CONNECTICUT YANKEE ATOMIC POWER COMPANY

HADDAM NECK PLANT
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June 19, 2002

Docket No. 50-213
CY-02-075
Re: 10CFR50.90

U. S. Nuclear Regulatory Commission
Attention: Document Control Desk
Washington, DC 20555

Haddam Neck Plant
Proposed Technical Specification Change
Response to Request for Additional Information

On April 15, 2002,[1] the U. S. Nuclear Regulatory Commission (USNRC) issued a request for additional information (RAI) regarding the Connecticut Yankee Atomic Power Company's (CYAPCO) license amendment request dated September 10, 2001.[2] Attachment 1 provides our responses to your questions.

Supporting documentation is provided in Attachments 2, 3, and 4. Attachment 2 provides the current procedure regarding the control of heavy loads (i.e., WCM 2.2-8). Attachment 3 provides the current procedure regarding the control of crane operations (i.e., WCM 2.2-9). Attachment 4 provides a portion of Calculation Number 97C2968(B)-01, "Evaluation of the Yard Crane and Fuel Building Structure for the Haddam Neck Plant."

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1 J. E. Donoghue (NRC) letter to K. J. Heider (CYAPCO), "Request for Additional Information Regarding the Proposed Technical Specification Change for the Haddam Neck Plant Yard Crane (MB2926)," dated April 15, 2002.

2 K. J. Heider (CYAPCO) letter to the U. S. Nuclear Regulatory Commission, "Haddam Neck Plant, Proposed Technical Specification Change," dated September 10, 2001.

A001

Should you have any questions regarding this submittal, please contact Mr. Gerry van Noordennen at (860)-267-3938.

Sincerely,

CONNECTICUT YANKEE ATOMIC POWER COMPANY

Kenneth J Heider

K. J. Heider
Vice President-Operations and Decommissioning

Subscribed and sworn to before me: Gerard P. van Noordennen
Notary Public

This 19th day of June, 2002

Date Commission Expires: 12/31/2003

Attachments

cc: H. J. Miller, NRC Region I Administrator
Y. K. Diaz-Sanabria, NRC Project Manager
R. R. Bellamy, Chief, Decommissioning and Laboratory Branch, NRC Region I
E. L. Wilds, Jr., Director, CT DEP Monitoring and Radiation Division

Background

As discussed in Connecticut Yankee Atomic Power Company's (CYAPCO) letter to the NRC, dated September 10, 2001, CYAPCO requested a Technical Specification change to allow movement of heavy loads (greater than 1800 pounds) over fuel assemblies in the Spent Fuel Pool, as long as such loads were handled by a Single-Failure-Proof Handling System. The primary component of this Single-Failure-Proof Handling System is the upgraded Yard Crane, modified on site by Ederer, Incorporated, as described in Ederer Topical Report EDR-1 (P)-A, Revision 3, and associated plant specific supplements (Appendices B and C). The Ederer Topical Report was previously approved by the NRC as an acceptable method of compliance with the single failure proof requirements of NUREG-0554 and NUREG-0612. The Haddam Neck Plant (HNP) upgrade involved only the crane bridge and trolley, with the main component of the upgrade being the installation of the Ederer eXtra-Safety And Monitoring (X-SAM) hoist system.

In order to minimize the impact of the Yard Crane modification, the trolley that was actually modified for X-SAM was from the sister Turbine Building Crane, built by the same crane manufacturer, capable of the same 100-ton load capacity. The only significant difference from the Yard Crane was that the Yard Crane had a trolley-mounted cab. A cab is not being utilized in the present design, thus the actual weight of the modified trolley and hoist assembly is approximately 3,000 pounds less than the originally installed Yard Crane trolley.

No modifications were made to the Yard Crane support structure, and there has been no change to the seismic/quality classification as presented in Table 3.2-1 of CYAPCO's Updated Final Safety Analysis Report (UFSAR). Furthermore, no commitments to CYAPCO's compliance with the heavy load program requirements of NUREG-0612 have been changed.

In summary, the proposed Technical Specification change was submitted with the following premises:

1. Haddam Neck Plant previously demonstrated compliance with NUREG-0612 Section 5.1.1.
2. The plant will continue implementation of procedures and practices to provide conformance with NUREG-0612 Section 5.1.1.
3. Procedures are in place to maintain compliance with NUREG-0612 Section 5.1.1 and will be revised to incorporate single-failure-proof criteria upon receipt of the approved License Amendment and prior to utilizing the Yard Crane to perform lifts over the Spent Fuel Pool.
4. The existing Yard Crane support structure was previously seismically qualified (Reference 1) for the 100-ton rated capacity of the crane. The single-failure-proof upgrade does not change the rated capacity of the crane.
5. The additional plant specific information provided in Appendices B and C supplement the NRC approved Topical Report EDR-1 (P)-A, Revision 3,

"Ederer's Nuclear Safety Related eXtra-Safety And Monitoring (X-SAM) Cranes", dated August 26, 1983 to demonstrate compliance with NUREG-0554 and NUREG-0612.

Response

The responses contained herein are also made with these same premises. The NRC questions are re-stated in their entirety from the NRC Request for Additional Information dated April 15, 2002. Our responses follow and are in italicized text.

1. The submittal proposes a change to the facility technical specifications related to an upgrade of the yard crane to the single-failure guidelines of NUREG-0612, "Control of Heavy Loads at Nuclear Power Plants," NUREG-0554, "Single-Failure-Proof Cranes for Nuclear Power Plants," and the NRC approved Topical Report EDR-1 (P)-A, Revision 3, "Ederer's Nuclear Safety Related eXtra-Safety And Monitoring (X-SAM) CRANES," dated August 26, 1983. In accepting EDR-1 (P)-A for referencing in plant specific-licensing actions, the NRC staff indicated that acceptance was limited to those features discussed within the topical report, and did not constitute acceptance of the total overhead crane handling system, and that other requirements may be necessary to ensure safe application of the crane at the individual plant. The NRC staff concluded that EDR-1 satisfied NUREG-0554 guidelines in Section 4, "Hoisting Machinery" (except subsections 4.3 and 4.8) and in Section 6, "Drivers and Controls," (except subsection 6.4). The submitted information does not clearly demonstrate how the overhead handling systems satisfy the guidelines of the NUREG.

   a. Explain how the reconfigured yard crane handling system satisfies the single-failure guidelines of NUREG-0554 in Section 2, "Specification and Design Criteria," Section 3, "Safety Features," Section 5, "Bridge and Trolley," Section 7, "Installation Instructions," Section 8, "Testing and Preventive Maintenance," and Section 9, "Operating Manual."

   <u>Response</u>: *Compliance with NUREG-0554 was demonstrated with the issuance and NRC acceptance of Generic Licensing Topical Report EDR-1 (P)-A "Ederer's Nuclear Safety Related e<u>X</u>tra-<u>S</u>afety <u>A</u>nd <u>M</u>onitoring (X-SAM) Cranes," Revision 3, dated October 8, 1982, Amendment 3. The Topical Report EDR-1 (P)-A indicates that Appendices B and C identify the additional plant specific information that is needed to verify a specific retrofit crane's conformance with the NUREG guidelines. Appendices B and C were provided with the Proposed Technical Specification Change.*

   A matrix (Table 1) is provided to cross-reference NUREG-0554 Sections to the corresponding Sections of the Topical Report EDR-1 (P)-A. The matrix also *includes a cross-reference to the plant specific information provided in Appendices B and C.*

b. Demonstrate how the guidelines of NUREG-0612, Appendix C, "Modification to Existing Cranes," are satisfied with the reconfigured overhead crane handling system.

Response: *NUREG-0612 Appendix C acknowledges that application of certain features of NUREG-0554 may not be practical for existing cranes, since they would require replacement of certain components whose adequacy can be verified by alternate means (i.e., Appendix C is permissive not guidance). The Topical Report EDR-1 (P)-A, along with the plant specific information provided in Appendices B and C, define the alternatives utilized to demonstrate compliance to NUREG-0554.*

2. Demonstrate how the reclassified overhead crane handling system satisfies the guidelines of NUREG-0554, Section 10, "Quality Assurance," as it relates to the pertinent provisions of Regulatory Guide 1.28, "Quality Assurance Program Requirements (Design and Construction)."

   Response: *Topical Report EDR-1 (P)-A Section III.C. identifies the Quality Assurance requirements for the Ederer provided components. As stated there, "Ederer's Quality Assurance Manual implements the pertinent provisions of Appendix B, "Quality Assurance Criteria for Nuclear Power Plants and Fuel Reprocessing Plants," to 10 CFR Part 50 for design and manufacture of Nuclear Safety Related X-SAM Cranes."*

   The Proposed Technical Specification Change included Appendix C, which stated the following relative to non-replaced components: "The procurement documents for (A) the existing bridge structure and (B) the replacement trolley structure from the Turbine Building Crane did not invoke 10CFR50 Appendix B, since the cranes were built prior to the issuance of this Federal Regulation. However, both cranes were designed and manufactured by Manning, Maxwell & Moore per the requirements of AISC Specification for the Design, Fabrication and Erection of Structural Steel for Buildings, and the Electric Overhead Crane Institute Specification. Material for structural parts was specified to conform with the latest revision of Specification for Steel for Bridges of the ASTM designation A-7."

3. Demonstrate how the modified crane satisfies the guidelines of NUREG-0612 Section 5.1.1: (1), Definition of Safe Load Paths, (2), Development of load handling procedures, (3), Periodic inspection and testing of cranes, (4), Qualifications, training and specified conduct of operators, (5), Special lifting devices should satisfy the requirements of ANSI N14.6, (6), Lifting devices that

are not specifically designed should be installed and used following the requirements of ANSI B30.9, and (7), Design of cranes to include requirements of ANSI B30.2/CMAA-70.

Response: *Compliance to NUREG-0612 Section 5.1.1 (Phase 1) was previously demonstrated (Reference 5) except for Guidelines 4 (Special lifting devices) and 5 (Lifting devices not specially designed). The lifting devices to be used for the Single-Failure-Proof Handling System (both special and not specially designed) will meet the requirements of NUREG-0612 Section 5.1.2(1). Attachment 1 of the Proposed Technical Specification Change indicated that the proposed change satisfied the evaluation criteria of NUREG-0612 Section 5.1.1 by the continued implementation of such procedures and practices already in place for the Yard Crane. The Proposed Technical Specification Change also included a change to the Bases Section of the Technical Specification which requires compliance with NUREG-0612 Sections 5.1.1 and 5.1.2(1). Upon receipt of the License Amendment and prior to utilizing the Yard Crane to perform lifts over the spent fuel pool, the existing plant heavy load procedures will be revised to incorporate such requirements.*

Attachments 2 and 3 provide the current procedures regarding the control of heavy loads and crane operations (WCM 2.2-8 and WCM 2.2-9, respectively).

a. Also, demonstrate how special lifting devices satisfy the requirements within Sections 4, 6, and 7 of ANSI N14.6.

Response: *The Spent Fuel Transfer cask, lifting yoke and extension bar are designed, fabricated and tested in accordance with ANSI N14.6, including the additional requirements for critical loads as required by NUREG-0612 Section 5.1.6 (1) (a). The members were designed with twice the normal stress design factor based on the combined maximum static and dynamic loads and also tested to three times the weight that the devices are to support.*

Slings utilized for critical lifts will be in accordance with ANSI B30.9, including the requirement for redundant slings or selecting slings based on twice the load that is called for meeting B30.9, as required by NUREG-0612 Section 5.1.6 (1) (b). In selecting the proper slings, the load used will be the sum of the static and maximum dynamic load.

Additionally, the interfacing lifting points such as the transfer cask trunnions, which are a non-redundant or non-dual lift point system, will have a design safety factor of ten (10) times the maximum combined concurrent static and dynamic load as required by NUREG-0612 Section 5.1.6 (3)(b).

b. Additionally, demonstrate how the specific requirements of B30.2 at Section 2-1, 2-2, and 2-3 are satisfied for handling system operation.

Response: *As stated in response to Item 3 above, demonstration of compliance to NUREG-0612 General Guidelines: (3) Crane operators are trained, qualified and conduct themselves in accordance with Chapter 2-3 of ANSI B30.2, (6) Crane should be inspected, tested, and maintained in accordance Chapter 2-2 of ANSI B30.2, and (7) Crane should be designed to meet the applicable criteria and guidelines of Chapter 2-1 of ANSI B30.2, were previously completed (Reference 5). All design, fabrication, and testing to upgrade the crane by Ederer was in accordance with ANSI B30.2. The existing plant procedures for maintenance, periodic inspections, and testing are being revised to incorporate the requirements from the vendor Operations and Maintenance Manual.*

4. Provide details concerning how the crane bridge and trolley were modified and the effects of these modifications on the structural integrity of the crane and its ability to operate as an integrated system.

Response: *Ederer performed a rated-load and seismic qualification of the bridge, trolley and main hoist system (Reference 6). During this analysis, they identified that the existing trolley rail-girder configuration did not meet the limiting bearing stress in the girder diaphragms under the rated load case. As a result, the bridge girders were modified by installing reinforcement plates underneath the trolley rails for the entire length of the bridge girders. The existing welded trolley rails were removed from the girder top plates. Reinforcement plates were installed on top of the girders along with new rails on top of the reinforcement plates. The replacement connections for the rails were made with rail clips.*

In order to reduce the duration of the Yard Crane outage time for this upgrade, a decision was made to retrofit the Turbine Building Crane trolley with the Ederer main hoist assembly instead of the Yard Crane trolley. The Turbine Building trolley is essentially identical to the Yard Crane trolley. They were both manufactured and supplied by the same crane manufacturer. The difference is that the Yard Crane had a trolley-mounted cab, while the Turbine Crane did not. Since the upgrades included a conversion to a radio control system with a backup pendant system, the cab controls were not going to be utilized anyway. The modifications to the Turbine Building trolley included removal of all the main hoist components to facilitate installation of the new main hoist unit. A platform was also added to facilitate the installation of the electrical equipment.

The support structure was previously seismically qualified for the 100-ton rated capacity of the Yard Crane (Reference 1). The single-failure-proof upgrade does not change the rated capacity of the crane. The modified trolley/main hoist assembly weight was actually slightly reduced from the previous weight (approx. 87,000 lbs vs. 90,000 lbs). Therefore, the single-failure-proof *modifications to the Yard Crane did not require changes/upgrades to the existing support structure.*

5. The EDR-1, Appendix B Supplement in the submittal stated that the maximum critical load (MCL) of the upgraded yard crane is 100 tons. The total lifted load should include the weight of a loaded transfer cask added to the weight of the lifting devices. State whether the MCL given in the submitted Appendix B Supplement includes the weight of the lifting device.

   Response: *The EDR-1, Appendix B Supplement states that the Maximum Critical Load (MCL)* ***rating*** *of the main hoist is 100 tons. The maximum weight of a critical load including the lifting devices cannot be greater than this rating. The weight of the loaded transfer cask (~92 tons) plus the lifting devices (~5 tons) is less than this 100-ton rating.*

6. The submittal stated [in EDR-1 Appendix C Supplement, III.C (C.1.c)] that the crane supporting structure was seismically qualified while supporting the maximum critical load based upon the accelerations used in current plant design [CY calculation 97C2968(B)-01]. However, the submittal did not contain information to substantiate that conclusion. The licensee should:

   a. Describe the geometry of the crane supporting structure and the type of connections between the crane and the supporting structure, and any structural modifications of the supporting structure resulting from the crane upgrade.

   b. Describe the mathematical model(s) used to represent the crane and supporting structure.

   c. State the loads and load combinations used in the analysis for qualifying the crane supporting structure.

   d. Indicate whether the analysis was linear or nonlinear. If nonlinear analysis was performed, indicate whether material nonlinearity was included in the analysis.

   e. Discuss how the input response spectra were obtained, and the locations in the crane supporting structure to which the response spectra were applied.

   f. State the name and version of the computer code that was used for the structural analysis and whether the code had been qualified for such analysis.

g. Compare the maximum applicable stresses, such as flexure, tension, compression, shear, and torsion in the members of the crane supporting structure from the analysis to their corresponding allowable stresses. From the comparison, draw conclusions of member adequacy.

Supporting Structure

The Connecticut Yankee 100-ton Yard Crane supporting structure is a steel frame consisting of rigid frame construction in the east/west direction and braced frame construction in the north/south direction. Connections are primarily shop welded and field bolted. The supporting structure is founded mostly on concrete piers at grade, but has two main columns, which are founded on the elevated upper edge of the Spent Fuel Pool. In addition, the structure provides some common framing for the Spent Fuel Building. To provide additional lateral support in the east/west direction, the structure is braced off at its midpoint to the side of the containment at its uppermost elevation. Figures depicting a cross section of the SFB and defining the crane supporting structure are attached.

Aside from routine maintenance, no significant changes to the supporting structure have been made since its original installation. The supporting structure will not require modification as a result of the analysis performed to qualify the crane as a single-failure-proof crane.

The supporting structure, along with the Spent Fuel Building (SFB), was completely reanalyzed in 1998 by Stevenson & Associates (Reference 1). Note: this analysis is not associated with the effort to qualify the crane as single-failure proof. The Stevenson & Associates analysis conforms to the current licensing and design basis requirements for the Yard Crane and SFB as outlined in the UFSAR. A description of the calculation and its results are provided in Attachment 4. An overview is provided below.

The PD-STRUDL (Version DOS0496) computer program was used to produce a linear elastic finite element model of structure's geometry, loadings and dynamic response. Loads and load combinations were defined in accordance with the CY licensing and design basis (Reference 2), which, in effect, invokes Standard Review Plan (SRP) Section 3.8.4 (Reference 3). Multiple crane locations were modeled. Input seismic response was defined, again, in accordance with the plant licensing and design basis ground response spectrum, which was defined for the Yard Crane and supporting structure, as a .21g ZPA Levin-Crutchfield spectrum at 7% of critical damping (Reference 4). Vertical response was taken as 2/3 of horizontal response.

Modal responses in each of three orthogonal directions were combined by the Square Root Sum of the Squares (SRSS) method, with closely spaced modes first combined using the grouping method of Regulatory Guide 1.92. The responses in the three spatial directions were then combined by SRSS.

Analysis results included deflections, reactions, member forces and moments, and member stresses, as well as dynamic response parameters such as structural frequency, period and extent of modal participation.

Based on the analysis results, the supporting structure was concluded to be structurally adequate and in full compliance with the CY licensing and design basis as reflected in the UFSAR. Accordingly, no modifications to the supporting structure were required.

