DEPARTMENT OF THE NAVY
NAVAL AIR SYSTEMS COMMAND
ISSC-EAST, FRC-EAST, CHERRY POINT, NC
STRENGTH AND ANALYSIS REPORT

TITLE: H-60F Static Display, North Island

WEAPON SYSTEM / TMS: H-60F, BuNo 164073

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REFERENCES

(a) SER-520074 Structural Analysis of Mid Fuselage Section
(b) SER-520092 SH-60F Ground Loads Report
(c) MMPDS-16
(d) SER-520075 Structural Analysis Aft Fuselage.
(e) AISC Base Plate and Anchor Rod Design, second edition
(f) Structural Welding Code, AWS D1.1/D1.1M:2020,
(g) Roark's Formulas for Stress and Strain
(h) Bolt 3d rev v1.0
(i) A Supplemental to Analysis and Design of Flight Vehicle Structures, McCombs, 1998
(j) Sikorsky Aircraft Structures Manual, Rev A 5/92
(k) Aerospace Threaded Fastener Strength With Joint Shims, NASA/TM–20205000526

ENCLOSURES

(1) Configuration & Load Cases
(2) Load Sharing between Plate and RAST tube.
(3) Airframe Substantiation
(4) Plate & RAST Tube Analysis
(5) Fastener Loads and Analysis

INTRODUCTION

A request for assistance in the development and design of a H-60F static display was submitted to the H-60 Fleet Support Team (FST). The static display will be located at NAS North Island. The design is to mimic the current A-4 static display located at the NAS North Island front gate, per customer request. This results in the aircraft (A/C) being supported by the belly of the fuselage and mounted on a concrete station. The following analysis is to substantiate the A/C fuselage for the required loading and attachment of the fuselage to the static display. The FST is also substantiating the upper plate design, which contacts the fuselage. The remainder of the static display (anything below the upper plate) is not covered by this report. See concept below in Figure 1. Pitch and Roll angles for the A/C have been requested at 5 degrees nose down, and 3 degrees bank right.

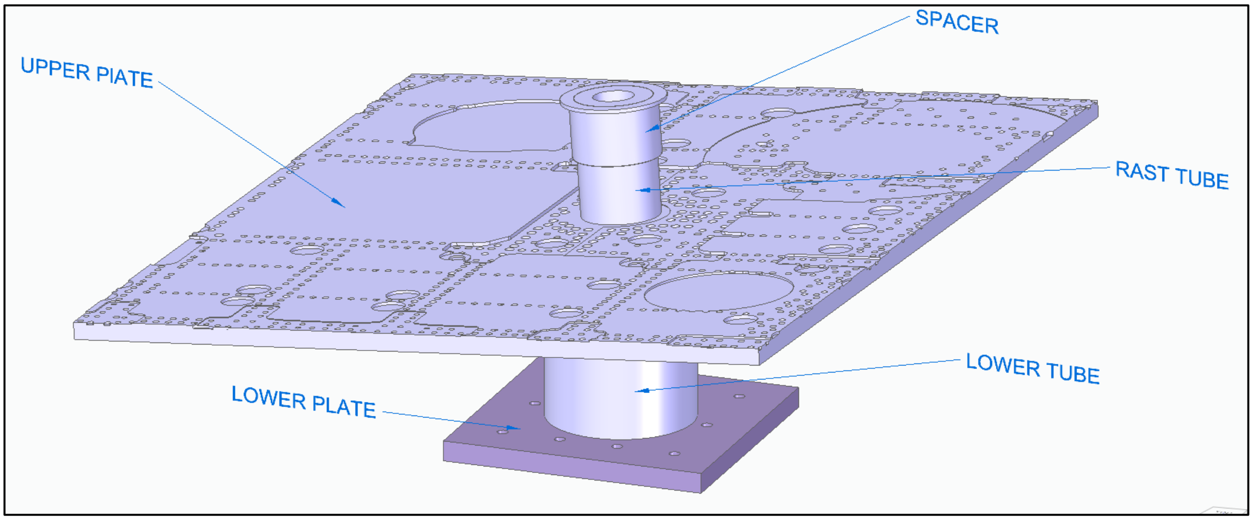


Figure 1, Static Display Stand Assembly

METHODS OF ANALYSIS

Details of the A/C configuration, Center of Gravity (CG), and Center of Pressure (CP) are found in enclosure (1). Load case requirements, along with seismic and wind factors were provided by the engineering firm of Wildman and Morris, and can be found in enclosure (1).

The design of the upper plate involves using the Recovery Assist Secure and Traverse (RAST) fitting in the A/C lower fuselage as a connection point. The original RAST fitting was designed to react large moments and vertical loads, with allowable ultimate loads available in ref (a) section 30. A steel tube (5.25” OD and 2.75” ID), made of A106 Grade B, will be welded to the top of the upper plate for transferring load to the RAST fitting (part of the airframe). Load sharing between the upper plate and RAST tube is determined using Finite Element Analysis (FEA). Details are provided in enclosure (2).

The load cases provided have load factors applied, using Load and Resistance Factor Design (LRFD), as such these loads will be checked against A/C ultimate flight conditions to show static Margins of Safety (MS) for the fuselage, see enclosure (3). Fastener bearing strength is checked in enclosure (3).

The upper plate and RAST tube are analyzed in enclosure (4).

Fastener loads, for the upper plate to fuselage attachment are approximated assuming rigid body distribution. All fasteners will be NAS6604 bolts (¼" diameter, 160 KSI Ftu). The critical fastener will be checked for combined tension, shear, and bending MS. See enclosure (5) calculations.

FINDINGS

Table 1, Margin of Safety

Description	Type	MS	Ref
STA 359 RAST Fitting	Airframe vertical load capacity	+0.91	Enclosure (3)
STA 359 Inner Frame	Airframe inner frame capacity	+0.07	Enclosure (3)
STA 334 Frame	Airframe vertical load capacity	+3.2	Enclosure (3)
STA 334 Frame	Fastener bearing strength	+3.0	Enclosure (3)
STA 379 Frame	Airframe vertical load capacity	+0.26	Enclosure (3)
STA 379 Frame	Fastener bearing strength	+4.0	Enclosure (3)
RBL 30 Beam	Airframe vertical load capacity	+3.7	Enclosure (3)
RBL 30 Beam	Fastener bearing strength	+4.3	Enclosure (3)
LBL 30 Beam	Airframe vertical load capacity	+1.1	Enclosure (3)
LBL 30 Beam	Fastener bearing strength	+4.5	Enclosure (3)
Upper Plate	Plate bending about X-axis	+1.7	Enclosure (4)
Upper Plate	Plate bending about Y-axis	+21.4	Enclosure (4)
RAST Tube	Weld	CJP full strength of Tube	Enclosure (4)
RAST Tube Base	Combined bending and shear	+0.55	Enclosure (4)
RAST Tube Top	Ring analysis, combined tension and shear	+1.3	Enclosure (4)
Fasteners	Tension, shear and bending	+16	Enclosure (5)

CONCLUSIONS

Positive static MS are shown for the design and airframe, for all load cases provided by Wildman and Morris Engineering.

Aircraft Center of Gravity

MK-46 Torpedo Mounted to starboard side via BRU-14/A (bomb rack), shown in Figure 2.

- Torpedo Weight: 505 lb.
- BRU Weight: 20.25 lb. (based on 70750-23300-013 instl weight)
- Mount location:
    - STA 398.5
    - WL 213 (bottom of bomb rack)
    - RBL 53.0 (from 70205-23001 RH Stores Pylon Drawing)

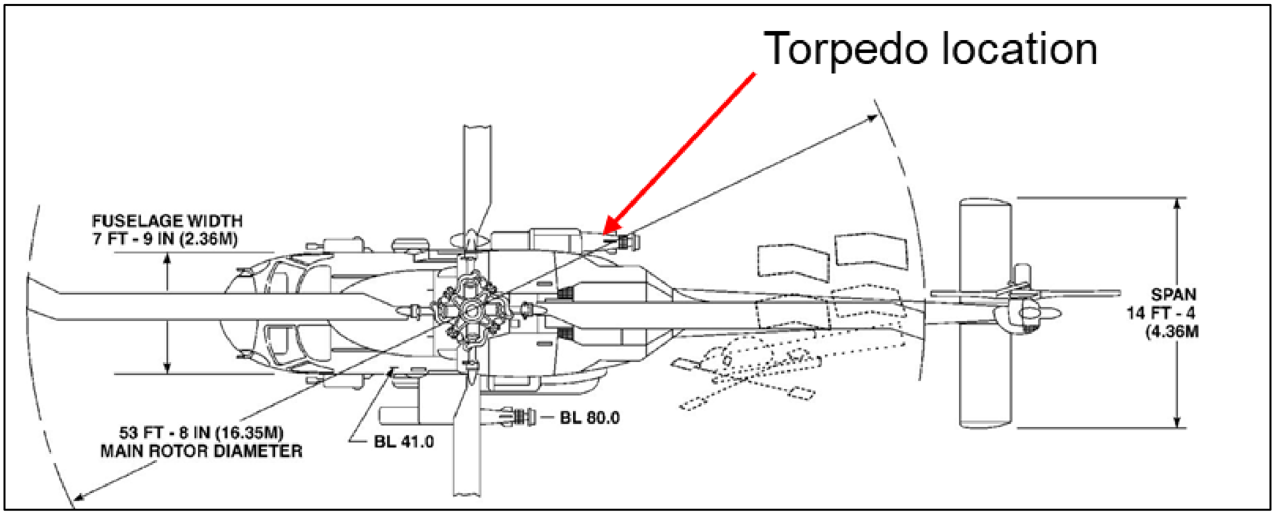


Figure 2, Torpedo Location

Aircraft was weighed to determine weight and station line CG. Aircraft was weighed without main rotor blades and torpedo installed so those items were accounted for by hand. See Table 2 and Figure 3.

- Blade weight found in IETM (DMC-NMH60-R-62-10-0000-000-520A-A). Blades are the same for SH-60F and MH-60R.

Table 2, Station line CG

	Net Weight (lbs)	Arm (in)	Moment (in-lb)
MLG	6,100	298.5	1,820,850
TLG	3,650	482.9	1,762,585
Rotors	840	341.2	286,608
MK-46 Torpedo	526	398.5	209,611
Total	11,116	367.01	4,079,654

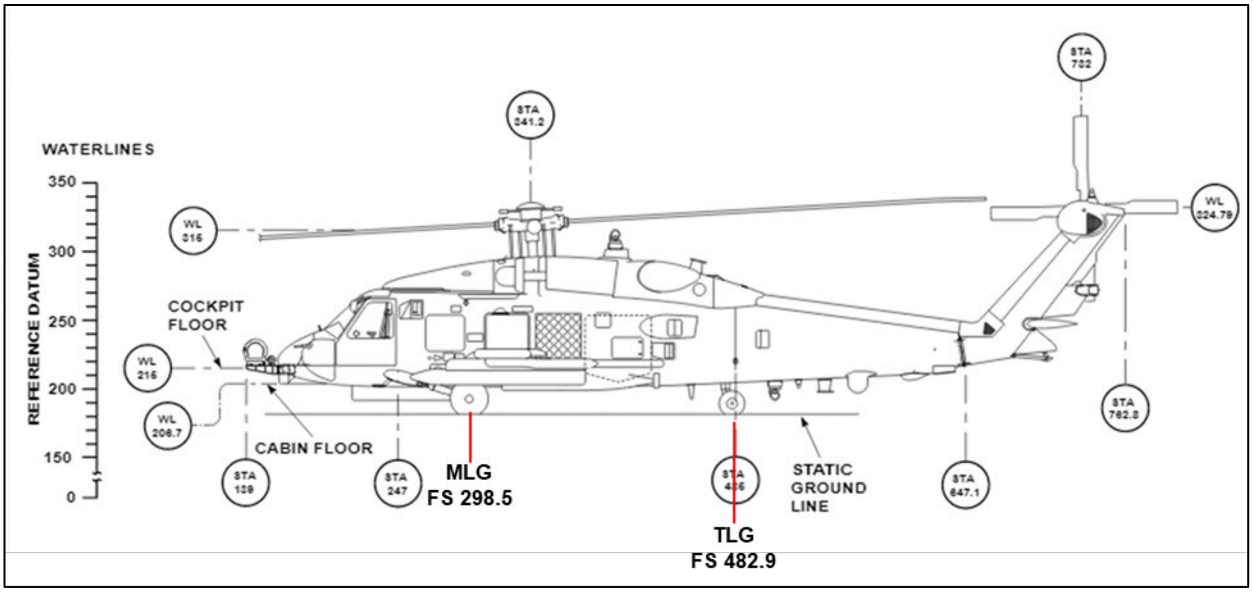


Figure 3, AC Weight

Vertical location of CG will be assumed to be at waterline (WL) 247.

