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TECHNICAL EVALUATION REPORT

CONTROL OF HEAVY LOADS (C-10)

COMMONWEALTH EDISON COMPANY

ZION STATION UNITS 1 AND 2

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## CONTENTS

<u>Section</u>	<u>Title</u>	<u>Page</u>
1	INTRODUCTION . . . . .	1
	1.1 Purpose of Review . . . . .	1
	1.2 Generic Background . . . . .	1
	1.3 Plant-Specific Background . . . . .	2
2	EVALUATION . . . . .	4
	2.1 General Guidelines . . . . .	4
	2.2 Interim Measures . . . . .	17
3	CONCLUSION . . . . .	20
	3.1 General Provisions for Load Handling. . . . .	20
	3.2 Interim Protection . . . . .	21
4	REFERENCES . . . . .	22

## 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. I. E. Sargent and Mr. D. J. Vito 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 (CWE) Zion Station Units 1 and 2. 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 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.

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 guideline is to ensure that Licensees at all operating nuclear power plants perform the following:

1. provide sufficient operator training, handling system design, load handling instructions, and equipment inspection to ensure 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 July 31, 1980, the NRC issued a letter [3] to CWE, the Licensee for Zion Station, requesting that the Licensee review provisions for handling and control of heavy loads at Zion Units 1 and 2, evaluate these provisions with

respect to the guidelines of NUREG-0612, and provide certain additional information to be used for an independent determination of conformance to these guidelines. On November 7, 1980 [4], January 2, 1981 [5], and April 10, 1981 [6], CWE responded to this request. Based upon this information, a draft Technical Evaluation Report (TER) was prepared and informally transmitted to the Licensee. A telephone conference call was subsequently conducted on January 28, 1982, between representatives of the NRC, FRC, and CWE to discuss unresolved issues in the draft TER. As a result of this conference call, CWE provided additional information on July 7, 1982 [7]. On October 12, 1982 [8], CWE provided documentation to support the remaining concerns.



## 2. EVALUATION AND RECOMMENDATIONS

This section presents a point-by-point evaluation of load handling provisions at Zion Station Units 1 and 2 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 guidelines 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:

- 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 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 the evaluation of this verification are contained in the succeeding paragraphs.

Table 2.1. Flow Station Delta 1 and 2/NUREG-0612 Compliance Matrix

Heavy Loads	Height or Capacity (Lbms)	Guideline 1 Safe Load Paths		Guideline 2 Crane Operator Training		Guideline 3 Special Lifting Devices		Guideline 4 Blings		Guideline 5 Crane - Test and Inspection		Guideline 6 Crane Design		Interim Measure 1 Technical Specifications		Interim Measure 6 Special Attention	
		Path	Procedure	Training	Special Lifting	Devices	Blings	Crane - Test and Inspection	Crane Design	Technical Specifications	Special Attention						
1. Polar Crane	225/35	--	--	C	--	--	--	--	--	C	--	C	--	--	--	--	--
a. RVV Head	73.5	C	C	--	P	--	--	--	--	--	--	--	--	--	--	C	--
b. RVV Upper Internals	60	C	C	--	P	--	--	--	--	--	--	--	--	--	--	C	--
c. RVV Lower Internals	170	C	R	--	P	--	--	--	--	--	--	--	--	--	--	C	--
d. RC Pump Motor	36	C	C	--	P	--	--	C	--	--	--	--	--	--	--	--	--
e. RC Pump	51	C	C	--	--	--	--	C	--	--	--	--	--	--	--	--	--
f. Concrete Blab	17	C	C	--	--	--	--	C	--	--	--	--	--	--	--	--	--
2. Fuel Handling Crane	125/15	--	--	C	--	--	--	--	--	C	--	C	--	--	--	--	--
a. Spent Fuel Cask	100	C	C	--	--	--	--	--	--	--	--	--	--	C	--	--	--
b. New Fuel Containers	3	C	C	--	--	--	--	--	--	--	--	--	--	C	--	--	--
3. Auxiliary Building																	
Monorail	2	--	--	C	--	--	--	--	--	C	--	--	--	--	--	--	--
a. Elec. Equipment	2	C	R	--	--	--	--	--	--	--	--	--	--	--	--	--	--
4. Diesel Generator Room	2	--	--	C	--	--	--	--	--	C	--	--	--	--	--	--	--
a. Diesel Generator Parts	2	C	R	--	--	--	--	--	--	--	--	--	--	--	--	--	--
5. Crib House																	
Monorail	10	--	--	C	--	--	--	--	--	C	--	--	--	--	--	--	--
a. Removal Blab	6	C	C	--	--	--	--	C	--	--	--	--	--	--	--	--	--
b. SW Pump	5	C	C	--	--	--	--	C	--	--	--	--	--	--	--	--	--
c. SW Pump Motor	7.5	C	C	--	--	--	--	C	--	--	--	--	--	--	--	--	--

