Enclosure

(DRAFT)

TECHNICAL EVALUATION REPORT

CONTROL OF HEAVY LOADS (C-10)

SOUTHERN CALIFORNIA EDISON COMPANY

SAN ONOFRE NUCLEAR GENERATING STATION UNIT 1

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FOREWORD

This Technical Evaluation Report was prepared by Franklin Research Center under a contract with the U.S. Nuclear Regulatory Commission (Office of Nuclear Reactor Regulation, Division of Operating Reactors) for technical assistance in support of NRC operating reactor licensing actions. The technical evaluation was conducted in accordance with criteria established by the NRC.

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nuclear power plants are designed and operated so 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, Sections 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 (1) 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 (2) 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.

The approach used to develop the staff guidelines for minimizing the potential for a load drop was based on defense-in-depth and the intent of the guidelines is to ensure that licensees of all operating nuclear power plants perform the following:

1. provide sufficient operator training, handling system design, load handling instructions, and equipment inspection to assure reliable operation of the handling system
2. define safe load travel paths through procedures and operator training so that, to the extent practical, heavy loads are not carried over or near irradiated fuel or safe shutdown equipment
3. provide mechanical stops or electrical interlocks to prevent movement of heavy loads over irradiated fuel or in proximity to equipment associated with redundant shutdown paths.

Staff guidelines resulting from the foregoing are tabulated in Section 5 of NUREG-0612. Section 6 of NUREG-0612 recommended that a program be initiated to ensure that these guidelines are implemented at operating plants.

1.3 PLANT-SPECIFIC BACKGROUND

On December 22, 1980, the NRC issued a letter [3] to Southern California Edison Company, the Licensee for San Onofre Unit 1, requesting that the Licensee review provisions for handling and control of heavy loads, evaluate

1. INTRODUCTION

1.1 PURPOSE OF REVIEW

This technical evaluation report documents an independent review of general load handling policy and procedures at Southern California Edison Company's San Onofre Nuclear Generating Station Unit 1. This evaluation was performed with the following objectives:

- o to assess conformance to the general load handling guidelines of NUREG-0612, "Control of Heavy Loads at Nuclear Power Plants" [1], Section 5.1.1
- o to assess conformance to the interim protection measures of NUREG-0612, Section 5.3.

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 in these measures. This activity was initiated by a letter issued by the NRC staff on May 17, 1978 [2] to all power reactor licensees, 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-part 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

2. EVALUATION AND RECOMMENDATIONS

The evaluation of load handling at San Onofre Unit 1 is divided into two categories. These categories deal separately with the general guidelines of Section 5.1.1 and the recommended interim protection measures of Section 5.3 of NUREG-0612. Applicable guidelines are referenced in each category. Conclusions and recommendations are provided in the summary for each guideline.

2.1 GENERAL GUIDELINES

The NRC has established seven general guidelines which must be met in order to provide the defense-in-depth approach for the handling of heavy loads. These guidelines consist of the following criteria from Section 5.1.1 of NUREG-0612:

- o Guideline 1 - Safe Load Paths
- o Guideline 2 - Load Handling Procedures
- o Guideline 3 - Crane Operator Training
- o Guideline 4 - Special Lifting Devices
- o Guideline 5 - Lifting Devices (Not Specially Designed)
- o Guideline 6 - Cranes (Inspection, Testing, and Maintenance)
- o Guideline 7 - Crane Design.

These seven guidelines should be satisfied for all overhead handling systems that handle heavy loads in the vicinity of the reactor vessel, near spent fuel in the spent fuel pool, or in other areas where a load drop may damage safe shutdown systems. The Licensee's verification of the extent to which these guidelines have been satisfied and the evaluation of that verification are contained in the succeeding paragraphs.

2.1.1 NUREG-0612, Heavy Load Overhead Handling Systems

a. Summary of Licensee Statements and Conclusions

The Licensee has stated that fixed overhead handling systems of sufficient capacity to be of interest at San Onofre Unit 1 include:

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. On February 5, 1982, Southern California Edison Company provided the initial response [4] to this request. Subsequent information was provided on February 22, 1982 [5], April 1, 1982 [6], April 9, 1982 [7], and May 10, 1982 [8].

- reactor service crane
- turbine gantry crane
- spent fuel bridge crane
- new fuel bridge crane
- diesel generator building
- monorail crane.

A review has indicated that the only heavy load handling systems which have the potential to drop a load on spent fuel or equipment required to achieve and maintain the conditions for residual heat removal (RHR) system operation are the reactor service crane, the turbine gantry crane, and the spent fuel pit bridge crane.

b. Evaluation

As discussed in Section 1.2, the NRC objective is to achieve a defense-in-depth approach for the handling of heavy loads which is to be accomplished in two distinct phases:

- First Phase: Overall improvement of procedures, training, and maintenance of cranes and lifting devices, as well as the establishment of safe travel paths which avoid irradiated fuel and safe shutdown equipment, as means to assure reliable operation of handling systems.
- Second Phase: Implementation of additional safeguards by satisfying single-failure-proof crane criteria, installing mechanical or electrical interlocks, or performing analyses that substantiate the Licensee's contention that (1) damage to irradiated fuel will not exceed limits for criticality or release of radioactivity, or (2) damage to dual safe-shutdown systems will not result in a loss of required safety functions.

The intent of the first phase of NUREG-0612 is to ensure that all handling devices operating with heavy loads in the vicinity of irradiated fuel or safe shutdown equipment meet the requirements of the general guidelines, including the criteria for lifting device and crane design, operation and maintenance, and development of safe load pathways. Section 5.1.1 of NUREG-0612 provides general guidelines for safe load handling that will reduce the potential for load drops, even though a single-failure-proof crane is provided or evaluations show that the consequences of postulated load drops are within established limits. These guidelines apply to the load handling devices mentioned above even if detailed structural analyses, interlocks, operating procedures, technical specifications, and physical separation of redundant equipment indicate that a system could still perform its safety function following a load handling accident. A load handling system may be excluded from the general guidelines of NUREG-0612 only if it can be demonstrated that adequate physical separation is provided between the load path and safety-related equipment or irradiated fuel, the capacity of the crane does not meet the plant's heavy load criteria, or the handling device serves a sole purpose lift function in which a load drop will damage only the lifted equipment.

