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U.S. NUCLEAR REGULATORY COMMISSION
STANDARD REVIEW PLAN
OFFICE OF NUCLEAR REACTOR REGULATION

SECTION 9.1.4 FUEL HANDLING SYSTEM

REVIEW RESPONSIBILITIES

Primary - Auxiliary and Power Conversion Systems Branch (APCSB)

Secondary - Reactor Systems Branch (RSB)
Structural Engineering Branch (SEB)
Mechanical Engineering Branch (MEB)
Materials Engineering Branch (MTEB)
Electrical, Instrumentation and Control Systems Branch (EICSB)
Radiological Assessment Branch (RAB)

I. AREAS OF REVIEW

The APCSB reviews the fuel handling system (FHS) from the receiving of the new fuel through the shipping of the spent fuel from the plant site. The design layout, which shows the functional geometric layout of the handling equipment, including the areas of movement over and around the fixed locations of safety-related facilities during fuel handling, is reviewed to determine that the various handling operations can be performed safely. The main emphasis in the FHS review is on critical load handling in which inadvertent operations or equipment malfunctions, either separately or in combination, could cause a release of radioactivity or prevent safe shutdown of the reactor.

1. The APCSB reviews the transporting, hoisting, and rigging operations in the fuel handling system as to methods, selection of handling equipment, and safety devices.

2. The APCSB reviews the design of the FHS with respect to the following aspects of individual components and the integrated system:

   a. Performance and load handling requirements specified for equipment.

   b. Handling control features.

   c. The methods and equipment for transferring fuel assemblies from the reactor core to the storage location.

   d. The methods and equipment for transferring stored fuel to the spent fuel shipping cask.

   e. Design codes and standards used for the handling and transportation mechanisms.

The applicant's proposed technical specifications are reviewed for operating license applications, as they relate to areas covered in this review plan.

Secondary reviews will be performed by other branches where necessary and as requested by APCSB to complete the overall evaluation of the FHS. The secondary reviews are as follows. The SEB will determine the acceptability of the design analyses, procedures, and criteria used to establish the ability of seismic Category I structures housing the system and supporting systems to withstand the effects of natural phenomena such as a safe shutdown earthquake (SSE), the probable maximum flood (PMF), and tornado missiles. The MEB will review the seismic qualification testing and operability of components and confirm that the components, piping, and structures are designed in accordance with applicable codes and standards. The RSB will determine that the seismic and quality group classifications for the system components are acceptable. The MTEB will verify that inservice inspection requirements are met for system components and, upon request, will verify the compatibility of the materials of construction with service conditions. The EICSB will determine the adequacy of the design, installation, inspection, and testing of all essential electrical components (sensing, control, and power). The RAB reviews the design of the fuel handling system and the spent fuel transfer process to determine whether occupational radiation exposures during spent fuel handling will be as low as practicable.

II. ACCEPTANCE CRITERIA

Acceptability of the FHS design, as described in the applicant's safety analysis report (SAR) including related sections of Chapters 2 and 3 of the SAR, is based on specific general design criteria, regulatory guides, and safety standards and engineering codes. An additional basis for determining the acceptability of the FHS will be the degree of similarity of the design with that of previously reviewed plants with satisfactory operating experience. Listed below are specific criteria as they relate to the FHS.

The FHS is acceptable if the integrated design of the structural, mechanical, and electrical elements, the manual and automatic operating controls, and the safety devices provide adequate system control for the specific procedures of handling operations, if the redundancy and diversity needed to protect against malfunctions or failures are provided, and if the design conforms to the following criteria:

1. General Design Criterion 2, as related to the ability of structures, equipment, and mechanisms to withstand the effects of natural phenomena such as earthquakes, tornadoes, floods, and hurricanes.

2. General Design Criterion 5, as related to the capability of shared equipment and components important to safety.

3. Regulatory Guide 1.29, as related to the seismic design classification of components.

4. ANSI standards for components, machinery, and subsystems.

5. Engineering society design standards, codes, or industry standard specifications applicable to the selection of components and subsystems.

6. Branch Technical Position APCSB 9-1, as related to overhead handling systems designed to preclude a load drop from a single failure.