C = license action complies with NUREG-0612 Guideline.  
 P = license action partially complies with NUREG-0612 Guideline.  
 -- = not applicable.  
 R = license has proposed revisions or modifications which, when implemented, will comply with the NUREG-0612 Guideline.

### 2.1.1 NUREG-0612, Heavy Loads Overhead Handling Systems

#### a. Summary of Licensee Statements and Conclusions

The Licensee has evaluated the load handling systems at Zion Station and concluded that the following systems should be subject to the general guidelines of NUREG-0612:

- o containment polar crane
- o underhung hand-gearred bridge crane (containment)
- o manipulator crane
- o fuel building crane
- o fuel handling bridge
- o 2-ton trolley attached to rail at 666' elevation at roof of auxiliary building
- o diesel generator room 2-ton trolley attached to two 10-ton monorails
- o crib house 10-ton hoist attached to 16-ton monorail.

In addition, the following heavy load-handling systems were excluded from NUREG-0612 based on physical separation from systems or components required for plant shutdown or core decay heat removal:

- o turbine building crane
- o radwaste crane
- o maintenance shop crane
- o two 4-ton monorails between the fuel building and the auxiliary building
- o two 25-ton monorails (auxiliary building).

#### b. Evaluation and Conclusion

The Licensee's conclusions concerning load handling systems subject to the general guidelines are consistent with the guidance in NUREG-0612. Further, the manipulator crane and the fuel handling bridge may be excluded since the heaviest load carried by these systems is a fuel assembly and

associated handling equipment; the underhung hand-gearred bridge crane may be excluded since it does not carry any heavy loads. However, since each of these systems is rated at a capacity (1 ton) greater than that defined to be a heavy load, the Licensee should derate and appropriately mark each handling system to that weight defined to be a heavy load.

### 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

Loads at Zion Station Units 1 and 2 are moved by the safest and shortest paths as shown on Zion drawings MS-16, 681, 682, and 683 (marked drawings were provided with the CWE submittal). The new fuel unloading and movement area has been identified as shown on drawing M-8. Load preparation and handling is performed by nuclear maintenance mechanics and supervised by maintenance foremen who have demonstrated through experience the knowledge and ability necessary to perform this work. Due to the configuration of the load paths (e.g., the load path for the reactor coolant pump (RCP) is from the pump deck up to the 617-ft level, then over grating to its laydown area; the service water pump motors are removed through the roof of the crib house and moved across the roof), it is not apparent that marking load paths on the floor is generally feasible, nor would it contribute to reactor safety. The crane operators at Zion Station move loads under the direction of the maintenance foreman or the fuel handling foreman, who has the load movement procedure in his possession during the load movement.

Load paths are defined in procedures by including reduced size load movement path drawings in the appropriate load handling procedures. Further,

since no deviations from the identified load paths are allowed, no alternate procedures are required.

b. Evaluation

Identification of safe load paths at Zion Station Units 1 and 2 is consistent with the guidance of Section 5.1.1(1) of NUREG-0612.