Therefore, on the basis of information provided by the Licensee, the decision to exclude the new fuel bridge crane and the diesel generator building monorail crane from the general guidelines of NUREG-0612 is consistent with the goal of improving load handling reliability by controlling the movement of heavy loads which have the potential to drop and to damage spent fuel and/or equipment required for safe shutdown.

c. Conclusions and Recommendations

The conclusions of the Licensee concerning San Onofre Unit 1 load handling systems are consistent with the guidance outlined in NUREG-0612.

2.1.2 Safe Load Paths [Guideline 1, NUREG-0612, Section 5.1.1(1)]

"Safe load paths should be defined for the movement of heavy loads to minimize the potential for heavy loads, if dropped, to impact irradiated fuel in the reactor vessel and in the spent fuel pool, or to impact safe shutdown equipment. The path should follow, to the extent practical, structural floor members, beams, etc., such that if the load is dropped, the structure is more likely to withstand the impact. These load paths should be defined in procedures, shown on equipment layout drawings, and clearly marked on the floor in the area where the load is to be handled. Deviations from defined load paths should require written alternative procedures approved by the plant safety review committee."

a. Summary of Licensee Statements and Conclusions

The Licensee has stated that safe load paths have been defined for the movement of heavy loads by the reactor service crane, the turbine gantry crane, and the spent fuel pit bridge crane as discussed below:

1. Reactor Service Crane

Restricted areas rather than safe load paths were chosen where possible to minimize interference with maintenance activities. Restricted area coverage varies depending on whether the reactor vessel head is removed. These restricted areas protect cabling and fuel in the reactor vessel from potential load drop damage. The restricted areas are included in the reactor service crane checkout and operation procedure.

The residual heat removal heat exchangers, pumps, and associated piping are protected by 3 to 5 feet of reinforced concrete. These load handling areas are not restricted because the 3- to 5-foot-thick concrete decks will function as a safe load path and will minimize the potential for heavy loads, if dropped, to impact irradiated fuel in the reactor vessel or to impact safe shutdown equipment.

Safe load paths for the reactor vessel head and for the upper internals assembly have been established. The safe load figures wil[l] be included in the special procedure for refueling.

Easily discernible physical boundaries rather than floor markings were chosen because floor markings are often obsured by protective coverings and maintenance activities. In addition, because the reactor service crane is pendant-operated, crane grid positions may not be as easily usable as in cab-controlled cranes.

2. Turbine Gantry Crane

The area to the west of the western rail of the turbine gantry crane contains some piping and cabling associated with shutdown systems. Drops inside of the rail are unlikely to cause interaction with systems required for shutdown.

The area under the turbine deck to the south of the turbine generat[or] contains no equipment or cabling required for normal plant shutdown and cooldown.

The area under the turbine deck between the containment sphere and the high pressure turbine (north deck extension) contains many pipi[ng] and cabling runs associated with systems required for shutdown, including auxiliary and main feedwater piping, main steam lines, RH[R] cabling, and changing pump cabling.

In order to ensure that equipment required for shutdown of the plant is not damaged by accidental load drops, turbine gantry crane load handling will be restricted in use to the safe load path area and load paths in the north deck extension area. Miscellaneous lighting will be permitted over the north turbine deck extension following, to the extent practical, structural floor members, beams, etc. such that if a load is dropped, the structure is more likely to withstand the impact. The restricted areas of operation are included in a proposed turbine gantry crane checkout and operation procedure.

3. Spent Fuel Pit Bridge Crane

San Onofre Unit 1 Technical Specification 3.8.B.1 currently prohibits loads in excess of 1500 pounds from traveling over fuel assemblies in the storage pool. The only heavy load lifted by the spent fuel pit bridge crane is the gate separating the transfer mechanism area from the spent fuel area.

Deviations from the load paths and the restricted areas described above will only be made using procedures approved by the on-site review committee.

b. Evaluation

The designation of safe load paths inside the containment for the reactor vessel head and the upper internals is consistent with Section 5.1.1(1) of NUREG-0612. Furthermore, while the designation of restricted areas partially addresses the goal of minimizing the severity of postulated load drop accidents, generic safe load paths should also be defined for such heavy loads as the inservice inspection tool, reactor coolant pumps, and missile shields. As long as the reactor vessel is fueled, controls should be imposed to minimize the movement of heavy loads over the vessel.

Although the north deck extension in the turbine building has been designated a safe load path area, the material provided by the Licensee is insufficient to determine the adequacy of the safe load paths. Also, since the turbine building crane is a cantilever gantry, the area to the west of the western rail which contains piping and equipment associated with safe shutdown systems should be evaluated for compliance with Section 5.1.1(1) of NUREG-0612.

Since the only area of concern relative to the movement of heavy loads in the spent fuel storage area is spent fuel in the storage pool, designation of the storage pool as a restricted area for the movement of loads in excess of 1500 lb is consistent with Guideline 1 of NUREG-0612.

While physical boundaries provide a method of identifying safe load paths and restricted areas, this method does not completely meet the intent of NUREG-0612. Visual aids should be provided to crane operators and their supervisors as a means to monitor the proper execution of load handling evolutions and to clearly identify those areas where the movement of heavy loads will occur. In addition, load path visual aids will alert personnel not involved in load handling to keep these pathways clear of non-related equipment in order to avoid interference when load handling is in progress.

The handling of deviations from designated load paths and restricted areas meets the intent of NUREG-0612.

c. Conclusions and Recommendations

San Onofre Unit 1 partially complies with Guideline 1 of NUREG-0612. In order to fully comply, the following Licensee action is required:

1. Define safe load paths for the movement of heavy loads inside the containment to minimize the potential for heavy loads, if dropped, to impact irradiated fuel in the reactor vessel or to impact safe shutdown equipment.

