SARGENT & LUNDY ENGINEERS

CALCULATION ISSUE SUMMARY AND STATUS

Component & Materials Engineering Division	Project No.: 9140-67 Calculation No.: CMED-058057 Project Name/Station/Unit: Zion Station Units 1 & 2 Client: Commonwealth Edison Company Spec. No.: -
[X] Safety-Related [ ] Non-Safety-Related	Calculation Title/Purpose: The purpose of this calculation is to evaluate the structural integrity and mounting details adequacy of the Portable Flame and Smoke Detector (PFSD) Sentry Units.

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1.0 PURPOSE

The purpose of this calculation is to evaluate the structural integrity and mounting details adequacy of the Portable Flame and Smoke Detector (PFSD) Sentry Units.

2.0 DESIGN INPUT

All the references listed in Sec. 7.0. The details in the figures shown in the calculation are updated from walkdown dated 11/22/93.

Equipment Data: Portable Flame and Smoke Detector Sentry Units
Location: Aux. Building (Ref. 7.1)
Elevation: Anywhere in Aux. Bldg.
Classifications: Non-Safety-Related
Modification No(s): N/A

3.0 ASSUMPTIONS

- Aluminum pole material is 6063, T6 or better
- Other assumptions are stated in the calculation, they are conservative and need no further verification.

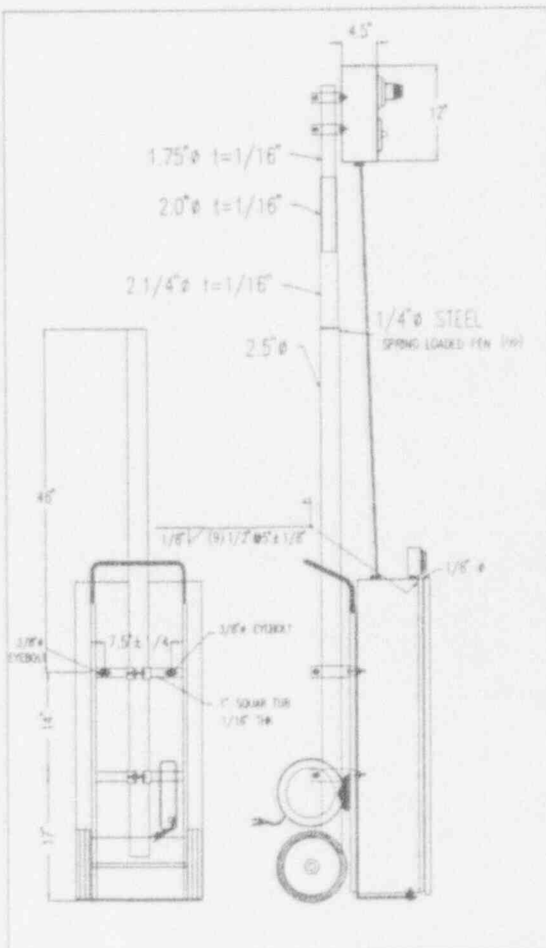


Fig. - 4.1

4.0 APPROACH

Background:
Per Ref. 7.1, The sentry portable flame and smoke detector is to replace the existing fire watch. The units can be located anywhere in the auxiliary

building. For now, the units temporarily will be placed in the corner of rooms for evaluation of the effectiveness. If the results of the evaluation show that the units are effective the units will be permanently mounted.

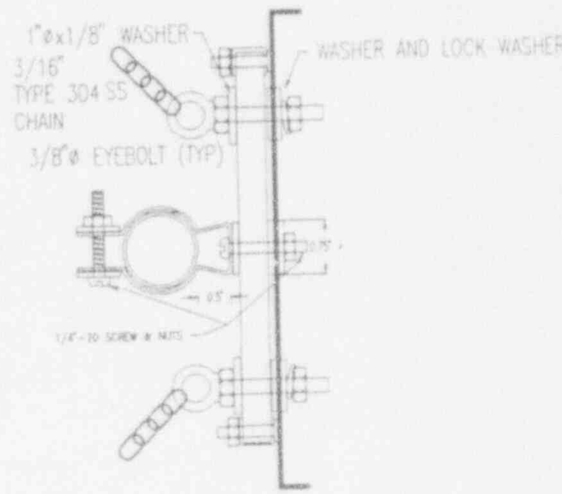


Fig. 4.2

Mounting of the unit to fixture (wall or column): The temporary attachment is such that the PFSD can be easily detached from the location of anchor. However, in the case of wall connection there must be means by which the unit can be anchored to the wall (i.e. existing unistrut on the wall or embedded plate). In cases where there are no existing means at the desired location, such means have to be provided for the anchoring purpose. Examples of such means are permanent fixture like a unistrut mounted to the wall by expansion anchor where the wall is a concrete wall, or threaded bar and plate (bolt through) for concrete block wall. In this case two (2) eyebolts are to be mounted to the cart on the horizontal member of the cart as shown in Figs. 4.2 and 4.3. Two pieces of chain with sufficient length are to be permanently connected to the two eyebolts on the cart. The other end of the chain should have adjustable hook which will be mounted to the wall fixture (i.e. eyebolt). The wall fixture could be 3/8"ϕ "U" bolt or eyebolt welded to the embedded plate or connected to unistrut using spring nuts, or eyebolt expansion anchor, directly embedded to the wall. In cases where the unit can be used next to a column the chain can be used to anchor the

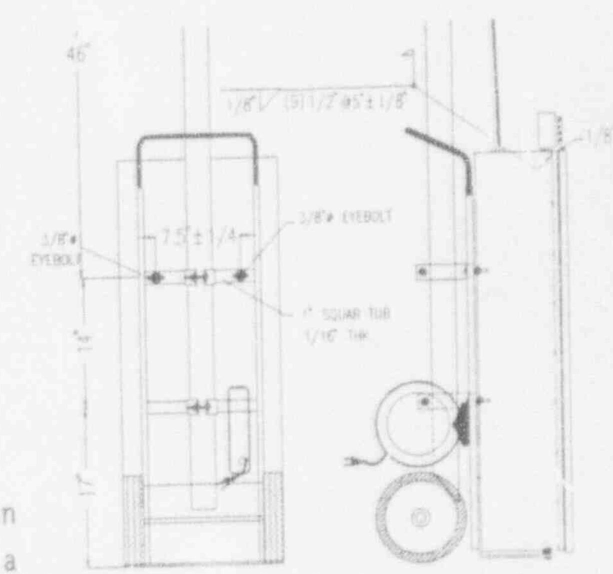


Fig 4.3

unit to the column, (i.e. chain from one eyebolt around the column to adjacent eyebolt) no permanent fix will be necessary in this case.
Where none of the above options are available the unit can be stand alone without any restraint, provided that the area where the unit may tip over and fall is clear of any equipment that may damage during the seismic event by the fall of portable fire detection unit. In this case the wedge or any other device that can be used to prevent the unit from rolling shall be utilized. Because, if the unit tips over backward the unit will roll forward (see Tip over Analysis).