Although Zion Station does not mark safe load paths, the use of load handling supervisors who refer to written procedures or drawings to guide the crane operator accomplishes the same objective as using permanent markings. However, the duties of these supervisors (specifically their responsibility for ensuring that designated load paths are followed) should be clearly delineated.

c. Conclusion and Recommendation

Zion Station Units 1 and 2 comply with Guideline 1. However, the Licensee should clearly define the duties of load handling supervisors to ensure that safe load paths in station procedures are followed.

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. 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 load path; and other special precautions."

a. Summary of Licensee Statements and Conclusions

The Licensee has stated that written procedures govern the handling of heavy loads in the vicinity of systems or components required for safe shutdown or decay heat removal. These procedures generally include sections such as Equipment Description, Purpose, References, Initial Plant and/or Component Conditions, and Precautions/Limitations, in addition to step-by-step instructions. These procedures satisfy Section 5.1.1(2) of NUREG-0612.

Additional procedures will be developed prior to load movement for applicable loads for which no handling procedure currently exists (e.g., reactor vessel lower internals).

b. Evaluation

Based on the list of procedures and heavy loads provided by the Licensee and certification that the guidance of Section 5.1.1(2) of NUREG-0612 is satisfied, Zion Station load handling procedures are consistent with the guidance in NUREG-0612.

c. Conclusion

Zion Station Units 1 and 2 comply with Guideline 2 of NUREG-0612.

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

"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 operators at Zion Station are qualified in accordance with ANSI B30.2-1976.

b. Evaluation

Crane operator training at Zion Units 1 and 2 meets the intent of NRC staff guidelines on the basis of the Licensee's verification that the crane operator training program is based on ANSI B30.2-1976, with no exceptions.

c. Conclusion

Zion Station Units 1 and 2 comply with Guideline 3.

### 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 reviewed design and procurement documents for the various lifting devices provided for the handling of heavy loads at Zion Units 1 and 2 and has concluded that this equipment was designed according to industrial standards using good engineering practices. The Licensee has identified three special lifting devices (reactor vessel head lift rig, internals lift rig, and reactor coolant pump motor tripod) specifically designated for handling heavy loads.

The special lifting devices were not designed to ANSI N14.6-1978, since this standard did not exist at the time of equipment procurement. In the particular case of stress design factors, the Licensee reported that these special lifting devices were designed with allowable stress equal to 1/5 of material ultimate stress (a design factor consistent with the requirements of ANSI N14.6-1978) and 1/2 of material yield strength (a design factor less conservative than the 1/3 required by ANSI N14.6-1978).

Special lift rigs are stored in a clean, dry area, and are visually inspected prior to use for evidence of physical abuse, damage, and defects. The special lift rigs are used only for the specific load for which they were purchased. The Licensee has stated that periodic load testing to 150% of the maximum load is neither practical nor economically justifiable. In addition, it is not feasible to bring such large test loads into the Zion Station

reactor containment building to test the load lift rig, the internals lift rig, and the reactor coolant pump tripod. An ongoing program for pre-lift inspections is adequate to detect potential failures. However, should an incident occur in which a special lift rig is overloaded, damaged, or distorted, an engineering assessment will be performed. This assessment will address ANSI N14.6 and will include considerations of the load test specified therein. The requirement to perform this assessment will be incorporated into plant procedures.

b. Evaluation

Although special handling devices in use at Zion Units 1 and 2 are not designed with a design margin of safety of 3 as required for material yield stress, the employment of a stress design factor of 2 on yield provides yield and ultimate stress margins comparable to those specified in ANSI N14.6-1978. Further, the Licensee's position that Zion special lifting device design conforms to good engineering practice is supported by the design data and drawings provided for each lifting rig. However, the visual inspection program identified by the Licensee is not sufficient to meet the intent of this guideline. Additional action is required to implement the requirements of ANSI N14.6-1978 for acceptance testing, inspection, and continued compliance contained in Sections 5.1, 5.3, 5.4, and 5.5. Additionally, no information has been provided to verify the performance of a load test substantially in excess of the maximum load lifted, whether in accordance with the criteria of this guideline or that of a comparable industrial standard (ANSI B30.2-1976, Section 2-2.2.2). This load test is deemed necessary to substantiate the structural integrity of the lifting device and as proof of workmanship of the device. Use of the devices at or near rated capacity for several years with relatively infrequent usage is not sufficient to satisfy this requirement.