2. Provide equipment layout drawings of the turbine building north deck extension which identify safe load paths and the associated safe shutdown equipment.

3. Re-examine the need for controlled areas for heavy load movement west of the western rail of the turbine gantry crane.

4. Verify that safe load paths and restricted areas are identified by visual aids in areas where loads are handled.

2.1.3 Load Handling Procedures [Guideline 2, NUREG-0612, Section 5.1.1(2)]

"Procedures should be developed to cover load handling operations for heavy loads that are or could be handled over or in proximity to irradiated fuel or safe shutdown equipment. At a minimum, procedures should cover handling of those loads listed in Table 3-1 of NUREG-0612. These procedures should include: identification of required equipment; inspections and acceptance criteria required before movement of load; the steps and proper sequence to be followed in handling the load; defining the safe path; and other special precautions."

a. Summary of Licensee Statements and Conclusions

The Licensee has provided tables which summarize heavy loads handled by the turbine gantry crane, the spent fuel bridge crane, and the reactor service crane. Safety classes define when the lifts are made with respect to the vessel head being in place or removed, fueled or defueled.

Safety Class 1: Loads greater than the weight of a fuel assembly (about 1500 lb) that must be carried over fuel in an open reactor vessel.

Safety Class 2: Loads greater than 1500 lb that could be lifted and removed by the containment crane when the head is off and the fuel is in the reactor vessel, but that are not required to be moved over the reactor vessel.

Safety Class 3: Loads greater than 1500 lb that are normally lifted only when the reactor vessel head is in place or when the reactor is defueled.

b. Evaluation

Although the Licensee has provided a listing of loads and the respective handling procedures, insufficient information has been provided to determine whether the procedures contain the detail required by Section 5.1.1(2) of NUREG-0612, specifically:

1. Identification of required equipment
2. Inspection and acceptance criteria required before movement of the load
3. Steps and proper sequence of load handling
4. Safe load path
5. Special precautions.

In addition, while the load handling safety classes may detail handling restrictions, load clarification is only a part of the administrative controls required to ensure load handling safety and reliability.

c. Conclusions and Recommendations

Insufficient information has been provided to determine if the administrative controls of load handling at San Onofre Unit 1 meet the intent of this guideline. The Licensee should verify that load handling procedures used comply with Section 5.1.1(2) of NUREG-0612.

2.1.4 Crane Operator Training [Guideline 3, NUREG-0612, Section 5.1.1(3)]

"Crane operators should be trained, qualified and conduct themselves in accordance with Chapter 2-3 of ANSI B30.2-1976 'Overhead and Gantry Cranes' [9]."

a. Summary of Licensee Statements and Conclusions

The Licensee has stated that crane operator and rigging training programs at San Onofre Unit 1 satisfy the intent of ANSI B30.2-1976 and NUREG-0612, with no deviations.

b. Evaluation

Operator training at San Onofre Unit 1 is consistent with the intent of Section 5.1.1(3) of NUREG-0612 on the basis of their full compliance to ANSI B30.2-1976.

c. Recommendations and Conclusions

San Onofre Unit 1 complies with Guideline 3 on the basis of the Licensee's certification that the operator training program is in accordance with ANSI B30.2-1976.

2.1.5 Special Lifting Devices [Guideline 4, NUREG-0612, Section 5.1.1(4)]

"Special lifting devices should satisfy the guidelines of ANSI N14.6-1978, 'Standard for Special Lifting Devices for Shipping Containers Weighing

10,000 Pounds (4500 kg) or More for Nuclear Materials' [10]. This standard should apply to all special lifting devices which carry heavy loads in areas as defined above. For operating plants certain inspections and load tests may be accepted in lieu of certain material requirements in the standard. In addition, the stress design factor stated in Section 3.2.1.1 of ANSI N14.6 should be based on the combined maximum static and dynamic loads that could be imparted on the handling device based on characteristics of the crane which will be used. This is in lieu of the guideline in Section 3.2.1.1 of ANSI N14.6 which bases the stress design factor on only the weight (static load) of the load and of the intervening components of the special handling device."

a. Summary of Licensee Statements and Conclusions

The Licensee has stated that four special lifting devices are used at San Onofre Unit 1 to lift the reactor vessel head, the upper internals assembly, the core barrel, and the inservice inspection tool. Detailed information concerning these lifting devices has been requested but is not yet available. When the information does become available, comaparison to ANSI N14.6-1978 will be limited to Section 3.2 and Section 5 for the following reasons:

1. The devices listed above were designed prior to both the adoption of ANSI N14.6-1978 and the NRC's decision (NUREG-0612) to apply the standard to these types of devices. There are a number of sections in the standard that are difficult to apply in retrospect: Designer's Responsibilities (Section 3.1), Design Considerations (Section 3.3), Fabricator's Responsibilities (Section 4.1), Inspector's Responsibilities (Section 4.2), and Fabrication Considerations (Section 4.3).

2. Section 1.0 (Scope), Section 2.0 (Definitions), Section 3.4 (Design Considerations to Minimize Decontamination Effects in Special Lifting Device Use), Section 3.5 (Coatings), and Section 3.6 (Lubricants) are not pertinent to load handling reliability.

3. Section 6 is applicable to lifting devices used for critical loads. None of the loads lifted using the lifting rigs identified above has as yet been determined to be a critical load.

b. Evaluation

The Licensee's response that the following sections of ANSI N14.6-1978 are not applicable or pertinent to special lifting devices as San Onofre Unit 1 is consistent with the intent of Section 5.1.1(4) of NUREG-0612 for the reasons indicated below:

1. Section 1.0 (Scope), Section 2.0 (Definitions), Section 3.4 (Design Considerations to Minimize Decontamination Effects in Special Lifting Device Use), Section 3.5 (Coatings), and Section 3.6 (Lubricants) are not directly related to load handling reliability.

2. Section 4 (Fabrication) is difficult to apply in retrospect and need not be addressed since these lifting devices were manufactured prior to the imposition of ANSI N14.6-1978.