- Source: ref (b) Appendix B, Table B.1.1, Configuration 1, Basic Design Gross Weight (BDGW).
- Much of the main rotor pylon components are removed (engines, APU, etc). In reality, vertical CG is much lower which makes this a conservative assumption.

Lateral CG is assumed to be at buttline (BL) 0 (per SER-520092 Appendix B) without torpedo. After factoring in the torpedo, the lateral CG location is shown in Table 3 below.

Table 3, Lateral CG (Buttline)

	Net Weight (lbs)	Arm (in)	Moment (in-lb)
Aircraft	10,590	0	0
MK-46 Torpedo	526	53.0	27,878
Total	11,116	2.5 (RBL)	27,878

The A/C CG location is shown below, Figure 4 and Figure 5.

- Location : STA 367, WL 247, RBL 2.5

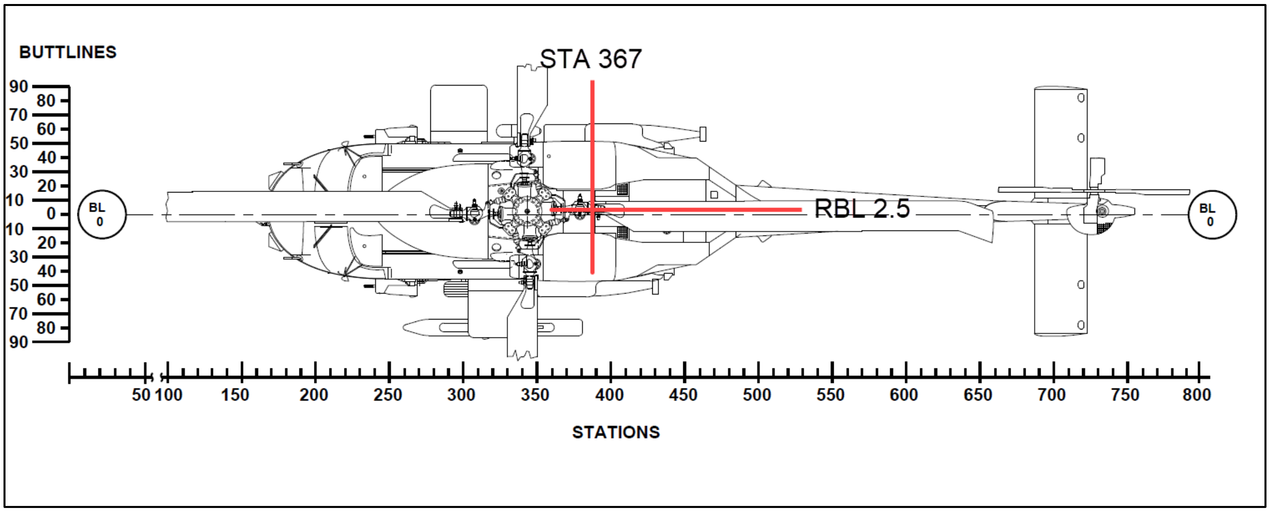


Figure 4, Station and Buttline CG

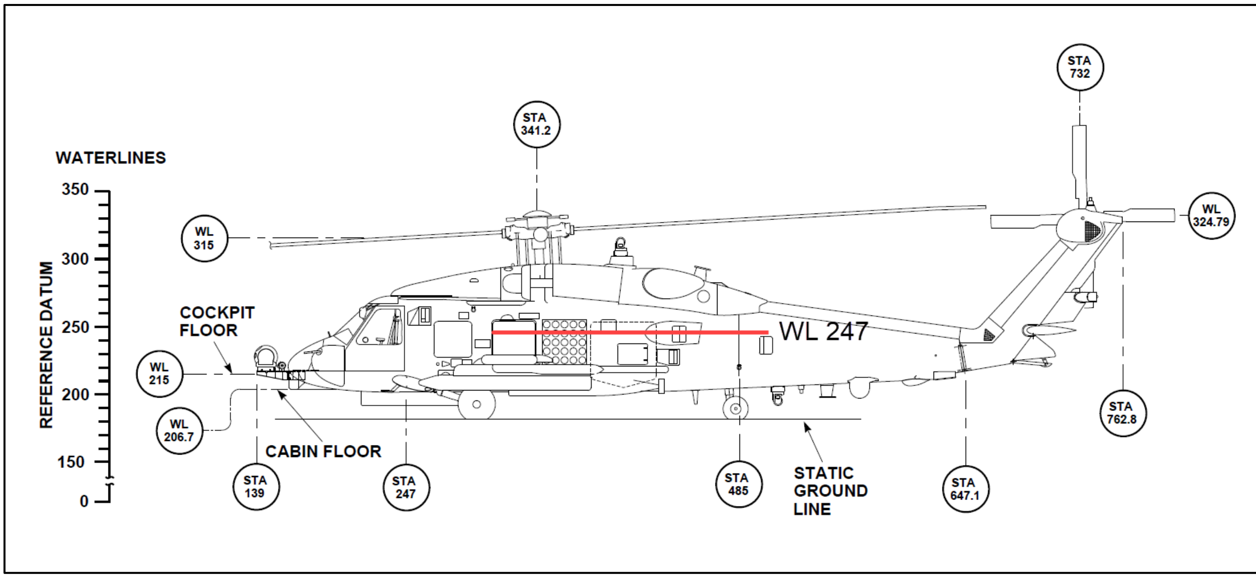


Figure 5, Waterline CG

Aircraft Center of Pressure and Wind load

Two checks are done to determine CP and wind load. One method using limited data from ref (b), and a second method assuming flat plate, and side view projected area.

Method 1: From ref (b) table B.3.4, a lateral wind load is given of 5,000 lb for a 60 knot wind . Drag coefficient and area for aircraft is not available, but as they do not change, the 60 knot wind case can be used to find the 100 mph wind case.

$$\frac{F_{wind_1}}{\cancel{\frac{1}{2}}\rho V_1^2 \cancel{AC_d}} = \frac{F_{wind_2}}{\cancel{\frac{1}{2}}\rho V_2^2 \cancel{AC_d}} \rightarrow \frac{5{,}000\ lb}{69.05^2} = \frac{F_{wind_2}}{100^2} \rightarrow F_{wind_2} = 10{,}500\ lb$$

$F_{w_1} = wind\ force$ at 60 knot.
$\rho = density\ of\ air$
$A = projected\ area$
$C_d = drag\ coefficient$

Method 2: assuming a flat plate drag coefficient, and projected area from Figure 6.

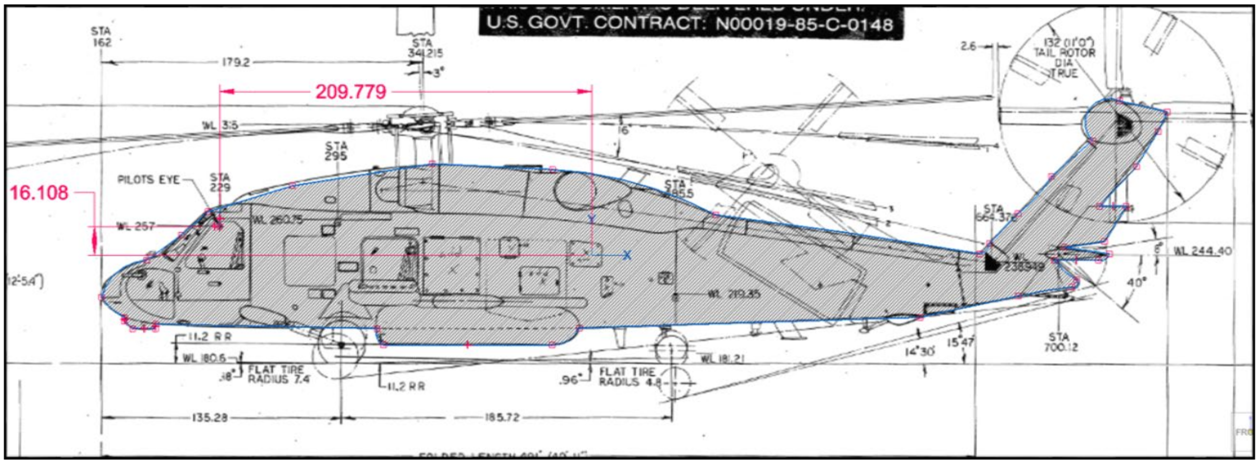


Figure 6

$$F_{wind} = \frac{1}{2}\rho V^2 A C_d$$

A = 272.85 ft^2
ρ = 0.002377 slugs/ft^3
C_d (flat plate) = 1.28
V = 100 mph = 146.667 ft/s

$$F_{wind} = 8{,}397\ lb$$

Method 1: 10,500 lb > Method 2: 8,397 lb and will be used for conservatism.

The center of pressure for the Aircraft is found from (b), appendix B, page B-12, provided below Figure 7

```
*Center of Pressure FS 420.0
                    WL 244.0
                    BL   0
```

Figure 7, Center of Pressure Location

CP = STA 420 WL 244 BL 0
F_{wind} = 10,500 lb

Aircraft orientation

The following roll and pitch angles were selected for the design, and provided as the design requirement.

5-degree dose down

3-degree roll to the right.

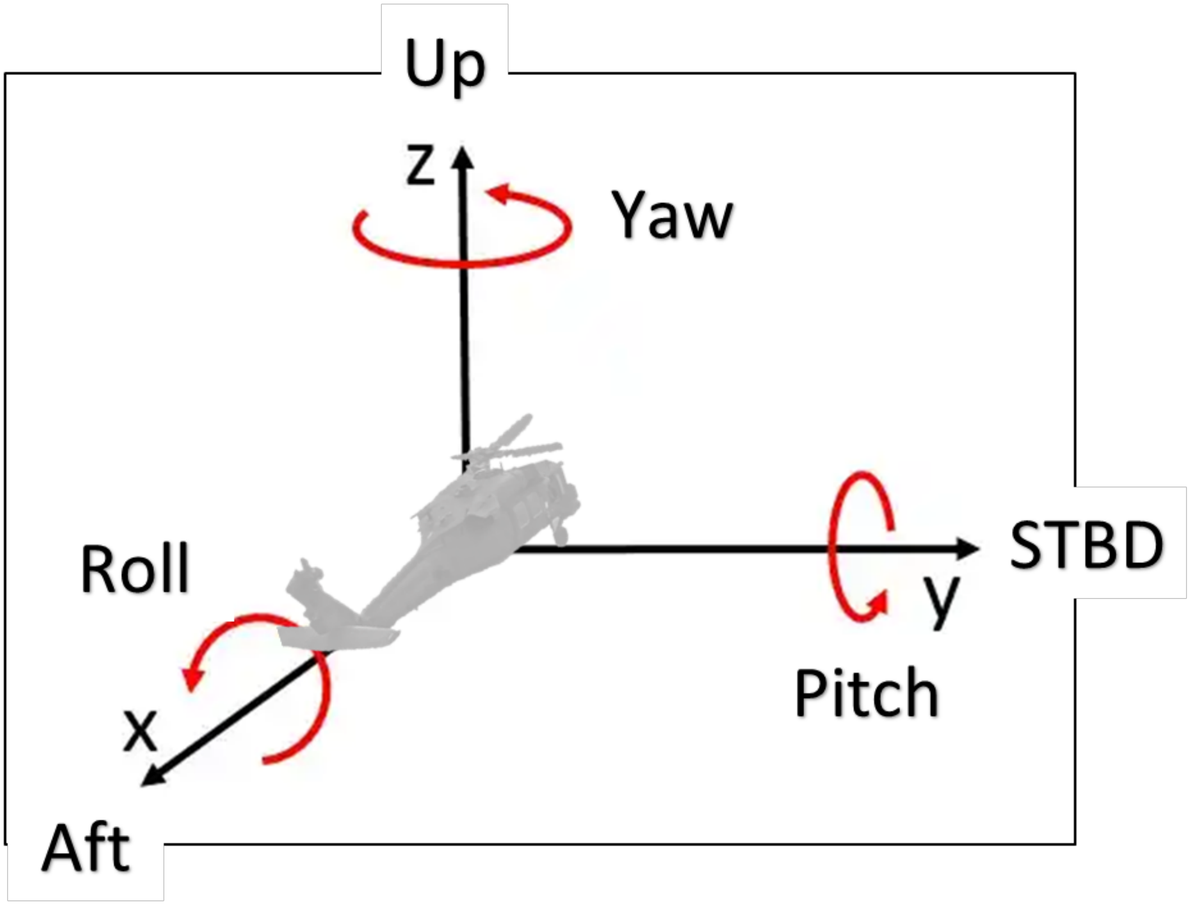


Figure 8, Coordinate System

Figure 8, shows the non-rotated A/C coordinate system, consistent with the right hand rule. The pitch and roll angles would be -5 and -3, respectively. To continue using a non-rotated coordinate system, for convenience of not having to rotate the load vectors, the change in CG must be accounted for. This is done with the below rotation matrix.

