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To Facility Engineering	From Fluid Systems Engineering	Page 1 of 1
		Date 10/25/94
Project Title/Work Order SEISMIC QUALIFICATION OF A SWITCH BOX		EDT No. 604372
		ECN No. N/A

Name	MSIN	Text With All Attach.	Text Only	Attach./ Appendix Only	EDT/ECN Only
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ENGINEERING DATA TRANSMITTAL

Page 1 of 1

1. EDT 604372

2. To: (Receiving Organization) Facility Engineering	3. From: (Originating Organization) Fluid Systems Engineering	4. Related EDT No.: N/A
5. Proj./Prog./Dept./Div.: Waste Management	6. Cog. Engr.: B. A. Schwehr	7. Purchase Order No.: N/A
8. Originator Remarks: APPROVAL		9. Equip./Component No.: N/A
		10. System/Bldg./Facility: 225 B Bldg.
11. Receiver Remarks:		12. Major Assm. Dwg. No.: H-2-66462
		13. Permit/Permit Application No.: N/A
		14. Required Response Date: 10/25/94

15. DATA TRANSMITTED					(F)	(G)	(H)	(I)
(A) Item No.	(B) Document/Drawing No.	(C) Sheet No.	(D) Rev. No.	(E) Title or Description of Data Transmitted	Approval Designator	Reason for Trans- mittal	Orig- inator Dispo- sition	Receiv- er Dispo- sition
1	WHC-SD-WM-ER-393		0	SEISMIC QUALIFICATION OF A SWITCH BOX	SQ	1	1	

16. KEY		
Approval Designator (F)	Reason for Transmittal (G)	Disposition (H) & (I)
E, S, Q, D or N/A (see WHC-CM-3-5, Sec.12.7)	1. Approval 2. Release 3. Information 4. Review 5. Post-Review 6. Dist. (Receipt Acknow. Required)	1. Approved 2. Approved w/comment 3. Disapproved w/comment 4. Reviewed no/comment 5. Reviewed w/comment 6. Receipt acknowledged

17. SIGNATURE/DISTRIBUTION (See Approval Designator for required signatures)										(G)	(H)
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18. S. M. Miller <i>S. M. Miller</i> Signature of EDT Originator	19. B. A. Schwehr <i>B. A. Schwehr</i> Authorized Representative for Receiving Organization	20. B. J. Gray <i>B. J. Gray</i> Cognizant Manager	21. DOE APPROVAL (if required) Ctrl. No. ☐ Approved ☐ Approved w/comments ☐ Disapproved w/comments
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BD-7400-172-2 (04/94) GEF097

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DEC 21 1994
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BD-7400-172-1 (07/91)

RELEASE AUTHORIZATION

Document Number: WHC-SD-WM-ER-393, Rev. 0

Document Title: Seismic Qualification of a Switch Box

Release Date: November 23, 1994

**This document was reviewed following the
procedures described in WHC-CM-3-4 and is:**

APPROVED FOR PUBLIC RELEASE

WHC Information Release Administration Specialist:

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11/23/94

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SUPPORTING DOCUMENT

1. Total Pages **2319**

2. Title

SEISMIC QUALIFICATION OF A SWITCH BOX

3. Number

WHC-SD-WM-ER-393

4. Rev No.

0

5. Key Words

B-Plant, Transfer Box

6. Author

Name: **S. M. Miller**

S. M. Miller 10/27/94
Signature

Organization/Charge Code **8D450/KB00E**

7. Abstract

This supporting document details the results of a seismic analysis on a switch box assembly. The switch box is mounted to a Unistrut frame and is attached to the concrete floor in the 225B Building with Hilti Kwik bolts. The assembly was found to meet safety class 3 requirements.

8. RELEASE STAMP

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Sta. 21

SEISMIC QUALIFICATION OF A SWITCH BOX

Prepared by:

S. M. Miller

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TABLE OF CONTENTS

1.0 INTRODUCTION	1
2.0 SUMMARY	1
3.0 SYSTEM DESCRIPTION	1
4.0 DISCUSSION	1
5.0 RECOMMENDATIONS	2
6.0 REFERENCES	3

APPENDICES

CALCULATIONS	4
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SEISMIC QUALIFICATION OF A SWITCH BOX

1.0 INTRODUCTION

This report will detail the results of a seismic analysis performed on a switch box assembly to be installed in the 225-B building. Recommendations based on the analysis performed will also be noted.

