NRC PDR

UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D. C. 20555

August 4, 1980

Docket Nos. 50-259
50-260
and 50-296

Mr. Hugh G. Parris
Manager of Power
Tennessee Valley Authority
500A Chestnut Street, Tower II
Chattanooga, Tennessee 37401

Dear Mr. Parris:

Our report providing the resolution of Generic Task A-36 will be issued shortly as NUREG-0612, "Control of Heavy Loads at Nuclear Power Plants," providing staff criteria in this area. Following issuance, licensees will be requested to demonstrate compliance with the criteria in NUREG-0612. These criteria allow various alternatives, one of which includes use of a high reliability handling system whose crane satisfies NUREG-0554.

In your letter of June 30, 1976, you provided information comparing the Browns Ferry Reactor Building crane with the criteria contained in Branch Technical Position APCSB 9-1; these criteria were subsequently incorporated into NUREG-0554. In order to facilitate early resolution of the Control of Heavy Loads issue at Browns Ferry, we have commenced a review of the Browns Ferry reactor building crane to determine whether it conforms to NUREG-0554, "Single-Failure-Proof Cranes for Nuclear Power Plants," May 1979. The information reviewed included applicable Browns Ferry Nuclear Plant (BFNP) FSAR sections and your June 30, 1976 response to our request for a documented comparison of the Reactor Building crane with the positions given in Branch Technical Position APCSB 9-1.

We have made a comparison of the Reactor Building crane design, fabrication, installation, inspection, testing, and operation with NUREG-0554. Where we found that direct compliance with some of the recommendations would be difficult or impractical to follow, alternate solutions included in NUREG-0554 were used, where applicable. In addition, other alternatives not explicitly stated in NUREG-0554 were accepted where alternative measures provided equivalent protection.

Our review has identified some areas in which the Browns Ferry crane does not appear to meet NUREG-0554 guidelines nor any of the alternatives. In addition, the reviewed BFNP FSAR sections and your June 30, 1976 response do not address all of the guidelines expressed in NUREG-0554. To complete our evaluation, we need the additional information included in the attached Request for Additional Information.

This request for additional information has been structured to state explicitly the current staff position and to indicate the information required. To facilitate review by our consultant, we request that you provide the information requested within 90 days of receipt of this letter.

Sincerely,

T M Novak

Thomas M. Novak, Assistant Director
for Operating Reactors
Division of Licensing

Enclosure:
Request for Additional
Information

cc w/enclosure:
See next page

cc:

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REQUEST FOR ADDITIONAL INFORMATION

BROWNS FERRY UNITS 1, 2, AND 3

REACTOR BUILDING CRANE

1. NUREG-0554 titled, "Single-Failure-Proof Cranes For Nuclear Power Plants," recognized the general value of existing standards. It is the staff's position that the Browns Ferry Nuclear Plant (BFNP) reactor building crane should 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 Electrical Overhead Traveling Cranes." Tables 12.2-14 and 12.2-15 of the Browns Ferry FSAR provide the load combinations and allowable stresses for the reactor building crane. Indicate the degree to which these allowable stresses comply with those provided in CMAA 70-1975 for welded box girders, bridge end trucks, and trolley frames.
2. In response to R. A. Purple's letter of June 10, 1975, to James E. Watson, which requested a documented comparison of the BFNP reactor building crane with the positions given in Branch Technical Position APCSB 9-1, the evaluation provided for Position 3.o is not clear. The effects of cyclic loading induced by jogging or plugging an uncompensated hoist control system should be included in the design. Describe the features inherent in the maxspeed dc adjustable voltage system used on both hoist and travel drives to prevent abrupt change in motion. Describe whether the electric power system allows the brakes to be released while the hoist or drive motors are not energized.
3. In response to Position 4.c of the Branch Technical Position APCSB 9-1, a statement was made that the maximum-working-load capacity will be maintained at 100% of the design-rated load (DRL). A single-failure-proof crane should be designed to handle the maximum critical load (MCL) that will be imposed. A single-failure-proof crane may handle non-critical loads of a magnitude greater than the MCL. For such cases, the maximum non-critical load or maximum working load can be the design-rated load. For the reactor building crane, define the MCL.