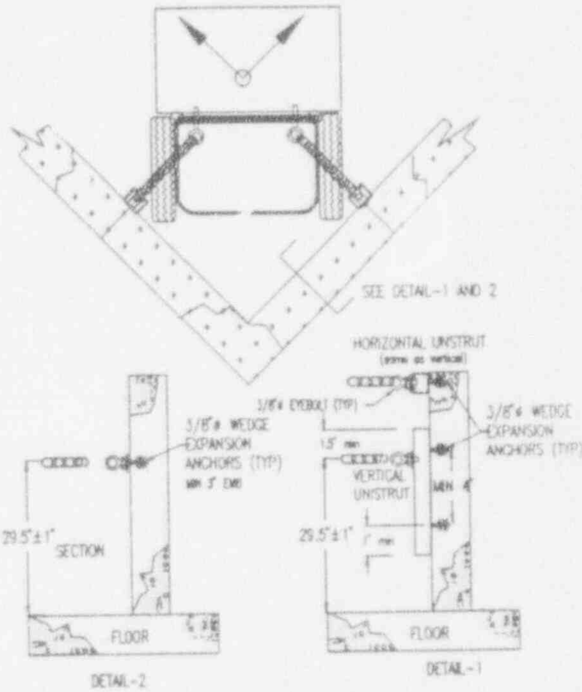


Fig 4.4

Structural integrity: Per Ref. 7.1, the structural integrity and mounting details for the subject equipment will be evaluated for the gravity and seismic forces. From Ref. 7.2, the enveloping response spectra for all the elevations in the Auxiliary Building are developed as shown in attachment 2. The peak acceleration from the enveloped response spectra will be used as the seismic accelerations. The maximum seismic acceleration will be calculated by multiplying the peak seismic acceleration by Seismic Amplification Factor (S_{AF} = 1.5). The dead loads and seismic forces will be applied through the center of gravity for evaluating the structural integrity of critical links and adequacy of mounting details.
The stresses in the critical areas of the equipment will be calculated and will be compared to the allowables (AISC, Ref. 7.6) to show the structural integrity of the equipment.

Note 1: The reaction loads will be calculated at the anchor point to the wall or wall fixture (i.e. unistrut) due to one horizontal and the vertical seismic factor and the gravity force.

Acceptance Criteria:

The stresses in the mounting bolts and the weak links will be compared to the allowable stresses shown in the AISC Code (Ref. 7.6), for their acceptability.

5. <u>Calculations</u>

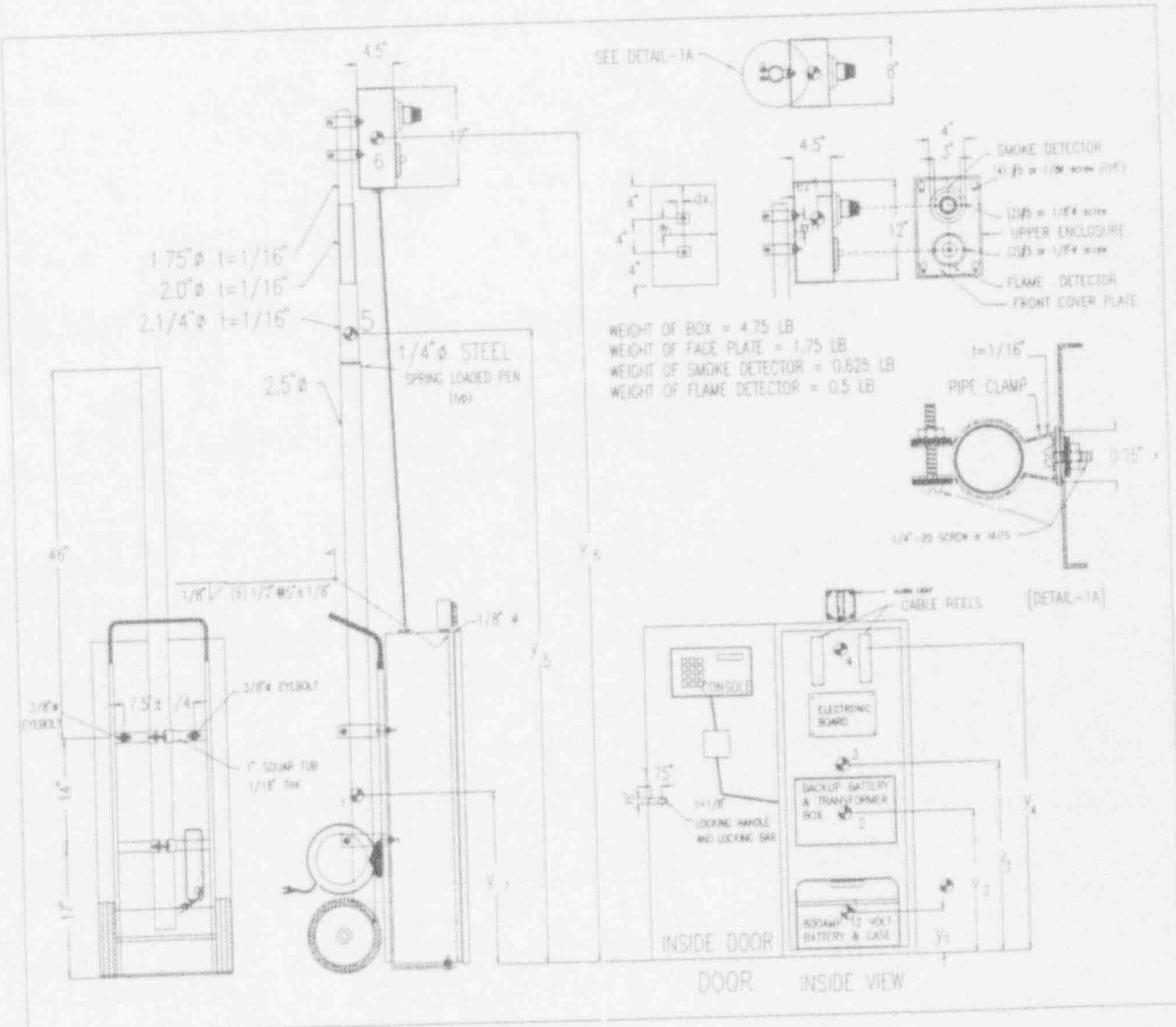


FIGURE 5.1

Basic Units:

$in \equiv \frac{2.54}{cm}$ $in \equiv 1L$ $lb \equiv 1m$ $ft \equiv 12 \cdot in$ $kips \equiv lb \cdot 1000$

$gm \equiv \frac{1}{453.582} \cdot lb$ $psi \equiv \frac{lb}{in^2}$ $cm \equiv \frac{1}{2.54} \cdot in$ $m \equiv 100 \cdot cm$ $ksi \equiv 1000 \cdot \frac{lb}{in^2}$

GENERAL PROPERTIES:

Assuming Sheet Gage #18 for Upper Enclosure - thickness:	$t_{ue} := 0.0516 \cdot in$	Ref. 7.5
Weight of Face Plate for Upper Enclosure (fp) :	$W_{fp} := 1.75 \cdot lb$	
Weight of Upper Enclosure (ue) :	$W_{ue} := 4.75 \cdot lb$	
Weight of Smoke Detector (SD) :	$W_{SD} := 0.625 \cdot lb$	
Weight of Smoke Detector (SD) :	$W_{FD} := 0.5 \cdot lb$	

Total Weight of Upper Enclosure including the devices:

$W_6 := W_{fp} + W_{ue} + W_{SD} + W_{FD}$ $W_6 = 7.625 \cdot lb$

Main Enclosure thickness (Sheet Gage #16, Ref. 7.5, 7.4): $t_E := 0.0625 \cdot in$

Aluminum Pole:

Outside Diameters (4 sections): $i := 1..4$ $D_1 := 2.5 \cdot in$ $D_3 := 2.0 \cdot in$

$D_2 := 2.25 \cdot in$ $D_4 := 1.75 \cdot in$

Thickness: $t_p := \frac{1}{16} \cdot in$

Cross-sectional Area (for each section): $A_i := \frac{\pi}{4}\left[(D_i)^2 - (D_i - 2 \cdot t_p)^2\right]$ $A = \begin{bmatrix} 0.479 \\ 0.43 \\ 0.38 \\ 0.331 \end{bmatrix} \cdot in^2$

Moment of inertia: $I_i := \frac{\pi}{64}\left[(D_i)^4 - (D_i - 2 \cdot t_p)^4\right]$ $I = \begin{bmatrix} 0.356 \\ 0.257 \\ 0.179 \\ 0.118 \end{bmatrix} \cdot in^4$

Sectional Modulus: $S_i := \frac{\pi}{32}\left[\frac{(D_i)^4 - (D_i - t_p)^4}{D_i}\right]$ $S = \begin{bmatrix} 0.148 \\ 0.119 \\ 0.094 \\ 0.071 \end{bmatrix} \cdot in^3$

Material Properties:

Weight density: $w_{d.A} := 2.8 \cdot \frac{gm}{cm^3}$ $\quad w_{d.A} = 0.10116 \cdot lb \cdot in^{-3}$

Mass Density $m_{d.A} := \frac{w_{d.A}}{386.4}$ $\quad m_{d.A} = 0.0002618 \cdot lb \cdot in^{-3}$

Sectional Length: $L_1 := 6 \cdot ft$ $\quad L_2 := 4 \cdot ft$ $\quad L_3 := 4 \cdot ft$ $\quad L_4 := 4 \cdot ft$

C.G. of each Sec. $y'_1 := 3.5 \cdot ft$ $\quad y'_2 := 8 \cdot ft$ $\quad y'_3 := 12 \cdot ft$ $\quad y'_4 := 16 \cdot ft$

$$W_5 := \left(\sum_i A_i \cdot L_i\right) \cdot \left(w_{d.A}\right) \qquad W_5 = 9.03 \cdot lb$$

Calculating the C.G. of aluminum pole: $y_5 := \frac{\sum_i A_i \cdot L_i \cdot y'_i \cdot \left(w_{d.A}\right)}{W_5}$ $\quad y_5 = 102.079 \cdot in$

	Weight *	y * dimension see Fig 5.1
Weight of Battery (800 AMP):	$W_1 := 60 \cdot lb$	$y_1 := 6 \cdot in$
Weight of Backup Enclosure and components:	$W_2 := 16 \cdot lb$	$y_2 := 18 \cdot in$
Weight of Enclosure (Item-3): $W_3 := (2 \cdot ((16 \cdot in + 40 \cdot in) \cdot 9 \cdot in + (16 \cdot in \cdot 40 \cdot in))) \cdot \left(t_E \cdot 0.283 \cdot \frac{lb}{in^3}\right)$	$W_3 = 40.469 \cdot lb$	$y_3 := \frac{40}{2} \cdot in$
Weight of Miscellaneous Items (assumed): (Including the two cable reels, alarm light, control circuit board, console, wire...)	$W_4 := 15 \cdot lb$	$y_4 := 34 \cdot in$
Weight of Aluminum Pole from above:	$W_5 = 9.027 \cdot lb$	$y_5 = 102.079 \cdot in$
Weight of upper enclosure including devises:	$W_6 = 7.625 \cdot lb$	$y_6 := 17.5 \cdot ft$
Weight of cart and power cord reels:	$W_7 := 23 \cdot lb$	$y_7 := \frac{1}{4} \cdot 43 \cdot in$

* Based on approximate measurement and conservative assumptions

C.G. of the assembly: $j := 1..7$ $Y1 := \frac{\sum_j W_j \cdot y_j}{\sum_j W_j}$ $Y1 = 27.684 \cdot in$

C.G. of the cart assembly without pole and upper enclosure:

$i := 1..4$ $Y2 := \frac{\sum_i W_i \cdot y_i}{\sum_i W_i}$ $Y2 = 14.965 \cdot in$ $W_{TL} := \sum_i W_i$

C.G. of pole and upper enclosure:

$Y3 := \frac{W_5 \cdot y_5 + W_6 \cdot y_6}{W_5 + W_6}$ $Y3 = 151.495 \cdot in$

Natural Frequency of Aluminum Pole:

Assuming aluminum pole to be uniform beam, one end fixed, the other end free.
The uniform load 'w' per unit length plus an end load 'W'

Per Ref. 7.8, page 576, case 3c, the natural frequency can be calculated from formula shown below:

$$f_1 = \frac{1.732}{2 \cdot \pi} \sqrt{\frac{E \cdot I \cdot g}{W \cdot L^3 + 0.236 \cdot w \cdot L^4}}$$

where:

L = total length $L_t := \sum_i L_i$ **I** = area moment of inertia $I_m := \frac{\sum_i I_i \cdot L_i}{L_t}$

E = modulus of elasticity (Ref. 7.4) $E := 10.6 \cdot 10^6 psi$ **w** = uniform load per unit length $wp := \frac{W_5}{L_t}$

g = gravitational acceleration $g := 386.4 \cdot \frac{in}{sec^2}$

W = end load [(Upper Enclosure) + (Smoke & Flame Detector)]: $W_6 = 7.625 \cdot lb$

$L_t = 216 \cdot in$

$I_m = 0.242 \cdot in^4$ $f_1 := \frac{1.732}{2 \cdot \pi} \sqrt{\frac{E \cdot I_m \cdot g}{W_6 \cdot L_t^3 + 0.236 \cdot wp \cdot L_t^4}}$ $f_1 = 0.875 \cdot sec^{-1}$

$wp = 0.042 \cdot lb \cdot in^{-1}$

The following are maximum accelerations applicable to Aux-Turb-D.G. Building:

——— OBE 0.5% damping ———

OBE Vert. Per Ref. 7.2, p. 6 — $aov = 0.06$ (g)

OBE Horiz.Per Ref. 7.2: — $aoh = 2.1$ (g)

——— SSE 2% damping ———

SSE Vert. Per Ref. 7.2, p. 6 — $asv = 0.12$ (g)

SSE Horiz.Per Ref. 7.2, — $ash = 2$ (g)

See Attachment "2" Enveloped Response Spectra

Use amplification factor of (1.5): $S_{AF} = 1.5$

$ax = S_{AF} \cdot max(aoh, ash)$ — $ax = 3.15$ (g)

$ay = S_{AF} \cdot max(aov, asv) + 1$ — $ay = 1.18$ (g)

$az = S_{AF} \cdot max(aoh, ash)$ — $az = 3.15$ (g)

Per Ref. 7.2, p 7, "The direction of the earthquake motion can be parallel to **either** of the principal axes of the equipment and/or equipment supports. The direction causing the most severs combination of stresses shall be used for design."