Crane

The upgrade of the crane to single-failure-proof did not result in additional loads to the support structure. The approach used to perform rated-load and seismic qualification of the bridge and upgraded trolley portion of the system was to model the support structure and the crane, with the trolley modeled as a rigid element. The support structure was included to approximately capture the dynamic effects of the support structure on the crane forces. Modal analyses of the support structure and crane were executed for a number of load cases to determine controlling forces. The assessment of the induced effects then followed the criteria included in CMAA 70 and AISC ASD for the non-seismic load cases. The approach outlined in ASME NOG-1 was used as a guideline to meet the requirements of NUREG-0554.

The method of analysis was to construct a relatively simple model (Figure 4) to closely approximate the behavior of the existing runway structure and give an accurate prediction of the forces in the bridge crane, trolley and rope. The runway structure with its permanent components, the Yard Crane bridge and the trolley were modeled with a 3-D frame model. The GT-STRUDL (Version 9901 NT) computer program was used to produce a linear elastic finite element model of structure's geometry, loadings and dynamic response.

During the analysis the existing trolley rail-girder configuration did not meet the limiting bearing stress in the diaphragm under the rated load case. The modification to the bridge to correct this was to install a reinforcement plate underneath the trolley rails for the entire length of the bridge girders. The existing welded trolley rails were removed from the girder top plates. Reinforcement plates were installed on top to the girders along with new rails on top of the plates. The replacement connections for the rails were made with rail clips.

Based upon the above modification, it was concluded that the bridge crane system was adequate for the rated load for the CMAA load cases and the SSE seismic event. The analysis indicated no wheel uplift for the bridge or trolley wheels during a SSE seismic event.

References:

1. Stevenson & Associates Calculation 97C2968(B)-01, "Evaluation of the Yard Crane and Fuel Building Structure for the Haddam Neck Plant"
2. CY Specification SP-CY-CE-0022, "Structural Criteria for Spent Fuel Pool Island Systems, Structures and Components"
3. NUREG-0800, Standard Review Plan, Section 3.8.4, "Other Seismic Category I Structures", Rev. 1, July 1981
4. USNRC Memo from H. Levin to D. Crutchfield dated September 17, 1980, "Digitized Pseudo Spectral Acceleration Data for SEP Plants"
5. Letter from W. G. Counsil (CYAPCO) to D. M. Crutchfield (USNRC), "Haddam Neck Plant Control of Heavy Loads", dated August 3, 1983
6. Calculation 24265-500-V00-MJKG-G0019, "Rated Load and Seismic Qualification, Rev. 3, 100-Ton Yard Crane Upgrade Connecticut Yankee Nuclear Plant"

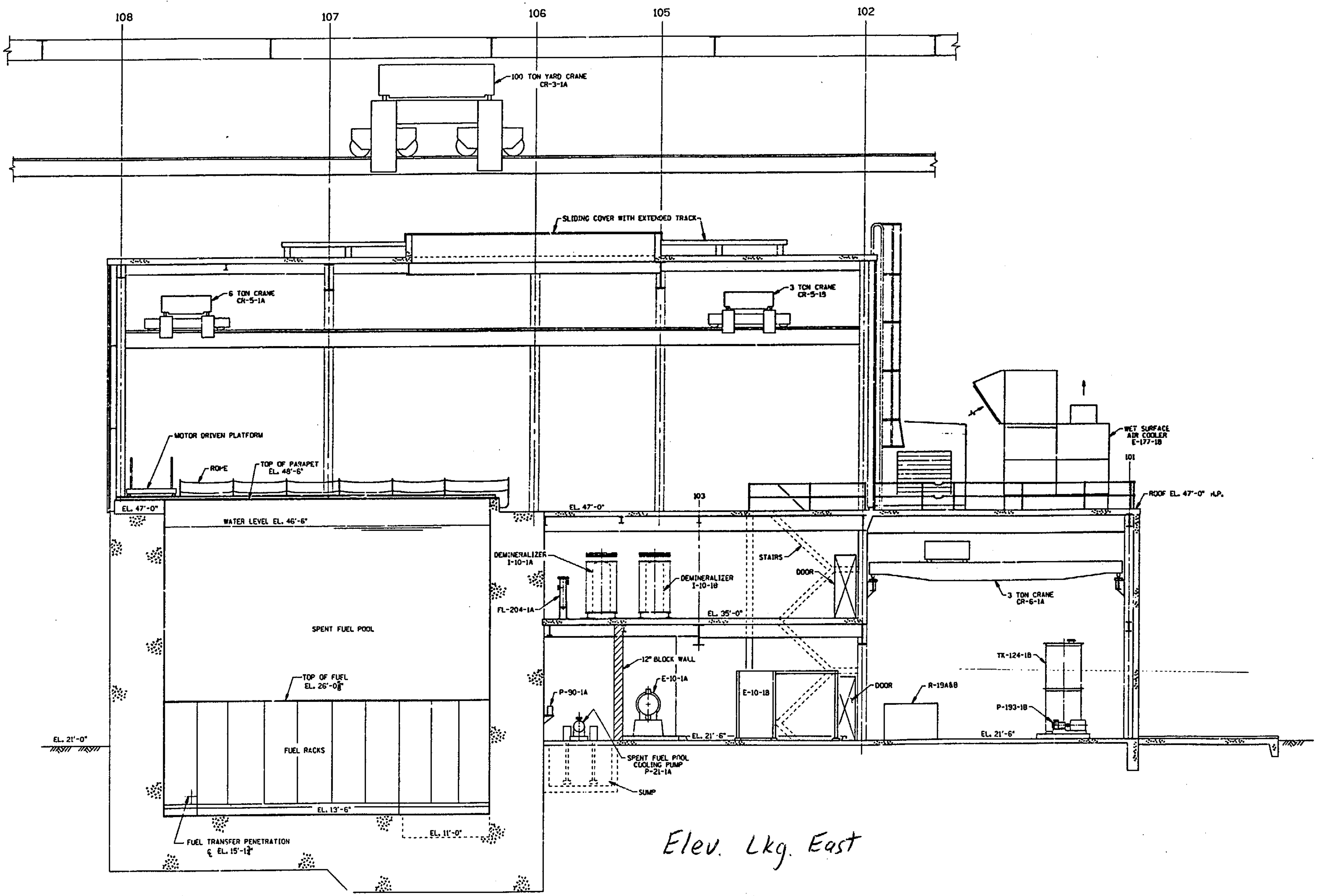
Attachments:

Table 1	NUREG-0554 Cross Reference with Topical Report
Figure 1	SFB Cross Section showing supporting structure looking East
Figure 2	SFB Cross Section showing crane looking North
Figure 3	Sketch of the TFR moving sequence from the pool to the VCC
Figure 4	Summary of Support Conditions for Yard Crane

NUREG-0554 CROSS-REFERENCE WITH TOPICAL REPORT

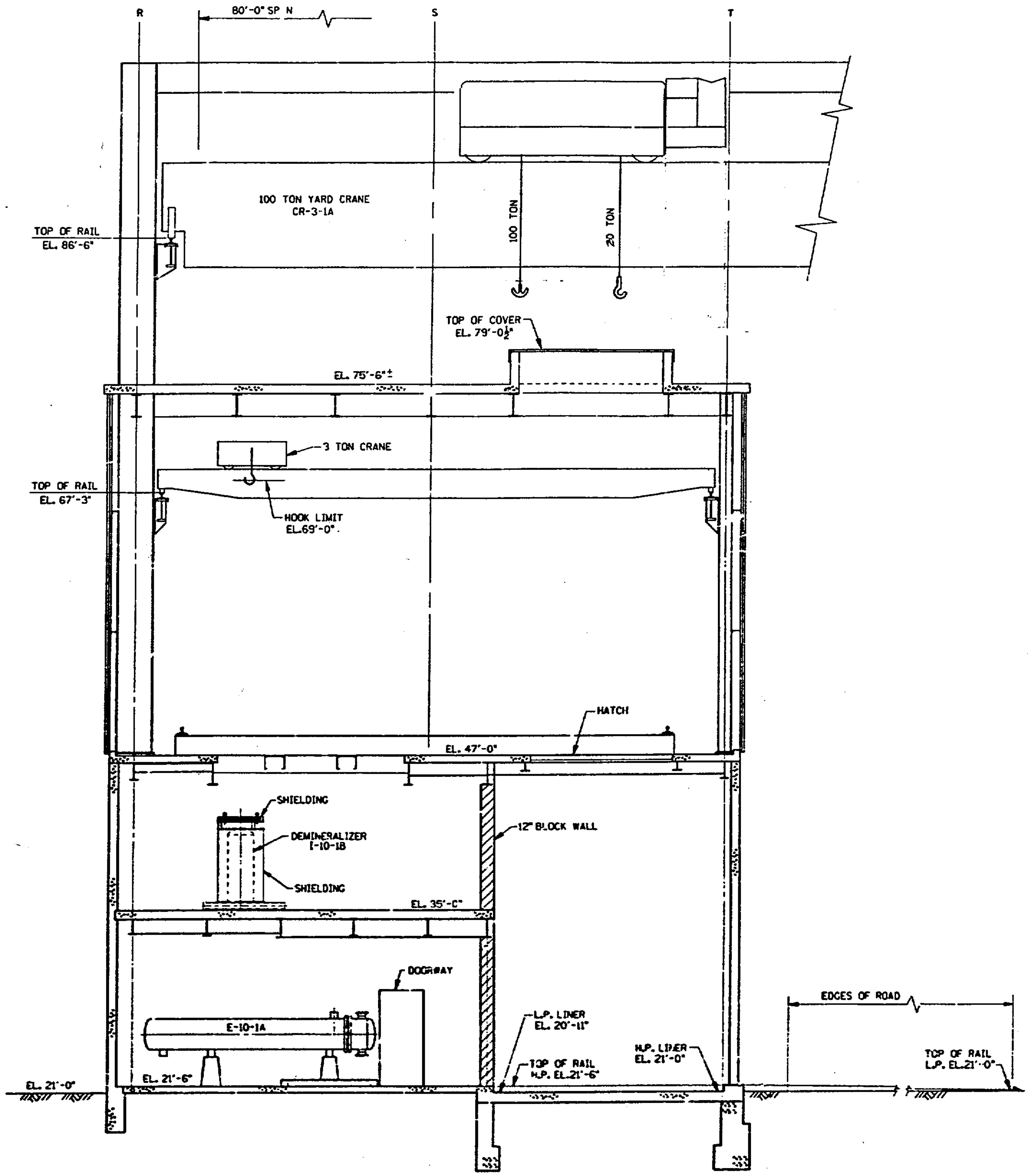
NUREG-0554 SECTION	TITLE	RG 1.104 POSITION	APPENDIX	TOPICAL REPORT SECTION
2.0	SPECIFICATION AND DESIGN CRITERIA			
2.1	Construction and Operating Periods	C.1.a C.1.e	B Page 1 C Page 3	III.C(C.1.a) III.C(C.1.e)
2.2	Maximum Critical Load	C.3.s		III.C(C.3.s)
2.3	Operating Environment	C.1.b (1) C.1.b (1)	B Page 1 C Page 1	III.C(C.1.b (1)) III.C(C.1.b (1))
2.4	Material Properties	C.1.b (2) C.1.b (3) C.1.b (4) C.4.d	 C Page 1 C Page 1 C Page 1	III.C(C.1.b (2)) III.C(C.1.b (3)) III.C(C.1.b (4)) III.C(C.4.d)
2.5	Seismic Design	C.1.c	C Page 1	III.C(C.1.c)
2.6	Lamellar Tearing	C.1.d	C Page 2	III.C(C.1.d)
2.7	Structural Fatigue	C.1.e	C Page 3	III.C(C.1.e)
2.8	Welding Procedures	C.1.f	C Page 3	III.C(C.1.f)
3.0	SAFETY FEATURES			
3.1	General	C.2.a		III.C(C.2.a) III.A III.B
3.2	Auxiliary Systems	C.2.b C.2.b	B Page 1,2 C Page 4	III.C(C.2.b) III.C(C.2.b)
3.3	Electrical Control Systems	C.2.a		III.C(C.2.a)
3.4	Emergency Repairs	C.2.c C.2.d	C Page 4 C Page 4,5	III.C(C.2.c) III.C(C.2.d)
4.0	HOISTING MACHINERY			
4.1	Reeving System	C.3.e C.3.f	B Page 2 B Page 3	III.C(C.3.e) III.C(C.3.f)
4.2	Drum Support	C.3.k	B Page 5	III.C(C.3.k)
4.3	Head and Load Blocks	C.3.a C.3.d C.3.g		III.C(C.3.a) III.C(C.3.d) III.C(C.3.g)
4.4	Hoisting Speed	C.3.e		III.C(C.3.e)
4.5	Design Against Two-Blocking	C.3.j	B Page 4	III.C(C.3.j)
4.6	Lifting Devices	C.3.b	C Page 5	III.C(C.3.b)
4.7	Wire Rope Protection	New		III.D.7 III.E.9

NUREG-0554 SECTION	TITLE	RG 1.104 POSITION	APPENDIX	TOPICAL REPORT SECTION
4.8	Machinery Alignment	C.3.n		III.C(C.3.n)
4.9	Hoist Braking System	C.3.m		III.C(C.3.m)
5.0	BRIDGE AND TROLLEY			
5.1	Braking Capacity	C.3.p	B Page 5	III.C(C.3.p)
5.2	Safety Stops	C.3.p C.3.r	B Page 5	III.C(C.3.p) III.C(C.3.r)
6.0	DRIVERS AND CONTROLS			
6.1	Driver Selection	C.3.l		III.C(C.3.l)
6.2	Driver Control Systems	C.3.i	B Page 3	III.C(C.3.i)
6.3	Malfunction Protection	C.3.h	B Page 3	III.C(C.3.h) III.E.11
6.4	Slow Speed Drives	C.3.o	B Page 5	III.C(C.3.o)
6.5	Safety Devices	C.3.j	B Page 4	III.C(C.3.j)
6.6	Control Stations	C.3.q	B Page 6	III.C(C.3.q)
7.0	INSTALLATION INSTRUCTIONS			
7.1	General	C.3.u	C Page 6	III.C(C.3.u)
7.2	Construction and Operating Periods	C.3.t	C Page 6	III.C.(C.3.t)
8.0	TESTING AND PREVENTATIVE MAINTENANCE			
8.1	General	C.4.a	C Page 7	III.C(C.4.a)
8.2	Static and Dynamic Load Tests	C.4.a C.4.b	C Page 7 C Page 7	III.C(C.4.a) III.C(C.4.b)
8.3	Two-Block Test	C.4.b	C Page 7	III.C(C.4.b)
8.4	Operational Tests	C.4.b	C Page 7	III.C(C.4.b)
8.5	Maintenance	C.4.c	C Page 7	III.C(C.4.c)
9.	OPERATING MANUAL	C.3.u C.4.a	C Page 6 C Page 7	III.C(C.3.u) III.C(C.4.a)
10.	QUALITY ASSURANCE	C.5.a C.5.b	C Page 7	III.C(C.5.a) III.C(C.5.b)