2.0 SUMMARY

The results of the analysis show the switch box assembly complies with safety class three seismic criteria. The assembly was checked for dead weight and seismic loading. Since the switch box assembly falls into a safety class three category, seismic loads were chosen from the Uniform Building Code (ICBO). Although the ICBO requires a horizontal load of 0.12 g's, the structure was conservatively analyzed for a 0.5 g horizontal load. The resulting loads and stresses in the Unistrut frame (see section 3-System Description) induced by both dead weight and seismic loading were checked against Unistrut and American Institute of Steel Construction (AISC) allowables.

The resulting loads and stresses fell within AISC & Unistrut allowables, and showed large margins of safety, where the margin of safety is defined as:

$$\bullet \text{Margin of safety (MS)} = (\text{Allowable Load}/\text{Applied Load}) - 1$$

For all cases analyzed, the minimum margin of safety was conservatively found to be 0.58.

3.0 SYSTEM DESCRIPTION

The switch boxes are supported by a Unistrut frame (see pages A-3 and A-4). Specifically, three switch boxes are attached to 75 inch (1.90 m) long Unistrut P1000 columns on both sides. These columns are anchored with P1358 braces at the top and bottom to a Unistrut frame comprised of two vertical and one horizontal Unistrut P1001 members. The top horizontal member is approximately 45 inches (1.14 m) long. Unistrut P2452 knee bases provide lateral stability. The base of the Unistrut frame is anchored to the concrete floor with 5/8 inch x 8 1/2 inch (1.59 cm x 21.59 cm) Hilti Kwik bolts.

4.0 DISCUSSION

The Unistrut P1000 columns were analyzed for bending from seismically induced horizontal loads representing a 0.5 g seismic phenomenon. Similarly, these columns were analyzed for vertical compression loads resulting from a 0.5 g vertical earthquake load plus dead weight. In both cases, the P1000 columns showed large margins of safety. A 0.5 g horizontal load was then applied in both horizontal directions (in-plane and out-of-plane) to the P1001 frame. The minimum margin of safety was +0.92 for the frame excited in the in-plane direction based on Unistrut allowables. The knee braces (Unistrut part number 2452) were checked against axial compression loads induced by

seismic phenomenon, and found to have a safety margin of +0.58 based on Unistrut allowable loads.

The Hilti Kwik bolts anchoring the frame to the concrete floor were found to have an adequate margin of safety against combined tensile and shear loading based on SDC 4.2 allowables.

5.0 RECOMMENDATIONS

Although all components analyzed were found to be structurally adequate, some changes are recommended. Moreover, installation specifications should be added to the work plan as noted below.

To comply with SDC 4.2 specifications, the Hilti Kwik bolts should be:

- Placed at least 8 1/4 inches (21 cm) from the edge of the concrete floor.
- Should have a minimum spacing of 8 inches (20.3 cm) from any Kwik bolt.
- Embedded 5 1/2 inches (14 cm) into the concrete. The minimum embedment distance is 2 3/4 inches (7 cm).

Furthermore, when the bolts are installed, rebar within the concrete should not be cut or damaged. Finally, the length of the Hilti Kwik bolt should be sized such that the distance from the top of the bolt to the top of the nut is not less than 2 thread pitches, and not more than 3/4 inch (1.90 cm) (see page A-12).

Unistrut part numbers P2626 and P1315 currently connect the P1001 frame to the base. Substituting Unistrut part number P2225 would provide a stronger connection. This change is not required, but is recommended for future assemblies.

6.0 REFERENCES

AISC, *Manual of Steel Of Construction, Allowable Stress Design*, 9th Edition, Chicago, Illinois.

Unistrut Corporation, *General Engineering Catalog No 12*, 1992, Wayne, Michigan.

ICBO, *Uniform Building Code*, International Conference of Building Officials, 1991 Edition, Whittier, California.