If the MCL is within 15% of the DRL, define any degradation considered for components (due to wear and exposure), and describe the procedures that are followed to detect and correct degraded conditions. Describe any design features that will effectively limit the load, experienced by the wire rope and other wear-susceptible components.

4. Lamellar tearing is a ductile failure of the parent steel and occurs while the steel is cooling after the welding process. The tearing serves to relieve the tensile stresses imparted during the welding process. Such stresses--and the subsequent tearing--can be directly related to the welding method (heat input), the difference in strength between base and weld metals (weld metal is typically much stronger), the amount of restraint of the welded joint, the geometry (configuration) of the joint itself, and other factors. Identify any fabrication requirements, design requirements, and manufacturing/assembly procedures employed to minimize the introduction of lamellar tearing.
5. In response to Position 1.c of the Branch Technical Position APCSB 9-1, a reference was made to FSAR Section 12.2.2.5.3. In keeping with a "defense-in-depth" philosophy, reliance on single failure protection for critical parts is not acceptable For critical rotating parts, which must endure a greater number of cycles or varying reversed stresses, confirm that these parts are designed to accommodate cumulative damage from fatigue. Identify load-bearing rotating parts that are subjected to stress cycles. This identification should include the material used and the basis for determining satisfactory component design.
6. In response to Position 2.b of the Branch Technical Position APCSB 9-1, a reference was made to FSAR Section 12.2.2.5.2 for details of compliance. FSAR Section 12.2.2.5.2 does not clearly indicate that the auxiliary handling system of the reactor building crane is single-failure-proof. Indicate whether the auxiliary hoisting system is employed to lift or assist in handling critical loads (defined in NUREG 0554). If the auxiliary handling system is employed, describe the degree of redundancy provided for the hoisting system.

7. The selection of the rope reeving systems should have accounted for the effects of impact loadings, acceleration, and emergency stops. It is the staff's position that the maximum load (including static and inertial forces) on each individual wire rope should not exceed 10% of the manufacturer's published breaking strength. Your response to Position 3.e of the Branch Technical Position APCSB 9-1 states that, "for the main hoist with design rated load the dynamic stress in the lead line is 15.6% of its breaking stress..." For the MCL (identified in 3.) provide the maximum stress (including static and inertial forces) on each individual wire rope in the dual reeving system, and compare it to the manufacturer's published breaking strength. If the auxiliary hoisting system is employed to lift or assist in handling critical loads, provide the weight of the load and the maximum stress in the rope. Compare this stress to the manufacturer's published breaking strength.

8. The load-block assembly should be provided with two load-attaching points (hooks or other means) so designed that each attaching point will be able to support a load three times the load (static and dynamic) being handled without permanent deformation of any part of the load block assembly other than localized for wear. For the load-block assembly illustrated in FSAR Figure 12.2-22d, indicate whether the attachment points for the safety cables can support three times the weight of the load. For the safety cables, provide the factor of safety as compared with the critical load being handled. Indicate whether the safety cables are loaded during fuel-cask-handling operations. If they are not loaded, describe how the impact loading from a hook failure was utilized in establishing the cable design. Since the safety cables are acting in conjunction with the load-handling hook, state whether a 200% static-type-load test has been performed on the safety cables.

   For other critical loads (assuming spent fuel cask is a critical load), describe the means employed to achieve the equivalent of dual attachment points. In lieu of dual attachment points, a single attachment point would be acceptable if the factor of safety is increased to ten.

If dual attachment points are not provided for other critical loads, demonstrate that the stress levels are less than 10% of the load-carrying capability of the hook.