In this case the horizontal accelerations are the same for either directions, therefore, the results will be the same also. The C.G. of the whole assembly is approximately in the same highs as the location of the eyebolt.

$WT = \sum_j W_j$ — $WT = 171.121 \cdot lb$

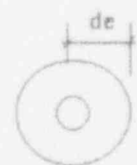


Fig. 5.2

Fig. 5.2a

Eyebolt diameter: $d_1 = 0.375 \cdot in$

Stress Area: $At_1 = 0.0773 \cdot in^2$

Shear Area: $As_1 = 0.0678 \cdot in^2$

$\alpha = 45 \cdot deg$ — $de = 0.375 \cdot in$

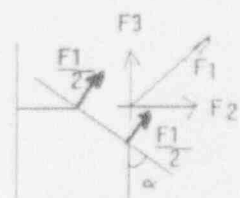


Fig. 5.2b

Seismic force could be F1 or F2 or F3 — $F = F1 = F2 = F3$

$F = ax \cdot WT$ (1 eyebolts in each side) — $F = 539.033 \cdot lb$

$F_t = F \cdot sin(\alpha)$ — $F_t = 381.154 \cdot lb$

$F_s = F \cdot cos(\alpha)$ — $F_s = 381.154 \cdot lb$

assuming: $b = 1.75 \cdot in$ — $de1 = 0.25 \cdot in$

$M = 2 \cdot f \cdot de1$ $\quad f = \frac{M}{2 \cdot de1}$ $\quad M^* = F_s \cdot b$ $\quad f = \frac{M}{2 \cdot de1}$ — $f = 1334.038 \cdot lb$

Note: M will be slightly smaller than M = Fsb - Ft(e*)

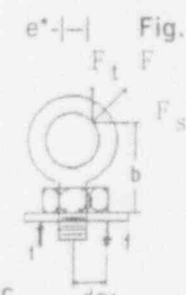


Fig. 5.2c

$\sigma := \frac{F_t + f}{At_1}$ $\sigma = 22.189 \cdot ksi$ < $20 \cdot ksi \cdot \left(\frac{4}{3}\right) = 26.667 \cdot ksi$ (Ref. 7.6- assuming A307 material)

$\tau := \frac{F_s}{As_1}$ $\tau = 5.622 \cdot ksi$ < $10 \cdot ksi \cdot \left(\frac{4}{3}\right) = 13.333 \cdot ksi$

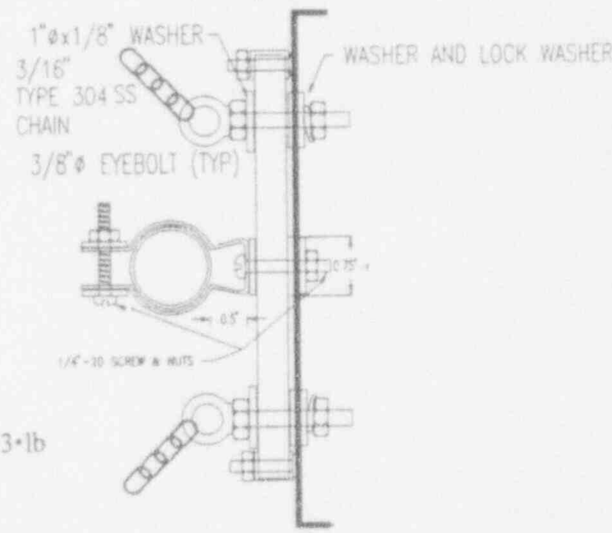
$\frac{4}{3} \cdot 26 \cdot ksi - 1.8 \cdot \tau = 24.548 \cdot ksi$ > $\sigma = 22.189 \cdot ksi$ (Ref. 7.6- assuming A307 material)

Chain Connection to the Wall:

Per Ref. 7.7,	Trade Size	Cat. No.	Work Load Limits	
Type 304 Stainless Steel Chain	3/16"	3392T29	1200·lb	Recommended
Passing Link Chain	40.........0.219"	3596T16	600·lb	>* $F = 539.033 \cdot lb$

* Using one chain in each side of the cart

Chain can be permanently bolted or welded at one end to the cart and in the other end can be attached temporary (adjustable hook) or permanently (weld, etc.) to Unistrut eyebolt / Expansion Anchor eyebolt, etc.).



Unistrut: the capacity per Ref. 7.11

Type	Span	Load Capacity	
P1000	24"	$1690 \cdot lb \cdot 0.5^* = 845 \cdot lb$	$F = 539.033 \cdot lb$
P3000	24"	$1330 \cdot lb \cdot 0.5^* = 665 \cdot lb$	

* safety factor

A 3/8"Ø eyebolt attached to the unistrut can be used to provide connection for the chain's adjustable hook. The other suggestion is a 3/8"Ø eyebolt expansion anchor, as shown in Fig. 4.4, Detail -2, that may be mounted directly to the wall.

Per Ref. 7.9, 3/8" Wedge Type Expansion Anchors can be used recommended effective embedded length is 3", capacity for 1 5/8" EMB = 2328*lbs tension and 4767 lbs shear.

$F_{tension} := \sigma \cdot At_1$ $F_{tension} = 1715.192 \cdot lb$

$F_{shear} := \tau \cdot As_1$ $F_{shear} = 381.154 \cdot lb$

These loads for Expansion Anchor will be increased by 30% for conservatism and will be given to the SED if it is requested.

$F_{exp.tens} := (1.3) \cdot F_{tension}$ $F_{exp.tens} = 2229.749 \cdot lb$ $F_{exp.shr} := (1.3) \cdot F_{shear}$ $F_{exp.shr} = 495.5 \cdot lb$

3/8" expansion is adequate.

