CONTROL OF HEAVY LOADS AT NUCLEAR POWER PLANTS
FLORIDA POWER AND LIGHT CO.
ST. LUCIE PLANT UNIT 2
(PHASE II)
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ABSTRACT

The Nuclear Regulatory Commission (NRC) has requested that all nuclear plants, either operating or under construction, submit a response of consistency with NUREG-0612, "Control of Heavy Loads at Nuclear Power Plants." EG&G Idaho, Inc., has contracted with the NRC to evaluate the responses of those plants presently under construction. This report contains EG&G's evaluation and recommendations for St. Lucie Plant Unit 2 for the requirements of Sections 5.1.2, 5.1.3, 5.1.5, and 5.1.6 of NUREG-0612 (Phase II). Section 5.1.1 (Phase I) was covered in a separate report [1].

EXECUTIVE SUMMARY

St. Lucie Plant Unit 2 is not totally consistent with the guidelines of NUREG-0612. In general, inconsistencies exist in the following areas:

- The spent fuel area has three minor situations needing improvement to show consistency with guideline requirements of NUREG 0612 Article 5.1.2.
- The submittal for the Reactor Building fails to provide suitable information to show consistency with any one of the three options specified by NUREG 0612 Article 5.1.3.
- The submittal on the hoists in other areas, shows general consistency however there are three situations which require additional improvement.

The main report contains recommendations which will aid in making the above items consistent with the appropriate guidelines.

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(PHASE II)

1. INTRODUCTION

1.1 Purpose of Review

This technical evaluation report documents the EG&G Idaho, Inc., review of general load-handling policy and procedures at St. Lucie Plant Unit 2 (St. Lucie 2). This evaluation was performed with the objective of assessing conformance to the general load-handling guidelines of NUREG-0612, "Control of Heavy Loads at Nuclear Power Plants" [2], Sections 5.1.2, 5.1.3, 5.1.5, and 5.1.6. This constitutes Phase II of a two-phase evaluation. Phase I assesses conformance to Section 5.1.1 of NUREG-0612 and was documented in a separate report [1].

1.2 Generic Background

Generic Technical Activity Task A-36 was established by the U.S. Nuclear Regulatory Commission (NRC) staff to systematically examine staff licensing criteria and the adequacy of measures in effect at operating nuclear power plants to assure the safe handling of heavy loads and to recommend necessary changes to these measures. This activity was initiated by a letter issued by the NRC staff on May 17, 1978 [3], to all power reactor applicants, requesting information concerning the control of heavy loads near spent fuel.

The results of Task A-36 were reported in NUREG-0612, "Control of Heavy Loads at Nuclear Power Plants." The staff's conclusion from this evaluation was that existing measures to control the handling of heavy loads at operating plants, although providing protection from certain potential problems, do not adequately cover the major causes of load-handling accidents and should be upgraded.

In order to upgrade measures for the control of heavy loads, the staff developed a series of guidelines designed to achieve a two-phase objective using an accepted approach or protection philosophy. The first portion of the objective, achieved through a set of general guidelines identified in NUREG-0612, Article 5.1.1, is to ensure that all load-handling systems at nuclear power plants are designed and operated such that their probability of failure is uniformly small and appropriate for the critical tasks in which they are employed. The second portion of the staff's objective, achieved through guidelines identified in NUREG-0612, Articles 5.1.2 through 5.1.5, is to ensure that, for load-handling systems in areas where their failure might result in significant consequences, either (a) features are provided, in addition to those required for all load-handling systems, to ensure that the potential for a load drop is extremely small (e.g., a single-failure-proof crane) or (b) conservative evaluations of load-handling accidents indicate that the potential consequences of any load drop are acceptably small. Acceptability of accident consequences is quantified in NUREG-0612 into four accident analysis evaluation criteria as follows:

- "Releases of radioactive material that may result from damage to spent fuel based on calculations involving accidental dropping of a postulated heavy load produce doses that are well within 10 CFR Part 100 limits of 300 rem thyroid, 25 rem whole body (analyses should show that doses are equal to or less than 1/4 of Part 100 limits);

- "Damage to fuel and fuel storage racks based on calculations involving accidental dropping of a postulated heavy load does not result in a configuration of the fuel such that k_{eff} is larger than 0.95;

- "Damage to the reactor vessel or the spent-fuel pool based on calculations of damage following accidental dropping of a postulated heavy load is limited so as not to result in

water leakage that could uncover the fuel, (makeup water provided to overcome leakage should be from a borated source of adequate concentration if the water being lost is borated); and

- "Damage to equipment in redundant or dual safe shutdown paths, based on calculations assuming the accidental dropping of a postulated heavy load, will be limited so as not to result in loss of required safe shutdown functions."

The approach used to develop the staff guidelines for minimizing the potential for a load drop was based on defense in depth. This plan includes proper operator training, equipment design, and maintenance coupled with safe load paths and crane interlock devices restricting movement over ciritical areas.

Staff guidelines resulting from the foregoing are tabulated in Section 5 of NUREG-0612.

1.3 Plant-Specific Background

On December 22, 1980, the NRC issued a letter [4] to Florida Power and Light Company, the applicant for St. Lucie 2 requesting that the applicant review provisions for handling and control of heavy loads at St. Lucie 2, evaluate these provisions with respect to the guidelines of NUREG-0612, and provide certain additional information to be used for an independent determination of conformance to these guidelines. Florida Power and Light Company provided responses to this request on August 6, 1981 [5] and September 21, 1982 [6].

2. EVALUATION AND RECOMMENDATIONS

2.1 Overview

The following sections summarize Florida Power and Light Company's review of heavy load handling at St. Lucie 2 accompanied by EG&G's evaluation, conclusions, and recommendations to the applicant for making the facilities more consistent with the intent of NUREG-0612.

2.2 Heavy Load Overhead Handling Systems

Table 2.1 presents the applicant's list of overhead handling systems which are subject to the criteria of NUREG-0612. The applicant has indicated that the weight of a heavy load for the facilities as 1330 pounds per the NUREG-0612 definition.

2.3 Guidelines

The basic guidelines of NUREG 0612 for Phase II evaluations are quoted below and followed with the applicant's statements and the EG&G evaluations with recommendations. Since the guideline of 5.1.4 is specifically for Boiling Water Reactors it is not discussed. The intent of NRC is for St. Lucie 2 to show that they are consistent with one each of the applicable options of guidelines for 5.1.2, or 5.1.3, or 5.1.5 and as appropriate 5.1.6.

2.3.1 Spent-Fuel Pool Area [NUREG-0612, Article 5.1.2].

(1) "The overhead crane and associated lifting devices used for handling heavy loads in the spent-fuel pool area should satisfy the single-failure-proof guidelines of Section 5.1.6 of this report.

OR

(2) "Each of the following is provided:

(a) Mechanical stops or electrical interlocks should be provided that prevent movement of the overhead crane load block over or within 15 feet horizontal (4.5 meters) of the spent-fuel pool. These mechanical

TABLE 2.1 OVERHEAD HANDLING SYSTEMS SUBJECT TO NUREG 0612

Name	Capacity
Systems Over the Spent Fuel Pool	
Fuel Cask Bridge Crane	150 Ton Main Hook 15 Ton Auxiliary Hook
Refueling Canal Bulkhead Moncrail	3 Ton
Cask Storage Pool Bulkhead Monorail	3 Ton
Systems Operating in the Containment	
Polar Crane	200 Ton Main hook 50 Ton Auxiliary Hook
Auxiliary Telescoping Jib Crane	1 Ton
Refueling Machine Hoist	1 Ton
Systems Operating in Other Areas	
Pump Room Monorails	1 Ton
Charging Pump Monorails	5 Ton
Diesel Generator Monorails	1 Ton
Component Cooling Water Pump Monorail	3 Ton
Turbine Gantry Cranes	200 Ton Main Hook 35 Ton Auxiliary Hook
Intake Structure Bridge Crane	45 Ton

stops or electrical interlocks should not be bypassed when the pool contains "hot" spent fuel, and should not be bypassed without approval from the shift supervisor (or other designated plant management personnel). The mechanical stops and electrical interlocks should be verified to be in place and operational prior to placing "hot" spent fuel in the pool.