7. For the case where a single failure-proof crane has not been provided, the proposed facility design will be acceptable if it can be determined that the consequences of a load drop would not affect the ability of the plant to be shut down or result in the release of significant amounts of radioactive materials.

III. REVIEW PROCEDURES

The fuel handling system provides for handling of fuel assemblies, spent fuel casks, and other critical loads. The general objective of the review is to confirm that the FHS design precludes system malfunctions or failures that would prevent safe shutdown of the reactor or cause a release of radioactivity. There are variations in the designs of proposed handling systems, hence there will be variations in system requirements and the type and number of critical loads to be handled. For the purpose of this review, the FHS is assumed to include one of two crane types:

1. Cranes whose critical loads, if dropped while being handled, can damage essential equipment or cause a release of radioactivity and are, therefore, designed (including associated rigging and connections to the load) to be "single failure-proof" so that the load could not fall in the event of a single failure.

2. Cranes whose critical loads, if dropped while being handled, cannot damage essential equipment or cause a release of radioactivity because of facility design provisions such as physical separation of essential equipment from load-handling pathways or load limitations.

The procedures listed here are used in the construction permit (CP) review to determine that the FHS design criteria and bases and the preliminary FHS design described in the SAR meet the acceptance criteria given in Section II of this plan. For operating license (OL) reviews the procedures are used to verify that the design criteria and bases have been appropriately implemented in the FHS final design.

The reviewer will select and emphasize material from this review plan, as may be appropriate for a particular case.

1. The system performance requirements for the FHS are reviewed to determine that they cover the handling system concept used in the design, and describe the component and subsystem functions within the integrated system. The performance requirements should also define any degradation considered for components and describe the procedures that are followed to detect and correct degraded conditions.

2. The performance specifications required as part of the design and described in the SAR are reviewed to determine that the design, material selection, manufacturing, installation, testing, and operating procedures are in accordance with state-of-the-art practice. The reviewer verifies that the consensus standards, engineering codes, and industrial or manufacturing association standards selected and used are adequate and appropriate for the FHS.

3. For cranes of "type 2", as defined above, the information presented in the SAR is reviewed to determine that the specific arrangement of the system and subsystems and the load handling paths to be used are described with respect to locations of essential equipment. For overhead cranes and other lifting devices with load limitations or that are separated from essential equipment, the reviewer covers the following points:

   a. The size, shape, and dimensions of the potentially most damaging load (the load which, if dropped by the crane, will cause the most damage), its weight and center of gravity, lifting points, stability, and handling speeds, are compared with the performance specifications to determine the compatibility of the design with load handling and movement requirements. The reviewer uses the requirements of codes and standards and, if required, performs an independent analysis to determine acceptability of the system.

   b. The instrumentation and control system, including the limit and safety devices provided for automatic and manual operation for both normal and emergency conditions, that are required to operate to maintain safety in the event of a failure of the system are reviewed. The results of failure modes and effects analyses are used by the reviewer to determine that the control system adequately limits loads or limits crane load movement, assuming a single failure, without affecting the function of essential equipment or causing the release of radioactivity.

   c. The description of operating and test procedures presented in the SAR is reviewed to determine that load proof-testing, design-rated load testing, nondestructive testing, preventative checks, and examinations of hookup are in accordance with the requirements of the safety standards set forth in ANSI standards.

4. For cranes that have been designed to be single failure-proof, i.e., cranes of "type 1," as defined above, the reviewer determines that the design conforms to Branch Technical Position APCSB 9-1.

5. The information presented in the SAR for the fuel handling equipment, including the equipment storage areas, is reviewed to determine that a seismic event cannot result in damage to spent fuel or essential equipment.

6. The fuel transfer carriage design is reviewed to determine the means of preventing damage to fuel assemblies due to movement of the carriage when the "upender" is in the vertical position.

7. The review for OL applications includes a determination that the content and intent of the technical specifications are in agreement with the requirements for system testing, minimum performance, and surveillance developed as a result of the staff's review.

