EBASCO SERVICES INCORPORATED

SYSTEM ANALYSIS OF CABLE TRAY AND HANGER ASSEMBLY

FOR

COMANCHE PEAK STEAM ELECTRIC STATION

UNITS 1 AND 2

REVISION	PREPARED BY	REVIEWED BY	APPROVED BY	DATE	PAGE AFFECTED
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1.0 INTRODUCTION

This document is prepared to provide guidelines for the system analysis of cable tray and hanger assembly for the Comanche Peak Steam Electric Station (CPSES) Units 1 and 2. This system analysis, which uses a detailed three dimensional model including the tray routing, the hanger details, and more sophisticated analysis methods, is primarily used to qualify those cable tray hangers which could not satisfy the acceptance criteria by using a more conservative equivalent static force approach. This document is consistent with the design criteria and methodology specified in Reference 13.

2.0 REFERENCE DOCUMENTS

The following lists the applicable documents including the codes and regulatory guides. Some of these documents were prepared by Gibbs & Hill Inc. and will continue to be used for the design of Seismic Category I cable tray hangers for Comanche Peak Steam Electric Station Units No. 1 and 2.

1. APPLICABLE CODES AND REGULATORY GUIDES

   - Regulatory Guide 1.29 - Seismic Design Classification, Rev. 3, September 1978.
   - Regulatory Guide 1.61 - Damping Values for Seismic Design of Nuclear Power Plants, October 1973.
   - Regulatory Guide 1.89 - Qualification of Class 1E Equipment for Nuclear Power Plants, Rev. 1, June 1984.
   - Regulatory Guide 1.92 - Combining Modal Responses and Spatial Components in Seismic Response Analyses, Rev. 1, February 1976.
   - NUREG 0800 - Standard Review Plan for the Review of Safety Analysis Reports for Nuclear Power Plants, July 1981.
   - AISC - Manual of Steel Construction, 7th Edition, including Supplements No. 1, 2 & 3.
   - AWS D1.1-75 - Structural Welding Code.
   - AISI - Cold-Formed Steel Design Manual, 1968 edition.

2. Cable tray Specification No. 2323-ES-19, Revision 1, dated November 22, 1976, by Gibbs & Hill, Inc.

3. CPSES/FSAR Section 3.8.4.3.3

   "Load Combinations and Acceptance Criteria for Other Seismic Category I Steel Structures"

4. Design Criteria for Cable Tray Supports and Their Arrangement, Gibbs and Hill Calculation Book No. SCS - 11?C 3/9-3/24.

5. Structural Embedments Specification No. 2323-SS-30, by Gibbs & Hill, Inc.

6. Design procedure: DP-1 Seismic Category I, Electrical Cable Tray Supports dated June 11, 1984, by Gibbs & Hill, Inc.

7. Refined Response Spectra for Fuel Handling Building, dated October 1985, for SSE and OBE.

8. Refined Response Spectra for Reactor Building Internal Structure, dated January 1985, for SSE and January 1983 for OBE.

9. Refined Response Spectra for Containment Building, dated January 1985 for SSE and January 1983 for OBE.

10. Refined Response Spectra for Auxiliary Building, dated November 1984 for SSE and January 1983 for OBE. R1

11. Refined Response Spectra for Electrical Building, dated November 1984 for SSE and November 1982 for OBE.

12. Refined Response Spectra for Safeguards Building, dated November 1984 for SSE and January 1983 for OBE.

13. Seismic Design Criteria for Cable Tray Hangers for CPSES Unit No. 1, Revision 3, January 15, 1987, by Ebasco Services Incorporated. R2

14. Seismic Design Criteria for Cable Tray Hangers for CPSES Unit No. 2, Revision 6, January 15, 1987, by Ebasco Services Incorporated. R2

15. General Instructions for Cable Tray Hanager Analysis for CPSES Units No. 1 and 2, Revision 4, January 15, 1987, by Ebasco Services Incorporated. R2

16. Dynamic Analysis of Cable Tray Systems, Revision 5, October 10, 1986, Impell Instruction No. PI-02. R1

3.0 DESIGN LOADS AND PARAMETERS

See "Seismic Design Criteria for Cable Tray Hangers" (References 13 and 14) for design loads and parameters. R2

4.0 SYSTEM ANALYSIS PROCEDURES

4.1 Overview

Presented in the following sections is a comprehensive procedure to be used for the analysis/qualification of cable tray raceway systems at CPSES. This procedure is intended to provide guidelines on the assembly of analytical system models, the evaluation of the system response to applied loads, both static and dynamic, and the criteria to be used to show acceptance of the tray systems.

The cable tray system analyses will be performed using three dimensional finite element models prepared to accurately predict the system response to the design loads. To do this, all of the significant components of the cable tray system will be modelled in detail. More specifically, tray components, including straight tray, bends, tees, crosses, reducers, etc. and support components, including tray-to-support clips, member connections, support anchorage, etc., will be modelled to accurately represent their behavior. Also included in the following sections are basic guideline for determining logical analysis boundary locations so that model sizes can be made manageable.

Generally, the cable tray system dynamic analysis is beneficial in terms of load reduction. It shall be used to qualify those cable tray hangers which could not satisfy the acceptance criteria by using the more conservative static equivalent analysis method. The candidate hangers for the system analysis shall be selected and properly identified on the cable tray span length drawings. R1

4.2 Modelling

Analysis of the cable tray systems shall be performed using the PD STRUDL program. The modelling of cable tray systems is discussed in this section. First, the procedure to select the model size is described. The required design input, modelling techniques for various component types, and the proper selection for boundary conditions are then followed. These modelling procedure are intended to establish a standard approach for an accurate and consistent production work. R1

4.2.1 Model Size Selection

The purpose of the 3-D model cable tray system analysis is to qualify those cable tray hangers which could not satisfy the acceptance criteria by using the more conservative static or static equivalent analysis methods. From the tray routing and hanger span layout drawings, the analyst shall first identify these hangers and then determine the size and the boundary cut-off for the analysis model based on the following criteria:

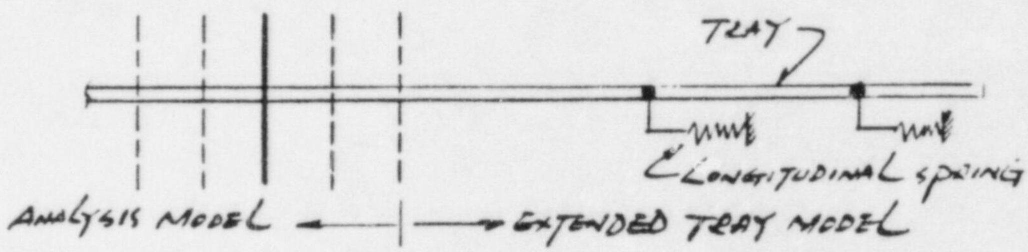
a) There should be at least two tray spans (transverse and vertical) in each side of end hangers under consideration. These hangers at the ends of the model are used only to simulate the boundary conditions and are defined as "analysis-only" hangers (see Figure 4.1). Loads on those "analysis-only" hangers are not used for qualification. It is desirable to use those R1 hangers already qualified as the "analysis-only" hangers.

b) The analysis model may not cover all the longitudinal hangers in a straight run tray due to the limitation of the model size. To properly consider the dynamic load distribution in the longitudinal direction, the following procedure shall be applied in the modeling:

   i) Determine the stiffness of the decoupled longitudinal hangers in the longitudinal direction at each of the tray attachment points. This shall be performed by simultaneously applying a unit load at each tray attachment point. The stiffness shall be calculated as the value of the load divided by the resulting deflection. R1

   ii) Calculate the combined stiffness of the support and clamp which are in series. The clamp stiffness is discussed in Section 4.2.5.

   iii) Extend the tray model all the way to the ends of the straight run and add spring elements to simulate the support and clamp stiffness at tray attachment points as illustrated below. At the extended portion of the tray model, all degrees of freedom other than the one for the longitudinal translation shall be fully restrained.



   iv) Lump the appropriate portion of the hanger weight at tray attachment points.

c) For more efficient analysis, the model shall be limited to approximately 250 nodal points. Cable tray systems consisting of a single tray run should be limited to roughly 20-25 hangers; systems with two tray runs should be limited to 15-20 hangers, and systems with three or more tray runs should be limited to 10-15 hangers. R1

Figure 4.1 illustrates some example of the model.

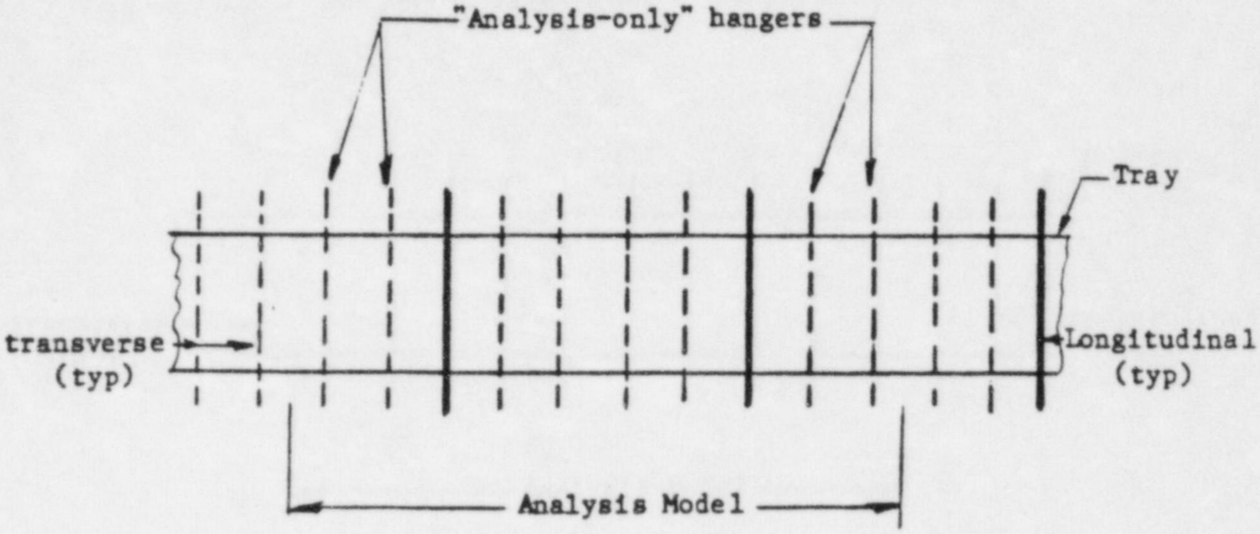
4.2.2 Mass Point Spacing

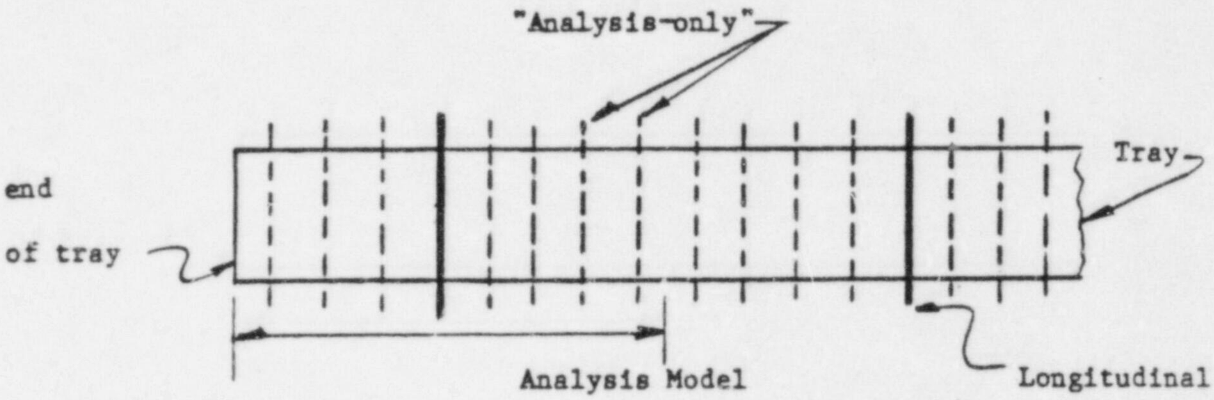
Dynamic analyses using a lumped mass idealization require that a sufficient number of mass points be defined. The mass point spacing shall be calculated using the following equation:

$$Sm = \frac{1}{2}\left(\frac{\pi}{2f}\right)^{1/2} \left(\frac{EIg}{W}\right)^{1/4}$$

