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		Date 11/9/94
Project Title/Work Order ANALISYS OF K-1 FAN SYSTEM FOR REPLACEMENT OF VALVE ACTUATOR, B PLANT/WASTE ECAPCULATION AND STORAGE FACILITY/KB222		EDT No. 142185
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Document Title: ANALYSIS OF K-1 FAN SYSTEM FOR REPLACEMENT OF VALVE ACTUATOR, B PLANT/WASTE ENCAPSULATION AND STORAGE FACILITY

Release Date: 12/29/94

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APPROVED FOR PUBLIC RELEASE

WHC Information Release Administration Specialist:

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12/29/94

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2. Title

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Signature

Organization/Charge Code 8D430/KB222

7. Abstract

Components of the K-1 fan system were evaluated for structural adequacy to accommodate an actuator weighing approximately 540 lb. The components evaluated were the connectors between the actuator and the valve, the duct between the valve and the facility wall, and the stud anchors connecting the duct to the facility wall. The loads applied were deadload, snow, operating loads, and seismic loads. The components were found to be structurally adequate for these loads.

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9. Impact Level SQ

ANALYSIS OF K-1 FAN SYSTEM FOR REPLACEMENT OF VALVE ACTUATOR,
B PLANT/WASTE ECAPSULATION AND STORAGE FACILITY

November 1994

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CHECKLIST FOR INDEPENDENT REVIEW

Document Reviewed WHC-SD-WM-ANAL-038, REV. 0

Author J. S. Burgess

Yes No NA

☒	☐	☐	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.

MANDATORY Software QA Log Number _____

B. D. Flanagan
Reviewer - B. D. Flanagan

11/28/94
Date

DESIGN VERIFICATION METHOD

The need for design verification has been reviewed with the method selected as indicated below: (ESR/Work Plan # 325).

<u> X </u>	Independent Review
<u> </u>	Alternative Calculations
<u> </u>	Qualification Testing
<u> </u>	Formal Design Review

R. B. Pan
Cognizant/~~Project~~/Design Manger

SD # WHC-SD-WM-ANAL-038, REV. 0

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DWG(S) #

CONTENTS

	<u>Page</u>
1.0 INTRODUCTION	1
2.0 SUMMARY.	1
3.0 DISCUSSION	1
4.0 ASSUMPTIONS	4
5.0 REFERENCES	4

TABLES

TABLE 1 APPLIED LOADS	2
TABLE 2 MODEL COMPONENTS	3

APPENDICES

APPENDIX A ENGINEERING CALCULATIONS	A-1
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ANALYSIS OF K-1 FAN SYSTEM FOR REPLACEMENT OF VALVE ACTUATOR, B PLANT/WASTE ENCAPSULATION AND STORAGE FACILITY

1.0 INTRODUCTION

The purpose of this task was to evaluate the structural capacity of the K-1 fan system in the B Plant/Waste Encapsulation and Storage Facility (WESF). The purpose of the evaluation was done to accommodate the replacement of a valve actuator. The existing actuator will be replaced with a model that is approximately 100 lb heavier. This increase in weight led to a concern that the fan system would not adequately support the new actuator.

2.0 SUMMARY

Components of the K-1 fan system were evaluated for structural adequacy to accommodate an actuator weighing approximately 540 lb. The components evaluated were the connectors between the actuator and the valve, the duct between the valve and the facility wall, and the stud anchors connecting the duct to the facility wall. The loads applied were deadload, snow, operating loads, and seismic loads. The components were found to be structurally adequate for these loads.

3.0 DISCUSSION

The fan system was analyzed as a safety class 3 item. The appropriate loads and load combinations for a safety class 3 item are shown in Table 1.

Table 1. Applied Loads.

Load	Value (lbf)	Reference
Deadload	540	Biffi, 1994
Snow	10	SDC 4.1
Operating	675	SDC 4.1
Wind	60	AISC 7-93
Seismic	204.12	SDC 4.1

These loads were applied at the center of gravity (CG) of the actuator. The CG was assumed to be at the same elevation as the location of the lifting lug and at the centerline of the body. The operating load was modeled as an impact load from the motion of the actuator (125% of the deadload). The loads were combined and applied to the fan components as shown in Table 2.