IV. EVALUATION FINDINGS

The reviewer verifies that the information provided and his review support conclusions of the following type, to be included in the staff's safety evaluation report:

> "The fuel handling system includes all components and equipment used in moving fuel from the receiving of new fuel to the shipping of spent fuel from the plant site. The scope of review of the fuel handling system (FHS) for the ____________________ plant included layout drawings, piping and instrumentation diagrams, and descriptive information for the system and the supporting systems that are essential to the safe operation of the FHS. [The review has included the applicant's proposed design criteria and design bases for the FHS, the adequacy of those criteria and bases, and the requirements for safe operation of the FHS during normal and abnormal conditions. (CP)] [The review has included the applicant's analysis of the manner in which the design of the FHS and supporting systems conforms to the design criteria and design bases. (OL)]
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> "The basis for acceptance in the staff review has been conformance of the applicant's designs, design criteria, and design bases for the FHS and supporting systems to the Commission's regulations as set forth in the general design criteria, and to applicable regulatory guides, staff technical positions, and industry standards.
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> "The staff concludes that the design of the FHS conforms to all applicable regulations, guides, staff positions, and industry standards and is acceptable."

V. REFERENCES

1. 10 CFR Part 50, Appendix A, General Design Criterion 2, "Design Bases for Protection Against Natural Phenomena."

2. 10 CFR Part 50, Appendix A, General Design Criterion 5, "Sharing of Structures, Systems and Components."

3. Regulatory Guide 1.29, "Seismic Design Classification," Revision 1.

4. Regulatory Guide 8.8, "Information Relevant to Maintaining Occupational Radiation Exposure As Low As Practicable (Nuclear Reactors)."

5. Branch Technical Position, APCSB 9-1, "Overhead Handling Systems for Nuclear Power Plants," attached to this plan.

BRANCH TECHNICAL POSITION APCSB 9-1
OVERHEAD HANDLING SYSTEMS FOR NUCLEAR POWER PLANTS

A. BACKGROUND

Overhead handling systems are used for handling heavy items at nuclear power plants. The handling of heavy loads such as a spent fuel cask raises the possibility of damage to the load and to safety-related equipment or structures under and adjacent to the path on which it is transported should the handling system suffer a breakdown or malfunction.

Two methods are used in nuclear power plants to prevent damage to safety features or release of radioactive material due to dropping of heavy loads, such as a spent fuel cask. One is protection by physical design of the facility to preclude damage to spent fuel and safety-related systems if a heavy load should be dropped. The other is to provide an overhead handling system that is designed so that a connected load would not fall in the event of a failure or malfunction.

An overhead handling system includes all the structural, mechanical, and electrical components that are needed to lift and transfer a load from one location to another. Primary load-bearing components, equipment, and subsystems such as the driving equipment, drum, rope reeving, control, and braking systems require special attention. Proper support of the rope drums ensures that they would be retained and prevented from failing or disengaging from the braking and control system in case of a shaft or bearing failure. If the hoisting system (raising and lowering) includes two mechanical holding brakes, each with better than full-load stopping capacity, that are automatically activated when electric power is off or when mechanically tripped by overspeed or overload devices, a critical load will be safely held or controlled in case of failure in the individual load-bearing parts of the hoisting machinery. Failure of the bridge or trolley travel to stop when power is shut off or an overspeed or overload condition due to malfunction or failure in the drive system can be prevented and controlled by appropriate safety and limit devices and brake systems.

Since the crane industry has not yet developed codes or standards that adequately cover the design, operation, and testing for a "single failure-proof" crane, the APCSB has developed a branch position to provide a consistent basis for reviewing equipment and components for such overhead handling systems. The position below delineates acceptable codes and standards and supplements them with specific recommendations on features that will prevent, control, or stop inadvertent operation or malfunction of the mechanical supporting and moving components of the handling system.

B. BRANCH TECHNICAL POSITION

Overhead handling systems intended to provide single failure-proof handling of loads should be designed so that no single failure or malfunction will result in dropping or loosing control of the heaviest (critical) loads to be handled. Such handling systems should be designed, fabricated, installed, inspected, tested, and operated in accordance with the following:

1. General Performance Specifications

a. Separate performance specifications should be prepared for a permanent crane which is to be used for construction prior to use for plant operation. The allowable design stress limits should be identical for both cases, and the sum total of simultaneously applied loads should not result in stress levels causing any permanent deformation other than that due to localized stress concentrations.

