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Committed to Nuclear Excellence

DAEC Plant Support Center
Operated by Nuclear Management Company, LLC

December 21, 2001
NG-01-1428

Office of Nuclear Reactor Regulation
U. S. Nuclear Regulatory Commission
Attn: Document Control Desk
Mail Station 0-P1-17
Washington, DC 20555-0001

Subject: Duane Arnold Energy Center
Docket No: 50-331
Op. License No: DPR-49
Single-Failure-Proof Status of Reactor Building Crane

References:
1. NG-96-1035, dated May 10, 1996, from J. Franz to NRC; IES Response to NRC Bulletin 96-02: Movement of Heavy Loads Over Spent Fuel, Over Fuel in the Reactor Core, or Over Safety-Related Equipment
2. Letter dated August 3, 2001, from B. Mozafari (NRC) to G. Van Middlesworth (NMC); Duane Arnold Energy Center - Single-Failure-Proof Status of Reactor Building Crane
3. NG-01-1029, dated August 31, 2001, from G. Van Middlesworth to NRC; Single-Failure-Proof Status of Reactor Building Crane

File: A-101a, T-31, SPF-164

In April of 1996, the NRC issued Bulletin 96-02, "Movement of Heavy Loads Over Spent Fuel, Over Fuel in the Reactor Core, or Over Safety-Related Equipment." The Bulletin requested that licensees review plans and capabilities for handling heavy loads while the reactor is at power in accordance with existing regulatory guidelines and licensing basis. The Duane Arnold Energy Center's (DAEC's) response to Bulletin 96-02 was provided by letter dated May 10, 1996 (Reference 1).

As discussed in that letter, the DAEC's review identified an issue involving the single-failure-proof status of the reactor building crane. As described in more detail in Attachment 1, when the reactor building crane was upgraded in 1985, the NRC did not review the seismic analysis which was performed to verify that the crane would be capable of safely supporting its rated load during a seismic event.

By letter dated August 3, 2001 (Reference 2), the Staff requested that Nuclear Management Company, LLC (NMC) revise the DAEC Updated Final Safety Analysis Report (UFSAR) to clarify that the NRC had not endorsed the crane as single-failure-proof. The DAEC UFSAR was revised accordingly (Reference 3).

A001

3313 DAEC Road • Palo, Iowa 52324-9646
Telephone: 319.851.7611

Rec'd 01/23/02

It is desirable to resolve the single-failure-proof status of the DAEC reactor building crane well in advance of the implementation of dry spent fuel storage, currently anticipated in the Summer of 2003. In support of anticipated heavy load handling, additional seismic calculations have been performed regarding the reactor building crane. A summary of the assumptions and conclusions of these calculations is provided in Attachment 1. Attachment 2 contains portions of the seismic analysis for the Staff's review, as well as the "Static Load Test Procedure for New Reactor Building Crane," dated December 4, 1984.

NMC requests the Staff's review and approval of the seismic analysis prior to December 31, 2002, so that this issue may be resolved prior to implementation of dry spent fuel storage. Upon approval of the seismic analysis by the NRC, NMC will revise the DAEC UFSAR to reflect the Staff's review.

Should you have any questions regarding this matter, please contact this office.

Sincerely,

Gary Van Middlesworth

Gary Van Middlesworth
DAEC Site Vice President

Attachments: 1. Summary of Analysis
2. Portions of Calculations and Static Load Test Procedure

cc: T. Vine
C. Rushworth
R. Anderson (NMC)
B. Mozafari (NRC-NRR)
J. Dyer (Region III)
NRC Resident Office
DOCU

Summary of Analysis

In 1985, the DAEC reactor building crane was modified under 10 CFR 50.59. A new Ederer single-failure-proof crane trolley and main hoist system meeting the guidelines of Regulatory Guide 1.104, "Overhead Crane Handling Systems for Nuclear Power Plants," and NUREG-0554, "Single Failure Proof Cranes for Nuclear Power Plants," was installed. The design of the Ederer hoist and trolley system was evaluated in a Staff Safety Evaluation Report (SER) of the Generic Licensing Topical Report EDR-1, Rev. 3, for Ederer's Nuclear Safety-Related Extra Safety and Monitoring (X-SAM) Cranes, dated August 3, 1983.

The trolley system was installed on the existing bridge; the bridge itself was not replaced. A seismic analysis was performed to verify that the reactor building overhead crane would be capable of safely supporting its rated load during a seismic event after installation of the new, heavier, single-failure-proof trolley. This calculation concluded that the combined vertical and horizontal stresses developed in an operational basis earthquake (OBE) and a design basis earthquake (DBE) are within the allowable stress limits defined in Crane Manufacturers Association of America (CMAA) 70 - 1975 (Specification for Electric Overhead Traveling Cranes). This analysis was not reviewed by the NRC.

Calculation for Reactor Building Crane Girders

The purpose of the calculation is to check the design of the reactor building crane girders for the increased loadings imposed by the trolley upgrade. The calculation utilizes standard engineering practice and follows analysis methods described in previous DAEC calculations. Conservative inputs and assumptions are used throughout this calculation. Specific assumptions include:

- CMAA #70 1975 edition was used.
- UFSAR earthquake accelerations are used for the reactor building and runway.
- Vertical accelerations of 0.09g OBE and 0.18g DBE are used. The vertical seismic load combinations include the weight of the crane and the lifted load (100 tons).
- The horizontal accelerations used were 0.60g OBE and 1.20g DBE at the crane level. The lifted load and lower load block are assumed to be decoupled from the bridge and trolley with respect to horizontal earthquake accelerations.

The new analysis concluded that the existing crane girders are adequate. The girder combined stresses were shown to be less than allowable stresses. Deflections are less than allowable. Wheel loads are higher than recommended, possibly increasing wheel wear by a small amount; however, this is judged to be acceptable given the number of maximum rated lifts over the remaining plant life. Diaphragm spacing is greater than recommended (because of the increased trolley wheel loads), but is acceptable by similar reasoning to the wheel loads above. End truck stresses are less than allowable. The girder to end truck connections are acceptable.

Calculation for Reactor Building Structure

The purpose of this calculation is to check the design of the reactor building structure for the new loadings imposed by the 100 ton capacity single-failure-proof reactor building crane. The calculation also evaluates the design condition of maximum lifted loads during a seismic event. The calculation utilizes standard engineering practice and follows analysis methods described in previous DAEC calculations. Conservative inputs and assumptions are used throughout this calculation. Specific assumptions include:

- Vertical accelerations of 0.04g OBE and 0.08g DBE are used. The vertical seismic load combinations include the weight of the crane and the lifted load (100 tons).
- The horizontal accelerations used were 0.35g OBE and .70g DBE at the crane level and .52g OBE and 1.04g DBE at the roof level. The lifted load and lower load block are assumed to be decoupled from the bridge and trolley with respect to horizontal earthquake accelerations.

The analysis concluded that the existing crane runway girders and rigid frame are adequate. The reactor building crane support structure is adequately designed for the increased weight of the replacement trolley and for all appropriate load combinations, including maximum lifted load plus seismic.

Attachment 2
to NG-01-1428

Portions of Calculations
and Static Load Test Procedure

DOCUMENT NUMBER: CAL-M01-273

Title : REACTOR BUILDING CRANE GIRDER CHECK

Contents :

REV	DATE	REVISION	DFT.	CHK.	ENG.	APR.
1	11-29-2001	ISSUED FOR DDC-4260	PAW	AJ	TVV	[illegible]

STONE & WEBSTER ENGINEERING CORPORATION

CALCULATION TITLE PAGE

CLIENT & PROJECT: DAEC – DUANE ARNOLD ENERGY CENTER – UNIT NO. 1				PAGE 1 OF 21
CALCULATION TITLE (Indicative of Objective): **REACTOR BUILDING CRANE GIRDER CHECK**				QA CATEGORY ☐ ☒ - I Nuclear Safety Related ☐ - II ☐ - III ☐ - Non-Safety Related ☐ - Fossil/Industrial Plant
CALCULATION IDENTIFICATION NUMBER				
J.O. or W.O. NO.	DIVISION & GROUP	CURRENT CALC NO.	OPTIONAL TASK CODE	OPTIONAL WORK PACKAGE NO.
12133	CIVIL/STRUCT	12133-SS-3	N/A	N/A

APPROVALS - SIGNATURE & DATE

PREPARER(S)/DATE(S)	REVIEWER(S)/DATE(S)	INDEPENDENT REVIEWER(S)/ DATES(S)	REV. NO. OR NEW CALC. NO.	SUPERCEDES CALC. NO. OR REV. NO.	CONFIRMATION REQUIRED ☐ YES	NO
D.M. HERMANN 10/8/2001 [signature]	R. MA 10/8/2001 [signature]	J.E. Greer 10/8/2001 [signature]	0	—	☐	☒
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CALCULATION SHEET

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J.O. OR W.O. NO. 12133	DIVISION & GROUP CIVIL/STRUCT	CALCULATION NO. 12133-SS-3	OPTIONAL TASK CODE N/A	

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Attachments

Record of Changes

Rev. No.	Description Of Changes	Pages Revised	Pages Added	Pages Replaced

1. OBJECTIVE OF CALCULATION

The purpose of this calculation is to check the design of the Reactor Building crane girders for the increased loadings imposed by the trolley upgrade installed in 1984. The upgrade replaced the original P&H Harnischfeger trolley with an Ederer XSAM single-failure-proof trolley, which weighs 20,800 pounds more than the original trolley. The original P&H trolley weighed 65,100 pounds (Ref. #3, pg. 11). S&W Report No. 12133.1004-S(C)-1, Rev. 1 (Ref. #1) reported a trolley weight of 82,000 pounds (an increase of 17,000 pounds), as indicated in several DAEC calculations. However Attachment #1 and Ederer Drawing A13151 indicate an as-built trolley weight of 85,898 pounds as used in this calculation, for an increase of 20,800 pounds from the P&H trolley.

The calculation is a follow-up effort to the S&W Report No. 12133.1004-S(C)-1, Rev. 1 (Ref. #1). The calculation provides a new and more detailed study of the structural adequacy of the Reactor Building crane girders for the increased weight (21 kips) of the trolley. The calculation also evaluates the design condition of maximum lifted loads during a seismic event.