Where Sm = mass point spacing (in)
f = analysis cutoff frequency, 33 Hz
E = 29.5×10^6 psi
I = moment of inertia (weak bending axis) (in^4)
g = 386.4 in/sec^2
W = unit weight of component (lb/in)

This mass point spacing assures that all significant modes below 33 Hz are considered. Moreover, a minimum of 3 mass points shall be used to represent the tray between two neighboring hangers. R1





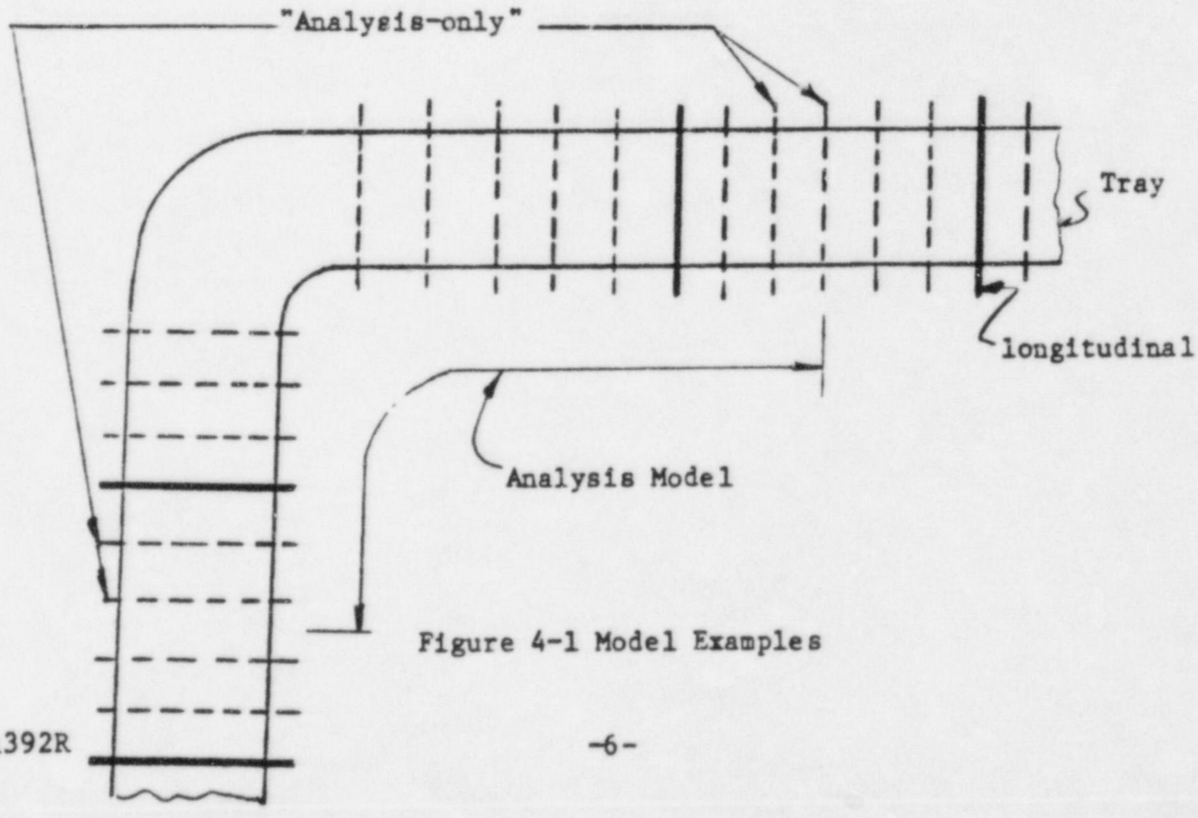
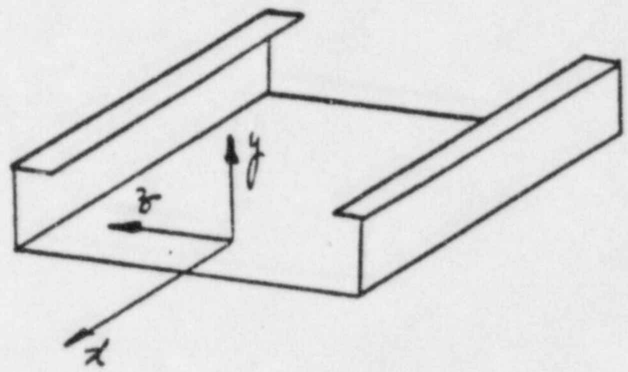


Figure 4-1 Model Examples

4.2.3 Cable Tray Components

a. Straight Trays

Straight cable tray runs shall be modelled as general beam elements with section properties calculated as indicated below.



The tray axial area, A_x, shall be the total cross-sectional area of the side rails. The results from the test shall be used to calculate the moments of inertia Iyy and Izz, and torsional constant J. R1

It should be noted that, while only Burndy/Husky trays were used throughout the Unit 2 plant, both Burndy/Husky and T.J. Cope trays were used in Unit 1 cable tray routings. Documents also show that only T.J. Cope tray was used in the non-common area building (such as Diesel Generator Building) and both Burndy/Husky and T.J. Cope trays were installed in the common area buildings (Auxiliary Building, Fuel Handling Building, Electrical and Control Buildings). Furthermore, even from the same tray manufacturer, there exist two different tray properties; one covers the ladder type tray and the other covers the solid trough type tray.

Unless the walk-down report clearly differentiates the type and the brand name of the tray for every installed system, an enveloped sectional properties shall be used. Table 4-1 shows T.J. Cope tray properties for various tray sizes and types and Tables 4-2 and 4-3 show the enveloped properties. While Table 4-2 is intended to be used in analyzing the systems installed in the common area buildings, Table 4-3 shall only be used for systems inside Diesel Generator Building.

TABLE 4-1
T J COPE TRAY PROPERTIES

T J Cope Tray Cat. No.	Description	Ax (in^2)	J	Iyy (in^4)	Izz
GI-30SL-12	30x6 1/4x1 1/4 Ladder 12 GA. Siderail	1.787	0.0066	2.46	2.32
GI-24SL-12	24x6 1/4x1 1/4 Ladder 12 GA. Siderail	1.787	0.0066	2.20	3.32*
JM-36SL-12	36x6 1/4x1 1/4 Corrug. Through 12 GA. Siderail	1.787	0.0066	2.89	2.10
JM-30SL-12	30x6 1/4x1 1/4 Corrug. Through 12 GA. Siderail	1.787	0.0066	3.27	2.10
JM-24SL-12	24x6 1/4x1 1/4 Corrug. Through 12 GA. Siderail	1.787	0.0066	3.30	2.10
JM-18SL-12	18x6 1/4x1 1/4 Corrug. Through 14 GA. Siderail	1.285	0.0024	1.835	1.439
GG-36SL-12-06	36x4x1 1/4 Ladder 12 GA. Siderail	1.316	0.0048	3.68	2.53
GG-30SL-12-06	30x4x1 1/4 Ladder 12 GA. Siderail	1.316	0.0048	4.02	2.53
GG-24SL-12-06	24x4x1 1/4 Ladder 14 GA. Siderail	0.949	0.0018	2.20	1.63
GG-18SL-12-06	18x4x1 1/4 Ladder 14 GA. Siderail	0.949	0.0018	2.46	1.63
GG-12SL-12-06	12x4x 13/16 Ladder 16 GA. Siderail	0.658	0.0008	1.50	0.813
GG-06SL-12-06	6x4x 13/16 Ladder 16 GA. Siderail	0.658	0.0008	1.30	0.813
GF-36SL-12	36x4x1 1/4 Corrug. Trough 12 GA. Siderail	1.316	0.0048	3.41	2.07
GF-30SL-12	30x4x1 1/4 Corrug. Trough 12 GA. Siderail	1.316	0.0048	3.72	2.07
GF-24SL-12	24x4x1 1/4 Corrug. Trough 12 GA. Siderail	1.316	0.0048	4.46	2.07

R1

*See Note 3.

TABLE 4-1
T J COPE TRAY PROPERTIES (Cont'd)

T J Cope Tray Cat. No.	Description	(in^2) Ax	J	(in^4) Iyy	Izz
GF-18SL-12	18x4x1 1/4 Corrug. Trough 14 GA. Siderail	0.949	0.0018	1.17	1.288
GF-12SL-12	12x4x1 1/4 Corrug. Trough 14 GA. Siderail	0.949	0.0018	1.24	1.288
GF-06SL-12	6x4x 13/16 Corrug. Trough 16 GA. Siderail	0.658	0.0008	0.64	0.839

R1

Notes:

1. All ladders have 16 GA. rungs.
2. Transverse shear areas, Ay and Az, are assumed equal to 1000 in^2.
3. The tray properties given for GI-24SL-12 are preliminary pending test data.

TABLE 4-2

BURNDY/HUSKY & T.J. COPE TRAY PROPERTIES
FOR UNIT #1 COMMON AREAS

Tray Size	Burndy/Husky Ladder				Enveloped T.J. Cope Ladder & Solid Trough				Enveloped Tray Properties Burndy/Husky & T.J. Cope			
	A in^2	J in^4	Izz in^4	Iyy in^4	A in^2	J in^4	Izz in^4	Iyy in^4	Area (in^2)	J in^4	Izz (in^4)	Iyy (in^4)
6"x4"	1.102	0.004	-	-	0.658	0.0008	0.813	0.638	0.658	0.0008	0.813	0.638
6"x6"						Use Same as 6"x4"						
12"x4"	1.102	0.002	1.465	5.793	0.658	0.0008	0.813	1.24	0.658	0.0008	0.813	1.24
12"x6"						Use Same as 12"x4"						
18"x4"	1.102	0.002	1.664	4.755	0.949	0.0018	1.288	1.17	0.949	0.0018	1.288	1.17
18"x6"	1.402	0.002	-	-	1.285	0.0024	1.439	1.835	1.285	0.002	1.439	1.835
24"x4"	1.531	0.0056	1.198	4.231	0.949	0.0018	1.63	2.195	0.949	0.0018	1.198	2.195
24"x6"	1.402	0.0056	-	-	1.787	0.0066	2.10	3.30	1.402	0.0056	2.10	3.30
30"x4"	1.531	0.0056	2.51	3.783	1.316	0.0048	2.07	3.72	1.316	0.0048	2.07	3.72
30"x6"	1.402	0.0056	3.268	7.223	1.787	0.0066	2.10	2.455	1.402	0.0056	2.10	2.455
36"x4"	1.636	0.006	1.891	5.705	1.316	0.0048	2.07	3.41	1.316	0.0048	1.891	3.41
36"x6"	1.951	0.006	3.948	10.695	1.787	0.0066	2.10	2.89	1.787	0.006	2.10	2.89

R1

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TABLE 4-3

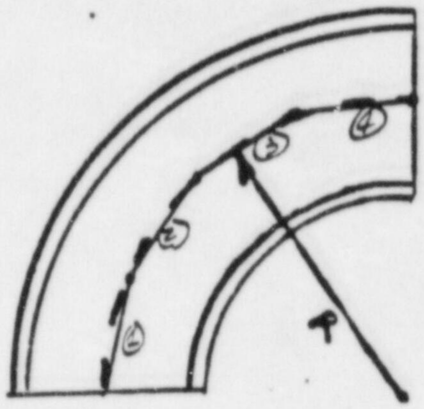
ENVELOPED T.J. COPE TRAY PROPERTIES
FOR DIESEL GENERATOR BUILDING (UNIT 1)

Tray Size	A in^2	J in^4	Izz in^4	Iyy in^4
6"x4"	0.658	0.0008	0.813	0.638
6"x6"	0.658	0.0008	0.813	0.638
12"x4"	0.658	0.0008	0.813	1.24
12"x6"	0.658	0.0008	0.813	1.24
18"x4"	0.949	0.0018	1.288	1.17
18"x6"	1.285	0.0024	1.439	1.835
24"x4"	0.949	0.0018	1.63	2.195
24"x6"	1.787	0.0066	2.10	3.30
30"x4"	1.316	0.0048	2.07	3.72
30"x6"	1.787	0.0066	2.10	2.455
36"x4"	1.316	0.0048	2.07	3.41
36"x6"	1.787	0.0066	2.10	2.89

