TECHNICAL EVALUATION REPORT

CONTROL OF HEAVY LOADS (C-10)

COMMONWEALTH EDISON COMPANY

QUAD CITIES STATION UNITS 1 AND 2

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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.

Mr. L. H. Sargent and Mr. C. Bomberger contributed to the technical preparation of this report through a subcontract with WESTEC Services, Inc.

1. INTRODUCTION

1.1 PURPOSE OF REVIEW

This technical evaluation report documents a review of general load handling policy and procedures at Commonwealth Edison's Quad Cities Station Units 1 and 2. This evaluation was performed with the following objectives:

- 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
- 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 ensure 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, Section 5.1.1, is to ensure that all load handling systems at

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.

A defense-in-depth approach was used to develop the staff guidelines to ensure that all load handling systems are designed and operated so that their probability of failure is appropriately small. The intent of the guidelines is to ensure that licensees of all operating nuclear power plants perform the following:

- 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
- provide sufficient operator training, handling system design, load handling instructions, and equipment inspection to assure reliable operation of the handling system.

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 Commonwealth Edison, the Licensee for Quad Cities Station, requesting that the Licensee review provisions for handling and control of heavy loads, 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. On May 15, 1981 [4], June 22, 1981 [5], and December 11, 1981 [6], Commonwealth Edison provided responses to this request. As a result of this information, a draft Technical Evaluation Report was prepared and informally transmitted to the Licensee for comment. On February 22, 1982, a telephone conference call involving NRC, FRC, and Commonwealth Edison was held to discuss the draft Technical Evaluation Report concerning control of heavy loads at Quad Cities Station. In response to this telephone call, on May 4, 1982 [7], November 18, 1982 [8], and April 15, 1983 [9], Commonwealth Edison provided additional information that has been incorporated into this final technical evaluation.

2. EVALUATION

This section presents a point-by-point evaluation of load handling provisions at Quad Cities Nuclear Power Station with respect to NRC staff guidelines provided in NUREG-0612. Separate subsections are provided for both the general guidelines of NUREG-0612, Section 5.1.1 and the interim measures of NUREG-0612, Section 5.3. In each case, the guideline or interim measure is presented, Licensee-provided information is summarized and evaluated, and a conclusion as to the extent of compliance, including recommended additional action where appropriate, is presented. These conclusions are summarized in Table 2.1.

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:

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

These seven guidelines should be satisfied for all overhead handling systems and programs in order to 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 FRC's evaluation of this verification are contained in the succeeding paragraphs.

Table 2.1 Quad Cities Units 1 and 2/NUREG-0612 Compliance Matrix

Heavy Loads	Height 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. Units 1/2 Reactor Bldg Cranes	125/9	--	--	C	--	--	C	C	--	--
Reactor Cavity Shield Plugs	110	C	C	--	--	C	--	--	--	C
Drywell Head	65	C	C	--	C	--	--	--	--	C
Dryer Separator Blocks	46	C	C	--	C	--	--	--	--	C
Reactor Vessel Head	96	C	C	--	C	--	--	--	--	C
Steam Dryer	32	C	C	--	C	--	--	--	--	C
Steam Separator	62.5	C	C	--	C	--	--	--	--	C
Refueling "Cattle Chute"	11	C	C	--	--	C	--	--	--	C
TN-9 Cask	100	C	R	--	C	--	--	--	C	C
Misc. Equipment	--	C	C	--	--	C	--	--	--	C
Fuel Pool Gates	0.7	C	C	--	--	C	--	--	C	C
Refuel Pool Slot Plugs	6.5	C	C	--	--	C	--	--	C	--
Vessel Service Platform	5	C	C	--	--	C	--	--	--	--

C = Licensee action complies with the NUREG-0612 Guideline.
R = Licensee has proposed revisions/modifications designed to comply with NUREG-0612 Guideline.

