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ANALYSIS OF BRACKET ASSEMBLY FOR DIVERSION BOX LEAK DETECTOR

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Abstract: This Supporting Document Presents Structural and Stress Analysis of a Bracket Assembly for the diversion box leak detectors related to the Cross Site Transfer Project. The results show that the assembly meets the requirements for dead load and natural phenomena hazards loads (seismic and wind).

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ANALYSIS OF BRACKET ASSEMBLY
FOR DIVERSION BOX LEAK
DETECTORS

May 1999

By
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Richland, Washington

For
Lockheed Martin Hanford Corporation
Richland, Washington

CHECKLIST FOR INDEPENDENT REVIEW

Document: Analysis of Bracket Assembly for Diversion Box Leak Detectors

Document No: HNF-4256, Rev. 0

Author: Hassan H. Ziada

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☒	☐	☐	Problem completely defined.
☒	☐	☐	Necessary assumptions explicitly stated and supported.
☐	☐	☒	Computer codes and data files documented.
☒	☐	☐	Data used in calculations explicitly stated in document.
☒	☐	☐	Data checked for consistency with original source information as applicable.
☒	☐	☐	Mathematical derivations checked including dimensional consistency of results.
☒	☐	☐	Models appropriate and used within range of validity or use outside range of established validity justified.
☒	☐	☐	Hand calculations checked for errors.
☐	☐	☒	Code run streams correct and consistent with analysis documentation.
☐	☐	☒	Code output consistent with input and with results reported in analysis documentation.
☒	☐	☐	Acceptability limits on analytical results applicable and supported limits checked against sources.
☒	☐	☐	Safety margins consistent with good engineering practices.
☒	☐	☐	Conclusions consistent with analytical results and applicable limits.
☒	☐	☐	Results and conclusions address all points required in the problem statement.

Larry Julyk
Reviewer

5/5/99
Date

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Originator Harmon H. Zisch Date 3-22-99
Checker S. Jalyk Date 4/19/99

ANALYSIS OF BRACKET ASSEMBLY FOR
DIVERSION BOX LEAK DETECTORS

1.0 INTRODUCTION

This supporting document presents the structural and stress analysis and evaluation of a bracket assembly to support the diversion box leak detectors related to the Cross Site Transfer Project.

This design analysis supports the design modifications provided in Engineering Change Notice (ECN) number 649063 (ECN, 1999) to revise drawing numbers H-2-822507, Rev. 2 (ICF, 1995a) and H-2-822510, Rev. 3 (ICF, 1995b).

1.1 OBJECTIVE

The objective of this analysis is to ensure that the bracket assembly is structurally qualified to withstand the natural phenomena hazards loads (seismic and wind) and dead weight in accordance with basic criteria documents and standards.

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 Originator Hsin H. Zink Date 3-22-99
 Checker J. Gulyk Date 4/19/99

1.2 EVALUATION

The bracket assembly has been evaluated as a Performance Category 3 (PC3) structure.

The bracket is supporting Safety Class Leak detectors. The seismic and wind loads were determined in accordance with basic criteria documents HNF-PRO-097 (HNF, 1997), DOE 6430.1A (1989), UCRL-15910 (1990), ASCE 7-95 (1995), ASCE 4-86 (1986), and UBC (1994).

The structural components were evaluated in accordance with AISC (1989) design stress allowables. The anchor bolts were evaluated in accordance with the load allowables provided in SDC 4-2 (1994).

No credit was taken for the $\frac{1}{3}$ increase of allowables for wind and seismic loads as specified in AISC (1989).

The channels and fittings are made of UNISTRUT⁽¹⁾ (1995) Components.

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(1) UNISTRUT, Trade name of UNISTRUT Metal Framing, UNISTRUT Corporation, Unistrut Diversified Products, Wayne, Michigan.

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2.0 CONCLUSIONS

All components of the bracket assembly meet the requirements for dead load and natural phenomena hazards loads (seismic and wind) in accordance with the requirements of HNF(1997), and the assembly is qualified for use as a PC3 structure.

The structural components were evaluated in accordance with AISC (1989) design stress allowable. The anchor bolts were evaluated in accordance with SDC 4.2 (1994) load allowables.