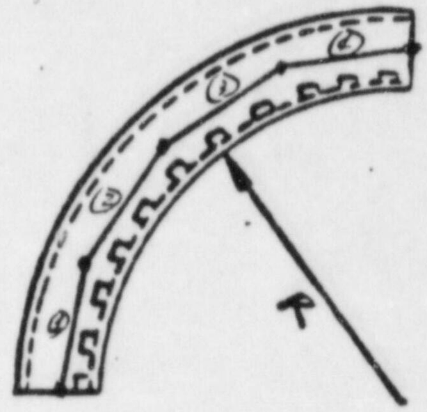
R1

b. Bends

In cable tray hanger system analysis for dynamic load using STRUDL program, cable tray bends shall be modelled as a series of straight prismatic members with the lumped mass option to specify the load. The mass and cross-sectional properties for straight trays shall be used for curved tray sections. Available test data shall be incorporated in the modelling where appropriate. R1



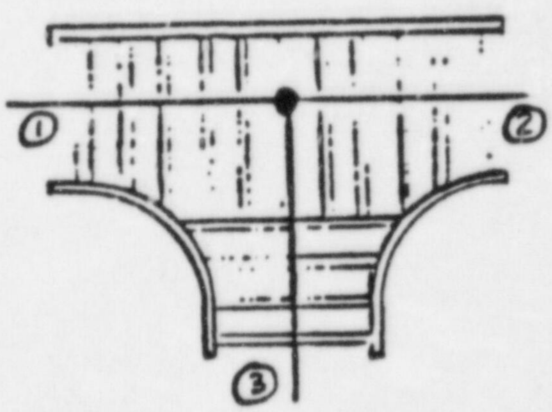
HORIZONTAL OR FLAT BEND



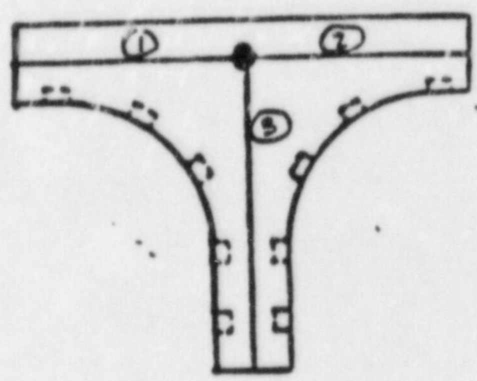
VERTICAL OR RISER BEND

c. Tees

Cable tray tees can be idealized as follows:



HORIZONTAL TEE



VERTICAL TEE

Model a node at the tee intersection.

Element	Cross-section Properties
1, 2	Same as straight tray for run side
3	Same as straight tray for branch side

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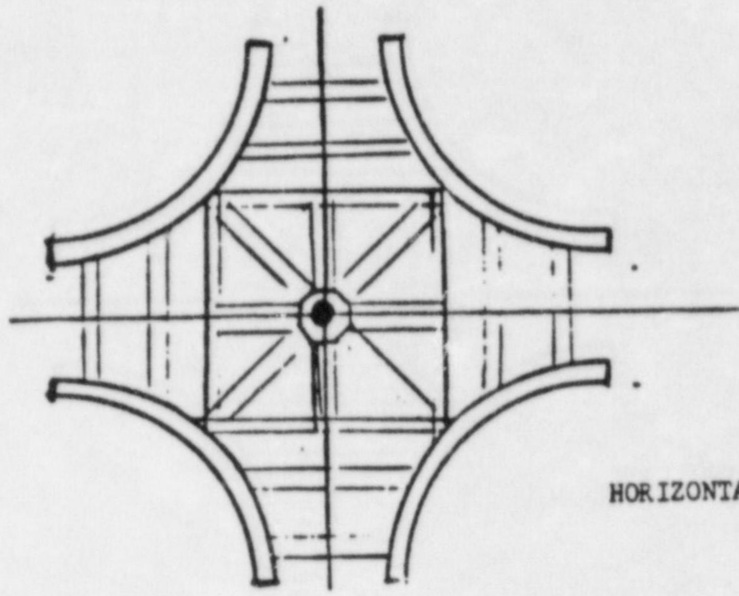
d. Crosses

The cable tray cross shall be modelled as follows:

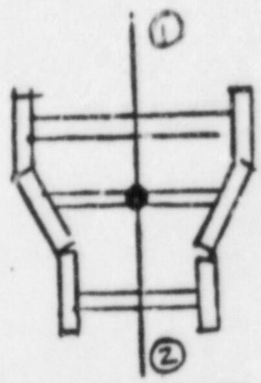


HORIZONTAL CROSS

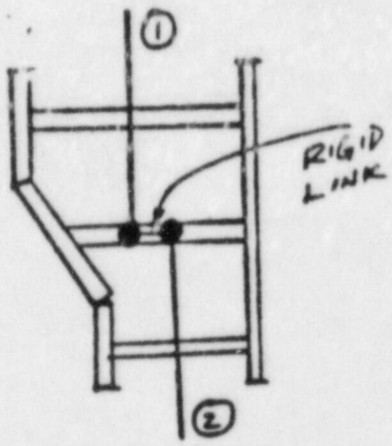
1. Model a node at the cross intersection

2. Model each leg using straight tray properties corresponding to the appropriate tray type.

e. Reducers



STRAIGHT REDUCER



OFFSET REDUCER

1. Model a node at the change in cross-section (middle of transition).

2. Model a rigid link for each offset between the centerlines of the trays.

f. Special Components

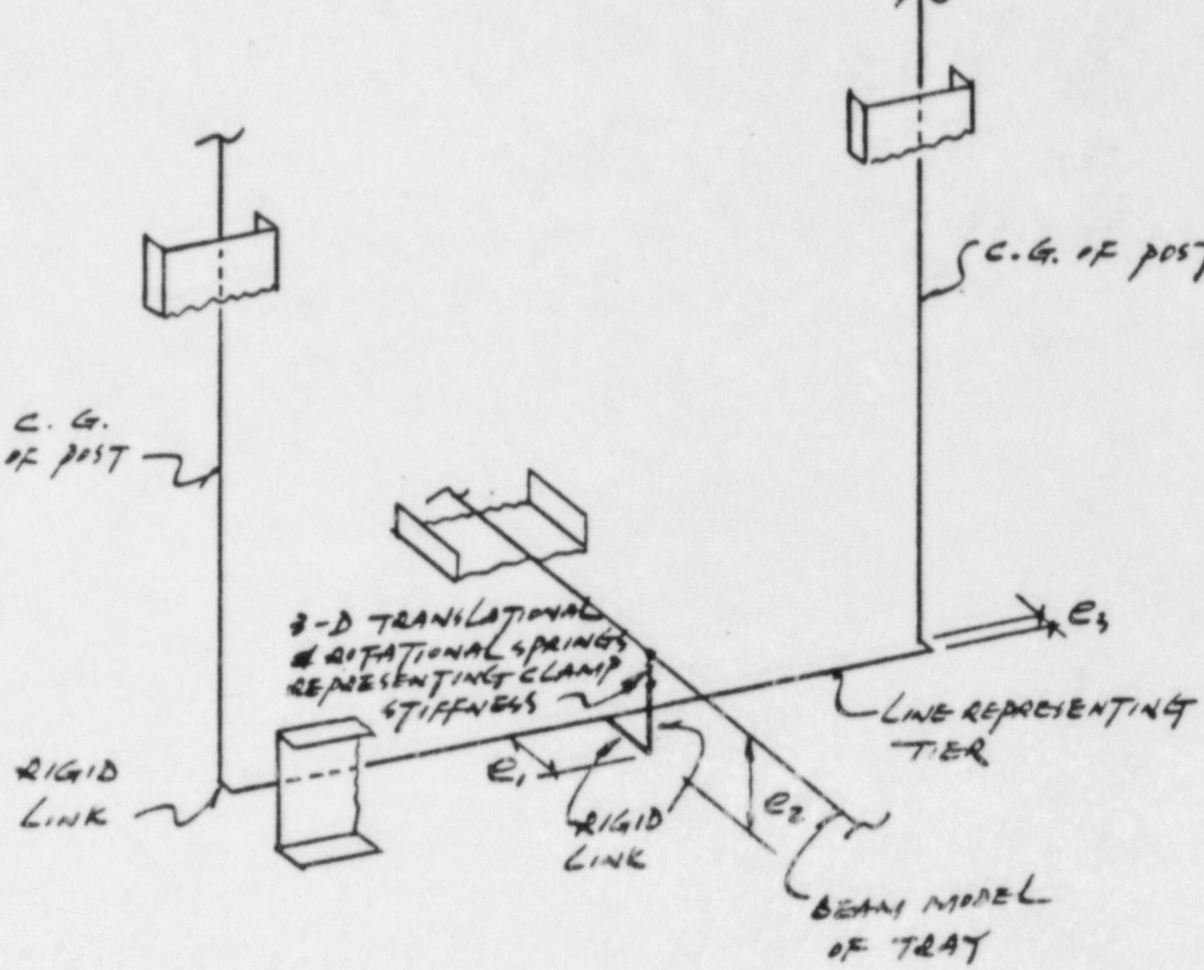
In addition to the basic components described above, cable tray systems may consist of hinged connections, adjustable bends, vertical cable support elbows, Y-branches, and other less commonly used components. The modelling of these components shall follow similar rules defined for the basic components. Particular attention shall be given to the special features of these components. For example, the hinged trays shall be modelled with the appropriate rotational degrees-of-freedom released. For the vertical cable support elbows, rigid members shall be used to reflect the rigidity provided by the gusset plates.

4.2.4 Hangers

See modelling of hangers in the General Instructions for Cable Tray Hanger Analysis for CPSES No. 2 (Reference 14). For "analysis-only" hangers, an equivalent simplified model consisting of springs and masses can be used in the model if justifiable.

4.2.5 Connections from Tray to Hangers

The cable trays are connected to support beams with a variety of clamps. The various clamp types are shown in Appendix A. The translational and rotational stiffness of the clamp elements listed in the Appendix A shall be used to connect the tray and hanger model together. The "Released" and the "Non-Released" transverse clamp properties represent the degree of connectivity existing between the tray and the clamp. While the "Released" clamp properties shall be used for cases where minimum connectivity is expected, the "Non-Released" clamp properties R2 shall be used to count for the full connectivity. Figure 4.2 shows the sketch of the model to be used in the system analysis. For proper consideration of the clamp stiffness in system analysis, Section 4.3.6 shall be referred.



e_1 = Distance from the centroid of the web to the shear center of the tier member

e_2 = Distance from the midplane of the tier member to the centroid of the tray.

e_3 = Distance between the shear center of the tier and the centroid of the post.

Figure 4-2 Model Sketch

4.2.6 Boundary Conditions

a. Hanger Anchorage

In general, cable tray hanger anchorages consist of three types: base angles, expansion (and insert) anchor plates, and embedded plates as shown in Figure 4-3.