Upper Box Face Plate Details:

Plate Dimension: 8.0" x 12.0" (Ref. 7.5) $h = 12 \cdot in$ $w = 8 \cdot in$

Thickness: $t_{ue} = 0.052 \cdot in$

Weight of Face Plate + component:

$W_{fp} = 1.75 \cdot lb$ $W_{SD} = 0.625 \cdot lb$ $W_{FD} = 0.5 \cdot lb$

$W_{pt} = W_{fp} + W_{SD} + W_{FD}$ $W_{pt} = 2.875 \cdot lb$

For conservatism in the analysis, assume the eccentricities to be as:

$ex = 0 \cdot in$ $ey = 3 \cdot in$ $ez = 2 \cdot in$

Seismic & Dead Loads:

Forces:

$Fx = W_{pt} \cdot ax$ $Fx = 9.056 \cdot lb$

$Fy = W_{pt} \cdot ay$ $Fy = 3.392 \cdot lb$

$Fz = W_{pt} \cdot az$ $Fz = 9.056 \cdot lb$

Moments:

$Mx = Fy \cdot ez + Fz \cdot ey$ $Mx = 33.954 \cdot lb \cdot in$

$My = Fx \cdot ez + Fz \cdot ex$ $My = 18.113 \cdot lb \cdot in$

$Mz = Fy \cdot ex + Fx \cdot ey$ $Mz = 27.169 \cdot lb \cdot in$

Screw: Per Ref. 7.5 # 5 screws are used

Screw diameter (Ref. 7.4): $d_5 = 0.125 \cdot in$

Tensile Stress Area (Ref. 7.4): $A_{5.t} = 0.0079 \cdot in^2$

Shear Area (Ref.7.4): $A_{5.s} = 0.0067 \cdot in^2$

see Fig 5.3 conservatively assuming $\left\{ \begin{array}{l} c = 3.25 \cdot in \\ h = 5 \cdot in \end{array} \right.$

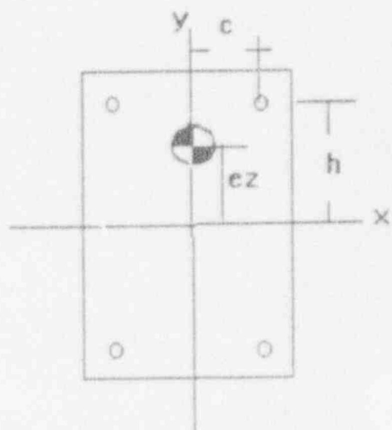


Fig. 5.3

Moment of Inertia:

$I_{xx} := 4 \cdot A_{5.t} \cdot h^2$ $\qquad I_{xx} = 0.79 \cdot in^4$

$I_{yy} := 4 \cdot \left(A_{5.t} \cdot c^2\right)$ $\qquad I_{yy} = 0.334 \cdot in^4$

$I_{zz} := I_{xx} + I_{yy}$ $\qquad I_{zz} = 1.124 \cdot in^4$

Stresses in Screw:

$$\sigma_5 := \frac{Fz}{\left(4 \cdot A_{5.t}\right)} + \frac{Mx \cdot h}{I_{xx}} + \frac{My \cdot c}{I_{yy}} \qquad \sigma_5 = 677.85054 \cdot psi$$

$$\tau_5 := \frac{\sqrt{Fx^2 + Fy^2}}{4 \cdot A_{5.s}} + \frac{Mz \cdot \left(\sqrt{c^2 + h^2}\right)}{I_{zz}} \qquad \tau_5 = 505.025 \cdot psi$$

Allowable Stresses:

Screw material is assumed to be A-307. Per Ref. 7.6, Table 1.5.2.1, the Allowable Stresses on Fasteners with A-307 material are:

Allowable Tension: $F_t := 20 \cdot ksi \quad > \quad \sigma_5 = 0.678 \cdot ksi$

Allowable Shear : $F_v := 10 \cdot ksi \quad > \quad \tau_5 = 0.505 \cdot ksi$

Therefore, the 4 # 5 screws are adequate to withstand the seismic loading and are sufficient to mount the face plate for upper enclosure.

Checking the Mounting of Flame and Smoke Detector:

(The Smoke and flame detector, both have a similar mounting details evaluating the mounting details for smoke detector envelop the other)

For conservatism in the analysis, assume the eccentricities to be as:

$ex := 1. in \qquad ey := 1 \cdot in \qquad ez := 3 \cdot in$

Weight of Smoke Detector assumed: $W_s := 1 \cdot lb \quad > \quad W_{SD} = 0.625 \cdot lb$

Seismic & Dead Loads: Forces:

$Fx := W_s \cdot ax \qquad Fx = 3.15 \cdot lb$

$Fy := W_s \cdot ay \qquad Fy = 1.18 \cdot lb$

$Fz := W_s \cdot az \qquad Fz = 3.15 \cdot lb$

Moments: $Mx := Fy \cdot ez + Fz \cdot ey$ $\quad Mx = 6.69 \cdot lb \cdot in$

$My := Fx \cdot ez + Fz \cdot ex$ $\quad My = 12.6 \cdot lb \cdot in$

$Mz := Fy \cdot ex + Fx \cdot ey$ $\quad Mz = 4.33 \cdot lb \cdot in$

Screw: Per Ref. 7.5 # 5 screws are used

Screw diameter (Ref. 7.4): $d_5 := 0.125 \cdot in$

Tensile Stress Area (Ref. 7.4): $A_{5.t} := 0.0079 \cdot in^2$

Shear Area (Ref. 7.4): $A_{5.s} := 0.0067 \cdot in^2$

see Fig. 5.4, conservatively assuming $\left\{ \begin{array}{l} c := 1.5 \cdot in \\ de2 := 4 \cdot in \end{array} \right.$

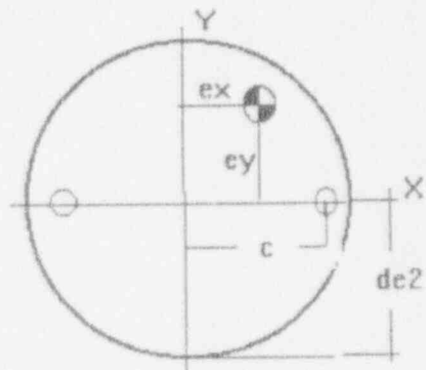


Fig. 5.4

Moment of Inertia: $I_{yy} := 2 \cdot \left(A_{5.t} \cdot c^2\right)$ $\quad I_{yy} = 0.036 \cdot in^4$

Stresses in Screw:

$$\sigma_5 := \frac{Fz}{\left(2 \cdot A_{5.t}\right)} + \frac{\frac{Mx}{2 \cdot de2}}{A_{5.t}} + \frac{My \cdot c}{I_{yy}} \qquad \sigma_5 = 836.86709 \cdot psi$$

$$\tau_5 := \frac{\sqrt{Fx^2 + Fy^2}}{2 \cdot A_{5.s}} + \frac{\frac{Mz}{2 \cdot c}}{A_{5.s}} \qquad \tau_5 = 466.45 \cdot psi$$

Allowable Stresses:

Screw material is assumed to be A-307. Per Ref. 7.6, Table 1.5.2.1, the Allowable Stresses on Fasteners with A-307 material are:

Allowable Tension: $F_t := 20 \cdot ksi$ $\quad > \quad \sigma_5 = 0.837 \cdot ksi$

Allowable Shear : $F_v := 10 \cdot ksi$ $\quad > \quad \tau_5 = 0.466 \cdot ksi$

Therefore, the 2 # 5 screws are adequate to withstand the seismic loading.