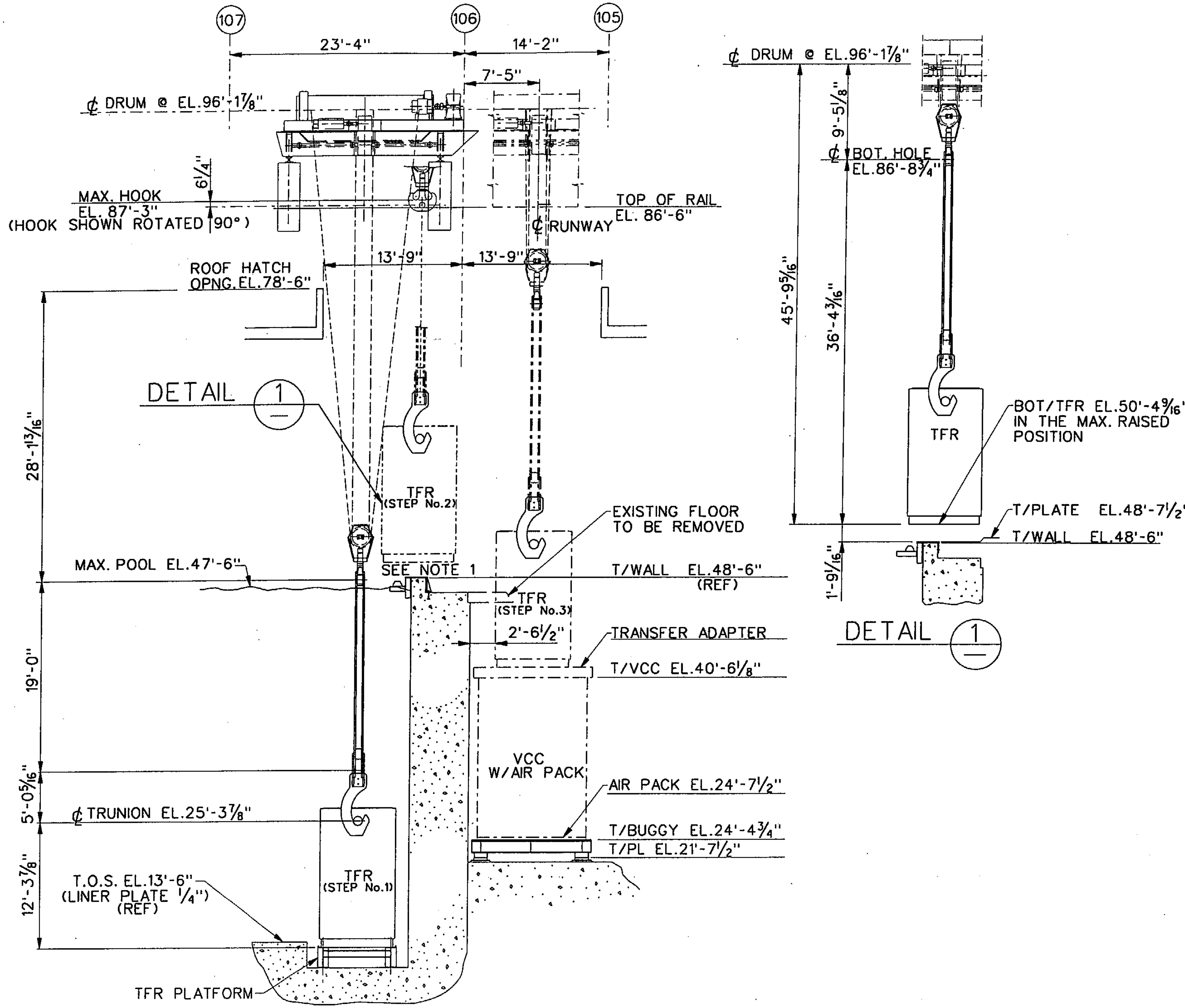
Elev. Lkg. East

Figure 1



Elev. Lkg. North

Figure 2



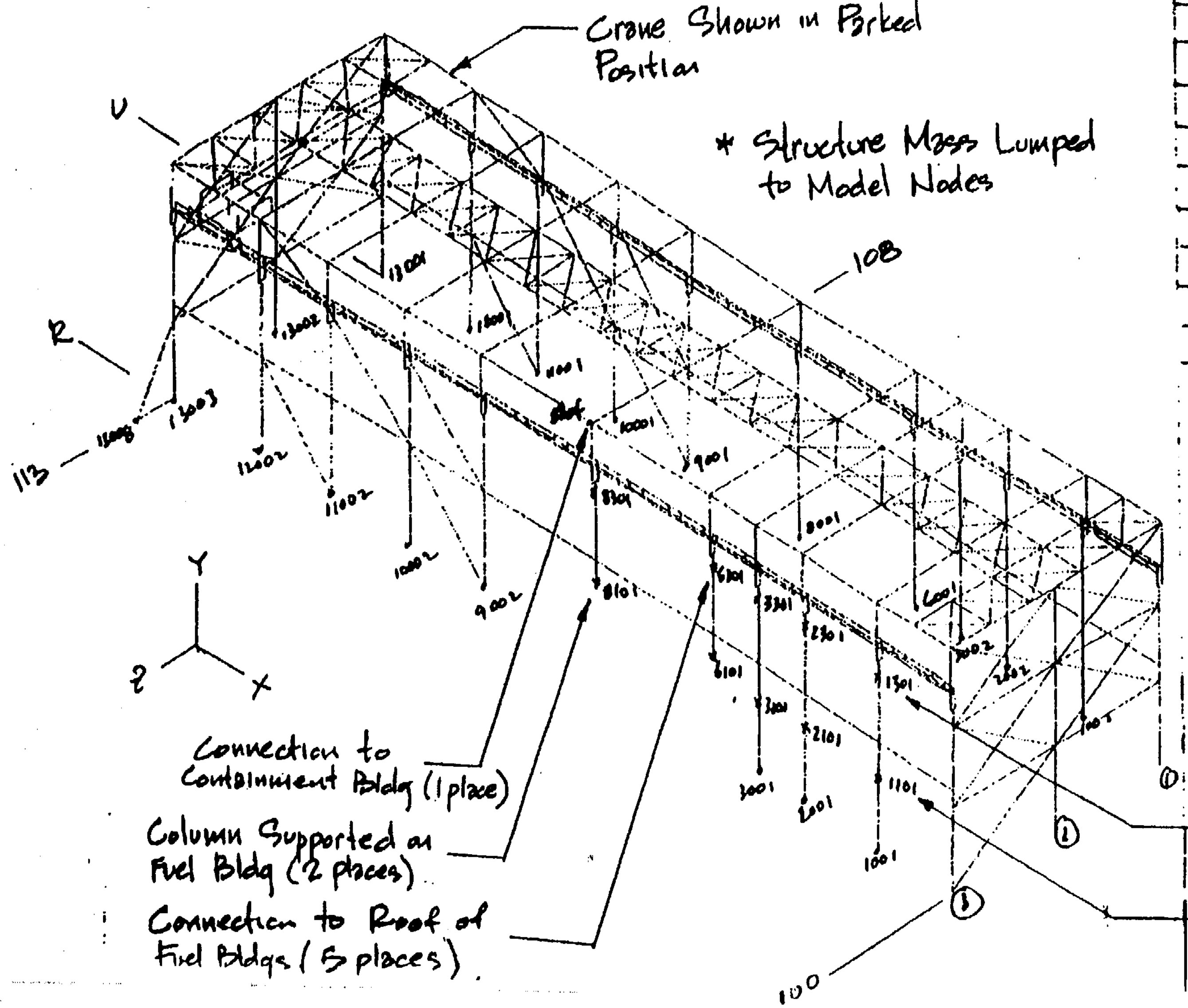
ELEVATION - LIFT SEQUENCE - LOOKING EAST

Figure 3

- Connecticut Yankee Yard Crane Upgrade
- F-2675, A0102B
  Bechtel Power Subcontract
  24265-SC-117

SUMMARY OF SUPPORT CONDITIONS FOR YARD CRANE

5/9/01 YT CHK'D LM



Joint		Support
1, 2, 3		FX FY FZ MY
1001	1002	FX FY FZ MY
2001	2002	FX FY FZ MY
3001	3002	FX FY FZ MY
6001	8001	FX FY FZ MY
9001	9002	FX FY FZ MY
10001	10002	FX FY FZ MY
11001	11002	FX FY FZ MY
12001	12002	FX FY FZ MY
13001	13002	FX FY FZ MY
13003		FX FY FZ MY
1101	1301	FX FZ
2101	2301	FX FZ
3101	3301	FX FZ
~~6101~~	6301	FX FZ
~~8101~~	8801	FX FZ
13008		ALL FIXED
6101		FX FY FZ MY
8101		FX FY FZ MY
62210		FX FZ MX MY FZ
8804		FX FZ

Figure 4

ATTACHMENT 2 to CY-02-075

WCM 2.2-8, “Control of Heavy Loads”

AUG 15 2001

CONNECTICUT YANKEE ATOMIC POWER COMPANY
WORK CONTROL MANUAL

*Control of Heavy Loads*1

WCM 2.2-8

Rev. 6 Major

This procedure provides controls to minimize the effects and potential for load drops from overhead lifting devices. Additionally, this procedure provides the administrative controls regarding the movement of loads in the Spent Fuel Storage Pool Building.

VERIFY MOST RECENT REVISION
AGAINST MDI:

INITIALS	DATE

Approval: K. M. McGill
Unit Director - Haddam Neck Station

PORC Mtg. No.: 2001-23 / Date: 8-8-01

Effective Date: 8-15-01

Level of Use
Information

Responsible Individual:
Jean Gagnon

ACP 1.2-6.5B

AUG 15 2001

Connect Yankee
Work Control Manual

Control of Heavy Loads[1]

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Level of Use
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1.0 INSTRUCTIONS

1.1 Applicability

1.1.1 This procedure is applicable to "Heavy Load" handling operations and the equipment and personnel involved in these operations. The "Heavy Load" handling operations include "Heavy Load" handling operations over the spent fuel pool and the spent fuel building. This procedure is intended to be used in conjunction with WCM 2.2-9, Control of Crane Operations.

1.1.2 Additionally this procedure addresses requirements for rigging reviews.

1.2 Requirements For Heavy Load Operations

1.2.1 A properly prepared work order has been approved and appropriate departments have been notified. For "Heavy Load" operations over the Spent Fuel Pool, or the Spent Fuel Building. The work package shall contain a specific task procedure, approved by PORC. If one is not available, then one must be written.

1.2.2 The Job Supervisor has verified that only qualified personnel are assigned as crane operators, load directors, and riggers in accordance with station procedures.

1.2.3 The Job Supervisor shall verify that the number and qualifications of load handlers as required by the specific task procedure are present and met.

1.2.4 The Job Supervisor shall verify that the maintenance and inspection requirements have been met and are current.

1.2.5 The load director shall verify that all prerequisites required have been satisfied and that the load is ready to have the lifting device(s) attached to it for lifting.

1.2.6 The load director shall establish the weight of the load and SELECT the appropriate rigging equipment per Attachment 3.

1.2.7 Persons involved shall be familiar with Attachments 1, 2 and 3 as applicable.

1.2.8 The following constraints shall be verified during heavy load handling over the areas listed below.

a. Spent Fuel Pool - A Spent Fuel Cask will not be moved into or over the Spent Fuel Pool (currently unanalyzed condition)

b. Spent Fuel Building - No loads are permitted to be moved over the Spent Fuel Building between columns 106 to 108, R to T on arrangement NUSCO drawing 16103-27036, or without prior Engineering approval and Directors signature.

c. Unit Manager approval prior to moving any load over the Spent Fuel Pool is required.

1.2.9 Per Technical Specifications - Loads in excess of 1800 pounds shall be prohibited from travel over fuel assemblies in the storage pool.

1.2.10 For any load manipulations within five (5) feet of the Spent Fuel Pool at any elevation at or above the level of the pool, NOTIFY Engineering to perform the following:

a. Review of load operations.

b. Determination of any restrictions

c. Determine if Spent Fuel Storage Air Cleanup System Operation is required.

1.2.11 The load director is in charge of the load lifting operation and all personnel assigned to the load lifting task. The load director shall assure that the following activities are completed.

a. Establish and test communications between the load director, the crane operator and load handlers. (This could be voice communications only).

b. The load director shall instruct the crane operator and load handlers as to what the load path will be. If a safe load path has been established for the load being lifted, it must be followed. Any deviation from established load paths require approval from engineering. If restricted areas have been designated in lieu of a specific safe load path, the load director will designate the safe load path for the lift. In this case, the safe load path will not go over a restricted area at any time.

c. Visually inspect cables, lifting eyes, etc.

d. Return all lifting gear to proper storage.

e. Secure lifting rig.

2.0 REFERENCES

2.1 ANSI N14.6-1978, Special Lifting Devices

2.2 ANSI B30.2, Overhead and Gantry Cranes

2.3 ANSI B30.9, Slings

2.4 WCM 2.2-9, Control of Crane Operations

2.5 Denise S. Reed/J. M. Lappen memo NE-83-R-444 dated September 8, 1983.

2.6 Memo from N. W. Featherston/R. M. Mitchell/B. W. Holmgren, Subject: Control of Lifting /Rigging Operations

3.0 COMMITMENTS

3.1 Technical Specification 3/4.9.7, Crane Travel - Spent Fuel Storage Pool Building

3.2 Technical Specification 6.1.2, Administrative Controls.

4.0 SUMMARY OF CHANGES

STEP	CHANGE	REASON
1.2.1	Removed	Yard Crane (CR-3-1A) transitioned to Bechtel
1.2.2. & Att. 1 (1.1b), Att. 2 (#8)	Removed	Polar Crane (CR-1-1A) transitioned to Bechtel
1.2.6	Removed Reference 2.13 and a thru d	Reference 2.13, PMP 9.5-131, has been cancelled. A thru D, all dealing with reactor components lifting devices transitioned to Bechtel.
1.2.10	Removed	Transitioned to Bechtel
1.2.8.c	Added	Required by Tech. Spec. 6.1.2
1.2.9 & Att. 1 (1.1a)	Changed 1650 pounds to 1800 pounds	Tech. Spec.3/4.9.7, Amendment 195
2.4, 2.5	Removed ANSI Standards	No longer applicable
References 2.7, 2.10 thru 2.17	Removed	No longer applicable, procedures canceled.
3.2	Added	Tech. Spec. 6.1.2, Amendment 195
All occurrences	Engineering Manager changed to Construction Oversight Manager and Unit Director changed to Unit Manager	Responsibility change.

Level of Use
Information

Attachment 1
Definitions and Responsibility

1.0 Definitions

1.1 Heavy Load:

a. For loads over the spent fuel pool, a heavy load is any load including the load block which is more than 1,800 pounds, excluding the handling of fuel assemblies.

b. No loads are permitted to be moved over the Spent Fuel Building between columns 106 to 108 R to T on NUSCO arrangement drawing 16103-27036 without prior engineering approval and task specific PORC approved procedures.

2.0 Responsibilities

2.1 Unit Manager has the overall responsibility to ensure the implementation of the Heavy Loads Handling Program. Unit Manager approval prior to moving any load over the Spent Fuel Pool is required. Specific responsibilities are assigned to various departments and individuals as discussed below.

2.2 Construction Oversight Manager is responsible for the evaluation of heavy load lifts. He acts as liaison between the plant and off-site groups and provides direction and guidance in the development of procedures and design changes pertaining to the lifting of heavy loads.

2.3 Assistant Maintenance / Assistant Operations Manager/ or Designee is responsible for ensuring that all repairs, functional tests, checks, inspections and service of affected lifting equipment are accomplished. He is also responsible for the development and maintenance of the procedures and documentation necessary to support the proper performance of his department's assigned responsibilities. In addition, he shall ensure that all maintenance / operations department personnel are cognizant of this procedure and have received maintenance training and operational requirements of Reference 2.2.

2.4 CY Oversight is responsible for verifying the results of all inspections of Special Lifting Devices.

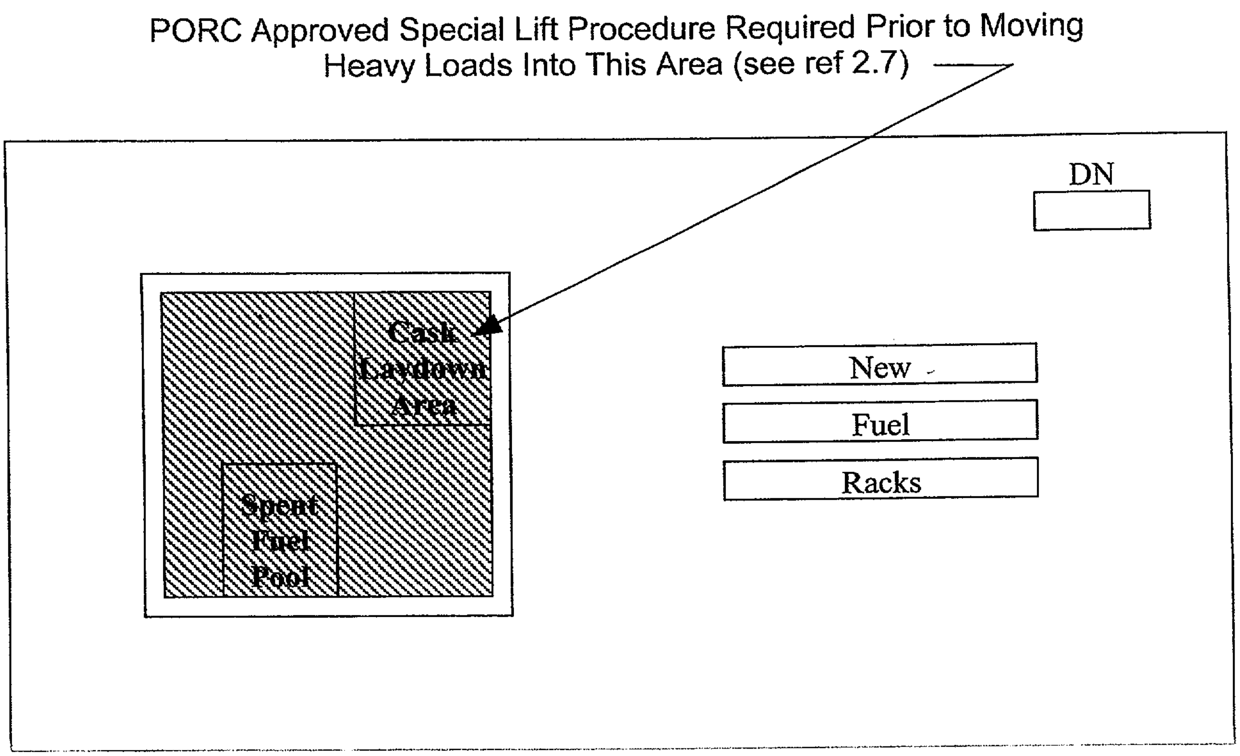
2.5 Health Physics/Rad Waste Manager is responsible to ensure that all Rad Waste Department personnel are cognizant of the requirements of this procedure and of the appropriate operational requirements of Reference 2.2.

Attachment 1
Definitions and Responsibility
(Continued)

2.6 Job Supervisor is responsible to ensure that all personnel handling heavy loads are cognizant of the requirements of this procedure and of the appropriate operational requirements of Reference 2.2.

2.7 Load Directors/Crane Operators are responsible to ensure that all heavy loads are handled safely and in accordance with proper procedures.

Attachment 2
Spent Fuel Building



Attachment 3
Non-Routine / Routine Rigging Review Requirements

1.1 Non Routine Rigging Review Requirements

1.1.1 The following criteria has been established to identify non-routine rigging evolutions.

a. Lifting / rigging loads exceeding five (5) tons (10,000 lbs.) where the lift / rigging equipment and configuration has not been previously reviewed by engineering, or:
b. The use of specialized rigging and unique lift operations not previously reviewed by Engineering or vendors (spreader bars, lift beams, etc.) or:
c. The use of welded or bolted attachments and special anchorages (dead weight anchors, tie backs etc.) to permanent plant structures or components:
d. The use of load paths not specifically designed for the intended applied load (rolling loads).

1.1.2 A rigging review shall be conducted for all rigging evolutions designated as non-routine.

1.1.3 Any calculations performed in support of rigging reviews for QA category 1 components will meet the requirements of the DCM.

1.1.4 Non-routine rigging applications should include a sketch developed or reviewed / approved by the Rigging Engineer for field use.

a. Sketches may include pertinent instructions (as necessary) to ensure proper rigging techniques are utilized.
b. Engineering will maintain a file for all Rigging Engineer reviews.

1.1.5 Major lifts or heavy loads activities with significant safety implications (SG load tests etc.) shall be controlled by procedures approved by the Construction Oversight Manager and Decommissioning Manager or designees.

a. The Construction Oversight Manager or Decommissioning Manager may also request review by PORC.

1.2 Routine Rigging

1.2.1 All routine rigging evolutions shall be conducted utilizing the guidance contained in Bobs Rigging and Crane Handbook (or equivalent).

1.2.2 All Qualified site riggers shall have read and understood this procedure.

ATTACHMENT 3 to CY-02-075

WCM 2.2-9, "Control of Crane Operations"

AUG 15 2001

CONNECTICUT YANKEE ATOMIC POWER COMPANY
WORK CONTROL MANUAL PROCEDURE

Control of Crane Operations

WCM 2.2-9

Rev. 6 Major

The purpose of this procedure is to provide guidance for the safe operation of cranes in the Owner Controlled Area and near energized sources.

This procedure is applicable to all Systems and contract personnel that operate cranes and boom-supported elevating work platforms (Condors) at CY.