Table 2.1 (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
RV Head Insulation	6	C	C	--	C	--	--	--	--	C
In-Vessel Work Skid	7	C	B	--	--	C	--	--	--	C
New Fuel/ Metal Shipping Container	1.5	C	C	--	--	C	--	--	C	C
Test Weights- Refuel Bridge	0.9	C	B	--	--	C	--	--	--	C
2. Units 1/2 Drywell First Level Monorail	20	--	--	C	--	--	C	--	--	--
Misc. PWR Plant Equipment	--		B	--	--	C	--	--	--	--
3. a. 2nd Floor Jib Crane	2	--	--	C	--	--	C	--	--	--
b. CRD Jib Crane	0.5	--	--	C	--	--	C	--	--	--
c. New Fuel Inspection Stand Jib Crane	0.5	--	--	C	--	--	C	--	--	--
Misc. PWR Plant Equipment	--		B	--	--	C	--	--	--	--

Table 7.1 (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
4. Turbine Bldg Crane										
Unit 1	125/10	--	--	C	--	--	C	C	--	--
Unit 2	175/25	--	--	C	--	--	C	C	--	--
Upper/Lower Turbine Diaphragms	9	C	B	--	--	C	--	--	--	--
Low Pressure Rotor	114	C	B	--	--	--	--	--	--	--
High Pressure Rotor	59	C	B	--	--	--	--	--	--	--
High Pressure Casing	72	C	B	--	--	C	--	--	--	--
Exhaust Hood	28	C	B	--	--	C	--	--	--	--
Inner Casing	51	C	B	--	--	C	--	--	--	--
Generator Rotor	175	C	B	--	--	--	--	--	--	--
Miscellaneous	--	C	B	--	--	C	--	--	--	--
5. Reactor Service Platform Jib Crane Unit 1/2	0.5	--	--	C	--	--	C	--	--	--
Jet Pumps and Misc. Reactor Internals During Repair Work	--	--	C	--	--	C	--	--	--	C

2.1.1 NUREG-0612, Heavy Load Overhead Handling Systems

a. Summary of Licensee Statements and Conclusions

The Licensee has evaluated the load handling systems at Quad Cities Units 1 and 2 and concluded that the following systems should be subject to the general guidelines of NUREG-0612:

- Unit 1 and 2 reactor building overhead crane
- second floor jib crane
- Unit 1 drywell first level monorail
- Unit 2 drywell first level monorail
- new fuel inspection stand jib crane
- CRD repair floor jib crane
- Unit 1 and 2 reactor service platform jib crane
- Unit 1 turbine building overhead crane
- Unit 2 turbine building overhead crane.

Several other overhead handling systems have been excluded from the general guidelines of NUREG-0612 on the basis that either sufficient physical separation exists from safety-related equipment or, in cases where a crane has been provided over a specific piece of equipment solely to aid in its disassembly and reassembly, load drops would affect no equipment or system not already out of commission.

b. Evaluation and Conclusion

The Licensee's conclusions regarding those load handling systems at Quad Cities Station which are subject to the general guidelines for safe load handling are consistent with the intent of 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

An evaluation of Quad Cities Station Units 1 and 2 has been performed by the Licensee to develop safe load paths. Specific load paths have been provided for the drywell and reactor vessel heads, the dryer/separator, and the spent fuel cask. These load paths and the location of spent fuel and safety-related equipment have been identified and provided in appropriate sketches [5]. In the case of other miscellaneous loads carried by the reactor building main and auxiliary hoists, the safe load path has been specified as the shortest route, without travelling over spent fuel in the fuel pools or the reactor cavity, and the lowest practical height from lift point to laydown area. This requirement has been incorporated into appropriate procedures, and its implementation will be under the direction of a signalman, as discussed below concerning load path marking. This approach to safe load paths for miscellaneous loads is appropriate since the reactor building refueling floor has been designed for a live load of 1000 lb/ft^2 and the reactor building crane meets the single-failure criteria of Branch Technical Position APCSB 9-1 as indicated in the staff's Safety Evaluation Report, Docket Nos. 50-254 and 50-265, dated January 27, 1977.

Due to the configuration and the number of load paths, marking the paths on the floor is generally not feasible, nor would it contribute to health and safety of plant personnel or the public. Crane operators at Quad Cities Station move the heavy loads shown on MS-165 (Sheet 2) under the direction of an appropriate signalman whose responsibilities will be defined in a procedure currently being written. Existing procedures are being revised to reflect this administrative requirement.

The Licensee has stated that deviations from load handling procedures are reviewed and approved according to station Technical Specifications.

b. Evaluation

A review of the Licensee's response and drawings indicates that the alternative methods of controlling load movement used at the Quad Cities plant are consistent with the guidance in NUREG-0612 Section 5.1.1(1).