The following specific points will be addressed by this calculation:

- Design check of crane girders (including rail) using increased trolley load of 20,800 lbs.
- Design check using revised trolley wheelbase geometry
- Design check for unequal wheel loads
- Design check for locations of wheel loads at worst-case positions along the girder
- Design check of welds at girder web to flanges
- Design check of diaphragms and stiffeners
- Provide reference to seismic documentation (UFSAR and specifications) in calculation

2. CALCULATION METHODS/ASSUMPTIONS

The calculation utilizes standard engineering practice and follows analysis methods described in previous DAEC calculations. Conservative inputs and assumptions are used throughout this calculation. Specific assumptions, are identified below:

- CMAA #70 1975 edition (Ref. #12) is to be used
- Vertical earthquake accelerations include the lifted load and the hook
- Horizontal earthquake accelerations exclude the lifted load and the hook
- The earthquake accelerations to be used are from References #14 & #15 and are specific to the crane girder. The UFSAR (Ref. #2) accelerations are used for the reactor building and runway only

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3. SOURCES OF DATA/EQUATIONS

Vertical impact is 15% of the rated load. Lateral loads are 2½% of live & dead loads. Deflection allowance is 0.00125 inches per inch of span.

The list of references used in this calculation is shown below in Section 5. This calculation uses vertical accelerations of 0.09g OBE and 0.18g DBE (Ref. #14 & #15). The vertical seismic load combinations include the weight of the crane and lifted load. The horizontal accelerations used were 0.60g OBE and 1.20g DBE at the crane level. Horizontal seismic loads include only the dead loads of the trolley and girders (i.e., not the lifted load or hook). The lifted load and hook in horizontal seismic load combinations are typically not included since they are free to sway.

4. CONCLUSIONS

The analysis of the existing crane girders were shown to be adequate as designed. The girder combined stresses were shown to be less than allowable stresses (see page 13). Deflections are less than allowable (see page 19). Wheel loads are greater than recommended, possibly increasing wheel wear by a minor amount. This is judged to be acceptable given the number of maximum rated lifts over the remaining plant life (see page 19). Diaphragm spacing is greater than recommended and diaphragm thickness is less than allowable (both because of the increased trolley wheel loads), but both are acceptable (see page 16) by similar reasoning to the wheel loads above. End truck stresses are less than allowable (see pages 20 & 21). The girder to end truck connections are acceptable.

5. REFERENCES

1. *Phase I Structural Evaluation Report for DEAC Reactor Building Crane Bridge Girders*, Duane Arnold Energy Center, 12133.1004-S(C)-1, Rev. 0, dated 06/04/01
2. DAEC *UFSAR*, Sections 2.5 Rev. 14, 3.7 Rev 14 and 3.8, Rev. 12
3. Bechtel DAEC *Calculation 3-F-6*, Rev. 0, dated 05/08/70, Crane Frame (Space Frame) Reactor Building
4. P&H DAEC *Calculation M-023-051*, Rev. 3, dated 11/14/84, Reactor Building Crane
5. Iowa Electric Light and Power Company DAEC *Calculation C-85-19*, Rev. 0, dated 07/18/85, Static Seismic Analysis of Rx Bldg. Overhead Crane
6. Iowa Electric Light and Power Company DAEC *Calculation C-87-14*, Rev. 0, dated 12/04/87, Girder Loading for Rx Bldg. Crane
7. Bechtel DAEC *Drawing C-437*, Rev. 4, R.B. Craneway Plan & Details
8. P&H *Drawing 28A11849*, sheets 1 & 2, dated 02/23/71
9. P&H *Drawing 105A3310*, Rev C (M-23-97 Sheets 1&2)
10. P&H *Drawing 31A5826-5*, Rev A (M23-98-1)
11. American Institute of Steel Construction *Manual of Steel Construction*, Allowable Stress Design, 9th edition
12. Crane Manufacturers Association of America CMAA *Specification #70*, 1975
13. John A. Blume & Associates Report *DAEC Reactor Building Earthquake Analysis APED-A61-047*, Rev. 1

14. DAEC *Specification 7884-M-23A*, Rev. #2 (BECH-MRS-M23A), Technical Specification for the Modification to the Reactor Building Crane
15. DAEC *Specification 7884-M-23.1*, Specific Conditions for Rector Building Crane Modifications (Engineering Only)
16. Omar Blodgett *Design of Welded Structures*, 1966
17. William Weaver, *Whiting Crane Handbook*, 1979
18. P&H *Drawing 29E5472*, Rev A

6. DESIGN BASIS AND ASSUMPTIONS

1. Design method in general is based upon existing calculations (Ref. #4, #5 and #6) with allowable stresses from CMAA #70 (Ref. #12).
2. OBE and DBE design earthquake accelerations based on References #14 and #15, and are specific to the crane girders.
3. Impact is taken as 15% of rated capacity.
4. Lateral load is 2.5% of live load and crane bridge.
5. Trolley load distribution is based upon email dated 07/28/01 from Jim Nelson of Ederer to Stephen Parkhurst, Crane & Equipment Handling Specialist (Attachment #1 to this calculation).
6. E-60xx electrodes used for welding.

7. Analysis

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Dain 9/11/2001	[illegible] 9/27/01	[illegible] 10-02-01

SUBJECT/TITLE	QA CATEGORY/CODE CLASS
DAEC CRANE GIRDER CHECK	I

DETERMINE SECTION PROPERTIES (MIDSPAN)

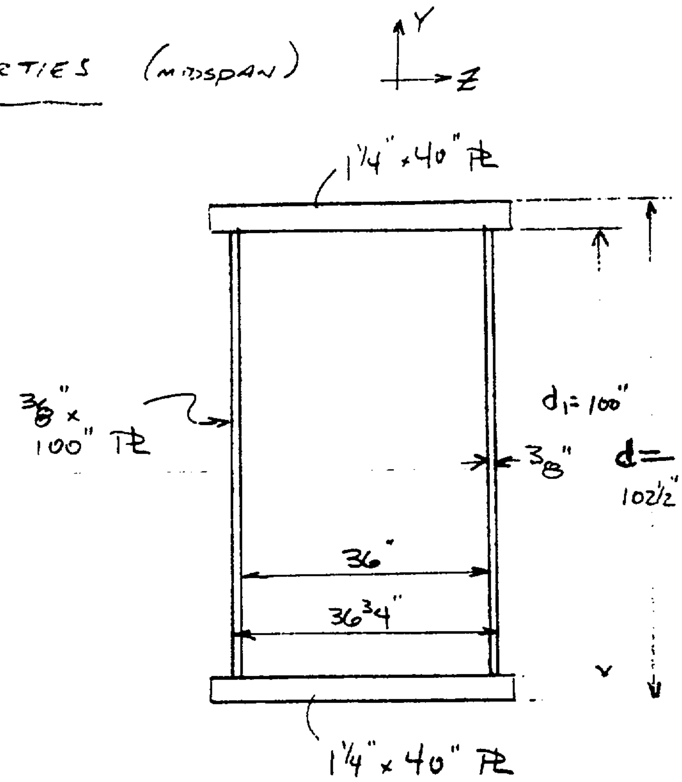
[FLANGES] [WEB]

$$I_Z = \frac{b(d^3 - d_1^3)}{12} + 2\left(\frac{bd^3}{12}\right)$$

$$= \frac{40(102.5^3 - 100^3)}{12} + \frac{3/8(100)^3}{6}$$

$$I_Z = 318,802 \text{ in}^4$$

$$S_Z = 318,802 \times \frac{2}{102.5''} = 6221 \text{ in}^3$$



SECTION @ END

(REF # 8)

$$I_y = \frac{100(36.75^3 - 36^3)}{12} + \frac{1.25(40)^3}{6}$$

$$I_y = 38,143 \text{ in}^4$$

$$S_y = 38,143 \times \frac{2}{40''} = 1907 \text{ in}^3$$

DETERMINE MOMENTS

GIRDER DL

GIRDER = 78.8^k
PLATFORM = 10.3
MACHINERY = 4.5
MISC = 2.0

$95.6^k \Rightarrow$ UNIFORM LOAD $= \frac{95.6^k}{97'} = .986\ ^k/ft$

ADD'L ℄ LOAD = 0.2^k (1.5 ton HOIST @ ℄) (SEE ATTACH. #2)

TROLLEY & LIFTED LOAD (ATT #1)

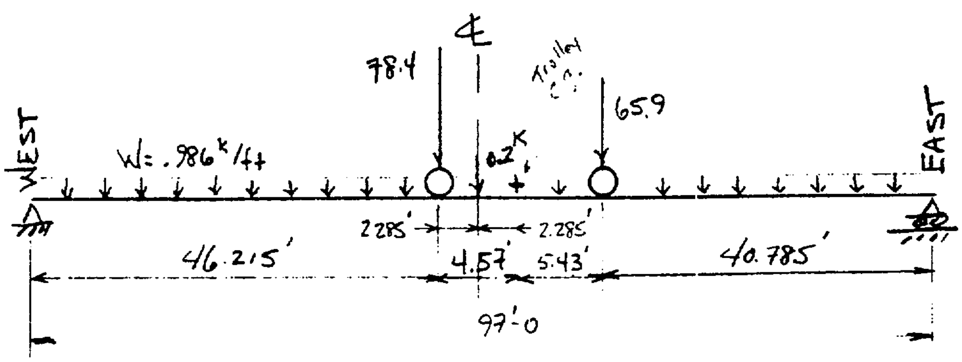
WORST CASE GIRDER IS G1 (NORTH) (REF #5 & #6)

WHEEL LOADS ARE 78.4^k NORTHWEST, 65.9 NORTHEAST } WHEELS INCLUDE LL & HOOK (8^k)

wheelbase = 10'

c.g. @ $\frac{78.4^k \times 10'}{78.4^k + 65.9^k} = 5.43^{ft}$ from east wheel

WORST CASE BENDING DUE TO TROLLEY/LL IS WHEN C.G & LARGEST WHEEL LOAD ARE PLACED SYMMETRIC ABOUT ℄ GIRDER



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[illegible] CHECK	1

MAX. MOMENT DUE TO LL & DL OCCURS @ 46.22' (BELOW WHEEL)

$M_{DL} = \frac{Px}{2} + \frac{wx}{2}(l-x)$ where $x = 46.22'$

$= \frac{0.2 \times 46.22}{2} + \frac{.986\,(97-46.22)\,46.22}{2}$

$M_{DL} = 1162^{k \cdot ft}$

$M_{LL} = \left[\frac{P_1 (l-a)}{l} + \frac{P_2 b}{l}\right] a$

$a = 46.215'$
$b = 40.785'$
$l = 97'$
$P_1 = 78.4^k$ } TROLLEY DL + LL WHEEL LOADS
$P_2 = 65.9^k$

$M_{LL} = 3178^{k \cdot ft}$ (TROLLEY + LL)

$M_{TROLLEY\ ONLY} = 908.9^{k \cdot ft}$

$P_{D_1} = 78.4^k - 50^k - 2^k = 26.4^k$ (50 = LL, 2 = HOOK) } TROLLEY DL ONLY WHEEL LOADS
$P_{D_2} = 65.9 - 52 = 13.9^k$