Schwehr, Ben, FAX dated September 13, 1994

SDC 4.2, *Hanford Plant Standard, Design and Installation of Expansion Anchors*, Rev. 0

Kleinlogel, A, et. al., *Rigid Frame Formulas*, 2nd American Edition, Ungar Publishing Company, 1978

APPENDIX A
CALCULATIONS

ANALYTICAL CALCULATIONS

Page 1 of 12

Subject STRESS CHECK OF B-PLANT SWITCH BOX ASMB.
 Originator SCOTT MILLER Date 9/13/94
 Checker B F NORMAN Date 9/16/94

OVERVIEW

A SWITCH BOX ASSEMBLY IS TO BE INSTALLED IN B-PLANT. THE ASSEMBLY CONSISTS OF THREE (3) MANUAL TRANSFER SWITCH BOXES, WHICH ARE HELD BY A UNI-STRUTTM FRAME. THE FRAME IS TIED TO A CONCRETE FLOOR W/ 5/8" HILTITM KWIK BOLTS. (SEE PD. 3 & 4)

THE UNI-STRUT FRAME & HILTI BOLTS WILL BE CHECKED FOR SEISMIC LOADS USING A STATIC EQUIVALENT METHOD FOR SAFETY CLASS 3 STRUCTURES.

ASSUMPTIONS ARE STATED & MUST BE UNDERSTOOD FOR CORRECT INTERPRETATION OF THESE CALCULATIONS. RECOMMENDATIONS ON INSTALLATION WILL ALSO BE PROVIDED.

REFERENCES

- o) FAX FROM BEN SCHWEHR (372-0363)
DATED 9/13/94 (2 PAGES)
- o) SDC 4.2, HANFORD PLANT STANDARD, DESIGN & INSTALLATION OF EXPANSION ANCHORS, REV 0
- o) RIGID FRAME FORMULAS, KLEINLOGEL, A,
2ND AM. ED, UNGAR PUB. CO, 1978
- o) UNI-STRUT, GEN ENGR. CATALOG, NO. 12
35660 CLINTON STR, WAYNE, MI 48184

ANALYTICAL CALCULATIONS

Page 2 of 12

Subject STRESS CHECK FOR B-PLANT SWITCH BOX ASMB
 Originator SCOTT MILLER J. M. Miller Date 9/13/94
 Checker ESR Date 9/16/94

SUMMARY OF RESULTS

PER THE DWGS ON PAGES 3 & 4, THE UNISTRUT FRAME IS SIZED APPROPRIATELY FOR SEISMIC LOADS.

THE $\frac{5}{8}$ " HILTI KWIK BOLTS PROVIDE ADEQUATE MARGIN AGAINST SEISMIC PHENOMENON.

RECOMMENDATIONS (SEE P. 11 & 12 FOR DWG MARK-UP)

- 1) USE UNISTRUT PART NUMBER P2225 IN PLACE OF PART NUMBERS P2626 & P1315 (4 PLS) (SEE P. 12)
- 2) HILTI'S SHOULD BE LOCATED $1\frac{1}{4}$ " FROM EDGE OF UNISTRUT FRAME (SEE P. 12).
- 3) THE $\frac{5}{8}$ " HILTI KWIK BOLTS SHOULD BE EMBEDDED TO A DEPTH OF $5\frac{1}{2}$ " & AT LEAST 8" AWAY FROM THE EDGE OF THE CONCRETE SLAB.
- 4) THE LENGTH OF THE HILTI BOLTS SHOULD BE CHOSEN SUCH THAT
 - (i) A MAXIMUM OF $\frac{3}{4}$ " GAP EXISTS BETWEEN THE TOP OF THE BOLT & THE TOP OF THE NUT,
 - (ii) A MINIMUM GAP EQUAL TO 2 THREAD LENGTHS EXISTS BTWN THE TOP OF THE BOLT & THE TOP OF THE NUT.

SCOTT MILLER *L.W. Miller*
BOM

9/13/94
9/16/94

SCOTT MILLER L.M. Miller 7/23/94
BPR 7/16/94

ANALYTICAL CALCULATIONS

Page 5 of 12

Subject STRESS CHECK OF B-PLANT SWITCH BOX ASMB
 Originator SCOTT MILLER J.M. Miller Date 9/13/94
 Checker BEAM Date 9/16/94

ANALYSISCHECK UNI-STRUT FRAME FOR SEISMIC LOADS

USE A STATIC EQUIVALENT METHOD. USE
 DESIGN ACCELERATION OF $0.5g$'s (CONSERVATIVE).

FIRST CHECK P1000 UNI-STRUTS SWITCH BOXES
 ARE MOUNTED ON.

