5.1.2 through 5.1.6 of NUREG-0612. Both the 6-month and 9-month responses were referred to as Phase I and Phase II, respectively. The Phase I actions were to provide protection until the Phase II actions were completed.

All the licensees implemented the interim actions and Phase I of GL 80-113 and submitted a response for Phase II. During this period the staff began to reconsider the actions requested in Phase II. The staff decided to perform detailed reviews of the Phase II submittals from 12 operating sites (encompassing 20 operating plants)(8BWRs and 12 PWRs).

It was determined that the actions already taken by these licensees had significantly decreased the likelihood of a heavy load drop. Note that each of the licensee submittals reviewed included a combination of Phase I actions plus load drop analyses, interlocks, and/or single-failure-proof cranes in their heavy load control programs. The staff also performed brief reviews of the remaining Phase II submittals looking for any obvious problems that should be addressed. There is no documentation of the results of these less detailed reviews except for a few brief statements in GL 85-11.

GL 85-11 dismissed the need for licensees to implement the requirements of NUREG-0612, Phase II. It informed licensees that implementation of Phase II of NUREG-0612 was not necessary and exempted licensees from having to use either electrical interlocks and mechanical stops, or a single-failure-proof crane, or load drop and consequence analyses to assure the safety of their handling of heavy loads. However, GL 85-11 encouraged licensees to implement actions they perceive to be appropriate to maintain safety. A cost-benefit justification for the change in the staff's position from NUREG-0612 was included in the GL. The cost-benefit justification is focused on polar cranes and pressurized water reactors and is silent on boiling-water reactors. It addresses the excessive cost of upgrading to or installing a single-failure-proof crane, versus the benefits that would be gained.

In 1995, the staff audited GPU Nuclear (GPUN) Corporation's 10 Code of Federal Regulations (10 CFR 50.59) evaluation for the movement of spent fuel dry storage casks, weighing 100-tons each, over safety-related equipment during power operation at the Oyster Creek plant. The audit found that GPUN reduced the probability of dropping a cask by increasing the reliability of its overhead crane. The staff also found that the consequences of a cask drop would be greater than previously analyzed in the plant's Final Safety Analysis Report. Therefore, the staff concluded that although GPUN reduced the potential for a load drop, the potential consequences of a load drop were more severe than previously analyzed in the plant's licensing basis. In other words, there was a low probability that the cask would be dropped but potentially severe consequences if the cask is dropped.

In April 1996, the staff issued NRC Bulletin (NRCB) 96-02, "Movement of Heavy Loads Over Spent Fuel, Over Fuel in the Reactor Core, or Over Safety-Related Equipment." It alerted licensees to the importance of complying with existing regulatory guidelines on the control and handling of heavy loads. Licensees were also reminded of their responsibilities for providing

adequate protection of public health and safety when handling heavy loads during plant operation. In addition, NRCB 96-02 alerted licensees to the potentially high consequences that may result from a cask drop, and the importance of taking measures to mitigate such consequences in addition to measures to preclude the load drops. In NRCB 96-02, the staff was concerned that although licensees complied with the guidelines in Phase I of NUREG-0612, they may have disregarded the potentially high consequences that could result from a heavy load drop when GL 85-11 was implemented. The staff also reasserted its position taken in GL 85-11 that licensees are to implement actions they perceive to be appropriate to maintain safety.

Review of responses to NRCB 96-02 indicated that a majority of the plants operated in accordance with GL 85-11 and did not implement NUREG-0612, Phase II guidelines to assure additional safety in their load handling operations. This is evidenced by the fact that approximately 80 plants do not have a single-failure-proof crane while about 15 of those plants have increased the reliability of their lifting system. In addition, approximately 73 plants have not performed load drop and/or consequence analyses. Therefore, the responses to NRCB 96-02 revealed that although some plants may have reduced the potential for load drops through upgrades to the lifting system, a majority of the plants either did not evaluate or was uncertain of their plans to evaluate the potential consequences of heavy load drops. The staff closed its review of the responses to NRCB 96-02 generically and committed to perform more detail reviews of licensees' load handling operations on a plant specific basis.