(b) The mechanical stops or electrical interlocks of 5.1.2(2)(a) above should also not be bypassed unless an analysis has demonstrated that damage due to postulated load drops would not result in criticality or cause leakage that could uncover the fuel.

(c) To preclude rolling if dropped, the cask should not be carried at a height higher than necessary and in no case more than six (6) inches (15 cm) above the operating floor level of the refueling building or other components and structures along the path of travel.

(d) Mechanical stops or electrical interlocks should be provided to preclude crane travel from areas where a postulated load drop could damage equipment from redundant or alternate safe shutdown paths.

(e) Analyses should conform to the guidelines of Appendix A.

OR

(3) Each of the following are provided (Note: This alternative is similar to (1) above, except it allows movement of a heavy load, such as a cask, into the pool while it contains "hot" spent fuel if the pool is large enough to maintain wide separation between the load and the "hot" spent fuel.):

(a) "Hot" spent fuel should be concentrated in one location in the spent-fuel pool that is separated as much as possible from load paths.

(b) Mechanical stops or electrical interlocks should be provided to prevent movement of the overhead crane load block over or within 25 feet horizontal (7.5 m) of the "hot" spent fuel. To the extent practical, loads should be moved over load paths that avoid the spent-fuel pool and kept at least 25 feet (7.5 m) from the "hot" spent fuel unless necessary. When it is necessary to bring loads within 25 feet of the restricted region, these mechanical stops or electrical interlocks should not be bypassed unless the spent fuel has decayed sufficiently as shown in Table 2.1-1

and 2.1-2, or unless the total inventory of gap activity for fuel within the protected area would result in off-site doses less than 1/4 of 10 CFR Part 100 if released, and such bypassing should require the approval from the shift supervisor (or other designated plant management individual). The mechanical stops or electrical interlocks should be verified to be in place and operational prior to placing "hot" spent fuel in the pool.

(c) Mechanical stops or electrical interlocks should be provided to restrict crane travel from areas where a postulated load drop could damage equipment from redundant or alternate safe shutdown paths. Analyses have demonstrated that a postulated load drop in any location not restricted by electrical interlocks or mechanical stops would not cause damage that could result in criticality, cause leakage that could uncover the fuel, or cause loss of safe shutdown equipment.

(d) To preclude rolling, if dropped, the cask should not be carried at a height higher than necessary and in no case more than six (6) inches (15 cm) above the operating floor level of the refueling building or other components and structures along the path of travel.

(e) Analyses should conform to the guidelines of Appendix A.

OR

(4) "The effects of drops of heavy loads should be analyzed and shown to satisfy the evaluation criteria of Section 5.1 of this report. These analyses should conform to the guidelines of Appendix A."

A. Summary of Applicant's Statements

The fuel cask bridge crane heaviest load carried is the 100 ton Spent Fuel Cask. This crane is not single failure proof however, the following operational and design features demonstrate that no single failure will affect the spent storage pool.

- The cask is lifted through an L shaped opening in the Fuel Handling Building roof, and north wall

then lowered into the fuel cask storage pool which is adjacent to the spent fuel storage pool, but is separated from it by a 5.5 foot thick reinforced concrete wall

- Protection against dropping the cask in the spent fuel pool is provided by layout of the building--e.g.: it is physically impossible to pass the cask over the spent fuel pool

- Fully redundant limit switches are provided to confine the hook centerline within a 2 foot wide corridor that is centered over the cask storage pool.