b. The operating environment, including maximum and minimum pressure, temperature, humidity, and rates of change of these parameters, should be specified to determine the venting and drainage required for box girder sections. The specifications should also state the corrosive and hazardous conditions that may occur during operation. Fracture toughness for the steel structural materials should be considered. Plate thickness, with a margin for the lowest operating temperatures, should determine the type of steel that can be used with or without toughness tests. The selection of steel materials will be reviewed on a case-by-case basis.

c. The crane should be classified as seismic Category I and should be capable of retaining the maximum design load during a safe shutdown earthquake, although the crane may not be operable after the seismic event. The bridge and trolley should be provided with means for preventing them from leaving their runways with or without the design load during operation or under seismic loadings. The design rated load plus operational and seismically-induced pendulum and swinging load effects on the crane should be considered in the design of the trolley, and they should be added to the trolley weight for the design of the bridge.

d. All weld joints for load-bearing structures, including those susceptible to lamellar tearing, should be inspected by nondestructive examinations for soundness of the base metal and weld metal.

e. A fatigue analysis should be considered for critical load-bearing structures and components of the crane handling system. The cumulative fatigue usage factors should reflect effects of cyclic loadings from both the construction and operating periods.

f. Preheat and postheat treatment temperatures for all weldments should be specified in the weld procedures. For low-alloy steel, the recommendations of Regulatory Guide 1.50 should be followed.

2. Safety Features

a. The automatic and manual controls and devices required for normal crane operation should be designed such that a malfunction of these controls and devices, and possible subsequent effects during load handling, will not prevent the handling system from being maintained at a safe neutral holding position.

b. Auxiliary systems, dual components, or ancillary systems should be provided such that in case of subsystem or component failure the load will be retained and held in a safe position.

c. Means should be provided for devices which can be used in repairing, adjusting, or replacing failed components or subsystems when failure of an active component or subsystem has occurred and the load is supported and retained in the safe (temporary) position with the system immobile. As an alternative to repairing the crane in place, means may be provided for moving the handling system with load to a laydown area that has been designed for accepting the load and making the repairs.

3. Equipment Selection

a. Dual load attaching points should be provided on the load block or lifting device, designed so that each attaching point will be able to support a static load of 3W (W is weight of the design rated load), without permanent deformation other than that due to localized stress concentrations in areas for which additional material has been provided for wear.

b. Lifting devices such as lifting beams, yokes, laddle or trunnion type hooks, slings, toggles, or clevises should be of redundant design with dual or auxiliary devices or combinations thereof. Each device should be designed to support a static load of 3W without permanent deformation.

c. The vertical hoisting (raising and lowering) mechanism which uses rope and consists of upper sheaves (head block), lower sheaves (load block), and rope reeving system, should be designed with redundant means for hoisting. Maximum hoisting speed should be no greater than 5 fpm.

d. The head and load blocks should be designed to maintain a vertical load balance about the center of lift from the load block through the head block, and should have a dual reeving system. The load block should maintain alignment and a position of stability with either system and be able to support 3W and maintain load stability and vertical alignment from the center of the head block through all hoisting components to the center of gravity of the load.

e. The design of the rope reeving system should be dual, with each system providing separately the load balance on the head and load blocks through the configuration of ropes and rope equalizers. Selection of the hoisting rope or running rope should consider the size, construction, lay, and means or type of lubrication to maintain efficient working of the individual wire strands as the rope passes over sheaves during the hoisting operation. The effects of impact loadings, acceleration, and emergency stops should be included in selection of the rope and reeving system. The wire rope should be 6 x 37 Iron Wire Rope Core (IWRC) or comparable classification.

The stress in the lead line to the drum during hoisting at the maximum design speed with the design rated load should not exceed 20% of the manufacturer's rated strength of the rope. The static stress in rope (load is stationary) should not exceed 12-1/2% of the manufacturer's rated strength. Line speed during hoisting (raising or lowering) should not exceed 50 fpm.