$M_{LIFT\ ONLY} = 3178 - 908.9 = 2269^{k \cdot ft}$

M_{IMPACT} = 15% OF RATED CAPACITY

$= .15 \times 2269 = 340.4^{k \cdot ft}$

$M_{LATERAL}$ = 2½% (LL + DL) = .025 (3178 + 1162) = 108.5

OBE ACCEL. (REF #14) HORIZ = 0.60g
VERT = 0.09g

DBE ACCEL HORIZ = 1.2g
VERT = 0.18g

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DAEC [illegible]	[illegible]

$(M_{OBE})_{VERT}$ [INCLUDES VERT. LOAD] = 0.09(1162 + 3178) $\underline{390.6^{k \cdot ft}}$

$(M_{OBE})_{HORIZ}$ [NEGLECTS LIFT] = 0.60(1162 + 908.9) = $\underline{1243^{k \cdot ft}}$

$(M_{DBE})_{VERT}$ = 0.18(1162 + 3178) = $\underline{781.2^{k \cdot ft}}$

$(M_{DBE})_{HORIZ}$ = 1.2 (1162 + 908.9) $\underline{2485^{k \cdot ft}}$

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[illegible]	1

DETERMINE STRESSES

$$\sigma_{DL} = \frac{1162 \times 12}{6221} = 2.24 \text{ ksi}$$

$$\sigma_{LL} = \frac{3178 \times 12}{6221} = 6.13 \text{ ksi}$$

$$\sigma_{TROLLEY} = \frac{908.9 \times 12}{6221} = 1.75 \text{ ksi}$$

$$\sigma_{LOAD\ ONLY} = \frac{2269 \times 12}{6221} = 4.38 \text{ ksi}$$

$$\sigma_{IMPACT} = \frac{340.4 \times 12}{6221} = 0.66 \text{ ksi}$$

$$\sigma_{LATERAL} = \frac{108.5 \times 12}{1907} = 0.68 \text{ ksi}$$

$$\sigma_{OBE-V} = \frac{390.6 \times 12}{6221} \quad 0.75 \text{ ksi}$$

$$\sigma_{OBE-H} = \frac{1243 \times 12}{1907} = 7.82 \text{ ksi}$$

$$\sigma_{DBE-V} = \frac{781.2 \times 12}{6221} = 1.51 \text{ ksi}$$

$$\sigma_{DBE-H} = \frac{2485 \times 12}{1907} = 15.64 \text{ ksi}$$

DETERMINE COMBINATIONS

(REF #14 & 15) DL + LL + OBE ≤ WORKING STRESSES LOADCASE #3

DL + LL + DBE ≤ 150% WORKING STRESSES L.C. #4

(REF # 12 & 4) DL + LL + IMPACT ≤ WORKING STRESSES L.C. #1

DL + LL + LATERAL ≤ WORKING STRESSES L.C. #2

ALLOWABLE STRESSES

WORKING STRESS (REF # 12) : 17.6 ksi TENSION

Sect. 3.3.3.1.3 check $b/c \le 38$ b = DIST. BTW WEB PL = 36"

$b/c = 28.8 < 38$ ok C = THICKNESS FLANGE = 1.25"

$\therefore f_c = 17.6$ ksi

SHEAR = 13.2 ksi

BEARING = 26.4 ksi

L.C. #1 2.24 + 6.13 + 0.66 = 9.03 ksi < 17.6 ksi ok

L.C. #2 2.24 + 6.13 + 0.68 = 9.05 ksi < 17.6 ok

L.C. #3 2.24 + 6.13 + 0.75 + 7.82 = 16.94 ksi < 17.6 ok

LC #4 2.24 + 6.13 + 1.51 + 15.64 = 25.52 ksi < 17.6 × 1.5 = 26.4 ok

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DHEC [illegible]	1

DIAPHRAGM & VERTICAL STIFFENERS — REF: #12 Sect. 3.3.3.1.4 & #17 Pg 89

SPACING BTW DIA. $\leq \frac{108{,}000\ S}{W}$

S = SECTION MODULUS of RAIL (in^3)

W = wheel LOAD, (LBS.) [No IMPACT]

135 LB RAIL, S = 17.3 in^3

W = 78,400 LB

Spacing ≤ 23.8" ACTUAL spacing APPROX. 24"

OK, SINCE APPROX EQUAL BY ENGINEERING JUDGEMENT

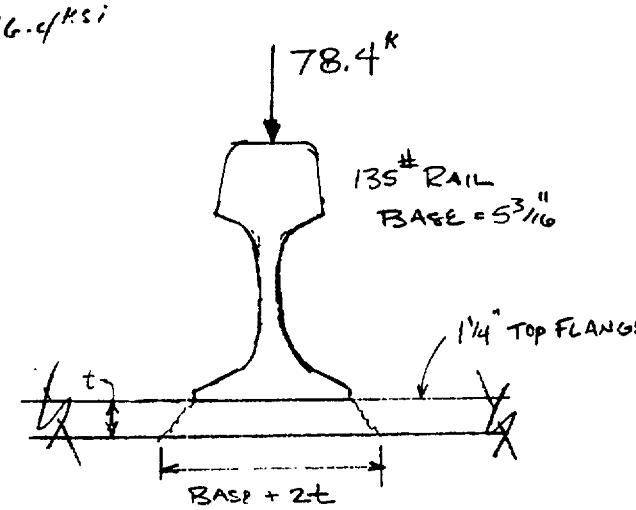
NOTE: DIA. SPACING IS 24" MAX, MOST IS LESS.

THICKNESS of DIA. · SUFFICIENT TO RESIST WHEEL IN BEARING @ 26.4 ksi

$$26.4^{ksi} = \frac{78.4^{K}}{t \times (5\tfrac{3}{16}" + 2 \times 1\tfrac{1}{4}")}$$

$$t \geq \frac{78.4}{26.4 \times 7\tfrac{11}{16}} = 0.386"$$

ACTUAL t = 3/8"



THICKNESS UNDER = $\frac{.386 - .375}{.375}$ = 2.9%

SAY OK, SEE BELOW.

ACTUAL BRG STRESS $= \frac{78.4}{.375\,(5\tfrac{3}{16} + 2 \times 1.25")}$ = 27.19 ksi 3% OVER

SAY OK SINCE [illegible] MAX. WHEEL LOADS & BEARING STRESS IS $\frac{27.2}{36}$ = [illegible]% of YIELD, JUDGED TO BE OK

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CALCULATION SHEET

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SUBJECT/TITLE	QA CATEGORY/CODE CLASS
TAEC Crane [illegible]	I

$\Delta_{LL\#2}$ Take @ center span $a = b = x = \ell/2 = 582''$

$$= \frac{Pbx}{6EI\ell}(\ell^2 - b^2 - x^2) = 0.234''$$

$$\Delta_{TOT} = 0.235'' + 0.278'' + 0.234'' = 0.747'' < 1.455'' \quad ok//$$

CHECK TROLLEY WHEEL LOAD VS. RECOMMENDED VALUES

[Ref #12 Table 4.11.3 & Ref #16 Pg 103,104]

MAX WHEEL LOAD = 78.4k (Ref. #5, Att'd Ederer Calc.)

MAX RECOMMEND (21"ø, 135# RAIL, CLASS A1) = 75.6k

FROM WHITING: "Table 4 (Pg. 104) IS A GUIDE.... THE FORMULA USED IN DETERMINING THE VARIOUS RECOMMENDED WHEEL LOADS IS EMPIRICAL."

WHITING CONTINUES BY STATING THAT BY EXCEEDING RECOMMENDED WHEEL LOADS THE USER MAY SEE MORE WEAR ON THE WHEELS. IN THIS CASE, DUE TO INFREQUANCY OF USE, THE WEAR SHOULD BE MINOR OVER THE REMAINING LIFE OF THE PLANT.

THEREFORE ALTHOUGH THE TROLLEY LOADS ARE HIGHER THAN RECOMMENDED SAY ok// BY JUDGEMENT.

CONSIDERING WHEEL HARDNESS, XSAM TROLLEY WHEEL LOADS ARE ACCEPTABLE SEE CALCULATION ATT # 4

CALCULATION SHEET

STONE & WEBSTER, INC.

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[illegible] 33- [illegible] 3	0	20

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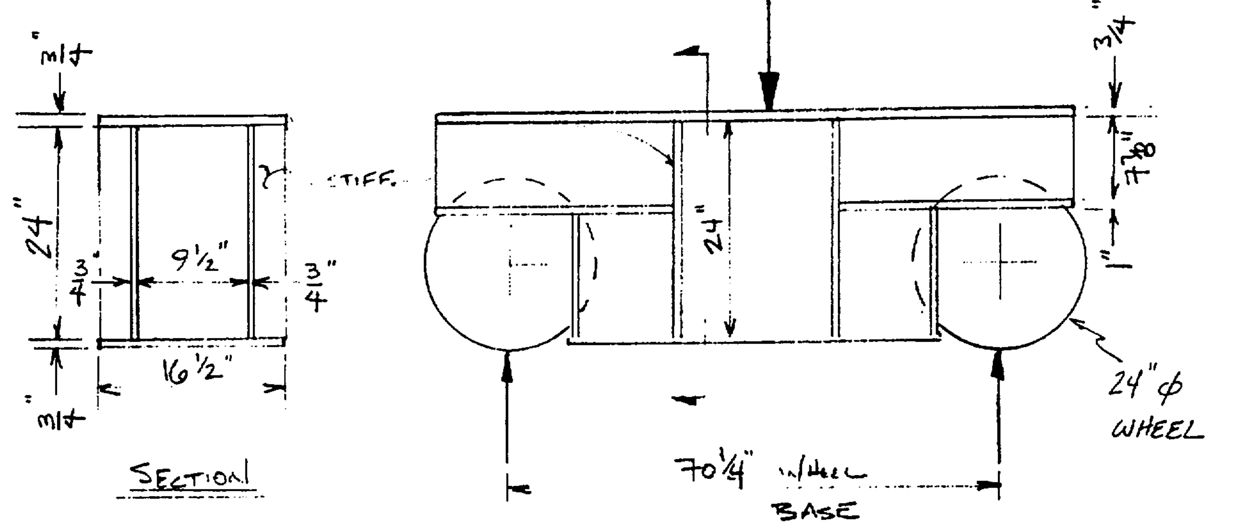
[illegible]	[illegible] 09/27/01	[illegible] 10-02-01

SUBJECT/TITLE	QA CATEGORY/CODE CLASS
[illegible]	I

CHECK END TRUCK (REF # 4 & 10)

OBE = 51.02 + 137.5 + 16.97 = 205.49^k

DBE = 51.02 + 137.5 + 33.97 = 222.46^k



SECTION

NOTE: BY INSPECTION [illegible] > [illegible] DESIGN FOR EQ & NOT IMPACT & NORMAL ALLOWABLES

