LOFT TECHNICAL REPORT LTR 1310-23
RE & C REPORT NUMBER RE-A-77-153
MARCH 24, 1978

SEISMIC STRESS ANALYSIS OF FEEDER LINES TO LOFT PRIMARY COOLANT PUMP MOTORS

C. J. Kuehster

EG&G Idaho, Inc.

IDAHO NATIONAL ENGINEERING LABORATORY

DEPARTMENT OF ENERGY

IDAHO OPERATIONS OFFICE UNDER CONTRACT EY-76-C-07-1570

DISCLAIMER

FORM EG&G-1916
(Rev. 6-77)

LOFT TECHNICAL REPORT LTR 1310-23
RE&C Report # RE-A-77-153
DATE March 24, 1978
WORK REQUEST NO.

RESEARCH, ENGINEERING AND CONSTRUCTION REPORT
ENGINEERING ANALYSIS DIVISION

APPLIED MECHANICS BRANCH

SEISMIC STRESS ANALYSIS OF FEEDER LINES
TO LOFT PRIMARY COOLANT PUMP MOTORS

C. J. Kuehster/ C. J. Kuehster
AUTHOR

CHECKED BY: R. G. Rahl/ R G Rahl APPROVED BY: C. A. Moore/ CA Moore 12/27/77

EG&G Idaho, Inc.

FORM EG&G-229
(Rev. 12-76)

LOFT TECHNICAL REPORT
LOFT PROGRAM

TITLE SEISMIC STRESS ANALYSIS OF FEEDER LINES TO LOFT PRIMARY COOLANT PUMP MOTORS	REPORT NO. LTR 1310-23
	RE-A-77-153
AUTHOR C. J. Kuehster	GWA NO.
PERFORMING ORGANIZATION Applied Mechanics Branch	DATE
LOFT APPROVAL PSB Mgr. P&CSB Mgr. RSB Mgr.	March 24, 1978

ABSTRACT

The conduit system in the LOFT Support Building was analyzed for seismic loading. The conduit itself plus its various supports were subjected to both horizontal and vertical forces. The results show the system loads or stresses to be within allowables.

CONTENTS

SEISMIC STRESS ANALYSIS OF FEEDER LINES TO LOFT PRIMARY COOLANT PUMP MOTORS

I. INTRODUCTION

The conduit from PSMG-A and PSMG-B to the primary pumps is located in the TAN LOFT support buildings. The conduit restraints include 1/2" allthread hangers combined with P1001 channels and P3200 concrete inserts, P1000 channels, P4000 channels, and malleable cast iron straps.

II. LOADING CONDITIONS

Seismic accelerations are calculated using 4% damping curves for LOFT[1]. Levels of LOFT facilities below ground are considered to respond to ground motion. These accelerations are less than 1G for 4% damping. Horizontal and vertical loads were calculated. Forces are calculated according to Ref. 1 in Appendix A.

1. VERTICAL LOADING

Vertical loading consists of conduit weight plus seismic acceleration. The weight of channels and straps is considered negligible. Vertical conduit is assumed to be supported at fixed ends (such as PBX) but not at channels. The system was found to be satisfactory for vertical loading.

2. HORIZONTAL LOADING

The horizontal conduit, attached to the ceiling with hangers, is assumed to be supported at PSMG and wall.

The sealtite flexible conduit is assumed to be able to withstand both the horizontal and vertical loading without damage.

III. RESULTS

Using either given allowables or those from AISC Manual[2], the stresses in all parts of the system are within stated limits.

For the conduit, the allowable stress is used to find the allowable length. For both the horizontal and vertical loadings, the allowable length is greater than the actual.

The actual stresses or loads in the supports, as compared to the allowables, are as follows:

Support	Type	Actual	Allowable
Hangers	Vertical Stress	8.1 ksi	15.55 ksi
	Horizontal Stress	19.2 ksi	22.66 ksi
P1001	Vertical Load	927 lb/ft	1690 lb/ft
P3200	Vertical Load	1156 lb/ft	2000 lb/ft
P1000	Horizontal Stress	10.7 ksi	18 ksi
	Vertical Stress	.89 ksi	16 ksi
P1010 Nuts	Slip Load	123 lb	1500 lb
	Pull Out Load	70 lb	2000 lb
Cast Iron Straps	Vertical Stress	1.45 ksi	22 ksi
P4000 Channel	Horizontal Stress	8.75 ksi	17.68 ksi
	Bolt Load	82.5 lb/bolt	1000 lb/bolt
	Vertical Stress	1.1 ksi	16 ksi
	Bolt Load	126.5 lb/bolt	1000 lb/bolt.

IV. CONCLUSIONS

The system, consisting of conduit and various supports, is satisfactory when subjected to seismic loading.