Regarding inspections of these devices, it is noted that in addition to the visual inspections identified by the Licensee, periodic inspections (annual or prior to use) also require the performance of dimensional and nondestructive testing of major welds and critical areas.

Therefore, on the basis of the above discussion, the development and implementation of a rigorous program of continued testing, maintenance, and repair, combined with a load test sufficiently in excess of the maximum load lifted by the device, will provide a degree of load handling reliability consistent with that provided through conformance with this guideline.

c. Conclusion and Recommendation

Zion Station Units 1 and 2 partially comply with Guideline 4 of NUREG-0612. In order to provide special lifting devices with load handling reliability consistent with this guideline, the Licensee should institute a program that verifies, through conformance with ANSI N14.6-1978, Sections 5.1, 5.3, 5.4, and 5.5, and performance of a load test sufficiently in excess of the maximum load lifted, that the lifting device continues to meet its performance criteria and continues to be capable of reliable and safe performance of its functions.

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' that produces the maximum static and dynamic load. Where this restricts slings to use on only certain cranes, the slings should clearly indicate the cranes with which they may be used."

a. Summary of Licensee Statements and Conclusions

The Licensee stated that the reactor coolant pump (RCP) motor lifting cable and 17-ton shield block slings comply with ANSI B30.9-1971. The RCP motor lifting cable is an eight-part braided rope of 6x19 construction using 1-inch diameter improved plow steel grade component ropes rated at 50 tons. Four 1-inch, 6x19

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\*For the purpose of selecting the proper sling, loads imposed by the SSE need not be included in the dynamic loads imposed on the sling or lifting device."

improved plow steel grade ropes with independent wire rope core make up a bridle sling for lifting the shield blocks for a load lift of 24 tons.

The only additional slings that are used at Zion Station are (1) slings used in the diesel generator rooms, (2) slings used on the 2-ton trolley in the auxiliary building, (3) the crib house slab removal sling, and (4) the service water pump removal slings.

The slings used in the diesel generator rooms and on the 2-ton auxiliary building trolley are selected in accordance with ANSI B30.9-1971. These slings are not sized with a 15% dynamic loading margin since review of load drops from the diesel trolley or auxiliary building trolley has shown that there will be no damage to any safety related equipment required for reactor shutdown.

A removable 10-ton trolley is attached to the 10-ton crib house monorail for service water pump motor removal. The concrete roof plug is picked up with a four point sling arrangement consisting of four 1/2-inch, 6x19 improved plow steel grade ropes with a vertical angle of 30° maximum with a mechanical splice. The rated sling capacity is 7.6 tons.

The sling arrangement for lifting the service water pump motor consists of a 1-1/8-inch, 6x19 improved plow steel grade rope with a vertical angle of 30° maximum. This provides a maximum rated sling load of 13 tons.

With the exception of the diesel room and the 2-ton auxiliary building trolley hoist, the slings used for load movement at Zion Station are selected to maintain a 15% dynamic margin.

Since no slings are restricted for use on a particular crane at Zion Station, no special marking of slings is required.

#### b. Evaluation

Zion Station Units 1 and 2 meet the intent of Section 5.1.1(5) of NUREG-0612 for the installation and use of slings for the handling of heavy loads.