SECT. PROPERTIES

$$I_z = \frac{16.5(25.5^3 - 24^3)}{12} + 2\,\frac{3/4 \times 24^3}{12} = 5519\ in^4$$

$$S_z = \frac{5519\ in^4}{12\,3/4"} = 432.9\ in^3$$

OBE

$$M = \frac{PL}{4} = \frac{(205.49^k)(70.5")}{4} = 3622^{"-k}$$

$$f_b = M/S = 8.37^{ksi} < 17.6^{ksi} \quad ok$$

DBE

$$M = 3921^{"-k}$$

$$f_b = 9.06^{ksi} < 1.5 \times 17.6 = 26.4^{ksi} \quad OK!!$$

SHEAR OVER WHEEL

A_v : [illegible] $7\frac{7}{8}" \times 3/4" = 11.8125 \square''$

OBE $R = \frac{1}{2}(205.49^k) = 102.7^k$

$f_v = 8.69^{ksi} < 13.2^{ksi}$ ok//

DBE $R = \frac{1}{2}(222.46) = 111.2^k$

$f_v = 9.41^{ksi} < 1.5 \times 13.2$ ok//

EARTHQUAKE RESTRAINT - (R.L. [illegible])

[illegible] LD

$12 \times 7/8"\phi$ H.S. BOLTS $V_{ALL} = 12 \times 12.6^k$ 151.2^k @ end

(say A325 N)   TOTAL EQ LOAD $\leq 2 \times 151.2 = 302.4^k$

MAX HORZ EQ LOAD = 107.9^k (DBE) << 302.4^k ok//

DOCUMENT NUMBER: CAL-C01-002

Title : REACTOR BUILDING CRANE SUPPORT STRUCTURE DESIGN CHECK

Contents :

REV	DATE	REVISION	DFT.	CHK.	ENG.	APR.
1	11-29-2001	ISSUED FOR DDC-4260	PAW	KS	TVV	BRW

STONE & WEBSTER ENGINEERING CORPORATION

CALCULATION TITLE PAGE

CLIENT & PROJECT **DAEC – DUANE ARNOLD ENERGY CENTER – UNIT NO. 1**	PAGE 1 OF 106 PLUS 3 PGS OF ATTACHMENTS
CALCULATION TITLE **REACTOR BUILDING CRANE SUPPORT STRUCTURE DESIGN CHECK**	QA CATEGORY (X) X I - NUCLEAR SAFETY RELATED ___ II ___ III ___ OTHER

CALCULATION IDENTIFICATION NUMBER				
J.O. OR W.O. NO.	DIVISION & GROUP	CURRENT CALC. NO.	OPTIONAL TASK CODE	OPTIONAL WORK PACKAGE NO.
12133	CIVIL/STRUCT	SS - 1		N / A

APPROVALS - SIGNATURE & DATE			REV. NO. OR NEW CALC. NO	SUPERSEDES CALC. NO. OR REV. NO.	CONFIRMATION REQUIRED (X)	
PREPARER(S)/DATE(S)	REVIEWER(S)/DATE(S)	INDEPENDENT REVIEWER(S)/DATE(S)			YES	NO
M.N. Scacco 9/27/01 M.N. Scacco	D. M. HERMANN 10/1/2001 [signature]	ROGER MA 10/01/01 [signature]	0	N / A		X

DISTRIBUTION					
GROUP	NAME & LOCATION	COPY SENT (X)	GROUP	NAME & LOCATION	COPY SENT (X)
RECORDS MGT. FILES (OR FIRE FILE IF NONE)	JOB BOOK FIRE FILE S. M. Macie	ORIG X X			

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SUBJECT/TITLE DAEC - Reactor Building Crane Support Structure Design Check		QA CATEGORY/CODE CLASS I	

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RECORD OF REVISIONS

REVISION 0

Original Issue

CALCULATION SUMMARY

OBJECTIVE OF CALCULATION:

The purpose of this calculation is to check the design of the Reactor Building structure for the new loadings imposed by the 100 ton capacity Reactor Building crane. The new loads are the result of increased weight associated with the replacement single-failure-proof trolley installed in 1986.

The calculation is a follow-up effort to the S & W Report No. 12133.1004-S(C) – 2, Rev. 0 **(Ref.#1)**. The calculation provides a new and more detailed study of the structural adequacy of the Reactor Building crane runway and support structure, for the increased weight (21 kips) of the trolley. The calculation also evaluates the design condition of maximum lifted loads during a seismic event.

The following specific points will be addressed by this calculation:

- Design check of crane runway (including rail) and runway support structure using increased trolley load of 20,800 lbs.
- Design check using the revised trolley wheelbase geometry.
- Design check for unequal wheel loads.
- Design check for locations of wheel loads at worst-case positions along the runway girders.
- Design check of welds at runway girder brackets and bearing stiffeners due to increased loads.
- Provide reference to seismic documentation (UFSAR) in calculation.
- Re-compute seismic load combinations using vertical accelerations stated in UFSAR.
- Design check of the capability to transfer lateral loads from the crane to the runway girder.

CALCULATION METHOD/ASSUMPTIONS:

The calculation utilizes standard engineering practice and follows analysis methods described in previous DAEC calculations. Specific assumptions, as required, are identified within the body of the calculation. Conservative inputs and assumptions are used throughout this calculation.

The original design assumptions were used for this analysis. They were taken from Ref. #4 and are listed on page 7 of this calculation. The analysis method used for this calculation is both hand calculation and GT STRUDL Version 25. Additional assumptions and discussion of analysis methods are given on page 10 of this calculation.

SOURCES OF DATA/EQUATIONS:

The list of references used in this calculation is shown on page 7. This calculation uses vertical accelerations of .04g OBE and .08g DBE (*Ref. 10, page 5*). The vertical seismic load combinations include the weight of the crane and the lifted load. The horizontal accelerations used were .35g OBE and .70g DBE at the crane level and .52g OBE and 1.04g DBE at the roof level. Horizontal seismic loads include only the dead load of the crane (i.e., not the lifted load). The lifted load in

horizontal seismic load combinations is typically not included due to the fact that the hanging load is free to sway.

CONCLUSIONS:

The analysis of the existing crane runway girders were shown to be adequate as designed. The combined stresses were shown to be less than the allowable stresses. See pages 41 - 43.

The rigid frame bents were then analyzed using the worst case loads from the runway analysis and were found to be adequate as designed, except for the DBE load combinations which were found to exceed the allowable stresses, when only one frame is considered. A new analysis was then performed which considered the contribution of the roof bracing and end walls. This analysis proved that the design is adequate for the DBE load cases as well. See pages 44 – 98.

The haunch at the top of the columns in the rigid frame was simplified for the analysis. This was considered a conservative approach, since the critical sections for moment were located in the transverse girder and the column base.

Connection details were then checked and found to be adequately designed. See pages 99 -106.

The Reactor Building crane support structure is adequately designed for the increased weight of the replacement trolley and for all appropriate load combinations, including maximum lifted load plus seismic.

The foundation design was not investigated, because the increase in column forces due to the increased trolley weight was not of significant magnitude to warrant a new analysis.

References:

1. Phase I Structural Evaluation Report for DAEC Reactor Building Crane Runway/Support Structure, Duane Arnold Energy Center, 12133.1004-S(C) – 2, Rev. 0, dated 6/25/01.

2. DAEC UFSAR, Sections 2.5, 3.7, and 3.8, Rev. 13.

3. Phase I Structural Evaluation Report for DAEC Reactor Building Crane Girders, Duane Arnold Energy Center, 12133.1004-S(C) – 1, Rev. 0, dated 6/04/01.

4. Bechtel DAEC Calculation 3-F-6, dated 5-8-70, Crane Frame (Space Frame) R.B.

5. Bechtel DAEC Calculation 3-F-6, April, 1971, Supplemental Calculation for Rigid Frame.

6. Bechtel DAEC Calculation 3-F-8, dated 11/7/73, Reactor Building Overloading of Reactor Crane.

7. Bechtel DAEC Drawings

   a. BECH-A008, Rev. 20, Arch. Roof Plan
   b. BECH-A009, Rev. 20, Arch. North, South & Partial Exterior elevations
   c. BECH-A010, Rev. 15, Arch. East, West & Partial Exterior Elevations
   d. C-435, Rev. 3, R.B. Roof Framing Plan, Sections & Details
   e. C-437, Rev. 4, R.B. Craneway Plan & Details
   f. C-438, Rev. 2, R.B. Framing Elevations & Details Sheet #1
   g. C-439, Rev. 1, R.B. Framing Sections & Details Sheet #2
   h. C-442, Rev. 1, R.B. Rigid Frame Cross Section & Details

8. AISC Manual of Steel Construction, Sixth (1963) & Seventh (1970) editions.

9. AISC Manual of Steel Construction, Ninth (1989) edition.

10. DEAC Reactor Building Earthquake Analysis, by John A. Blume & Associates, Engineers, APED-A61-047, Rev. 1

RECORD OF CONFIRMATIONS

Page No.	Description	Action	Confirmation Date
All	None		

ORIGINAL DESIGN ASSUMPTIONS (Ref. #4, page 5) (*comments in parentheses*)

1. Impact will be considered for the design of the crane runway girders and the related connections but not for frame design.
2. Lifted load will not act simultaneously with Tornado and Earthquake. The *(bridge and)* trolley is in stored position. *(no lateral force and impact)*
3. One third of siding area *(considered)* left *(intact)* for tornado. No roof suction is considered for this case.
4. Earthquake force is assumed to concentrate at the rigid frame at two points. El. 876'-6" and El. 894'-8". *(these elevations were modified slightly to coincide with as-built condition, see page 10, item 8 for details)*
5. Roof loads are assumed to be uniformly distributed directly to the rigid frame. Purlins and other bracing members do not take external load in the computer analysis. Purlins will be analyzed manually. *(purlins were not in the scope of this calculation)*
6. Assume that the roof girders are level. *(actual roof slope was modeled in GTSTRUDL)*
7. Ends of purlins and all bracing members will be released, hinged ends.
8. Assume that it is a space frame.
9. Wind force is assumed to be uniformly distributed directly to columns.
10. Assume that roof loads and parapet loads lumped at El. 894'-8".
    Column, siding, and crane lumped at El. 876-6". *(elevations were changed slightly to match as-built elevations)*

DESIGN BASIS AND ASSUMPTIONS

1. DESIGN METHOD BASED IN GENERAL ON EXISTING CALCS PREPARED BY BECHTEL (REF. #4 THRU #6) ANY DEVIATIONS AND EXCEPTIONS WILL BE NOTED BELOW.

2. OBE AND DBE DESIGN EARTHQUAKE HORIZONTAL AND VERTICAL ACCELERATIONS BASED ON ATTACHMENT 3 OF REF. #1. THE UFSAR (REF. #2) LISTS THE SAME VALUES.