9. For the lifting devices, that handle critical loads over the open reactor vessel and spent fuel and are identified in your response to Position 3.b of the Branch Technical Position APCSB 9-1 describe the degree of compliance with the following criteria.

   a. *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." This standard should apply to all special lifting devices which carry critical loads, as defined by NUREG 0554. 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.[1] This is in lieu of the guideline in Section 3.2.1.1 that bases the stress design factor on only the weight (static load) of the load and of the intervening components of the special handling device.

   b. *Lifting devices that are not specially designed* should be installed and used in accordance with guidelines of ANSI B30.9-1971, "Slings." However, the safety factor should be the ratio between the breaking strength and the maximum combined static and dynamic load.[2] 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 to identify the cranes with which they may be used.

10. In response to Position 3.h of Branch Technical Position APCSB 9-1, a reference was made to FSAR Section 12.2.2.5.2, which describes safety features that meet the "intent" of this position. Although the referenced FSAR section does describe safety devices that mitigate the effects of overpower and overspeed, there is no clear indi-

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[1] For the purpose of determining the safety factor, loads imposed by the safe shutdown earthquake need not be included in the dynamic loads imposed on the sling or lifting device.

[2] Ibid

cation that these controls are capable of stopping the hoisting movement within amounts of movement such that damage would not occur. Provide an evaluation of the controls on the BFNP reactor building crane that limit hoist movement upon sensing an overpower or overspeed condition.

11. In lieu of two-block testing of the main hoist, as delineated in Position 4.b of Branch Technical Position APCSB 9-1, two independent travel-limit switches are acceptable, provided there is periodic verification of the proper functioning of these switches. Describe the method and frequency of testing of the limit switches. In addition, the testing requirements of the current-limiting device on the hoist motor should be discussed, as well as any other device which may be required to function to mitigate the effects of load hangup.

12. NUREG 0554, "Single-Failure-Proof Cranes for Nuclear Power Plants," establishes the criterion that the minimum operating temperature be considered in conjunction with the structural material properties to reduce the possibility of brittle fracture of the ferritic load-carrying members of the crane. Either the drop weight test, in accordance with ASTM E-208, or the Charpy V-Notch (CVN) test, in accordance with ASTM A-370, are suggested for impact testing. As an alternative to establishing the fracture toughness by material testing, a cold-proof test with a dummy load equal to 1.25 times the maximum critical load is acceptable. In response to Position 1.b of the Branch Technical Position APCSB 9-1, a statement was made that "all structural portions of the bridge and trolley were fabricated from A-36 steel in accordance with AISC specifications. Fracture toughness tests were not performed since the lowest expected operating temperatures are 0°F during construction and 65°F as permanent plant equipment."

    A recent study conducted for our staff concluded with a confidence rating of about 90% that the nil ductility transition temperature (NDTT) is 39°F for A-36 steel.

    Since fracture-toughness data for the heat of steel used in the reactor building crane is not available, an alternate approach is to demonstrate that the minimum operating temperature exceeds the NDTT sufficiently to ensure the absence of brittle fracture. The fracture analysis diagram (FAD) advanced by Pellini can be used to develop design criteria by which to arrive at a minimum operating temperature. The criteria are[3]:

1. *NDT Temperature Design Criterion.* This is based on the existence of an acting yield point stress level, and the coexistence of only small flaws less than one inch in size. Restricting the service temperature to above this value assures ductile behavior. It provides fracture protection by preventing crack initiation; however, it does not provide for the arrest of a propagating crack.

2. *NDTT Plus 30° Design Criterion.* This criterion is based on a stress level of the order of one-half yield strength, commonly used for commerical vessel design, and its relation to the crack arrest temperature (CAT) curve. Restricting service temperature to above this value obviates the flaw-size evaluation problem. That is, fractures cannot initiate or propagate in this stress field.

3. *NDTT Plus 60° Design Criterion.* This criterion is based on the same considerations as design Criterion 2, except the level of stress is the yield strength of the material. This criterion is in frequent engineering use and is the basis of the American Society of Mechnical Engineer's Nuclear Code requirements.

4. *NDTT Plus 120° Design Criterion.* This criterion is based on the premise that the stress level will be above the yield point of the material. This restricts service to full shear fracture temperatures to develop maximum fracture resistance.