Following issuance of NRCB 96-02, the staff, in a Task Action Plan (TAP) on Heavy Loads Control and Crane Issues (copy attached), undertook efforts to assess the potential impact of GL 85-11 on plant safety. The staff's objectives were to either: (1) affirm its regulatory position of not requiring licensees to perform load drop and consequence analyses, or (2) revise its position and require licensees to perform the analyses. The key issues identified in the TAP to enable the staff to satisfy the objectives are (1) the reliability of overhead heavy load handling cranes (single-failure and non-single-failure proof), and (2) the risk significance of multiple failures resulting from a load drop. In January 1998, the Division of Systems Safety and Analysis discussed with the Office of Nuclear Regulatory Research (RES) the need to perform a reliability analysis of cranes. The staff planned to use the crane reliability analysis as a basis for either revising or retaining the guidelines in GL 85-11. The assessment of crane reliability involved: (1) identifying and assessing the causes of crane failures, (2) determining the probability of load drops and the potential consequences, and (3) recommending any necessary changes to GL 85-11. It was later determined that this effort could not be undertaken by RES because of resource limitations in its FY98 budget.

#### Safety Significance - Potential for a Heavy Load Drop

GPUN's plans for handling dry storage casks at Oyster Creek involved the use of an upgraded reactor building crane (non-single-failure-proof) to transfer 100-ton spent fuel dry storage casks to an independent spent fuel storage facility (ISFSI) while the plant is operating. GPUN reduced the probability of a load drop by (1) modifying the crane to include a fixed-link system to support the casks; (2) using a crush pad along the safe load path to absorb the impact of a dropped cask; and (3) upgrading the training, management and oversight, and cask-handling

procedures. Although GPUN reduced the probability of a load drop, a potential cask drop that could damage both isolation condensers and the torus, possibly creating an unisolable loss-of-coolant accident outside containment still existed. According to the licensee, core cooling could be maintained by steaming to the condenser using the normal feedwater system and providing makeup from the condensate storage tank and fire water systems by way of the core spray system.

GPUN evaluated postulated load drops of a cask in the reactor building equipment hatchway (from the 119-foot elevation to the 23-foot elevation) and at a laydown area on the 119-foot elevation and found that a cask drop could damage the torus, causing it to drain. Consequently, the pressure suppression function of the primary containment could be disabled. They expected the reactor to scram successfully, reducing power so that only post-scram decay heat would have to be removed. The primary coolant system piping would not be affected by the drop; therefore, the need for vessel inventory makeup would not be required immediately. Some safety-related equipment would be damaged, for example, one set of containment spray pumps and one containment spray heat exchanger. However, containment spray would be unavailable in any event since GPUN has assumed no water would be present in the torus. The isolation condenser shell-side makeup could be accomplished remotely by using condensate transfer. If needed, a reactor building entry to establish shell-side makeup could be performed in approximately 1 hour. The load-drop analysis concluded that the reactor could be safely shutdown following a drop of the cask and that the offsite consequences of a load drop are bounded by high-energy line break evaluations. The licensee determined that releases resulting from damage to the 52 fuel assemblies in the cask would not exceed 25 percent of the limits set out in 10 CFR Part 100 because the fuel assemblies will be more than 10 years old.

GPUN's 10 CFR 50.59 evaluation concluded that the requirements of both NUREG-0612 and GL 85-11 would be satisfied and no unreviewed safety questions were involved. This was based on the determination that movement of casks can be accomplished in a safe manner because the probability of dropping the load was reduced through enhancements to the crane and the implementation of the Phase I guidelines in Section 5.1.1 of NUREG-0612.