For each of these types of anchorages, the boundary assumptions should reflect the actual configuration. The boundary conditions which should be used for each of the configurations shown in Figure 4-3 are as follows:

1) Base Angle - 1 bolt

a) Attachment to bolted leg

Translation X - Fixed
Y - Fixed
Z - Fixed

Rotation XX - K from Table 4-4 R1
YY - K from Table 4-4
ZZ - Free

b) Attachment to free leg

Translation X - Fixed
Y - Fixed
Z - Fixed

Rotation XX - K from Table 4-4 R1
YY - K from Table 4-4
ZZ - Free

2) Base Angle - 2 & 3 bolt

a) Attachment to bolted leg

Translation X - Fixed
Y - Fixed
Z - Fixed

Rotation XX - K from Table 4-4
YY - K from Table 4-4
ZZ - K from Table 4-4 | R1

b) Attachment to free leg

Translation X - Fixed
Y - Fixed
Z - Fixed

Rotation XX - K from Table 4-4
YY - K from Table 4-4
ZZ - K from Table 4-4 | R1

3) Expansion and Insert Anchor Plates ($\geq$ 2 bolts along 2 uniques axes) | R2

Translation X - Fixed
Y - Fixed
Z - Fixed

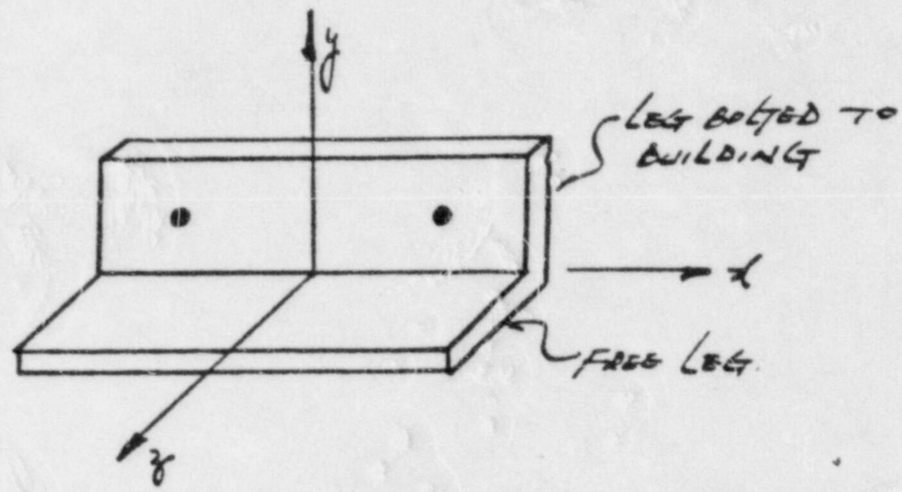
Rotation X - Fixed
Y - Fixed
Z - Fixed

4) Embedded Plates

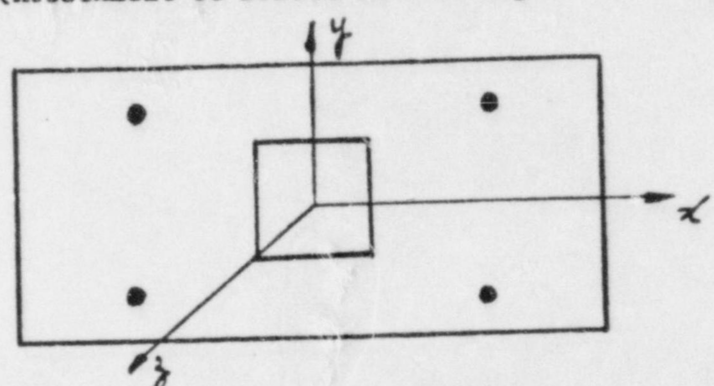
Translation X - Fixed
Y - Fixed
Z - Fixed

Rotation X - Fixed
Y - Fixed
Z - Fixed

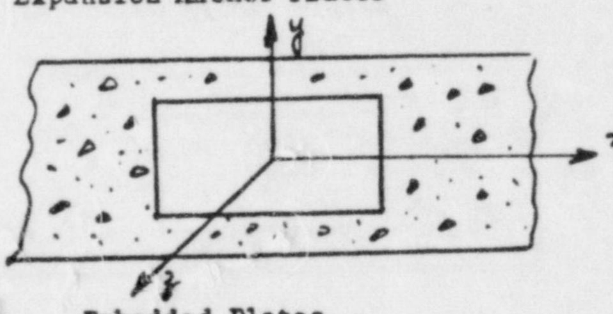
The anchorage stiffness to be used in representing the boundary condition for base angle with one or two bolts are shown on Tables 4-4A and 4-4B. For anchorage system not covered in the tables, an unique analysis shall be performed to establish proper anchorage stiffness. | R1



1 and 2 Bolt Base Angles
(Attachment to Bolted or Free Leg)



Expansion Anchor Plates



Embedded Plates

Figure 4-3 Anchorage Types

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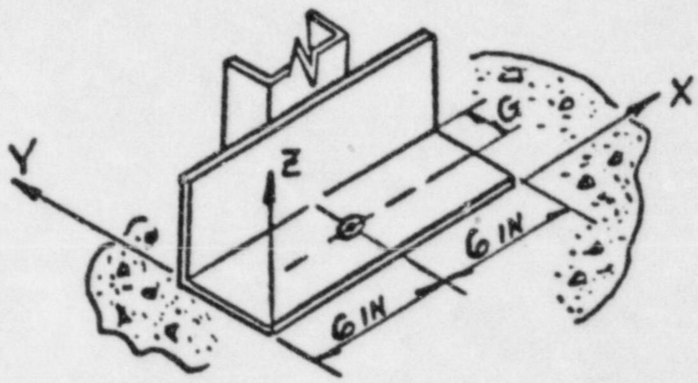
TABLE 4-4A R1

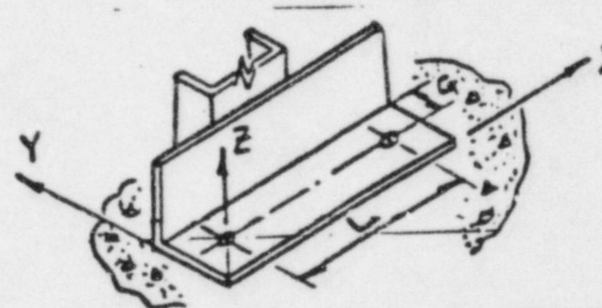
ANCHOR STIFFNESS

CASE 1A: 1 BOLT PATTERN R1



ANGLE SIZE	L (in.)	KMX (in.k/deg.) 1.25 dia SU. HILTI	KMX (in.k/deg.) 1.5 dia. INSERT	KMY (in.k/deg.) 1.25 dia SU. HILTI	KMY (in.k/deg.) 1.5 dia. INSERT	KMZ (in.k/deg.) 1.25 dia SU. HILTI	KMZ (in.k/deg.) 1.5 dia. INSERT
L5X5X.75	---	14	27	86	180	---	---
L6X6X.75	---	16	26	80	165	---	---
L8X8X.75	---	18	22	72	134	---	---

CASE 2A: 2 BOLT PATTERN R1



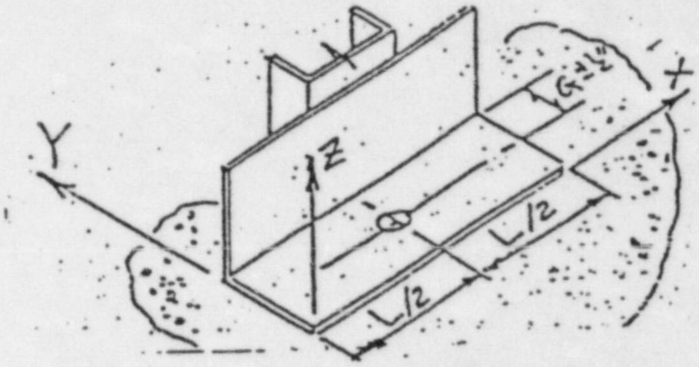
ANGLE SIZE	L (in.)	KMX (in.k/deg.) 1.25 dia SU. HILTI	KMX (in.k/deg.) 1.5 dia. INSERT	KMY (in.k/deg.) 1.25 dia SU. HILTI	KMY (in.k/deg.) 1.5 dia. INSERT	KMZ (in.k/deg.) 1.25 dia SU. HILTI	KMZ (in.k/deg.) 1.5 dia. INSERT
L5X5X.75	12	20	41	277	651	113	171
	18	21	46	417	904	152	199
	24	22	49	544	1084	172	206
	30	22	49	653	1187	180	206
	36	22	48	740	1229	184	202
L6X6X.75	12	27	39	295	606	107	156
	18	30	46	457	878	144	182
	24	32	50	612	1091	163	192
	30	33	52	749	1237	172	195
	36	33	52	863	1323	176	194
L8X8X.75	12	28	33	266	497	94	129
	18	33	40	431	771	126	153
	24	36	46	601	1021	145	166
	30	39	50	764	1229	155	173
	36	40	52	914	1396	160	175

1392R

TABLE 4-4B

ANCHOR STIFFNESS

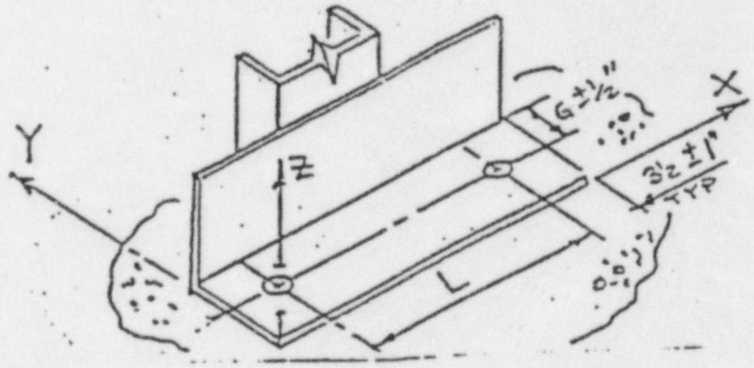
CASE 1B: **1 BOLT PATTERN**



ANGLE SIZE	L (in.)	KMX (in.k/deg.) HILTI KWIK 1.0 & 1.25	KMX (in.k/deg.) R.I. 1.0	KMY (in.k/deg.) HILTI KWIK 1.0 & 1.25	KMY (in.k/deg.) R.I. 1.0	KMZ (in.k/deg.) HILTI KWIK 1.0 & 1.25	KMZ (in.k/deg.) R.I. 1.0
L5X5X.75	12	8	25	55	162	---	---
	9	7	21	34	102	---	---
L6X6X.75	12	10	25	53	149	---	---
	9	9	20	33	94	---	---

R1

CASE 2B: **2 BOLT PATTERN**



ANGLE SIZE	L (in.)	KMX (in.k/deg.) HILTI KWIK 1.0 & 1.25	KMX (in.k/deg.) R.I. 1.0	KMY (in.k/deg.) HILTI KWIK 1.0 & 1.25	KMY (in.k/deg.) R.I. 1.0	KMZ (in.k/deg.) HILTI KWIK 1.0 & 1.25	KMZ (in.k/deg.) R.I. 1.0
L5X5X.75	12	12	35	200	512	69	161
	18	12	39	304	732	109	193
	24	12	41	400	902	137	204
	30	12	41	486	1020	154	206
	36	12	40	562	1090	164	205
L6X6X.75	12	18	38	202	553	66	149
	18	20	44	314	810	105	180
	24	20	48	425	1018	131	193
	30	21	50	532	1169	148	197
	36	21	50	629	1269	158	196

b. Hanger supported by steel frames

If the cable tray hanger is supported by a flexible steel building frame, the flexibility of the steel frame should be considered. This can be achieved by inducing proper spring elements at the support locations.

c. Tray cut-off boundary

A free end boundary condition shall be assumed at the end of the tray model. As discussed in Section 4.2.1, at least two extra tray spans (transverse and vertical) should be used to simulate the tray behavior at the boundary. In addition, the extended tray model should be used to account for the load distribution in the longitudinal direction.

d. Separation of tray at ganged hangers R1

In some instances the analyst may find two or more trays ganged together by common hangers. It is desirable to include all tray runs at the ganged hangers in a single model. In some cases, one of the tray may have to be separated from the analysis model. Loading from the omitted tray should be properly considered. The procedure presented in Section 3.1.2d of Reference 16 can be followed.

4.3 Load Case Analysis

The cable tray systems shall be analyzed for deadweight, thermal expansion, and seismic loading. Live loads shall be assumed to be negligible.

4.3.1 Deadweight

The cable tray system shall be analyzed for gravity loading (deadweight), which is a sustained mechanical loading on the tray and supports. The weight of tray components, cable fill, support components, and any fire protection or other permanently attached materials (such as tray cover, side rail extension, etc.) shall be considered in this analysis. R1

The actual cable tray fill with a margin of 3 pounds per square foot of tray area shall be used in calculating the dead load of cable bundles. However, the sum of this load plus the deadweight of the tray itself shall not exceed 35 pounds per square foot of tray. This is shown as follows:

$W_{design} = W_{tray} + W_{actual\ fill}$ + 3 lbs/SF of Tray + $W_{fireproofing}$

$\leq$ 35 lbs/SF of Tray if fireproofing is not present R1

$\leq$ 35 lbs/SF of Tray + $W_{fireproofing}$ if fireproofing is present

Weights of the tray, cover, side rail extensions, thermolag, thermoblanket and 3 PSF allowance for future cable fill are given in detail in Table 4-5. Actual cable fill data shall be obtained from cable fill sheets or from the marked-up span length drawings which have the fill data summarized for each tray run. If the as-built data is unavailable the tray component weights should be based on 100 percent fill assumption. R1

4.3.2 Thermal

In general, support loads resulting from cable tray thermal expansion when considering the small variation between installation and maximum ambient temperature, are insignificant. There are many factors which contribute to this result. The most significant is the composition of the cable tray system. The system is composed of a series of bolted components. These bolted connections ensure that when the tray system is heated there exists sufficient flexibility to allow unrestrained thermal growth.