Checking 1/4" screw holding the upper enclosure to pipe clamps: (see Fig 5.1)

For conservatism in the analysis, assume the eccentricities to be as:

$ex := 1 \cdot in$ $\qquad ey := 3 \cdot in$ $\qquad ez := 3.5 \cdot in$

Weight of Upper Enclosure: $W_6 = 7.625 \cdot lb$

Seismic & Dead Loads:

Forces:

$Fx := W_6 \cdot ax \qquad Fx = 24.019 \cdot lb$

$Fy := W_6 \cdot ay \qquad Fy = 8.997 \cdot lb$

$Fz := W_6 \cdot az \qquad Fz = 24.019 \cdot lb$

Moments:

$Mx := Fy \cdot ez + Fz \cdot ey \qquad Mx = 103.548 \cdot lb \cdot in$

$My := Fx \cdot ez + Fz \cdot ex \qquad My = 108.084 \cdot lb \cdot in$

$Mz := Fy \cdot ex + Fx \cdot ey \qquad Mz = 81.054 \cdot lb \cdot in$

Screw: Per Ref. 7.5 1/4"-20 screws are used

Screw diameter (Ref. 7.4): $d_c := 0.25 \cdot in$

Tensile Stress Area(Ref. 7.4): $A_{c.t} := 0.0317 \cdot in^2$

Shear Area (Ref. 7.4): $A_{c.s} := 0.0269 \cdot in^2$

see Fig.5.5 & 5.1: $dx_1 := 0.375 \cdot in$, $dy_1 := 2 \cdot in$

Moment of Inertia: $I_{xx} := 2 \cdot \left(A_{c.t} \cdot dy_1^2\right) \qquad I_{xx} = 0.254 \cdot in^4$

Stresses in Screw:

$$\sigma_c := \frac{Fz}{(2 \cdot A_{c.t})} + \frac{Mx \cdot dy_1}{I_{xx}} + \frac{\frac{My}{dx_1}}{2 \cdot A_{c.t}} \qquad \sigma_c = 5.7416 \cdot ksi$$

$$\tau_c := \frac{\sqrt{Fx^2 + Fy^2}}{2 \cdot A_{c.s}} + \frac{Mz \cdot dy_1}{I_{xx}} \qquad \tau_c = 1.116 \cdot ksi$$

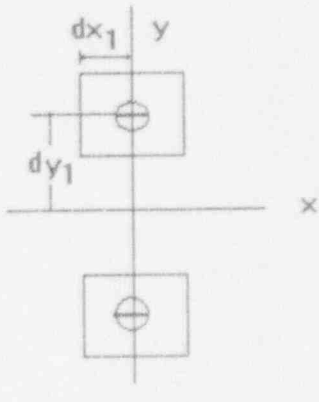


Fig. 5.5 (screws holding upper enclosure to pipe clamp)

Allowable Stresses:

Screw material is assumed to be A-307. Per Ref. 7.6, Table 1.5.2.1, the Allowable Stresses on fasteners with A-307 material are:

Allowable Tension: $F_t := \left(\frac{4}{3}\right) \cdot 20 \cdot ksi$ $\quad F_t = 26.667 \cdot ksi$ $\quad > \quad \sigma_c = 5.742 \cdot ksi$

Allowable Shear : $F_v := \left(\frac{4}{3}\right) \cdot 10 \cdot ksi$ $\quad F_v = 13.333 \cdot ksi$ $\quad > \quad \tau_c = 1.116 \cdot ksi$

Therefore, the (2) 1/4"-20 screws are adequate to withstand the seismic loading.

Checking 1/4" screw holding the Aluminum Pole to Cart:

Weight: $WA := W_6 + W_5$ $\quad WA = 16.652 \cdot lb$

Eccentricities:

$ex := 0 \cdot in$ $\quad ey := \left| Y3 - \left(15.5 + \frac{13.5}{2}\right) \cdot in \right|$ $\quad ey = 129.245 \cdot in$ $\quad ez := \frac{3.5 \cdot in \cdot W_6}{WA}$ $\quad ez = 1.603 \cdot in$

$k := 1..2$ $\quad ax_1 := 0$ $\quad ax_2 := 3.15$ $\quad az_1 := 3.15$ $\quad az_2 := 0$

Seismic & Dead Loads: Seismic force acting in only one horizontal direction + vertical $\quad ax = \begin{pmatrix} 0 \\ 3.15 \end{pmatrix}$ $\quad az = \begin{pmatrix} 3.15 \\ 0 \end{pmatrix}$

Forces: $Fx := WA \cdot ax$ $\quad Fx^T = (0 \quad 52.455) lb$

$Fy := WA \cdot ay$ $\quad Fy = 19.65 \cdot lb$

$Fz := WA \cdot az$ $\quad Fz^T = (52.455 \quad 0) lb$

Moments: $Mx := Fy \cdot ez + Fz \cdot ey$ $\quad Mx^T = (6811.083 \quad 31.491) lb \cdot in$

$My := Fx \cdot ez + Fz \cdot ex$ $\quad My^T = (0 \quad 84.066) lb \cdot in$

$Mz := Fy \cdot ex + Fx \cdot ey$ $\quad Mz^T = (0 \quad 6780) lb \cdot in$

Screw: Per Ref. 7.5 1/4"-20 screws are used

Screw diameter (Ref. 7.4): $d_c := 0.25 \cdot in$

Tensile Stress Area (Ref. 7.4): $A_{c.t} := 0.0317 \cdot in^2$

Shear Area (threads are excluded from shear planes) $\quad A_{c.s} := \frac{\pi}{4} \cdot d_c^{\ 2}$ $\quad A_{c.s} = 0.049 \cdot in^2$

see Figs. 5.6 & 5.1 $\quad dx_1 := 0.375 \cdot in$ $\quad dy := \frac{13.5}{2} \cdot in$

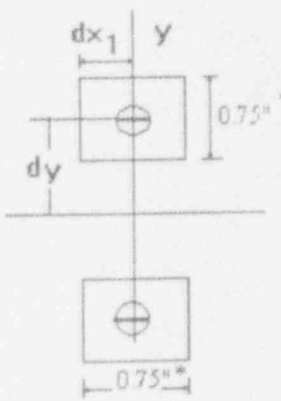


Fig. 5.6

Moment of Inertia: $I_{xx} := 2 \cdot \left(A_{c.t} \cdot dy^2\right)$ $\quad I_{xx} = 2.889 \cdot in^4$

Stresses in Screw:

$$\sigma_A := \frac{Fz}{\left(2 \cdot A_{c.t}\right)} + \frac{Mx \cdot dy}{I_{xx}} + \frac{My}{2 \cdot A_{c.t} \cdot dx_1} \qquad \sigma_A = \begin{pmatrix} 16.74298 \\ 3.60947 \end{pmatrix} \cdot ksi$$

$$\tau_{A_k} := \frac{\sqrt{\left(Fx_k\right)^2 + (Fy)^2}}{2 \cdot A_{c.s}} + \frac{Mz_k \cdot dy}{I_{xx}} \qquad \tau_A = \begin{pmatrix} 0.2 \\ 16.413 \end{pmatrix} \cdot ksi$$