Roll angle = α = -3
Pitch angle = β = -5
Yaw angle = γ = 0

$$R = R_z(\gamma)\, R_y(\beta)\, R_x(\alpha) = \begin{bmatrix} \cos\gamma & -\sin\gamma & 0 \\ \sin\gamma & \cos\gamma & 0 \\ 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} \cos\beta & 0 & \sin\beta \\ 0 & 1 & 0 \\ -\sin\beta & 0 & \cos\beta \end{bmatrix} \begin{bmatrix} 1 & 0 & 0 \\ 0 & \cos\alpha & -\sin\alpha \\ 0 & \sin\alpha & \cos\alpha \end{bmatrix}$$

The point of rotation is STA 359, WL 198.75 (bottom surface of upper plate), BL0.
The difference between CG and point of rotation is subtracted before the rotation matrix is applied and then added back afterwards. The result is shown below.

$$\left([R]\begin{bmatrix} 367-359 \\ 2.5-0 \\ 247-198.75 \end{bmatrix}\right)+\begin{bmatrix} 359 \\ 0 \\ 198.75 \end{bmatrix}=\begin{bmatrix} 362.8 \\ 5.0 \\ 247.3 \end{bmatrix}$$

After pitch and roll angles are applied, the CG in a non-rotated Aircraft coordinate system, is then:

- CG $_{\text{Rotated}}$: STA: 362.8, RBL 5.0, WL 247.3
- This location will be used for applying seismic and gravity loads.

Using the same rotation method as above, the center of pressure can be found after applying pitch and roll angles.

- New CP $_{\text{Rotated}}$: STA: 415.8, RBL 2.4, WL 249.1
- This location will be used for applying wind loads.

Seismic and Wind Factors

The following wind speed, seismic loads, and load cases were provide by the engineering firm Wildman and Morris, see Figure 9, and Figure 11.

The min wind requirement is 97 mph. Due to a wind force at 100 mph already being provided, it will be used for consistency, as it is slightly conservative.

WBDG Structural Load Data:

UNITED STATES - CALIFORNIA - NAS NORTH ISLAND, CORONADO

Latitude / Longitude 32.7015195, -117.2076912

WIND SPEED (MPH)					WIND SPEED (KM/H)				
RISK CATEGORY					RISK CATEGORY				
I	II	III	IV	V	I	II	III	IV	V
90	97	103	107	140	145	156	166	172	225

SNOW LOADING			
GROUND SNOW (PSF)	FROST PENETRATION (IN)	GROUND SNOW (KPA)	FROST PENETRATION (MM)
0	0	0	0

SEISMIC DATA (SITE CLASS D)				
PGA (%G)	S_S (%G)	S_1 (%G)	S_{MS} (%G)	S_{M1} (%G)
62.4	139.3	47.1	139.3	0

Wind Speed: 97 mph

Figure 9, Wind Load

Seismic Load: (Strengtn Level)

Risk Category II

Seismic Importance Factor $I_p := 1.0$

Site Class D

Seismic Design Category D

Minimum Analysis = Equivalent Lateral Force Procedure

Per UFC 3-301-01, *Structural Engineering*, 11 April 2023 & WBDG Structural Loads Tool

Latitude = 32.7015° N $S_s := 1.393$ $F_a := 1.0$

Longitude = -117.2077° E $S_1 := 0.471$ $F_v := 1.83$

$S_{MS} := S_s \cdot F_a$ $S_{MS} = 1.393$

$S_{M1} := S_1 \cdot F_v$ $S_{M1} = 0.862$

$S_{DS} := \frac{2}{3} \cdot S_{MS}$ $S_{DS} = 0.93$

$S_{D1} := \frac{2}{3} \cdot S_{M1}$ $S_{D1} = 0.575$

Non-Structural Components:

Appendages and Ornamentations: $a_p := 2.5$ $R_p := 2.5$

Height of attachment: $z := 15.5 \cdot ft$ $h := 15.5 \cdot ft$

$$F_p := min\left(1.6 \cdot S_{DS} \cdot I_p, \max\left(\frac{0.4 \cdot a_p \cdot S_{DS}}{\left(\frac{R_p}{I_p}\right)} \cdot \left(1 + 2 \cdot \frac{z}{h}\right), 0.3 \cdot S_{DS} \cdot I_p\right)\right)$$

(Eq 13.3-2) **(Eq 13.3-1)** **(Eq 13.3-3)**

$F_p = 1.114$

Lateral seismic force is F_p time aircraft weight applied at aircraft center of gravity

$F_{pv} := 0.2 \cdot S_{DS} = 0.186$

Concurent vertical force is +/- F_{pv} times aircraft weight applied at the aircraft center of gravity

Figure 10, Seismic Factors

Loads on Anchor Bolts

Dead Load:

$P_D := W = 12.143\ kip$

Wind Load:

$M_{wind\_x} = 35\ kip \cdot ft$

Seismic Load:

$F_{pv} = 2.255\ kip$

$M_{seismic} := M_z = 52.982\ kip \cdot ft$

LC 1: 1.4D	$1.4 \cdot P_D = 17\ kip$	
LC 2: 1.2D	$1.2 \cdot P_D = 14.572\ kip$	
LC 3: 1.2D+0.5W	$1.2 \cdot P_D = 14.572\ kip$	$0.5 \cdot M_{wind\_x} = 17.5\ kip \cdot ft$
LC 4: 1.2D-0.5W	$1.2 \cdot P_D = 14.572\ kip$	$-0.5 \cdot M_{wind\_x} = -17.5\ kip \cdot ft$
LC 5: 1.2D+W	$1.2 \cdot P_D = 14.572\ kip$	$M_{wind\_x} = 35\ kip \cdot ft$
LC 6: 1.2D-W	$1.2 \cdot P_D = 14.572\ kip$	$-M_{wind\_x} = -35\ kip \cdot ft$
LC 7: 0.9D+W	$0.9 \cdot P_D = 10.929\ kip$	$M_{wind\_x} = 35\ kip \cdot ft$
LC 8: 0.9D-W	$0.9 \cdot P_D = 10.929\ kip$	$-M_{wind\_x} = -35\ kip \cdot ft$
LC 9: 1.2D+E	$1.2 \cdot P_D + F_{pv} = 16.827\ kip$	$M_{seismic} = 52.982\ kip \cdot ft$
LC 10: 1.2D-E	$1.2 \cdot P_D - F_{pv} = 12.316\ kip$	$-M_{seismic} = -52.982\ kip \cdot ft$
LC 11: 0.9D+E	$0.9 \cdot P_D + F_{pv} = 13.184\ kip$	$M_{seismic} = 52.982\ kip \cdot ft$
LC 12: 0.9D-E	$0.9 \cdot P_D - F_{pv} = 8.673\ kip$	$-M_{seismic} = -52.982\ kip \cdot ft$

Figure 11, Load Cases

Load cases 1 through 12, shown in Figure 11 will be used. Values shown are at the anchor bolts actual values will vary based on location. The load factors will remain the same.

Waterline 200 is the bottom of the fuselage and the most relevant location for loads to be resolved at. Table 4 below provides the applied loads at STA 359 , BL 0, Wl 200, in a non-rotated coordinate system.

Table 4, Non-Rotated Coordinate System

Load Case Number	Fx	Fy	Fz	Mx	My	Mz
1	0	0	-15,562	-78,151	58,849	0
2	0	0	-13,339	-66,987	50,442	0
3	0	5,250	-13,339	-324,670	50,442	298,355
4	0	-5,250	-13,339	190,697	50,442	-298,355
5	0	10,500	-13,339	-582,353	50,442	596,710
6	0	-10,500	-13,339	448,380	50,442	-596,710
7	0	10,500	-10,004	-565,607	37,831	596,710
8	0	-10,500	-10,004	465,127	37,831	-596,710
9	0	12,383	-15,407	-663,312	58,260	46,827
10	0	-12,383	-11,272	529,339	42,623	-46,827
11	0	12,383	-12,072	-646,565	45,650	46,827
12	0	-12,383	-7,937	546,085	30,013	-46,827

Table 5 is the same location (STA 359, BL 0, WL 200), but in the rotated coordinate system (5 pitch , 3 roll). Table 5 are the loads used throughout the report.

Table 5, Rotated Coordinate System

Load Case Number	Fx	Fy	Fz	Mx	My	Mz
1	**-1,354**	**814**	**-15,482**	**-77,585**	**58,768**	**9,879**
2	**-1,161**	**698**	**-13,270**	**-66,502**	**50,373**	**8,468**
3	**-1,137**	**5,941**	**-12,997**	**-297,237**	**34,758**	**327,739**
4	**-1,185**	**-4,545**	**-13,544**	**164,233**	**65,987**	**-310,803**
5	**-1,113**	**11,184**	**-12,723**	**-527,972**	**19,143**	**647,010**
6	**-1,209**	**-9,787**	**-13,818**	**394,968**	**81,602**	**-630,073**
7	**-823**	**11,009**	**-9,405**	**-511,346**	**6,550**	**644,893**
8	**-919**	**-9,962**	**-10,500**	**411,594**	**69,009**	**-632,190**
9	**-1,284**	**13,173**	**-14,681**	**-656,446**	**55,730**	**107,433**
10	**-1,038**	**-11,776**	**-11,859**	**523,443**	**45,015**	**-90,497**
11	**-994**	**12,998**	**-11,364**	**-639,821**	**43,136**	**105,316**
12	**-747**	**-11,951**	**-8,541**	**540,069**	**32,422**	**-92,614**

Load Sharing Between RAST Tube and Upper Plate

To efficiently transfer load to the inboard frame cap (WL 205.69), in the manner the structure was designed for, the design will include a RAST tube fixed to the upper plate, see Figure 12. The RAST tube connection will react out of plane moments Roll (Mx), and Pitch (My) to the inner frame cap. In-plane moments, Yaw (My), is assumed to be reacted only by the upper plate fasteners. Vertical loading will also be reacted only by the upper plate. The RAST tube is sized for clearance with the outboard (lower) frame cap (at ~WL 200). The above boundary conditions are used to evaluate stiffness and load sharing between the tube and upper plate. Forces and moments are applied to the bottom of the plate to an annular ring 10" OD representing the lower tube, which reacts all loads.