Despite the presence of these inherent conditions, thermal loads induced in the cable tray system shall be determined as described below, which is consistent with Ref. 15.

a. Cable tray system thermal loads shall be based on the temperature difference between normal operating ambient temperature and installation temperature, which are listed in Attachment P of Ref. 15 for various building and rooms. An effective coefficient of thermal expansion of 0.0001 in./in./100°F shall be used.

b. Only the thermal loads induced by the tray longitudinal thermal expansion are significant. The modelling procedure described in Section 4.2.1(c) will adequately represent the stiffness of hangers as well as tray in the longitudinal direction. Therefore, the analysis model described before can be used directly in the thermal analysis. R1

c. The temperature differential input shall only be applied to the tray.

4.3.3 Seismic

The seismic events must be considered for the design of the cable tray raceway systems at CPSES. They are represented by response spectra for OBE and SSE, assuming 4 percent and 7 percent structural damping respectively.

TABLE 4-5

CABLE TRAY UNIT WEIGHT WITH AND WITHOUT THERMOLAG/THERMOBLANKET
WEIGHT IN LB/FT

Tray Size	Tray (1)	Cover (2)	Side Rail (3)	Future Cable Allow.(4)	Sum of (1) Thru (4)	Wt of Thermolag	Wt of Thermoblanket	Wt Limit w/o Thermolag or Thermoblanket	
6"x4"	5.0	1.3	2.7	1.5	11	13.0	Note 1	18	R1
6"x6"	5.0	1.3	2.7	1.5	11	14.5		18	
12"x4"	6.0	2.3	2.7	3.0	14	18.5		35	
12"x6"	6.0	2.3	2.7	3.0	14	20.0		35	
18"x4"	7.0	3.3	2.7	4.5	18	24.0		53	
18"x6"	8.0	3.3	2.7	4.5	19	25.5		53	
24"x4"	9.5	4.3	2.7	6.0	23	29.5		70	
24"x6"	9.0	4.3	2.7	6.0	23	31.0		70	
30"x4"	10.5	5.3	2.7	7.5	26	35.0		88	
30"x6"	10.0	5.3	2.7	7.5	26	36.5		88	
36"x4"	12.0	6.3	2.7	9.0	30	40.0		105	
36"x6"	13.0	6.3	2.7	9.0	31	42.0		105	

Note 1: See Appendix 1, Attachment C', Table 1, Sheet A4.2 of the CTH General Instruction Rev 4 dated January 15, 1987. (Ref. 15) R2

The seismic response of cable tray systems shall be analyzed using the "simple excitation" envelope response spectrum method. The design response spectra is the in-structure floor response spectrum which envelopes the building elevations between which the system is supported. For example, if the cable tray system being evaluated is supported in the Reactor Building between floor elevations 860.0 ft. and 885.5 ft., the response spectrum used in the analysis must envelop these elevations and any intermediate floor elevations.

The mode shapes and frequencies shall be calculated up to 33 Hz, or for highest cutoff frequency of the input spectra. Missing mass correction shall be applied to account for higher frequency response. The three orthogonal directions of earthquake loading shall be considered to act simultaneously. The modal responses shall be combined using the Grouping Method (10%) for closely spaced modes in accordance with Regulatory Guide 1.92 and CPSES FSAR. If any other method is used, the conservatism should be demonstrated. The response due to three directions of earthquake shall be combined using square root of the sum of the squares method.

When the response spectrum method is applied in calculating the seismic effect, not only the effect described above but also those effects due to differential anchorage displacements shall also be considered. While the former effect is generally termed as "inertia effect", the latter effect is regarded as "displacement effect". The displacement effect shall be generated in static fashion utilizing the maximum relative anchorage displacements as the input. This result shall then be combined with those induced by inertia effect to complete the analysis for seismic load. R2

For all tray systems the OBE and SSE load cases shall be evaluated in detail.

4.3.4 Modification Analysis

In the event that a support requires modifications, the analyst shall determine if a reanalysis is required to evaluate the impact on the system response. Reanalysis will be required if the modification significantly changes the stiffness and frequency of the cable tray system. (e.g., adding a brace for longitudinal loading). If it can be shown that the modified support has little or no impact on the system response, no reanalysis will be necessary. Reanalysis shall be performed using hand calculations when practical. Otherwise, reanalysis shall be performed in accordance with 4.3.3 above.

4.3.5 Alternative Analysis Methods

Generally, cable tray systems shall be analyzed with the simple excitation envelope response spectrum method for seismic load as discussed in 4.3.3. However, when it is deemed appropriate, a more sophisticated time history method may be used. Due to the excessive computing cost in obtaining the system response via time history method, such an approach shall be used only after all the other means have been exhausted. R1

4.3.6 Consideration of Connectivity between the Cable Tray and Transverse Hanger

The non-friction or "released" clamp properties shall be assumed for all transverse hangers when system analysis is performed. In addition, the friction or "Non-Released" effect shall also be considered. This can be accomplished by performing the system analysis via the use of the "Non-Released" clamp stiffness instead for all transfer hangers and enveloping the result with those obtained earlier with non-friction assumption. If effort shows that the one with non-friction clamp stiffness will generally induce a conservative result, then the re-analysis of all RSM systems may be avoided. R2

5.0 ACCEPTANCE CRITERIA

The acceptance criteria shall be in accordance with those specified in References 13 and 14. The evaluation for structural member, welding and anchorage adequacy shall be performed in accordance with the general instruction given in Reference 15. R2

APPENDIX A

CABLE TRAY CLAMP STIFFNESS AND EXAMPLE CLAMP TYPES | R2

In order to closely represent the cable tray clamp stiffness in system analysis model, the following guidelines should be followed:

1) The clamp stiffnesses shown on the next page shall be used at all times.

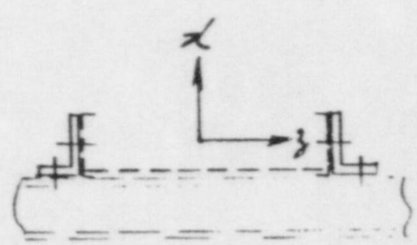
2) If the clamp types are known, the longitudinal clamp stiffnesses shall be used for all longitudinal clamps including types B, D, E, F, H, J, K, N, P, Q and R. For transverse clamps A, C and G, the transverse clamp stiffnesses shall be used. The most commonly used clamp types for Comanche Peak SES Units 1 and 2 are shown in this attachment. R2

3) If the clamp types are not known due to inaccessibility, the following procedure shall apply. First, the support type has to be determined. If the support is a longitudinal support, then the longitudinal clamp stiffnesses shall be specified. Otherwise, the transverse clamp stiffnesses shall be applied. A hanger is defined as a longitudinal hanger only if it is braced in the longitudinal direction or if the vertical members of the hanger are so oriented that the strong axis will act against longitudinal forces.

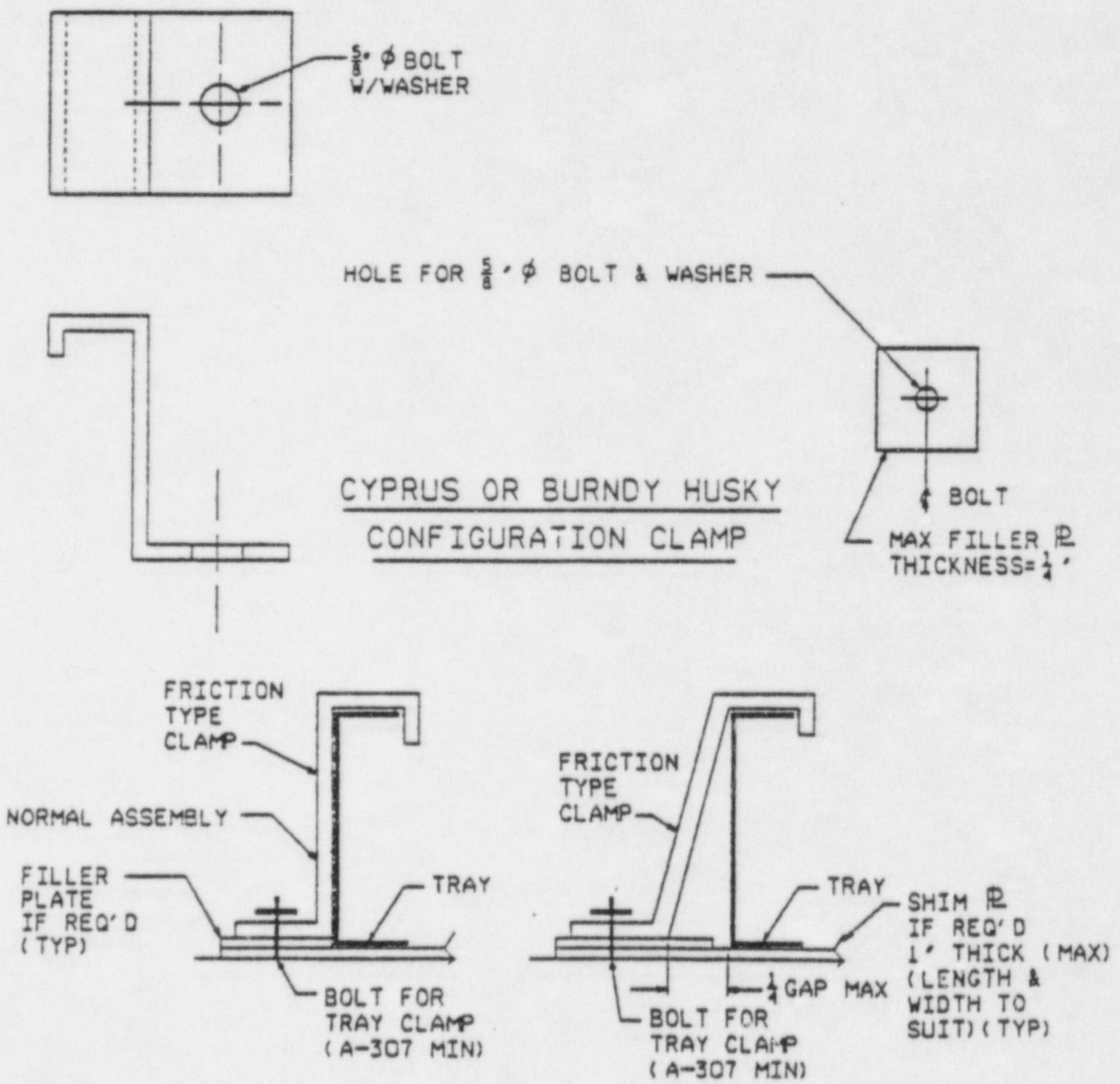
CABLE TRAY CLAMP STIFFNESS

W - Width of Cable Tray H - Height of Siderall

Clamp Type	Cable Tray Size	Translational Stiffness K/in			Rotational Stiffness K-in/rad		
		Kx	Ky	Kz	Kxx	Kyy	Kzz
Transverse Clamps	36x6	3.60	69.3	653.0	770.0	1.2E4	22.4
(Non Released)	30x6	3.60	69.3	653.0	660.0	1.1E4	22.4
	24x6	3.60	69.3	653.0	563.0	9.9E3	22.4
	18x6	3.60	69.3	653.0	472.0	776.0	22.4
	36x4	5.40	73.2	653.0	5.6E3	3.5E4	22.4
	30x4	5.40	73.2	653.0	5.2E3	3.3E4	22.4
	24x4	5.40	73.2	653.0	871.0	3.1E4	22.4
	18x4	5.40	73.2	653.0	679.0	913.0	22.4
	12x4	5.40	73.2	653.0	507.0	640.0	22.4
	6x4	5.40	73.2	653.0	360.0	411.0	22.4
Transverse Clamps (Released)	Use the corresponding values given above except Ky = Kxx = Kzz = 0.0						
Longitudinal Clamps	W x H	580.0	150.0	7.1E3	1.5E5	4.7E5	804.0