3. Section 6 (Special Lifting Devices for Critical Loads) need not be addressed pending completion of analysis and determination of secific critical loads at San Onofre Unit 1.

Insufficient information has been provided to evaluate special lifting devices at San Onofre Unit 1 against ANSI N14.6-1978 criteria detailed in Section 3.2 (Design Criteria) and Section 5 (Acceptance Testing, Maintenance, and Assurance of Continued Compliance). Further, the Licensee's conclusion that Section 3.1 (Designer's Responsibilities) and Section 3.3 (Design Considerations) are too difficult to apply in retrospect does not meet the intent of NUREG-0612. Verification of the criteria listed in these sections should include evidence that the information required in Section 3.1 is available and that the design considerations of Section 3.3 have been complied with for existing lifting devices. The Licensee's review of ANSI N14.6-1978 Sections 3.1, 3.2, 3.3, and Section 5 should specifically address the following items:

<u>Section 3.1</u>:

a. limitations on the use of the lifting devices (3.1.1)
b. identification of critical components and definition of critical characteristics (3.1.2)
c. signed stress analyses which demonstrate appropriate margins of safety (3.1.3)
d. indication of permissible repair procedures (3.1.4)

<u>Section 3.2</u>:

a. use of stress design factors of 3 for minimum yield strength and 5 for ultimate strength (3.2.1)
b. similar stress design factors for load bearing pins, links, and adapters (3.2.4)
c. slings used comply with ANSI B30.9-1971 (3.2.5)
d. subjecting materials to dead weight testing or Charpy impact testing (3.2.6)

Section 3.3:

a. consideration of problems related to possible lamellar tearing (3.3.1)
b. design shall assure even distribution of the load (3.3.4)
c. retainers fitted for load-carrying components which may become inadvertently disengaged (3.3.5)
d. verification that remote actuating mechanisms securely engage or disengage (3.3.6)

Section 5.1:

a. implementation of a periodic testing schedule and a system to indicate the date of expiration (5.1.3)
b. provisions for establishing operating procedures (5.1.4)
c. identification of subassemblies which may be exchanged (5.1.5)
d. suitable markings (5.1.6)
e. maintaining a full record of history (5.1.7)
f. conditions for removal from service (5.1.8)

Section 5.2:

a. load test to 150% and appropriate inspections prior to initial use (5.2.1)
b. qualification of replacement parts (5.2.2)

Section 5.3:

a. satisfying annual load test or inspection requirements (5.3.1)
b. testing following major maintenance (5.3.2)
c. testing after application of substantial stresses (5.3.4)
d. inspections by operating (5.3.6) and non-operating or maintenance personnel (5.3.7)

c. Conclusions and Recommendations

Insufficient information has been provided to determine the compliance of special lifting devices at San Onofre Unit 1 to Guideline 4 of NUREG-0612. The Licensee should review special lifting devices at San Onofre Unit 1 for compliance with ANSI N14.6-1978 criteria listed above.

2.1.6 Lifting Devices (Not Specially Designed) [Guideline 5, NUREG-0612, Section 5.1.1(5)]

"Lifting devices that are not specially designed should be installed and used in accordance with the guidelines of ANSI B30.9-1971, 'Slings' [11]. However, in selecting the proper sling, the load used should be the sum of the static and maximum dynamic load. The rating identified on the sling should be in terms of the 'static load' which produces the maximum static and dynamic load. Where this restricts slings to use on only certain cranes, the slings should be clearly marked as to the cranes with which they may be used."

a. Summary of Licensee Statements and Conclusions

The Licensee has stated that lifts requiring slings will utilize slings chosen in accordance with ANSI B30.9-1971.

b. Evaluation

The Licensee has not provided sufficient information to demonstrate that the following requirements of Guideline 5 are satisfied:

1. slings are installed and used in accordance with ANSI B30.9-1971
2. load rating of the sling is based upon the maximum static and dynamic loads
3. slings are marked with the static load which produces the maximum static and dynamic loads
4. slings restricted in use to certain cranes are clearly marked to so indicate.

c. Conclusions and Recommendations

San Onofre Unit 1 does not comply with Guideline 5. In order to comply, the Licensee should verify that:

1. slings are installed and used in accordance with ANSI B30.9-1971
2. the load used in selecting and marking the proper sling is based on the sum of the maximum static and dynamic loads
3. slings restricted in use to certain cranes are clearly marked to so indicate.

2.1.7 Cranes (Inspection, Testing, and Maintenance) [Guideline 6, NUREG-0612, Section 5.1.1(6)]

"The crane should be inspected, tested, and maintained in accordance with Chapter 2-2 of ANSI B30.2-1976, 'Overhead and Gantry Cranes,' with the exception that tests and inspections should be performed prior to use where it is not practical to meet the frequencies of ANSI B30.2 for periodic inspection and test, or where frequency of crane use is less than the specified inspection and test frequency (e.g., the polar crane inside a PWR containment may only be used every 12 to 18 months during refueling operations, and is generally not accessible during power operation. ANSI B30.2, however, calls for certain inspections to be performed daily or monthly. For such cranes having limited usage, the inspections, test, and maintenance should be performed prior to their use)."

a. Summary of Licensee Statements and Conclusions

The Licensee has stated that crane inspection, maintenance, and testing requirements of existing procedures were compared to the requirements of ANSI B30.2-1976, Chapter 2-2. Modifications to procedures and inclusion of daily operation and safety checks in the proposed reactor service crane and turbine gantry crane checkout and operation procedures brought overall crane inspection, maintenance, and testing requirements into compliance with ANSI B30.2-1976, Chapter 2-2, with two exceptions:

1. ANSI B30.2-1976, Chapter 2-2 requires full traverse of both the bridge/gantry and the trolley when load-testing cranes. The traverses are intended to test the bridge/gantry rails and spanning girders. However, evidence presented in NUREG-0612 suggests that failures of this nature are not significant contributors to historical crane failure rates. In addition, heavy loads are not usually handled at all extremes of hoist position. Therefore, load tests will not always be conducted for all bridge/gantry and trolley positions. Positions affected by extensive repair and/or alteration, however, will be load-tested.