3. FOR LATERAL CRANE IMPACT LOADS, WE USED 20% OF THE SUM OF THE WEIGHTS OF THE LIFTED LOAD AND CRANE TROLLEY, BUT EXCLUDING THE BRIDGE WEIGHT, IN ACCORDANCE WITH AISC, REF # 9.

4. LIFTED LOAD OF 200^{K} (100T) WAS NOT INCLUDED WHEN CALCULATING OBE AND DBE HORIZONTAL FORCES. THE LIFTED LOAD WAS INCLUDED IN DETERMINING VERTICAL OBE AND DBE FORCES.

5. ALL LOADS AND COMBINATIONS OF LOADS WERE BASED ON THE ORIGINAL CALCULATIONS AND UFSAR (REF. # 2). SEE PAGES 11 & 12 FOR DETAIL.

6. THE CRANE WHEEL GEOMETRY AND DISTRIBUTION OF WHEEL LOADS WAS ADJUSTED FROM THE ORIGINAL DESIGN TO MORE CLOSELY REFLECT THE ACTUAL INSTALLED CONDITIONS, USING THE EDERER TROLLEY (43 TON) AND ACTUAL WHEEL BASE DIMENSIONS. THIS DETAIL IS SHOWN ON PAGES 13 & 14.

7. CALCULATED WHEEL LOADS WERE PLACED ON THE CRANE RUNWAY AT 3 FT. INTERVALS TO DETERMINE WORST POSSIBLE REACTIONS. A GT STRUDL MODEL OF THE RUNWAY BEAM WAS CREATED TO FIND THE MAXIMUM REACTIONS AT THE LOCATIONS OF THE RIGID FRAME BENTS.

8. RIGID FRAME MODEL WAS CREATED FROM BECHTEL DWGS. REF # 7. ELEVATIONS ARE TOP OF STEEL FOR HORIZONTAL MEMBERS AND CENTERLINE FOR VERTICAL MEMBERS. ROOF SLOPE (1/4" / FT.) WAS ALSO INCLUDED.

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SUBJECT/TITLE	QA CATEGORY/CODE CLASS
DAEC - REACTOR BUILDING CRANE SUPPORT	I

LOADS FOR COMPUTER INPUT

BASIC LOADS (SELFWEIGHT ADDED TO ALL DL COMBS)

1. ROOF DL. (18 PSF - USED IN ORIGINAL DESIGN)
2. ROOF LL (40 PSF SNOW - USED IN ORIGINAL DESIGN)
3. WIND LOAD (MAX. TO RIGHT)
4. WIND LOAD (MAX. TO LEFT)
5. TORNADO (MAX. TO RIGHT)
6. TORNADO (MAX. TO LEFT)
7. EQ (OBE) (MAX. TO RIGHT)
8. EQ (OBE) (MAX. TO LEFT)
9. EQ (DBE) (MAX. TO RIGHT) (2x OBE VALUES)
10. EQ (DBE) (MAX. TO LEFT) (2x OBE VALUES)
11. CRANE W/IMPACT (MAX. TO RIGHT)
12. CRANE W/IMPACT (MAX. TO LEFT)

LOAD COMBINATIONS

1. D + L + CR (R) (NO STRESS INCREASE PER REF. #2)
   1 + 2 + 11
2. D + L + CR (L) (NO STRESS INCREASE PER REF. #2)
   1 + 2 + 12
3. D + L + W (R) (0.33 INCREASE ALLOWED - PER REF #2)
   1 + 2 + 3
4. D + L + W (L) (0.33 INCREASE ALLOWED - PER REF #2)
   1 + 2 + 4

LOAD COMBINATIONS (CONT.)

5. D + W (R) (0.33 STRESS INCREASE ALLOWED - PER REF. # 2)

6. D + W (L) (0.33 STRESS INCREASE ALLOWED - PER REF. # 2)

7. D + TORNADO (R) (0.50 STRESS INCREASE ALLOWED - PER REF. # 2)

8. D + TORNADO (L) (0.50 STRESS INCREASE ALLOWED - PER REF. # 2)

9. D + L + EQ (OBE-R) (0.25 STRESS INCREASE ALLOWED - PER REF # 2)

10. D + L + EQ (OBE-L) (0.25 STRESS INCREASE ALLOWED - PER REF. #2)

11. D + L + EQ (DBE-R) (0.50 STRESS INCREASE ALLOWED. - PER REF #2)

12. D + L + EQ (DBE-L) (0.50 STRESS INCREASE ALLOWED - PER REF. #2)

13. D + L + {W (L) / W (R)} + CR (R) (0.33 STRESS INCREASE ALLOWED - PER REF. # 2)

14. D + L + {W (L) / W (R)} + CR (L) (0.33 STRESS INCREASE ALLOWED - PER REF. # 2)

NOTE: THE DEAD LOAD OF THE CRANE IS INCLUDED IN ALL OF THE LOAD COMBINATIONS CONSIDERED.

THE LIVE LOAD (LIFTED LOAD = 100 TONS) OF THE CRANE WAS NOT INCLUDED IN THE SEISMIC COMBINATIONS FOR HORIZONTAL LOAD; ONLY FOR VERTICAL LOAD.

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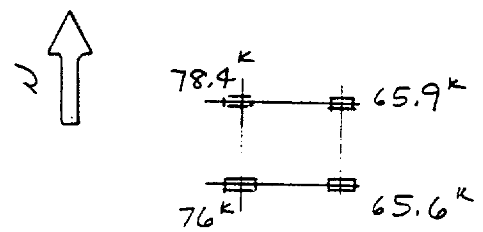
TROLLEY WEIGHT DISTRIBUTION

ACCORDING TO ATTACHMENT 1, E-MAIL FROM JIM NELSON OF EDERER CO., THE FOLLOWING DISTRIBUTION OF WHEEL LOADS WERE GIVEN:



LOADS INCLUDE LIFTED LOAD OF 50k EACH WHEEL

TOTAL 154.4k (WEST) 131.5k (EAST)

SUM = 285.9k { 200k LIFTED LOAD, 85.9k TROLLEY }

AVERAGE ÷ 2 = 77.2k 65.75k ← USE THIS LOAD FOR EACH BRIDGE GIRDER TO COMPUTE REACTIONS AT ENDS OF GIRDER

SEE NEXT PAGE FOR WHEEL LOADS INCLUDING BRIDGE WEIGHT = 220.1k

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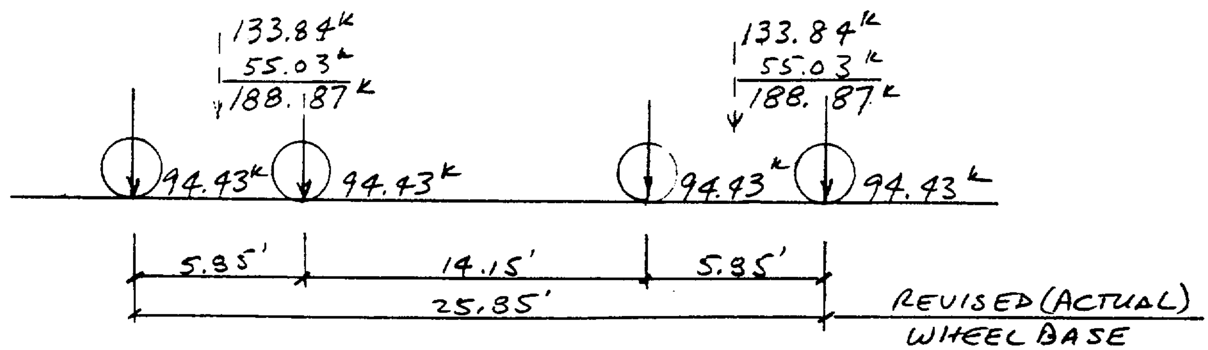
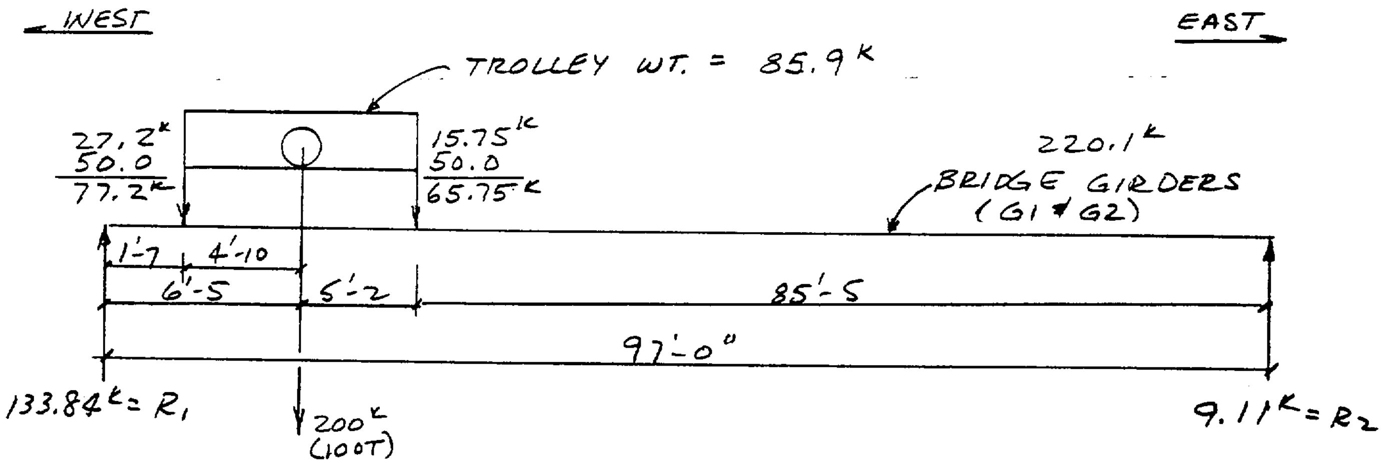
CRANE WHEEL GEOMETRY & LOADS (REF. #1)





REV'D TROLLEY WT. = 85.9^k GIRDER: $220.1^k / 4$ TRUCKS $= 55.03^k$

TROLLEY : SEE ABOVE DIAGRAM

LIFTED LOAD: $200^k / 4$ WHLS $= 50^k$

$$R_1 = \frac{77.2\,(97-1.58)}{97} + \frac{65.75\,(85.417)}{97} = 133.84^k$$

$$R_2 = 77.2 + 65.75 - 133.84 = 9.11^k$$

WHEEL LOAD w/o IMPACT (MAX.) $= \underline{\underline{94.43^k}}$

CRANE WHEEL LOADS (CONT.)