f. The maximum fleet angle from drum to lead sheave in the load block should not exceed 3-1/2 degrees at any point during hoisting and there should be only one 180° reverse bend for each rope leaving the drum and reversing on the first or lead sheave on the load block, with no other reverse bends other than at the equalizer if a sheave-type equalizer is used. The fleet angles for rope between individual sheaves should not exceed 1-1/2 degrees. Equalizers may be beam or sheave type. For the recommended 6 x 37 IWRC classification wire rope, pitch diameter of the lead sheave should be 30 times rope diameter for the 180° reverse bend, 26 times rope diameter for running sheaves, and 13 times rope diameter for equalizers. The pitch diameter is measured from the center of the rope in the sheave groove through the sheave center. The dual reeving system may be a single rope from each end of a drum terminating at a beam-type load and rope stretch equalizer with each rope designed for total load, or a 2-rope system may be used from each drum or separate drums with a sheave or beam equalizer, or any other combination which provides two separate and complete reeving systems.

g. The vertical hoisting system components, which include the head block, rope reeving system, load block, and dual load attaching device, should each be designed to sustain a load of 2W (W is the weight of the design rated load). A 2W static load test should be performed for each reeving system and load attaching point at the manufacturer's plant. Each reeving system and each one of the load attaching devices should be assembled with approximately a 6 inch clearance between head and load blocks and should support 200% of the design rated load without degradation of the components or permanent deformation other than that due to localized stress concentrations. Measurements of the geometric configuration of the attaching points should be made before and after test followed by nondestructive examination, which should consist of combinations of magnetic particle, ultrasonic, radiographic, and dye penetrant examinations to verify the soundness of fabrication and assure the integrity of this portion of the hoisting system. The results of examinations should be documented and recorded for the hoisting system for each overhead crane.

h. Means should be provided to sense such items as electric current, temperature, overspeed, overloading, and overtravel. Controls should be provided to stop the hoisting movement within 3 inches maximum of vertical travel through a combination of electrical power controls and mechanical braking and torque control systems should one rope of the dual reeving system fail.

i. The control systems may be designed as combination electrical and mechanical systems and may include such items as contractors, relays, resistors, and thyristors in combination with mechanical devices and mechanical braking systems. The electric controls should be selected to provide a maximum breakdown torque limit of 175% of the required rating for a-c motors or d-c motors (series or shunt wound) used for the hoisting drive motors. Compound wound d-c motors should not be used. The control systems provided should consider hoisting (raising and lowering) of all loads, including the design rated load, and the effects of inertia of the rotating hoisting machinery such as motor armatures, shafts and couplings, gear reducers, and drums.

j. The mechanical and structural components of the hoisting system should have the required strength to resist failure should "two-blocking"[1/] or "load hangup"[2/] occur during hoisting. The designer should provide means to absorb or control the kinetic energy of rotating machinery in the event of two-blocking or load hangup. The location and type of mechanical brakes and controls should provide positive and reliable means to stop and hold the hoisting drums for these occurrences. The hoisting system should be able to withstand the maximum torque of the driving motor, if a malfunction occurs and power to the driving motor cannot be shut off at the time of load hangup or two-blocking.

k. The load hoisting drum on the trolley should be provided with structural and mechanical safety devices to prevent the drum from dropping, disengaging from its holding brake system, or rotating, should the drum or any portion of its shaft or bearings fail.

l. To preclude excessive breakdown torque, the horsepower rating (HP) of the electrical motor drive for hoisting should provide no more than 110% of the calculated HP requirement to hoist the design rated load at the maximum design hoist speed.

m. The minimum hoist braking system should include one power control braking system (not mechanical or drag brake-type) and two mechanical holding brakes. The holding brakes should be activated when power is off and should be automatically tripped by mechanical means on overspeed to the full holding position if a malfunction occurs in the electrical brake controls. Each holding brake should be designed to 125% - 150% of maximum developed torque at the point of application (location of the brake in the mechanical drive). The minimum design requirements for braking

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[1/] "Two-blocking" is an inadvertently continued hoist which brings the load and head block assemblies into physical contact, thereby preventing further movement of the load block and creating shock loads to rope and reeving system.

