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U. S. Nuclear Regulatory Commission
ATTN: Document Control Desk
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Dresden Nuclear Power Station, Units 2 and 3
Facility Operating License Nos. DPR-19 and DPR-25
NRC Docket Nos. 50-237 and 50-249

Subject: Response to Request for Additional Information Regarding Heavy Loads Handling

Reference: Letter from U. S. NRC to O. D. Kingsley (Exelon Generation Company, LLC), "Dresden Nuclear Power Station, Units 2 and 3 – Request for Additional Information – Heavy Loads Handling," dated February 26, 2002

In the referenced letter, the NRC requested that Exelon Generation Company, LLC provide information regarding heavy loads handling at Dresden Nuclear Power Station, Units 2 and 3. The attachment to this letter provides the requested information.

Should you have any questions concerning this letter, please contact Mr. A. R. Haeger at (630) 657-2807.

Respectfully,

Keith R. Jury

Keith R. Jury
Director – Licensing
Mid-West Regional Operating Group

Attachments:
Attachment A: Response to Request for Additional Information Regarding Heavy Loads Handling at Dresden Nuclear Power Station, Units 2 and 3
Attachment B: Analysis of Record for Reactor Building Crane Bridge

cc: Regional Administrator - NRC Region III
NRC Senior Resident Inspector - Dresden Nuclear Power Station

A001

Attachment A

Response to Request for Additional Information Regarding Heavy Loads Handling at Dresden Nuclear Power Station, Units 2 and 3

Question

1. *In Nuclear Regulatory Commission Bulletin (NRCB) 96-02, "Movement of Heavy Loads over Spent Fuel, Over Fuel in the Reactor Core, or Over Safety-Related Equipment," dated April 1996, the NRC staff addressed specific instances of heavy load handling concerns and requested licensees to provide specific information detailing their extent of compliance with the guidelines and their licensing basis. The NRC staff, in a safety evaluation report dated May 20, 1998, concluded that (1) licensees who plan to move heavy loads at power should assess their capabilities to both mitigate and manage the adverse consequences of a heavy load drop, and (2) the staff would continue to review issues regarding the handling of heavy loads on a plant specific basis. Subsequently, NRC Inspection Report 07200037/2001-002(DNMS) identified a number of Unresolved Items (URI) concerning the reliability of Dresden Station's heavy load handling system. Commonwealth Edison (now Exelon) submitted special report number 41, dated November 8, 1974, seeking NRC approval of modifications to the reactor building crane and cask yoke assembly. In Section 3.2, "Component Failure Analysis," of Report 41 the licensee committed to analyze the handling system and its modifications in accordance with Crane Manufacturers Association of America (CMAA) Specification 70, Section 70-3. The licensee also committed to analyze the stress levels imposed on the handling system due to operating conditions under seismic considerations in accordance with American Institute of Steel Construction (AISC) Code requirements for operating-basis earthquake (OBE) and the design-basis earthquake (DBE). However, Supplement A, dated June 10, 1975, to Report 41 stated that the bridge and trolley would be analyzed in a manner consistent with the design codes applicable at the time of the original installation and that the allowable stress would be limited to 90-percent of yield, with only static lifted loads considered.*

   Subsequent staff evaluation of Dresden's overhead handling system and its modifications against NRC staff Branch Technical Position (BTP) APCSB 9-1, "Overhead Handling Systems For Nuclear Power Plants," was approved by a safety evaluation report dated June 3, 1976, for amendment numbers 19 and 22.

   In order to evaluate the Unresolved Items, the staff is requesting the analysis of record that supports the seismic qualifications of the bridge and trolley, and associated load bearing components of the Reactor Building crane. The staff is particularly interested in the design codes and standards used in the analysis to address the seismic qualification of the crane as single-failure-proof. Justification should be provided to specifically demonstrate how the crane and supporting structure met the intent of BTP 9-1, Section 1, General Performance Specifications, Paragraph c. For example, how did the analysis address safe-shutdown earthquake (SSE) plus maximum critical load (lifted load) and OBE plus maximum critical load, and how did the analysis determine that the bridge and trolley would not leave their respective runways?

   If the codes used to analyze the trolley are different from those used for the bridge, please explain why.

Response

In November 1974, Commonwealth Edison Company (ComEd), now Exelon Generation Company (Exelon), LLC submitted Dresden Special Report Number 41 to the NRC as part of a request for approval to use the Dresden Nuclear Power Station (DNPS), Units 2 and 3 reactor building crane to handle spent fuel casks of up to 100 tons (Reference 1). Subsequently, the NRC issued BTP 9-1 in April 1975 to provide guidance for single failure-proof heavy load handling systems. ComEd then submitted Supplement A to Dresden Special Report 41 in June 1975 to evaluate the DNPS reactor building crane against BTP 9-1 (Reference 2). Thus, Supplement A provides the most direct ComEd evaluation of the reactor building crane against BTP 9-1, with additional information provided by Dresden Special Report 41.

The evaluations in Special Report 41 and Supplement A distinguish between the bridge/trolley and the remainder of the handling system. As described in more detail below, these documents indicate that the bridge and trolley are designed to meet seismic requirements, while the remainder of the handling system is designed to meet the specified factors of safety for redundant and non-redundant components.

The following paragraphs compare the reactor building crane design to the provisions of BTP 9-1, including reference to the design codes and standards used.

Bridge and trolley
Section 1.c of BTP 9-1 establishes the expectation that the crane be classified as seismic Category I and stipulates that the crane should be capable of retaining maximum design load during an SSE event. Supplement A, Section 1.c provides the ComEd response to BTP 9-1 and states that the DNPS crane is Safety Class II (i.e., non-seismic) and that the bridge and trolley will be analyzed seismically. Note that BTP 9-1 does not discuss an OBE loading case.

As noted in Special Report 41, Section 2.1.A, for the normal loading condition (i.e., no seismic loads), the bridge and the trolley were analyzed for the component failure analysis with the lifted load based on CMAA #70 permissible stress ranges. For the bridge girder, the maximum vertical loading impact was based on Section 70-3 of CMAA # 70. For the operational condition including seismic loads, the bridge and trolley design values were based on AISC code allowables for OBE and 90% of the minimum yield strength for DBE.

Section 1.c of BTP 9-1 states that 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 conditions. A walk down of the reactor building crane has verified the presence of safety lugs on both the bridge and the trolley that prevent derailment during operation or during a seismic event. With these safety lugs in place, no additional analysis is required.

Section 1.c of BTP 9-1 further states, "The design rate 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." To address this, Supplement A states that the bridge and trolley will be analyzed consistent with design codes at the time of original installation with the allowable stress to 90% of yield with only static loads considered. No commitment was made to design for seismically induced pendulum and swinging load effects. Static loads considered included vertical live load (i.e., full crane lifted load) and dead load (i.e., girder, trolley, and accessories).

Attachment B provides the seismic analysis of record for the bridge. The component failure analysis for the bridge and the seismic and component failure analyses for the trolley are not available. However, based on the available seismic analysis of record for the bridge, it is evident that analyses for the bridge and trolley were completed to support the preparation of Supplement A. The results of these analyses were incorporated into Supplement A and the UFSAR. UFSAR Table 9.1-3, which contains the same information as Attachment 1 to Supplement A, provides factors of safety for various components of the reactor building crane and shows that the calculated factors of safety (yield and ultimate) for the trolley are at least 88% higher than the corresponding factors of safety for the bridge. Therefore, under similar loading conditions, the trolley structure will be less stressed than the bridge. As the trolley is located on the top of bridge, it will be subjected to similar seismic loading. Since the bridge has been qualified for OBE/DBE seismic conditions, the trolley is considered adequate for OBE/DBE seismic loads.