NEW LOADS: WHEEL LOAD W/IMPACT:

GIRDER WT. $= 55^{K}/2 = 27.5^{K}$

IMPACT $= 0.25 \times 27.5^{K} = 6.88^{K}$

TROLLEY $= \dfrac{27.2\,(95.42)}{97\,(2)} + \dfrac{15.75\,(85.42)}{97\,(2)} = 20.31^{K}$

IMPACT $= 0.25 \times 20.31 = 5.08^{K}$

LIFTED LOAD $= \dfrac{50\,(180.84)}{97\,(2)} = 46.6^{K}$

IMPACT $= 0.25 \times 46.6 = 11.65^{K}$

TOTAL $= 27.5 + 6.88 + 20.31 + 5.08^{K} + 46.6^{K} + 11.65^{K}$

$= \underline{\underline{118.02^{K}/\text{WHL}}}$

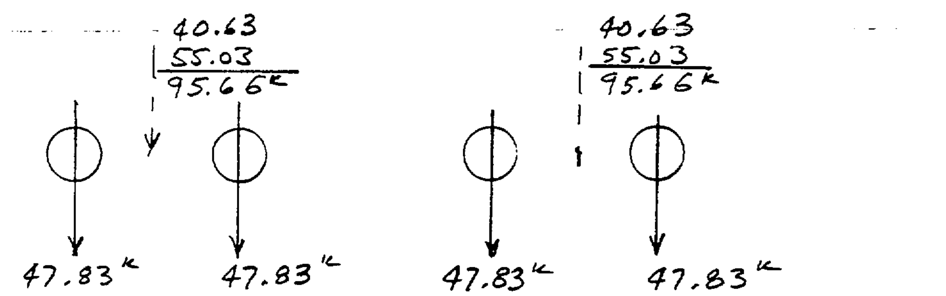
CRANE WHEEL LOADS (USED FOR SEISMIC FORCES)

NEGLECT LIFTED LOAD FOR HORIZONTAL EQ:

THEN $R_1 = \frac{27.2}{97}(97 - 1.58) + \frac{15.75}{97}(85.417) = 40.63^k$

$R_2 = 27.2 + 15.75 - 40.63 = 2.32^k$

SO GIRDER WT. = 220.1 / 4 TRUCKS = 55.03^k



WHEEL LOAD (W/O IMPACT; UNLOADED CRANE) = 47.83^k

EQ-LATERAL LOADS: OBE = 0.35g @ EL. 876.5'

$H_1 = 47.83(0.35) = 16.74^k$

$H_2 = 47.83\left(\frac{2.32}{40.63}\right)(0.35) = 0.96^k$

DBE = 0.70g @ EL 876.5'

$H_1 = 47.83(0.70) = 33.48^k$

$H_2 = 47.83\left(\frac{2.32}{40.63}\right)(0.70) = 1.91^k$

CRANE WHEEL LOADS (CONT.)

VERTICAL LOADS (DUE TO SEISMIC): (REF: PG 14)

OBE = 0.04 g × LOADED CRANE W/NO IMPACT

$V_1 = 94.43\,(0.04) = 3.78^k$

$V_2 = 94.43\left(\frac{2.32}{40.63}\right)(0.04) = 0.22^k$

DBE = 0.08 g × LOADED CRANE W/NO IMPACT

$V_1 = 94.43\,(0.08) = 7.55^k$

$V_2 = 94.43\left(\frac{2.32}{40.63}\right)(0.08) = 0.43^k$

PART I

ANALYSIS OF CRANE RUNWAY GIRDER

ANALYSIS OF RUNWAY BEAM (CONT.)

$F_{bx} = 19.99$ ksi

$F_{by} = 0.75\ F_y = 0.75\ (36) = 27.0$ ksi

AXIAL FORCE ON THE RUNWAY BEAM = TRACTIVE FORCE (LONGITUDAL) = 10% OF MAX. WHEEL LOAD (W/ IMPACT)

$= 0.10 \times 118.1^k \times 4$ WHEELS $= 47.24^k$

$f_a = \frac{P}{A} = \frac{47.24}{75.5} = 0.626$ ksi

MAXIMUM $\frac{Kl}{r} = \frac{K l_y}{r_y} = \frac{1.0(22.75)(12)}{5.25} = 52.0$

$\frac{Kl/r}{C_c} = \frac{52.0}{126.1} = 0.41 \Rightarrow C_a = 0.506$ (AISC TABLE 3 REF. 9)

$F_a = 0.506 \times F_y = 0.506\ (36) = 18.17$ ksi

$\frac{K l_x}{r_x} = \frac{1.0\ (22.75)(12)}{14.95} = 18.26$

$F'_{ex} = 338.62$ ksi (AISC, TABLE 3 ; REF #9)

$F'_{ey} = 55.23$ ksi $C_{mx} = C_{my} = 1.0$ (CONS.)

CHECK COMBINED STRESSES:

$$\frac{f_a}{0.6F_y} + \frac{f_{bx}}{F_{bx}} + \frac{f_{by}}{F_{by}} \leq 1.0 \quad \text{(AISC H1-2)}$$

$$\frac{0.626}{0.6(36)} + \frac{15.78}{19.99} + \frac{3.35}{21.6} \leq 1.0$$

$$= 0.029 + 0.789 + 0.155 = \boxed{0.973} < 1.0 \therefore OK$$

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ANALYSIS OF RUNWAY BEAM (CONT.)

$$\frac{f_a}{F_a} + \frac{C_{mx} f_{bx}}{\left(1-\frac{f_a}{F'_{ex}}\right)F_{bx}} + \frac{C_{my} f_{by}}{\left(1-\frac{f_a}{F'_{ey}}\right)F_{by}} \le 1.0 \quad \text{(AISC H1-1)}$$

$$= \frac{0.626}{18.17} + \frac{(1.0)(15.78)}{\left(1-\frac{0.626}{338.62}\right)19.99} + \frac{(1.0)(3.35)}{\left(1-\frac{0.626}{55.23}\right)21.6} \le 1.0$$

$$= 0.034 + 0.791 + 0.157 = \boxed{0.982} < 1.0 \therefore OK$$

ALTERNATIVELY; CHECK EQN. H1-3:

$$\frac{f_a}{F_a} + \frac{f_{bx}}{F_{bx}} + \frac{f_{by}}{F_{by}} \le 1.0 \quad \text{(AISC H1-3)}$$

$$= \frac{0.626}{18.17} + \frac{15.78}{19.99} + \frac{3.35}{21.6} \le 1.0$$

$$= 0.034 + 0.789 + 0.155 = \boxed{0.978} < 1.0 \quad OK$$

∴ COMBINED SECTION (W36 x 194 + W21x62) IS ADEQUATE.

CHECK SHEAR STRESS:

$V_{MAX} = 236^k \qquad f_v = \frac{236}{36.98(0.77)} = 8.40$ ksi

$F_v = 0.4 F_y = 0.4 \times 36 = 14.4$ ksi ∴ OK

CHECK RUNWAY BEAM FOR {H = UNLOADED, V = LOADED CRANE + EQ − OBE:

SEE PG. 17 FOR OBE LOADS (VERTICAL)

$$\text{RATIO} - \frac{\text{UNLOADED CRANE}}{\text{LOADED CRANE}} = \frac{144.75}{357.3} = \underline{\underline{0.405}}$$

SO, MAX. MOMENT (STRONG-AXIS) = 977 K-FT × 0.405 = $\underline{\underline{395.7}}$ K-FT.

MAX. MOMENT (WEAK-AXIS) = 395.7 × $\underline{\underline{0.35g}}$ = $\underline{\underline{138.50}}$ K-FT.

ADD'L MOMENT DUE TO VERTICAL EQ ACCELERATION:

M_V = $\underline{0.04}$ g × 977.0 = 39.08 K-FT.

$$f_{bx} = \frac{M_x + M_V}{S_x} = \frac{(395.7 + 39.08)(12)}{742.93} = 7.02 \text{ ksi}$$

$$f_{by} = \frac{M_y}{S_y} = \frac{138.50\,(12)}{198.02} = 8.39 \text{ ksi} \qquad f_a = 0$$

0.25 STRESS INCREASE ALLOWED − BY INSPECTION, THIS CASE IS LESS CRITICAL THAN LOADED CRANE W/IMPACT.

CHECK RUNWAY BEAM FOR {H = UNLOADED, V = LOADED CRANE + EQ − DBE:

MAX. MOMENT (STRONG-AXIS) = $\underline{\underline{395.7}}$ K-FT. (SAME AS ABOVE)

MAX. MOMENT (WEAK-AXIS) = 395.7 × $\underline{0.70g}$ = $\underline{\underline{276.99}}$ K-FT

M_V = 0.08 g × 395.7 = 31.66 K-FT.

$$f_{bx} = \frac{(395.7 + 78.16)(12)}{742.93} = 7.65 \text{ ksi}$$

$$f_{by} = \frac{276.99\,(12)}{198.02} = 16.79 \text{ ksi} \qquad f_a = 0 \text{ (NO TRACTIVE FORCE)}$$

$$\frac{f_a}{F_a}^{0} + \frac{f_{bx}}{F_{bx}} + \frac{f_{by}}{F_{by}} \le 1.50$$

← 0.5 STRESS INCREASE ALLOWED (AISC H1-3)

$$\frac{7.65}{19.99} + \frac{16.79}{21.6} = 1.16 < 1.50 \quad \therefore \underline{\underline{OK}}$$

COVER PAGE FOR

(DESCRIPTION OF DOCUMENT) STATIC LOAD TEST PROCEDURE FOR NEW REACTOR BUILDING CRANE

DOCUMENT NUMBER N/A REV/DATE 0/12-4-84

NUMBER OF SHEETS ~~10~~ (INCLUDING COVER) 12 DCP 1294 Closure

FOR DCR 1294 USE ONLY	DCR PACKAGE INDEX ITEM NO. 3.06

REV	PREPARED BY	VERIFIED BY	REVISION
3	/	/	
2	JCB / 12-29-88	RB / 12-29-88	Revised Pg. CT.
1	[illegible] / 12-21-84	DRB / 12-27-84	ATTACHMENT I REVISED PER FCR-1294-3 REV 0
0	[illegible] / 12-6-84	JCB / 12-6-84	ADDED PER FCR 1294-3 REV. 0

Form NG-036Z Rev. 0

STATIC LOAD TEST PROCEDURE FOR NEW REACTOR BUILDING CRANE

NOTE: Before the static load test is performed, all inspections and non-load pre-operational tests shall be completed and documented.

1.0 SCOPE

Prior to declaring the crane operational, a static load test must be performed on the crane to verify its structural and component integrity. This test procedure was developed by Design Engineering with input from Ederer Inc. Procedure No. 250, Test Sections 250.14 and 250.15. Test Section 250.14 is designed to test the integrity of the bridge and trolley structures. Test Section 250.15 is designed to test the trolley and bridge components by moving the bridge and trolley while suspending a test load. Due to the configuration of the DAEC, Test Section 250.14 cannot be performed without bringing the test load to the refuel floor. Therefore, this procedure shall combine Test Sections 250.14 and 250.15 to minimize the movement of the test load.