VERIFY MOST RECENT REVISION
AGAINST MDI:

INITIALS	DATE

Approval: R. M. Mitchell
Unit Director - Haddam Neck Station

PORC Mtg. No.: 2001-23 / Date: 8-8-01

Effective Date: 8-15-01

Level of Use
Information

Responsible Individual:
J. Gagnon

ACP 1.2-6.5B

AUG 15 2001

Connecticut Yankee
Work Control Manual

Control of Crane Operations

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Level of Use
Information

1.0 INTRUCTIONS

1.1 Introduction

1.1.1 This procedure provides instructions for the safe operation of cranes at Connecticut Yankee.

1.2 Prerequisites

1.2.1 Personnel

a. *Crane Operators, Load Directors, Riggers, and Load Handlers shall be qualified IAW reference 2.4, program requirements.*[1]

b. *Overhead Crane Operators shall be physically/medically qualified IAW reference 2.1, ANSI B30.2.

1.2.2 Equipment

a. Radio Communications as required

b. Traffic Cones as required

c. Caution Tape or Barriers as required

d. Tag Lines as required

e. Safety Vests / Personal Flotation Devices

f. Rigging Equipment

1.2.3 Preliminary Conditions

a. Operations Department has completed tagging out plant equipment that has a potential to interfere with the safe completion of crane operations.

b. Work Order signed as required.

c. RWP issued if required.

d. ALARA Controls are read and understood, if required.

e. Job Supervisor or designee has reviewed this procedure and job requirements prior to start of work. Conduct a pre-job brief as required.

f. If lifted load exceeds 10,000 lbs., and is non-routine, have Engineering review in accordance with Attachment 5.

g. Job Supervisor or designee CONTACT the Safety Department to INSPECT all non-company owned mobile cranes brought on site prior to their use. The pre-operational checklist should be with the crane operation manual and shall be used instead of Attachment 3. Should a checklist not be provided with the crane, refer to the operators manual for that crane to determine the necessary inspections

1.3 Precautions

1.3.1 Cautions

a. Procedure contains cautions that apply to specific steps and are displayed in the procedure immediately prior to the applicable step.

1.3.2 Warnings

a. Procedure contains warnings that apply to specific steps and are displayed in the procedure immediately prior to the applicable step.

1.4 Overhead Crane Operations

(New & Spent Fuel Bldg. Cranes, Spent Fuel Bldg. Lower Level Crane)

1.4.1 ASSIGN qualified personnel to the following positions:

a. Crane Operator

b. Load Director (as required)

c. Load Handlers (as required)

1.4.2 PERFORM/VERIFY a pre-operational check and inspection of the crane is completed at least once per day when crane is in use. Attachment 3 is the checklist that shall be utilized*[2]

1.4.3 INSPECT to ensure the crane path is clear of obstructions.

1.4.4 IDENTIFY the load to be lifted.

1.4.5 DETERMINE the weight and approximate center of gravity of the load and SELECT the appropriate rigging equipment. (Refer to Attachment 5 for Routine/Non-Routine Rigging).

1.4.6 *IDENTIFY the safe load path and ENSURE that the load path meets the requirements of WCM 2.2-8, Control of Heavy Loads*[1].

1.4.7 For any load manipulations within five (5) feet of the Spent Fuel Pool at any level at or above the level of the pool, NOTIFY Engineering to perform the following:

a. Review of load operations.

b. Determination of any restrictions

c. Determine if Spent Fuel Storage Air Cleanup System Operation is required.

1.4.8 CONDUCT a briefing with each of the individuals involved in the pick that includes:

a. Review of the load path.

b. Concerns of any individual on the lift team.

c. Identify interference's and the precautions to be taken.

d. Communications to be used.

e. Individual task assignments.

1.4.9 ESTABLISH communications between the Crane Operator, Load Director, and Load Handlers (as required).

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WARNING

Only the load Director may signal/direct the crane to move. Anyone who sees any unsafe condition shall yell, "STOP".

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1.4.10 PERFORM the pick with the Load Director controlling the entire operation.

1.4.11 REPEAT steps 1.4.1 through 1.4.10 as required.

1.5 Spent Fuel Manipulator Crane Operations

1.5.1 *PERFORM / VERIFY a pre-operational check and inspection of the crane is completed at least once per day when crane is in use. Attachment 3 is the checklist that shall be utilized*[2].

1.5.2 INSPECT to ensure the load path is clear of obstructions.

1.5.3 CONDUCT a briefing with each of the individuals involved in the pick that includes:

1.5.3 CONDUCT a briefing with each of the individuals involved in the pick that includes:

a. Review of the load path requirements.

b. Concerns of any individual on the lift team.

c. Identify interferences and the precautions to be taken.

d. Communications to be used.

e. Individual task assignments.

f. Use of fall protection and/or personnel flotation devices when working near the cavity.

g. See Reference 2.2, WCM 2.2-8, "Control Of Heavy Load".

1.5.4 PERFORM the pick with the Load Director/Crane Operator controlling the entire operation.

1.5.5 REPEAT steps 1.5.1 through 1.5.4 as required.

2.0 REFERENCES

2.1 Standards:

ANSI A92.5-1992, Boom-Supported Elevating Work Platforms
ANSI B30.2, Overhead and Gantry Cranes
ANSI B30.10-1982, Hooks
ANSI B30.11-1980, Monorails and Underhung Cranes

2.2 WCM 2.2-8, Control of Heavy Loads

2.3 WCM 2.2-12, Control of 115Kv/345Kv Yards and Lines

2.4 ADM 1.1-305, Maintenance Training Program

2.5 Health and Safety Manual

2.6 Technical specification 3/4.9.12, Fuel Storage Bldg. Air Clean-up System

3.0 COMMITMENTS

3.1 [1]*NUREG 0612, Control of Heavy Loads at Nuclear Power Plants*

3.2 [2]*NML B&M Evaluation Report Recommendation BM-96-1 (Memo REB 96-009)*

4.0 SUMMARY OF CHANGES

Step	Change	Reason
1.2.1 b	Removed references to ANSI B30.4 and B30.17	Relates specifically to Containment Jib crane and Reactor Shield Cavity Manipulator crane aux. Hoist.
Throughout	Removed references to all cranes that are no longer used by CY	Cranes have been abandoned or have been transitioned to Bechtel. The only cranes used and maintained by CY are CR-5-1A&1B New & Spent Fuel Bldg.. Crane, CR-6-1A SFB Lower Level crane.
1.5, Att 4	Removed section 1.5 and all references to mobil cranes, i.e., crane topple analysis, spotters, etc	Mobile cranes are no longer owned, leased, operated or maintained by CY
2.1	Removed	Removed ANSI Standards no longer Applicable.
2.4, 2.7	Changed, Removed	Changed 2.4 to present Maintenance Training Program, 2.7 cancelled.
Attachment 4	Revised	To reflect Crane/Rigging Specs. Applicable to cranes used/maintained by CY.
2.5, 2.8	Removed reference	Not Applicable
All occurrences	Engineering Manager changed to Construction Oversight Manager	Responsibility change.

Attachment 1
Definitions

1. Pick One complete crane operation moving a load from Point A to Point B.

Attachment 2
Spent Fuel Building

1.	Load Director	The Load Director directs the crane movement and is responsible for the entire lift. Only the Load Director may signal/direct the crane to move. The Load Director directs the rigging of the load. When multiple cranes are in use in the same area, the Load Director shall coordinate with the other load director(s) to ensure the load paths do not interfere with one another. One of the Load Directors shall be designated as Lead Load Director. The Lead Load Director shall coordinate the activities of all lifts in the same area to ensure the load paths do not interfere with one another.
2.	Crane Operator	The Crane Operator operates the crane as directed by the Load Director. Shall ensure daily crane operability checks are performed and documented. In some cases (i.e., fuel movement) the Crane Operator may also be the Load Director.
3.	Load Handler	Use the tag lines to stabilize the load. Rigs the load.
4.	Department Managers	Shall ensure that the qualification and re-qualification of personnel is properly maintained, including contractor personnel under their jurisdiction.
5.	Job Supervisor	Shall ensure the crane operator, load director, load handler, and spotters are qualified in accordance with the program requirements of reference 2.4.

Attachment 3
Daily Crane / Hoist Operators Checklist

These checks, as applicable, shall be completed each day prior to crane operation. Any discrepancies or any other problems found during these checks or during operation shall be reported to an Operations/Maintenance Manager. Do not operate the crane until all discrepancies which could affect safe crane operation are corrected or declared acceptable by a Operations/Maintenance Manager or Engineer.

1. **Safety Equipment**
   a. Lights
   b. Warning Bells
   c. Fire Extinguisher
   d. Escape Device
   e. Communication Equipment
2. **Controls (check all speeds and all directions)**
   a. Bridge
   b. Trolley(s)
   c. Hoist(s)
3. **Brakes**
   a. Bridge
   b. Trolley(s)
   c. Hoist(s)
4. **Upper Hoist Limit Switch(es), All Hoists**
5. **Leakage (Air, Oil, etc.)**
6. **Hook(s)**
7. **Hook Latch(es)**
8. **Wire Rope(s)**

Attachment 4
CRANE/RIGGING SPECS

ANSI	TITLE	COMPONENT
B30.2	Overhead and Gantry Cranes (Top Running Bridge, Single or Multiple Girder, Top Running Trolley Hoists)	CR-5-1A&B New & Spent Fuel Bldg Crane CR-6-1A Spent Fuel Bld. Lower Lvl. Crane

Attachment 5
Non-Routine/Routine Rigging Review Requirements

1.1 Non Routine Rigging Review Requirements

1.1.1 The following criteria has been established to identify non-routine rigging evolutions:

a. Lifting/rigging loads exceeding five (5) tons (10,000 lbs.) where the lift/rigging equipment and configuration has not been previously reviewed by engineering or;
b. The use of specialized rigging and unique lift operations not previously reviewed by engineering or vendors (spreader bars, lift beams, etc.) or;
c. The use of welded or bolted attachments and special anchorages (dead weight anchors, tie backs etc.,) to permanent plant structures or components,
d. The use of load paths not specifically designed for the intended applied load (rolling loads).

1.1.2 A rigging review shall be conducted for all rigging evolutions designated as non-routine.

1.1.3 Any calculations performed in support of rigging reviews for QA Category I components will meet the requirements of the DCM.

1.1.4 Non-routine rigging applications should include a sketch developed or reviewed/approved by the Rigging Engineer for field use.

a. Sketches may include pertinent instructions (as necessary) to ensure proper rigging techniques are utilized.
b. Engineering will maintain a file for all Rigging Engineer reviews.

1.1.5 Major lifts or heavy loads activities with significant safety implications shall be controlled by procedures approved by the Construction Site Manager and Decommissioning Manager or designees.

a. The Construction Site Manager or Decommissioning Manager may also request review by PORC.

1.2 Routine Rigging

1.2.1 All routine rigging evolutions shall be conducted utilizing the guidance contained in Bobs Rigging and Crane Handbook (or equivalent).

1.2.2 All qualified site riggers shall have read and understood this procedure.

ATTACHMENT 4 to CY-02-075

Portion of Calculation Number 97C2968(B)-01

Evaluation of the Yard Crane and Fuel Building Structure
for the Haddam Neck Plant

@MP

CALCULATION TITLE PAGE

TITLE **Evaluation of the Yard Crane and Fuel Building Structure for the Haddam Neck Plant.** **Total No. of Pages** 1081

CY Calculation No. N/A **Rev. No.** N/A

Vendor Calc. No. 97C2968(B)-01 **Rev. No.** 0

System N/A **Structure** FB **Component** N/A

Calculation Supports:	NUCLEAR INDICATORS
☐ DCR ☐ MMOD ☐ DWP ☒ OTHER Doc. No. ACR#97-0034	☒ CAT 1 ☐ SFQA ☐ FPQA ☐ RWQA ☐ NON-QA
☐ Revises ☒ Supersedes ☐ Voids ☐ N/A Existing Calc. No. CY-524990-178-GC and 94-NS-02-1050-CY	Safety Evaluation Required? ☐ Yes ☒ No Safety Evaluation No. (Attach Applicability Review Form)

Executive Summary

The purpose of this calculation is to evaluate the Yard Crane and Fuel Building Structure at CY for the load and load combinations specified in NU Specification SP-CY-CE-0022, "Structural Criteria for Spent Fuel Island Systems, Structures and Components." The structural analysis criteria specified for the evaluation of these structures is the Standard Review Plan (SRP) 3.8.4 criteria. Portions of the Yard Crane and Fuel Building Structure which were evaluated are Non-QA. They are evaluated for seismic interaction with the Spent Fuel Pool (below a portion of the Fuel Building Structure) which is a Category 1 structure.

(Continued)

DOCUMENTATION CHANGE REQUESTS				
Technical Specification Changes Initiated?	☐ YES	☒ N/A	Amendment No.	
Technical Specification Clarification Initiated?	☐ YES	☒ N/A	C-TSC-	
TRM Change Initiated?	☐ YES	☒ N/A	TRMCR No.	
UFSAR Change Initiated?	☐ YES	☒ N/A	FSARCR No.	
LB/DB Change Initiated?	☒ YES	~~☒ N/A~~ MAP	LB/DBCR No.	99-LB-17
Regulatory Commitment Changes Initiated?	☐ YES	☒ N/A	ATS. No.	
Station Procedure Changes Required?	☐ YES	☒ NO	If Yes, List Below:	

APPROVALS	NAME (PRINT/SIGN)	DISCIPLINE	DATE
Preparer	Charlie L. Napa / Charlie L. Napa	Civil/Mech	10-12-99
Interdiscipline Reviewer	N/A		
Interdiscipline Reviewer	N/A		
Independent Reviewer	Mark A. Powers / M A Powers	Civil/Mech	10-20-99
Discipline Supervisor	S.J. Weyland / S J Weyland		10/20/99

Level Of Use
Information

Executive Summary (Continued)

The structures were evaluated for a maximum crane loading on the Yard Crane Structure of 100 tons simultaneously with the maximum crane loads applied to all cranes in the Fuel Building. This calculation evaluates the structures for this loading at any location across the entire lifting location range of the Yard Crane. CY's design basis earthquake loading, defined for the Spent Fuel Rerack Project design change (PDCR #1592), was applied with the maximum crane loadings.

This calculation provides the basis for meeting the structural licensing and design basis for the Fuel Building and Yard Crane as defined in PDCR #1592. SRP 3.8.4 criteria used for this evaluation exceeds the current licensing and design basis established for structures at CY, with USNRC acceptance of PDCR #1592. The calculation indicates that all structural members, connections, and foundations for the structures evaluated meet SRP 3.8.4 criteria when redistribution of loadings acting on secondary brace members is appropriately taken into account.

This calculation supersedes calculations CY-524990-178-GC ("Yard Crane") and 94-NS-02-1050 CY ("Fuel Building") in their entirety. Review of these superseded calculations resulted in the documented conclusion in ACR 97-0034 that the calculations had insufficient documentation to clearly support their conclusions.

Client: Connecticut Yankee Atomic Power Co. Calculation Number: 97C2968(B)-01

Title: Evaluation of the Yard Crane and Fuel Building Structure for the Haddam Neck Plant

Project: Seismic Qualification of Yard Crane and Fuel Building to Current Criteria

Method: Finite Element Analysis using PD-STRUDL supplemented with Manual Calculations

Acceptance Criteria: See Sections 1.0, 2.0, and 7.0 of Calculation

Remarks:

Verification Method ☒ Design Review Method ☐ Alternate Calculation ☐ Qualification Test ☐ Other ☐ No Verification Necessary

Results:

REVISIONS

Revision No.	0		
Description	Original Issue		
Total Pages (Cumulative)			
By/Date	Paul R. Wilson 9-21-98		
Checked/Date	Ram Srinivasan 9/22/98		
Approved/Date	George D. [illegible] 9/27/98		

S&A Stevenson and Associates

CALCULATION COVER SHEET

CONTRACT NO. 97C2968(B)

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- D2. STRUCTURAL EVALUATIONS OF YARD CRANE PLATE GIRDERS

E. STRUCTURAL STEEL CONNECTION EVALUATIONS

- E1. YARD CRANE CONNECTION LOADS AND EVALUATIONS
- E2. FUEL BUILDING CONNECTION LOADS AND EVALUATIONS

F. ANCHORAGE AND FOUNDATION EVALUATIONS

- F1. COLUMN BASES AND FUEL POOL WALL PLATE EVALUATIONS
- F2. FOOTING AND PIER EVALUATIONS

G. CRANE SEISMIC STABILITY

1.0 PURPOSE

The purpose of this calculation is to evaluate the Yard Crane and Fuel Building Structure at the Connecticut Yankee Atomic Power Company Haddam Neck Plant for the loads and load combinations specified in NU Specification SP-CY-CE-0022, "Structural Criteria for Spent Fuel Pool Island Systems, Structures and Components," (Ref. 1). The structural analysis criteria specified for the evaluation of the Fuel Building and Yard Crane structures is the current Standard Review Plan SRP 3.8.4 criteria (Ref. 2). The maximum crane loading for the yard crane structure is 100 tons. The calculation evaluates the structures for this loading at any location across the entire lifting location range of the Yard Crane structure.

This calculation provides the basis for meeting the current structural licensing and design basis for the Fuel Building and Yard Crane. The SRP 3.8.4 criteria used for this evaluation exceeds the current structural licensing and design basis established for the structures, with USNRC acceptance, of the Spent Fuel Pool Rerack Project design change (PDCR #1592 -- Ref. 3).

2.0 SUMMARY AND CONCLUSIONS

The CY Yard Crane and Fuel Building were evaluated in accordance with the acceptance criteria specified in NU Specification SP-CY-CE-0022, "Structural Criteria for Spent Fuel Pool Island Systems, Structures and Components," (Ref. 1). The method of analysis is discussed in the Methodology section of this calculation. All structural members, connections and foundations for the Fuel Building and Yard Crane structures meet current Standard Review Plan SRP 3.8.4 criteria (Ref. 2), when redistribution of loadings acting on secondary brace members is appropriately taken into account. The evaluations were performed using a PD-STRUDL (Ref. 4) finite element model. Attachments A, B, and C provide details for the model and input for the evaluations. Attachments D, E, F, and G include the structural evaluations. A summary of the results of the evaluation are included in Section 7.0 for the members, connections and foundations with the highest interaction and the corresponding allowables from the acceptance criteria.