The Licensee has designated the reactor vessel and spent fuel pool areas as restricted areas for the 9-ton auxiliary hook. By limiting lifts with the 9-ton hook to 7 feet in other areas, the Licensee can ensure that no damage will occur to equipment located below the refueling floor. In addition, to the extent practical, the reactor building crane main hoist has been found to be a single-failure-proof lifting device. The movement of the 100-ton spent fuel cask is specially controlled by operating the reactor building crane in the restricted mode, which limits the cask's travel path to a specific controlled area. Therefore, the movement of heavy loads along designated safe load paths on the refueling floor meets the intent of NUREG-0612.

Although specific safe load paths have not been defined for the second floor jib crane, the new fuel inspection stand jib crane, the CRD repair floor jib crane, and the Units 1 and 2 reactor service platform jib crane, the limited areas covered by these cranes are adequately controlled by procedures. In addition, safe load paths for the drywell first level monorails are defined by the physical location of the supporting rails.

The turbine building cranes are identified by area of coverage. Considering the size of the loads, the limited frequency of handling, and the use of specific load handling procedures, control of load movement in the turbine building meets the intent of NUREG-0612.

Although safe load paths are not marked at the Quad Cities plant, the objective of providing a visual aid for operators is accomplished by having load handling supervisors present with procedures to guide the crane operator. In addition, the duties of these supervisors/foremen relative to safe load handling will be clearly defined in procedures currently being developed by the Licensee.

Station Technical Specifications indicate that deviations from load handling procedures are reviewed and approved by the plant safety review committee.

c. Conclusion

Quad Cities Units 1 and 2 comply with Guideline 1 of NUREG-0612.

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

A detailed list of heavy loads and procedures governing the handling of each load has been supplied by the Licensee, who states that these procedures, either implemented or under development, meet the intent of Section 5.1.1(2) of NUREG-0612 and generally include sections such as equipment description, purpose, references, initial conditions, and appropriate precautions or limitations. Although most of the loads are governed by these procedures, the Licensee notes that all loads will be handled under a generic rigging practices procedure that is currently being developed as a result of the review of NUREG-0612. This procedure will prohibit handling of loads over spent fuel in the fuel pools or over the open reactor cavity when fuel is in the reactor unless a specific procedure has been written directing or permitting such action.

b. Evaluation

The specific procedures identified by the Licensee for load handling at the Quad Cities plant are consistent with the the requirements of Guideline 2 and contain the information specified in this guideline.

c. Conclusion

Load handling procedures at Quad Cities Station are consistent with Guideline 2.

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' [10]."

a. Summary of Licensee Statements and Conclusions

The Licensee states that Quad Cities Station does comply with ANSI B30.2-1976 with respect to operator training, qualification, and conduct.

b. Evaluation

Quad Cities Station satisfies the criteria of Guideline 1 on the basis of the Licensee's verification that no exceptions are taken to the guidelines of ANSI B30.2-1976.

c. Conclusion

Quad Cities Station complies with Guideline 1.

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" [11]. 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 states that all lifting devices were designed according to industrial standards using good engineering practices. In addition, load tests have been performed on the following lifting devices to the weights specified:

1. reactor head strongback - 129 tons (129% of load)
2. moisture separator hook box - 129 tons (180% of load)
3. dryer/separator lifting rig - 130 tons (205% of load).

The reactor head strongback and the moisture separator hook box comply with ANSI N14.6-1978, Section 3.2.1. Stress design safety factors of 3 for minimum yield strength and 5 for ultimate strength were used in their design. Further, welding and coating comply with ANSI N14.6-1978.

For the dryer/separator lifting rig, the Licensee states that the calculated value of the ratio of ultimate strength to rated load is greater than 5 for all components except for the weld of the lug to the W6 x 25 beam, which is 4.5. The calculated value of the ratio of yield over the rated load is above 3 for all components except for the weld of the lug to the W6 x 25 beam (value 2.17) and the weld of the lug to the hook box (value 2.6).

Quad Cities procedures comply with Section 5, "Acceptance Testing, Maintenance, and Assurance of Continued Compliance" with some exceptions. In Commonwealth Edison's judgment, the periodic load testing of the special lifting devices to 150% of the maximum load is not practical nor warranted, and may invalidate any vendor product guarantees. Additionally, the logistics of moving heavy test loads into the reactor building to accommodate such periodic load testing are difficult.