During the load test the ambient temperature on the refuel floor must be lowered to 50°F (+5°, -0°) to fulfill a commitment made to the NRC. (Reference the DCP form, page 5.) All tests shall be performed under the supervision of the Ederer Field Engineer. The Responsible Construction Engineer (RCE) shall be responsible for the overall coordination of the testing. Operations shall be responsible for the actual operation of the crane.

2.0 EQUIPMENT REQUIRED

The equipment required for the static load testing shall include but not be limited to the following:

A. Test platform for supporting test weights (see Attachment I for requirements).

B. Assortment of test weights in arrangements of approximately 6.25, 50, 100, and 125 tons (see Attachment I for details).

3.0 ADDITIONAL RECOMMENDATIONS

A. To successfully satisfy the requirements of the Ederer procedures, the tests only need to be performed with a test load weight of 1.25 times the crane rating (6.25T, 125T). However, Design Engineering recommends that for the main hoist the test be run with increasing amounts of weight (50T, 100T, 125T) to provide greater assurance that the trolley and bridge will support the 125T load. This procedure has been developed based on this criteria. If DAEC personnel feel that only the 125T test is required, consult Design Engineering for resolution.

B. During the load test, Design Engineering recommends that personnel traffic in the Reactor Building be kept to a minimum and personnel be restricted from the load path on floors below elevation 855'-0".

C. Attachment 1 provides the various configurations of weights required to obtain the 6.25, 50, 100, and 125T test loads. Recommended methods for stacking the weights are also provided; however, the field may utilize other methods if desired.

4.0 LOAD TEST FOR MAIN HOIST

A. 50 Ton Test Load

1. Connect the main hoist hook to the 50 ton test load and raise the test load approximately 6" above the 757'-6" floor using the slowest hook speed. To satisfy the requirements of Ederer Procedure 250 (Attachment I to Index Item 3.02), Test Section 250.14.c and Test Section 250.15.b, the test load shall be suspended approximately 5 minutes to ensure that the brakes are able to hold the load. If the hoist is not able to lift and hold the test load, refer to Section 251.12 of Ederer Procedure 251 (Attachment II to Index Item 3.02) for adjustment. The RCE shall verify that the crane is able to hold the load and that any adjustments have been completed.

J. Fray 1-9-85
Signed: RCE/Date

2. Raise the test load approximately 3' off of the floor, hold the load and then lower load using the slowest hook speed. After load speed has stabilized, stop the test load and ensure the brake holds the load. The RCE shall verify that the brakes were able to stop and hold the test load.

J. Fray 1-9-85
Signed: RCE/Date

3. Raise the test load up to the refuel floor using the slowest hook speed and follow the load path shown on Fig. 1. After completing the load movement on the refuel floor, the test load shall be lowered back down the equipment hatch at the slowest hook speed and set on the 757'-6" elevation, in the location shown in Fig. 2. The RCE shall verify that during the lift and trolley/bridge movements, the crane operates smoothly and performs normally.

J. Fray 1-9-85
Signed: RCE/Date

B. 100 Ton Test Load

1. Perform the test described in Section 4.A.1 above for a 100T test load. The RCE shall verify that the crane is able to hold the load and that any adjustments have been completed.

J. Fray 1-10-85
Signed: RCE/Date

2. Perform the test described in Section 4.A.2 above for the 100T test load. The RCE shall verify that the brakes were able to stop and hold the test load.

[signature] 1-10-85
Signed: RCE/Date

3. Perform the test described in Section 4.A.3 above for the 100T test load. The RCE shall verify that during the lift and trolley/bridge movements, the crane operates smoothly and performs normally.

[signature] 1-10-85
Signed: RCE/Date

C. 125 Ton Test Load

1. Perform the test described in Section 4.A.1 above for a 125T test load. The RCE shall verify that the crane is able to hold the load and that any adjustments have been completed. The RCE shall verify that the checklists and Test Sections 250.14 and 250.15 have been filled out.

[signature] 1-10-85
Signed: RCE/Date

2. Perform the test described in Section 4.A.2 above for the 125T test load. The RCE shall verify that the brakes were able to stop and hold the test load. The RCE shall verify that the checklists in Test Sections 250.14 and 250.15 have been filled out.

[signature] 1-10-85
Signed: RCE/Date

3. Perform the test described in Section 4.A.3 above for the 125T test load. The RCE shall verify that during the lift and trolley/bridge movements, the crane operates smoothly and performs normally. The RCE shall verify that the checklists in Test Sections 250.14 and 250.15 have been filled out.

[signature] 1-10-85
Signed: RCE/Date

5.0 LOAD TEST FOR AUXILIARY HOIST

A. 6.25 Ton Test Load

1. Connect the auxiliary hoist hook to the 6.25 ton test load. Raise the test load approximately 3 ft. off of the 757'-6" floor using the slowest hook speed and stop the load and hold for approximately 5 minutes. The RCE shall verify that the brakes are able to hold the load without lowering the load. The RCE shall

2. Perform the test described in Section 4.A.2 above for the 100T test load. The RCE shall verify that the brakes were able to stop and hold the test load.

Signed: RCE/Date

3. Perform the test described in Section 4.A.3 above for the 100T test load. The RCE shall verify that during the lift and trolley/bridge movements, the crane operates smoothly and performs normally.

Signed: RCE/Date

C. 125 Ton Test Load

NCLUDED FOR THE ST RETEST

1. Perform the test described in Section 4.A.1 above for a 125T test load. The RCE shall verify that the crane is able to hold the load and that any adjustments have been completed. The RCE shall verify that the checklists and in Test Sections 250.14 and 250.15 have been filled out.

Jack Bergman 1/26/85
Signed: RCE/Date

2. Perform the test described in Section 4.A.2 above for the 125T test load. The RCE shall verify that the brakes were able to stop and hold the test load. The RCE shall verify that the checklists in Test Sections 250.14 and 250.15 have been filled out.

Jack Bergman 1/26/85
Signed: RCE/Date

3. Perform the test described in Section 4.A.3 above for the 125T test load. The RCE shall verify that during the lift and trolley/bridge movements, the crane operates smoothly and performs normally. The RCE shall verify that the checklists in Test Sections 250.14 and 250.15 have been filled out.

Jack Bergman 1/26/85
Signed: RCE/Date

5.0 LOAD TEST FOR AUXILIARY HOIST

A. 6.25 Ton Test Load

1. Connect the auxiliary hoist hook to the 6.25 ton test load. Raise the test load approximately 3 ft. off of the 757'-6" floor using the slowest hook speed and stop the load and hold for approximately 5 minutes. The RCE shall verify that the brakes are able to hold the load without lowering the load. The RCE shall

ensure that the checklists on Test Sections 250.14 and 250.15 have been filled out.

J. Fay 12-30-84
Signed: RCE/Date

2. Lower the test load using the slowest hook speed. After the hook speed has stabilized, stop the test load and ensure the brakes hold the load. The RCE shall verify that the brakes were able to stop and hold the test load. The RCE shall also verify that the checklists in Test Sections 250.14 and 250.15 have been filled out.

J. Fay 12-30-84
Signed: RCE/Date

NOTE: It is not necessary to raise the 6.25 ton test load to the refuel floor. Lifting the test load close to the 757'-6" floor will sufficiently test the auxiliary hoist components.

Attachment:

I Platform Fabrication/Testing and Test Weight Transportation/ Arrangement

Figures:

1 Static Load Test Path for the New Crane Trolley

2 Test Weight Location on 757'-6" Floor

Attachment I to Static Load Test Procedure

PLATFORM FABRICATION/TESTING AND
TEST WEIGHT TRANSPORTATION/ARRANGEMENT

FCR-1294-3 REV 0

1. The test weights and associated lifting bail will be delivered to the DAEC. (Reference DCP Index Item 8.19). All required equipment will be provided to transfer the weights from the yard (Reference DCP Index Item 8.18) AND 8.19. The transference of the weights from the area outside the fence to the yard, and from the yard to the reactor building shall be coordinated by the RCE. FCR-1294-3 REV 0 FCR-1294-3 REV 0

Note: One ~~of two~~ lifting bail ~~shall~~ SHOULD be used for loading of the test weights on the truck in the yard TO FORM THE REQUIRED TEST LOAD ~~while the other bail shall be used for unloading of weights and stacking them up inside the Reactor Building~~. (The heaviest single weight handled in this operation is - test weight #50 29670 lbs ~~and bail 4752 lbs total 34422 lbs. or 17.211 ton~~.) FCR-1294-3 REV 0

2. The lifting platform and lifting slings have been designed to support the 125% load with a factor of safety of 10 to 1 as is required by NUREG 0612. A calculation (DCP Index Item 5.03) defines the platform design. The lifting platform will be supplied and fabricated in accordance with DCP Index Item 8.18. In accordance with ANSI Standard N14.6-1978, an acceptance test will be performed on the platform. The platform will be subjected to a load test equal to 150% of the maximum load to which the device will be subjected.

Prior to the acceptance test on the platform, QC shall perform NDE (Liquid Penetrant or Magnetic Particle) on all welds where practicle. If weld is inaccessible, a visual examination should be performed on the weld. Inspections shall be in accordance with procedures defined in the Special Process Procedures Manual 1500 series (latest revision). Location for the testing should be coordinated with Design Engineering. QC and the RCE shall verify that all welds have been inspected and are acceptable.

[signature] 12-17-84 Signed: QC/Date

[signature] 1-9-85 Signed: RCE/Date

The load test will be conducted at FMC per DCP Index Item 8.08.

The RCE shall coordinate the platform testing witn QC and FMC. The RCE snall verify that the platform has been tested with a load 150% greater than the expected maximum load (125T) and has successfully passed the test.

[signature] 12-30-84 Signed: RCE/Date

Subsequent to testing, QC shall perform NDE (Liquid Penetrant or Magnetic Particle) on all welds where practicle to verify their integrity. If a weld is inaccessible, a visual examination should be performed on the weld. The examinations shall be in accordance with procedures defined in the Special Process Procedures Manual 1500 Series (latest revision) QC and the RCE shall verify that all welds have been inspected and are acceptable.

[signature] 12-19-84 Signed: QC/Date

[signature] 1-9-85 Signed: RCE/Date

The slings for the platform will be furnished in accordance with DCP Index Item 8.~~36~~10. Note that the platform will be used for the 125% load test and the 100% operational test for both the main and auxiliary hoist.

3. The allowable floor loading on the Reactor Building - 757'-6" level in the vicinity of the Equipment Hatch has been calculated (DCP Index Item 5.04). The floor can support the testing platform and weights in the location shown in attached Figure 2. The RCE shall ensure that the test weights and platform are located in this area during the 125% load test and the 100% operational test.