The NDTT Plus 120°F Criterion is too conservative for application to the BFNP reactor building crane, since the maximum allowable stress is 0.9Fy during severe load combinations. The NDTT Plus 60°F Criterion provides fracture-arrest protection if the nominal stress does not exceed yield level. This criterion is applicable to the BFNP reactor building crane for the following reasons:

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[3] Harvey, J., Theory and Design of Modern Pressure Vessels, Van Nostrand Reinhold Co., N. Y., 1974.

1. The allowable stress approaches the minimum yield stress during dynamic load conditions.

2. Commercial materials do have flaws or inherent, minute defects. The materials used in the BFNP reactor building crane were of commerical standards and were apparently manufactured without stringent controls to minimize flaw size.

3. Regardless of the type of loading, fatigue can result in subcritical crack growth by various means. Thus, even though the initial flaw size may be small (based on quality of fabrication), the possibility of larger cracks is present when the structure is subjected to repeated loading over the 40-year design life.

4. The consequences of structural failure are unacceptable.

Rolfe and Barsom stated[4] that low-strength structural steels (e.g., steels with yield strengths less than 140 ksi) generally are temperature-and loading-rate-sensitive. That is, these steels exhibit a considerable increase in crack toughness with either increasing temperature or decreasing loading rate. Therefore, the NDTT Plus 30°F (and lower) Criterion may be acceptable for cranes if the loading rate is slow. For low-strength steels, the rate of change of absorbed energy as a function of temperature is greater in the impact test than in the slow-bend tests. The general effect of a slow loading rate (compared with standard impact-loading rates for CVN specimens) is to shift the CVN curve to the left and to lower the upper shelf values. If the loading rates of the crane structure are closer to those of slow-bend loading than to those of impact loading, a considerable difference in the behavior of the crane would be expected. Since the failure of a single member can lead to the collapse of the entire crane, it is prudent to design on the basis of dynamic loading.

The NDTT Plus 30°F Criterion may also be acceptable for thinner plates (e.g., less than 1 inch in thickness for A-36 steel). Because of the limited statistical data and the recognition of metallurgical

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[4] Rolfe, S. T. and Barsom, J. M., Fracture and Fatigue Control in Structures, Prentice-Hall, Englewood Cliffs, N. J., 1977.

variations within a given plate, it is not feasible to refine the relationship between temperature and plate thickness. Rolphe and Barsom make the following statement about plate thickness:

> From a qualitative viewpoint, the effect of a plate thickness on the fracture toughness of steel plates tested at room temperature has been generally established. As the plate thickness is decreased, the state of stress changes from plane strain to plane stress, and ductile fractures generally occur along 45° planes through the thickness. Except for very brittle materials, failure is usually preceded by through-thickness yielding and is not catastophic. Conversely, in thick plates the state of stress is generally plane strain, and fractures usually occur normal to the direction of loading...[5]

Some of the BFNP reactor building crane sections are greater than 1 inch in thickness, the loading rate is assumed to be dynamic, and the allowable stresses are greater than 0.5 Fy; therefore, the NDTT Plus 30°F Criterion should not be used. When using the effective NDTT calculated early and the NDTT Plus 60°F Criterion, an acceptable minimum operating temperature would be 99°F (39°F + 60°F). In conclusion, a minimum operating temperature of 65°F in the absence of fracture-toughness data is not acceptable in lieu of cold-proof testing.

Provide a commitment to conduct a cold-proof test, followed by a nondestructive examination of welds whose failure could result in the drop of a critical load.

13. NUREG 0554 establishes the criterion that the maximum torque capability of the driving motor and gear reducer for trolley motion and bridge motion should not exceed the capability of gear train and brakes to stop the trolley or bridge at the maximum speed with the design-rated load (DRL) attached. It further requires that the control and holding brakes should each be rated at 100% of the maximum drive torque that

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[5] Ibid.

can be developed at the point of application.