2. The turbine gantry crane is not tested to 125% of rated load. The crane was originally rated at 115 tons, but the rating was adjusted to 100 tons when the crane manufacturer did not recommend proof load testing to 125% of 115 tons as required by CAL OSHA standards adopted in the 1970s. The crane is currently certified by the state of California by lifting the heaviest load it is required to lift - the generator rotor, which weighs 108 tons.

b. Evaluation

San Onofre Unit 1 substantially meets the intent of Section 5.1.1(6) of NUREG-0612 based on certification of compliance to ANSI B30.2-1976 with the exception of satisfying rated load test requirements.

The Licensee's contention that load handling failures at the extremes of bridge/gantry or trolley travel are not significant contributions to load handling failure rates is not adequate justification to limit the extent of crane load testing. However, physical restrictions to load travel, such as mechanical stops which prevent load travel in certain bridge/gantry or trolley locations, could certainly be considered a reasonable rationale to exclude testing in those areas.

Further, considering that the turbine gantry crane appears to be designed to lift the 115-ton turbine spindle, it is unclear why the manufacturer did not recommend the proof load test of 125% of 115 tons as required by ANSI B30.2-1976. Although the crane is currently certified by the state of California to lift the 108-ton generator rotor, this load testing is not consistent with the guidance of Section 5.1.1(6) of NUREG-0612.

c. Conclusions and Recommendations

San Onofre Unit 1 substantially complies with Guideline 6 of NUREG-0612 with the exception of certain aspects of rated load testing. In order to fully comply with this guideline, the Licensee should provide additional information:

1. Substantiate the location restriction of the bridge/gantry and trolley for load testing

2. Clarify the basis of the turbine gantry crane load test criteria.

2.1.8 Crane Design [Guideline 7, NUREG-0612, Section 5.1.1(7)]

"The crane should be designed to meet the applicable criteria and guidelines of Chapter 2-1 of ANSI B30.2-1976, 'Overhead and Gantry Cranes,' and of CMAA-70, 'Specifications for Electric Overhead Traveling Cranes' [12]. An alternative to a specification in ANSI B30.2 or CMAA-70 may be accepted in lieu of specific compliance if the intent of the specification is satisfied."

a. Summary of Licensee Statements and Conclusions

The Licensee has stated that the San Onofre Unit 1 turbine gantry and reactor service cranes were built prior to the issuance of ANSI B30.2-1976 and CMAA-70-1975. The cranes were procured, designed, and fabricated by P & H Hornischfeger in accordance with the criteria of Bechtel Power Corporation Specification B30-254 of April 17, 1964. The cranes were designed to the governing criteria in EOCI-61. The Licensee has further stated that as a result of an evaluation of crane design, the reactor service and turbine gantry cranes meet the requirements of CMAA-70 and ANSI B30.2-1976, with the exception of the bridge and trolley stops.

b. Evaluation

The design of the turbine gantry and reactor service cranes substantially meets the requirements of NUREG-0612, Section 5.1.1(7) on the basis of certification by the Licensee of compliance with EOCI-61. However, several more restrictive design requirements were imposed by CMAA-70 which could affect the crane's ability to safely handle heavy loads. The recommendations of CMAA-70 have been compared with those of EOCI 61 and several areas have been identified where revisions incorporated into CMAA-70 may affect crane safety. The Licensee should address the following issues to determine whether the intent of NUREG-0612 is satisfied:

1. Torsional forces. CMAA-70, Article 3.3.2.1.3 requires that twisting moments due to overhanging loads and lateral forces acting eccentric to the horizontal neutral axis of a girder be calculated on the basis of the distance between the center of gravity of the load, or force center line, and the girder shear center measured normal to the force vector. EOCI-61 states that such moments are to be calculated with reference to the girder center of gravity. For girder sections symmetrical about each principal central axis (e.g., box section or I-beam girders commonly used in cranes subject to this review), the shear center coincides with the centroid of the girder section and there is no difference between the two requirements. Such is not the case for nonsymmetrical girder sections (e.g., channels).

2. Longitudinal stiffeners. CMAA-70, Article 3.3.3.1 specifies (1) the maximum allowable web depth/thickness (h/t) ratio for box girders using longitudinal stiffeners and (2) requirements concerning the location and minimum moment of inertia for such stiffeners. EOCI-61 allows the use of longitudinal stiffeners but provides no similar guidance. The requirements of CMAA-70 represent a codification of girder design practice and they are expected to be equivalent to design standards employed in cranes built to EOCI-61 specifications.

3. Allowable compressive stress. CMAA-70, Article 3.3.3.1.3 identifies allowable compressive stresses of approximately 50% of yield strength of the recommended structural material (A-36) for girders, where the ratio of the distance between web plates to the thickness of the top cover plate (b/c ratio) is less than or equal to 38. Allowable compressive stresses decrease linearly for b/c ratios in excess of 38. EOCI-61 provides a similar method for calculating allowable compressive stresses except that the allowable stress decreases from approximately 50% of yield only after the b/c ratio exceeds 41. Consequently, structural members with b/c ratios in the general range of 38 to 52 designed under EOCI-61 will allow a slightly higher compressive stress than those designed under CMAA-70. This variation is not expected to be of consequence for cranes subject to this review since b/c ratios of structural members are expected to be less than 38.

4. Fatigue considerations. CMAA-70, Article 3.3.3.1.3 provides substantial guidance with respect to fatigue failure by indicating allowable stress ranges for various structural members in joints under repeated loads. EOCI-61 does not address fatigue failure. The requirements of CMAA-70 are not expected to be of consequence for cranes subject to this review since the cranes are not generally subjected to frequent loads at or near design conditions (CMAA-70 provides allowable stress ranges for loading cycles in excess of 20,000) and are not generally subjected to stress reversal (CMAA-70 allowable stress range is reduced to below the basic allowable stress for only a limited number of joint configurations).