Table 2. Fan System Components.

Component	Description (number, size, material)
Bolts connecting actuator to valve	4, 1/2-in. dia., A307
Duct	36-in. dia., 16 gauge stainless
Concrete Anchors	4, 1/4 by 2 11/16 in.
Concrete wall	3000 lbf/in ² (strength)

4.0 ASSUMPTIONS

Many of the components lacked definitive design drawings or specifications. Because the lack of information, the following assumptions were made:

- The duct is as called out in the design specification (36-in. diam, 16 gage)
- The concrete stud anchors are equal or greater than 1/4 x 2 11/16:
- The connectors used are A307 or better.

Even with these assumptions the system was found to be structurally adequate for the loads evaluated.

5.0 REFERENCES

- AISC, 1989, *Manual of Steel Construction, Allowable Stress Design*, Ninth Edition, American Institute of Steel Construction, Inc., Chicago, Illinois.
- Biffi, 1991, *Algas Pneumatic Actuators*, Vendor Catalog, Keystone Controls Inc., Houston, Texas.
- DOE-RL 1993, *Standard Architectural-Civil Design Criteria, Design Loads for Facilities*, Hanford Plant Standard SDC-4.1, Revision 13, U.S. Department of Energy, Richland Field Office, Richland, Washington.
- TRW 1977, *Embedment Properties of Headed Studs*, Construction Design Data, TRW Nelson Division, Elyria, Ohio.
- UCRL-1990, *Design and Evaluation Guidelines for U.S. Department of Energy Facilities Subjected to Natural Phenomena Hazards*, UCRL-15910, University of California Research Laboratory, Livermore, California.
- UBC 1988, *Uniform Building Code*, International Conference of Building Officials, Whittier, California.
- Vitro 1971, *Specification for Waste Encapsulation and Storage Facility*, 200 East Area, Building 225-B, Project HAP-631, HWS-8951, Vitro Corporation of America, Richland, Washington.

APPENDIX A

ENGINEERING CALCULATIONS

DESIGN CALCULATION

- (1) Drawing (2) Doc. No. (3) Page 1 of 6
(4) Building (5) Rev. (6) Job No.
(7) Subject B-PLANT ACTUATOR
(8) Originator J.S. BURGESS Date 11/9/94
(9) Checker B.D. Date 11/14/94

(10)

PURPOSE: EVALUATE THE K-FAN SYSTEM COMPONENTS
FOR USE WITH A HEAVIER ACTUATOR

DESIGN LOADS: [SDC 4.1]

Dead load
Live load
Snow
Soil
Operating
Extr wind
Seismic

0.125% UCL -> 0.125%
0.125% UCL -> 0.125%
0.125% UCL -> 0.125%
0.125% UCL -> 0.125%
0.125% UCL -> 0.125%

DL = 5/10"

SDC 4.1
 $P_g = 0.7 A C I P_g$
 $P_g = 0.7(1)(1.2)(1)(17)$
 $P_g = 12.6 \text{ psf}$
 $P_g = 15 \text{ psf SDC 4.1 (p.18)}$
 $C_e = 1.0 \text{ TABLE 12}$
 $C_t = 1.2 \text{ TABLE 19}$
 $I = 1.0 \text{ SDC 4.1 (WIND)}$

Diagon of act = 12' = 1'
 $F_{sh} = 12.6 (\pi) (1)^2 = 10.16 \text{ k}$

SDC 4.1
CONSIDER IMPACT AS ACTUATOR OPERATES
 $F_{op} = 1.25 (540) = 675 \text{ lb}$

$W = F = g_2 g_2 C_p A_g$ [TABLE 4] [ASCE 7-92]

$g_2 = 0.00256 K_2 (I)^2$
 $= 0.00256 (0.80) (1.0 \cdot 70)^2$
 $g_2 = 10.03$
 $g_2 = 10.03$
 $F = 10.03 (1.22) (1.0) (1.5)$
 $F = 60 \text{ lb}$