- The cask yoke design eliminates the possibility of a double pendulum type of drop--e.g.: can fall in vertical drop only

- The walls of the cask storage area slab are designed for the impact load of a dropped cask.

The above features of the cask handling system demonstrate that no single failure can result in a drop of the spent fuel cask into the spent fuel storage pool. For maximum practicable, "defense-in-depth the general guidelines and interim requirements for safe load handling of NUREG 0612 will be implemented. Use of the 15 ton Auxiliary Hoist or its safety is not discussed.

The Refueling Canal Bulkhead and Cask Storage Pool Bulkhead Monorails are used to lift these pool gate bulkheads to and from their normal location in the pool walls and the designated storage locations. Although the weight of the bulkheads is below 1.25 tons, monorail systems with a 3 ton rated capacity have been provided. The following table

represents the factors of safety for the various components of the monorail systems based upon a maximum lifted load of 1.25 tons.

Category	Safety Factor	Condition
Hoist and trolley parts	10	Ultimate strength
Hoist ropes	12	Ultimate strength
Machinery	10	Ultimate strength
Structural steel	4.3	Yield strength
Hooks	10	Ultimate strength

Due to the conservative design of these monorails, in conjunction with operators using special procedures, a failure that could result in an uncontrolled descent of the pool bulkheads is extremely unlikely.

B. EG&G Evaluation

It appears that the options of NUREG 0612, Article 5.1.2, Options 1, 3 or 4, were not used for the Fuel Cask Bridge crane. Using option 2 the presentation generally shows consistency with the intent of this guideline. However sub-items 2c and 2e are not addressed. There is no mention if other loads are handled, or auxiliary hoist use.

Relative to the Refueling Canal Bulkhead and Cask Storage Pool Bulkhead monorails, there is no claim that they are single failure proof. In NUREG 0612, Article 5.1.2 there is a call for assurance that the evaluation criteria of 5.1 are met. In 5.1 an either-or assurance is permitted with 5.1 (1) being to show that, "the potential for a load drop is extremely small." It also calls for defense-in-depth and summarizes this to three guidelines with alternative measures to compensate for deficiencies of the numbers (2)

or (3) of the guidelines. Among the alternatives is, "increased safety factors" reported by Florida Power and Light. In Phase I report they have shown consistency with number (1) and (2) alternatives, therefore the intent of 5.1 objective (1) is met.

C. EG&G Conclusions and Recommendations

The response for the Fuel Cask Bridge Crane using option 2 has insufficient information to show consistency with all of the guideline. Provide, for 2(c), information to show that the cask is handled at 6 inches or less above the operating floor level or other structures. Provide better information to show consistency on the analysis following the Appendix A of NUREG 0612. Indicate if the Fuel Cask Bridge Crane or auxiliary hoist is to handle any other heavy loads, if so, address their risk.

The EG&G analysis made from information submitted on the Refueling Canal Bulkhead and Cask Storage Bulkhead monorails, indicate that St. Lucie 2 is consistent with guideline 5.1.2 requirements.

2.3.2 Reactor Building [NUREG-0612, Article 5.1.3]

(1) "The crane and associated lifting devices used for handling heavy loads in the containment building should satisfy the single-failure-proof guidelines of Section 5.1.6 of this report.

OR

(2) "Rapid containment isolation is provided with prompt automatic actuation on high radiation so that postulated releases are within limits of evaluation Criterion I of Section 5.1 taking into account delay times in detection and actuation; and analyses have been performed to show that evaluation criteria II, III, and IV of Section 5.1 are satisfied for postulated load drops in this area. These analyses should conform to the guidelines of Appendix A.