ASSUME ENDS ARE SUPPORTED (NOT FIXED),
 THEREBY MAXIMIZING STRESS IN BEAM. ASSUME
 ONE BEAM TAKES 50% OF LOAD. COMBINE 3
 INDIVIDUAL FORCES (F_s) INTO ONE ($3F_s$) AT
 BEAM CENTER.

$$\begin{aligned}
 \text{SEISMIC LOAD} &= \bar{F}_s = 0.5 \text{ (150\% W)} \\
 &= 0.5 (1.5 (20\#)) \\
 &= 15\#
 \end{aligned}$$

(CONSERVATIVE)

ANALYTICAL CALCULATIONS

Page 6 of 12

Subject STRESS CHECK OF B-PLANT SWITCH BOX ASMB
 Originator SCOTT MILLER L. W. Miller Date 9/13/94
 Checker BGM Date 9/16/96

MAXIMUM BENDING MOMENT.

$$\begin{aligned}
 M_{MAX} &= \frac{1}{4} P L = \frac{1}{4} \left(\frac{1}{2} 3 F_s \right) (75") \\
 &= \frac{1}{4} \left(\frac{1}{2} 3 (15\#) \right) (75") \\
 &= 211 \text{ IN} \cdot \text{LBF}
 \end{aligned}$$

$$\sigma_b = \frac{M_{MAX}}{S_{P1000-1}} = \frac{211 \text{ IN} \cdot \text{LBF}}{0.202 \text{ IN}^3} = 1.05 \text{ KSI} \quad (\text{LOW})$$

(P. 25)

MAXIMUM ALLOWABLE MOMENT P1000 = 5080 IN·LBF
 (P. 23)

$$MS_b = \frac{M_{ALL}}{M_{MAX}} - 1 = \frac{5080}{211} - 1 = \text{HIGH}$$

CHECK VERTICAL LOADING, ASSUME VERTICAL
 ACCELERATION OF 0.5g.

$$\begin{aligned}
 F_{AX} &= \frac{1}{2} 3 (150\% W) 1.5 \\
 &= \frac{1}{2} 3 (1.5 (20\#)) 1.5 \\
 &= 67.5\#
 \end{aligned}$$

(P. 25)

ALLOWABLE AXIAL LOAD (P1000) APPLIED AT SLOT
 FACE FOR K=1.0 & 72" UNBRACED HEIGHT

$$F_{AX} = 1970\# \quad (\text{P. 25})$$

$$MS_{AX} = \frac{1970}{67.5} - 1 = \text{HIGH}$$

ECCENTRIC LOADING WILL NOT BE CONSIDERED BECAUSE OF
 LARGE MARGIN.

ANALYTICAL CALCULATIONS

Page 7 of 12Subject STRESS CHECK OF B-PLANT SWITCH BOX ASMBOriginator SCOTT MILLER S.M. Miller Date 9/13/94Checker BSPAL Date 9/16/94CHECK DIAGONAL LEGS AT BASE OF FRAME

ASSUME TOTAL FRAME WEIGHT IS 300 #
INCLUDING 4" X 4" WIREWAY
TOTAL WEIGHT OF FRAME
PLUS SWITCH BOXES,

$$W_{TOT} = 300\# + 3(150\% 20\#)$$

$$\approx 400\#$$

AGAIN, ASSUME 0.5g ACC.

$$F_s = 0.5(400\#) = 200\#$$

ASSUME CG IS AT TOP OF FRAME (CONSERVATIVE)

$$\oplus \sum M = -\frac{\sqrt{2}}{2} 14" (F_B) - \frac{1}{2} 75" F_s = 0$$

$$\Rightarrow F_B = \frac{75"}{\frac{\sqrt{2}}{2} 14"} F_s = 3.8(200\#) = 758\#$$

ALLOWABLE AXIAL^{COMPRESSION} LOAD (P.110) = 1200 #

$$MS_{Ax} = \frac{1200}{758} - 1 = +0.58$$

CHECK BENDING IN VERTICAL MEMBERS (P1001)

$$\oplus \sum F_x = \frac{1}{2} F_s - \frac{\sqrt{2}}{2} F_B - H = 0$$

$$\Rightarrow H = \frac{1}{2}(200) - \frac{\sqrt{2}}{2}(758) = 436 \text{ LBF}$$

ANALYTICAL CALCULATIONS

Page 8 of 12

Subject STRESS CHECK OF BY-LANT SWITCH BOX ASMB
 Originator SCOTT MILLER A. M. MILLER Date 9/13/94
 Checker BOJAL Date 9/16/94

MAXIMUM ALLOWABLE BENDING MOMENT FOR
 D100 I = 14,390 IN-LBF (P. 23)

$$MS_b = \frac{14,390}{6100} - 1 = +1.3$$

CHECK FRAME FOR SEISMIC LOADING (LEFT &
 RIGHT IN FRONT VIEW). ANALYZE AS FRAME.