Handling system components besides bridge and trolley
Dresden Special Report 41 and Supplement A do not state that the handling system and/or load bearing components, beyond the bridge and trolley, will be seismically designed. Dresden Special Report 41, Section 3.1 states all redundant elements (except rope) within the dual load path will comply with CMAA Specification 70 allowable stresses and that all other single element components will be designed to a minimum factor of safety of 7.5 based on the ultimate strength of the material. Supplement A, Section 1.e refers to a crane component failure analysis and to a table in Attachment 1 of the supplement. It states that the factor of safety on all critical components exceeds 3.0 to yield strength and exceeds 4.5 to ultimate strength, which exceed the factors of safety if calculated in accordance with the allowable stresses in accordance with CMAA Specification 70.

Dresden Special Report 41, Section 3.2, refers to vertical impact as defined in section 70-3 of CMAA #70 and seismic events (i.e., OBE and DBE), and is similar to a statement in Section 2.1.A. The statement in Section 3.2 does not appear to be consistent with the more detailed statements made in Sections 2.1.A and 2.1.C. Section 2.1.A clearly states that the seismic requirement is applicable only to the bridge and trolley. Section 2.1.C states that all crane parts are designed in accordance with CMAA 70, and does not refer to seismic considerations. Seismic requirements are not applicable to the other components. This understanding is also reflected in the NRC Safety Evaluation (Reference 3), which states, "Within the dual load path, the design criteria is such that all dual elements comply with CMAA #70 allowable stresses except for the hoisting rope which is governed by more stringent job specification criteria. All single element components, within the load path, have been designed to a minimum safety factor of 7.5 based on the ultimate strength of the material."

Supplement A, Sections 3-a and 3-g, compares the factors of safety of the load bearing components of the crane to the provisions of BTP 9-1, and demonstrates that the head block, rope reeving system, load block assembly, and dual load attaching device compare favorably to BTP 9-1.

The component failure analyses to validate the factors of safety provided in the UFSAR Table 9.1-3 for the load bearing components have not been located either at Exelon or at the Whiting Corporation, which performed the analyses. However, these analyses were prepared to support preparation of Supplement A, and the results were incorporated into Supplement A and the UFSAR.

In summary, the reactor building crane is classified as Safety Class II equipment. However, the bridge and trolley were designed to AISC criteria, where applicable, for OBE and DBE events. The remainder of the handling system was designed with factors of safety as specified in our submittals. The NRC approved the DNPS reactor building crane as a single failure-proof crane in Reference 3. The safety evaluation states, "Based on our review of data provided by the licensee, we have concluded that the integrated design of crane, controls, and cask lifting devices meets the intent of BTP APCSB 9-1 as regards single failure criteria except in the specific areas of the crane reeving system, and protection against 'two-blocking.'" The safety evaluation discusses acceptable DNPS compensatory measures for these areas.

Question

2. *The overhead handling system is supported by the building superstructure, and the building superstructure must be capable of supporting the crane with its design rated load during a SSE for the handling system to be single-failure-proof. Updated Final Safety Analysis Report (UFSAR) Section 3.2.1 classifies the reactor building as a Class I structure. UFSAR, Section 3.8.4.1.3, "Loads and Load Combinations," states that the following load combinations will be used for Class I structures, with OBE and SSE:*

   - *D + R + E (OBE)*
   - *D + R + E'(SSE)*

   UFSAR Section 3.8.4.1.3 defines a dead load (D) to be the load of a structure and equipment plus any other permanent loads contributing stress, such as soil or hydrostatic loads, operating pressures, and live loads expected to be present when the plant is operating. Inspection report 07200037/2001-002 states that Exelon considers SSE analysis with lifted load on the handling system to be beyond-design-basis. The staff considers the SSE as well as the OBE with lifted load on the crane to be required load combinations within the Dresden design basis for evaluating the structural integrity of the crane and the superstructure. Since the crane is now being used to lift heavy loads during operation, the live loads component of D should include the lifted loads.

   (a) Demonstrate compliance with the design basis criteria for the building superstructure as well as the building components below the crane rails (e.g., walls and columns supporting the overhead crane) under all loading conditions. The maximum allowable stresses to be used for the various conditions should satisfy those stated in UFSAR Table 3.8-11 for Class I structures.

Describe the analysis performed to seismically qualify the building superstructure and state the results of such analysis. Discuss whether any modifications were determined to be necessary based on the results of the analysis and describe any modifications that were implemented to assure that the building superstructure is seismically adequate.

Response
The original design basis for the reactor building superstructure did not consider the crane lifted load with the OBE and SSE seismic loads. During the 1974-76 time period, the reactor building crane was upgraded to support fuel cask loading and movements. A review of various submittals to the NRC, including Dresden Special Report 41 and Supplement A, shows that these documents focused on the crane and that there was no mention of the impact on the existing licensing or design basis of the reactor building superstructure.

Section 3.8.4 of the DNPS UFSAR identifies the applicable loading combinations for Class I structures. Although the UFSAR indicates that live loads expected to be present during operation will be considered, this statement is not detailed enough to clearly reflect the design intent. A review of the original DNPS design calculations indicates that the design basis for the reactor building superstructure was to consider normal (non-earthquake) loads with a full crane lifted load and to consider the OBE and SSE seismic loads without a crane lifted load. This is consistent with the design basis for several other plants of this vintage.

In 1997, a corrective action program Problem Identification Form (PIF) identified inadequate documentation relating to the design of the reactor building structure. Calculation DRE98-0020, which is the current calculation of record, was performed in response to this PIF. The following paragraphs provide a description of the assumptions, methods, and results in this calculation.

Analysis Assumptions and Methods (Calculation DRE98-0020)
This calculation computed the level of stress and the interaction coefficients (ICs), where the IC equals actual stress divided by allowable stress for the reactor building structural steel superstructure.

A detailed seismic model of the steel superstructure, including the vertical bracing of the walls and the roof truss configuration as well as the crane column and girder framing system, was generated and incorporated with the rest of the reactor-turbine building design basis model.

From the detailed seismic model discussed above, two refined seismic models were created to obtain the realistic responses of major superstructure elements in the north-south and east-west directions. The El Centro ground acceleration time history analyses adjusted to maximum ground acceleration of 0.20g for SSE (in accordance with the UFSAR) were used to obtain seismic responses from the two models. Additionally, response spectrum analyses using the Housner spectrum were performed.

The forces from the above analyses (El Centro and Housner) were enveloped and used in the design of the members and their connections. The constant accelerations of 0.067g for OBE and 0.133g for SSE were used for the vertical seismic response in accordance with the UFSAR.

The pendulum effect of the crane lifted load under the SSE loading condition for the beyond design basis loading condition was considered in the analysis.

The following loading combinations and acceptance criteria were considered.

(i) Normal load condition (includes full crane lifted load)
Acceptance criteria: Normal AISC allowables.

(ii) Wind load condition (includes full crane lifted load)
Acceptance criteria: UFSAR Table 3.8-11 allowable stresses for loading condition 2

(iii) OBE seismic condition (no crane lifted load)
Acceptance criteria: UFSAR Table 3.8-11 allowable stresses for loading condition 1

(iv) SSE seismic condition (no crane lifted load)
Acceptance criteria: UFSAR Table 3.8-11 allowable stresses for loading condition 3

(v) SSE seismic condition (full crane lifted load) – "beyond design basis" condition
Acceptance criteria: UFSAR Table 3.8-11 allowable stresses for loading condition 3

Calculation results

(i) Normal load condition (includes full crane lifted load) The roof girder has an adjusted IC of 1.03, which was judged acceptable based on other conservatisms in the calculation. All other members meet design allowables (IC ≤ 1.0).