V. REFERENCES

1. V. W. Gorman and R. C. Guenzler, "LOFT SSE Definition and Seismic Analysis Methods", LOFT Technical Report LTR 10-19, October 8, 1974.

2. American Institute of Steel Construction, Steel Construction Manual, Seventh Edition, 1971.

APPENDIX A

CALCULATIONS

FORM INEL-1592
(Rev. 4-76)

IDAHO NATIONAL ENGINEERING LABORATORY

CALCULATION WORK SHEET

SUBJECT ____ DATE ____

PREPARED BY ____ CHECKED ____ WORK REQUEST ____

Peak response spectrum acceleration for the LOFT site is 19.5 ft/sec² as shown in reference 1.

Maximum ground acceleration is 2/3's horizontal acceleration acting up or down. The hangers prevent conduit moving up or down but not sideways. Channels on vertical sections prevent horizontal but don't contribute vertical support. Straps prevent BOTH horizontal & vertical motion.

RDT-F9-2T

Levels of LOFT facilities below ground are considered to respond as ground motion, therefore;

$$A = 1.5 \times A_s$$

where

A = resulting acceleration
A_s = peak ground motion acceleration from response spectrum

$A_H = (1.5) \times 19.5\ ft/sec^2$
$= 29.12\ ft/sec^2$
$= .91G$

$A_V = 2/3\ A_H$
$= .61G$

FORM INEL-1592
(Rev. 4-76)

IDAHO NATIONAL ENGINEERING LABORATORY

LTR 1310-23

CALCULATION WORK SHEET

SUBJECT ____ DATE ____

PREPARED BY ____ CHECKED ____ WORK REQUEST ____

THE FOLLOWING ANALYSIS BREAKS THE CONDUIT SYSTEM DOWN SUCH THAT THE CONDUIT AND THE DIFFERENT TYPES OF SUPPORTS WERE ANALYSED SEPARATELY. THE FOLLOWING INFORMATION WAS USED:

RIGID 4" STEEL CONDUIT $WT = 972\#/100'$; $\sigma_{ALLOWABLE} = 36^{KSI}$

$d_i = 4.026\,IN$, $d_o = 4.5\,IN$

$I = \frac{\pi(d_o^4 - d_i^4)}{64} = 7.5\,IN^4$, $c = 4.5/2 = 2.25\,IN$

CABLE $WT = 1882\#/1000'$

SINCE THE CABLE IS NOT ATTACHED TO THE CONDUIT ITS MOMENT OF INERTIA WAS NOT CONSIDERED

HANGERS

1/2" ALL THREAD, $A_{TENSILE} = 0.142\,IN^2$

ASSUME ALLOWABLE 36^{KSI}, TENSILE STRESS FROM AISC 1.5.1.1 $F_T = 0.6F_y = 22^{KSI}$

ALLOWABLE BENDING STRESS AISC 1.5.1.4.1

$F_b = 0.66F_y = 24^{KSI}$; THIS ALLOWABLE CAN BE INCREASED BY 1/3 ACCORDING TO AISC 1.5.6 SO THAT $F_b = 32^{KSI}$

P1000 BRACKET

STRESS RECOMMENDED IS $25000\#/IN^2$ WITH UNIFORM LOAD $1690\#/FT$

STRENGTH OF P1010 NUTS

RESISTANCE TO SLIP 1500 #/BOLT

PULL OUT STRENGTH 2000 #/BOLT

$I = .186\,IN^4$, $c = r/2 = .579/2 = .289$

$A = .555\,IN^2$

P3200 SERIES CONTINUOUS INSERTS

ALLOWABLE GIVEN AS 2000#

FORM INEL-1592
(Rev. 4-76)

IDAHO NATIONAL ENGINEERING LABORATORY

CALCULATION WORK SHEET

SUBJECT ______ DATE ______

PREPARED BY ______ CHECKED ______ WORK REQUEST ______

P4000 CHANNEL

STRESS RECOMMENDED IS 25000#/IN² WITH UNIFORM LOAD 420#/FT

STRENGTH OF P4010 NUTS

RESISTANCE TO SLIP 1000#/BOLT

PULL OUT STRENGTH 1000#/BOLT

$I = 0.022 \quad c = r/2 = .31/2 = .16\,\text{IN}\ ; A = .230$

ALL ALLOWABLE STRESSES MULTIPLIED BY .707 TO COMPENSATE FOR STRESS INTENSITY.