SE $F_{se} = 1.5 (0.6) (0.42) (540)$ [SDC 4.1 TABLE 2]

$F_{se} = 204.12 \text{ lb}$

A-2

DESIGN CALCULATION

WHC-SD-WM-ANAL-038

Rev. 0

(1) Drawing _____ (2) Doc. No. _____ (3) Page 2 of 6
 (4) Building _____ (5) Rev. _____ (6) Job No. _____
 (7) Subject B-PLANT ACTUATOR
 (8) Originator J.S. BURGESS Date 11/9/94
 (9) Checker B.D. FLYNN Date 11/14/94

(10)

USE LOAD CASE $P = DL + SU + OP + SE$
 $\begin{matrix} SE \\ \nearrow \\ SE > W \end{matrix}$

SCHEMATIC

DESIGN CALCULATION

WHC-SD-WM-ANAL-038

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(1) Drawing _____ (2) Doc. No. _____ (3) Page 3 of 6
 (4) Building _____ (5) Rev. _____ (6) Job No. _____
 (7) Subject B-PLANT ACTUATOR
 (8) Originator J.S. BURGESS Date 11/9/91
 (9) Checker B.D. Flanagan Date 11/14/94

(10)

EVALUATE BOLTS CONNECTING ACTUATOR TO VALVE

- FIELD MEASUREMENTS INDICATE THAT
 4-1" ϕ HEX HEAD BOLTS WERE USED.

BOLT (B) HAS HIGHEST REACTION.

SHEAR $\Rightarrow$ DIRECT $\Rightarrow R_x = \frac{1}{4} SE = \frac{1}{4} (204) = 51$
 $R_y = \frac{1}{4} (DL + OP + SW) = \frac{1}{4} (540 + 10 + 675) = 306.25$

TENSION $\Rightarrow$ BENDING $\Rightarrow 16(SE) + 16(DL + OP + SW) = 2 R_B (7.5) + 2 R_B (8.75)$
 $16(204) + 16(540 + 10 + 675) = [2(7.5) + 2(8.75)] R_B$
 $R_B = 703.5 \text{ lbs}$

SHEAR $\Rightarrow$ TWISTING $\Rightarrow R_T = \frac{SE(1/2)}{\frac{2x^2 + 2y^2}{2(3.25)^2 + 2(1.325)^2}} = 24.576$

$R_x = R_T(\frac{y}{x}) = 24.576(4.375) = 107.52$

$R_y = R_T(x) = 24.576(3.75) = 92.16$

$R_B(\text{shear}) = [(R_{xT} + R_x(\text{dir}))^2 + (R_{yT} + R_y(\text{dir}))^2]^{1/2}$
 $= [(51 + 107.52)^2 + (306.25 + 92.16)^2]^{1/2}$

$R_B(\text{shear}) = 428.79 \text{ lbs}$

$T = \frac{R_B(\text{tension})(4)}{\pi(1)^2} = \frac{703.5(4)}{\pi} = 895.7 \text{ psi}$

$T = \frac{R_B(\text{shear})(4)}{\pi(1)^2} = \frac{428.79(4)}{\pi} = 546 \text{ psi}$

$T_{all} = 20 \text{ ksi}$ $T_{all} = 10 \text{ ksi}$ [AISC]

$\therefore$ Bolts are o.k.

$T = \frac{896}{20000} + \frac{546}{10000} = 0.09 < 1$

(1) Drawing _____ (2) Doc. No. _____ (3) Page 4 of 6
 (4) Building _____ (5) Rev. _____ (6) Job No. _____
 (7) Subject B-PLAN ACTUATOR
 (8) Originator J.S. BURGESS Date 11/3/94
 (9) Checker JD 72 Date 11/14/94

(10)