The roof girder calculation showed an IC of 1.05. This was subsequently changed to an IC of 1.03. The change was based on revising the allowable stress to 22 ksi instead of the 21.6 ksi originally considered. The allowable stress of 22 ksi for 36 ksi yield stress steel is permitted by AISC codes. The AISC code sixth edition (i.e., the code of record) provides this value in Appendix 5-67 and the current AISC code (ninth edition) provides this value in Table 1 on page 5-117.

The calculation concluded that the overstress of 3% is considered acceptable based on its small magnitude. Standard structural engineering practices permit small amounts of overstress. Many textbook examples on member sizing accept a small amount of overstress. For example, the textbook "Steel Structures – Design & Behavior" by Salmon and Johnson – Second Edition; page 324 shows acceptance of overstress of 3% and pages 347 and 705 show acceptance of small overstresses. This is because there is significant margin between the code allowables and the ultimate strength of the structure.

Additionally, the maximum IC of the roof girder for all other loading conditions including SSE + crane lifted load is 0.95. Hence, the roof girder is structurally adequate even during the SSE loading condition. The calculated member stresses are below the yield stress and hence will not result in any permanent deformation. Therefore, the small overstress for the roof girder under the normal load condition is acceptable.

(ii) Wind load condition (includes full crane lifted load) All members meet design allowables (IC $\leq$ 1.0).

(iii) OBE seismic condition (no crane lifted load) All members meet design allowables (IC $\leq$ 1.0).

(iv) SSE seismic condition (no crane lifted load) All members meet design allowables (IC $\leq$ 1.0).

(v) SSE seismic "beyond design basis" condition (full crane lifted load) All members meet design allowables (IC $\leq$ 1.0). The design allowable considered is yield stress, in accordance with the UFSAR. Thus, no member will be stressed beyond yield. Therefore, there will be no permanent deformation of any member.

A review of all the approved calculations since the original calculation in 1966-67, including calculation DRE98-0020, did not identify any requirements for modification of the reactor building superstructure. Some early, non-record, calculations identified potential plant modifications, but these calculations were deemed to be overly conservative and were not approved.

NUREG/CR-0891 "Seismic Review of Dresden Nuclear Power Station - Unit 2 for the Systematic Evaluation Program (SEP)," dated April 1980 states that the reactor and turbine building structures are considered adequate for SSE. The NRC Safety Evaluation on SEP Safety Topic III-6, "Seismic Design Considerations," states, "The results of structural evaluation showed that reactor-turbine building complex is capable of withstanding the postulated SSE event." (Reference 4)

Exelon will revise the DNPS UFSAR to discuss the beyond design basis calculation that showed the superstructure to be adequate for the load combination of crane lifted load with SSE.

The OBE was not considered with a crane lifted load in calculation DRE98-0020. Exelon considers that requiring the superstructure to meet the more restrictive allowables for this case would not provide significant benefit to the health and safety of the public. As described in 10 CFR 100, "Reactor Site Criteria," paragraph III(d), the regulatory requirements related to the OBE ensure that the features of the nuclear power plant necessary for continued operation without undue risk to the health and safety of the public are designed to remain functional. The reactor building crane is not a system which is relied upon for continued operation of the nuclear plant. Further, as noted above, the reactor building superstructure has been shown to meet design allowables for a lifted load with an SSE. Thus, the occurrence of an OBE, which is less severe than an SSE, concurrent with a lifted load, will not jeopardize the continued operation of the nuclear plant, since there will be no effect on the integrity of the reactor coolant pressure boundary, the capability to shut down the reactor, or the capability to prevent or mitigate the consequences of an accident.

Plant abnormal procedure DOA 0010-03, "Earthquakes," requires lowering the lifted load and securing the reactor building crane following seismic activity that actuates the plant seismic indicator. Exelon will revise plant abnormal procedure DOA 0010-03, to include a requirement for the engineering department to inspect the reactor building superstructure following seismic activity that actuates the plant seismic indicator, if the crane had been engaged in lifting a heavy load.

In summary, the DNPS original design basis for the reactor building superstructure did not include consideration of seismic activity with a reactor building crane lifted load. The design basis as stated in the UFSAR is not detailed enough to clearly reflect this design intent. Calculation DRE98-0020 showed that the reactor building superstructure is capable of withstanding an SSE with a crane lifted load without permanent deformation to any structural member. The DNPS UFSAR will be updated to reflect the load combination of SSE with crane lifted load. The reactor building superstructure has not been formally evaluated for the case of the OBE with a crane lifted load. The safety significance of this OBE case is minimal, and Exelon has provided a commitment to inspect the reactor building superstructure following seismic activity that actuates the plant seismic indicator.

<u>Question</u>

3. *Amendments 19 and 22 approved lifting devices in accordance with the criteria established in BTP 9-1, Section 3(a) and (b). The special lifting device reviewed for Amendments 19 and 22 is shown in Figure 7 of Special Report 41, dated November 11, 1974. Inspections conducted by NRC Region III identified that current lifting devices are not in accordance with those approved by the staff in Amendments 19 and 22 in June 1976. NUREG-0612-1980, "Control of Heavy Loads at Nuclear Power Plants," Section 5.1.1(4), "Special lifting devices," states that special lifting devices should satisfy the requirements of ANSI N14.6-1978, "Standard for Special Lifting Devices for Shipping Containers Weighing 10,000 pounds (4500 kg) or More for Nuclear Material."*

   If the licensee is utilizing a current lifting device other than that approved in the June 1976 SER, demonstrate that the special lifting device satisfies requirements in Section 3.2.1.1 of ANSI N14.6, and includes the maximum static and dynamic (lateral) loads that could be imparted on the new lifting devices currently installed for operation.

   Demonstrate how the Dresden Station special lifting devices meet the guidelines of NUREG-0612, Section 5.1.6(1), "Special lifting devices," (a) and (b), and in particular how the special lifting devices meet the requirements of ANSI N14.6, Section 6.

Demonstrate how the special lifting devices at Dresden Station meet the guidelines of NUREG-0612, Section 5.1.6(3), "Interfacing lift points," (a) or (b). In addition, if an actuating (latching) mechanism is used as part of the special lifting device, demonstrate how the actuating mechanism meets the requirements of ANSI N14.6 - 1978, Sections 3.3.3, 3.3.4, 3.3.5, 3.3.6, and 3.3.7.

Response
DNPS is currently using a lifting device for spent fuel casks that is different from that described in Dresden Special Report 41 (Reference 1). The current device being used is a HI-TRAC 125 ton lift yoke assembly. The use of this device was evaluated in Exelon calculation DRE00-0078, "Structural Analysis of HI-TRAC 125-Ton Lift Yoke Assembly," to ensure that the lifting device meets the requirements of ANSI N14.6-1993. A review of ANSI N14.6-1978 and ANSI N14.6-1993 shows that sections 3.2.1.1 and 6 of ANSI N14.6-1978 are technically the same as sections 4.2.1.1 and 7 of ANSI N14.6-1993. The paragraphs below describe how the HI-TRAC 125 ton lift yoke assembly meets the requirements discussed in the question.

ANSI N14.6-1978, Section 3.2.1.1 and NUREG-0612-1980, Section 5.1.1(4)
ANSI N14.6-1978, Section 3.2.1.1 states that all load-bearing members of a special lifting device shall be capable of lifting three times the total weight (including weight of all intervening components) without exceeding minimum yield strength. The load-bearing members shall also be capable of lifting five times the total weight without exceeding the ultimate strength.

NUREG-0612-1980, Section 5.1.1(4) states that special lifting devices should satisfy the requirements of ANSI N14.6 – 1978, Section 3.2.1.1, except that the stress design factor shall be based on combined maximum static and dynamic loads.