The rated capacity for the RCP motor lifting cable is specified in ANSI B-20.9-1971 as 47 tons. This capacity allows a dynamic load of 30% when compared with the 36-ton load weight identified for the RCP motor by the Licensee. The rated capacity for the shield block sling was determined, from ANSI B30.0-1971, to be 24 tons for a 60° horizontal angle with a hand-tucked splice. The Licensee indicated that its sling geometry does provide a 60° horizontal angle. This capacity also provides sufficient dynamic load allowance for the 17-ton load weight identified by the Licensee for these components. Further, with the exception of the diesel room and 2-ton auxiliary building trolley hoists, the remaining slings used for load movement at Zion Station are selected to maintain a 15% dynamic margin. Since the diesel room and auxiliary building 2-ton trolley hoists are physically separated from any safety-related equipment required for reactor shutdown, selection in accordance with ANSI B30.9-1971 is consistent with NUREG-0612.

c. Conclusion

Zion Station Units 1 and 2 comply with Guideline 5.

2.1.7 Crane Inspection, Testing, and Maintenance [Guideline 6, NUREG-0612, Section 5.1.1]

"The crane should be inspected, tested and maintained in accordance with Chapter 2-3 of ANSI B30.2-1976, 'Overhead and Gantry Cranes,' with the exception that tests and inspections should be performed prior to equipment use when it is not practical to meet the frequency requirements 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 operations. ANSI B30.2, however, calls for certain inspections to be performed daily or monthly. For such cranes having limited use, the inspections, tests, and maintenance should be performed prior to their use)."

a. Summary of Licensee Statements and Conclusions

The Licensee has determined that crane inspection, maintenance, and operating procedures are all based upon ANSI B30.2-1976.

b. Evaluation

Zion Station's crane inspection, testing, and maintenance program meets the intent of NRC staff guidelines on the basis of the Licensee's verification that procedures are based on ANSI B30.2-1976 without exception.

c. Conclusion

Zion Station Units 1 and 2 comply with Guideline 6.

2.1.8 Crane Design [Guideline 7, NUPEG-0612, Section 5.1.1]

"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 Conclusion

The Licensee has reviewed procurement specifications for overhead cranes installed at Zion Units 1 and 2 and has determined that, in general, these cranes were procured with structural design requirements that are identical to or exceed those required by Crane Manufacturers Association of America (CMAA) Specification 70-1976. Specifically, the cranes were purchased to C&E engineers' specification for electric overhead traveling bridge cranes, which was based on the American Institute of Steel Construction specifications, the USAS Safety Code B30.2.0-1967, and the Electric Overhead Crane Institute specifications (the predecessor to CMAA Specification 70). The Licensee's review of the engineers' specification indicated that procurement of cranes that fulfill requirements of this specification satisfies the intent of CMAA Specification 70. Two differences between the requirements of the procurement specification and CMAA Specification 70 were identified. These differences were associated with design impact force and allowable compressive stress in structural elements. In each case, specific crane characteristics, maximum hoist speed (in the case of impact force), and the ratio of the distance between web plates to the thickness of the top cover plate (b/c ratio) of

structural elements (box girders, in the case of allowable compressive stress) are in accordance with the more restrictive design requirements of CMAA Specification 70.

b. Evaluation

Crane design at Zion Station Units 1 and 2 meets the intent of NUREG-0612. The Licensee has verified original crane design requirements at Zion Station against the existing criteria in CMAA-70, noting only two differences: design impact allowance and allowable compressive stress in structural elements.

CMAA-70, Section 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 hoisting speed but not less than 15%. EOCI specifies only a minimum allowance of 15%. Consequently, for cranes with hoist speeds in excess of 30 ft/min, it is possible that the impact allowance applied under EOCI-61 will be less than that required by CMAA-70. The Licensee has noted that both the polar crane and the fuel building crane provide maximum hoist speeds of 5 ft/min, satisfying the requirements of CMAA-70.