I. CONDUIT

ASSUME HANGERS & BRACKETS

$w = (\text{CONDUIT WT} + \text{CABLE WT})$

$= 972/100 + 1882/1000 = 11.6\ \#/\text{FT}$

$\sigma_{H,V} = .707\,\sigma_{ALL} = 0.707 \times 36^{KSI} = 25.45^{KSI}$

CALCULATE ALLOWABLE LENGTH & COMPARE TO ACTUAL

$\sigma_H = \frac{M_H c}{I} \qquad M_H = .1 w_H \ell^2 \qquad$ (AISC 2-2.10, 36.)

$w_H = 11.6 \times .91 = 10.56\ \#/\text{FT}$

$\sigma_H = \frac{.1 \times 10.56\#/\text{FT} \times \text{FT}/12\text{IN} \times \ell^2 \times 2.25\text{IN}}{7.50\text{IN}^4} = 0.03\,\ell^2$

$0.03\,\ell^2 = 25450^{PSI}, \quad \ell = 928^{IN} = 82^{FT}$

ALL LENGTHS ARE LESS THAN 82^FT

∴ SATISFACTORY FOR ALL HORIZONTAL LOADING

$\sigma_V = \frac{M_V c}{I}\ ; M_V = .1 w_V \ell^2$

$w_V = 11.6\#/\text{FT} \times 1.61 = 18.68\ \#/\text{FT}$

SUBJECT ____ DATE ____

PREPARED BY ____ CHECKED ____ WORK REQUEST ____

$$\sigma_v = \frac{18.68 \times .1 \times \ell^2 \times 2.25 \times 1/12}{7.5} = 0.05\ell^2$$

$$0.05\ell^2 = 25450^{PSI} \quad \ell = 738^{IN} = 62^{FT}$$

SATISFACTORY FOR VERTICAL LOADING

II HANGERS

VERTICAL LOADING

$R_B = 1.10w\ell = 1.10 \times 18.68 \times 56 = 1151^{\#}$ (AISC 2-210, 36.)

R_B REFERS TO VERTICAL REACTION

$\sigma_{ACTUAL} = \frac{P}{A} = 1151 / 0.142 = 8.1 < .707 \times 22 = 15.55^{KSI}$

HORIZONTAL; THE 4% DAMPING USED IN THE MAJORITY OF THIS ANALYSIS IS CONSERVATIVE; BUT 7% CAN BE USED SINCE IT IS A BOLTED STRUCTURE

FROM THE RESPONSE SPECTRUM, FOR 7% DAMPING $A_S = 16^{FT}/SEC^2$

THEREFORE $A_H = 1.5 \times 16^{FT}/SEC^2$
$= 0.75$

$w = 10.56 \times 0.75 = 7.87^{\#}/FT$

$M = .1w\ell^2$; WHERE ℓ IS LONGEST SPAN WHICH IS 10^{FT}

$M = .1 \times 7.87 \times 10^2 \times 12 = 944^{\#-IN}$

$$\sigma = \frac{Mc}{I} = \frac{944 \times .25}{\frac{\pi .5^2}{64}} = 19239^{PSI} = 19.2^{KSI}$$

$\sigma_{ACTUAL} = 19.2 < \sigma_{ALLOWABLE} = .707(32) = 22.6^{KSI}$

SATISFACTORY

LTR 1310-23

IDAHO NATIONAL ENGINEERING LABORATORY

FORM INEL-1592
(Rev. 4-76)

CALCULATION WORK SHEET

PAGE A4a OF ____ PAGES

SUBJECT ____ DATE ____

PREPARED BY ____ CHECKED ____ WORK REQUEST ____

II P1001

HORIZONTAL LOADING DEPENDENT ON HANGERS

VERTICAL LOADING COMES FROM MOMENT DUE TO CONDUIT

$$.1 \times 18.68 \times 2 \times 62 = \frac{w \times 2}{8}$$

$w = 927$ #/FT < 1690 #/FT FOR 25 KSI

FORM INEL-1592
(Rev. 4-76)

IDAHO NATIONAL ENGINEERING LABORATORY

CALCULATION WORK SHEET

SUBJECT ______ DATE ______

PREPARED BY ______ CHECKED ______ WORK REQUEST ______

III P3200 CONCRETE INSERTS

MAXIMUM LOAD CONSIDERING AVERAGE GOOD CONCRETE $2000^{\#} > 1156^{\#}$ THEREFORE SATISFACTORY.