ANSI N14.6-1978, Section 6 and NUREG-0612-1980, Section 5.1.6(1)(a)
ANSI N14.6-1978, Section 6, specifies requirements for special lifting devices when they handle critical loads. The special lifting device shall have either of the following.

a. Non-redundant load bearing members are to be designed with at least twice the normal stress design factor (ratio of ultimate or yield stress to actual stress).
b. Redundant attachments from a crane to special device shall be two distinct load paths, each capable of supporting the critical load independently. The dual-load-path attachment points on the special lifting device shall be designed so each load path will be able to support a static load of 3W (W being total load) plus the impact load due to any weight transfer that occurs due to failure of one load path, without exceeding the yield point.

NUREG-0612-1980, Section 5.1.6(1)(a) states that if only a single lifting device is provided instead of dual devices, the lifting device should have twice the design safety factor as required to satisfy the guidelines of Section 5.1.1(4).

DNPS HI-TRAC 125 Ton Lifting Device
For the DNPS HI-TRAC 125 ton lifting device, the load considered was the sum of 250,000 pounds plus the dead weight of yoke assembly of 3,600 pounds. A dynamic

load of 15% of the total static load was added to the total static load to arrive at the design load. The following stress design factors were used in the analysis.

- The maximum stress in any non-redundant structural component is limited to the minimum of either 1/10 of the ultimate strength or 1/6 of the yield strength.
- Where there is redundancy, the maximum stress in any structural component is limited to the minimum of either 1/5 of the ultimate strength or 1/3 of the yield strength.

Examples of redundant and non-redundant components and their safety factors are as follows.

- Crane hook engagement pin loads (redundant) are a maximum of 1/5 of the ultimate strength, which is the governing case, when compared to yield strength.
- Strongbacks (non-redundant) loads are a maximum of 1/10 of the ultimate strength, which is the governing case when compared to yield strength.
- The actuation plate and engagement pin loads (non-redundant) is a maximum of 1/10 of the ultimate strength, which is the governing case when compared to yield strength.
- The lift yoke arm loads (non-redundant) are a maximum of 1/10 of the ultimate strength, which is the governing case when compared to yield strength.

Thus, the HI-TRAC 125 ton lifting device meets the requirements of ANSI N14.6-1978, Section 3.2.1.1 and Section 6 and NUREG-0612-1980, Section 5.1.1(4) and Section 5.1.6(1)(a). NUREG-0612, Section 5.1.6(1)(b) is not applicable to the special lifting devices.

Lateral loads were not considered as part of the dynamic load. A detailed review of ANSI 14.6-1978, Section 3.2 and Section 6 was performed. It was noted that there is no mention of lateral dynamic load. Calculation DRE00-0078, "Structural Analysis of HI-TRAC 125-Ton Lift Yoke Assembly," incorporates a vertical dynamic load equal to 15% of the total lifted load in the design of the yoke assembly. No lateral load is considered in the design.

NUREG-0612-1980, Section 5.1.6(3) and ANSI N14.6-1978, Sections 3.3.3 through 3.3.7

NUREG-0612-1980, Section 5.1.6(3) is applicable to interfacing lift points. Part (a) states that dual-path components should be designed to an ultimate strength of five times the maximum static and dynamic load. Part (b) specifies that the non-redundant or non-dual lift point system should have a design safety factor of ten times the maximum combined concurrent static and dynamic loads.

The HI-TRAC 100 transfer cask utilizes non-redundant lift trunnions as interfacing lift points. The design basis requirements for the HI-TRAC lift trunnions are contained in the Holtec International Inc., Final Safety Analysis Report for the HI-STORM 100 Cask System, Docket No. 72-1014. The Holtec International HI-STORM 100 Cask System Safety Evaluation (SE) (Reference 5) issued by the NRC as part of the Certificate of Compliance 72-1014 for the HI-STORM 100 Cask System documents acceptance of the

HI-TRAC 100 transfer cask trunnion design. Specifically, Sections 3.1.1, 3.1.2 & 3.5.1 of the SE document NRC acceptance of the trunnion design. Thus, the HI-TRAC 100 transfer cask lift trunnions meet the requirements of NUREG-0612-1980, Section 5.1.6(3). The supporting analysis for the design of the HI-TRAC 100 trunnions is the proprietary property of the certificate holder, Holtec International, and therefore is not discussed in this response.

The HI-TRAC 125 ton lift yoke is designed to meet the requirements of ANSI N14.6 - 1978. The following describes how the yoke complies with ANSI N14.6-1978, Sections 3.3.3 through 3.3.7.

ANSI N14.6-1978, Section 3.3.3 requires that special lifting devices that require remote engagement with the shipping container shall be provided with lead-in guides and sufficient clearance between the container attachment points and the lifting device hook to allow simple motion engagement.

- Holtec specification HI-982044, Rev. 5, Section 4.2 specifies that the lift yoke arms will be articulating. The design has one pivot point and is articulated by pneumatic pistons (Ref. Holtec Drawings 2626, Rev. 4 and 2692, Rev. 2)
- Holtec specification HI-982044, Rev. 5, Section 4.4 requires a minimum of 1/4" diametrical clearance between the hole in the lift yoke arm and the diameter of the HI-TRAC lifting trunnion.
- Holtec Drawing 3419, Sht. 4, Rev. 0, Detail of Item 14 requires chamfers on the side of the hole that engages the HI-TRAC lifting trunnions. The hole itself is elongated in a teardrop design.

These features allow simple motion engagement with the shipping container. Thus, the HI-TRAC 125 ton lift yoke complies with ANSI N14.6-1978, Section 3.3.3.

ANSI N14.6-1978, Section 3.3.4 requires that special lifting devices shall be designed to assure distribution of the load to all load-bearing attachment points.

- Analysis which demonstrates that the Unit 2/3 lift yoke is designed to assure distribution of the load to all load bearing members is contained in Exelon Calculation DRE00-0078 Rev. 0, "Structural Analysis of the HI-TRAC 125 Ton Lift Yoke Assembly."

Thus, the lift yoke complies with ANSI N14.6-1978, Section 3.3.4.

ANSI N14.6-1978, Section 3.3.5 requires that load-carrying components that may become inadvertently disengaged shall be fitted with cotter pins or lock pins of a positive locking type, lock wired, or provided with a retaining latch.

- Holtec specification HI-982044, Rev. 5, Section 4.9 specifies that all yoke pins shall have a means to secure the pins in the engaged position. This is accomplished in the final design by the use of bolted end caps on the main pins (2), actuator pins (2) and block pin. (Ref. Holtec Drawing 3419, Sht. 2, Rev.0)

- Holtec specification HI-982044, Rev. 5, Section 4.17 describes the mechanism used to maintain engagement between the lift yoke arms and HI-TRAC lifting trunnions. The design of the lift yoke ensures that the lift yoke arms hang plumb to engage the lifting trunnions thereby creating no side loads. The trunnion end caps provide visual verification of full trunnion engagement. Additionally, there are no crane design basis scenarios that apply seismic side loads between the cask lifting trunnions and the lift yoke arm. Therefore the lift yoke is not equipped with a device to maintain attachment between the lift yoke arm and trunnion.

Thus, the HI-TRAC 125 ton lift yoke complies with ANSI N14.6-1978, Section 3.3.5.

ANSI N14.6-1978, Section 3.3.6 requires that an actuation mechanism shall be used, if needed, to securely engage or to disengage a special lifting device and a container. A position indicator shall be used in conjunction with an actuating mechanism when it is difficult to see the connection between the lifting device and the container.