Allowable Stresses:

Screw material is assumed to be A-307. Per Ref. 7.6, Table 1.5.2.1, the Allowable Stresses on Fasteners with A-307 material are:

Allowable Shear when threads are excluded from shear plane: $F_v := 60 \cdot ksi \cdot 0.22$

Allowable Tension: $F_t := \frac{4}{3} \cdot 20 \cdot ksi$ $\quad F_t = 26.667 \cdot ksi$ $\quad > \quad \sigma_A = \begin{pmatrix} 16.743 \\ 3.609 \end{pmatrix} \cdot ksi$

Allowable Shear: $F_v := \frac{4}{3} \cdot F_v$ $\quad F_v = 17.6 \cdot ksi$ $\quad > \quad \tau_A = \begin{pmatrix} 0.2 \\ 16.413 \end{pmatrix} \cdot ksi$

$$\sigma_{al_k} := \min\left(\frac{4}{3} \cdot 26 \cdot ksi - 1.8 \cdot \tau_{A_k}, F_t\right) \qquad \sigma_{al} = \begin{pmatrix} 26.667 \\ 5.124 \end{pmatrix} \cdot ksi \quad > \quad \sigma_A = \begin{pmatrix} 16.743 \\ 3.609 \end{pmatrix} \cdot ksi$$

Therefore, the (2) 1/4"-20 screws are adequate to withstand the seismic loading.

Checking Clamp for Bending:

Clamp Thickness & width: $t_{p2c} := .0625 \cdot in$ $\quad b_{pc} := 1.25 \cdot in$

$$\sigma_{pc} := \frac{Fx \cdot 1.25 \cdot in}{2 \cdot 2 \cdot \left(\frac{b_{pc} \cdot t_{p2c}^{\,2}}{6}\right)} \qquad \max\left(\sigma_{pc}\right) = 20.143 \cdot ksi$$

$\max\left(\sigma_{pc}\right) = 20.143 \cdot ksi$ $\quad < \quad 36 \cdot ksi \cdot 0.9 = 32.4 \cdot ksi$

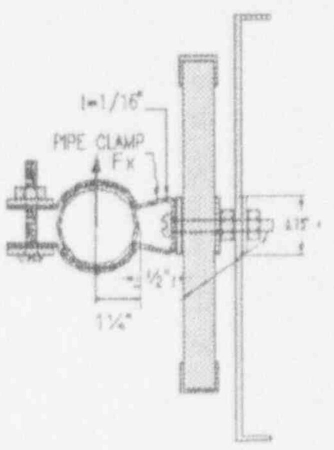


Fig. 5.7

Checking Aluminum Pole:

$$\sigma_{Ap} := \frac{Fy}{A_1} + \frac{Mx \cdot \frac{D_1}{2}}{I_1} + \frac{Mz \cdot \frac{D_1}{2}}{I_1} \qquad \max(\sigma_{Ap}) = 23.978 \cdot ksi$$

$$\tau_{Ap_k} := \frac{\sqrt{(Fx_k)^2 + (Fz_k)^2}}{A_1} + \frac{My_1 \cdot D_1}{I_1 \cdot 2} \qquad \max(\tau_{Ap}) = 0.11 \cdot ksi$$

Yield for the assumed Aluminum (6063, T6) from Ref. 7.4: $Sy_{Ap} := 31 \cdot ksi$

$S_{allow\,Ap} := Sy_{Ap} \cdot 0.9$ $\qquad S_{allow\,Ap} = 27.9 \cdot ksi$ >> $\max(\sigma_{Ap}) = 23.978 \cdot ksi$

Checking the mounting of Main Enclosure to Cart:

Weight: $WE := WT - W_7$ $\qquad WE = 148.121 \cdot lb$

calculating the bolt center: $y_1 := 13.5 \cdot in$ $y_3 := 13.5 \cdot in$ $y_2 := 13.5 \cdot in$ $y_4 := 0 \cdot in$

$$Y := \frac{\sum_i y_i}{4} \qquad Y = 10.125 \cdot in$$

Eccentricities:

$ex := 0 \cdot in$ $\qquad ez := 4.5 \cdot in$

$ey := |Y1 - Y|$ $\qquad ey = 17.559 \cdot in$

Seismic & Dead Loads:

Forces:

$Fx := WE \cdot ax$ $\qquad Fx^T = (0 \quad 466.583) lb$

$Fy := WE \cdot ay$ $\qquad Fy = 174.783 \cdot lb$

$Fz := WE \cdot az$ $\qquad Fz^T = (466.583 \quad 0) lb$

Moments:

$Mx := Fy \cdot ez + Fz \cdot ey$ $\qquad Mx^T = (8979.447 \quad 786.525) lb \cdot in$

$My := Fx \cdot ez + Fz \cdot ex$ $\qquad My^T = (0 \quad 2099.622) lb \cdot in$

$Mz := Fy \cdot ex + Fx \cdot ey$ $\qquad Mz^T = (0 \quad 8192.922) lb \cdot in$

Per Ref. 7.5 1/4"-20 screws are used

Screw diameter (Ref. 7.4): $d_c := 0.25 \cdot in$

Tensile Stress Area (Ref. 7.4): $A_{c.t} := 0.0317 \cdot in^2$

Shear Area (Ref. 7.4): $A_{c.s} := 0.0269 \cdot in^2$

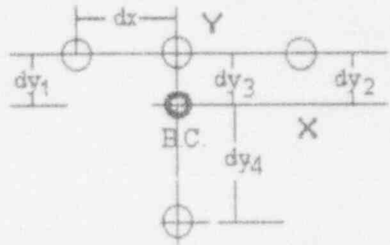


Fig. 5.8

$dy_1 := |y_1 - Y|$ $dy_1 = 3.375 \cdot in$ $dx_1 := 3.75 \cdot in$

$dy_2 := |y_2 - Y|$ $dy_2 = 3.375 \cdot in$ $dx_2 := 3.75 \cdot in$

$dy_3 := |y_3 - Y|$ $dy_3 = 3.375 \cdot in$ $dx_3 := 0 \cdot in$

$dy_4 := |y_4 - Y|$ $dy_4 = 10.125 \cdot in$ $dx_4 := 0 \cdot in$

Moment of Inertia: $I_{xx} := \sum_i A_{c.t} \cdot (dy_i)^2$ $I_{xx} = 4.333 \cdot in^4$

$I_{yy} := \sum_i A_{c.t} \cdot (dx_i)^2$ $I_{yy} = 0.892 \cdot in^4$

Stresses in Screw:

$R_i := \left[\sqrt{(dy_i)^2 + (dx_i)^2}\right]$ $\max(R) = 10.125 \cdot in$

$\sigma_E := \frac{Fz}{(4 \cdot A_{c.t})} + \frac{Mx \cdot \max(dy)}{I_{xx}} + \frac{My \cdot \max(dx)}{I_{yy}}$ $\sigma_E = \begin{pmatrix} 24.662 \\ 10.669 \end{pmatrix} \cdot ksi$