5. Hoist rope requirements. CMAA-70, Article 4.2.1 requires that the capacity load plus the bottom block divided by the number of parts of rope not exceed 20% of the published rope breaking strength. EOCI-61 requires that the rated capacity load divided by the number of parts of rope not exceed 20% of the published rope breaking strength. The effect of this variation on crane safety margins depends on the ratio of the weights of the load block and the rated load.

6. Drum design. CMAA-70, Article 4.4.1 requires that the drum be designed to withstand combined crushing and bending loads. EOCI-61 requires only that the drum be designed to withstand maximum load, bending and crushing

loads, with no stipulation that these loads be combined. This variation is not expected to be of consequence since the requirements of CMAA-70 represent the codification of the same good engineering practice that would have been incorporated in cranes built to EOCI-61 specifications although a specific requirement was not contained in EOCI-61.

7. Drum design. CMAA-70, Article 4.4.3 provides recommended drum groove depth and pitch. EOCI-61 provides no similar guidance. The recommendations in CMAA-70 constitute a codification of good engineering practice with regard to reeving stability and reduction of rope wear and are not expected to differ substantially from practices employed in the design of cranes subject to this review and built to EOCI-61 specifications.

8. Gear design. CMAA-70, Article 4.5 requires that gearing horsepower rating be based on certain American Gear Manufacturers Association Standards and provides a method for determining allowable horsepower. EOCI-61 provides no similar guidance. The recommendations in CMAA-70 constitute a codification of good engineering practice for gear design and are not expected to differ substantially from the practices employed in the design of cranes subject to this review and built to EOCI-61 specifications.

9. Bridge brake design. CMAA-70, Article 4.7.2.2 requires that bridge brakes, for cranes with cab control and the cab on the trolley, be rated at least 75% of bridge motor torque. EOCI-61 requires a brake rating of 50% of bridge motor torque for similar configurations. A cab-on-trolley control arrangement is not expected for cranes subject to this review.

10. Hoist brake design. CMAA-70, Article 4.7.4.2 requires that hoist holding brakes, when used with a method of a control braking other than mechanical, have torque ratings no less than 125% of the hoist motor torque. EOCI-61 requires a hoist holding brake torque rating of no less than 100% of the hoist motor torque without regard to the type of control brake employed.

This variation is not expected to be of consequence for cranes subject to this review since mechanical load brakes were typically specified for cranes built to EOCI-61 specifications. The addition of a holding brake safety margin in conjunction with electric control braking is a codification of good engineering practice. Some manufacturers provide holding brakes rated at up to 150% of hoist motor torque when used with electrical control braking systems.

11. Bumpers and stops. CMAA-70, Article 4.12 provides substantial guidance for the design and installation of bridge and trolley bumpers and stops for cranes which operate near the end of bridge and trolley travel. No similar guidance is provided in EOCI-61. This variation is not expected to be of significance for cranes subject to this review since these cranes are not expected to be operated under load at substantial bridge or trolley speed near the end of travel. Further, the guidance of CMAA-70 constitutes the codification of the same good engineering practice that would have been used in the design of cranes built to EOCI-61 specifications.

12. Static control systems. CMAA-70, Article 5.4.6 provides substantial guidance for the use of static control systems. EOCI-61 provides guidance for magnetic control systems only. This variation is not expected to be of safety significance because magnetic control systems were generally employed in cranes designed when EOCI-61 was in effect and the static control requirements identified in CMAA-70 constitute a codification of the same good engineering practice that would have been used in the design of static control systems in cranes built to EOCI-61 specifications.

13. Restart protection. CMAA-70, Article 5.6.2 requires that cranes not equipped with spring-return controllers or momentary-contact pushbuttons be provided with a device that will disconnect all motors upon power failure and will not permit any motor to be restarted until the controller handle is brought to the OFF position. No similar guidance is provided in EOCI-61. This variation is not expected to be of consequence for cranes subject to this review since they are generally designed with spring-return controllers or momentary-contact pushbuttons.

c. Conclusions and Recommendations

The turbine gantry and reactor service cranes at San Onofre Unit 1 comply with Guideline 7 to a substantial degree on the basis of compliance with

EOCI-61 criteria. However, the Licensee should provide information to verify that the following CMAA-70 requirements have been satisfied for cranes subject to this review or provide suitable justification for concluding that these requirements have been satisfied by equivalent means:

1. nonsymmetrical girder sections were not used in construction of the cranes
2. any longitudinal stiffeners in use conform to the requirements of CMAA-70, and allowable h/t ratios in box girders using these stiffeners do not exceed ratios specified in CMAA-70
3. girders with b/c ratios in excess of 38 were not used
4. fatigue failure was considered in crane design and the number of design loading cycles at or near rated load was less than 20,000 cycles
5. maximum crane load weight, plus the weight of the bottom block, divided by the number of parts of rope does not exceed 20% of the manufacturer's published breaking strength
6. drum design calculations were based on the combination of crushing and bending loads
7. drum groove depth and pitch conform to the recommendations of CMAA-70
8. gear horsepower ratings were based on design allowables and calculation methodology equivalent to that incorporated into CMAA-70
9. cab-control, cab-on-trolley configurations were not used
10. mechanical load brakes or hoist holding brakes with torque ratings of approximately 125% of the hoist motor torque were used
11. crane operation under load near the end of the bridge or trolley travel is not allowed or is compensated for by bumpers and stops which satisfy the intent of CMAA-70
12. any static control systems in use conform to the requirements of CMAA-70
13. controllers used were of the spring-return or momentary-contact pushbutton type.

In addition, the Licensee should provide design criteria for the spent fuel bridge crane.