The structure should be constructed of the following minimum sizes and materials (larger sizes and stronger materials may be used).

- 1- Use minimum five vertical channels. All channels are UNISTRUT P1000 with hole pattern style K0.
- 2- Fitting bolts are $\frac{3}{8}$ -in diameter (minimum), A36 carbon steel with U-shape fitting UNISTRUT P1047.
- 3- Anchor bolts are $\frac{3}{8}$ -in diameter (minimum) with $2\frac{1}{2}$ -in embedment, stainless steel Hilti Kwik-Bolt II.

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3.0 CONFIGURATION AND MATERIAL

The configuration of the assembly is shown in Figure 1. The dimension and weights of the structural components are provided in UNISTRUT (1995).

The material of the structural channels and fittings is ASTM A446, Grade A, pre-galvanized steel (or ASTM A570, Grade 33, Hot-Dipped galvanized or perma-green II) as provided by UNISTRUT.

The yield strength (S_y) of these two materials is 33,000 lb_f/in^2 and the ultimate strength (S_u) is 45,000 lb_f/in^2 (ASTM, 1995).

The fastening screws material is assumed to be ASTM A36 with S_y of 36,000 lb_f/in^2 and S_u of 58,000 lb_f/in^2 .

The anchor bolts are stainless steel Hilti Kwik-Bolt II, $3/8$ -in. diameter with $2\frac{1}{2}$ -in. embedment depth (minimum).

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Figure 1: Bracket Assembly Configuration
(ECN, 1999)

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4.0 CRITERIA AND LOADING

The bracket assembly has been evaluated to withstand dead load and natural phenomena hazards loads (seismic and wind). The assembly is analyzed as a PC3 structure.

4.1 CRITERIA

The structural components have been evaluated in accordance with AISC (1989) allowable stress design. SDC 4.2 (1994) provides the load allowables for the anchor bolts.

No credit was taken for the $\frac{1}{3}$ increase of allowables for seismic and wind loads (AISC, 1989).

4.2 ALLOWABLE STRESSES AND LOADS

4.2.1 Channels.

The channels are carbon steel ASTM A446 GRA. They are bent around their weak axis (1-1).

(P1000)

$$I_{11} = 0.185 \text{ in}^4, S_{11} = 0.202 \text{ in}^3$$

$$I_{22} = 0.236 \text{ in}^4, S_{22} = 0.29 \text{ in}^3$$

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The allowable bending stress around the weak axis is obtained from AISC(1989).

$$\sigma_{ball} = 0.75 \times S_y = 0.75 \times 33,000 = 24,750 \text{ lb}_f/\text{in}^2$$

This value is ^{more} conservative than the allowable given in UNISTRUT (1995).

The allowable moment in UNISTRUT (1995) for P1000 is 5,080 in-lb_f, the modulus of section (S_{11}) is 0.202 in³, this gives an allowable bending stress ($\frac{M_{all}}{S_{11}}$) of 25,148 lb_f/in².

However, for conservatism, the channels are considered as noncompact sections.

The allowable bending stress for noncompact section is $0.6 \times S_y$.

$$\sigma_{ball} (\text{noncompact}) = 0.6 \times 33,000 = 19,800 \text{ lb}_f/\text{in}^2$$

This allowable is used for evaluation.

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4.2.2 Fittings

The fittings are made of the same material of the channels. The allowables are the same as the channel allowable stresses.

However, the UNISTRUT (1995) provides design load data for several channel connections, the U-shape fitting (P1047) has an effect equivalent to fitting P1026 or plate plate fitting P1065 (see page 81 of UNISTRUT). The load capacity of these two fittings is 1000 lbf. The load capacity of U-shape P1047 fitting may be stronger. For conservatism, Load capacity of P1047 = 1,000 lbf.

4.2.3 Hilti Kwik-Bolt II

The allowable loads for stainless steel Hilti Kwik-Bolt II ($\frac{3}{8}$ -in diameter, $2\frac{1}{2}$ -in. embedment depth) and concrete compressive strength of 2,000 lbf/in² are obtained from SDC 4.2 (1994), Table 14.