- Holtec specification HI-982044, Rev. 5, Section 4.2 specifies that the lift yoke arms will be articulating.
- Holtec specification HI-982044, Rev. 5, Section 4.10 specifies that the lift yoke shall accept pneumatic cylinders.
- Holtec specification HI-982044, Rev. 5, Section 4.12 specifies that the lift yoke arms shall be painted different colors to aid the operator during engagement.
- Holtec Drawings 2626, Rev. 5 and 2692, Rev. 2 specify the design of the actuation mechanism. The actuation mechanism is powered to disengage the lift yoke. When the actuation mechanism is not energized, the lift yoke arms will remain in their engaged position.

Thus, the HI-TRAC 125 ton lift yoke complies with ANSI N14.6-1978, Section 3.3.6

ANSI N14.6-1978, Section 3.3.7 requires that special lifting devices that are used in pools shall have a method of retrieval if unintentional disengagement with the crane occurs.

- The structural arrangement and dimension of the lift yoke components is such that it will allow retrieval by use of standard rigging practices.

Thus, the HI-TRAC 125 ton lift yoke complies with ANSI N14.6-1978, Section 3.3.7.

In summary, DNPS is using a HI-TRAC 125 ton lifting device for spent fuel casks, which is a different lifting device than described in Amendments 19 and 22. The HI-TRAC 125 ton lift yoke and interface points meet the applicable requirements of NUREG-0612-1980 and ANSI N14.6-1978.

References to docketed correspondence

1. Letter from J. S. Abel (Commonwealth Edison Company) to U. S. NRC, "Dresden Station Units 2 and 3, Quad Cities Station Units 1 and 2, Dresden Special Report No. 41, Quad Cities Special Report No. 16, 'Reactor Building Crane and Cask Yoke Assembly Modifications,' AEC Dckt. 50-237, 50-249, 50-254 and 50-265," dated

November 8, 1974

2. Letter from J. S. Abel (Commonwealth Edison Company) to U. S. NRC, "Dresden Station Units 2 and 3, Quad Cities Station Units 1 and 2, Dresden Special Report No. 41, Supplement A, Quad Cities Special Report No. 16 – Supplement A, 'Reactor Building Crane and Cask Yoke Assembly Modifications,' NRC Dckts. 50-237, 50-249, 50-254 and 50-265," dated June 3, 1975

3. Letter from U. S. NRC to R. L. Bolger (Commonwealth Edison Company), dated June 3, 1976

4. Letter from U. S. NRC to L. DelGeorge (Commonwealth Edison Company), "SEP Safety Topic III-6, Seismic Design Consideration and III-11, Component Integrity - Dresden Nuclear Power Station Unit No. 2," dated June 30, 1982

5. Letter from U. S. NRC to K. P. Singh (Holtec International), "Certificate of Compliance for Holtec International HI-STORM 100 Cask System," dated May 4, 2000

<u>Attachment B</u>

Response to Request for Additional Information Regarding Heavy Loads Handling at Dresden Nuclear Power Station, Units 2 and 3

ANALYSIS OF RECORD FOR REACTOR BUILDING CRANE BRIDGE

FORM N-:

WHITING REQN. 63697 DATE 10-10-74
BY LFC PAGE 1 OF

COMMONWEALTH EDISON CO. CRANE # 9492

STRESS ANALYSIS
GIRDER STRUCTURE - SEISMIC LOADING

SEISMIC CRITERIA

LOADS IMPOSED SIMULTANEOUSLY.

1. LIVE LOAD - CRANE CAPACITY
2. DEAD LOAD - GIRDER, ACCESSORIES, TROLLEY
3. SEISMIC LOAD - PROBABLE (OBE) AND POSSIBLE (DBE)

CASE I - SPECTRAL ACCELERATIONS DUE TO SIMULTANEOUS GROUND ACCELERATIONS.
0.44 g HORIZONTAL
0.07 g VERTICAL
STRESSES LIMITED TO 22,000 PSI - AISC

CASE II - SPECTRAL ACCELERATIONS DUE TO SIMULTANEOUS GROUND ACCELERATIONS.
0.88 g HORIZONTAL
0.15 g VERTICAL
STRESSES LIMITED TO .90 FY = 32,400 PSI

PERTINENT DATA.

CRANE CAPACITY - 125 TONS LIVE LOAD
CRANE SPAN - 113'-1"
DEAD LOAD OF DRIVE GIRDER - 85,055#
DEAD LOAD OF TROLLEY - 116,000#
TROLLEY WHEEL BASE - 168".
TROLLEY WHEEL LOAD #1 - 84600#
TROLLEY WHEEL LOAD #2 - 99300#

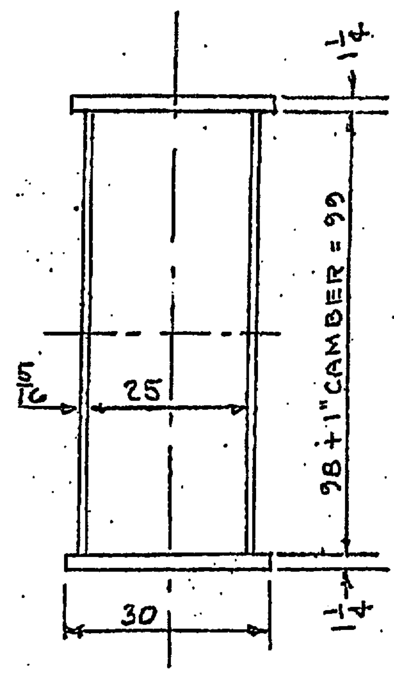
BRIDGE ARRGT -
TROLLEY ARRGT. -

FORM No:

WHITING REQN. 63697 DATE 10-10-74
BY LFC PAGE 2 OF

GIRDER U-53617-M

GIRDER CROSS SECTION



VERTICAL SECTION

$$I_{xx} = \frac{BH^3 - bh^3}{12} = \frac{30 \times 101.5^3 - 29.375 \times 99^3}{12}$$

$$= 239{,}000 \text{ "}^4$$

$$Z_{xx} = \frac{I}{C} = \frac{239{,}000}{50.75}$$

$$= 4709 \text{ "}^3$$

LATERAL SECTION

$$I_{YY} = \frac{bd^3}{12} + A\bar{Y}^2 = \frac{2.5 \times 30^3}{12} + 2 \times 99 \times .31 \times 12.65^2$$

$$= 5625 + 9822$$

$$= 15{,}447 \text{ "}^4$$

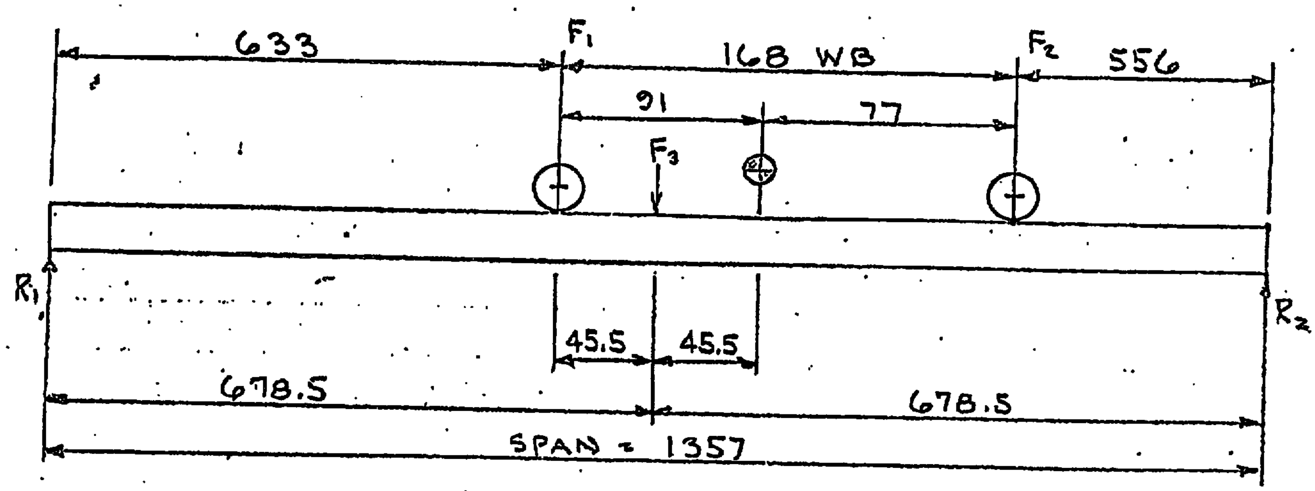
$$Z_{YY} = \frac{I}{C} = \frac{15447}{15} = 1029 \text{ "}^3$$