OR

(3) "The effects of drops of heavy loads should be analyzed and shown to satisfy the evaluation criteria of Section 5.1. Loads analyzed should include the following: reactor vessel head; upper vessel internals; vessel inspection platform; cask for damaged fuel; irradiated sample cask; reactor coolant pump; crane load block; and any other heavy loads brought over or near the reactor vessel or other equipment required for continued decay heat removal and maintaining shutdown. In this analysis, credit may be taken for containment isolation if such is provided; however, analyses should establish adequate detection and isolation time. Additionally, the analysis should conform to the guidelines of Appendix A."

A. Summary of Applicant's Statements

Table 2.1 provides a list of heavy load handling systems physically capable (i.e. ignoring interlocks, moveable mechanical stops, or operating procedures) of carrying heavy loads over the reactor vessel.

The St. Lucie plant administrative procedure AP 100438 "Control of Heavy Loads Lifts" covers heavy load handling operations for these cranes. A safe load path is defined which prohibits hook travel over the reactor vessel without prior special approval. However, during plant maintenance and refueling operations it is sometimes necessary to carry heavy loads over the reactor vessel. Special procedures for 14 heavy loads have been prepared for those loads which are handled periodically over the reactor vessel. These procedures identify the required equipment; inspection and acceptance criteria required before movement of the load; the steps and proper sequence to be followed in handling the load; the load path and any special precautions. Any load lifts not covered by special procedure are controlled generically by the plant administrative procedure AP100438 previously mentioned. This procedure requires that Facility Review Group approval be obtained prior to movement of these loads over the reactor vessel. The Facility Review Group will assure that the proper controls are present.

In addition to these procedures, which are available at the site for review, safe operation of the cranes is assured by the crane maintenance and operator training and qualification programs which follow ANSI B30.2-1976 guidelines. Based upon Florida Power and Light Company's review of the procedures, equipment and personnel used in load handling operations over the core, we believe that the likelihood of the load drop in the area is extremely small and that no problem exists.

B. EG&G Evaluation

NUREG 0612 Article 5.1.3 calls for two assurances that the criteria of Article 5.1 are met. One is to satisfy the guidelines of 5.1.1 (which were covered in Phase I), two is to satisfy one of the three options in Article 5.1.3 that are quoted above. The applicant's statement reiterates the information used to show consistency with Guideline 5.1.1, but, does not provide information for the requested assurances that 5.1 is met.

- There is no information to indicate that the cranes and associated lifting devices are single failure proof

- There is no discussion on radiation activated containment isolation along the guides of Article 5.1 I and supplementary analyses of 5.1 II, III, and IV

- There is no load drop analysis as requested in the guidelines of Article 5.1 and using the details given in NUREG 0612 Appendix A.

C. EG&G Conclusions and Recommendations

Insufficient information is provided for a valid evaluation of measures that show consistency with 5.1.3. Florida Power and Light should select the most appropriate of the three options permitted by 5.1.3 and present those plant features that show the plant is consistent with that options requirement. These comments apply equally to the four hoists in the Containment Building.

2.3.3 Other Areas [NUREG-0612, Article 5.1.5]

(1) "If safe shutdown equipment are beneath or directly adjacent to a potential travel load path of overhead handling systems, (i.e., a path not restricted by limits of crane travel or by mechanical stops or electrical interlocks) one of the following should be satisfied in addition to satisfying the general guidelines of Section 5.1.1:

(a) The crane and associated lifting devices should conform to the single-failure-proof guidelines of Section 5.1.6 of this report;

OR

(b) If the load drop could impair the operation of equipment or cabling associated with redundant or dual safe shutdown paths, mechanical stops or electrical interlocks should be provided to prevent movement of loads in proximity to these redundant or dual safe shutdown equipment. (In this case, credit should not be taken for intervening floors unless justified by analysis.)

OR

(c) The effects of load drops have been analyzed and the results indicate that damage to safe shutdown equipment would not preclude operation of sufficient equipment to achieve safe shutdown. Analyses should conform to the guidelines of Appendix A, as applicable.