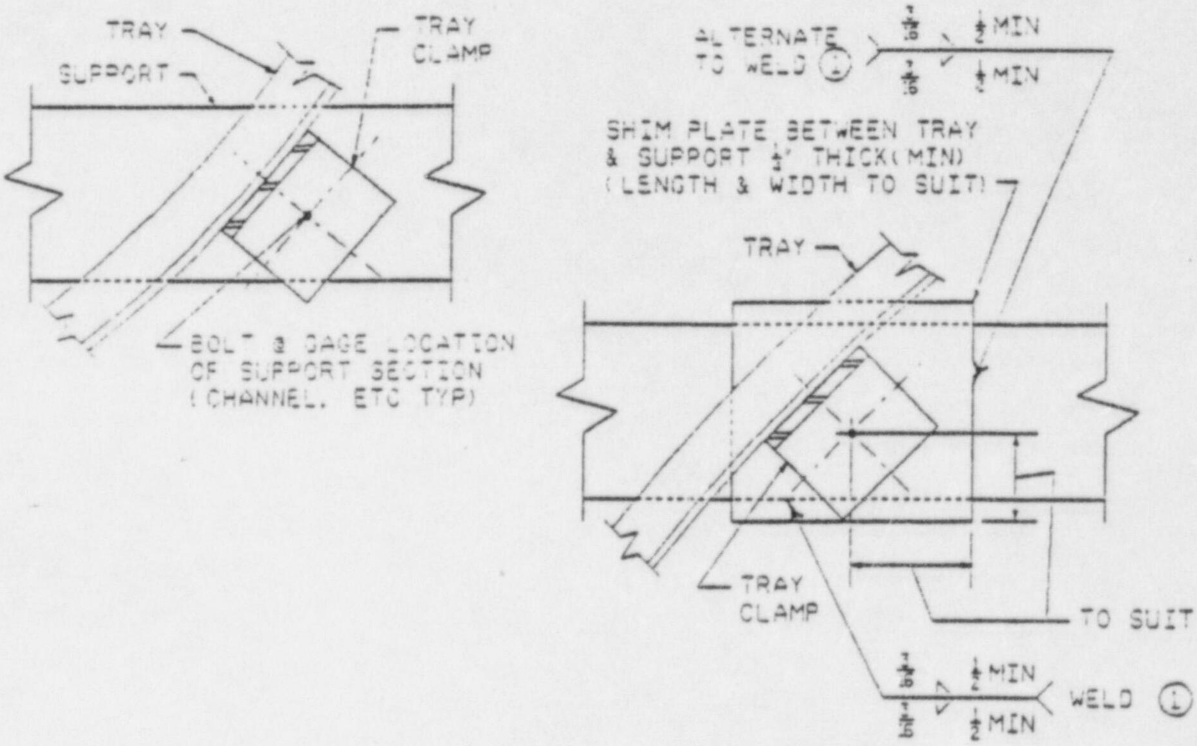
ATTACHMENT "A"



NOTE:
FOR WASHER (IF REQ'D) DETAILS
AND ORIENTATION SEE ATTACHMENT "E".

TYPE 'A' CLAMP SH 1 OF 2

ATTACHMENT "A" (Cont'd)



NOTE:
OVERHANG OF 'CLAMP' FROM SUPPORT STRUCTURE IS ACCEPTABLE AS LONG AS BOLT HEAD OR NUT OR WASHER (IF USED) HAS TOTAL BEARING WITH SUPPORT STRUCTURE.

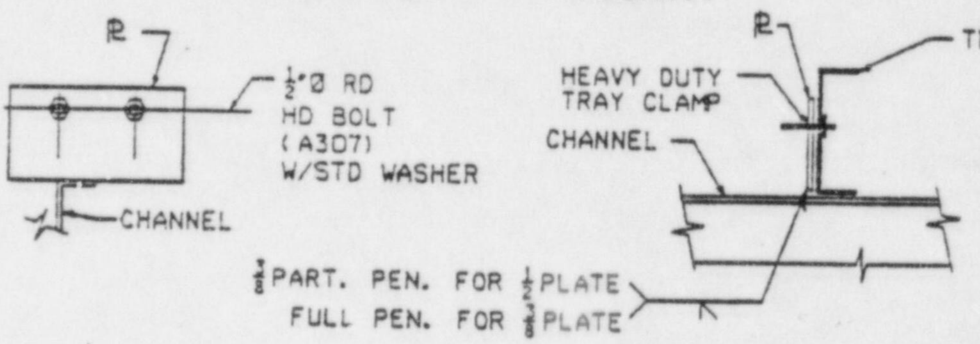
SHIM PLATE MAY BE FIELD FABRICATED AND PAINTED WITH 'GALVANOX PAINT'

WELDS FOR SHIM PLATE TO CTH MEMBER ARE NON-Q WELDS

TYPE 'A' CLAMP

SH 2 OF 2

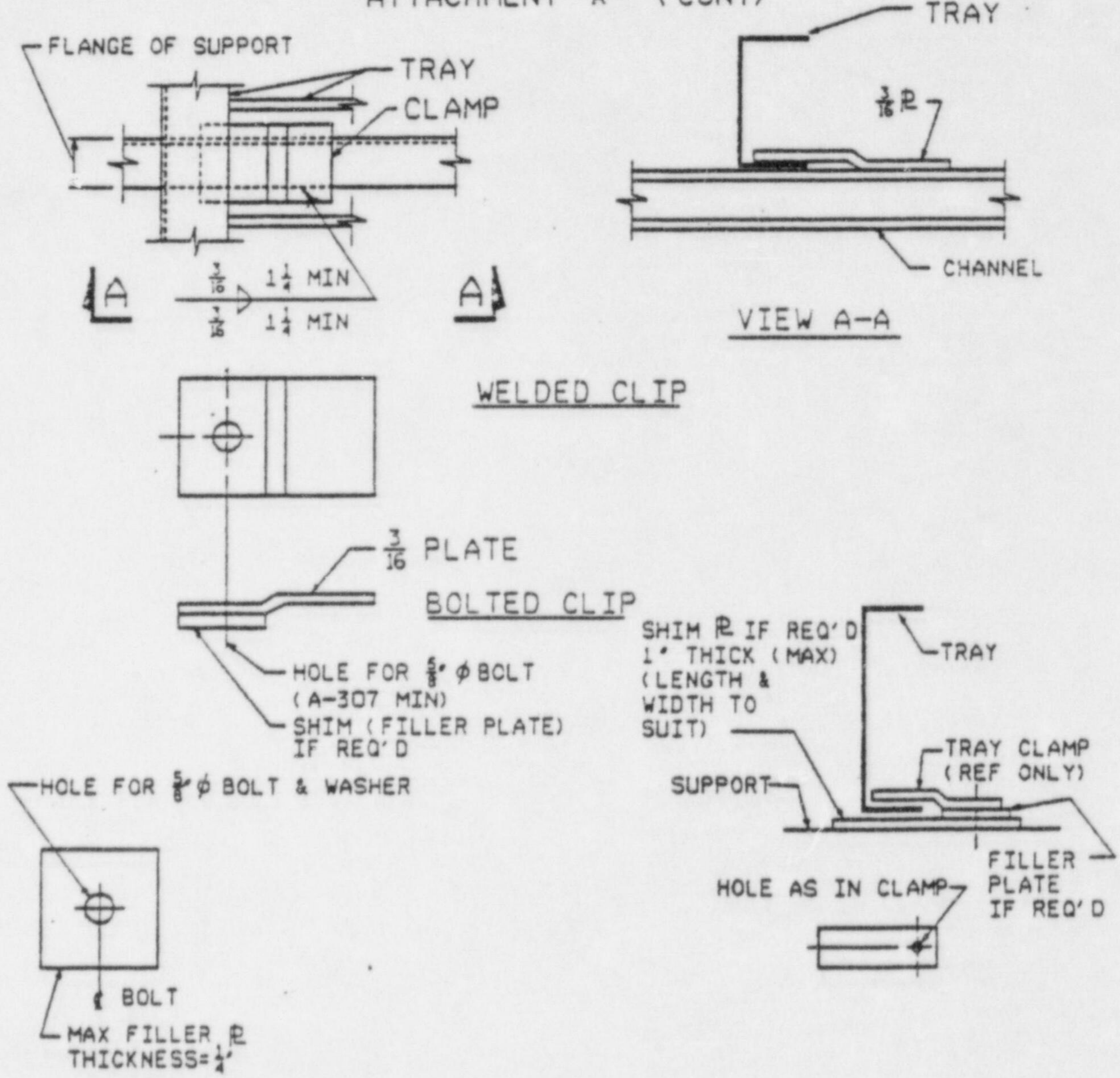
ATTACHMENT "A" (CONT.)



NOTE:
THE PLATE MAY BE BENT TO FIT THE CURVATURE OF TRAY.

TYPE 'B' HEAVY DUTY CLAMP

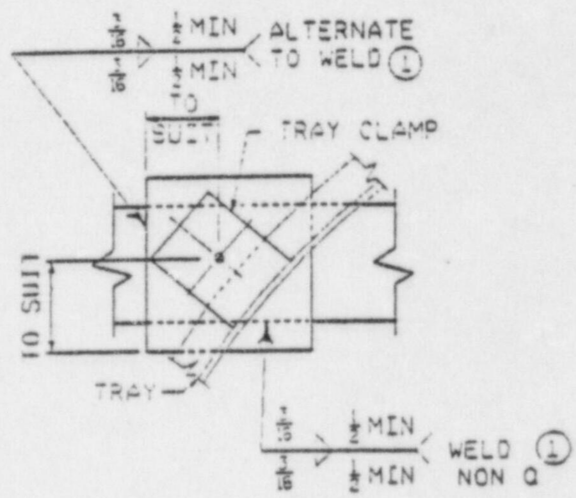
ATTACHMENT "A" (CONT)

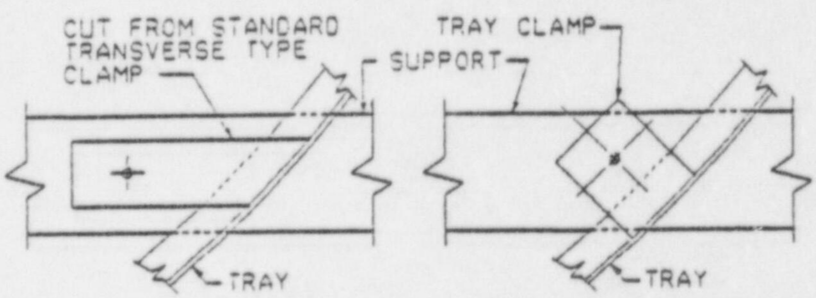


NOTE:
SHIM PLATE MAY BE FIELD FABRICATED AND PAINTED WITH 'GALVANOX PAINT'.
WELDS FOR SHIM PLATE TO CTH MEMBER ARE NON-Q WELDS.

TYPE 'C' CLAMP BOLTED OR WELDED SH 1 OF 2

ATTACHMENT "A" (Cont'd)





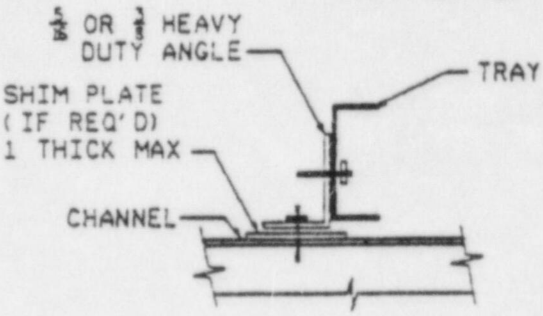
NOTE:
OVERHANG OF 'CLAMP' FROM SUPPORT STRUCTURE IS ACCEPTABLE AS LONG AS BOLT HEAD OR NUT OR WASHER (IF USED) HAS TOTAL BEARING WITH SUPPORT STRUCTURE.

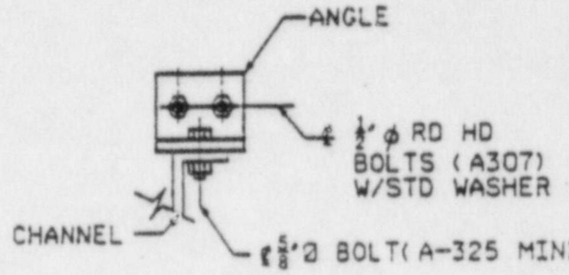
FOR WASHER (IF REQ'D) DETAILS AND ORIENTATION SEE ATTACHMENT 'E'.

TYPE 'C' CLAMP

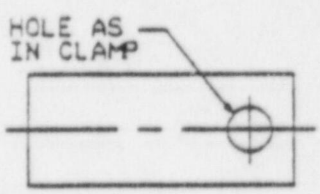
SH 2 OF 2

ATTACHMENT "A" (CONT.)