FORM N-2

WHITING REQN. 63697 DATE 10-10-74
BY LFC PAGE 3 OF

GIRDER LOADING - CASE I

VERTICAL BENDING - SPECTRAL ACCELERATION = 0.07g



$F_1 = 84600 \times 1.07 = 90500$ #

$F_2 = 99300 \times 1.07 = 106250$ #

$F_3 = 2000 \times 1.07 = 2140$ #

$w = 735 \times 1.07 = 786$ #/FT

$$R_1 = \frac{90500 \times 724 + 106250 \times 556 + 2140 \times 678.5 + 786 \times 113.1 \times 678.5}{1357}$$

$$= \frac{65.5 \times 10^6 + 59.1 \times 10^6 + 1.45 \times 10^6 + 60.3 \times 10^6}{1357}$$

$= 137{,}300$ #

MAXIMUM BENDING MOMENT AT F_1 (ZERO SHEAR)

$$M_v = 137300 \times 633 - 786 \times 52.75 \times 316.5 = 73.8 \times 10^6$$

$$\sigma_{xx} = \frac{M_v}{Z} = \frac{73.8 \times 10^6}{4709} = 15{,}670 \text{ PSI}$$

FORM N-249/

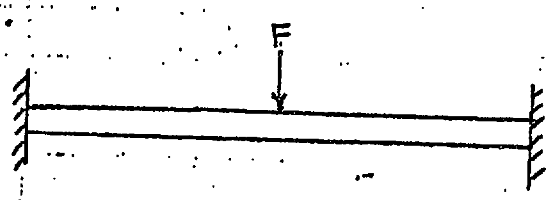
WHITING REQN. 63697 DATE 10-10-74

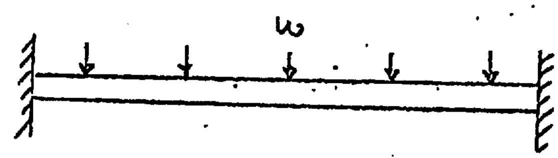
BY LFC PAGE 4 OF

GIRDER LOADING - CASE I

HORIZONTAL BENDING - SPECTRAL ACCELERATION = 0.44 g

ASSUME TROLLEY DEAD LOAD AT CENTER OF SPAN.





F = 60,000 × .44 = 26,400 #

W = 735 × .44 = 323 #

CONCENTRATED LOAD STRESS

$$M = \frac{Fl}{8} = \frac{24,600 \times 1357}{8} = 4.5 \times 10^6$$

$$\sigma = \frac{M}{Z} = \frac{4.5 \times 10^6}{1029} = 4373 \text{ PSI}$$

DISTRIBUTED LOAD STRESS

$$M = \frac{wl^2}{24} = \frac{323 \times 113.1 \times 1357}{24} = 2.06 \times 10^6$$

$$\sigma = \frac{M}{Z} = \frac{2.06 \times 10^6}{1029} = 2002 \text{ PSI}$$

HORIZONTAL BENDING STRESS

$\sigma = 4373 + 2002 = 6375$ PSI

COMBINED BENDING STRESS

$\sigma = 15,670 + 6375 = 22,045$ PSI (ALLOWABLE = 22,000)

GIRDER LOADING - CASE II

VERTICAL BENDING - SPECTRAL ACCELERATION = 0.15g

$F_1 = 84{,}600 \times 1.15 = 97{,}300$ #

$F_2 = 99{,}300 \times 1.15 = 114{,}200$ #

$F_3 = 2{,}000 \times 1.15 = 2{,}300$ #

$w' = 735 \times 1.15 = 845$ #/FT

$$R_1 = \frac{97300 \times 724 + 114200 \times 556 + 2300 \times 678.5 + 845 \times 113.1 \times 678.5}{1356}$$

$$= \frac{70.4 \times 10^6 + 63.5 \times 10^6 + 1.56 \times 10^6 + 64.8 \times 10^6}{1356}$$

$= 147{,}600$ #

MAXIMUM BENDING MOMENT AT F_1 (ZERO SHEAR)

$M_V = 147{,}600 \times 633 - 845 \times 52.75 \times 316.5 = 79.3 \times 10^6$

$$\sigma_{xx} = \frac{M_V}{Z} = \frac{79.3 \times 10^6}{4709} = 16{,}840 \text{ PSI}$$

HORIZONTAL BENDING - SPECTRAL ACCELERATION = 0.88 g

STRESS VALUES ARE DOUBLE THOSE OF CASE I

$\sigma = 8746 + 4004 = 12750$ PSI

COMBINED BENDING STRESS

$\sigma = 16{,}840 + 12750 = 29{,}590$ PSI (ALLOWABLE = 32,400)

SHEAR STRESS DUE TO TORSIONAL LOADS IS NEGLIGABLE

BRIDGE BOGIE TRUCKS U-38321-N-P.

TRUCK CROSS SECTION

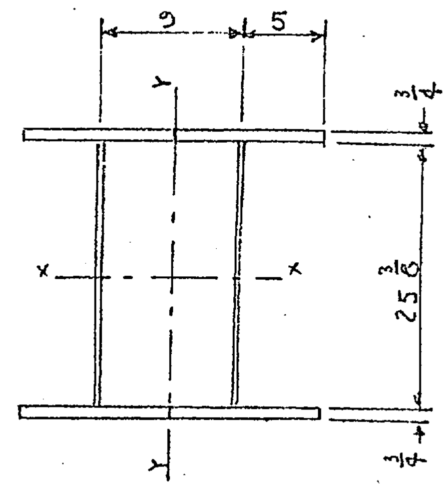
VERTICAL SECTION

$$I_{xx} = \frac{BH^3 - bh^3}{12} = \frac{19 \times 26.9^3 - 18 \times 25.4^3}{12}$$

$$= 6239 \text{ in}^4$$

$$Z_{xx} = \frac{I}{C} = \frac{6239}{13.4} = 466 \text{ in}^3$$

$$=$$



LATERAL SECTION

$$I_{YY} = \frac{bd^3}{12} + A\bar{r}^2 = \frac{1\frac{1}{2} \times 19^3}{12} + 2 \times 25\tfrac{1}{2} \times \tfrac{1}{2} \times 4\tfrac{1}{2}^2$$

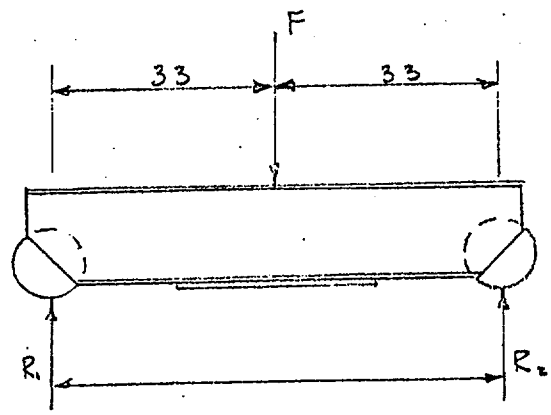
$$= 857 + 516$$

$$= 1373 \text{ in}^4$$

$$Z_{YY} = \frac{I}{C} = \frac{1373}{9.5} = 145 \text{ in}^3$$

TRUCK LOADING - CASE I

VERTICAL BENDING - SPECTRAL ACCELERATION = 0.07g



$F = 228{,}000 \times 1.07 = 243{,}960^{\#}$

$w = 200 \times 1.07 = 214\ ^{\#}/FT$

$$R_1 = \frac{243{,}960 \times 33 + 214 \times 5.5 \times 33}{66} = 122{,}570^{\#}$$

MAXIMUM BENDING MOMENT AT CENTER.