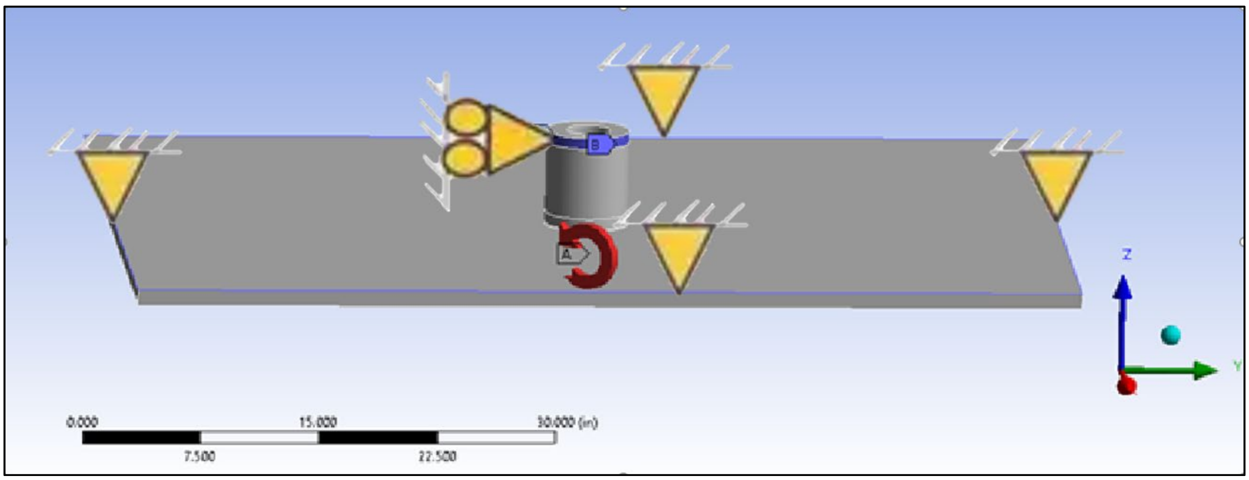


Figure 12, FEA Free Body Diagram

The reactions at STA 359, BL 0, WL 198.75 (bottom of upper plate), are applied to the FEA model for all 12 load cases. A coordinate system transformation has been applied (5° pitch, and 3° roll) and the reactions are in the plane of the plate. The result of the load sharing are shown below in Table 6 for moments and Table 7 for forces. The average values shown in Table 8 will be used throughout the report.

Table 6, Moment Reactions

Load Case	Pipe Reactions			Plate Reactions			Applied Moments			percent pipe			percent plate	
	Mx	My		Mx	My		Mx	My		Mx	My		Mx	My
1	-59,568	43,962		-18,017	14,806		77,585	-58,768		76.8%	74.8%		23.2%	25.2%
2	-51,059	37,681		-15,443	12,691		66,502	-50,373		76.8%	74.8%		23.2%	25.2%
3	-228,210	25,999		-69,022	8,759		297,237	-34,758		76.8%	74.8%		23.2%	25.2%
4	126,100	49,364		38,137	16,623		-164,233	-65,987		76.8%	74.8%		23.2%	25.2%
5	-405,370	14,317		-122,600	4,826		527,972	-19,143		76.8%	74.8%		23.2%	25.2%
6	303,250	61,046		91,716	20,556		-394,968	-81,602		76.8%	74.8%		23.2%	25.2%
7	-392,610	4,897		-118,740	1,654		511,346	-6,550		76.8%	74.8%		23.2%	25.2%
8	316,020	51,626		95,577	17,383		-411,594	-69,009		76.8%	74.8%		23.2%	25.2%
9	-504,010	41,685		-152,440	14,044		656,446	-55,730		76.8%	74.8%		23.2%	25.2%
10	401,890	33,678		121,550	11,338		-523,443	-45,015		76.8%	74.8%		23.2%	25.2%
11	-491,250	32,265		-148,570	10,872		639,821	-43,136		76.8%	74.8%		23.2%	25.2%
12	414,660	24,258		125,410	8,165		-540,069	-32,422		76.8%	74.8%		23.2%	25.2%
								average =		**76.8%**	**74.8%**		**23.2%**	**25.2%**

Table 7, Force Reactions

Load Case	Pipe Reactions			Plate Reactions			Applied Forces			percent pipe			percent plate	
	Fx	Fy		Fx	Fy		Fx	Fy		Fx	Fy		Fx	Fy
1	-129	73		-1,225	742		1,354	-814		9.5%	9.0%		90.5%	91.0%
2	-111	62		-1,050	636		1,161	-698		9.5%	9.0%		90.5%	91.0%
3	-108	532		-1,029	5,409		1,137	-5,941		9.5%	9.0%		90.5%	91.0%
4	-113	-407		-1,072	-4,138		1,185	4,545		9.5%	9.0%		90.5%	91.0%
5	-106	1,001		-1,007	10,183		1,113	-11,184		9.5%	9.0%		90.5%	91.1%
6	-115	-876		-1,094	-8,911		1,209	9,787		9.5%	9.0%		90.5%	91.0%
7	-79	986		-744	10,024		823	-11,009		9.5%	9.0%		90.5%	91.1%
8	-88	-892		-831	-9,070		919	9,962		9.5%	9.0%		90.5%	91.0%
9	-123	1,179		-1,162	11,993		1,284	-13,173		9.5%	9.0%		90.5%	91.0%
10	-99	-1,054		-939	-10,722		1,038	11,776		9.5%	9.0%		90.5%	91.0%
11	-95	1,164		-899	11,834		994	-12,998		9.5%	9.0%		90.5%	91.0%
12	-71	-1,070		-676	-10,881		747	11,951		9.5%	9.0%		90.5%	91.0%
								average =		**9.5%**	**9.0%**		**90.5%**	**91.0%**

Table 8, Load Sharing Results Summary

Force	RAST Tube %	Aircraft Plate %
Mx	77	24
My	75	26
Mz	0	100
Fx	10	91
Fy	10	91
Fz	0	100

Airframe Attachment

The H-60F airframe has been structurally analyzed and shown good for a range of ultimate conditions. Comparison of the static display loads to previously analyzed loads on the airframe will be used to show margins of safety (MS).

Figure 13 below shows the primary frames in the fuselage used for attachment of the upper plate. Figure 14 below shows the same frames with other structure removed for clarity. The location of the RAST fitting, centered at STA 359 BL 0, is also shown.

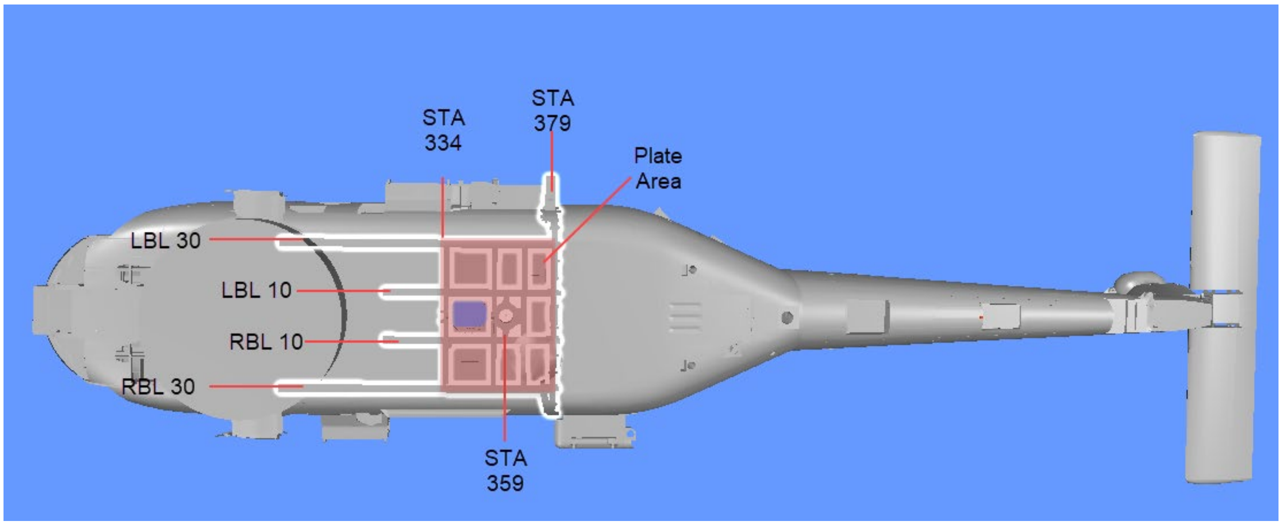


Figure 13, Upper Plate Installation Location

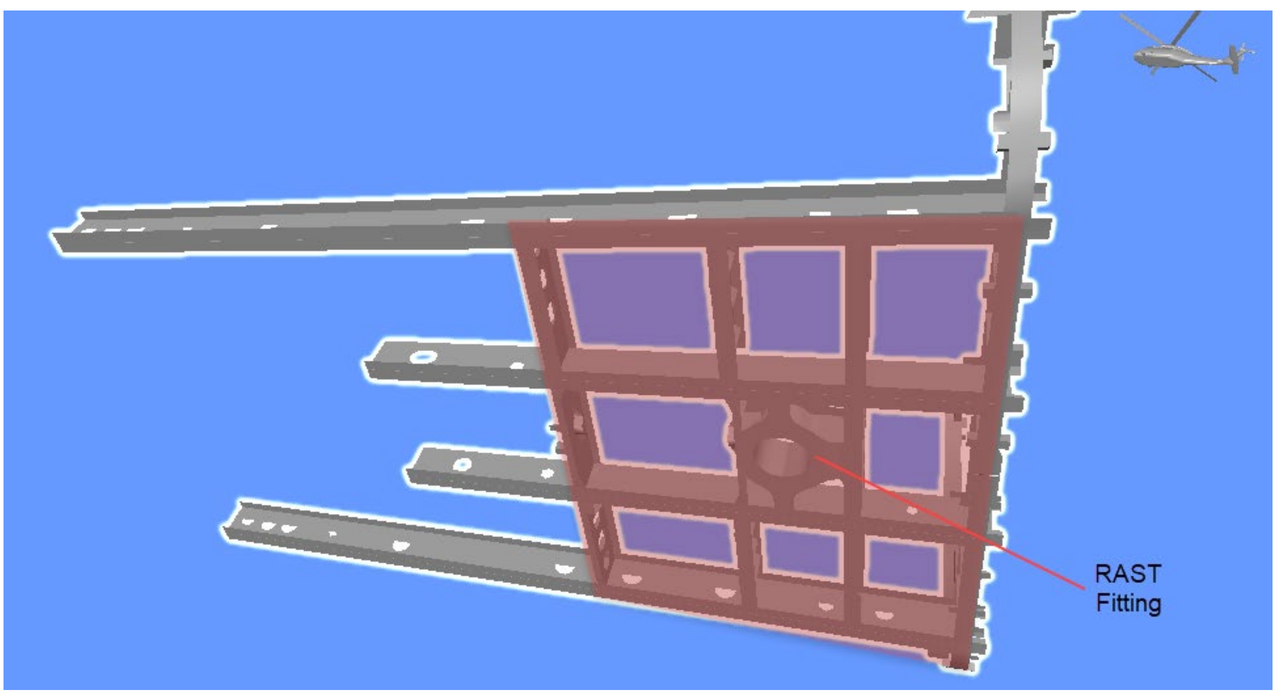


Figure 14, Upper Plate Installation Location

RAST fitting Structure

A section view of the RAST probe and fitting are shown in Figure ***15***, below, taken from ref (a). This is at Station 359, BL 0. The original design loads are shown in Figure ***16***, below.