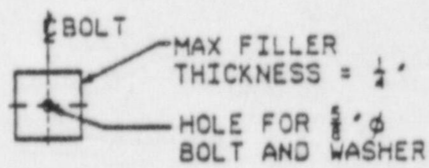


NOTE:
THE ANGLE MAY BE BENT TO FIT THE CURVATURE OF THE TRAY



SHIM PLATE

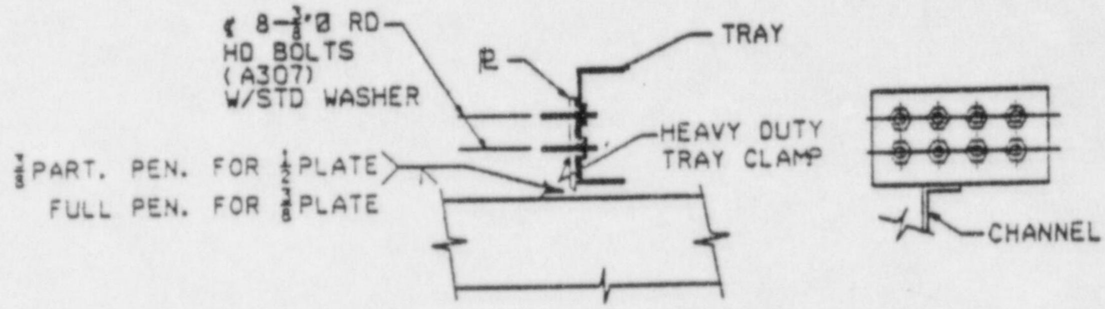
(LENGTH & WIDTH TO SUIT)



NOTE:
OVERHANG OF 'CLAMP' FROM SUPPORT STRUCTURE IS ACCEPTABLE AS LONG AS BOLT HEAD OR NUT OR WASHER (IF USED) HAS TOTAL BEARING WITH SUPPORT STRUCTURE.
SHIM PLATE MAY BE FIELD FABRICATED AND PAINTED WITH GALVANOX PAINT.
FOR WASHER (IF REQ'D) DETAILS AND ORIENTATION SEE ATTACHMENT 'E'.

TYPE 'D' HEAVY DUTY CLAMP

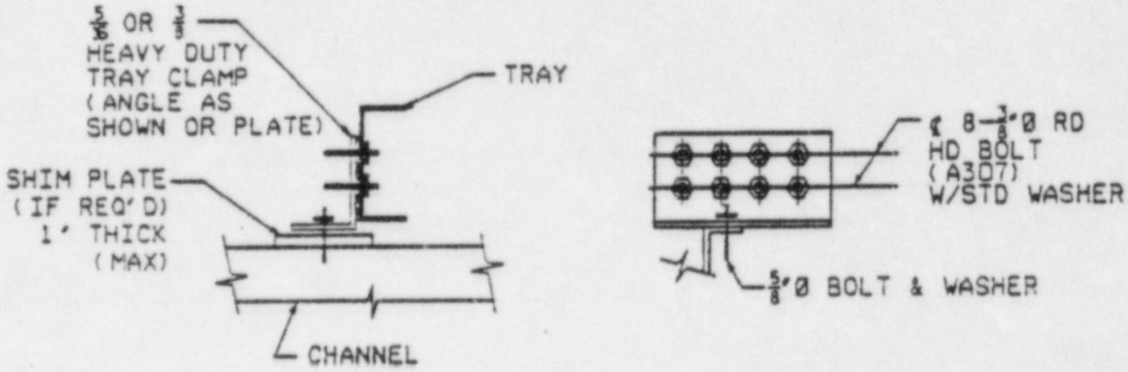
ATTACHMENT "A" (CONT.)

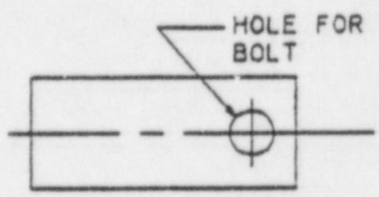


<u>NOTE:</u>
THE PLATE MAY BE BENT TO FIT THE CURVATURE OF TRAY.

<u>TYPE 'E' HEAVY DUTY CLAMP</u>
AT TRAY SPLICE

ATTACHMENT "A" (CONT.)





NOTE:
THE ANGLE MAY BE BENT TO FIT THE CURVATURE OF TRAY.

SHIM PLATE
(LENGTH & WIDTH TO SUIT)

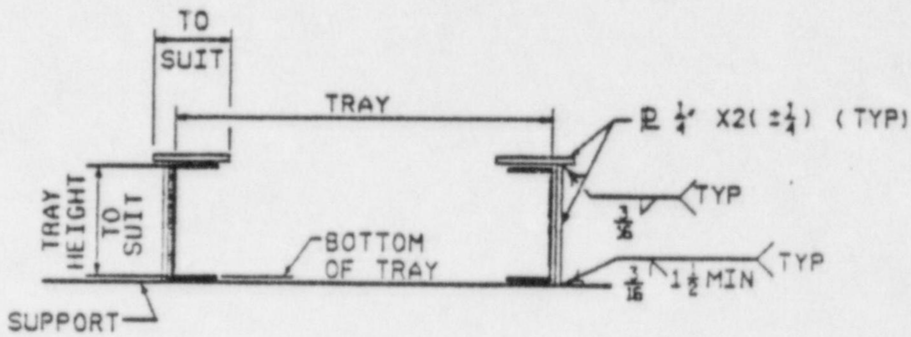
NOTE:
OVERHANG OF 'CLAMP' FROM SUPPORT STRUCTURE IS ACCEPTABLE AS LONG AS BOLT HEAD OR NUT OR WASHER (IF USED) HAS TOTAL BEARING WITH SUPPORT STRUCTURE.

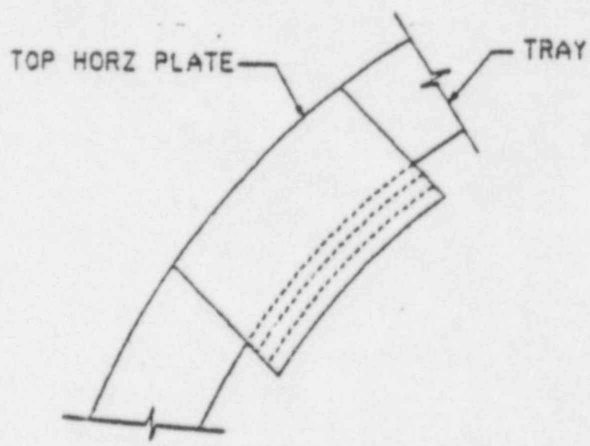
SHIM PLATE MAY BE FIELD FABRICATED AND PAINTED WITH GALVANOX PAINT.

FOR WASHER (IF REQ'D) DETAILS AND ORIENTATION SEE ATTACHMENT 'E'.

TYPE 'F' HEAVY DUTY CLAMP
AT TRAY SPLICE

ATTACHMENT "A" (CONT)

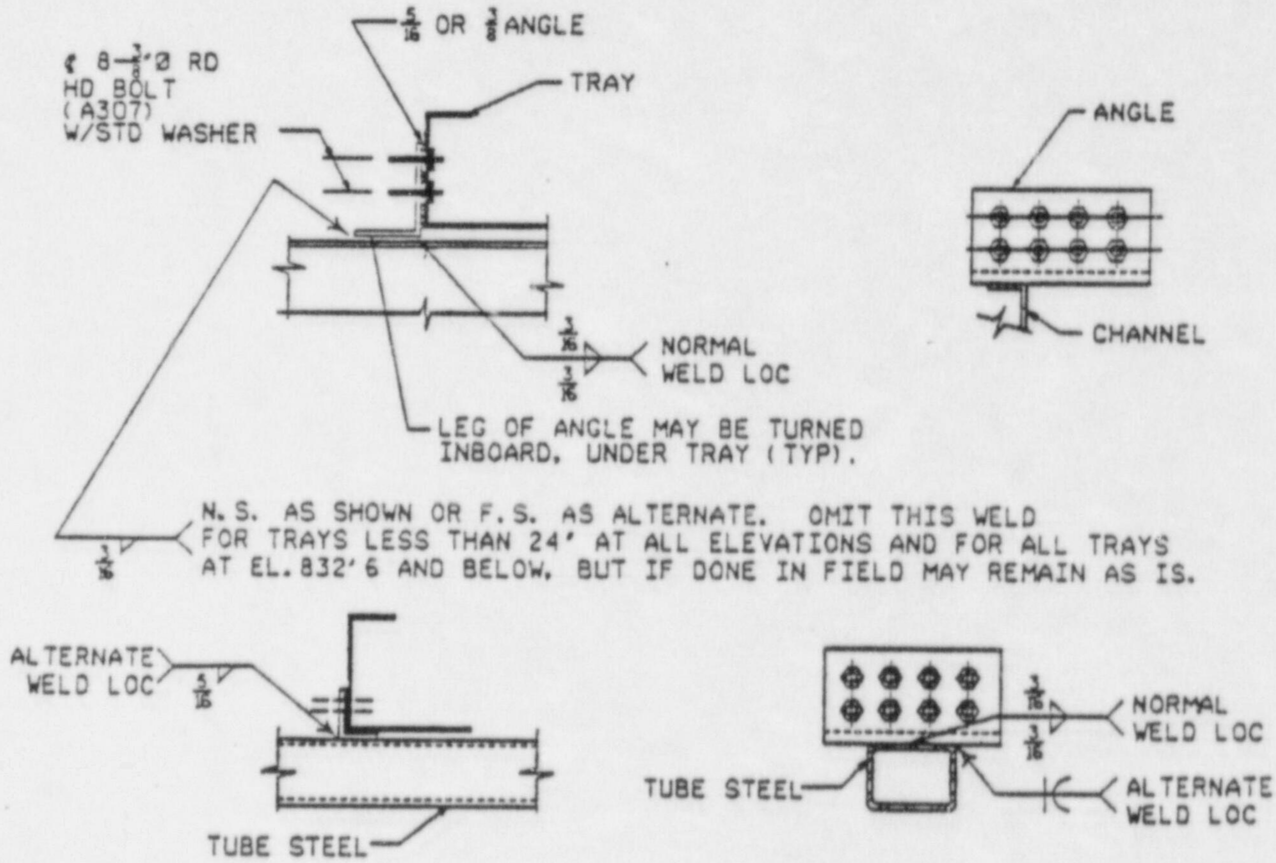




THIS DETAIL MAY BE USED WHERE TRAY BENDS. IF REQUIRED, THE VERTICAL PLATE MAY BE BENT TO FIT THE CURVATURE OF TRAY. TOP HORIZONTAL PLATE MAY ALSO BE CUT TO MATCH TRAY.

TYPE 'G' CLAMP

ATTACHMENT "A" (CONT.)



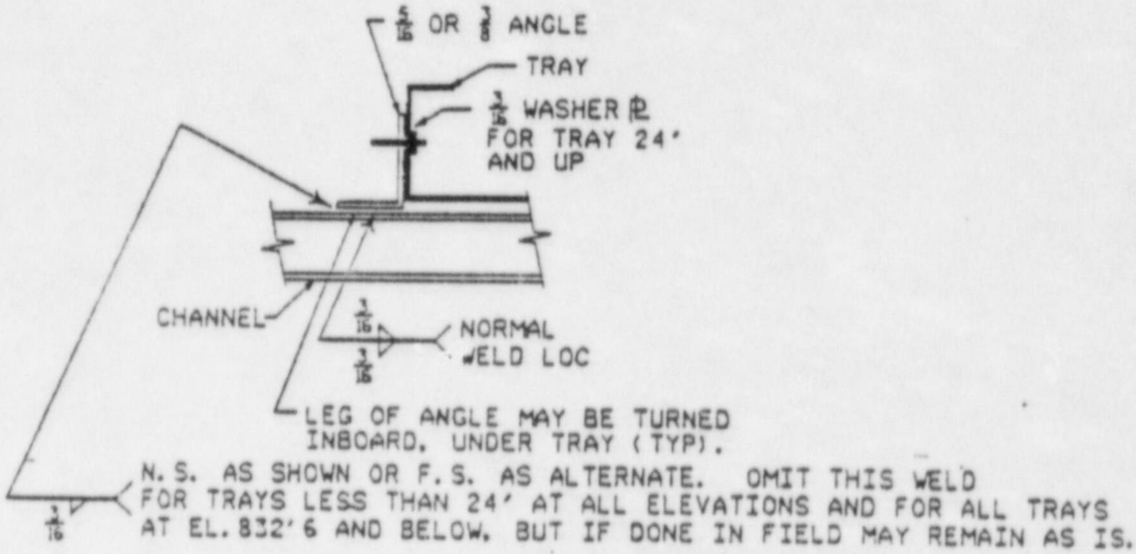
NOTE:

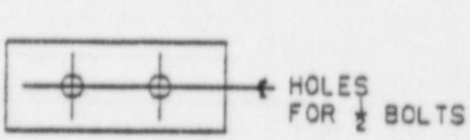
THE ANGLE MAY BE BENT TO FIT THE CURVATURE OF TRAY.