3.0 REFERENCES

1) NU Specification SP-CY-CE-0022, "Structural Criteria for Spent Fuel Pool Island Systems, Structures and Components," Rev. 0, June 20, 1997.

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4.0 BACKGROUND AND DISCUSSION

The Yard Crane Structure and Fuel Building at CY were originally designed for loads including seismic, with the seismic loading applied as static coefficients (References 5 and 6). The seismic static coefficient for the portion of the Fuel Building which contains the fuel pool (between Column lines 106 to 108 and R to T) was .36g (reduced by .81 to .292g to be comparable to wind), based on the original design basis SSE ground response spectrum definition. The rest of the Fuel Building and the Yard Crane Structure were designed to a static coefficient of .064g (also reduced by .81 to .052g to be comparable to wind). A one-third increase in allowable stress was used for the seismic and wind loads, consistent with AISC and UBC criteria. This static coefficient analysis was the design basis for the structure until the issuance of PDCR #1592 (Ref. 3). The design change for the Spent Fuel Pool rerack essentially changed the design basis for the Spent Fuel Pool Building and Yard Crane structures.

The licensing and design basis for the Yard Crane and the New and Spent Fuel Building can be summarized as follows:

1. Under the design basis loads, the subject structures must not collapse onto or into the Spent Fuel Pool resulting in damage to the fuel assemblies or pool causing an off-site radiological release.

2. Under design basis loads, the reactions of the subject structures must not affect the structural integrity of the spent fuel pool.

Separate calculations were performed for the Yard Crane and Spent Fuel Building (Ref. 7 and 8) during the 1995 to 1996 time frame to provide the basis for meeting the structural licensing and design basis as established for the Safety Evaluation (Ref. 9) performed for the structural aspects of the Spent Fuel Pool Rerack Project (PDCR #1592 -- Ref. 3). The calculations evaluated the structures to meet current Standard Review Plan, SRP 3.8.4 criteria (Ref. 2). The design basis response spectrum input for these calculations increased in comparison to the original design basis earthquake input. The design basis response spectrum is defined by the Levin /Crutchfield earthquake developed (Ref. 10) during the Systematic Evaluation Program (SEP) at CY. This criterion is considered a seismic qualification criterion and is a higher threshold than the licensing criteria described above. The results of these analyses indicated that all structural components of these structures met the acceptance criteria and therefore, the structures met the licensing and design criteria. The establishment of the acceptance criteria was solidified with the issuance of the USNRC Safety Evaluation (Ref. 11) for the rerack licensing amendment.

The structural 10CFR50.54(f) licensing and design basis for the Yard Crane and Spent Fuel Pool structures were reconstituted as part of the Design Basis re-verification effort at CY. Concerns regarding some of the modeling assumptions and analysis methodology were raised as a result of a review of the Reference 7 and 8 calculations. ACR #97-0034 (Ref. 12) which resulted from this review identified that the structural calculations of the SFB and Yard Crane structure (Ref. 7 and 8) were found to have insufficient documentation to clearly support the conclusions.

The calculation documented in this analysis provides the basis for meeting the structural licensing and design basis for the Yard Crane and Spent Fuel Building currently established. The analysis addresses all of the concerns documented with the issuance of ACR #97-0034 (Ref. 12). The Yard Crane and Fuel Building Structures were modeled together and analyzed for deadweight, live load, snow load, wind loads, and seismic loading, using the computer program PD-STRUDL (Reference 4). The seismic loading is defined by the Levin-Crutchfield site specific ground response spectrum (Ref. 10).

This analysis utilized structural models appropriate for the reevaluation of an existing structure. These models were evaluated for the load inputs and combinations specified in Reference 1. Section 5.0 describes the methodology used to perform the analyses and the loads and load combinations. A detailed model description is included in Section 6.0.

5.0 METHODOLOGY

A combined finite element model of the CY New and Spent Fuel Building and Yard Crane structures was developed for analysis using PD-STRUDL (Ref. 4). PD-STRUDL is a general purpose finite element code used in the analysis and design of structures. The PD-STRUDL DOS0496 version used for this application has been validated in accordance with Stevenson & Associates Quality Assurance Program (Ref. 13). The program runs in an MS-DOS PC environment. Plots and sketches of the model are provided in Attachment A.

The Spent Fuel Pool Building and Yard Crane structure are integral to one another, in that the New and Spent Fuel Building uses two of the Yard Crane main columns for structural support. Both structures are partially founded on the top edge of the Spent Fuel Pool. The PD-STRUDL model was subjected to all loadings in the CY design licensing basis using the appropriate load combination of SRP 3.8.4. A detailed description of the loadings is included in Section 5.1 below. Loading applied statically to the models included dead load, crane impact loads, live loads, snow loads, and wind loads. Seismic (earthquake) loadings were applied as dynamic loadings using response spectra modal analysis techniques.

As discussed in Section 5.2, when all members were modeled using their full section properties, there were four secondary bracing members that were over the allowable stress criteria. A review of the analysis results indicated that members included in the primary lateral load path had high safety margins. In order to evaluate the structure accounting for redistribution of loadings acting on the brace members, two additional series of analyses were conducted as discussed in Section 5.2. The first removed all the overstressed members from the model and the second was a series of iterative analyses where the areas of the brace members were reduced until the results converged on a solution where the load carried by the members were below their allowable load for their full sections. The results indicate that the structure meets SRP 3.8.4 allowable stress criteria for the redistributed loadings.

5.1 Model Loadings

This section describes the load cases to which the structural model was subjected. The load cases were numbered with three digit numbers. The first digit of the load case indicated main Yard Crane locations 1, 2, and 3 respectively. These locations are discussed in Section 6.1.

5.1.1 Dead Load

The Dead Load Cases include Load Cases 105, 205, and 305 (for Crane Locations 1,2,3, respectively).

Dead load is defined as the self-weight of the structure and permanent structural components. The weights of the steel members, floor and roof slabs, interior walls, exterior walls, and the four crane bridges are calculated based on areas and densities of the model members input to PD-STRUDL. The weights of the Fuel Building steel siding above Elev. 47 feet, the Fuel Building roof hatch, the Elev. 47 feet hatch, and crane trolleys and lifted loads are modeled as concentrated masses distributed to appropriate joints. For deadweight, these concentrated masses were evaluated as concentrated loads by multiplying the mass times the gravitational constant.

5.1.2 Crane Impact Loads

The Crane Impact Load Cases include Load Cases 110, 210, and 310 (for Crane Locations 1,2,3, respectively).

The vertical and horizontal impact loads for the Yard Crane are calculated in accordance with Section A4 of AISC Steel Specification, 9th Edition (Reference 14).

Vertical impact loads for the three Fuel Building Cranes (CR-5-1A and -1B, and CR-6-1A) are calculated as described in Section 6.6. Crane runway horizontal loads are calculated based on the AISC, 9th edition, Section A4.3 [14].

5.1.3 Live Load

The Live Load Cases include Load Cases 120, 220, and 320 (for Crane Locations 1,2,3, respectively).

A live load of 150 psf (Reference 3, and 16) is applied as a uniform surface load to all plate elements comprising the Fuel Building floors.

5.1.4 Snow Load

Snow Load Cases include Load Cases 130, 230, and 330 (for Crane Locations 1,2,3, respectively).

A snow load of 40 psf (Reference 3, and 16) is applied to the Fuel Building roof, roof hatch, and the Yard Crane bridge. The load is applied to the plate elements comprising the roof as a uniform surface load. Snow load on the Fuel Building roof hatch is applied as calculated joint loads on the supporting structural steel members. The snow load on the Yard Crane is applied as a uniform member load to the members representing the crane bridge, and as a calculated joint load at the joint representing the trolley.

5.1.5 Wind Load

Wind Load Cases include Load Cases 140, 240, and 340 - Z (South) Wind (for Crane Locations 1,2,3, respectively) and Load Cases 150, 250, and 350 - X (East) Wind (for Crane Locations 1,2,3, respectively). Wind load is applied as a uniform, horizontal pressure of 28 psf to exposed steel, exterior walls, and the Yard Crane surfaces that are perpendicular to the direction of the wind.

The wind load is applied to structural steel and to the crane bridge as a calculated uniform linear member load based on the depth of steel exposed to the wind. Wind pressure on exterior walls is applied as calculated joint loads. The joint loads are based on the wall tributary area.

5.1.6 Seismic

Seismic Load Cases include the following:
Load Cases 171, 271, and 371 - X (East-West) (for Crane Locations 1,2,3 respectively),
Load Cases 172, 272, and 372 - Y (Vertical) (for Crane Locations 1,2,3 respectively),
Load Cases 173, 273, and 373 - Z (North-South) (for Crane Locations 1,2,3 respectively), and
Load Cases 174, 274, and 374 - SRSS (X,Y,Z) (for Crane Locations 1,2,3 respctively).

Seismic loads are based on the 0.21g ZPA Levin-Crutchfield ground response spectrum at 7% of critical damping (Reference 3). The vertical response spectrum is taken as 2/3 of the horizontal response spectrum. The ground response is applied at all supports and anchorages.

Structural response was calculated in two horizontal directions and one vertical direction. Modal responses for each direction were combined by Square Root Sum of the Squares (SRSS) in the PD-STRUDL analyses, with closely spaced modes first combined in accordance with the "grouping" method of Reg. Guide 1.92 (Reference 15). The responses in the three spatial directions are then combined by SRSS.

5.2 Loading Combinations

Table 5.2-1 provides the load combinations used in the PD-STRUDL evaluations.

Table 5.2-1
PD-STRUDL Load Combinations (Note 1)

Load	Description (Note 2)	Combined Load Cases Combined Loading Numbers
1001	Normal Loads: D+I+L+S	105+110+120+130
1002	Normal Load w/Z-Wind: D+I+L+S+Wz	105+110+120+130+140
1003	Normal Load w/X-Wind: D+I+L+S+Wx	105+110+120+130+150
1004	Normal Load, Concrete Evaluation: 1.4D+1.7(I+S+L)	1.4(105)+1.7(110+120+130)
1005	Normal Load w/Z-Wind, Concrete Eval: 1.4D+1.7(I+S+L+Wz)	1.4(105)+1.7(110+120+130+140)
1006	Normal Load w/X-Wind, Concrete Eval: 1.4D+1.7(I+S+L+Wx)	1.4(105)+1.7(110+120+130+150)
1007	Normal Load w/X-Wind, Concrete Eval: 1.2 D + 1.7 (Wx)	1.2(105)+1.7(140)
1008	Normal Load w/X-Wind, Concrete Eval: 1.2 D + 1.7 (Wx)	1.2(105)+1.7(150)
1009	+Seismic: D+L+S+SSE	105 + 120 +130+ 174
1010	-Seismic: D+L+S-SSE	105 + 120 +130- 174
1013	PD-STRUDL Code Check, Faulted Loads: 0.625(D+L+S+SSE) (Note 3)	0.625 (1009)
1014	PD-STRUDL Code Check, Faulted Loads: 0.625(D+L+S-SSE) (Note 3)	0.625 (1010)
1015	PD-STRUDL Code Check, Normal Loads: w/Z-Wind: 0.75(D+I+L+S+Wz) (Note 4)	0.75(1002)
1016	PD-STRUDL Code Check, Normal Loads: w/X-Wind: 0.75(D+I+L+S+Wx) (Note 4)	0.75(1003)

Notes:
(1) The load combination and load case numbers provided in the table are for Crane Location 1. The load combinations and load case numbers for Crane Locations 2 and 3 can be obtained by replacing the first number of the combination/case number with the Crane Location number.

(2) D = Deadweight I = Crane Impact L = Live Load S = Snow Wz = Z (South) Wind Wx = X (East) Wind SSE = Seismic

(3) Per SP-CY-CE-0022 (Ref. 1), the normal allowable stresses/loads defined in the AISC Code may be increased by a factor of 1.6 for evaluation of load combinations which include seismic. Multiplying the member loads/stresses by 0.625 and comparing with unfactored allowables is equivalent to multiplying the allowables by 1.6 and not factoring the loads/stresses.

(4) Per SP-CY-CE-0022 (Ref. 1), the normal allowable stresses/loads defined in the AISC Code may be increased by a factor of 1.33 for evaluation of load combinations which include wind. Multiplying the member loads/stresses by 0.75 and comparing with unfactored allowables is equivalent to multiplying the allowables by 1.33 and not factoring the loads/stresses.

5.3 Analysis Iterations

There were several different analyses performed for the three crane locations. The first (Base Case) was a response spectra modal analysis with all of the members modeled with their full section properties. As indicated in the Section 7.0, there were four brace members that exceeded the SRP 3.8.4 criteria and a fifth with a relatively high interaction (0.92). All of these brace members were located in the upper floor of the Fuel Building and contribute to the lateral load resistance of the Fuel Building Roof at Elevation 75'. These members are relatively slender (slenderness ratios vary from about 143 to 150) and therefore had low allowable axial compression stresses (from about 10 to 12 ksi) even with the 1.6 increase over normal stresses included in the SRP 3.8.4 criteria.

A response spectra analysis was performed for the three crane locations with the four overstressed braces removed. This caused the fifth brace to become overstressed with an interaction against SRP 3.8.4 criteria of about 1.3. Therefore, the fifth brace was removed and a (Worst Case) response spectra analysis was performed. The purpose of removing the braces from the analysis was to assess how the structures would redistribute the lateral loadings to the welded frame Yard Crane structure. The results from these analyses confirmed that the structure had tremendous lateral load capacity with the primary resistance coming from the large columns and the welded frame action of the structure in the East - West direction. Removing the braces also had an effect on the overall dynamics of the structures. The primary lateral frequencies were reduced which also reduced the overall lateral loads (since the predominant lateral frequencies are on the soft side of the peak spectral accelerations of the input Ground Response Spectra). The analysis confirmed that should any of the braces become partially effective the overall lateral loads will reduce and there is sufficient lateral residual capacity from the structure to carry all of the lateral loads. The braces are a secondary load path and are overstressed primarily due to differential displacement between the two supporting columns. All of the other members of the structure met the SRP 3.8.4 criteria with the five members removed except for two other braces that had interaction coefficients of 1.10 and 1.12 respectively. These overstressed conditions were only for the extremely unlikely case that the crane will be fully loaded at the far North end of the Yard Crane Structure when a SSE level event occurs.

Iterative evaluations of the structures were performed by modifying the areas of the five braces that potentially could be loaded above the SRP 3.8.4 allowable stress. The areas were modified to adjust the brace stiffness with successive analyses until the results converged on a solution where the load carried by the five members were all at or below their allowable load for their full section. This allowed these members to withstand a portion of the load up to their allowable while redistributing the additional load they would withstand if the total stiffness were modeled as in the Base Case. The final converged solution (Iterative Case) is a reasonable engineering solution for the problem given the analytical capabilities of PD-STRUDL. PD-STRUDL is used for linear elastic response spectra or time history analysis. The program does not have the capability of modeling the non-linear material properties that are necessary to account for the post-buckling behavior of the braces.

The final Iterative Case converges on an iterative stiffness of the braces that is between the Base Case and

Worst Case and allows additional load to be redistributed to other portions of the structure. The final Iterative Case also has the effect on the overall dynamics of the structure as discussed above for the Worst Case evaluations, in that the overall lateral loads are reduced. This reduction in load based on a comparison of the 7% damped spectral accelerations at the dominant lateral natural frequencies from the ground response spectrum is on the order of only 10%. Therefore, the change in dynamics from the Base Case to the Iterative Case does not affect the overall acceptability of the structures. The residual capacity of the structure, qualitatively evaluated by reviewing the interactions for the members forming the primary lateral load resistance of the structure, is more than adequate to withstand the higher inertial loads predicted by the Base Case response. The evaluations for all but four of the connections, anchorages and footings are finalized based on the reaction loads from the Iterative Case since it represents the most credible load distribution for the structures. The Base Case is used for evaluating the connections of the brace members that exceeded the SRP 3.8.4 criteria for the compression loading, since these loadings are the most conservative. The loadings on the most heavily loaded members, connections, anchorage and footings that govern the analysis are essentially the same for both the Base Case and Iterative Case. This is due to the reduction in lateral load capacity modeled by reducing the brace member areas being compensated by the 10% reduction in load from the change in the structure dynamics. The evaluations of the connections, anchorage, and footings indicate that they are all acceptable.

6.0 MODEL DESCRIPTION

6.1 General

The Spent Fuel Pool Building and Yard Crane structure are integral to one another in that the New and Spent Fuel Building uses two of the Yard Crane main columns for structural support. Both structures are partially founded on the top edge of the Spent Fuel Pool.

A finite element model of the CY Fuel Building and Yard Crane combined structures was developed for analysis using the general finite element code PD-STRUDL (Ref. 4). Plots and sketches of the model are provided in Attachment A with the detailed model information documented in the input files provided in Attachment C.

PD-STRUDL was used to calculate deflections, individual member forces and moments, and reactions at support points due to the input loads and load combinations. Loads and load combinations are discussed in Section 5.0. The code check capabilities in PD-STRUDL are used to evaluate practically all of the members within the Fuel Building and Yard Crane structure. The deflections, member forces and moments, and support reactions are used in the evaluations of the Yard Crane plate girders, structural steel connections, anchorages and foundations, and crane seismic stability.

The structural model and loading definitions in this calculation use the following global axis convention:

X = East-West
Y = Vertical
Z = South-North

The PD-STRUDL model comprises both the Fuel Building and Yard Crane support frame, since those structures are interconnected. They are depicted in the drawings listed as References 16 through 36, modified by walkdown information (References 37 & 38) and including Yard Crane data from Reference 5. Additionally, the Wet Surface Air Coolers, as shown in Reference 39, are modeled on the Fuel Building Elevation 47 feet roof.

The basic structural model is analyzed for three different configurations, in order to assess the effect of the Yard Crane location in the structural response. The three crane positions are briefly described next.

- Crane Location No. 1 corresponds to the Yard Crane located along column line 106, with its trolley centered over the Fuel Building hatch. This position represents the most likely crane location other than parked, and is also reasonably close to the Containment Building connection (line 108).

- Crane Location No. 2 corresponds to the Yard Crane in parked position, at the South end of the support structure (one end aligned with column 100), with the trolley located at its easternmost position.

- Crane Location No. 3 corresponds to the Yard Crane at the North end of the combined structure (one end aligned with column 113), with the trolley located at its easternmost position.

The three configurations above are considered representative of the Yard Crane requirements. The crane locations considered represent the most probable configuration and thus are appropriate for a seismic calculation.