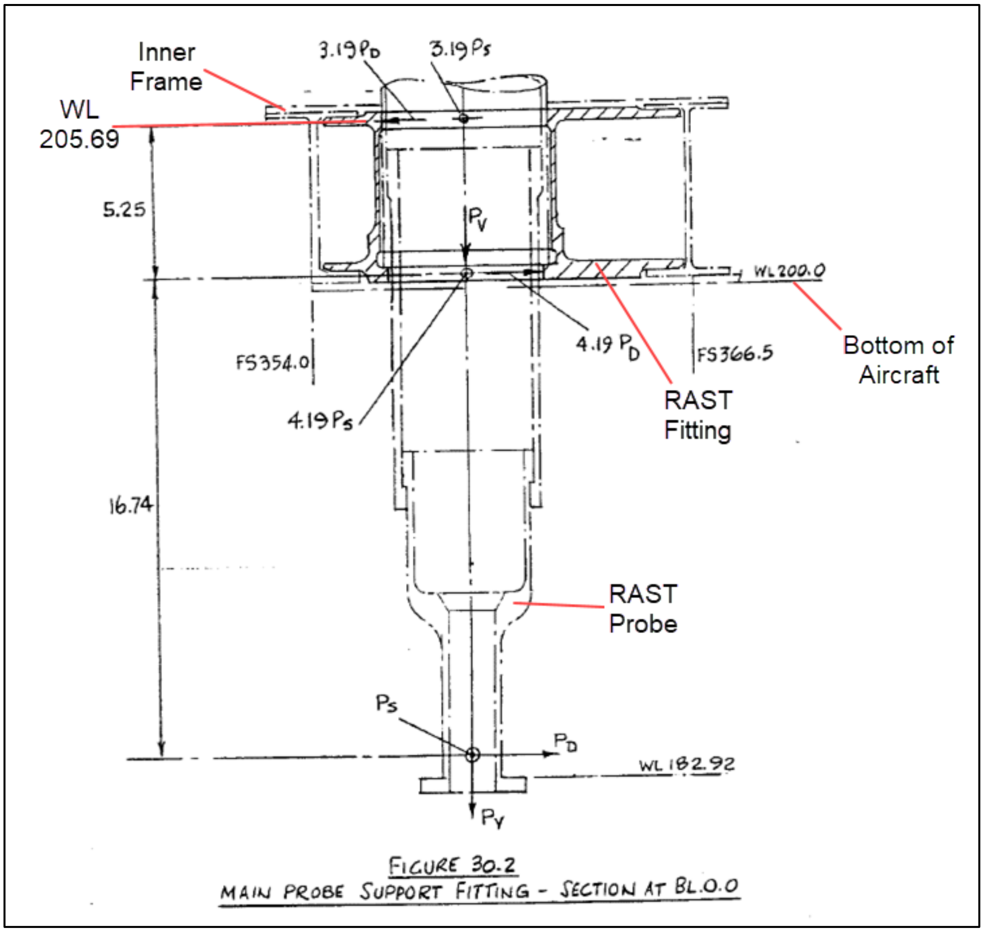


Figure 15, RAST Probe in Airframe Sta 359

MAIN PROBE SUPPORT FITTING

APPLIED LOADS AT PROBE. REF FIG 30.2

CONDITION	P_V	P_D	P_S	$P_R = P_D \to P_S$
258	21675	-19071	-22469	29470
259	29676	-7158	-28937	24810
260	23276	6882	-29175	29980
261	5720	19026	-23183	29990
262	0	27009	-12245	29660

TABLE 30.3a
MAIN PROBE APPLIED LOADS

Ult vertical design load at RAST Fitting

Figure 16, RAST Probe Ultimate Design Loads

Figure ***16*** shows the max vertical design load for the RAST probe is, Pv = 29,676 lb. Original design reacts this through bearing against the bottom flange of the RAST fitting, and then it is distributed into the surrounding frames. The static display design will support the aircraft centered about station 359, BL 0. Conservatively neglecting the load distribution of the upper plate, the critical vertical load (z-direction) can be compared to the RAST fitting vertical load.

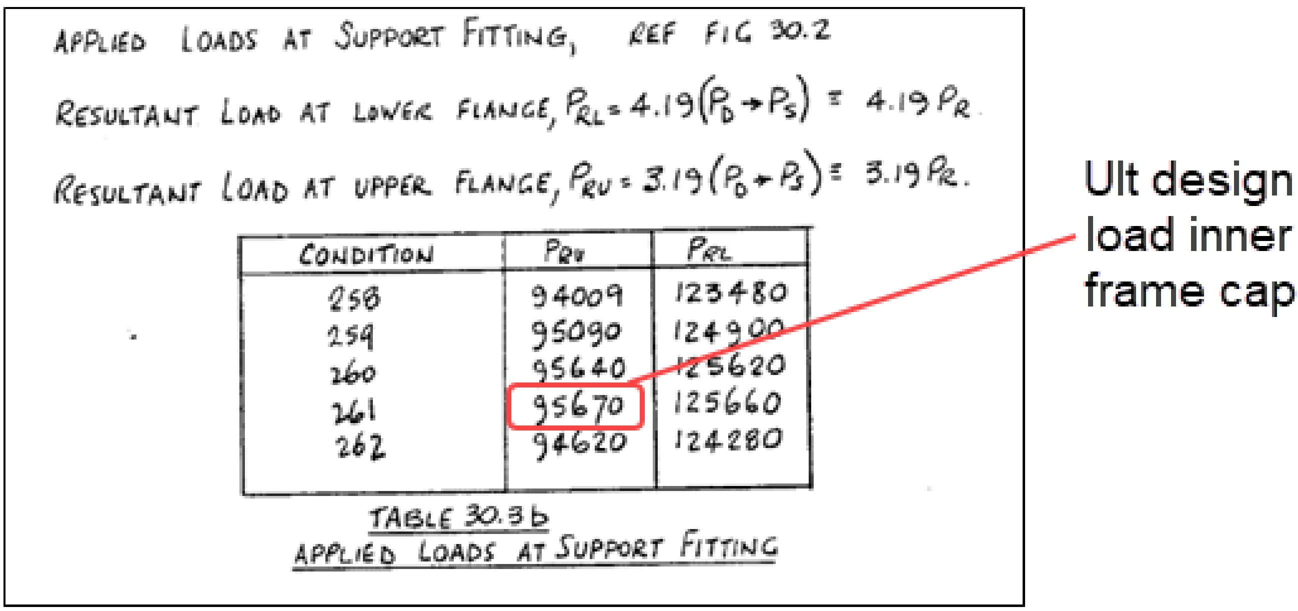
Ref enclosure (1), Table 5, Load case 1 Fz = -15,482 lb

$$MS = \frac{F_{allowed}}{F_{applied}} - 1 = \frac{-29{,}676\ lb}{-15{,}482\ lb} - 1 = +0.91$$

Static Display load on inner frame, STA 359

The static display design, involves load sharing with the RAST tube and inner frame, see enclosure (2). Note the RAST tube does not react Fz or Mz, due to its connection type of bearing against a cylindrical surface.

The max ultimate design load for the inner frame is given in Figure 17, from ref (a), P_{RU} = 95,670 lb.


APPLIED LOADS AT SUPPORT FITTING, REF FIG 30.2

RESULTANT LOAD AT LOWER FLANGE, $P_{RL} = 4.19(P_D + P_S) = 4.19 P_R$

RESULTANT LOAD AT UPPER FLANGE, $P_{RU} = 3.19(P_D + P_S) = 3.19 P_R$.

CONDITION	P_{RU}	P_{RL}
258	94009	123480
259	95090	124900
260	95640	125620
261	95670	125660
262	94620	124280

TABLE 30.3b
APPLIED LOADS AT SUPPORT FITTING

Figure 17, RAST Probe Ultimate Design Load, Inner Frame

- The critical case load case from enclosure (1), Table 5, Load Case 9
  - Fx = -1,284 lb
  - Fy = 13,173 lb
  - Mx = -656,446 in lb
  - My = 55,730 in lb

- Load ratios applied from enclosure (2), ***Table 8***

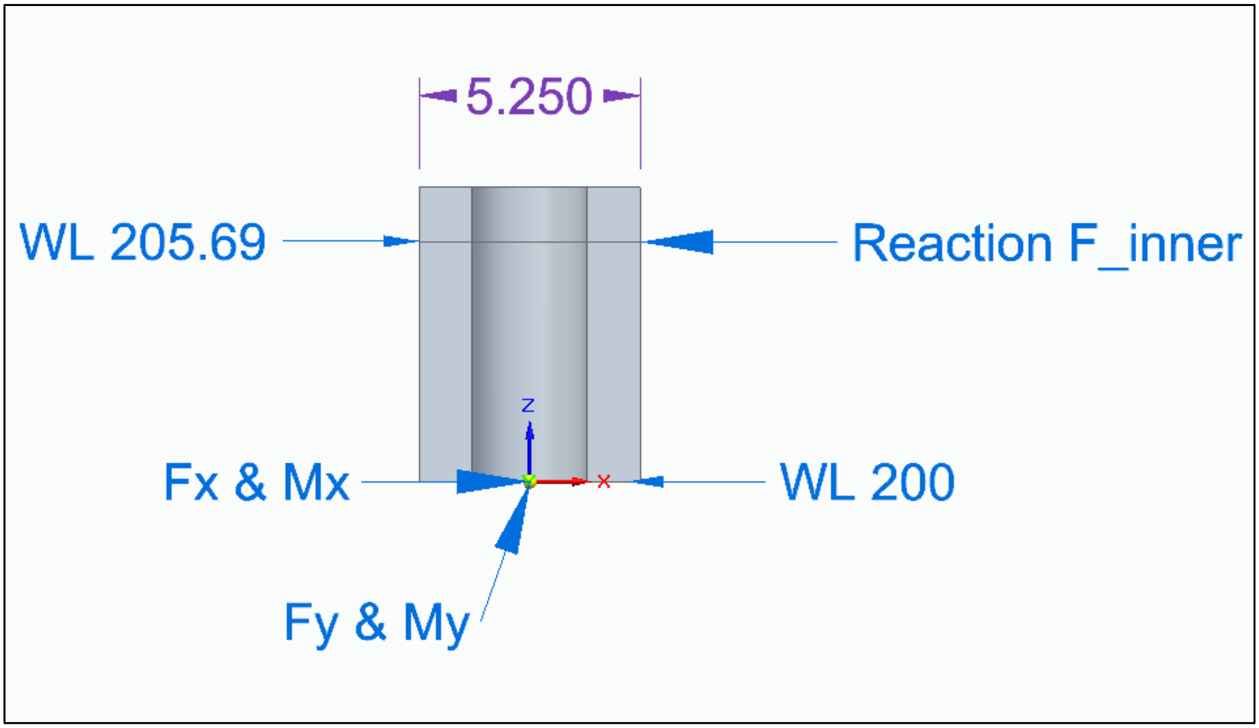


Figure 18, RAST Tube Reaction Free Body Diagram

- RAST tube geometry shown in Figure 18.
- Inner frame (WL205.69) – WL 200 = 5.69"

$$Fx_{inner} = 0.1Fx + \frac{.77Mx}{5.69} = 0.1(-1{,}284) + \frac{.77(-656{,}446)}{5.69} = -88{,}962\ lb$$

$$Fy_{inner} = 0.1Fy + \frac{.75My}{5.69} = 0.1(13{,}173) + \frac{.75(55{,}730)}{5.69} = 8663\ lb$$

$$F_{inner} = \sqrt{Fx^2 + Fy^2} = 89{,}383\ lb$$

$$MS = \frac{F_{allowed}}{F_{applied}} - 1 = \frac{95{,}670\ lb}{89{,}383\ lb} - 1 = +0.07$$

Station 334 Structure

The forward edge of the aircraft plate is located st station 334, see Figure 13. A rigid body distribution is done to determine fastener loads, see enclosure (5). The tension or compression loads in the fasteners (axial load) can be compared to the max shear load (V), see Figure 19 and Figure 20, from ref (a), appendix D.