EVALUATE DUCT BENDING @ A

$$\sigma_B = \frac{M}{S}$$

$$M = (DL+OP+SN)(22) + SE(4)$$

$$t_{min} = 0.0595 \text{ [AISC-B2]}$$

$$M = (540 + 10 + 675)(22) + (204)(4)$$

$$M = 27766 \text{ in-lb} \quad S = \frac{I}{C} = \frac{\frac{1}{4} \pi (18.055^4 - 13^4)}{18.0555} \\ S = 61 \text{ in}^3$$

$$\sigma_B = \frac{27766}{61} = 455 \text{ PSI}$$

BEARING @ A

$$\sigma_c = \frac{SE}{A} \quad SE = 204 \\ A = \pi(r_o^2 - r_i^2) \\ A = 6.774 \text{ in}^2$$

$$\sigma_c = \frac{204}{6.8} = 30.11 \text{ PSI}$$

SHEAR @ A

$$\tau = \frac{DL+OP+SN}{A} \\ = \frac{540 + 10 + 675}{6.8}$$

$$\tau = 181 \text{ PSI}$$

TORSION @ A

$$\tau = \frac{T}{J} \quad T = DL+OP+SN(39.675) \\ = (540 + 10 + 675)(39.675) \\ T = 48602 \text{ in-lb}$$

$$\tau = \frac{48602}{122}$$

$$\tau = 399 \text{ PSI}$$

$$S_T = \frac{J}{C} = \frac{2I}{C}$$

$$S_T = 122$$

$$S_T = 122$$

$$F_s = [\sigma_B + \sigma_c + \tau + \tau_T]^{1/2}$$

$$F_s = [(455 + 30)^2 + (181 + 399)^2]^{1/2}$$

$$F_s = 756 \text{ PSI}$$

$$F_{all} = 16 \text{ KSI [AISC B2]}$$

$$MS = \frac{16000}{765} - 1 = 20 \therefore \text{O.K.}$$

(1) Drawing _____ (2) Doc. No. _____ (3) Page 5 of 6
 (4) Building _____ (5) Rev. _____ (6) Job No. _____
 (7) Subject B-PLANT ACTUATOR
 (8) Originator J.S. BURGESS Date 11/19/94
 (9) Checker B.D. Thompson Date 11/14/94

(10)

EVALUATE CONCRETE ANCHORS

- DUE TO LACK OF INFO THE ANALYSIS WILL BE REVERSE ENGINEERED.
- ASSUME 4 STUDS
- CONCRETE STRENGTH GIVEN AS 3 KSI
- ANCHORS CARRY SHEAR ONLY
- STRESSES CALCULATED FOR DUCT ARE REACTED @ ANCHORS

DIRECT SHEAR

$$R_5 = \frac{1}{4}(SE) + \frac{1}{2}(DL+OP+SN) = \frac{1}{4}(204) + \frac{1}{2}(540+10+675)$$

$$R_5 = 633.5$$

BENDING

$$\Sigma M_A \Rightarrow 2R_5(18) = (DL+OP+SN)(18) + SE(4)$$

$$R_5 = \frac{(540+10+675)(18) + 204(4)}{18(2)}$$

$$R_5 = 635.17$$

TENSION

$$\Sigma M_A \Rightarrow 4R_5(18) = (DL+OP+SN) 34.675$$

$$R_5 = \frac{(540+10+675) 34.675}{4(18)}$$

$$R_5 = 590$$

$$R_{5\text{ TOTAL}} = 633.5 + 635.17 + 590 = 1859.16$$

DESIGN CALCULATION

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Rev. 0

(1) Drawing _____ (2) Doc. No. _____ (3) Page 6 of 6
 (4) Building _____ (5) Rev. _____ (6) Job No. _____
 (7) Subject B. PLANT ACTUATOR
 (8) Originator J. S. BURGESS Date 11/9/94
 (9) Checker B. D. FLYNN Date 11/14/94

(10)

CONCRETE ANCHORS CONT.

ASSUMING THE SMALLEST ANCHOR AVAILABLE WAS USED ($\frac{1}{4}$ " $\times$ 2" $\frac{1}{16}$ ") THE CONCRETE SHEAR ALLOWABLE MAY BE MET. BECAUSE THESE ASSUMP. ARE CONSERVATIVE AND THE CONC. ALLOWABLE IS NOT EXCEEDED THE SYSTEM IS O.K.