$M_V = 122{,}570 \times 33 - 214 \times 2.75 \times 16.5 = 4.0 \times 10^6$ "#

$$\sigma_{xx} = \frac{M_V}{Z} = \frac{4.0 \times 10^6}{466} = 8584 \text{ PSI}$$

FORM

WHITING REQN. 63697 DATE 10-10

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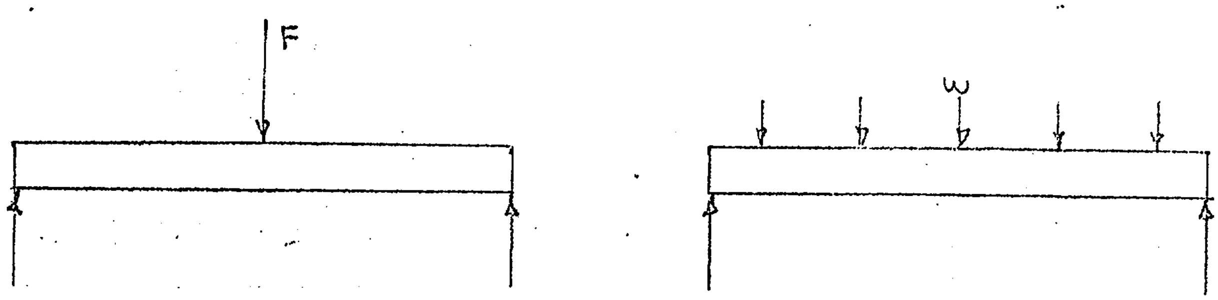
TRUCK LOADING - CASE I

HORIZONTAL BENDING - SPECTRAL ACCELERATION = 0.44 g



$F = (735 \times 56.5 + 30{,}000) \times .44 = 31{,}472^{\#}$

$w = 200 \times .44 = 88^{\#}/FT$

CONCENTRATED LOAD STRESS

$$M = \frac{Fl}{4} = \frac{31{,}472 \times 66}{4} = .52 \times 10^{6}\ ''^{\#}$$

$$\sigma = \frac{M}{Z} = \frac{.52 \times 10^{6}}{145} = 3586 \text{ PSI}$$

DISTRIBUTED LOAD STRESS

$$M = \frac{wl^{2}}{8} = \frac{88 \times 5.5 \times 66}{8} = 3993\ ''^{\#}$$

$$\sigma = \frac{M}{Z} = \frac{3993}{145} = 28 \text{ PSI}$$

HORIZONTAL BENDING STRESS

$$\sigma = 3586 + 28 = 3614 \text{ PSI}$$

COMBINED BENDING STRESS

$$\sigma = 8584 + 3614 = 12{,}198 \text{ PSI}$$ (ALLOWABLE = 22,000)

TRUCK LOADING - CASE II

VERTICAL BENDING - SPECTRAL ACCELERATION - 0.15 g

$F = 228000 \times 1.15 = 262{,}200$ #

$w = 200 \times 1.15 = 230$ #/FT.

$$R_1 = \frac{262{,}200 \times 33 + 230 \times 5.5 \times 33}{66} = 131{,}732\text{\#}$$

MAXIMUM BENDING MOMENT AT CENTER.

$$M_V = 131{,}732 \times 33 - 270 \times 2.75 \times 16.5 = 4.3 \times 10^6$$

$$\sigma_{xx} = \frac{M_V}{Z} = \frac{4.3 \times 10^6}{466} = 9227 \text{ PSI}$$

HORIZONTAL BENDING - SPECTRAL ACCELERATION - 0.88 g

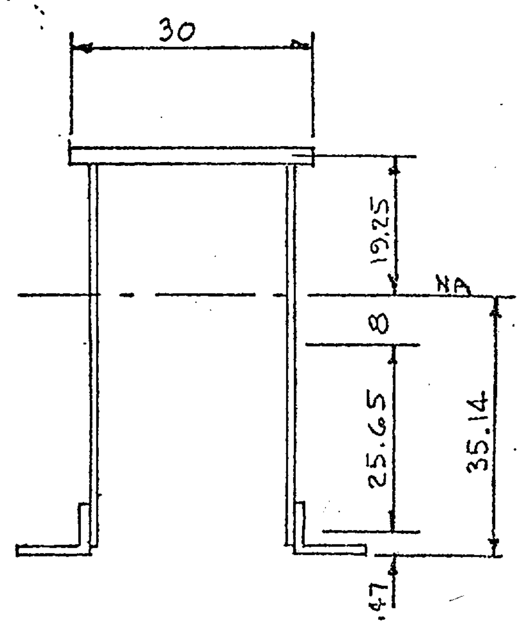
STRESS VALUES ARE DOUBLE THOSE OF CASE I

$$\sigma = 7172 + 56 = 7228 \text{ PSI}$$

COMBINED BENDING STRESS

$$\sigma = 9227 + 7228 = 16{,}455 \text{ PSI (ALLOWABLE } 32{,}400)$$

GIRDER END SECTION D-53617-M



WHEEL LOAD = 114,000#

MOMENT ARM = $10\frac{1}{2}$"

BENDING STRESS

$$\sigma = \frac{M}{S} = \frac{114000 \times 2 \times 10\frac{1}{2}}{1116}$$

σ = 2145 PSI

ALLOWABLE 17,600 PSI

SIZE	A	d	Ad	$\bar{Y}$	$A\bar{Y}^2$	I_o	I_{GR}
(2) $8 \times 6 \times \frac{1}{2}$ ∠	13.5	1.47	19.85	33.65	15286	43.4	15329
(2) $\frac{5}{16} \times 53\frac{1}{4}$	33.3	27.12	903.3	8	2131	7864	9995
$1\frac{1}{4} \times 30$	37.5	54.37	2038.9	19.25	13895	—	13895
	84.3	35.14	2962				39,219

$$S = \frac{I}{C} = \frac{39{,}219}{35.14} = 1116\text{"}^3$$

END SHEAR

$$\tau = \frac{P}{A} = \frac{114{,}000}{\frac{5}{16} \times 53.25} = 6850 \quad \text{PSI}$$

ALLOWABLE 13,200 PSI

FORM N

WHITING REQN. 63697 DATE 10-10-74

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GIRDER U-53617-M

BRIDGE RAIL. 132 LB. AREA BASE. 6" $S = 22.5''^3$

STIFFENER SPACING. 22" WHEEL LOAD 99,300#

BENDING STRESS IN RAIL.