The staff states in GL 85-11 that "our review has indicated that satisfaction of the Phase I guidelines assures that the potential for a load drop is extremely small." GPUN considered that GL 85-11 was satisfied because: (1) the fixed links support system, which enhanced the crane, provided redundant load support for the casks; (2) safe shutdown can be achieved if a heavy load drop occurred when the fixed-link support system is not used, and (3) although a postulated load drop could damage safety-related equipment, the probability of a drop is extremely low.

GL 85-11 does not grant blanket NRC approval for all load paths identified in the Phase II submittals. Rather, the GL indicates that, at that time (June 1985), licensees were not required to comply with the Phase II requirements because by meeting the Phase I requirements licensees had provided assurance of "maximum practical defense in depth." As indicated above, the majority of the Phase II submittals did not receive a detailed review. However, the staff made a decision that they would not perform these detailed reviews nor issue any safety evaluation reports associated with the completed reviews. Under these circumstances, the lack of response from the staff can not be interpreted as an approval.

In addition, the GL did not relieve licensees from their responsibility under 10 CFR 50.59 to evaluate new activities with respect to the Safety Analysis Report and the Technical Specifications to determine whether the activity involves an unreviewed safety question or a change in the technical specifications. Realistically, if a licensee performs a review, under 10 CFR 50.59, of a heavy load lift not bounded by previous analyses, they will perform something very similar to a load drop analysis. If licensees have installed interlocks and mechanical stops that will prevent a crane from carrying heavy loads over spent fuel and safety-related equipment, they may be able to justify a numerical analysis in the 10 CFR 50.59 evaluation (i.e., showing that fuel and safety-related loads are unaffected by a load drop).

Furthermore, GL 85-11 concluded that the risks associated with damage to safety-related systems are relatively small because (1) nearly all load paths avoid this equipment, (2) most equipment is protected by an intervening floor, (3) there is redundancy of components, and (4) crane failure probability is generally independent of safety-related systems. As is demonstrated by Oyster Creek's proposed activities, this conclusion may not always be valid.

#### Possible Solutions

One obvious solution to the identified concerns is to rescind GL 85-11 and require all licensees to perform load drop and consequence analyses as recommended in NUREG-0612, Phase II. This would be the most expeditious approach to a resolution and would require licensees to implement a limited portion of NUREG-0612 Phase II. This resolution may or may not require RES to revisit USI A-36. However, this resolution would involve a backfit, in accordance with 10 CFR 50.109, because it requires that licensees take regulatory action to ensure that they provide adequate protection to public health and safety.

If this approach is taken, a technical basis in support of a backfit is needed. Agency policy dictates that a risk-informed approach should be used wherever possible when adding, removing, or modifying NRC regulations. Therefore, any supporting technical basis to modify GL 85-11 should involve an assessment of the risk of crane failure that results in a heavy load drop. Accordingly, the staff believes that the potential of dropping heavy loads should be better understood, particularly when licensees are placing reliance on increases in the reliability of load-handling systems through increased safety factors or redundant components.

Table 5.2-1 of NUREG-0612 identified that the probability of a heavy load drop resulting in exceeding the 10 CFR Part 100 consequences is on the order of  $2 \times 10^{-7}$  per reactor-year (this is the median value with an upper bound of  $10^{-5}$  per reactor-year). This probability estimate has a high degree of uncertainty. In light of the uncertainty in the existing estimate in NUREG-0612 and the potential risk significance of a cask drop on spent fuel and safe shutdown equipment, the staff should perform an updated load drop data acquisition and analysis. State of the art probability estimate methods should be applied to determine the risk of crane failure.

Tasks envisioned in assessing the probability of crane failure should include the following:

- (1) identifying a source of crane failure data regarding operationally initiated load drop events at nuclear power plants and other industries that use similar cranes and obtain the data. The data should be accurate to the extent practicable and be useable for predicting crane load drop risk;

- (2) analyzing the data to identify the major operational failure modes or causes of events;
- (3) developing fault trees associated with load drops for both single-failure-proof and non-single-failure-proof crane designs as identified in NUREG-0554, "Single-Failure-Proof-Cranes for Nuclear Power Plants," and NUREG-0612;
- (4) using the information identified above, apply the current state of the art risk assessment methods to establish the probabilities of failure of both types of cranes; and
- (5) applying a risk informed decision logic to recommend the necessary changes to the current position in GL 85-11.