4. The recommended stacking sequences for the 5, 6.25, 50, 100 and 125 ton loads are listed below. It may be necessary for the RCE to coordinate the use of the tuning weights to obtain a more representative test weight. (Note: The actual weights are approximate due to the size of the individual test weights.)

A. Main Hoist

50 Ton Load

Sequence of Stacking	Weight No.	Weight (lbs.)
	Sled [WITH SLINGS & SHACKLES]	~~4,752~~ 11,064
	51	29,470
	52	29,430
	57	19,280
	60	9,990
	~~65~~	~~5,150~~
	~~70~~	~~2,030~~
		~~100,102~~
		99,234

[△1 FCR-1294-3 REV 0]

100 Ton Loading

Sequence of Stacking	Weight No.	Weight (lbs.)
	Sled [WITH SLINGS & SHACKLES]	~~4,752~~ 11,064
	51	29,470
	52	29,430
	54	29,430
	56	20,680
	59	20,370
	75	20,299
	77	20,240
	57	19,280
	~~65~~	~~5,150~~
	~~71~~	~~1,990~~
		~~201,091~~
		200,263

[△1 FCR-1294-3 REV 0]

125 Ton Loading

Weight No.	Weight (lbs.)
Sled (WITH SLINGS & SHACKLES)	~~4,752~~ 11,064
51	29,470
52	29,430
54	29,430
56	20,680
59	20,370
-75	20,299
77	20,240
57	19,280
50	29,670
~~75~~ 60	~~20,299~~ 9990
65	5,150
71	1,990
73	~~251,060~~ 2000
	250,064

△ FCR-1294-3 REV 0

B. Auxiliary Hoist

6.25 Ton

Weight No.	Weight (lbs.)
Sled (WITH SLINGS & SHACKLES *)	~~4,752~~ 6700
65	5,150
~~70~~	~~2,030~~
Tuning Weights	Approx. ~~600~~ 650
	~~12,532~~ 12500

△ FCR-1294-3 REV 0

5 Ton

Weight No.	Weight (lbs.)
Sled (WITH SLINGS & SHACKLES *)	~~4,752~~ 6700
~~65~~ 71	~~5,150~~ 1990
73 ~~Tuning Weights~~	~~Approx. 100~~ 2000
	~~10,002~~ 10,450

△ FCR-1294-3 REV 0

5. After the load and operational testing has been satisfactorily completed, the test weights shall be removed from the reactor building and placed in the yard. The weights and the bails will be returned to FMC at a later date per DCP Index Item 8.~~10~~ 66 #. The RCE shall be responsible for coordinating the removal of the weights from the DAEC.

△ FCR-1294-3 REV 0

* FOR THE AUXILIARY LOAD TEST, SLINGS FROM THE DAEC SUPPLY SHOULD BE USED.
THE FOLLOWING SLINGS ARE RECOMMENDED:
SLING NO'S 312, 313, 424 AND 425. (STORED IN TURBINE AREA)
EACH SLING IS 3/4" DIA, 20'-0" LONG AND RATED FOR 4.9 TONS.
OTHER SETS OF SLINGS OF AT LEAST 12.5 TONS OR GREATER CAPACITY MAY BE USED IF ABOVE SLINGS ARE NOT AVAILABLE

FIELD NOTE

WEIGHTS USED FOR NST RETEST

NO.	WEIGHT (lbs)
SLED	11,064
51	29,470
52	29,430
54	29,430
56	20,680
59	20,370
75	20,299
77	20,240
57	20,280
50	29,670
60	9,990
65	5,150
71	1,990
73	2,000
70	2,030
66	5,140
	257,233

125 Ton Loading

Weight No.	Weight (lbs.)
Sled (WITH SLINGS & SHACKLES)	~~4,752~~ 11,064
51	29,470
52	29,430
54	29,430
56	20,680
59	20,370
75	20,299
77	20,240
57	19,280
50	29,670
~~75~~ 60	~~20,299~~ 4990
65	5,150
71	1,990
73	~~251,060~~ 2000
	250,064

FCR-1294-3 REV 0

ACCEPTABLE WEIGHT RANGE WAS 250,000 - 260,000 lbs

B. Auxiliary Hoist

6.25 Ton

Weight No.	Weight (lbs.)
Sled (WITH SLINGS & SHACKLES *)	~~4,752~~ 6700
65	5,150
~~70~~	~~2,030~~
Tuning Weights	Approx. ~~600~~ 650
	~~12,532~~ 12500

FCR-1294-3 REV 0

5 Ton

Weight No.	Weight (lbs.)
Sled (WITH SLINGS & SHACKLES *)	~~4,752~~ 6700
~~65~~ 71	~~5,150~~ 1990
73 ~~Tuning Weights~~	~~Approx. 100~~ 2000
	~~10,002~~ 10,450

FCR-1294-3 REV 0

5. After the load and operational testing has been satisfactorily completed, the test weights shall be removed from the reactor building and placed in the yard. The weights and the bails will be returned to FMC at a later date per DCP Index Item 8.~~10~~ 8.13. The RCE shall be responsible for coordinating the removal of the weights from the DAEC.

FCR-1294-3 REV 0

* FOR THE AUXILIARY LOAD TEST, SLINGS FROM THE DAEC SUPPLY SHOULD BE USED.
THE FOLLOWING SLINGS ARE RECOMMENDED:
SLING NO'S 312; 313; 424 AND 425. (STORED IN TURBINE AREA)
EACH SLING IS 3/4" DIA, 20'-0" LONG AND RATED FOR 4.9 TONS.
OTHER SETS OF SLINGS OF AT LEAST 12.5 TONS OR GREATER CAPACITY MAY BE USED IF ABOVE SLINGS ARE NOT AVAILABLE

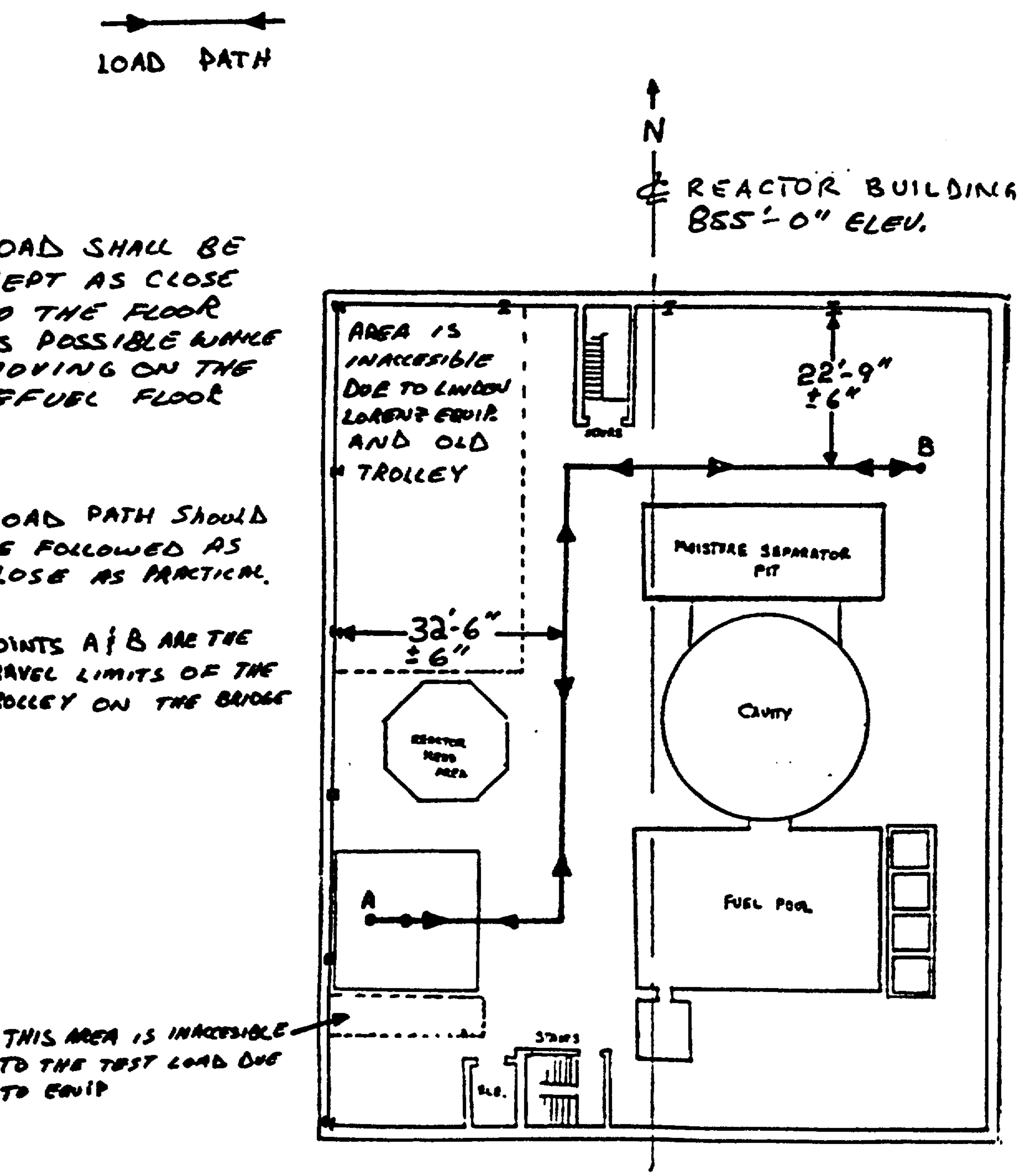
FIGURE 1

STATIC LOAD TEST PATH FOR THE NEW CRANE TROLLEY (50, 100, & 125 TON LOADS)

LOAD SHALL BE KEPT AS CLOSE TO THE FLOOR AS POSSIBLE WHILE MOVING ON THE REFUEL FLOOR

LOAD PATH SHOULD BE FOLLOWED AS CLOSE AS PRACTICAL.

POINTS A & B ARE THE TRAVEL LIMITS OF THE TROLLEY ON THE BRIDGE



NOTE: USE MINIMUM SPEEDS FOR BRIDGE AND TROLLEY WHEN HOISTING AND MOVING ANY TEST LOAD.

LOAD PATH IS SHOWN FOR CENTER OF TEST LOAD

LOAD CANNOT BE BROUGHT DOWN EAST SIDE DUE TO CLEARANCES between MOISTURE SEP. PIT AND FUEL POOL

Iowa Electric Light and Power Company
Cedar Rapids, Iowa

DEPT.
PROJECT
SUBJECT
Sheet No. 2 of 4
Computed by Jos Rysdm Date 11/27/84 Checked by [illegible] Date 12/3/84

FIGURE 2