2.2 INTERIM PROTECTION MEASURES

The NRC has established six interim protection measures to be implemented at operating nuclear power plants to provide reasonable assurance that no heavy loads will be handled over the spent fuel pool and that measures exist to reduce the potential for accidental load drops to impact on fuel in the core or spent fuel pool. Four of the six interim measures of the report consist of general Guideline 1, Safe Load Paths; Guideline 2, Load Handling Procedures; Guideline 3, Crane Operator Training; and Guideline 6, Cranes (Inspection, Testing, and Maintenance). The two remaining interim measures cover the following criteria:

1. Heavy load technical specifications
2. Special review for heavy loads handled over the core.

The status of the Licensee's implementation and the evaluation of these interim protection measures are summarized in the succeeding paragraphs of this section.

2.2.1 Technical Specifications [Interim Protection Measure 1, NUREG-0612, Section 5.3(1)]

"Licenses for all operating reactors not having a single-failure-proof overhead crane in the fuel storage pool area should be revised to include a specification comparable to Standard Technical Specification 3.9.7, 'Crane Travel - Spent Fuel Storage Pool Building,' for PWR's and Standard Technical Specification 3.9.6.2, 'Crane Travel,' for BWR's, to prohibit handling of heavy loads over fuel in the storage pool until implementation of measures which satisfy the guidelines of Section 5.1."

a. Evaluation

The Licensee has stated that San Onofre Unit 1 Technical Specification 3.8.B.1 currently prohibits loads in excess of 1500 pounds from traveling over fuel assemblies in the storage pool.

b. Conclusion and Recommendations

San Onofre Unit 1 Technical Specification 3.8.B.1 is consistent with the guidance in Interim Protection Measure 1.

2.2.2 Administrative Controls [Interim Protection Measures 2, 3, 4, and 5, NUREG-0612, Section 5.3(2)-5.3(5)]

"Procedural or administrative measures [including safe load paths, load handling procedures, crane operator training, and crane inspection]... can be accomplished in a short time period and need not be delayed for completion of evaluations and modifications to satisfy the guidelines of Section 5.1 of [NUREG-0612]."

a. Summary of Licensee Statements and Conclusions

Summaries of Licensee statements and conclusions are contained in discussions of the respective general guidelines in Sections 2.1.2, 2.1.3, 2.1.4, and 2.1.7.

b. Evaluation, Conclusions, and Recommendations

The evaluations, conclusions, and recommendations are contained in discussions of the respective general guidelines in Sections 2.1.2, 2.1.3, 2.1.4, and 2.1.7.

2.2.3 Special Reviews for Heavy Loads Over the Core [Interim Protection Measure 6, NUREG-0612, Section 5.3(1)]

"Special attention should be given to procedures, equipment, and personnel for the handling of heavy loads over the core, such as vessel internals or vessel inspection tools. This special review should include the following for these loads: (1) review of procedures for installation of rigging or lifting devices and movement of the load to assure that sufficient detail is provided and that instructions are clear and concise; (2) visual inspections of load bearing components of cranes, slings, and special lifting devices to identify flaws or deficiencies that could lead to failure of the component; (3) appropriate repair and replacement of defective components; and (4) verify that the crane operators have been properly trained and are familiar with specific procedures used in handling these loads, e.g., hand signals, conduct of operations, and content of procedures."

a. Summary of Licensee Statements and Conclusions

The Licensee has stated that there are three lifts which are routinely scheduled over the open reactor vessel when fuel is in the vessel:

1. reactor vessel head
2. upper internals assembly
3. reactor vessel inservice inspection tool.

Each of the four areas addressed in Interim Action 5 (Interim Protection Measure 6 of NUREG-0612) are addressed below:

1. A draft operating procedure for the reactor service crane and draft changes to each edition of the special procedure for refueling have been prepared and are currently being reviewed. The information contained therein addresses the installation of rigging or lifting devices and movement of the load to ensure that sufficient detail is provided and the instructions are clear and concise.

2 Draft revisions to the maintenance and inspection program for cranes have been prepared and are currently being reviewed. The information contained therein includes visual inspection of load bearing components of cranes, slings, and special lifting devices to identify flaws or deficiencies that could lead to failure of the component.

3. Draft revisions to the maintenance and inspection program for cranes have been proposed and are currently being reviewed. The information contained therein addresses repair and replacement of defective components.

4. Draft administrative changes to the crane operation and rigging training programs at San Onofre Unit 1 have been prepared and are currently being reviewed. The information contained therein ensures that crane operators are properly trained and familiar with specific procedures used in handling heavy loads.

b. Evaluation

The Licensee's special review of heavy load handling over the core is consistent with Section 5.3(1) of NUREG-0612 relative to procedures and operator training. The Licensee has previously stated that crane operators are trained in accordance with ANSI B30.2-1976, which meets the intent of NUREG-0612. Further, operating, maintenance, and inspection procedures have been reviewed and revisions are in progress. However, although maintenance and inspection procedures have been revised to provide for visual inspections of load bearing components of cranes, slings, and special lifting devices, there is no indication that these inspections have been performed and any deficiencies corrected.

c. Conclusions and Recommendations

The Licensee has substantially completed the special review of heavy load handling over the core with the exception of addressing the actual performance of the one-time visual inspection of load bearing components of cranes, slings, and special lifting devices. In order to complete this interim action, the Licensee should verify that the visual inspections have been completed and any observed deficiencies corrected.

3. CONCLUDING SUMMARY

This summary is provided to consolidate the conclusions and recommendations of Section 2 and to document the overall evaluation of the handling of heavy loads at San Onofre Unit 1. It is divided into two sections, one dealing with general provisions for load handling at nuclear power plants (NUREG-0612, Section 5.1.1) and the other with the staff recommendations for interim protection, pending complete implementation of the guidelines of NUREG-0612, Section 5.3. In each case, recommendations for additional Licensee action, and additional NRC staff action where appropriate, are provided.