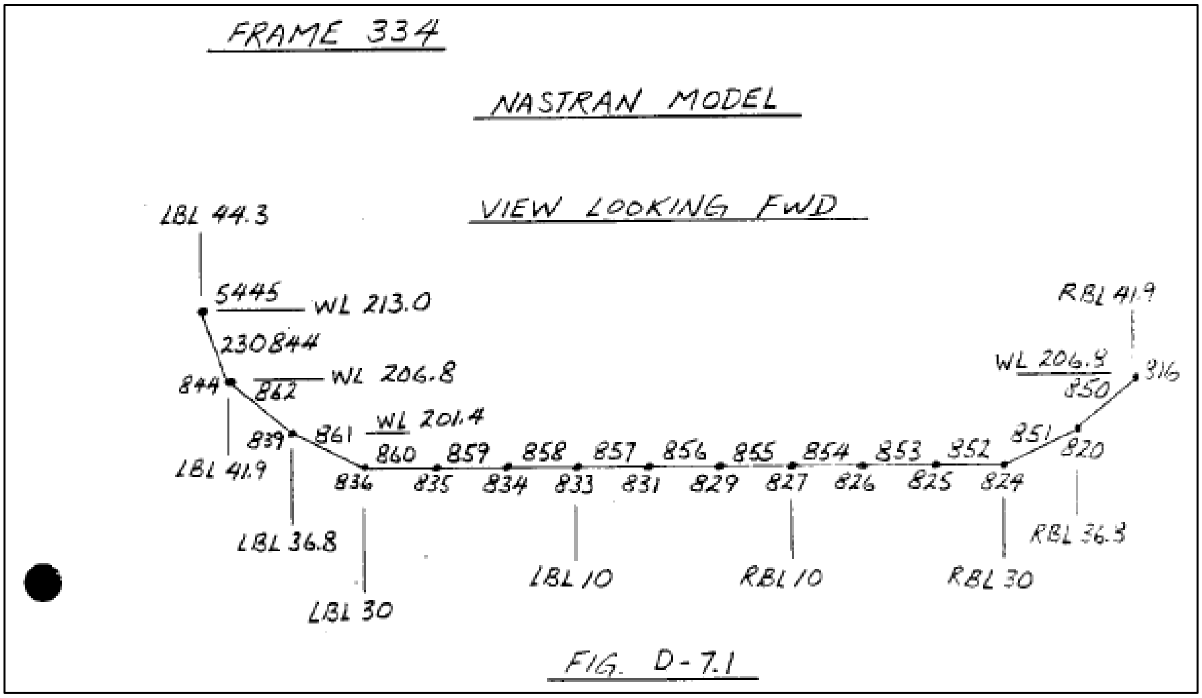


Figure 19, STA 334 Loads Model

TABLE D-7.2

FRAME F.S. 334.0 - INTERNAL LOADS, CBAR ELEMENTS

GRID PT.	CBAR NO.	(+) BEND. MOMENT			(-) BEND. MOMENT			MAX. SHEAR	
		+M	P	COND.	-M	P	COND.	V	COND.
816	850	520	-390	6006	-1103	-390	6006	716	6006
820	851	1363	288	3152	-3720	803	6006	742	6006
824	852	3536	230	3152	-7125	-202	3057	3105	6006
825	853	12176	-54	6005	-3551	-34	3057	3105	6006
826	854	26664	-1800	6005	-3856	2045	9002	2818	6005
827	855	38388	-4409	6005	-1869	4300	9002	2818	6005
829	856	28508	-888	6005	-3668	428	9003	2483	9004
831	857	29678	1906	6005	-3283	2298	9003	2483	9004
833	858	41374	-3388	6001	-13643	3780	9003	2749	6001
834	859	21938	-3518	6001	-7492	2589	9003	2749	6001
835	860	7788	-1820	6001	-3778	-2404	3152	2972	6001
836	861	2611	698	3057	-6920	-2833	3152	2972	6001
839	862	7553	725	3057	-15978	-3560	3152	3250	3152
844	230844	14383	-148	3057	-37950	-1492	3152	7460	3152
5445		25499	189	3057	-84940	-2138	3152	7463	3152

Figure 20, Frame Station 334 Ultimate Design Loads

- Grid points are spaced 6 2/3 inches.
- Fastener spacing around the perimeter of the plate is 5 inches per fastener.

$$\frac{1\ fastener / 5\ inch}{1\ grid\ point / 6.667\ inch} = 1.3 \frac{fasteners}{grid\ point}$$

- Conservatively the 2 highest loaded fasteners will be used for comparison.

- Station 334 highest axially loaded fasteners, Load case 9, ref enclosure (5) Figure ***42***

    - Fastener 1, location Sta 334, BL 30, axial load F_{A1} = 383 lb
    - Fastener 2, location Sta 334, BL 25, axial load F_{A2} = 351 lb

$$MS = \frac{F_{allowed}}{F_{applied}} - 1 = \frac{V_{Pt\ 824}}{F_{A1} + F_{A2}} - 1 = \frac{3105\ lb}{734\ lb} + 3.2$$

- Bearing Strength at Station 334, RBL 30
    - Web P/N 70201-82310-108, QQ-A-250/18, 7075-T6, 0.050"thick
        - $F_{bru\ (1.5)}$ = 109 ksi, ref (c), Table 3.7.10.0(c1)
    - Gusset P/N 70203-22300-149, QQ-A-250/13, 7075-T6 0.050" thick
        - $F_{bru\ (1.5)}$ = 109 ksi, ref (c), Table 3.7.10.0(c1)
    - Skin P/N 70203-82300-108, QQ-A-250/13, 7075-T6, 0.050" thick
        - $F_{bru\ (1.5)}$ = 109 ksi, ref (c), Table 3.7.10.0(c1)
    - BL 30 Tee Cap Lwr P/N 70202-82318-102, QQ-A-200-11, RE27810 extrusion, 7075-T6511, 0.078" thick
        - $F_{bru\ (1.5)}$ = 111 ksi, ref (c), Table 3.7.10.0(g1)
    - Station 334 highest shear loaded fastener, Load case 5, ref enclosure (5) Figure ***41***
    - Fastener 1, location Sta 334, BL 30, shear load F_{S1} = 542 lb
    - Fastener 1 will pass through the list of parts shown above and identified in Figure 21 and Figure ***22*** below. For conservatism and to qualify the other fasteners attaching the plate to station 334, only the web and skin (which all fasteners at STA 334 will pass through) will be used to show MS.

`

$$MS = \frac{F_{allowed}}{F_{applied}} - 1 = \frac{(F_{bru} * D * t)}{F_{S1}} - 1 = \frac{(109\ ksi * .25 * (.050 + .050))}{542\ lb} - 1 = +3.0$$

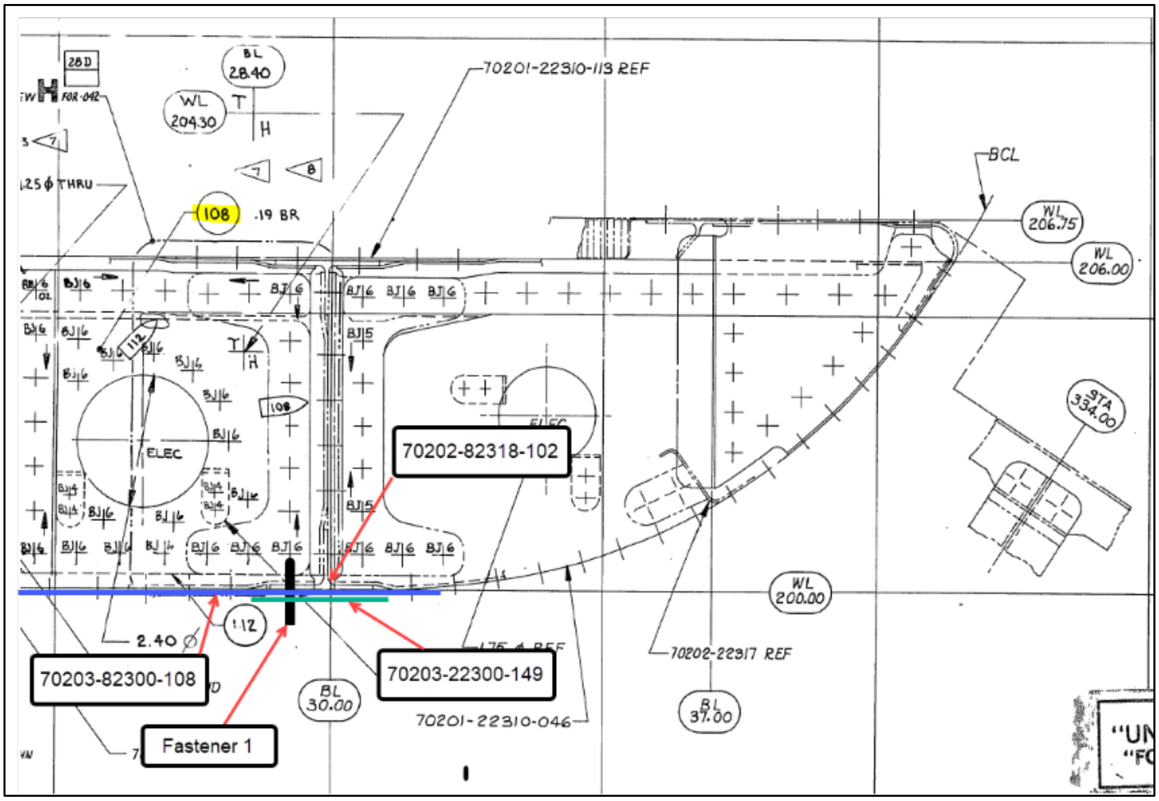


Figure 21, Station 334 RBL 30 Structure

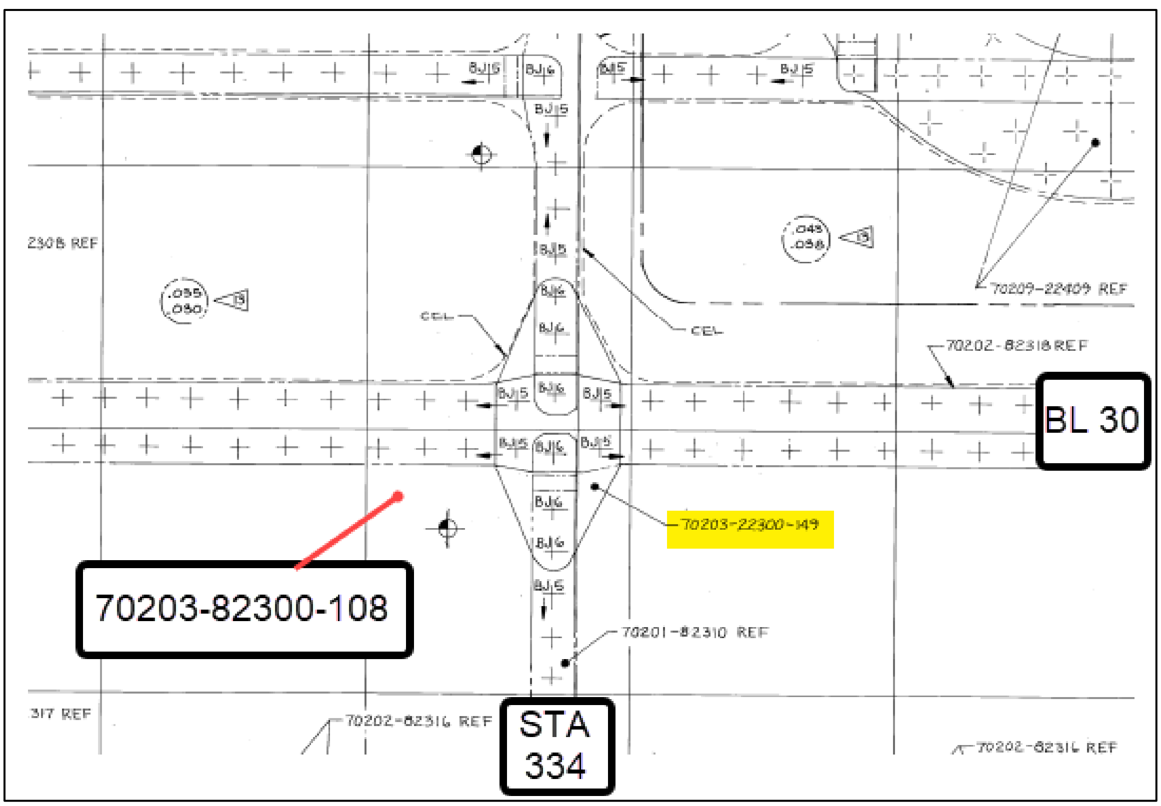


Figure 22, Station 334 RBL 30 Skin

Station 379 Structure

The aft edge of the plate terminates on station 379. Station 379 is a primary frame supporting the Main Gear Box loads, and internal mission gear and cargo tie down points. The internal fuel tanks are also supported at STA 379. Detailed frame loads, from original Sikorsky analysis, was not found for the frame, however, comparison to the internal fuel tank loads, shows the static display loads to be less critical. This is considered a conservative comparison, as the frame is not critical for the internal fuel loads.