6.2 Supports and Anchorages

The combined structure is supported at the following locations: column bases, Spent Fuel Pool wall, and one connection point with the Containment Building. All locations are considered ground supports and are therefore subjected to the ground response spectra. This assumption is justified by:

- The column foundations are located on bedrock (except for columns along line 100),
- The Spent Fuel Pool is a thick, reinforced concrete structure which is significantly stiffer than the Yard Crane/Fuel Building structure, and does not exhibit substantial amplification of ground motion.
- The containment undergoes small seismic displacements (less than 1/8") (Ref. 40). The seismic displacements for the containment exterior shell are calculated based on a response spectra analysis with a response spectra input which has generally higher accelerations, but a lower value for the PGA (peak ground acceleration) than the Levin-Crutchfield response spectrum. However, a correction to the disparity in response spectra would not significantly alter the magnitude of the horizontal displacement at the containment connection.

The connection of the model to Containment and the connections of the Fuel Building floor beams to the Spent Fuel Pool walls are modeled with restraints against displacements.

All column base moments are released in the global X and Z directions. This is consistent with the reference drawings. The global Y moment, which is torsion on a column, is not released in order to maintain structural stability.

Beams anchored to the Spent Fuel Building embedded wall plates, consistent with the reference drawings, have moments released in all three directions. These connections are knife-edge type shear connections.

The Containment connection is a pin in a slotted hole which resists translational movement perpendicular to the Yard Crane structure (model Global X direction). Therefore, this connection was released for all moments and for forces in the global Y and Z directions.

6.3 Member End Releases and Bracing Members

Member load transmission capabilities are released as follows:

- All beam-beam and beam-column connections had moments in the local Y and Z axes released, except for the rigid-frame beam-column connections at the top of the Yard Crane structure, at each bay, on both the East and West sides of the Yard Crane support structure, which are moment connections (no releases). This is consistent with the structural connections (generally framed beam shear connections) shown on the drawings, walkdown information, and the original design calculation. Local X moments (torsion) were generally not released in order to maintain individual member structural stability.

- Bracing in the vertical and horizontal planes was modeled using truss members (all moments and all forces except for axial are released).

Normal design practice for the modeling of cross braces when the slenderness ratio (Kl/r as defined in AISC Specifications) approaches or exceeds 200 is to assume that the compression members will buckle and hence are not effective. This is the case for the longer cross-brace members located in the end frames of the yard crane support structure, and is consistent with the original design assumptions (Reference 5).

The cross-bracing members of the roof of the yard crane structure, however, were designed in the original calculations to resist both tension and compression. The cross-bracing in the roof was therefore modeled as fully effective. The analysis results indicate that none of the roof cross-bracing members failed in compression, and hence the assumption of these members as fully effective was confirmed.

The areas of the members for the end frame cross-braces were modified such that the effective stiffness for dynamic analyses considered the members fully effective in tension, and included the small contribution of the members up to their buckling capacity in compression. The areas for these members were restored for the static analysis to their physical values, and they were evaluated as tension-only members. The members were evaluated as tension-only members for stress checking with combined dynamic and static results.

6.4 Steel Member Properties

Structural steel members were specified using standard AISC (Ref. 14) properties from the PD-STRUDL built-in library whenever possible. Member properties were computed for compound members and for members not available from the PD-STRUDL library, and input by creating a user section property table, with all the properties of the built-in libraries.

Rigid links were modeled with properties (AX, IX, IY, IZ) sufficient to directly transmit loads between linked members without causing problems in the stiffness matrix due to significant stiffness differences.

6.5 Floors and Walls

The Fuel Building floor slabs, exterior walls and internal walls, and the Yard Crane girder plates were modeled using quadrilateral shell elements to account for the bending and membrane stiffness contributions of these structural components.

The fuel building design drawings indicate that the exterior concrete walls are tied to the steel structure by "metal anchors" embedded in the concrete and welded to the steel at 2'-0" and 3'-0" intervals for the steel columns and beams respectively. The walls were modeled with the steel framing. Duplicate node points were defined for the walls at points defined for the steel framing, and linear springs were attached between corresponding nodes to tie the walls and framing together for translational degrees-of-freedom.

6.5.1 Slab Connections to Pool Wall

The floor slab at Elevation 47'-0" is shown to be connected to the pool wall in Section F-F of Reference 30 in a 2"x7" keyway with #4 dowels. Similarly for the slab at Elevation 35'-0", Section N-N of Reference 30 shows this slab to be in a 2"x8" keyway, also with #4 dowels. Reference 30, shows the #4 dowels to be spaced at 12" O.C. for both elevations.

6.5.2 Elevation 47'-0" Floor Slab/Roof Slab

The floor slab at Elevation 47'-0" between Column line 102 and the pool wall, and the roof slab at Elevation 47'-0" between Column lines 101 and 102 are shown to be continuous in Reference 30, Section B-B. The two slabs were joined in the model, and for convenience, all the beam and plate elements were modeled at one elevation.

6.5.3 Exterior Walls and Slabs

The exterior walls of the fuel building are shown in Reference 22 to be connected with metal ties at 2'-0" on center vertically at steel columns, and at 3'-0" on center along the beams adjacent to the walls. In addition, these walls are continuous with the slabs at Elevation 47'-0" as shown in Reference 30, Sections J-J, J'-J', E-E, E'-E', and K-K. The slab at Elevation 35'-0" is connected in a 1-1/2" x 8" key with #4 dowels at 12" on center as shown in Reference 30, Section A-A.

Connections of the walls to the structural steel were modeled with translational springs, and the walls and slabs were connected appropriately. These walls are also modeled as continuous with the pool walls.

6.6 Crane Models

Four cranes are included in the model. These are the Yard Crane (CR-3-1A) and the three cranes located in the Fuel Building (CR-5-1A, CR-5-1B, and CR-6-1A).

The Yard Crane is modeled as an "H" shaped structure. The "H"-structure is in a horizontal position.

Vertical rigid links are modeled at each end of the "H". The links represent the distance from the crane bridge centerline to the top of the crane rail. Local Y and Z moments are released at the crane rail ends of the vertical links, correctly modeling the crane rail/crane wheel interface.

The portion of the "H" representing the bridge is modeled as a rigid member with an area and density which will provide the proper bridge weight. The trolley and hoist weight and lifted load are modeled as lumped weights at a node on the bridge member. The legs of the "H" represent the crane end trucks and are modeled as rigid members.

The crane modeling was chosen to maximize structure response. Modeling the lifted load as a lumped weight at the crane bridge is conservative. The full rated lifted load was included for all cranes for all analyses.

The two Spent Fuel Pool (SFP) cranes (CR-5-1A and -1B) are identical except that 1A has an upgraded trolley and hoist, and some minor structural modifications to uprate the crane capacity from 3 tons to 6 tons. Conservatively, it is assumed both cranes have a 6-ton capacity.

The three cranes located in the Fuel Building (CR-5-1A, CR-5-1B, and CR-6-1A) are modeled using a single stiff horizontal member to represent the crane bridge girders. Two stiff, vertical members are used to represent the end trucks and wheels. The vertical members run from the crane girder centerline to the top of the crane rail. The vertical members are fixed to the crane rails, maximizing input to the supporting structure.

The members representing the three crane bridges are modeled with the proper area and density to represent the bridge weights. The bridge weights for 5-1A and -1B are assumed to be 9, 000 lbs. based on a total crane weight of 12,200 lbs. (Reference 41). The bridge weight for 6-1A is assumed to be 6,000 lbs. based on a total weight of 8,500 lbs. The 6-1A total weight is based on the weight provided on the reference drawings.

For CR-5-1A and -1B, the trolley weight and lifted load are combined and modeled as a lumped weight/joint load located at the end of the crane bridge. This combined load is multiplied by a vertical impact factor of 1.35, resulting in a total vertical load of 20,600 lbs. This load is divided between the deadweight (lumped weight of 10,300 lbs.) and crane impact (joint force of 10,300 lbs.) load cases.

The trolley weight and lifted load for CR-6-1A are also combined and modeled as a lumped weight/joint load located at the end of the crane bridge. The combined load is 2,500 lbs. (trolley) plus 6,000 lbs. (lifted load). This combined load is conservatively used for both the deadweight (lumped weight of 8500 lbs.) and crane impact (joint force of 8,500 lbs.) load cases.

6.7 Chillers

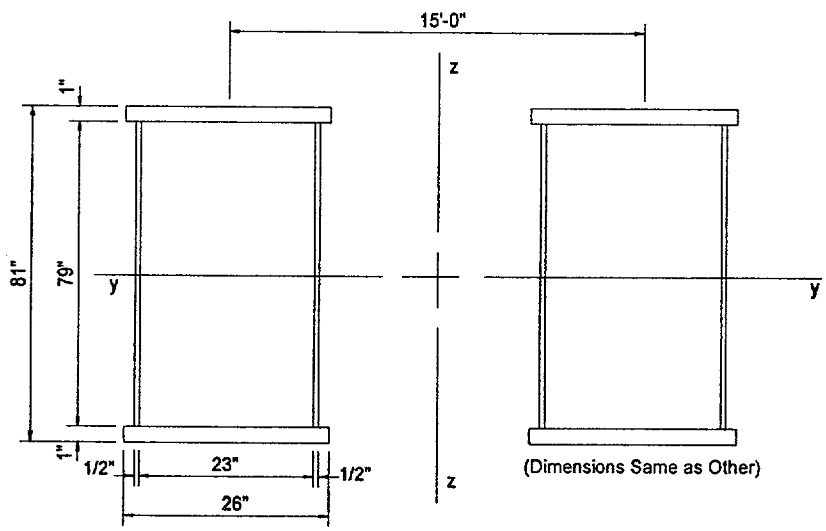
The wet surface air coolers (WSACs), E-177-1A and E-177-1B were modeled using information provided in Ref. 39, which provided locations of the chillers on the Fuel Building Roof, dimensions of the chiller support framing, weights of the chillers, and the location of their center of gravity (c.g.). The chiller support frames were modeled explicitly at the proper elevation, and were connected to the Fuel Building beams with rigid elements. The mass (weight) of each chiller was modeled as a concentrated mass, located at the c.g.'s, connected to the chiller frames with rigid links.

6.8 Section Properties

For non-standard sections, properties were calculated as follows, and were entered into a user table for PD-STRUDL to facilitate modeling and allow for code checking by the program.

6.8.1 Crane Girder Properties

The main crane girder consists of dual box beam sections, each 6'-9" Deep and 24" wide as determined from References 34, 35, and 36.



$$\text{Area} = 4(.5\ \text{in})(79\ \text{in}) + 4(1\ \text{in})(26\ \text{in}) = 262\ \text{in}^2$$

Use density = (180,000 lb) / ((80 ft) (12 in/ft) (262 in^2)) = .7156 lb/in^3
to account for total weight of bridge assembly.

$$I_{yy} = 2[2(\frac{1}{12})(.5\ \text{in})(79\ \text{in})^3 + 2(\frac{1}{12})(26\ \text{in})(1\ \text{in})^3 + 2(26\ \text{in})(1\ \text{in})(40\ \text{in})^2] = 248581.8\ \text{in}^4$$

$$I_{zz} = 2[2(\frac{1}{12})(79\ \text{in})(.5\ \text{in})^3 + 2(\frac{1}{12})(1\ \text{in})(26\ \text{in})^3 + 2(79\ \text{in})(.5\ \text{in})(11.75\ \text{in})^2] = 27675.8\ \text{in}^4$$

Reduced Sections at ends are not explicitly modeled. They are accounted for by pinning the ends of the bridge girder at the rails.

Torsional constant for a closed section is given as (Reference 42):

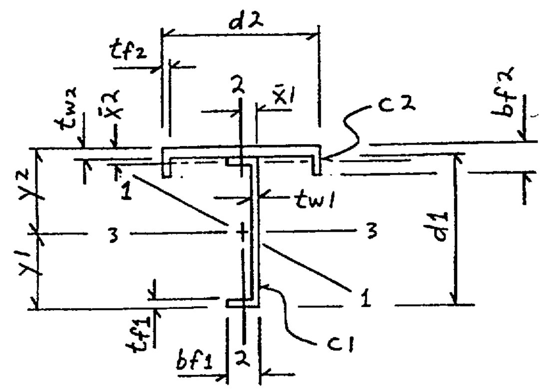
$$J = \frac{4\bar{A}^2}{\int \frac{ds}{t}}$$

where: $\bar{A}$ = Area enclosed by the centerline of the wall
$\int 1/t\, ds$ = the contour integral along the centerline s of the section
$t = t(s)$ = Wall thickness

Take the torsional constant equal to the sum of the torsional constants for the two girder sections.

$$J = \frac{2(4\bar{A}^2)}{\int \frac{ds}{t}} = \frac{2(4[(80\ \text{in})(24\ \text{in})]^2)}{\frac{2(80\ \text{in})}{.5\ \text{in}} + \frac{2(24\ \text{in})}{1\ \text{in}}} = 80139\ \text{in}^4$$

6.8.2 Built-up Double Channel Sections



MEMBER : 2 CHANNELS

C1 IN A VERT. UPRIGHT POSITION WITH C2 MOUNTED ABOVE IT WITH THE FLANGES POINTING DOWN

MEMB 1:	C10 x 15.3		MEMB 2:	C10 x 15.3	
A1 =	4.49	IN^2	A2 =	4.49	IN^2
d1 =	10	IN.	d2 =	10	IN.
bf1 =	2.6	IN.	bf2 =	2.6	IN.
tw1 =	0.24	IN.	tw2 =	0.24	IN.
tf1 =	0.436	IN.	tf2 =	0.436	IN.
Xbar1 =	0.634	IN.	Xbar2 =	0.634	IN.
IZ1 =	67.4	IN^4	IZ2 =	67.4	IN^4
IY1 =	2.28	IN^4	IY2 =	2.28	IN^4

A' = A1 + A2 = 8.98 IN^2

y1 = (A1*(d1/2)+A2*(d1+tw2-Xbar2)) / (A1+A2) = 7.30 IN.

y2 = d1 + tw2 - y1 = 2.94 IN.

IX = (d1*tw1^3 + 2*bf1*tf1^3 + d2*tw2^3 + 2*bf2*tf2^3) / 3 = 0.38 IN^4

IY = IY1 + IZ2 = 69.68 IN^4

SY = IY / (d2 / 2) = 13.936 IN^3

IZ = IZ1 + A1 * (y1 - (d1 / 2))^2 + IY2 + A2 * (y2 - Xbar2)^2 = 117.31 IN^4

SZ1 = IZ / y1 = 16.06 IN^3 SZ2 = IZ / y2 = 39.94 IN^3

AZ = d2 * tw2 = 2.4 r2 = SQRT(I2 / A') = 2.79 IN.

AY = (d1 + tw2) * tw1 = 2.46 r3 = SQRT(I3 / A') = 3.61 IN.

MEMBER : 2 CHANNELS

C1 IN A VERT. UPRIGHT POSITION WITH C2 MOUNTED ABOVE IT WITH THE FLANGES POINTING DOWN

MEMB 1:	C15 x 33.9		MEMB 2:	C15 x 33.9	
A1 =	9.96	IN^2	A2 =	9.96	IN^2
d1 =	15	IN.	d2 =	15	IN.
bf1 =	3.4	IN.	bf2 =	3.4	IN.
tw1 =	0.4	IN.	tw2 =	0.4	IN.
tf1 =	0.65	IN.	tf2 =	0.65	IN.
Xbar1 =	0.787	IN.	Xbar2 =	0.787	IN.
IZ1 =	315	IN^4	IZ2 =	315	IN^4
IY1 =	8.13	IN^4	IY2 =	8.13	IN^4

A' = A1 + A2 = 19.92 IN^2

y1 = (A1*(d1/2)+A2*(d1+tw2-Xbar2)) / (A1+A2) = 11.06 IN.

y2 = d1 + tw2 - y1 = 4.34 IN.

IX = (d1*tw1^3 + 2*bf1*tf1^3 + d2*tw2^3 + 2*bf2*tf2^3) / 3 = 1.88 IN^4

IY = IY1 + IZ2 = 323.13 IN^4

SY = IY / (d2 / 2) = 43.084 IN^3

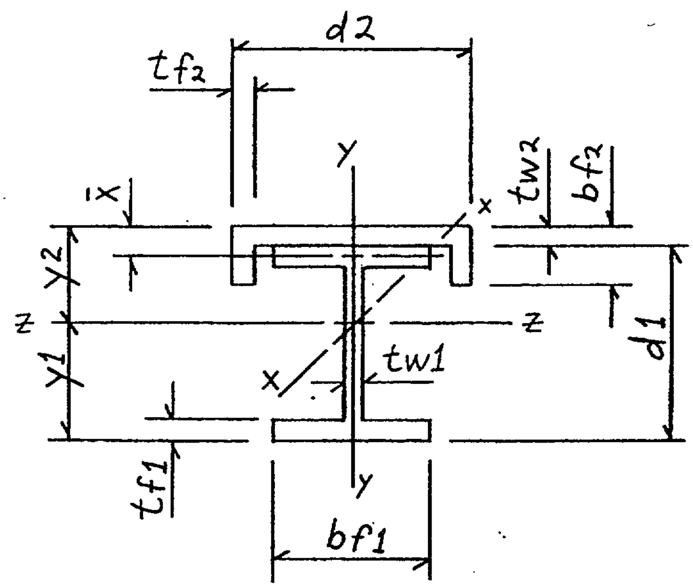
IZ = IZ1 + A1 * (y1 - (d1 / 2))^2 + IY2 + A2 * (y2 - Xbar2)^2 = 575.09 IN^4

SZ1 = IZ / y1 = 52.01 IN^3 SZ2 = IZ / y2 = 132.40 IN^3

AZ = d2 * tw2 = 6 r2 = SQRT(I2 / A') = 4.03 IN.

AY = (d1 + tw2) * tw1 = 6.16 r3 = SQRT(I3 / A') = 5.37 IN.