CMAA-70, Section 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. The b/c ratios for the polar crane and fuel building crane are all less than 38.

c. Conclusion

Zion Station Units 1 and 2 comply 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 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 independent 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]

"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 Building,' for PWRs and Standard Technical Specification 3.9.6.2, 'Crane Travel,' for BWRs, to prohibit handling of heavy loads over fuel in the storage pool until implementation of measures which satisfy the guidelines of Section 5.1 of NUREG-0612."

#### a. Summary of Licensee Statements and Conclusions

The Licensee has stated that operating licenses DPR 39 and DPR 48 for Zion Units 1 and 2 prohibit loads heavier than the combined weight of a single spent fuel assembly plus the tool for moving that assembly from being carried over fuel stored in the spent fuel pool.

b. Evaluation and Conclusion

Zion Station technical specifications include the required heavy load movement limitations as item C(7)(b) in the operating license.

2.2.2 Administrative Controls [Interim Protection Measures 2, 3, 4, and 5, NUREG-0612, Sections 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 modification 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 Review of Load Handling Operations [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 operation, and content of procedures."

a. Summary of Licensee Statements and Conclusions

The Licensee has stated that the visual inspection of load-bearing components of cranes, slings, and special lifting devices was performed before the initial lifts were made by the head lift rig, the internals lift rig, and the reactor coolant pump. In addition, the Zion Station inspection program ensures that inspections of these components are repeated at regular intervals.

b. Evaluation and Conclusion

Zion Units 1 and 2 comply with this interim protection measure on the basis of the information provided concerning load handling procedures, crane operator training, and the inspection of load-bearing components of lifting devices used to handle loads over the core.

### 3. CONCLUSION

This summary is provided to consolidate the results of the evaluation contained in Section 2 concerning individual NRC staff guidelines into an overall evaluation of heavy load handling at Zion Station Units 1 and 2. Overall conclusions and recommended Licensee actions, where appropriate, are provided with respect to both general provisions for load handling (NUREG-0612, Section 5.1.5) 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 Zion Station Units 1 and 2 can be expected to be conducted in a highly reliable manner consistent with the staff's objectives as expressed in these guidelines. In only one area was a need for further Licensee action identified.

- o CWE should develop and institute a program that verifies, through scheduled periodic testing and performance of a load test substantially in excess of the maximum load currently lifted, that special lifting devices continue to meet their performance criteria and continue to be capable of reliable and safe performance of their functions. Such a program should conform to the requirements of ANSI N14.6-1976, Sections 5.1, 5.3, 5.4, and 5.5 and should include an initial load test of each special lifting device.

### 3.2 INTERIM PROTECTION

The NRC staff has established (NUREG-0612, Section 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 guidelines of NUREG-0612, Section 5.1. Measures so specified 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. Evaluation of information provided by the Licensee indicates that the staff's measures for interim protection at Zion Units 1 and 2 have been satisfactorily implemented.



## 4. REFERENCES

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9. ANSI B30.2-1976  
"Overhead and Gantry Cranes"
10. ANSI N14.6-1978  
"Standard for Special Lifting Devices for Shipping Containers Weighing  
10,000 Pounds (4500 kg) or More for Nuclear Materials"

11. ANSI B30.9-1971  
"Slings"
12. CMAA-70  
"Specifications for Electric Overhead Traveling Cranes"



## ADDITIONAL INFORMATION REQUIRED FROM ZION STATION UNITS 1 AND 2

1.a. RECOMMENDATION/OPEN ITEM

As final assurance that loads are safely handled at Zion Station, Commonwealth Edison (CWE) should ensure that suitable visual aids are available to assist crane operators when moving heavy loads.

b. EVALUATION CRITERIA

To ensure compliance and avoid unnecessary distractions to crane operators while controlling suspended loads (e.g., trying to read procedural steps or drawings with the hook under load), NUREG-0612 requires that safe load paths be marked on the floors. Due to the number of load paths as well as contamination control methods, several licensees have argued against such markings; previously, it has been found acceptable to use other appropriate visual aids in lieu of permanent markings to accomplish the same purpose. Such visual aids may consist of tape, pylons, rope, crane benchmarks, or use of a crane supervisor/signalman (with responsibilities delineated in appropriate procedures) to direct the crane operator along the designated load path.