## REFERENCES

### Key Documents

1. NUREG-0410. "NRC Program for the Resolution of Generic Issues Related to Nuclear Power Plants - Report to Congress." (January 1978).
2. Generic Letter 78-11. "OT Position For Review and Acceptance of Spent Fuel Storage and Handling Applications." (April 14, 1978) - Issued NRC guidance on Spent Fuel pool modifications entitled "Review and Acceptance of Spent Fuel Handling Modifications."
3. Generic Letter 78-15. (May 16, 1978) - Issued RAs to licensees to support staff's review of current NRC requirements and licensee procedures for the movement of heavy loads near spent fuel.
4. Generic Letter 78-16. (May 17, 1978) (same letter as above - superseded GL 78-15).
5. NUREG-0554. "Single Failure Proof Cranes for Nuclear Power Plants," - including NUREG 0554 Checklist (May 1979).
6. NUREG-0612. "Control of Heavy Loads at Nuclear Power Plants." - Resolution of Generic Technical Activity A-36. (July 1980).
7. Generic Letter 80-113. "Control of Heavy Loads." (December 22, 1980). (unnumbered when issued).
8. Generic Letter 81-07. "Control of Heavy Loads." (February 3, 1981).
9. Generic letter 83-42. "Clarification of GL 81-07 Regarding Response to NUREG-0612, Control of Heavy Loads at Nuclear Power Plants." (December 19, 1983).
10. Generic Letter 85-11. "Completion of Phase II of Control of Heavy Loads at Nuclear Power Plants. NUREG-0612." (June 28, 1985).

### Supporting Documents

11. NUREG-0800. (formerly NUREG-75/087) Standard Review Plan (Rev 0 - July 1981)
  - SRP Section 9.1.4. "Light Load Handling Systems (Refueling)" (GDC 2,5,61,62)
  - SRP Section 9.1.5. "Overhead Heavy Load Handling Systems" (GDC2,5,61)
  - SRP Section 15.7.4. "Radiological Consequences of Fueling Accidents"
  - SRP Section 15.7.5. "Spent Fuel Cask Drop Accident"
12. Regulatory Guide 1.13. "Spent Fuel Storage Facility Design Basis."

13. Regulatory Guide 1.25. "Assumptions Used for Evaluating the Potential Consequences of a Fuel Handling Accident in the Fuel Storage Facility for Boiling and Pressurized Water Reactors." (March 1972)
14. Regulatory Guide 1.29. "Seismic Design Classification"
15. Regulatory Guide 1.40. "Qualification tests of Continuous Duty Motors Installed Inside Containment of Water-Cooled Nuclear Power Plants"
16. Regulatory Guide 1.104. "Overhead Crane Handling Systems For Nuclear Power Plants." (February 1978)
17. American National Standards Institute - ANSI N14.6/1978-1993, - for Radioactive Materials - "Special Lifting Devices for Shipping Containers Weighing 10,000 Pounds or More."
18. American National Standards Institute - ANSI B30.2.0-1976. "Overhead and Gantry Cranes "
19. American National Standards Institute - ANSI N57.1/ANSI N208, "Design Requirements For LWR Fuel Handling Systems."
20. American National Standards Institute - ANSI N57.2/ANSI N210, "Design Objectives for LWR Spent Fuel Storage Facilities At Nuclear Power Plants."
21. NRC Annual Report to Congress. 1986. - reported that a final technical resolution had been achieved for Task A-36.
22. NUREG-0933. "A Prioritization of Generic Safety Issues," (August 1987).