6.8.3 Built-up Wide-Flange with Channel Section



MEMBER : I-BEAM & CHANNEL

I-BEAM IN A VERT. UPRIGHT POSITION WITH C MOUNTED ABOVE IT
WITH THE FLANGES POINTING DOWN

MEMB 1:	W16 x 36		MEMB 2:	C15 x 33.9	
Aw =	10.6	IN^2	Ac =	9.96	IN^2
d1 =	15.86	IN.	d2 =	15	IN.
bf1 =	6.985	IN.	bf2 =	3.4	IN.
tw1 =	0.295	IN.	tw2 =	0.4	IN.
tf1 =	0.43	IN.	tf2 =	0.65	IN.
Xbar1 =	0	IN.	Xbar2 =	0.787	IN.
Izw =	448	IN^4	Izc =	315	IN^4
Iyw =	24.5	IN^4	Iyc =	8.13	IN^4
Jw =	0.54	IN^4	Jc =	1.02	IN^4

At = Aw + Ac = 20.56 IN^2

y1 = (Aw*(d1/2)+Ac*(d1+tw2-Xbar2)) / (Aw+Ac) = 11.58 IN.

y2 = d1 + tw2 - y1 = 4.68 IN. J t = Jw + Jc = 1.56 IN^4

AY = (d1+tw2) * tw1 = 4.80 IN^2 AZ = d2 * tw2 = 6.00 IN^2

Iy' = Iyw + Izc = 339.5 IN^4

Iz' = Izw + Aw * (y1 - (d1 / 2))^2 + Iyc + Ac * (y2 - Xbar2)^2 748.30 IN^4

Sy' = Iy' / (d2 / 2) = 45.27 IN^3 ry = SQRT(Iy' / At) = 4.06 IN.

Sz1' = Iz' / y1 = 64.60 IN^3 rz = SQRT(Iz' / At) = 6.03 IN.

Sz2' = Iz' / y2 = 160.03 IN^3

MEMBER : I-BEAM & CHANNEL

I-BEAM IN A VERT. UPRIGHT POSITION WITH C MOUNTED ABOVE IT WITH THE FLANGES POINTING DOWN

MEMB 1:	W24 x 76		MEMB 2:	C15 x 33.9	
Aw =	22.4	IN^2	Ac =	9.96	IN^2
d1 =	23.92	IN.	d2 =	15	IN.
bf1 =	8.99	IN.	bf2 =	3.4	IN.
tw1 =	0.44	IN.	tw2 =	0.4	IN.
tf1 =	0.68	IN.	tf2 =	0.65	IN.
Xbar1 =	0	IN.	Xbar2 =	0.787	IN.
Izw =	2100	IN^4	Izc =	315	IN^4
Iyw =	82.5	IN^4	Iyc =	8.13	IN^4
Jw =	2.68	IN^4	Jc =	1.02	IN^4

At = Aw + Ac = 32.36 IN^2

y1 = (Aw*(d1/2)+Ac*(d1+tw2-Xbar2)) / (Aw+Ac) = 15.52 IN.

y2 = d1 + tw2 - y1 = 8.80 IN.

J t = Jw + Jc = 3.70 IN^4

AY = (d1+tw2) * tw1 = 10.70 IN^2

AZ = d2 * tw2 = 6.00 IN^2

Iy' = Iyw + Izc = 397.5 IN^4

Iz' = Izw + Aw * (y1 - (d1 / 2))^2 + Iyc + Ac * (y2 - Xbar2)^2 3031.53 IN^4

Sy' = Iy' / (d2 / 2) = 53.00 IN^3

ry = SQRT(Iy' / At) = 3.50 IN.

Sz1' = Iz' / y1 = 195.31 IN^3

rz = SQRT(Iz' / At) = 9.68 IN.

Sz2' = Iz' / y2 = 344.57 IN^3

MEMBER : I-BEAM & CHANNEL

I-BEAM IN A VERT. UPRIGHT POSITION WITH C MOUNTED ABOVE IT WITH THE FLANGES POINTING DOWN

MEMB 1:	W18 x 45		MEMB 2:	C15 x 33.9	
Aw =	13.2	IN^2	Ac =	9.96	IN^2
d1 =	17.86	IN.	d2 =	15	IN.
bf1 =	7.477	IN.	bf2 =	3.4	IN.
tw1 =	0.335	IN.	tw2 =	0.4	IN.
tf1 =	0.499	IN.	tf2 =	0.65	IN.
Xbar1 =	0	IN.	Xbar2 =	0.787	IN.
Izw =	706	IN^4	Izc =	315	IN^4
Iyw =	34.8	IN^4	Iyc =	8.13	IN^4
Jw =	0.889	IN^4	Jc =	1.02	IN^4

At = Aw + Ac = 23.16 IN^2

y1 = (Aw*(d1/2)+Ac*(d1+tw2-Xbar2)) / (Aw+Ac) = 12.60 IN.

y2 = d1 + tw2 - y1 = 5.66 IN. J t = Jw + Jc = 1.91 IN^4

AY = (d1+tw2) * tw1 = 6.12 IN^2 AZ = d2 * tw2 = 6.00 IN^2

Iy' = Iyw + Izc = 349.8 IN^4

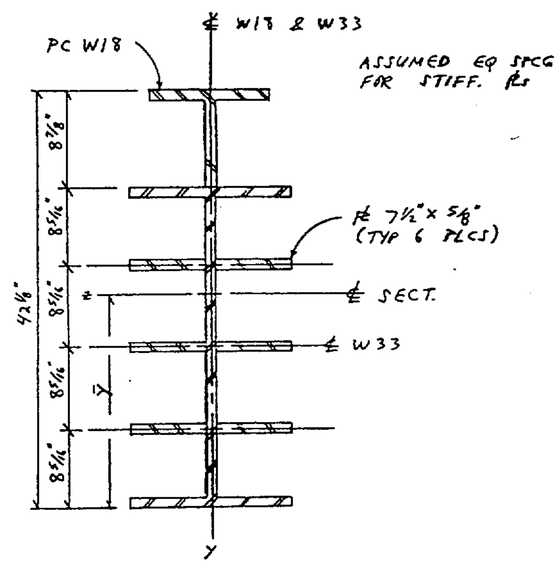
Iz' = Izw + Aw * (y1 - (d1 / 2))^2 + Iyc + Ac * (y2 - Xbar2)^2 1128.43 IN^4

Sy' = Iy' / (d2 / 2) = 46.64 IN^3 ry = SQRT(Iy' / At) = 3.89 IN.

Sz1' = Iz' / y1 = 89.53 IN^3 rz = SQRT(Iz' / At) = 6.98 IN.

Sz2' = Iz' / y2 = 199.51 IN^3

6.8.4 Yard Crane Built-up Column Section



MEMBER PROPERTIES FOR YARD CRANE

MEMBER : OVERLAPPED STIFFENED COLUMN

SEE ATTACHED SKETCH FOR MEMBER & AXIS ORIENTATION

MEMB 1:	W33 x 220		MEMB 2:	PC OF W18 x 114	
Aw1 =	64.8	IN^2	Aw2 =	N/A	IN^2
d1 =	33.25	IN.	d2 =	8.875	IN.
bf1 =	15.81	IN.	bf2 =	11.833	IN.
tw1 =	0.775	IN.	tw2 =	0.595	IN.
tf1 =	1.275	IN.	tf2 =	0.991	IN.
Xbar1 =	N/A	IN.	Xbar2 =	N/A	IN.
Izw1 =	12300	IN^4	Izw2 =	N/A	IN^4
Iyw1 =	841	IN^4	Iyw2 =	N/A	IN^4
Jw1 =	28.2	IN^4	Jw2 =	N/A	IN^4

STIFF. PLs: 7.5 IN. BY 0.625 IN.

OF PLs: 6

AX = 109.34 IN^2

FIND CENTERLINE OF SECTION: ybar = SIGMA (A * y) / AX = 20.19 IN.

SIGMA (A * y) = 2207.51 IN^3

AY = 31.05 IN^2

AZ = 81.62 IN^2

IX = 36.25 IN^4

IY = 1505.31 IN^4 SY = 190.43 IN^3

IZ = 21548.88 IN^4 SZ1 = 1067.36 IN^3

SZ2 = 982.35 IN^3

MEMBER PROPERTIES FOR YARD CRANE

MEMBER : OVERLAPPED STIFFENED COLUMN

SEE ATTACHED SKETCH FOR MEMBER & AXIS ORIENTATION

MEMB 1:	W33 x 200		MEMB 2:	PC OF W18 x 114	
Aw1 =	58.9	IN^2	Aw2 =	N/A	IN^2
d1 =	33	IN.	d2 =	8.875	IN.
bf1 =	15.75	IN.	bf2 =	11.833	IN.
tw1 =	0.715	IN.	tw2 =	0.595	IN.
tf1 =	1.15	IN.	tf2 =	0.991	IN.
Xbar1 =	N/A	IN.	Xbar2 =	N/A	IN.
Izw1 =	11100	IN^4	Izw2 =	N/A	IN^4
Iyw1 =	750	IN^4	Iyw2 =	N/A	IN^4
Jw1 =	21.1	IN^4	Jw2 =	N/A	IN^4

STIFF. PLs: 7.5 IN. BY 0.625 IN.

\# OF PLs: 6

AX = 103.44 IN^2

FIND CENTERLINE OF SECTION: ybar = SIGMA (A * y) / AX = 20.31 IN.

SIGMA (A * y) = 2100.89 IN^3

AY = 28.88 IN^2

AZ = 77.42 IN^2

IX = 29.15 IN^4

IY =	1414.31	IN^4	SY =	179.60	IN^3
IZ =	20286.25	IN^4	SZ1 =	998.84	IN^3
			SZ2 =	929.91	IN^3

MEMBER PROPERTIES FOR YARD CRANE

MEMBER : OVERLAPPED STIFFENED COLUMN
SEE ATTACHED SKETCH FOR MEMBER & AXIS ORIENTATION

MEMB 1:	W33 x 240		MEMB 2:	PC OF W18 x 114	
Aw1 =	70.6	IN^2	Aw2 =	N/A	IN^2
d1 =	33.5	IN.	d2 =	8.875	IN.
bf1 =	15.865	IN.	bf2 =	11.833	IN.
tw1 =	0.83	IN.	tw2 =	0.595	IN.
tf1 =	1.4	IN.	tf2 =	0.991	IN.
Xbar1 =	N/A	IN.	Xbar2 =	N/A	IN.
Izw1 =	13600	IN^4	Izw2 =	N/A	IN^4
Iyw1 =	933	IN^4	Iyw2 =	N/A	IN^4
Jw1 =	36.6	IN^4	Jw2 =	N/A	IN^4

STIFF. PLs: 7.5 IN. BY 0.625 IN.
OF PLs: 6

AX = 115.14 IN^2

FIND CENTERLINE OF SECTION: ybar = SIGMA (A * y) / AX = 20.10 IN.

SIGMA (A * y) = 2313.94 IN^3

AY = 33.09 IN^2

AZ = 85.83 IN^2

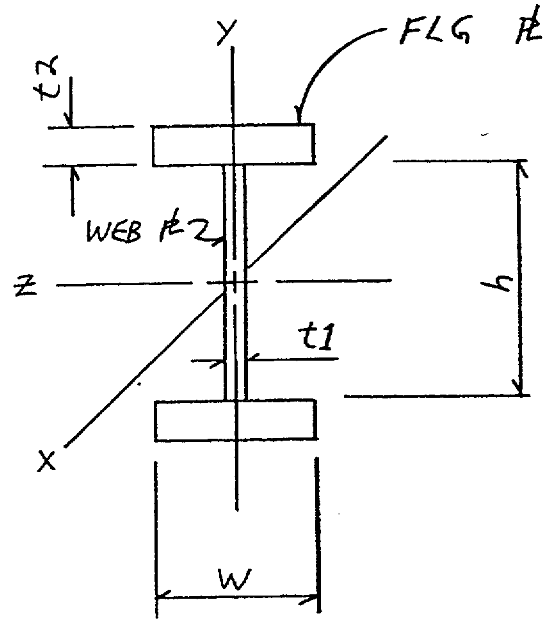
IX = 44.65 IN^4

IY = 1597.31 IN^4 SY = 201.36 IN^3

IZ = 22899.94 IN^4 SZ1 = 1139.51 IN^3

SZ2 = 1039.55 IN^3

6.8.5 Plate Girder Sections



S&A Stevenson and Associates — A Structural-Mechanical Consulting Engineering Firm	Client: Connecticut Yankee Atomic Power Co. Job No.: 97C2968(B) Subject: Evaluation of the Yard Crane and Fuel Building Structure for the Haddam Neck Plant	Sheet 37 of 51 Calculation No.: 97C2968(B)-01 Revision: 0 Date: 9-21-98 By: PR 9-21-98 Checked: RJ 9/22/98

GIRDER A & B

WEB PL SIZE:	h =	52	IN.	t1 =	0.5625	IN.
FLG PL SIZE:	w =	16	IN.	t2 =	2	IN.

Ax = h * t1 + 2 * w * t2 = 93.25 IN^2

Ay = ((2 * t2) + h) * t1 = 31.5 IN^2

Az = 2 * w * t2 = 64 IN^2

Ix = (h * t1^3 / 3) + (2 * w * t2^3 / 3) = 88.42 IN^4

Iy = (2 * t2 * w^3 / 12) + (h * t1^3 / 12) = 1366.10 IN^4

Iz = 2 * (w * t2^3 / 12) + (t1 * h^3 / 12) + 2 * ((Az / 2) * ((h + t2) / 2)^2)) = 53268.33 IN^4

Sy = Iy / (w / 2) = 170.76 IN^3

Sz = Iz / ((h + (2 * t2)) / 2) = 1902.44 IN^3

7.0 ACCEPTANCE CRITERIA

7.1 Steel Components

Consistent with Ref. 1, structural steel components of the Yard Crane and Fuel Building were evaluated to the allowable stress criteria of AISC Manual of Steel Design, Ninth Edition using working stress design. Normal allowable limits were used for evaluation to normal load combination cases, with a one-third increase in allowable limits permitted for load combinations including wind loads. For load combinations including SSE level seismic loads, the normal allowables were increased by a factor of 1.6 in accordance with SRP 3.8.4.

7.2 Concrete Components

Consistent with Ref. 1, concrete components of the Yard Crane and Fuel Building were evaluated to the ultimate strength criteria of ACI 318 and ACI-349. Load factors are as indicated above in Table 5.2-1.

7.3 Soil Bearing

Allowable soil bearing pressures are taken from Reference 43, which indicates use of 10 tons per square foot for footings on rock, and 3000 lbs per square foot for footings on soil. Footings are evaluated for unfactored loads. For load combinations including wind, these allowable values can be increased by a factor of 1.33, and for load combinations including seismic loads, these allowable values are increased by a factor of 1.6.

7.4 Crane Seismic Stability

Seismic stability of the cranes is considered acceptable if the crane wheels are indicated not to uplift from the rails or slide on the rails, and the crane rail is adequate for lateral loads imposed due to seismic loads. The crane rail and its anchorage are evaluated to the acceptance criteria for steel components.

8.0 RESULTS SUMMARY

8.1 Base Case Analysis Results (All Members Fully Effective)

Crane Location 1 - Yard Crane along Column Line 106, Most Likely Crane Position

Reference: PD-STRUDL Output File: CYFB1F.OUT

Table 8.1 - Base Case Analysis Results (Crane Location 1)
Members with Highest Interactions: Spent Fuel Pool Upper Level Braces

Brace Member #	Brace Load from Analysis (Kips)	Stress from Analysis (Ksi)	SRP 3.8.4 Allowable Stress (Ksi)	Euler Buckling Stress (Ksi)	Interaction With SRP 3.8.4 Allowable	Interaction with Euler Buckling Load
30910*	137.7	15.33	11.58	13.88	1.32	1.10
30911	47.0	11.24	10.70	12.84	1.05	0.88
30912	48.9	11.71	10.70	12.84	1.09	0.91
30916*	106.0	11.80	10.80	12.93	1.09	0.91
30917*	83.2	8.30	11.37	13.63	0.73	0.61

* Seismic load effects only considered

Other members with the highest interactions for a given member category:

Member: 20290 — Interaction with SRP 3.8.4 Allow. Stress: 0.70
Member Description: Column of the Spent Fuel Structure, W12x65 @ Column Line 106, segment from Elevation 66' to the roof at 74.7'.

Member: 8010 — Interaction with SRP 3.8.4 Allow. Stress: 0.78
Member Description: Column of the Yard Crane Structure, W18x114 @ Column Line 108, @ U-Line

Member: 13030 — Interaction with SRP3.8.4 Allow. Stress: 0.79
Member Description: Kickout Brace of the Yard Crane Structure, W14x68 @ Column Line 113

Member: 1560 — Interaction with SRP 3.8.4 Allow. Stress: 0.69
Member Description: Side Brace of the Yard Crane Structure, (2) C10 x 15 in a Tee Configuration, Between Column Lines 112 and 111

Member: 1547A — Interaction with SRP 3.8.4 Allow. Stress: 0.41
Member Description: Roof Brace of the Yard Crane Structure, WT 9 x 25, Between Column Lines 112 and Halfway Between 112 and 113

Member: 8029 Interaction with SRP 3.8.4 Allow. Stress: 0.75
Member Description: Upper Beam (in moment resisting frame) of the Yard Crane Structure, W36x160 at Column Line 108 at the R Line.

Column with a Vertical Reaction Closest to the Seismic Allowable Loading

Column at Node 910 (Col. 109-U)
Reaction from analysis: 96.33 Kips (Tension), Allowable Reaction: 157.06 Kips, Interaction: 0.61

Crane Location 2 - Yard Crane Parked at South End of Yard Crane Structure, Along Col. Line 100

Reference: PD-STRUDL Output File: CYFB2F.OUT

Table 8.2 - Base Case Analysis Results (Crane Location 2)
Members with Highest Interactions: Spent Fuel Pool Upper Level Braces

Brace Member #	Brace Load from Analysis (Kips)	Stress from Analysis (Ksi)	SRP 3.8.4 Allowable Stress (Ksi)	Euler Buckling Stress (Ksi)	Interaction With SRP 3.8.4 Allowable	Interaction with Euler Buckling Load
30910*	119.3	13.28	11.58	13.88	1.15	0.96
30911	50.6	12.12	10.70	12.84	1.13	0.94
30912	52.3	12.50	10.70	12.84	1.17	0.97
30916*	84.7	9.43	10.80	12.93	0.87	0.73
30917*	90.3	9.0	11.37	13.63	0.79	0.66

* Seismic load effects only considered

Other members with the highest interactions for a given member category:

Member: 20290 Interaction with SRP 3.8.4 Allow. Stress: 0.71
Member Description: Column of the Spent Fuel Structure, W12x65 @ Column Line 106, segment from Elevation 66' to the roof at 74.7'.