Prior to the use of specially designed lifting assemblies, visual inspection will be performed and certain critical and accessible parts or members such as hooks and pins will undergo nondestructive examination (NDE) at appropriate time intervals. In Commonwealth Edison's judgment, the visual inspection and limited NDE are adequate to detect potential failures.

However, should an incident occur in which a special lifting device is overloaded, damaged, or distorted, an engineering assessment will be performed. This assessment will address ANSI N14.6 and will include consideration of the load test up to the original procurement load test value or 150%, whichever is less. The requirement to perform this assessment will be incorporated into plant procedures.

b. Evaluation

Information provided by the Licensee indicates that stress design factors, welding processes, and coatings are consistent with the intent of

ANSI N14.6-1978 for the reactor head strongback, the moisture separator hook box, and the dryer/separator lifting rig. Further, all lifting devices in use at Quad Cities Station have been load tested to weights substantially in excess of the maximum load currently lifted and therefore meet the intent of ANSI N14.6-1978 guidelines for acceptance load testing.

The Licensee also states that current procedures meet the intent of Section 5 with some exceptions. The Licensee takes exception to periodic performance of load testing. It is noted that ANSI N14.6-1978 provides acceptable alternatives to periodic load-tests if an initial acceptance load test has been satisfactorily performed; the owner may opt to perform an annual (or prior-to-use, depending on frequency of use) series of inspections in accordance with Section 5.3.1(2) of the ANSI standard. This testing shall include "dimensional testing, visual inspection, and nondestructive testing of major load-carrying welds and critical areas." In this regard, the Licensee has proposed performance of visual inspections and limited NDE prior to each use of the lifting devices and is of the opinion that such an inspection program is adequate to detect potential failure. Considering the Licensee's assessment that the current inspection program is adequate, the degree of load handling reliability necessary to satisfy periodic inspection requirements of Section 5 has been satisfied. However, since only limited NDE is currently performed, it is recommended that the Licensee review the requirements for dimensional and nondestructive testing of these lifting devices and ensure that load bearing welds are nondestructively examined at an interval consistent with that required for safety-related component supports.

For the remaining Licensee exception, the commitment to assess potential damage to the lifting device and to determine the need for an overload test to a weight substantially in excess of the rated capacity is consistent with the intent of the ANSI standard.

c. Conclusion and Recommendation

Quad Cities Station complies with Guideline 4.

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' [12]. 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 states that lifting devices were designed according to industrial standards using good engineering practices. Procedures for the use, maintenance, and storage of slings and cables at Quad Cities Station are being developed in accordance with ANSI B30.9-1971. The slings used at the Quad Cities Station are selected in accordance with ANSI B30.9-1971. These slings are not sized with a 15% dynamic loading margin; however, the cranes on which these slings are used have controllers that provide smooth lift and low speed during the start of the lift without any jerking effect. It is the Licensee's opinion that slings and cables that are manufactured in accordance with ANSI B30.9 have a built-in 30% dynamic load factor.

Due to the relatively high speed of the Unit 1 turbine building crane auxiliary hoist (92 feet per minute), the Licensee states that the operating procedure is being revised to incorporate a limitation on the selection of slings. A safety factor of 2 will be used in sling selection to accommodate the dynamic loads imparted by this hoist.

b. Evaluation

Sling installation and use at Quad Cities Units 1 and 2 substantially meet the intent of NUREG-0612 on the basis of the Licensee's verification that procedures and practices comply with ANSI B30.9-1971.

NUREG-0612 requires additional considerations to accommodate routine dynamic loads so that the design margin of safety is not reduced by the

stresses involved with normal load movement. With one exception, the dynamic loads generated by cranes and hoists at Quad Cities Station are reasonably small percentages of the overall static load and therefore may be disregarded when using and selecting slings. The exception noted is the Unit 1 turbine building crane auxiliary hoist, which has a vertical hoist speed of 92 feet per minute (fpm) and a corresponding impact allowance of 46%. The Licensee's proposed actions, to use a sling rated at twice the static weight of the load, will adequately account for this additional load due to dynamic forces.

c. Conclusion and Recommendation

Quad Cities Units 1 and 2 comply with Guideline 5 of NUREG-0612.