Maximum allowable tensile load = $T_{max} = 870 \text{ lbf}$

Maximum allowable shear load = $V_{max} = 1,000 \text{ lbf}$

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The anchor bolts should satisfy the following criteria.

$$\frac{V_{\text{applied}}}{V_{\text{allowable}}} + \frac{T_{\text{applied}}}{T_{\text{allowable}}} \leq 1.0$$

4.2.4 Fitting screws

The screws are assumed to be made of ASTM A36. The allowable stresses are given in AISC (1989)

$$\begin{aligned} \text{Allowable tensile stress} &= 0.33 \sigma_u \\ &= 0.33 \times 58,000 \\ &= 19,140 \text{ lbf/in}^2 \end{aligned}$$

$$\begin{aligned} \text{Allowable shear stress} &= 0.17 \sigma_u \\ &= 9,860 \text{ lbf/in}^2 \end{aligned}$$

Assuming the shear force is carried in the thread area.

UNISTRUT (1995) provides maximum allowable load as follows (for 3/8-in. screw, pag 69):

Maximum allowable pull-out strength = 1,000 lbf

Maximum resistance slip load = 800 lbf

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4.3 LOADS

This section presents the weights and areas of the assembly. It also includes the calculations for wind and seismic loads.

4.3.1 Weights

Box weight = 21 lb_f

Equipment inside box (Assumed weight) = 9 lb_f

Total box weight 30 lb_f

Weight of four boxes $= 4 \times 30 = 120 \text{ lb}_f$

Weight of P1000 channels $= \frac{5 \times 60 + 4 \times 92 + 1 \times 46}{12} \times 1.9 = 113 \text{ lb}_f$

Assume fittings weight (20% of channels) = 23 lb_f

Total weight = 256 lb_f →

The center of gravity of the total weight is assumed to be at the center of the leak detectors boxes (Conservative). This is at a height of 52-in. above the lower anchor bolts.

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4.3.2 Areas

The bracket assembly is considered as an open sign according to the definitions of ASCE 7-95 (1995).

$$\text{Gross area } A_g = \frac{60 \times 92}{144} = 38.3 \text{ ft}^2$$

Total estimated solid projected area

$$A_f = \text{Box area} + \text{approximate channel and conduit areas.} \\ = \frac{4(14 \times 16)}{144} + \frac{(5 \times 60 + 4 \times 92 + 2 \times 46) 1.625}{144} = 14.8 \text{ ft}^2$$

4.1" / including conduits

$$\text{Open area} = 38.3 - 14.8 = 23.5 \text{ ft}^2 (>30\% \text{ of } A_g, \text{ open sign})$$

$$C = \text{Ratio of solid area / gross area} = \frac{14.8}{38.3} = 0.39$$

Ratio of height / width above ground < 6

4.3.3 Seismic Loads

The seismic load for PC3 structure has been calculated in accordance with

HNF-PRO-097 (HNF, 1997), ASCE 4-88 (1988), and UBC (1994).

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HNF(1997) specifies 4 percent damping for friction bolted metal structures (Table 8).

The response spectra for PC3 in 200 areas are given in Table 6 of HNF(1997).

The peak horizontal and vertical accelerations at 4 percent damping were obtained by interpolation between the 2 percent and 5 percent response spectra (approximation).

<u>Damping</u>	<u>Horizontal Acceln.</u>	<u>Vertical Acceln.</u>
2 %.	0.76	0.49
5 %.	0.58	0.37
4 %.	0.64	0.41

The combined peak acceleration per HNF(1997) is horizontal response spectrum + 0.4 of vertical spectrum. ASCE 4-86 (1986) specifies that a factor of 1.5 is to be applied to the peak acceleration of the simple-multi-degree-of-freedom models to obtain the equivalent static load.

$$\text{Seismic load} = 1.5(0.64 + 0.4 \times 0.41) \times 256 = \underline{309 \text{ lbf}}$$

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4.3.4 Wind Load

The wind load for PC3 (Safety Category) was calculated in accordance with HNF (1997) and ASCE 7-95 (1995).

$$q_z = 0.00256 K_z K_{zt} V^2 I$$

$I = 1.0$ importance factor, PRO-097 (1997).