Member: 21 Interaction with SRP 3.8.4 Allow. Stress: 0.95
Member Description: Column of the Yard Crane Structure, W14x61 – Center Column at the End Frame along Column Line 100

Member: 30 Interaction with SRP 3.8.4 Allow. Stress: 0.77
Member Description: Side Brace of the Yard Crane Structure, (2) C15x33 in a Tee Configuration @ Column Line 100 End Brace

Member: 1570 — Interaction with SRP 3.8.4 Allow. Stress: 0.69
Member Description: Side Brace of the Yard Crane Structure, (2) C10x15 in a Tee Configuration, Between Column Lines 112 and 111 along the R Line.

Member: 1547A — Interaction with SRP 3.8.4 Allow. Stress: 0.38
Member Description: Roof Brace of the Yard Crane Structure, WT 9 x 25, Between Column Lines 112 and Halfway Between 112 and 113

Member: 8029 — Interaction with SRP 3.8.4 Allow. Stress: 0.64
Member Description: Upper Beam (in moment resisting frame) of the Yard Crane Structure, W36x160 at Column Line 108 at the R Line.

Column with a Vertical Reaction Closest to the Seismic Allowable Loading

Column at Node 910 (Col. 109-U)
Reaction from analysis: 132.07 Kips, (Tension) Allowable Reaction: 157.06 Kips, Interaction: 0.84

Crane Location 3 - Yard Crane at the North End of the Structure - Along Col. Line 100

Reference: PD-STRUDL Output File: CYFB3F.OUT

Table 8.3 - Base Case Analysis Results (Crane Location 3)
Members with Highest Interactions: Spent Fuel Pool Upper Level Braces

Brace Member #	Brace Load from Analysis (Kips)	Stress from Analysis (Ksi)	SRP 3.8.4 Allowable Stress (Ksi)	Euler Buckling Stress (Ksi)	Interaction With SRP 3.8.4 Allowable	Interaction with Euler Buckling Load
30910*	158.59	17.66	11.58	13.88	1.53	1.27
30911	55.24	13.21	10.70	12.84	1.31	1.03
30912	56.94	13.62	10.70	12.84	1.35	1.12
30916*	113.84	12.68	10.80	12.93	1.17	0.98
30917*	99.24	9.89	11.37	13.63	0.87	0.73

* Seismic load effects only considered

Other members with the highest interactions for a given member category:

Member: 20290 — Interaction with SRP 3.8.4 Allow. Stress: 0.71
Member Description: Column of the Spent Fuel Structure, W12x65 @ Column Line 106, segment from Elevation 66' to the roof at 74.7'.

Member: 8010 Interaction with SRP 3.8.4 Allow. Stress: 0.75
Member Description: Column of the Yard Crane Structure, W18x114 - Column Line 108 at the U Line

Member: 13030 Interaction with SRP 3.8.4 Allow. Stress: 0.96
Member Description: Kickout Brace of the Yard Crane Structure, W14x68 @ Column Line 113

Member: 1547A Interaction with SRP 3.8.4 Allow. Stress: 0.30
Member Description: Roof Brace of the Yard Crane Structure, WT 9 x 25, Between Column Lines 112 and Halfway Between 112 and 113

Member: 8028 Interaction with SRP 3.8.4 Allow. Stress: 0.71
Member Description: Upper Beam (in moment resisting frame) of the Yard Crane Structure, W36x160 at Column Line 108 at the U Line.

Column with a Vertical Reaction Closest to the Seismic Allowable Loading

Column at Node 910 (Col. 109-U)
Reaction from analysis: 142.88 Kips (Tension), Allowable Reaction: 157.06 Kips, Interaction: 0.91

8.2 Worst Case Analysis (Five Most Heavily Loaded Braces Removed)

Crane Location 1 - Yard Crane along Col. Line 106, Most Likely Crane Position

Reference: PD-STRUDL Output File: CYFB1FW.OUT

Members with the highest interactions for a given member category:

Member: 30918 Interaction with SRP 3.8.4 Allow. Stress: 0.85
Member Description: Side Brace of the Spent Fuel Structure, (2) C10x18 in a Tee Configuration

Member: 20370 Interaction with SRP 3.8.4 Allow. Stress: 0.86
Member Description: Column of the Spent Fuel Structure, W33x220 at Column Line 108, R-Line Elevation 66' to Roof

Member: 21 Interaction with SRP 3.8.4 Allow. Stress: 0.70
Member Description: Column of the Yard Crane Structure, W14x61 -- Center Column at the End Frame along Column Line 100

Member: 13030 Interaction with SRP 3.8.4 Allow. Stress: 0.55
Member Description: Kickout Brace of the Yard Crane Structure, W14x68 @ Column Line 113

Member: 1574 Interaction with SRP 3.8.4 Allow. Stress: 0.56
Member Description: Side Brace of the Yard Crane Structure, (2) C15 x 33 in a Tee Configuration, Between Column Lines 109 and 110 along the R Line.

Member: 1527A Interaction with SRP 3.8.4 Allow. Stress: 0.32
Member Description: Roof Brace of the Yard Crane Structure, WT 9 x 25, Between Column Lines 108 and 106 at the 108 side

Member: 8029 Interaction with SRP 3.8.4 Allow. Stress: 0.83
Member Description: Upper Beam (in moment resisting frame) of the Yard Crane Structure, W36x160 at Column Line 108 at the R Line.

Column with a Vertical Reaction Closest to the Seismic Allowable Loading

Column at Node 950 (Col. 109-R)
Reaction from analysis: 103.9 Kips, Allowable Reaction: 157.06 Kips, Interaction: 0.66

Crane Location 2 - Yard Crane Parked at South End of Yard Crane Structure, Along Col. Line 100

Reference: PD-STRUDL Output File: CYFB2FW.OUT

Members with the highest interactions for a given member category:

Member: 30918 Interaction with SRP 3.8.4 Allow. Stress: 0.81
Member Description: Side Brace of the Spent Fuel Structure, (2) C10x18 in a Tee Configuration

Member: 20370 Interaction with SRP 3.8.4 Allow. Stress: 0.79
Member Description: Column of the Spent Fuel Structure, W33x220 at Column Line 108, R-Line Elevation 66' to Roof

Member: 21 Interaction with SRP 3.8.4 Allow. Stress: 0.86
Member Description: Column of the Yard Crane Structure, W14x61 -- Center Column at the End Frame along Column Line 100

Member: 30 Interaction with SRP 3.8.4 Allow. Stress: 0.68
Member Description: Side Brace of the Yard Crane Structure, (2) C15x33 in a Tee Configuration @ Column Line 100 End Brace

Member: 13030 — Interaction with SRP 3.8.4 Allow. Stress: 0.68
Member Description: Kickout Brace of the Yard Crane Structure, W14x68 @ Column Line 113

Member: 1564 — Interaction with SRP 3.8.4 Allow. Stress: 0.56
Member Description: Side Brace of the Yard Crane Structure, (2) C15 x 33 in a Tee Configuration

Member: 1547A — Interaction with SRP 3.8.4 Allow. Stress: 0.35
Member Description: Roof Brace of the Yard Crane Structure, WT 9 x 25

Member: 8029 — Interaction with SRP 3.8.4 Allow. Stress: 0.66
Member Description: Upper Beam (in moment resisting frame) of the Yard Crane Structure, W36x160 at Column Line 108 at the R Line.

Column with a Vertical Reaction Closest to the Seismic Allowable Loading

Column at Node 910 (Col. 109-U)
Reaction from analysis: 114.8 Kips, Allowable Reaction: 157.06 Kips, Interaction: 0.73

Crane Location 3 - Yard Crane at the North End of the Structure - One End Aligned with Col. 113

Reference: PD-STRUDL Output File: CYFB3FW.OUT

Members with the highest interactions for a given member category:

Member: 30918 — Interaction with SRP 3.8.4 Allow. Stress: 1.12
Member Description: Side Brace of the Spent Fuel Structure, (2) C10x18 in a Tee Configuration

Member: 20230 — Interaction with SRP 3.8.4 Allow. Stress: 0.82
Member Description: Column of the Spent Fuel Structure, W12x85 Between Elevation 35' and 47' at Column Line 105 and the T Line

Member: 6020 — Interaction with SRP 3.8.4 Allow. Stress: 0.65
Member Description: Column of the Yard Crane Structure, W18x114 -At Column Line 106 and the R Line Upper Portion

Member: 13030 — Interaction with SRP 3.8.4 Allow. Stress: 1.10
Member Description: Kickout Brace of the Yard Crane Structure, W14x68 @ Column Line 113

Member: 1525C — Interaction with SRP 3.8.4 Allow. Stress: 0.27
Member Description: Roof Brace of the Yard Crane Structure, WT 9 x 25 Between the 106 and 108 Lines

Member: 8029 — Interaction with SRP 3.8.4 Allow. Stress: 0.69
Member Description: Upper Beam (in moment resisting frame) of the Yard Crane Structure, W36x160 at Column Line 108 at the R Line.

Column with a Vertical Reaction Closest to the Seismic Allowable Loading

Column at Node 950 (Col. 109-R)
Reaction from analysis: 160.6 Kips, Allowable Reaction: 157.06 Kips, Interaction: 1.02

8.3 Iterative Case Analysis (Areas modified for 5 Fuel Building Brace Members)

Crane Location 1 - Yard Crane along Col. Line 106, Most Likely Crane Position

Reference: PD-STRUDL Output File: CYFB1FR.OUT

Table 8.4 - Iterative Case Analysis Results (Crane Location 1)
Members with Highest Interactions: Spent Fuel Pool Upper Level Braces

Brace Member #	Brace Load from Analysis (Kips)	Stress from Analysis (Ksi)	SRP 3.8.4 Allowable Stress (Ksi)	Euler Buckling Stress (Ksi)	Interaction With SRP 3.8.4 Allowable	Interaction with Euler Buckling Load
30910*	92.5	10.3	11.58	13.88	0.89	0.74
30911	38.3	9.16	10.70	12.84	0.86	0.71
30912	40.7	9.74	10.70	12.84	0.91	0.76
30916*	70.2	7.82	10.80	12.93	0.72	0.61
30917*	93.77	9.35	11.36	13.63	0.82	0.69

* Seismic load effects only considered

Other members with the highest interactions for a given member category:

Member: 20290 — Interaction with SRP 3.8.4 Allow. Stress: 0.69
Member Description: Column of the Spent Fuel Structure, W12x65 @ Column Line 106, segment from Elevation 66' to the roof at 74.7'.

Member: 8010 — Interaction with SRP 3.8.4 Allow. Stress: 0.74
Member Description: Column of the Yard Crane Structure, W18x114 @ Column Line 108, @ U-Line

Member: 1560 — Interaction with SRP 3.8.4 Allow. Stress: 0.69
Member Description: Side Brace of the Yard Crane Structure, (2) C10 x 15 in a Tee Configuration, Between Column Lines 112 and 111

Member: 1547A — Interaction with SRP 3.8.4 Allow. Stress: 0.35
Member Description: Roof Brace of the Yard Crane Structure, WT 9 x 25, Between Column Lines 112 and Halfway Between 112 and 113

Member: 8029 — Interaction with SRP 3.8.4 Allow. Stress: 0.70
Member Description: Upper Beam (in moment resisting frame) of the Yard Crane Structure, W36x160 at Column Line 108 at the R Line.

Column with a Vertical Reaction Closest to the Seismic Allowable Loading

Column at Node 910 (Col. 109-U)
Reaction from analysis: 102.2 Kips, (Tension) Allowable Reaction: 157.06 Kips, Interaction: 0.65

Crane Location 2 - Yard Crane Parked at South End of Yard Crane Structure, Along Col. Line 100

Reference: PD-STRUDL Output File: CYFB2FR.OUT

Table 8.5 - Iterative Case Analysis Results (Crane Location 2)
Members with Highest Interactions: Spent Fuel Pool Upper Level Braces

Brace Member #	Brace Load from Analysis (Kips)	Stress from Analysis (Ksi)	SRP 3.8.4 Allowable Stress (Ksi)	Euler Buckling Stress (Ksi)	Interaction With SRP 3.8.4 Allowable	Interaction with Euler Buckling Load
30910*	100.0	11.14	11.58	13.88	0.96	0.80
30911	42.1	10.07	10.70	12.84	0.94	0.78
30912	45.2	10.81	10.70	12.84	1.01	0.84
30916*	76.6	8.53	10.80	12.93	0.79	0.66
30917*	120.3	11.99	11.37	13.63	1.05	0.88

* Seismic load effects only considered

Other members with the highest interactions for a given member category:

Member: 20290 — Interaction with SRP 3.8.4 Allow. Stress: 0.70
Member Description: Column of the Spent Fuel Structure, W12x65 @ Column Line 106, segment from Elevation 66' to the roof at 74.7'.

Member: 21 — Interaction with SRP 3.8.4 Allow. Stress: 0.96
Member Description: Column of the Yard Crane Structure, W14x61 -- Center Column at the End Frame along Column Line 100

Member: 13030 — Interaction with SRP 3.8.4 Allow. Stress: 0.92
Member Description: Kickout Brace of the Yard Crane Structure, W14x68 @ Column Line 113

Member: 1570 — Interaction with SRP 3.8.4 Allow. Stress: 0.72
Member Description: Side Brace of the Yard Crane Structure, (2) C10 x 15 in a Tee Configuration, Between Column Lines 112 and 111 along the R Line.

Member: 1547A/C Interaction with SRP 3.8.4 Allow. Stress: 0.47

Member Description: Roof Brace of the Yard Crane Structure, WT 9 x 25, Between Column Lines 112 and Halfway Between 112 and 113

Member: 8029 — Interaction with SRP 3.8.4 Allow. Stress: 0.77
Member Description: Upper Beam (in moment resisting frame) of the Yard Crane Structure, W36x160 at Column Line 108 at the R Line.

Column with a Vertical Reaction Closest to the Seismic Allowable Loading

Column at Node 910 (Col. 109-U)
Reaction from analysis: 150.56 Kips, (Tension) Allowable Reaction: 157.06 Kips, Interaction: 0.96

Crane Location 3 - Yard Crane at the North End of the Structure - One End Aligned with Col. 113

Reference: PD-STRUDL Output File: CYFB3FR.OUT

Table 8.6 - Iterative Case Analysis Results (Crane Location 3)
Members with Highest Interactions: Spent Fuel Pool Upper Level Braces

Brace Member #	Brace Load from Analysis (Kips)	Stress from Analysis (Ksi)	SRP 3.8.4 Allowable Stress (Ksi)	Euler Buckling Stress (Ksi)	Interaction With SRP 3.8.4 Allowable	Interaction with Euler Buckling Load
30910*	98.86	11.01	11.58	13.88	0.95	0.79
30911	43.8	10.48	10.70	12.84	0.98	0.82
30912	44.7	10.69	10.70	12.84	1.00	0.83
30916*	68.7	7.65	10.80	12.93	0.71	0.59
30917*	116.3	11.6	11.37	13.63	1.02	0.85

* Seismic load effects only considered

Other members with the highest interactions for a given member category:

Member: 20290 — Interaction with SRP 3.8.4 Allow. Stress: 0.71
Member Description: Column of the Spent Fuel Structure, W12x65 @ Column Line 106, segment from Elevation 66' to the roof at 74.7'.

Member: 8010 — Interaction with SRP 3.8.4 Allow. Stress: 0.54
Member Description: Column of the Yard Crane Structure, W18x114 - Column Line 108 at the U Line

Member: 13030 — Interaction with SRP 3.8.4 Allow. Stress: 0.96
Member Description: Kickout Brace of the Yard Crane Structure, W14x68 @ Column Line 113

Member: 1564 Interaction with SRP 3.8.4 Allow. Stress: 0.65
Member Description: Side Brace of the Yard Crane Structure, (2) C15 x 33 in a Tee Configuration

Member: 1547A Interaction with SRP 3.8.4 Allow. Stress: 0.25
Member Description: Roof Brace of the Yard Crane Structure, WT 9 x 25, Between Column Lines 112 and Halfway Between 112 and 113

Member: 8029 Interaction with SRP 3.8.4 Allow. Stress: 0.63
Member Description: Upper Beam (in moment resisting frame) of the Yard Crane Structure, W36x160 at Column Line 108 at the R Line.

Column with a Vertical Reaction Closest to the Seismic Allowable Loading

Column at Node 910 (Col. 109-U)
Reaction from analysis: 145.19 Kips, (Tension) Allowable Reaction: 157.06 Kips, Interaction: 0.91

8.4 Analysis Summary

The results of this evaluation described above indicate that the Fuel Building and Yard Crane Structures meet SRP 3.8.4 criteria and the licensing basis for the structures with the Yard Crane fully loaded at all locations. A Base Case analysis was performed with all members modeled as fully effective for three crane locations selected to adequately evaluate the structure for this loading at any location across the entire lifting location range of the Yard Crane structure. The analysis results indicated that all but four bracing members met the SRP 3.8.4 criteria.

A Worst Case response spectra analysis was performed for the three crane locations with the five most heavily loaded braces removed (the 4 overstressed braces and a fifth). The results from this load case confirmed that the structure had tremendous lateral load capacity with the primary resistance coming from the large columns and the welded frame action of the structure in the East - West direction. The braces are a secondary load path and are overstressed primarily due to differential displacement between the two supporting columns. All of the other members of the structure met the SRP 3.8.4 criteria with the five members removed except for two other braces that had interaction coefficients of 1.10 and 1.12 respectively. This was for the extremely unlikely case of the crane being fully loaded at the far North end of the structure when the earthquake occurs.

Iterative evaluations of the structures were performed by modifying the stiffness of the five braces that potentially could be loaded above the SRP 3.8.4 allowable stress. The areas were modified to adjust the brace stiffness with successive analyses until the results converged on a solution where the load carried by the five members were all at or below their allowable load for their full section. This allowed these members to withstand a portion of the load up to their allowable while redistributing the additional load they would withstand if the total stiffness were modeled as in the Base Case. The final converged solution (Iterative Case) is believed to be a reasonable engineering solution for the problem. The final Iterative Case converges on an iterative stiffness of the braces that is between the Base Case and Worst Case and allows additional load to be redistributed to other portions of the structure. The results of this analysis is that all members meet the SRP 3.8.4 criteria. The results of all three cases (Base, Worst, and Iterative) indicate that the loads on the primary lateral load resisting members (the columns and upper beams in the Yard Crane) are essentially the same regardless of the case evaluated.