In response to Position 3.p of Branch Technical Position APCSB 9-1, it was stated:

> The next larger standard size motor above that calculated was selected. Travel drive sizes are based on acceleration time as well as running torque and this practice was followed in sizing these drives. . .The bridge is provided with one 50 percent brake for normal stopping and a 100 percent torque for holding. Both trolley brakes are 75 percent torque brakes.

The method of sizing the drive motor is acceptable. However, the control and holding brakes are not rated at 100% of the maximum drive torque that can be developed at the point of application. The braking system does not satisfy the single-failure criteria. The braking systems for the bridge and trolley do not ensure stopping of bridge or trolley movement if a single active failure of a brake is postulated. Provide additional information to demonstrate that the braking system has sufficient redundancy to overcome 100% of the maximum drive torque, assuming a single failure of the control or holding brakes. In lieu of this, provide a commitment to upgrade the brake capacities of the trolley and bridge.

14. The discussion provided in FSAR Section 12.2.2.5.1 concerning the seismic analysis is not sufficient for the staff to make an evaluation of its acceptability. In addition to the discussion provided in FSAR Section 12.2.2.5.1, expand the description of the seismic analysis employed to demonstrate that the reactor building crane can retain the MCL during a seismic event equal to a safe shutdown earthquake, and provide a description of the method of analysis and the assumptions used. The description of the method of analysis should include a discussion of the analytical model. The description of assumptions should include the basis for selection of trolley and load position.
15. In response to Position 1.f of Branch Technical Position APCSB 9-1, a statement was made that all welds requiring preheat and postheat were done by procedures that specified the required temperatures.

It is the staff's position that all welds whose failure could result in the drop of a critical load should be postweld heat treated in accordance with subarticle 4.4 of AWS D1.1, "Structural Welding Code." Indicate whether or not the welds whose failure could result in the drop of a critical load were postweld heat treated. In addition, describe the method used. If postweld heat treatment was not employed, the accessible welds whose failure could result in the drop of a critical load should be nondestructively examined to ascertain that the weldments are acceptable.

16. In reviewing the reactor building crane design against the guidelines of the NUREG 0554, some areas were indentified which the FSAR or your response to the positions of Branch Technical Position APCSB 9-1 did not specifically address. In order to complete the staff review, address the following guidelines of NUREG-0554:

    a. Item 2.4 states that cast iron should not be used for load-bearing components. Indicate whether cast iron was used for load-bearing components.

    b. Item 4.1 states that the pitch diameter of the drum should be selected in accordance with the recommendations of CMAA 70. Provide the ratio of drum diameter to the rope diameter for the reactor building crane main hoist. If the auxiliary hoisting system is employed to lift or assist in handling critical loads, compare the drum and sheave diameters with the rope diameter.

    c. Item 4.3 states that the load blocks should be nondestructively examined by surface and volumetric techniques. For the reactor building crane load blocks, indicate whether they have been nondestructively examined by surface and volumetric techniques.

    d. If the auxiliary hoisting system is employed to lift or assist in handling critical loads, describe the extent to which the design is protected against two-blocking, as delineated in Item 4.5.

    e. Describe the extent of compliance to Item 4.7 concerning wire rope protection.

f. Describe the extent of compliance to Item 6.2 concerning the driver control systems.

g. Item 6.6 states that cranes that use more than one control station should be provided with electric interlocks that permit only one control station to be operable at any one time. For the reactor building crane, which employs more than one control station, indicate whether or not electrical interlocks have been provided to permit only one control station to be operable at any one time.

h. Item 8.5 states that the MCL should be plainly marked on each side of the crane for each hoisting unit. Indicate the extent of compliance for the hoisting units for the reactor building crane.

i. The operating manual for the reactor building crane should contain, as a minimum, the information described in Item 9.0. Indicate the extent to which the information is contained in the reactor building crane operating manual. In addition, verify that the operating requirements for all travel movements incorporated in the design are clearly defined in the operating manual for hoisting and for trolley and bridge travel.

j. Describe the extent of compliance to Item 10.0 concerning the quality-assurance program used in the design, fabrication, installation, testing, and operation. The program should address the qualification requirements for crane operators.