c. DISCUSSION

Zion Station Units 1 and 2 are in compliance with the requirements of NUREG-0612 for safe load paths, with the exception of load path markings. The Licensee states that in lieu of the load path markings, load handling supervisors are used who refer to written procedures or drawings to guide the crane operator. Therefore, to fully satisfy the requirements of this guideline, CWE should verify that the duties of these supervisors have been clearly defined.

2.a. RECOMMENDATION/OPEN ITEM

CWE should develop and institute a program that verifies, through scheduled periodic testing which includes performance of a proof test, that special lifting devices continue to meet their performance criteria and to be capable of reliable and safe performance of their functions. Such a program should conform to the requirements of ANSI N14.6-1978, Section 5.

b. EVALUATION CRITERIA

The general guidelines of NUREG-0612 specify that special lifting devices used to carry heavy loads should satisfy the requirements of ANSI N14.6-1978. In order to determine if compliance or equivalence with the standard may be established, the licensee, as a minimum, should demonstrate that the following issues have been adequately addressed for each special lifting device identified:

- o adequacy of design (stress design factors, quality assurance, fabrication controls)
- o proof of workmanship and mechanical integrity (initial load test)
- o programs to ensure continuing compliance (test and inspection program).

c. DISCUSSION

Three special lifting devices have been identified by CWE to require compliance with NUREG-0612 requirements: the reactor vessel head lift rig, internals lift rig, and reactor coolant pump motor tripod.

Regarding requirements to load-test the devices, the Licensee states that periodic load testing to 150% of the maximum load is neither practical nor economically justifiable. It is not feasible to bring large test loads into the Zion Station containment building. It is CWE's opinion that an ongoing program of pre-lift inspections is adequate to detect potential failures.

It should be recognized that the intent of this load test is to provide an appreciable overstress condition above the maximum load lifted as a proof

of workmanship and mechanical elements in the assembled device. In addition, it is recognized that performance of such a load test may be difficult, depending upon load-test capabilities of the plant and contamination of the lifting device, as well as actual logistics of moving the device outside the containment.

From a technical viewpoint, the difficulty or impracticality of conducting a load test does not, of itself, justify a determination that a load test is not required. The circumstances under which a load test could be considered unnecessary, on the basis of engineering judgment, would include overall consideration of the following issues:

- o The device is of simple design. Simplicity of design eliminates complex, and therefore difficult to analyze, components. Simplicity also reduces the fabrication requirements and consequent potential for inadequate workmanship.
- o The device was fabricated under a rigorous quality program. A rigorous program of quality assurance and in-progress inspection, including thorough non-destructive examination (NDE), is expected to eliminate material flaws or errors in workmanship which would otherwise be detected by a proof test.
- o A conservative design was used. The use of substantial conservatism in design, for both stressed structural members and hardware (e.g., turnbuckles, U-bolts, threaded fasteners), could provide stress margins sufficient to accommodate potential material or fabrication shortcomings.

Information provided thus far by the Licensee is not sufficient to form a technical basis upon which an independent determination can be made that a proof test need not be conducted.

In addition, it is noted that one lifting device of concern is the internals lift rig. Since the upper internals are the only load of interest, it has previously been found acceptable to use a lift of the lower internals (if sufficiently in excess of the weight of the upper internals) as the equivalent of the required load test. Similar logic may also be applied to other lifting devices if circumstances allow.

Although the CWE indicates that an on-going program of pre-lift inspections has been implemented, insufficient detail has been provided to

ascertain whether this program complies with the inspection and maintenance criteria established in Section 5 of ANSI N14.6-1978. Therefore, CWE should review the existing program and modify it as necessary to comply with ANSI guidelines.