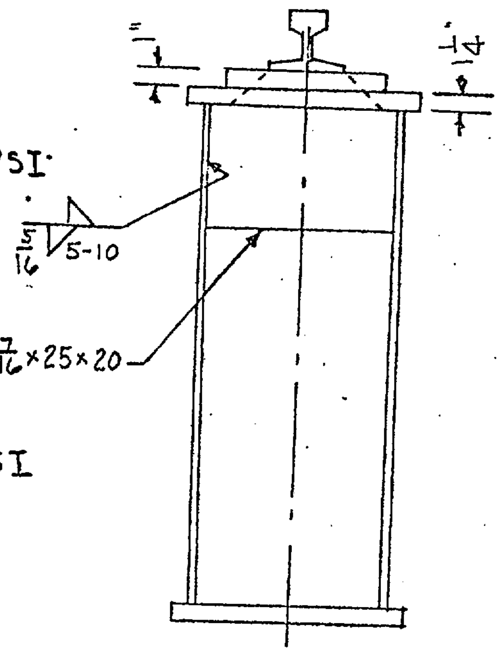
$$\sigma = \frac{PL}{6S} = \frac{99{,}300 \times 22}{6 \times 22.5} = 16{,}180 \text{ PSI}$$

ALLOWABLE 18,000 PSI

BEARING STRESS ON STIFFENER.

$$\sigma = \frac{P}{A} = \frac{99{,}300}{.44 \times (6 + 4\frac{1}{2})} = 21{,}450 \text{ PSI}$$

ALLOWABLE 26,400 PSI



STIFFENER WELD STRESS.

$$f = \frac{P}{A} = \frac{99{,}300}{4 \times 10 \times .31 \times .707} = 11{,}330 \text{ PSI}$$

ALLOWABLE 12,500 PSI

STIFFENER BENDING STRESS.

$$\sigma = \frac{Pl}{d^2 \times b} = \frac{99{,}300 \times 25}{20^2 \times .44} = 14{,}100 \text{ PSI}$$

ALLOWABLE 17,600 PSI

WHITING REQN. 63697 DATE 10-10-7
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BRIDGE WHEEL ASSEMBLY R-38447

AXLE BEARING TIMKEN 48290 - 48220 CUP

BEARING CAPACITY 12,900# @ 500 RPM 3000 HRS L-10

BEARING LOAD 28,500# @ 8 RPM

SPEED FACTOR $\left(\frac{500}{RPM}\right)^{3/10} = 3.458$

LIFE FACTOR $\frac{RATING \times S.F.}{LOAD \times .75} = \frac{12,900 \times 3.458}{28,500 \times .75} = 2.09$

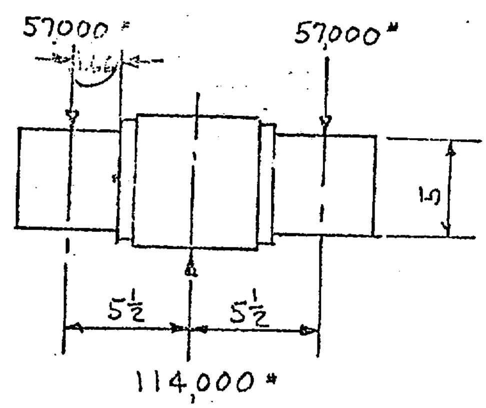
BEARING LIFE 35,000 HRS L-10

AXLE STRESS

$M = 57,000 \times 1.66 = 94,620$

$S = 12.27$

$\sigma = \frac{M}{S} = \frac{94620}{12.27} = 7712$ PSI



ALLOWABLE 10,000 PSI

MATERIAL 4150-HT

MAXIMUM WHEEL LOAD

WHEEL DIA. 24" RUNWAY RAIL 175 LBS

$P = 1600 \times W \times D = 1600 \times 3.125 \times 24 = 120,000$#

GIRDER STRESSES & DEFLECTION

CUSTOMER COMMONWEALTH EDISON CO. PROP. — ORIGINAL REQN. 78064 REQN. 63697

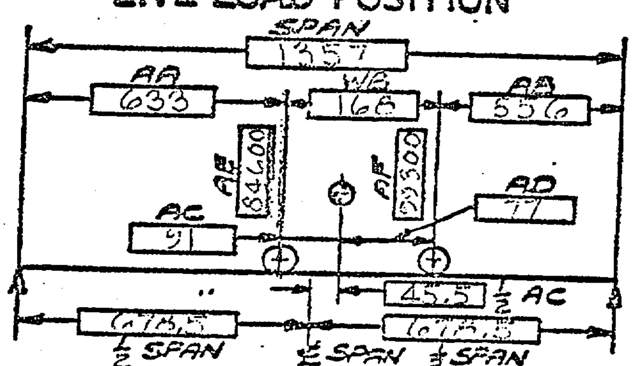
SPAN 113-1 CAPY. 125/5 TROLLEY DRG. TROLLEY WGT. 116,000

CUSTOMER SPECS.

GIRDER SIZE: TOP 14×30 WEB 5/16×98 BOTT. 14×30 $\frac{L}{B}=\frac{[illegible]}{25}=54.5$

COMMENTS DL+LL+15% IMPACT DL+LL+5% LATERAL

LIVE LOAD POSITION



LIVE LOAD REACTION

$\underset{AE}{84600} \times \frac{\overset{AB+WB}{724}}{\underset{SPAN''}{1357}} = 45,137$

$\underset{AF}{99300} \times \frac{\overset{AB}{556}}{\underset{SPAN''}{1357}} = 40,686$

W 183,900 TOTAL L.L. = 85823 = R_1

DEAD LOAD LBS/FT.

GIRDER	570
RAIL	45
WALK & RAILING	60
SQ. SHAFT	32
BRG. & COUPLINGS	18
MISC	10
TOTAL =	735 AJ

DEFLECTION

$LL = \frac{\overset{W}{183900} \times \overset{SPAN''3}{1357}}{48 \times 30,000,000 \times 239,000\ I} = 1.33$

$D.L = \frac{\overset{AJ}{735} \times \overset{SPAN'}{113.1} \times \overset{SPAN''3}{1357}}{77 \times 30,000,000 \times 239,000\ I} = .36$

DRIVE @ ℄ / CAB @ ℄ $= \frac{\overset{WEIGHT}{2000} \times \overset{SPAN''3}{1357}}{48 \times 30,000,000 \times 239,000\ I} = .01$

ALLOWABLE $\Delta'' = .00125 \times \overset{SPAN''}{1357} = \underset{ALLOWABLE}{1.70}$ Σ 1.70

VERTICAL BENDING MOMENT & STRESS

L.L = $\overset{R_1}{85823} \times \overset{AA'}{633} = 54326000$

D.L = $\overset{AJ}{735} \times \overset{SPAN'2}{113.1} \times 1.5 = 14103000$

DRIVE @ ℄ = 2000 113.1 × 3 = 678000

CAB @ ℄ = — — × 3 = —

TOTAL VERTICAL BM 69107000

$\frac{125}{164} \times .15 \times 54326000 = 5536000$

TOTAL B/M W/IMPACT = 74643000

$\frac{\overset{VBM}{69107000}}{\underset{S}{4709}} = 14675$ WITHOUT IMPACT

$\frac{\overset{VBM}{74643000}}{\underset{S}{4709}} = 15850$ WITH IMPACT

$\frac{B}{C} = \frac{25}{1.25} = 20$

MAX. ALLOW. COMB. STRESS = (A36) 17600

LATERAL BENDING MOMENT-STRESS & COMBINED STRESS

VERTICAL L.L. BM 54326000 INCL. DRIVE & CAB @ ℄ × % LATERAL .05 × .5 = 1358000

VERTICAL D.L. BM 14781550 × % LATERAL .05 × .333 = 246000

$\frac{\overset{LBM}{1604000}}{\underset{S}{1029}} = 1560$

TOTAL LATERAL BM 1604000 VBM W/O IMPACT 14675

BY LFC DATE 10-10-74

COMBINED COMPRESSION 16235

RE-ISSUED 4-12-67

L-680