From ref (d), page 26.1, the ult design load on station 379 from the internal fuel cells is 5,032 lbs. See Figure 23.

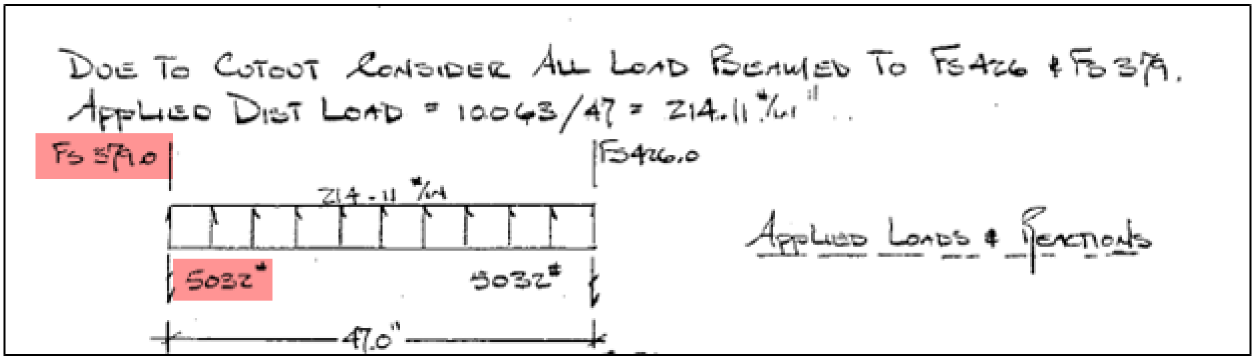


Figure 23, Station 379 Internal Fuel Tank Ult Design Load

Review of fastener loading from enclosure (5), Figure ***40*** shows load case 1 to have the highest total load for STA 379. The combined vertical load for all fasteners in STA 379 is 3,986 lb.

$$MS = \frac{F_{allowed}}{F_{applied}} - 1 = \frac{5{,}032}{3{,}986} - 1 = +0.26$$

- Bearing Strength at Station 334, RBL 30
  - Fitting RH, 70209-23001-103, Hand or Die Forging QQ-A-367, 7075-T73, varying thickness (0.100 to 0.160).
    - $F_{bru\,(1.5)}$ = 88 ksi, ref (c), Table 3.7.10.0(f2)
  - Skin P/N 70203-82300-108, QQ-A-250/13, 7075-T6, 0.050" thick
    - $F_{bru\,(1.5)}$ = 109 ksi, ref (c), Table 3.7.10.0(c1)
  - Station 379 highest shear loaded fastener, Load case 5, ref enclosure (5) Figure ***41***
  - Fastener 14, location Sta 334, RBL 30, shear load F_{S14} = 716 lb
  - Fastener 14 has max shear load for the frame. MS will be shown for frame cap and skin only, see Figure 24. Frame cap increases in thickness from 0.100" to 0.160" from BL 30 to BL 0. Other fasteners in frame are less critical.

$$MS = \frac{F_{allowed}}{F_{applied}} - 1 = \frac{(F_{bru} * D * t)}{F_{S14}} - 1 = \frac{\big((88\,ksi * .1) + (109\,ksi * .050)\big) * .25}{716\,lb} - 1 = +4.0$$

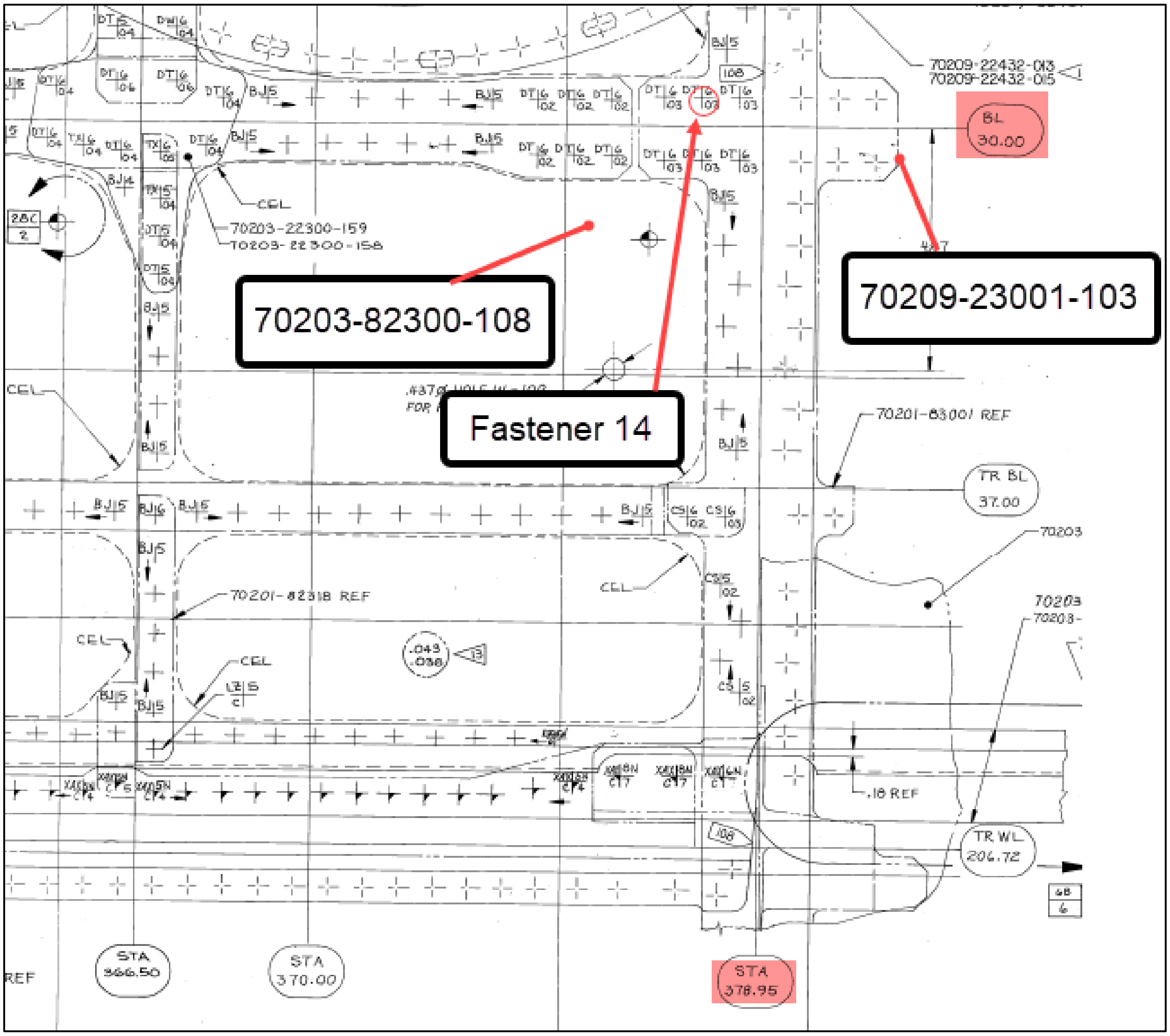


Figure 24, Station 379 Right Buttline 30 Structure

RBL 30 Structure

The right hand side of the plate terminates on RBL 30, see Figure 13.. A rigid body distribution is done to determine fastener loads, see enclosure (5). The tension or compression loads in the fasteners (axial load) can be compared to the max shear load (S), see Figure 25 from ref (a), appendix D.

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FIG. D-10.2

NASTRAN MODEL – RHS BL30 BEAM

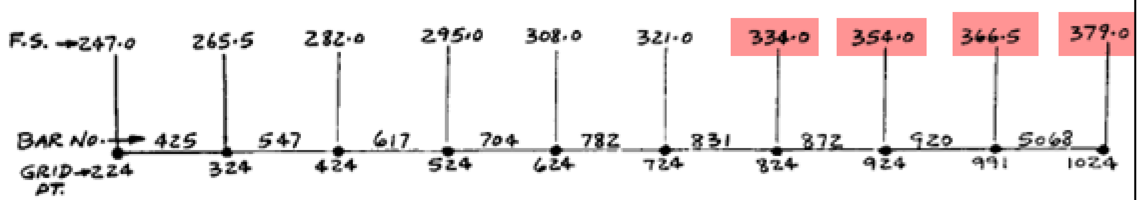

TABLE D-10.2

F.S.	GRID PT.	BAR NO.	MAX. POS. MOMENT			MAX. NEG. MOMENT			MAX. SHEAR	
			+M	P	COND.	−M	P	COND.	S	COND.
247.0	224	425	8697	1776	3061	-39253	-5249	3151	-2835	3057
265.5	324	547	29329	-1435	3057	-509	1573	3061	-2835	3057
282.0	424	617	224	-7346	3054	-17496	-1795	6005	2663	6005
295.0	524	704	1489	77	9002	-48453	-623	6005	9252	6005
308.0	624	782	12520	1591	9001	-177899	-3406	6005	9252	6005
321.0	724	831	8906	2761	6001	-58846	-3317	6004	-9183	6005
334.0	824	872	51946	-376	6005	-9834	1987	9002	-7361	6005
354.0	924	920	150720	2982	6005	-11466	3889	9002	4935	6005
366.5	991	5068	83812	1060	6005	-3104	-5285	4002	6707	6005
379.0	1024		5606	3442	6002	-11045	-2308	6006	6707	6005

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Figure 25, Right Buttline 30 Beam Loads

- Grid points are spaced 12.5 inches at STA 379.
- Fastener spacing around the perimeter of the plate is 5 inches per fastener.

$$\frac{1\,fastener/_{5\,inch}}{1\,grid\,point/_{12.5\,inch}} = 2.5\frac{fasteners}{grid\,point}$$

- Conservatively the 3 highest loaded fasteners will be used for comparison.
- BL 30 highest axially loaded fasteners, Load case 9, ref enclosure (5) Figure ***42***
  - Fastener 14, location Sta 379, BL 30, axial load F_{A14} = 480 lb
  - Fastener 34, location Sta 374, BL 30, axial load F_{A34} = 469 lb
  - Fastener 33, location Sta 369, BL 30, axial load F_{A33} = 458 lb

$$MS = \frac{F_{allowed}}{F_{applied}} - 1 = \frac{S_{Pt\,1024}}{F_{A14} + F_{A34} + F_{A33}} - 1 = \frac{6{,}707\,lb}{1{,}407\,lb} = +3.7$$

- Bearing Strength at Station RBL 30
  - TEE Cap Lower, 70202-22318-122, QQ-A-200-11, extrusion, 7075-T6511, 0.078 thick.
    - $F_{bru\,(1.5)}$ = 111 ksi, ref (c), Table 3.7.10.0(g1)
  - Skin P/N 70203-82300-108, QQ-A-250/13, 7075-T6, 0.050" thick
    - $F_{bru\,(1.5)}$ = 109 ksi, ref (c), Table 3.7.10.0(c1)
  - Buttline R30 highest shear loaded fastener, Load case 5, ref enclosure (5) Figure ***41***
  - Fastener 34, location Sta 374, RBL 30, shear load F_{S34} = 661 lb
  - Fastener 34 has max shear load for RBL 30 and MS will be shown for Tee Cap Lower and skin only, see Figure 26 for idealized fastener locations. All other fasteners pass through these members or more. Other fasteners in frame are less critical.

$$MS = \frac{F_{allowed}}{F_{applied}} - 1 = \frac{(F_{bru} * D * t)}{F_{S34}} - 1 = \frac{\big((111\,ksi * .078) + (109\,ksi * .050)\big) * .25}{661\,lb} - 1 = +4.3$$