IV P1000 CHANNEL USED FOR VERTICAL CONDUIT. ASSUME PROVIDES STABILTY HORIZONTAL DIRECTION BUT NOT VERTICAL (DWG 650-E-93)

HORIZONTAL $M_{MAX} = \frac{wl^2}{8} = \frac{10.56 \times 6^2}{8} = 48^{\#\text{-}FT}$

$\sigma = \frac{Mc}{I} = \frac{48 \times 12 \times .289}{.186} = 10.7^{KSI} < .707(25) = 18^{KSI}$

SATISFACTORY

VERTICAL LOADING PLACES CONDUIT IN TENSION. ASSUME 12 FT LENGTH

$\sigma = \frac{P}{A} = \frac{1.1 \times 18.68 \times 12'}{3.34} = 886 \ \#/IN^2 \ll .707(22000) = 16000^{PSI}$

NUTS

RESISTANCE TO SLIP

$R_B = 1.1\,wN \times 6 = 1.1 \times 18.68 \times 6$

$= 123^{\#} < 1500^{\#}$ ALLOWABLE

PULL OUT STRENGTH

$R_B = 1.1 \times 10.56 \times 6' = 69.70^{\#} < 2000^{\#}$ ALLOWABLE

V MALLABLE CAST IRON STRAPS

ATTACHED TO CONCRETE WALL WITH 1/2" HEX HEADED BOLT INSERTED IN A 1/2" PHILLIPS SHEILD DRIVEN INTO THE CONCRETE.

$F_t = 32^{KSI}$ $F_u = 50^{KSI}$

STRAP DIAMETER 4^{IN}

FORM INEL-1592
(Rev. 4-76)

IDAHO NATIONAL ENGINEERING LABORATORY

CALCULATION WORK SHEET

SUBJECT ____ DATE ____

PREPARED BY ____ CHECKED ____ WORK REQUEST ____

ASSUME ENDS WITH STRAPS ACT AS SIMPLE SUPPORTS, MOMENT IS $.1w\ell^2$. THERE'S ONE STRAP PER CONDUIT.

VERTICAL LOADING

$$\sigma = \frac{.1 w_v \ell^2 \times c}{I} = \frac{.1 \times 18.68 \times 12 \times 10^2 \times 4.0/2}{\frac{\pi 4^4}{64}}$$

$$= 5710^{PSI} < .707(32000) = 22625^{PSI}$$

@ STRAP $R_B = 1.10 w\ell$

$$= 1.10 \times 18.68 \times 10 = 205^{\#}$$

WALL CONNECTION 1/2" HEX-HEADED BOLT
$A_{TENSILE} = .142 IN^2$

$$\sigma = \frac{205}{.142} = 1450^{PSI}$$

ASSUME A307 BOLTS $F_y = 36^{KSI}$

ALLOWABLE TENSILE STRESS

$F_T = 22^{KSI} > 1.45^{KSI}$ SATISFACTORY

SINCE HORIZONTAL FORCES ARE LESS THAN VERTICAL FORCES (11.56 < 18.68) YET STILL UNDER THE SAME BOUNDARY CONDITIONS THE STRAPS WILL BE SATISFACTORY UNDER HORIZONTAL LOADING

VI P4000 CHANNEL (DWG LOFT 401-43)

LONGEST SPAN 7 FT

HORIZONTAL

$w_H = 10.56 \#/FT \times 2$ CONDUIT LINES $= 21.12 \#/FT$

$$\sigma = \frac{Mc}{I} = \frac{.1 \times 21.12 \times 7^2 \times .155 \times 12}{0.022} = 8750 \text{ PSI}$$

$$8.75^{KSI} < .707(25) = 17.68^{KSI}$$

$M_{CHANNEL} = .1 w l_c^2 = .1 w_H l_{SPAN}^2$

$.1 w 2^2 = .1 \times 21.12 \times 49$

$w = 260 \#/FT <$ ALLOWABLE LOAD $420 \#/FT$

$R_B = 1.1 w l = 1.1 \times 21.12 \times 7 = 165 \#$

ASSUME 2 BOLTS FOR EACH CHANNEL THEREFORE

$165\# / 2 \text{ BOLTS} = 82.5 \#/\text{BOLT} < 1000 \#\text{BOLT}$ SATISFACTORY

VERTICAL; ASSUME P4000 CHANNELS DON'T OFFER RESISTANCE THEREFORE SPAN 80 FT

$F_V = (972/100 + 1882/1000) \times 2 \times 80 \times 1.91 = 3550 \#$

$$\sigma = P/A = \frac{3550}{3.34} = 1.1^{KSI} < .707(22) = 16^{KSI}$$

FORM INEL-1592
(Rev. 4-76)

IDAHO NATIONAL ENGINEERING LABORATORY

LTR 1310-23

CALCULATION WORK SHEET

PAGE A-8 OF ____ PAGES

SUBJECT ____ DATE ____

PREPARED BY ____ CHECKED ____ WORK REQUEST ____

$1.1^{KSI} \times .23\ IN^2 = 253^{\#} / 2\ BOLTS = 126.5^{\#}/BOLT < 1000^{\#}/BOLT$