FOR WASHER (IF REQ'D) DETAILS AND ORIENTATION SEE ATTACHMENT 'E'.

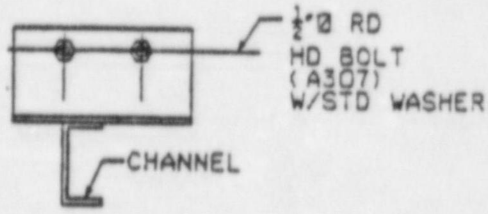
TYPE 'H' CLAMP HEAVY DUTY
AT TRAY SPLICE

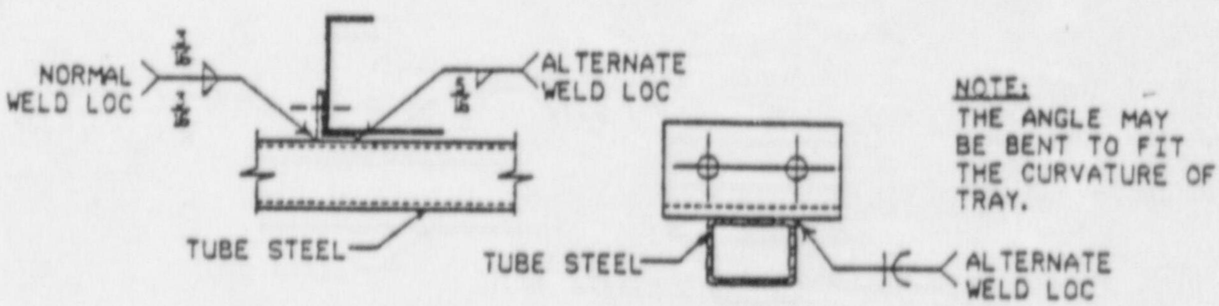
ATTACHMENT "A" (CONT.)





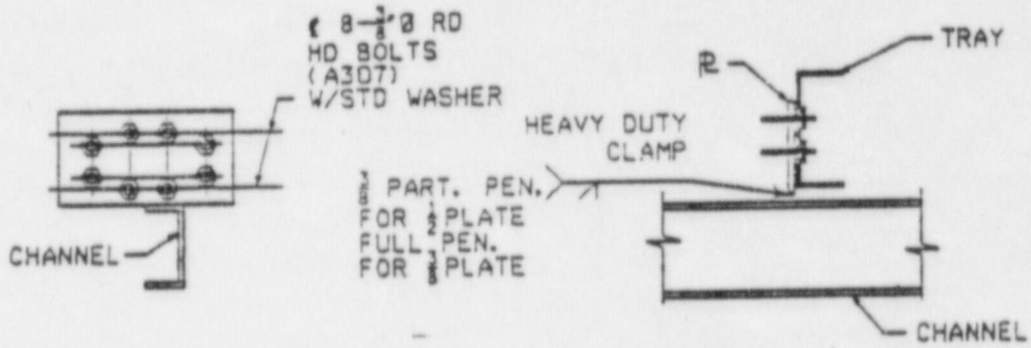
3/16 WASHER PLATE





TYPE 'J' CLAMP HEAVY DUTY

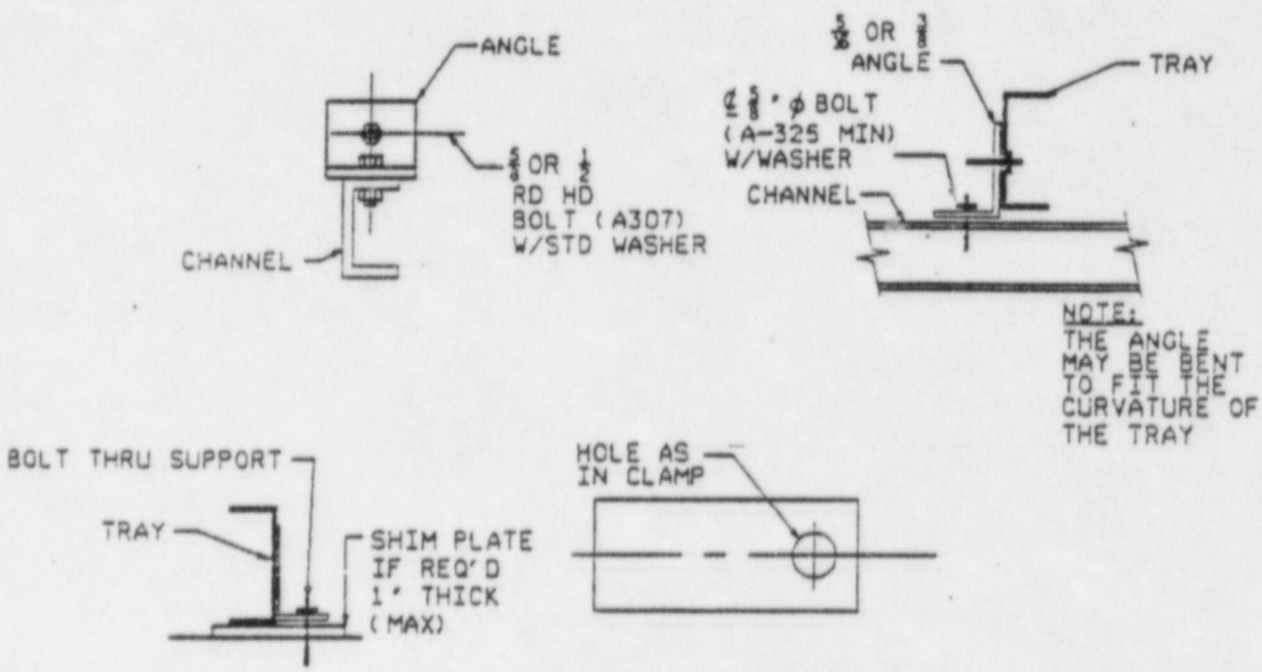
ATTACHMENT "A" (CONT.)



NOTE:
THE PLATE MAY BE BENT TO FIT
THE CURVATURE OF TRAY.

TYPE 'K' CLAMP HEAVY DUTY
AT TRAY SPLICE

ATTACHMENT "A" (CONT.)

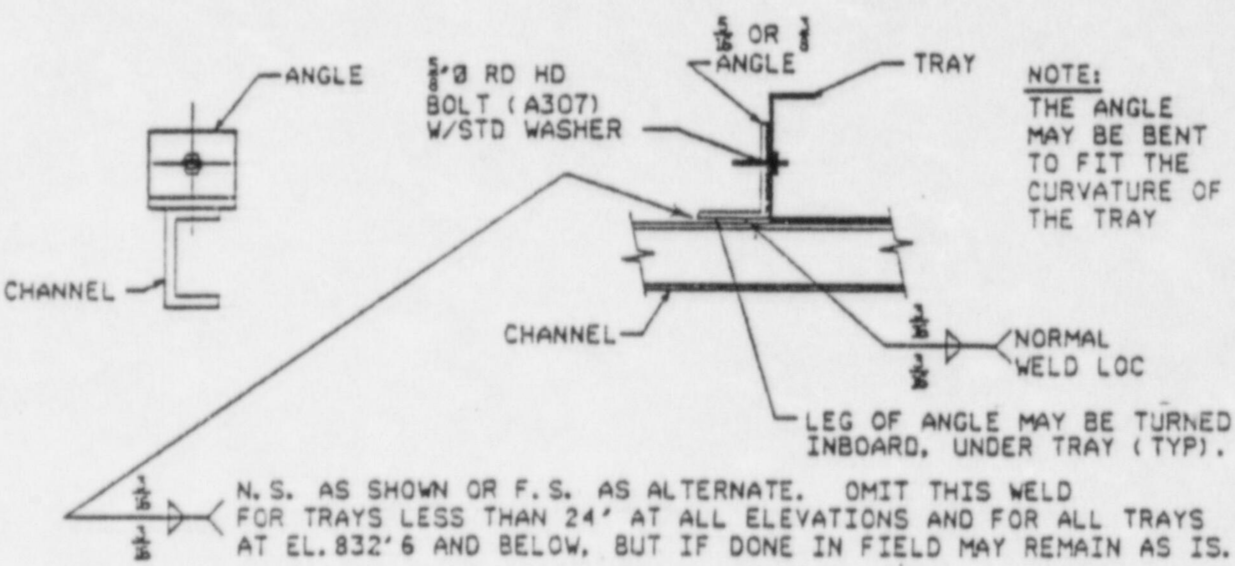


SHIM PLATE
(LENGTH & WIDTH TO SUIT)

NOTE:
OVERHANG OF 'CLAMP' FROM SUPPORT STRUCTURE IS ACCEPTABLE AS LONG AS BOLT HEAD OR NUT OR WASHER (IF USED) HAS TOTAL BEARING WITH SUPPORT STRUCTURE.
SHIM PLATE MAY BE FIELD FABRICATED AND PAINTED WITH GALVANOX PAINT.
FOR WASHER (IF REQ'D) DETAILS AND ORIENTATION SEE ATTACHMENT 'E'.

TYPE 'N' CLAMP HEAVY DUTY

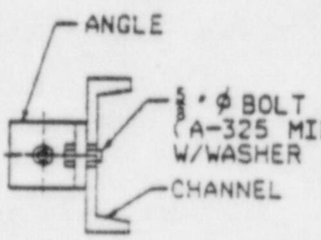
ATTACHMENT "A" (CONT.)

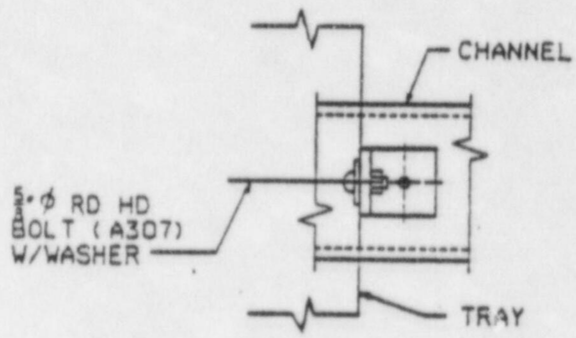


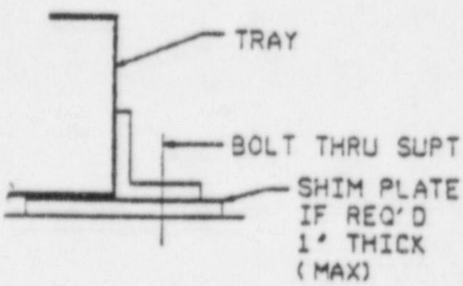
NOTE:
OVERHANG OF 'CLAMP' FROM SUPPORT STRUCTURE IS ACCEPTABLE AS LONG AS BOLT HEAD OR NUT OR WASHER (IF USED) HAS TOTAL BEARING WITH SUPPORT STRUCTURE.
SHIM PLATE MAY BE FIELD FABRICATED AND PAINTED WITH GALVANOX PAINT.

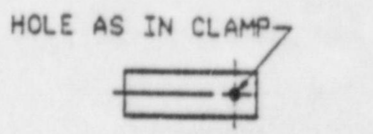
TYPE 'P' CLAMP HEAVY DUTY

ATTACHMENT "A" (CONT)









SHIM PLATE
(LENGTH & WIDTH TO SUIT)

NOTE:
OVERHANG OF 'CLAMP' FROM SUPPORT STRUCTURE IS ACCEPTABLE AS LONG AS BOLT HEAD OR NUT OR WASHER (IF USED) HAS A TOTAL BEARING WITH SUPPORT STRUCTURE.
SHIM PLATE MAY BE FIELD FABRICATED AND PAINTED WITH 'GALVANOX PAINT'.
FOR WASHER (IF REQ'D) DETAILS AND ORIENTATION SEE ATTACHMENT 'E'.

TYPE 'Q' CLAMP HEAVY DUTY