(2) "Where the safe shutdown equipment has a ceiling separating it from an overhead handling system, an alternative to Section 5.1.5(1) above would be to show by analysis that the

largest postulated load-handled by the handling system would not penetrate the ceiling or cause spalling that could cause failure of the safe shutdown equipment."

A. Summary of Applicant's Statements

The other area monorails and cranes which may affect equipment required for Reactor Shutdown, core decay heat removal or spent fuel pool cooling are listed in Table 2.1. The following related information presents data relative to control of the risk.

The Pump Room, Charging Pump and Diesel Generator monorails could potentially drop loads that could damage a safe shutdown system. However, the system would be inoperative for maintenance purposes. The monorails are used for maintenance only so plant safe shutdown capability or decay heat removal could not be defeated by a load drop on a component which is being serviced. The monorails are:

- physically incapable of carrying heavy loads over other equipment required for plant safe shutdown
- there is sufficient physical separation between redundant systems to preclude damage to both.

Technical specifications require one redundant system to be operative in order to remove the other from service for maintenance.

The Component Cooling Water Pump Monorail loads drop could damage a CCW pump, heat exchanger or piping. One redundant

A or B system is required. A "worst case" drop study shows that there is sufficient separation to preclude damage to both redundant systems.

The Unit No. 1 and Unit No. 2 Turbine Gantry Cranes can operate on the Unit No. 2 Turbine Building. Potential load drop risks exist for St. Lucie 2 from a load drop from Unit No. 1 over the steam trestle and a drop from No. 2 over buried intake cooling water pipes. Interlocks are provided to prevent crane travel over the steam trestle because it contains vital auxiliary feedwater pumps and isolation valves. Operational verification of the interlocks are made prior to initial use each shift. By-passing of interlocks is permitted during cold shutdown and refueling modes, or on special occasion with Facility Review Group approval. Interlock restoration requires functional verification.

The Unit No. 2 load drop risk to the two 30 inch diameter ICW pipes has been given special study. One area is at risk with very heavy loads and specific drop orientations. Conceivable movements of loads greater than 5 tons is restricted by area identification and load path to prevent such drops. Deviations require Facility Review Group approval, and Engineering determinations of precautions, rigging and load path. Also, interim requirements and general guidelines of NUREG 0612 have been adopted for operation of Turbine Gantry Cranes.

The Intake Structure Building Crane loads introduce risk to the A, B, and C Intake Cooling Water Pumps: one is required for safe shutdown or decay heat removal. A "Worst Case" study compared energy of a maximum load drop to design missile energy from tornado missile protection structure which encloses the ICW pump. The study shows the structure will preserve the integrity of the ICW pumps from a load drop. In addition, the interim requirements and general

guideline of NUREG 0612 will be implemented. This includes a safe load path restricting crane operation over the ICW pumps.

The Reactor Building Polar Crane and Auxiliary telescoping jib cranes are used during cold shutdown and refueling. The cooling system piping must remain functional and is at risk. The majority of the piping is inside the secondary shield wall below the 4 foot thick operating deck or inside an 11 foot deep pipe trench in base concrete. The piping is considered adequately protected. In the piping penetration area on the south side, the pipes exit the trench and secondary shield wall confines and penetrate the steel containment vessel. Protection exists by two levels of structural steel floor framing. However, load handling is restricted to the designated safe load paths. NUREG 0612 general guidelines and interim requirements have been adopted.

B: EG&G Evaluation

The Pump Room, Charging Pump and Diesel Generator monorails loads handled are over inoperative equipment. Since the loads can't be handled over equipment required for shutdown because there is adequate physical separation of redundant systems to preclude damage to both the hazard elimination is consistent with guidelines.

The Component Cooling Water Pump Monorail worst case load drop study indicates sufficient physical separation to introduce no unacceptable risk. This is consistent with guideline 5.1.5 1(c) requirements.

The Unit No. 1 and Unit No. 2 Turbine Gantry Cranes have dual considerations. The Unit No. 1 has interlocks to preclude load passage over the auxiliary feedwater pumps.