[2/] "Load hangup" occurs when the load block or load is stopped during hoisting by entanglement with fixed objects, thereby overloading the hoisting system.

systems that will be operable for emergency lowering after a single brake failure should be two holding brakes for stopping and controlling drum rotation. Provisions should be made for manual operation of the holding brakes. Emergency brakes or holding brakes which are to be used for manual lowering should be capable of operation with full load and at full travel and provide adequate heat dissipation. Design for manual brake operation during emergency lowering should include features to limit the lowering speed to less than 3.5 fpm.

n. The dynamic and static alignment of all hoisting machinery components including gearing, shafting, couplings, and bearings should be maintained throughout the range of loads to be lifted with all components positioned and anchored on the trolley machinery platform.

o. Increment drives for hoisting may be provided by stepless controls or inching motor drives. Plugging[3/] should not be permitted. Controls to prevent plugging should be included in the electrical circuits and the control system. Floating point[4/] in the electrical power system, when required for bridge or trolley movement, should be provided only for the lowest operating speeds.

p. To avoid the possibility of overtorque within the control system, the horsepower rating of the driving motor and gear reducer for trolley and bridge motion of an overhead bridge crane should not exceed 110% of the calculated requirement at maximum speed and with the design rated load. Incremental or fractional inch movements, when required, should be provided by such items as variable speed or inching motor drives. Control and holding brakes should each be rated at 100% of maximum drive torque at the point of application. If two mechanical brakes are provided, one for control and one for holding, they should be adjusted with one brake in each system for both the trolley and bridge leading the other and should be activated by release or shutoff of power. The brakes should also be mechanically tripped to the "on" or "holding" position in the event of a malfunction in the power supply or an overspeed condition. Provisions should be made for manual operation of the brakes. The holding brake should be designed so that it cannot be used as a foot-operated slowdown brake. Drag brakes should not be used. Opposite wheels on bridges or trolleys which support the bridge or trolley on the runways should be matched and have identical diameters. Trolley and bridge speeds should be limited. A maximum speed of 30 fpm for the trolley and 40 fpm for the bridge is recommended.

q. The complete operating control system and provisions for emergency controls for the overhead crane handling system should be located in the main cab on the

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[3/] Plugging is the momentary application of full line power to the drive motor for the purpose of promoting a limited movement.

[4/] The point in the lowest range of movement control at which power is on, brakes are off, and motors are not energized.

bridge. Additional cabs located on the trolley or lifting devices should have complete control systems similar to the bridge cab. Manual controls for hoisting and trolley movement may be provided on the trolley. Manual controls for the bridge may be located on the bridge. Remote controls or pendant controls for any of these motions should be the same as those provided in the bridge cab control panel. Provisions should be made in the design for devices for emergency control or operations. Limiting devices, mechanical and electrical, should be provided to indicate, control, and prevent overtravel and overspeed of hoist (raising or lowering) and for trolley and bridge travel movements. Buffers for bridge and trolley travel should be included.

r. Safety devices such as limit type switches provided for malfunction, inadvertent operation, or failure should be in addition to and separate from the control devices provided for operation.

s. The operating requirements for all travel movements (vertical and horizontal movements or rotation, singly or in combination) for permanent plant cranes should be clearly defined in the operating manual for hoisting and for trolley and bridge travel. The designer should establish the maximum working load (MWL). The MWL should not be less than 85% of the design rated load (DRL) capacity for the new crane at time of operation. The redundancy provided, design factors, selection of components, and balance of auxiliary-ancilliary and duel items in the design and manufacture should be taken into account in setting the maximum working load for the critical load handling crane system(s). The MWL should not exceed the DRL for overhead crane handling systems.

t. When the permanent plant crane is to be used for construction and the operating requirements for construction are not identical to those required for permanent plant service, the construction operating requirements should be defined separately. The crane should be designed structurally and mechanically for the construction loads, plant service loads, and the functional performance requirements for each. At the end of the construction period, the crane handling system should be adjusted for the performance requirements of permanent plant service. The conversion or adjustment may include the replacement of such items as motor drives, blocks, and reeving system. After construction use, the crane should be thoroughly inspected using nondestructive examinations and should be performance tested. If the load and performance requirements are different for construction and plant service periods, then the crane should be tested for both phases. The crane integrity should be verified by the designer and manufacturer and load testing to 125% of the design rated load required for the operating plant should be done before the crane is used as permanent plant equipment.

u. Installation instructions should be provided by the manufacturer. These should include a full explanation of the crane handling system, its controls, and the limitations for the system, and should cover the requirements for installation, testing, and preparations for operation.

4. Mechanical Checks, Testing, and Preventive Maintenance

a. A complete mechanical check of all crane systems as installed should be made to verify the method of installation and to prepare the crane for testing. During and after installation the proper assembly of electrical and structural components should be verified. The integrity of all control, operating, and safety systems is to be verified as to satisfaction of installation and design requirements.