USE RIGID FRAME
FORMULAS BY A.
 KLEINLOGEL.

$$k_1 = \frac{I_3}{I_2} \frac{h}{l} = \frac{h}{l}$$

$$k_2 = \frac{I_3}{I_2} \frac{h}{l} = \frac{h}{l}$$

$$B = 2k_1 + 3 = 2\left(\frac{h}{l}\right) + 3$$

$$C = 2k_2 + 3 = 2\left(\frac{h}{l}\right) + 3 = B$$

$$N = B + C = 4\left(\frac{h}{l}\right) + 6$$

FIND MAX MOMENT AT B.

$$M_B = H_A h = F_s \left(\frac{C}{N}\right) h = F_s \left(\frac{1}{2}\right) h = \frac{1}{2} (2000) 75''$$

$$M_B = M_C = 7500 \text{ IN-LBF}$$

ANALYTICAL CALCULATIONS

Page 9 of 12
 Subject STRESS CHECK FOR B-PLANT SWITCH BOX 43MB
 Originator Scott Miller & W. Miller Date 9/13/94
 Checker [Signature] Date 9/16/94

MAXIMUM ALLOWABLE MOMENT FOR P1001

$$= 24,390 \text{ NIBF}$$

$$M_{Sb} = \frac{14,380}{\pm 500} - 1 = +0.92$$

CONCLUSION

UNISTRUT FRAME IS STRUCTURALLY
 ADEQUATE FOR SEISMIC LOADING.

CHECK HITI BOLTS FOR SEISMIC LOADS.

CALCULATE TENSION & SHEAR
 BASED ON SAME SEISMIC
 LOADS AS USED IN FRAME
 ANALYSIS.

$$\textcircled{+} \sum M = F_s (4.5'') - (1.7'') T = 0$$

$$\Rightarrow T = \left(\frac{1.7}{4.5}\right) F_s \approx 4 F_s$$

$$= 4(200\#) = 882 \text{ LBF}$$

$$\textcircled{+} \sum F_x = V - F_s = 0 \Rightarrow V = F_s = 200 \text{ LBF}$$

PER SDC 4.2, TABLE 19, FOR 2000 PSI
 CONCRETE (CONSERVATIVE) & MINIMUM EMBEDMENT
 $T_{ALL} = 1.24 \text{ KIP}$, $V_{ALL} = 2.26 \text{ KIP}$

(5/8" HITI W/ 1/2" BOLTS)

ANALYTICAL CALCULATIONS

Page 10 of 12

Subject STRESS CHECK FOR B-PLANT SWITCH BOX ASMB
 Originator SCOTT MILLER A.H. Miller Date 7/13/94
 Checker BSF Date 9/16/94

$$\frac{V_{APL}}{V_{ALL}} + \frac{T_{APL}}{T_{ALL}} \stackrel{?}{\leq} 1.0$$

ASSUME ALL LOAD TAKEN BY 1 HILTI
 (CONSERVATIVE).

$$\frac{200 \text{ LBF}}{2260 \text{ LBF}} + \frac{882 \text{ LBF}}{1240 \text{ LBF}} = 0.79 < 1 \quad \checkmark$$

CONCLUSION

5/8" HILTI KWIK BOLTS WILL PROVIDE A
 LARGE MARGIN OF SAFETY AGAINST FAILURE
 DO TO SEISMICALLY INDUCED LOADS.

PLACEMENT OF HILTI BOLTS

-) HILTI'S SHOULD BE PLACED AT LEAST
 8 1/4" FROM EDGE (TABLE 1.0, SCC 4.2)
-) HILTI'S SHOULD HAVE A MINIMUM SPACING OF
 8" FROM EACH OTHER (TABLE 5.0, SCC 4.2)
-) REBAR SHOULD NOT BE CUT IN INSTALLATION
 PROCESS.
-) HILTI'S SHOULD BE EMBEDDED A MINIMUM OF
 2 3/4" (5 1/2" STANDARD)

SCOTT MILLER L.W. Miller 9/13/94

DWG. MARK UP

SCOTT MILLER S.M. Miller 9/23/94
1 1/2" MIN

DWG MARK-UP