$\tau_{E_k} := \frac{\sqrt{(Fx_k)^2 + (Fy)^2}}{4 \cdot A_{c.s}} + \frac{Mz_k \cdot \max(R)}{I_{xx} + I_{yy}}$ $\tau_E = \begin{pmatrix} 1.624 \\ 20.508 \end{pmatrix} \cdot ksi$

Allowable Stresses:

Screw material is assumed to be A-307. Per Ref. 7.6, Table 1.5.2.1, the Allowable Stresses on Fasteners with A-307 material are:

Allowable Tension: $F_t := \frac{4}{3} \cdot 20 \cdot ksi$ $F_t = 26.667 \cdot ksi$ > $\sigma_E = \begin{pmatrix} 24.662 \\ 10.669 \end{pmatrix} \cdot ksi$

Allowable Shear: $F_v := \frac{4}{3} \cdot (10 \cdot ksi)$ $F_v = 13.333 \cdot ksi$ > $\tau_E = \begin{pmatrix} 1.624 \\ 20.508 \end{pmatrix} \cdot ksi$

$\sigma_{E.al_k} := \min\left(\frac{4}{3} \cdot 26 \cdot ksi - 1.8 \cdot \tau_{E_k}\ \ F_t\right)$ $\sigma_{E.al} = \begin{pmatrix} 26.667 \\ -2.248 \end{pmatrix} \cdot ksi$ > $\sigma_E = \begin{pmatrix} 24.662 \\ 10.669 \end{pmatrix} \cdot ksi$

Therefore, the (4) 1/4"-20 screws are adequate to withstand the seismic loading.

SARGENT & LUNDY ENGINEERS	Calc. For: S.Q. of Portable Flame Detector Sentry Units	Calc. No. CMED-058057
	X Safety-Related / Non-Safety Related	Rev. 00 Date
		Page 18 of

Client Commonwealth Edison Co.	Prepared by	Date
Project Zion Station Unit(s) 1 & 2	Reviewed by	Date
Proj. No. 9140-67 Equip.	Approved by	Date

Tip Over Analysis:

Total Weight for Lower Enclosure (LE): $W_{TL} = 131.469 \cdot lb$

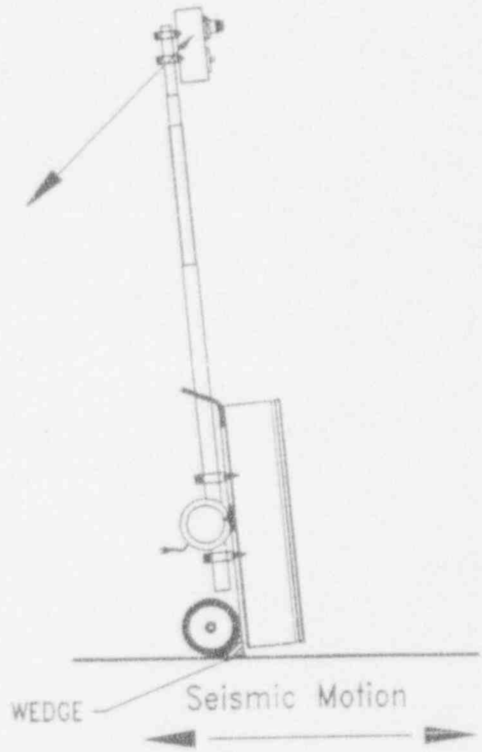


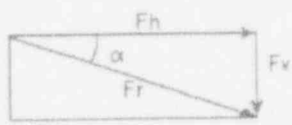
Fig. 5.9

Horizontal Acceleration: $ax_2 = 3.15$

Horizontal Force on C.G. of LE $Fh := W_{TL} \cdot ax_2$

$Fh = 414.127 \cdot lb$

Vertical Force on C.G. of LE: $Fv := W_{TL} \cdot ay$



$Fv = 155.133 \cdot lb$

$\alpha := atan\left(\frac{Fv}{Fh}\right)$

C.G. for LE: $Y2 = 14.965 \cdot in$ use 15" $\alpha = 20.536 \cdot deg$

70°>31° Therefore, the unit may tip over or roll or roll and tip over because the direction of the earthquake motion is reversible and the extension of the resultant force as shown in the Fig. 5.10 fails outside the perimeter of the unit's base.

To prevent the rolling of the unit devises such as wheel wedge may be used .

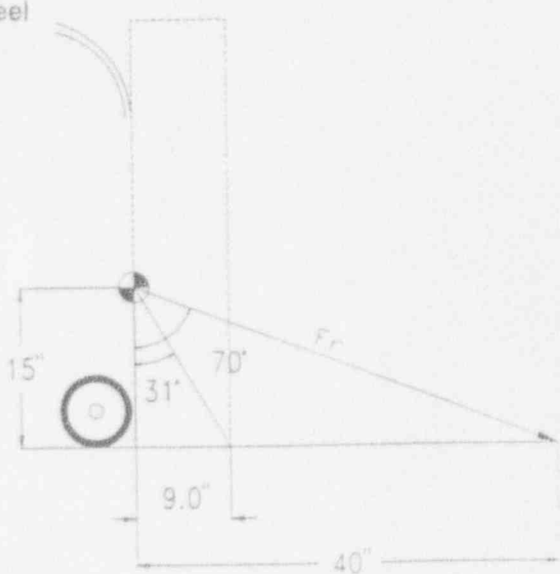


Fig. 5.10

Form GQ-3.08.1 Rev.2

6.0 CONCLUSIONS

The structural integrity and mounting details as shown in Fig. 4.2 and 4.3, for subject portable fire detection has been evaluated and found to be acceptable per Zion Station requirements.

7.0 REFERENCES

7.1 CMED-057954, meeting notes "Qualification of Portable Flame Detector Sentry Units to be installed at Zion Station" dated 07/13/93.

7.2 Seismic Design Criteria for Zion Station DC-SE-002-ZI, Rev. 03, Dated 06-03-91.

7.3 Faxed information from POEM Lighting Company, dated 07/12/93.

7.4 Marks' Standard Handbook for Mechanical Engineers, 8th Edition

7.5 Field walk_down information, dated 9/13/93 (updated on 12/22/93).

7.6 AISC, Manual of Steel Construction 8th Edition.

7.7 McMASTER-CARR Supply Co., Catalog 92. (attached)

7.8 Formulas for Stress and Strain Fifth Edition, Roark and Young, McGraw Hill.

7.9 SED file No. DC-SE-01-CE, Rev. 2, dated 04/29/81

7.10 Not used

7.11 Unistrut General Engineering Catalog No. 10R

8.0 <u>ATTACHMENTS</u>

8.1 Meeting Note Ref. 7.1

8.2 Walk_down Information Ref. 7.5

8.3 Enveloped Response Spectra for Aux. Building.

8.4 Faxed information From POEM Lighting Company Ref. 7.3

- end -