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 states that the Quad Cities standard for the testing, inspection, and maintenance of overhead cranes, QMS 100-2, was based on and does comply with ANSI B30.2-1976.

b. Evaluation

The Licensee satisfies the criteria of this guideline on the basis that crane inspection, testing, and maintenance programs at Quad Cities Station comply with ANSI B30.2-1976.

c. Conclusion

Quad Cities Station Units 1 and 2 comply with Guideline 6.

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" [13]. 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 states that the cranes used at Quad Cities Station were purchased to Sargent and Lundy specifications, which were based upon specifications of the American Institute of Steel Construction, the Electric Overhead Crane Institute, Inc. (EOCI) [15], and USAS Safety Code B30.2.0-1967. Based upon a comparison between actual design specifications and those of CMAA-70, the Licensee states that the Quad Cities procurement specification meets the intent of CMAA-70. Specific differences identified by the Licensee include the following: the EOCI-61 and procurement specifications require a design force equal to 15% of the rated capacity of the crane, while CMAA-70 specifies that the impact load be 0.5% of the load times the hoist speed (in fpm) and neither less than 15% nor greater than 50% of the rated capacity; therefore, Quad Cities cranes have been procured to a criterion which conforms to the requirements of CMAA-70 for a hoist speed of less than 30 fpm.

Quad Cities Special Report 16 [14], "Reactor Building Crane and Cask Yoke Assembly Modification," submitted under AEC Dockets 50-254 and 50-265 (November 8, 1974), indicates that "all crane parts shall equal or exceed design criteria as established by CMAA Specification 70 and shall be compatible with the requirements of the Occupational Safety and Health Act of 1970 (and as amended in 1971), as well as ANSI B30.2.0."

In addition, a detailed comparison of the turbine building crane has been prepared with the added requirements of CMAA-70. Results of this comparison are contained in the following paragraphs.

1. Impact allowance. CMAA-70, Article 3.3.2.1.1.3 requires that crane design calculations include an impact allowance of 0.5% of the load per foot per minute of hoist speed, but not less than 15%. EOCI-61 specifies only a minimum allowance of 15%. Consequently, for cranes with hoist speeds in excess of 30 fpm, it is possible that the impact allowance applied under EOCI-61 will be less than that required by CMAA-70. This variation is not expected to be of consequence for overhead cranes subject to this review since these cranes, in general, operate with hoist speeds below 30 fpm. The Quad Cities Unit 1 turbine building crane has a main hoist speed of 5 fpm and auxiliary hoist speed of 92 fpm; the Unit 2 turbine building crane has a main hoist speed of 5 fpm and an auxiliary hoist speed of 35 fpm. Further, although the auxiliary hoist speeds are greater than recommended CMAA-70 values, their respective impact allowance values (46%, 17%) are within the acceptable CMAA-70 impact allowance range (15% to 50%).

2. 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 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). The shear center coincides with the centroid of the girder section for the turbine building cranes; therefore, the girder sections are symmetrical.

3. 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. Longitudinal stiffeners in use conform to the requirements of CMAA-70, Article 3.3.3.1.2,

and the allowable b/t ratios in box girders using the stiffeners do not exceed the ratios specified in CMAA-70.

4. Allowable compressive stress. CMAA-70, Article 3.3.3.1.3 identifies allowable compressive stresses to be 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. The b/c ratios for the turbine building cranes are 21.6 (Unit 2) and 17.5 (Unit 1) and are therefore not an issue.

5. Fatigue considerations. CMAA-70, Article 3.3.3.1.1 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. Fatigue failure was considered in the design. Assuming two cycles per lift, 8 lifts of greater than 50% of rated capacity per year, and a 40-year life gives an estimated 640 lifts per lifetime, which is much less than that allowed by CMAA-70 (20,000 cycles).

6. 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. For the Unit 1 turbine building crane, ratios for the main and auxiliary hoists are 18.8% and 15.2%; for the Unit 2 turbine building crane, ratios for the main and auxiliary hoists are 21.1% and 21.3% and are considered to be acceptable.

7. 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. The Licensee states that the length-to-diameter ratio of these configurations is less than that which requires the drum to be considered as a beam in bending.

8. Drum design. CMAA-70, Article 4.4.3 provides recommended drum groove depth and pitch. EOCI-61 provides no similar guidance. For the turbine building crane, drum groove depths are equal to respective rope diameters. Groove pitch has a minimum value of 1/8-inch plus the rope diameter. Therefore, drum groove depth and pitch conform to CMAA-70.