The crane designer and crane manufacturer should provide a manual of information and procedures for use in checking, testing, and crane operation. The manual should also describe a preventive maintenance program based on the approved test results and information obtained during the testing; it should include such items as servicing, repair, and replacement requirements, visual examinations, inspections, checking, measurements, problem diagnosis, nondestructive examination, crane performance testing, and special instructions.

Information concerning proof testing on components and subsystems as required and performed at the manufacturer's plant to verify component or subsystem ability to perform should be available for the checking and testing performed at the place of installation of the crane system.

b. The crane system should be prepared for the static test of 125% of the design rated load. The tests should include all positions of hoisting, lowering, and trolley and bridge travel with the 125% rated load and other positions as recommended by the designer and manufacturer. After satisfactory completion of the 125% static test and adjustments required as a result of the test, the crane handling system should be given full performance tests with 100% of the design rated load for all speeds and motions for which the system is designed. This should include verifying all limiting and safety control devices. The crane handling system should demonstrate the ability to lower and move the design rated load by manual operation and with the use of emergency operating controls and devices which have been included in the handling system.

The complete hoisting machinery should be allowed to two-block during the hoisting test (load block limit and safety devices are bypassed). This test should be conducted without load and at slow speed, to provide assurance of the integrity of the design, equipment, controls, and overload protection devices. The test should demonstrate that the maximum torque that can be developed by the driving system, including the inertia of the rotating parts at the overtorque condition, will be absorbed or controlled prior to two-blocking.

The complete hoisting machinery should be tested for ability to sustain a load hangup condition by a test in which the load block attaching points are secured to a fixed anchor or excessive load. The drum should be capable of one full revolution before starting the hoisting test.

c. The preventive maintenance program recommended by the designer and manufacturer should also prescribe and establish the MWL for which the crane will be used. The maximum working load should be plainly marked on each side of the crane for each hoisting unit. It is recommended that critical load handling cranes should be continuously maintained at 95% of DRL capacity for the MWL capacity.

C. REFERENCES

1. Regulatory Guide 1.50, "Control of Preheat Temperature for Welding of Low-Alloy Steel."

2. "Table of Engineering, Manufacturing, and Operating Standards, Practices, and References," attached to this position.

TABLE OF
ENGINEERING, MANUFACTURING, AND OPERATING STANDARDS, PRACTICES, AND REFERENCES

AISE	Association of Iron and Steel Engineers (Std. No. 6). General items for overhead cranes and specifically for drums, reeving systems, blocks, controls, and electrical, mechanical, and structural components.
AISC	American Institute of Steel Construction, "Manual of Steel Construction." Runway and bridge design loadings for impact, and structural supports.
ASME	American Society of Mechanical Engineers. References for testing, materials, and mechanical components.
ASTM	American Society for Testing Materials. Testing and selection of materials.
ANSI	American National Standards Institute (A10, B3, B6, B15, B29, B30 and N45 series). N series of ANSI standards for quality control. ANSI consensus standards for design, manufacturing, and safety.
IEEE	Institute of Electrical and Electronics Engineers. Electrical power and control systems.
AWS	American Welding Society (D1.1.72 - 73/74 revisions). Fabrication requirements and standards for crane structure and weldments.
EEI	Edison Electrical Institute. Electrical systems.
SAE	Society of Automotive Engineers, "Standards and Recommended Practices." Recommendations and practices for wire rope, shafting, lubrication, fasteners, materials selection, and load stability.
CMAA	Crane Manufacturers Association of America (CMAA 70). Guide for preparing functional and performance specifications and component selection.
NEMA	National Electrical Manufacturers Association. Electrical motor, control, and component selections.
WRTB	Wire Rope Technical Board and their manufacturing members. Selection of rope reeving system, and reeving efficiencies.
MHI	Materials Handling Institute and their member associations and association members such as American Gear Manufacturing Association for gears and gear reducers and Antifriction Bearing Manufacturers Association for bearings selection.
WRC	Welding Research Council, "Control of Steel Construction to avoid Brittle Fracture," and Bulletin #168, "Lamellar Tearing."

11/24/75

SRP 9.2.1