$V = 100$ MPH Gust wind, PRO-097 (1997).

$K_z = 0.85$ For exposure category C, ASCE (1995).
(Table 6-3)

$K_{zt} = 1.0$ Section 6.5.5, ASCE (1995)

$$q_z = 0.00256 \times 0.85 (100)^2 \times 1.0 = 21.76 \text{ lb/ft}^2$$

Wind Force:

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$$F = q_z G C_f A_f$$

$G = 0.85$ For exposure category C, ASCE (1995),
Section 6.6.1.

$C_f = 1.6$ For solid area/gross area between 0.3 to 0.7
Table 6.9, ASCE (1995).

$$F = 21.76 \times 0.85 \times 1.6 \times 14.8 = \underline{438} \text{ lb}$$

Wind load governs.

$> 309 \text{ lb}$ seismic

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5.0 ANALYSIS

The bracket assembly has been analyzed for dead weight and wind load. The stresses were evaluated in accordance with AISC (1989) and compared to the load allowables of UNISTRUT (1995). The anchor bolts were evaluated in accordance with the load capacities of SDC 4.2 (1994).

The dimensions and loads are shown in Figure 1.

5.1 CHANNELS (P1000)

The maximum bending moment developed in the vertical channels is reacted at the upper anchors (point A in Figure 1).

$$\begin{aligned} \text{Moment about A} &= 438 \times 40 + 255 \times 6.25 \\ &= 19,114 \text{ in-lbf} \end{aligned}$$

$$\text{Bending stress } \sigma_b = \frac{MA}{5S_{xx}} \quad (5 \text{ channels})$$

$$\sigma_b = \frac{19,114}{5 \times 0.202} = 18,925 \text{ lbf/in}^2$$

Less than σ_b allowable $\leq 19,800 \text{ lbf/in}^2$

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5.2 FITTING SCREWS (3/8-in Diameter)

The bolt distances for the U-shape fitting are shown on the figure (on the right).

Assume the upper five fittings react the moment developed at the lower fittings (point B)

$$M_B = 5 F_A \times 12$$

$$438 \times 52 + 256 \times 6.25 = 5 F_A \times 12$$

$$F_A = 406 \text{ lbf}$$

Take moment about point O to get the load on edge screws (F_1). Use half of F_A for one side

$$\frac{F_A}{2} \times 2.6875 = 0.8 F_1$$

$$F_1 = \frac{406/2 \times 2.6875}{0.8} = 682 \text{ lbf}$$

$$\text{Area of } 3/8" \text{ screw} = \frac{\pi}{4} \left(\frac{3}{8} \right)^2 = 0.11 \text{ in}^2$$

P1047

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$$\text{Bolt tensile stress } \sigma_t = \frac{682}{0.11} = 6,204 \text{ lb}_f/\text{in}^2$$

Less than bolt tensile stress allowable $< 19,140 \text{ lb}_f/\text{in}^2$

The screw load of 682 lb_f is less than the design loads of the 1,000 lb_f pull-out load and the 800 lb_f slip load.

5.3 U-SHAPE FITTING (P1047)

The maximum load on any U-shape fitting will not exceed 682 lb_f. This load is less than the fitting design load of 1,000 lb_f (see section 4.2.2).

5.4 ANCHOR BOLTS

Assume four sets of anchor bolts (total 8) are used to support the structure, and the upper four anchor bolts react the moment around point B₁ (at the wall).

$$M_{B_1} = 4 F_{tb} \times 12$$

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$$438 \times 52 + 256 \times 7.875 = 4 F_{tb} \times 12$$

$$F_{tb} = 517 \text{ lbf}$$

$$F_v = \frac{256}{8} = 32 \text{ lbf}$$

$$F_T = 870 \text{ lbf}$$

$$F_v = 1,000 \text{ lbf}$$

} section 4.2.3

$$\frac{32}{1,000} + \frac{517}{870} = 0.63 < 1.0$$

Anchor bolts are acceptable.

6.0 OPEN ITEMS

There are no open Items related to this analysis.

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