3.1 GENERAL PROVISIONS FOR LOAD HANDLING

The NRC staff has established seven guidelines concerning provisions for handling heavy loads in the area of the reactor vessel, near stored spent fuel, or in other areas where an accidental load drop could damage safe shutdown systems. Compliance with these guidelines is necessary to ensure that load handling system design, administrative controls, and operator training and qualification are such that the possibility of a load drop is very small for the critical functions performed by cranes at nuclear power plants. These guidelines are partially satisfied at San Onofre Unit 1. This conclusion is presented in tabular form as Table 3.1. Specific recommendations for achieving full compliance with these guidelines are provided as follows:

Guideline	Recommendation
1	a. Define safe load paths for the movement of heavy loads inside of containment.
	b. Provide equipment layout drawings which identify safe load paths and the associated safe shutdown equipment located in the north deck extension of the turbine building.
	c. Re-examine the need for controlled areas for heavy load movement west of the western rail of the turbine gantry crane.

Table 3.1 San Onofre Unit 1/NUREG-0612 Compliance Matrix

Heavy Loads	Weight or Capacity (tons)	Guideline 1 Safe Load Paths	Guideline 2 Procedures	Guideline 3 Crane Operator Training	Guideline 4 Special Lifting Devices	Guideline 5 Slings	Guideline 6 Crane - Test and Inspection	Guideline 7 Crane Design	Interim Measure 1 Technical Specifications	Interim Measure 6 Special Attention
1. Reactor Service Crane	110/20	--	--	C	--	--	P	P	--	--
a. RV Head	65	P	P	--	I	--	--	--	--	P
b. Upper Internals Assembly	30	P	P	--	I	--				P
c. Missile Shields	93	NC	P	--	--	I	--	--	--	--
d. Auxiliary Shield	60	NC	P	--	--	I	--	--	--	--
e. Core Barrel	72	NC	P	--	I	--	--	--	--	--
f. CRDM Ventilation Ducts	2.5	NC	P	--	--	I	--	--	--	--
g. Reactor Cavity Seal Ring	10	NC	P	--	--	I	--	--	--	--
h. Sand Tank	23	NC	P	--	--	I	--	--	--	--
i. Stud Tensioners	2	NC	P	--	--	I	--	--	--	--
j. Stud Rack	20	NC	P	--	--	I	--	--	--	--
k. RCP Motor	31	NC	P	--	--	I	--	--	--	--
l. Inserivce Inspection Tool	5	NC	P	--	I	--	--	--	--	P

C = Licensee action complies with NUREG-0612 Guideline.
NC = Licensee action does not comply with NUREG-0612 Guideline.
I = Insufficient information provided by the Licensee.
P = Licensee information indicates partial compliance.
-- = Not applicable.

Table 3.1 (Cont.)

Heavy Loads	Weight or Capacity (tons)	Guideline 1 Safe Load Paths	Guideline 2 Procedures	Guideline 3 Crane Operator Training	Guideline 4 Special Lifting Devices	Guideline 5 Slings	Guideline 6 Crane - Test and Inspection	Guideline 7 Crane Design	Interim Measure 1 Technical Specifications	Interim Measure 6 Special Attention
2. Turbine Gantry Crane	100/25	--	--	C	--	--	P	P	--	--
*a. Turbine Spindle	115	--	--	--	--	I	--	--	--	--
b. New Fuel Container	2.5	P	P	--	--	I	--	--	--	--
c. Spent Fuel Cask (NAC 1)	30	P	P	--	--	I	--	--	--	--
3. Spent Fuel Bridge Crane	2.5	--	--	C	--	--	P	I	--	--
a. Upender Gate	1	C	P	--	--	I	--	--	C	--

*Note that turbine spindle weight is greater than the rated capacity of the turbine gantry crane.

d. Verify that safe load paths and restricted areas are identified by visual aids in areas where loads are handled.

2 Verify that load handling procedures contain the detail specified in Section 5.1.1(2) of NUREG-0612.

3 (San Onofre Unit 1 complies with this guideline.)

4 Compare special lifting devices used at San Onofre Unit 1 to the guidance in ANSI N14.6-1978 and NUREG-0612, Section 5.1.1(4).

5 a. Verify that slings are installed and used in accordance with ANSI B30.9-1971.

b. Verify that the load used in selecting and marking the proper sling is based on the sum of the maximum static and dynamic loads.

c. Verify that slings restricted in use to certain cranes are clearly marked to so indicate.

6 a. Provide additional information to substantiate location restriction for load testing of the bridge/gantry and trolley.

b. Clarify the basis of the turbine gantry crane load test criteria.

7 a. Provide design data for the turbine gantry and reactor service cranes as specified in Section 2.1.8 of this report.

b. Provide design criteria for the spent fuel bridge crane.

3.2 INTERIM PROTECTION

The NRC staff has established certain measures (NUREG-0612, Section 5.3) that should be initiated to provide reasonable assurance that handling of heavy loads will be performed in a safe manner until implementation of the general guidelines of NUREG-0612, Section 5.1 is complete. Specified measures include the implementation of a technical specification to prohibit the handling of heavy loads over fuel in the storage pool; compliance with Guidelines 1, 2, 3, and 6 of NUREG-0612, Section 5.1.1; a review of load handling procedures and operator training; and a visual inspection program, including component repair or replacement as necessary of cranes, slings, and special lifting devices, to eliminate deficiencies that could lead to component failure. The evaluation of information provided by the Licensee indicates that the following actions are necessary to ensure that the staff's measures for interim protection at the San Onofre Unit 1 plant are met:

Interim Measure	Recommendation
1	(San Onofre Unit 1 complies with this interim protection measure.)
2, 3	Implement the recommendations of Guidelines 1 and 2 in Section 3.1.
4	(San Onofre Unit 1 complies with this interim protection measure.)
5	Implement the recommendations of Guideline 6 in Section 3.1.
6	Verify that the visual inspections of load bearing components of cranes, slings, and special lifting devices have been completed and the resulting deficiencies corrected.

3.3 SUMMARY

The NRC's general guidelines and interim protection measures of NUREG-0612 have not been complied with at San Onofre Unit 1. Several programs that comply with NRC staff guidelines have been implemented, including technical specification restrictions and operator training. In order for the Licensee to fully comply with NUREG-0612, Licensee action is required on the remaining general guidelines and interim protection measures.

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