9. 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. GE motors and GE Maxspeed Drive and Controls were specified for the Quad Cities cranes.

10. 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. Cab-on-trolley control was not used on these cranes.

11. Hoist brake design. CMAA-70, Article 4.7.4.2 requires that hoist holding brakes, when used with a method of 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. The main and auxiliary hoists have power braking and two holding brakes. The brakes provided are DC magnet-operated electric shoe-type brakes with a maximum torque rating of 200% of motor torque. In addition, eddy current brakes are provided.

12. 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 ends of bridge and trolley travel. No similar guidance is provided in EOCI-61. Spring bumpers effective for both

directions of travel are provided on the outboard ends of the bridge trucks. Crane runway stops with four spring-type trolley bumpers are mounted on runway girders at the ends of the runway rails.

13. 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. GE Maxspeed Control Systems were specified for use.

14. Restart protection. CMAA-70, Article 5.6.2 requires that cranes not equipped with spring return controllers or momentary contact push buttons 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. Momentary pushbuttons are used on the pendant control system.

b. Evaluation

The reactor building cranes at Quad Cities Units 1 and 2 meet the intent of Section 5.1.1(7) of NUREG-0612 based on a review of the design data provided in References 7 and 14.

The turbine building cranes at Quad Cities Units 1 and 2 substantially satisfy the criteria of Guideline 7 on the basis of procurement to EOCI-61 and other industry standards of that period. In addition, the Licensee has documented compliance with 11 of 14 differences noted between CMAA-70 and EOCI-61, and has demonstrated adequacy of design for the three remaining items. Therefore, although not in verbatim compliance with CMAA-70, the design of the turbine building cranes currently in use at Quad Cities Units 1 and 2 provide a degree of load handling reliability consistent with the intent of Guideline 7.

c. Conclusion

Quad Cities Station complies with Guideline 7.

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 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. Summary of Licensee Statements and Conclusions

The Licensee has stated that the reactor building crane's main hook is single-failure-proof. In addition, Station Technical Specification 3.10/4.10 states refueling and spent fuel cask handling requirements. Station maintenance procedures prohibit movement of heavy loads over the spent fuel storage pools or the open reactor cavity except under special procedures that have been reviewed and approved by a designated onsite committee.

b. Evaluation

Quad Cities Station satisfies the requirements of Interim Protection Measure 1 because the reactor building crane is single-failure-proof. In addition, the fuel pool area is a restricted area for the reactor building crane's 9-ton auxiliary hook, which is not single-failure-proof.

c. Conclusion

Quad Cities Station complies with 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. Evaluations, Conclusions, and Recommendations

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 a special review of procedures, equipment, and personnel for handling of heavy loads over the core has been completed. The results of this special review are being implemented.

b. Evaluation and Conclusion

Quad Cities Station complies with Interim Protection Measure 6.

3. CONCLUSION

This summary is provided to consolidate the results of the evaluations contained in Section 2 concerning individual NRC staff guidelines into an overall evaluation of heavy load handling at Quad Cities Nuclear Station. Overall conclusions and recommended Licensee actions, where appropriate, are provided with respect to both general provisions for load handling (NUREG-0612, Section 5.1.1) and completion of the staff recommendations for interim protection (NUREG-0612, Section 5.3).

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 equipment required for safe shutdown or decay heat removal. The intent of these guidelines is twofold. A plant conforming to these guidelines will have developed and implemented, through procedures and operator training, safe load travel paths such that, to the maximum extent practical, heavy loads are not carried over or near irradiated fuel or safe shutdown equipment. A plant conforming to these guidelines will also have provided sufficient operator training, handling system design, load handling instructions, and equipment inspection to ensure reliable operation of the handling system. As detailed in Section 2, it has been found that load handling operations at Quad Cities Nuclear Station can be expected to be conducted in a highly reliable manner consistent with the staff's objectives as expressed in these guidelines.

3.2 INTERIM PROTECTION MEASURES

The NRC staff has established (NUREG-0612, Article 5.3) that certain measures should be initiated to provide reasonable assurance that handling of heavy loads will be performed in a safe manner until final implementation of the general guidelines of NUREG-0612, Article 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 Quad Cities Station Units 1 and 2 comply with the staff's measures for interim protection.

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