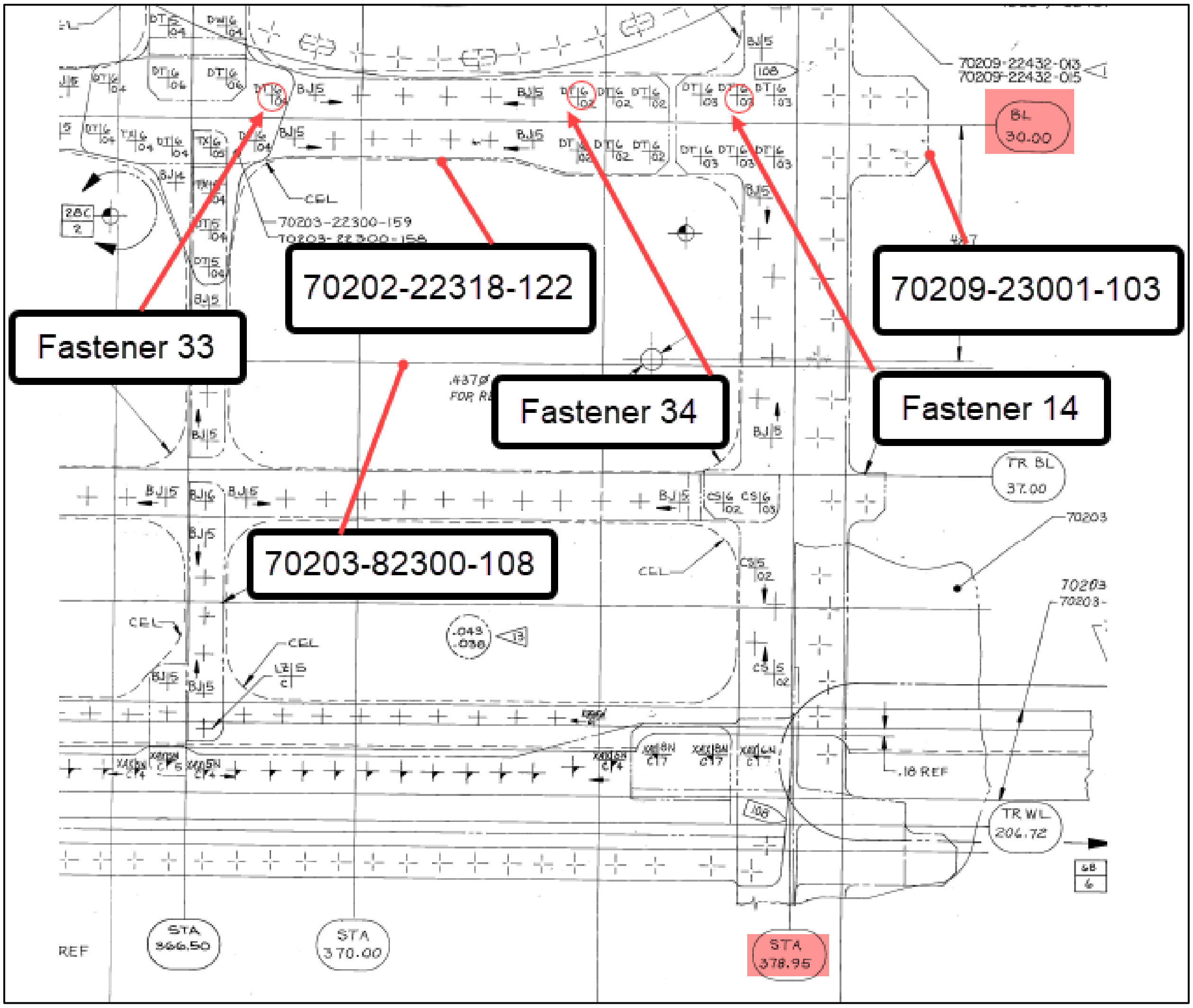

Figure 26, Right Buttline 30 Structure

LBL 30 Structure

The left hand side of the plate terminates on LBL 30, see Figure 13.. A rigid body distribution is done to determine fastener loads, see enclosure (5). The tension or compression loads in the fasteners (axial load) can be compared to the max shear load (S), see Figure 27 from ref (a), appendix D.

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FIG. D-10-1

NASTRAN MODEL – LHS BL30 BEAM

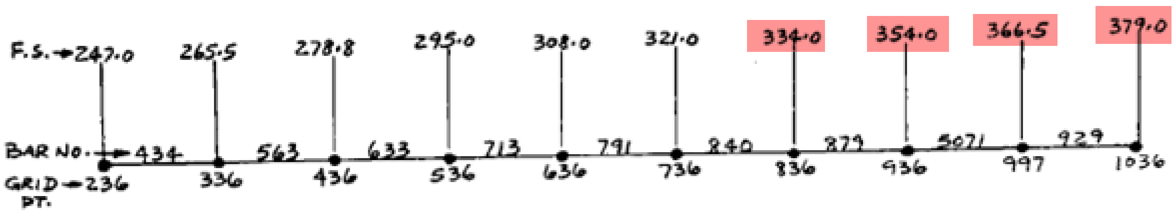

TABLE D-10.1

F.S.	GRID PT.	BAR NO.	MAX. POS. MOMENT			MAX. NEG. MOMENT			MAX. SHEAR	
			+M	P	COND.	−M	P	COND.	S	COND.
247.0	236	434	7779	1653	3060	-34023	-5355	3151	-3630	3152
265.5	336	563	38749	-2633	3152	-2869	1402	6005	-3640	3152
278.8	436	633	126	-2776	3152	-11230	-3919	6001	-3640	3152
295.0	536	713	2525	95	9003	-25383	-2667	3152	2980	6002
308.0	636	791	12056	1877	9004	-64517	-4996	6002	-3040	6001
321.0	736	840	7650	3698	6005	-19438	-8780	3054	-3040	6001
334.0	836	879	15019	2435	6001	-9669	1410	9003	-3312	6001
354.0	936	5071	52115	3580	6001	-20305	2522	9003	-3312	6001
366.5	997	929	43347	4563	6002	-14495	3234	9004	2450	6001
379.0	1036		16484	7061	6004	-4006	-2512	4001	2450	6001

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Figure 27, Left Buttline 30 Beam Loads

- Grid point spacing and fastener spacing same as above for RBL
- Conservatively the 3 highest loaded fasteners will be used for comparison.
- LBL 30 highest axially loaded fasteners, Load case 6, ref enclosure (5) table Figure ***41***
    - Fastener 26, location Sta 379, BL -30, axial load F_{A26} = 398 lb
    - Fastener 42, location Sta 374, BL -30, axial load F_{A42} = 385 lb
    - Fastener 41, location Sta 369, BL -30, axial load F_{A41} = 373 lb

$$MS = \frac{F_{allowed}}{F_{applied}} - 1 = \frac{S_{Pt\ 1024}}{F_{A26} + F_{A42} + F_{A41}} - 1 = \frac{2{,}450\ lb}{1{,}156\ lb} = +1.1$$

- Bearing Strength at Station LBL 30
    - TEE Cap Lower, 70202-22318-102, QQ-A-200-11, extrusion, 7075-T6511, 0.078 thick.
        - $F_{bru\,(1.5)}$ = 111 ksi, ref (c), Table 3.7.10.0(g1)
    - Skin P/N 70203-82300-101, QQ-A-250/13, 7075-T6, 0.050" thick
        - $F_{bru\,(1.5)}$ = 109 ksi, ref (c), Table 3.7.10.0(c1)
    - Buttline L30 highest shear loaded fastener, Load case 5, ref enclosure (5) Figure ***41***.
    - Fastener 42, location Sta 374, LBL 30, shear load F_{S42} = 636 lb
    - Fastener 42 has max shear load for LBL 30 and MS will be shown for Tee Cap Lower and skin only. See Figure 28 for idealized fastener locations. All other fasteners pass through these members or more. Other fasteners in frame are less critical.

$$MS = \frac{F_{allowed}}{F_{applied}} - 1 = \frac{(F_{bru} * D * t)}{F_{S34}} - 1 = \frac{((111\ ksi * .078) + (109\ ksi * .050)) * .25}{636\ lb} - 1 = +4.5$$

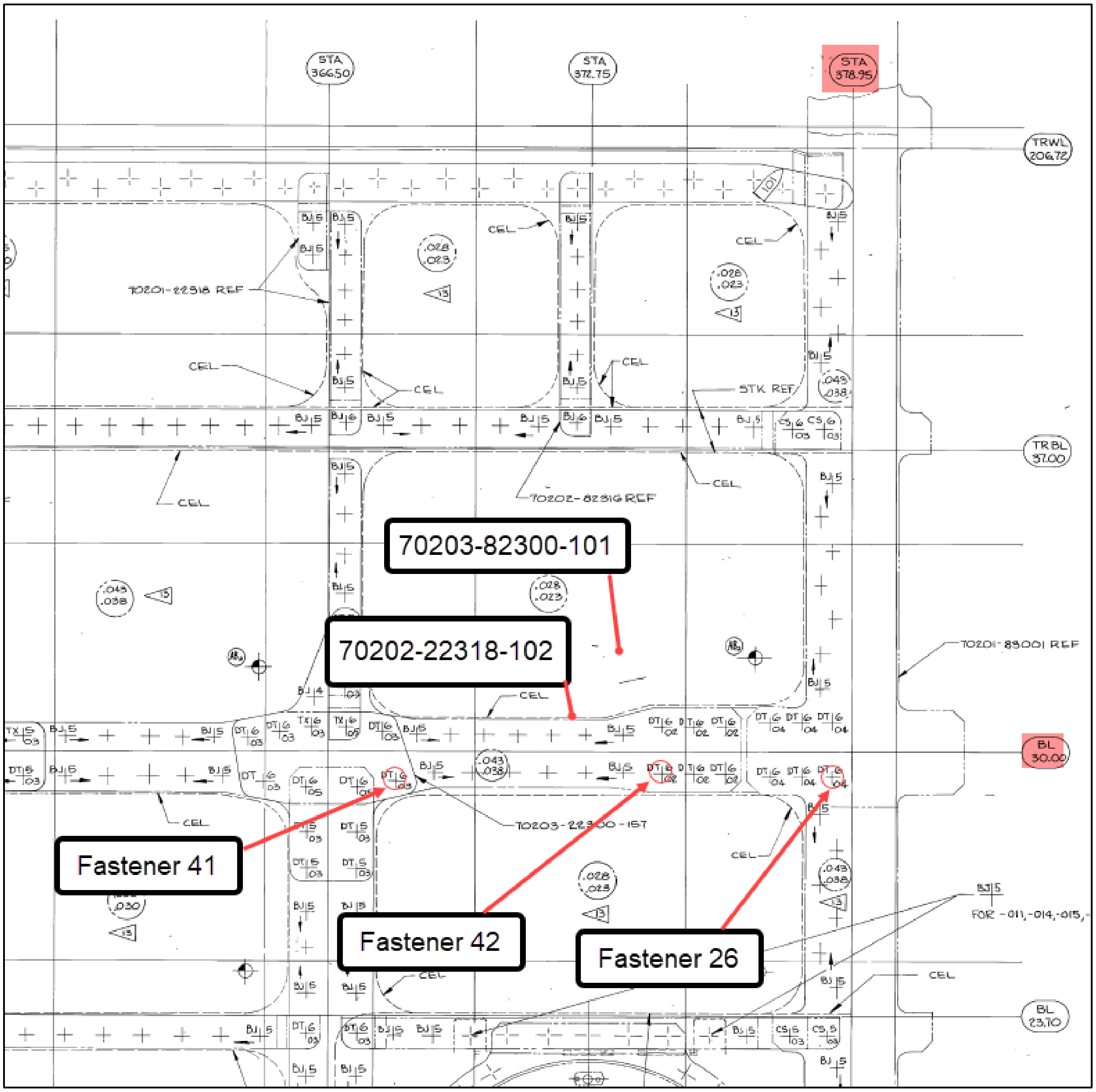


Figure 28, Left Buttline 30 Structure

Interior Fastener structure

The interior group of fasteners located LBL 10 to RBL 10, STA 334 to 356, see Figure 29. These fastener have lower loads then the perimeter fasteners and pass through substantially more material, due to the build up for the RAST probe. All fasteners pass through the doubler plate -108, details below. The doubler plate alone exceeds the bearing strength of perimeter fastener locations. Axial load can be compared to RAST loads, see Figure 16, which is a magnitude greater. Inner fastener structure is OK by inspection. All fasteners for installation (interior and perimeter) are shown in Figure 30.

- doubler plate 70209-22403-108, QQ-A-250/12, 7075-T651, 0.19 Thick,

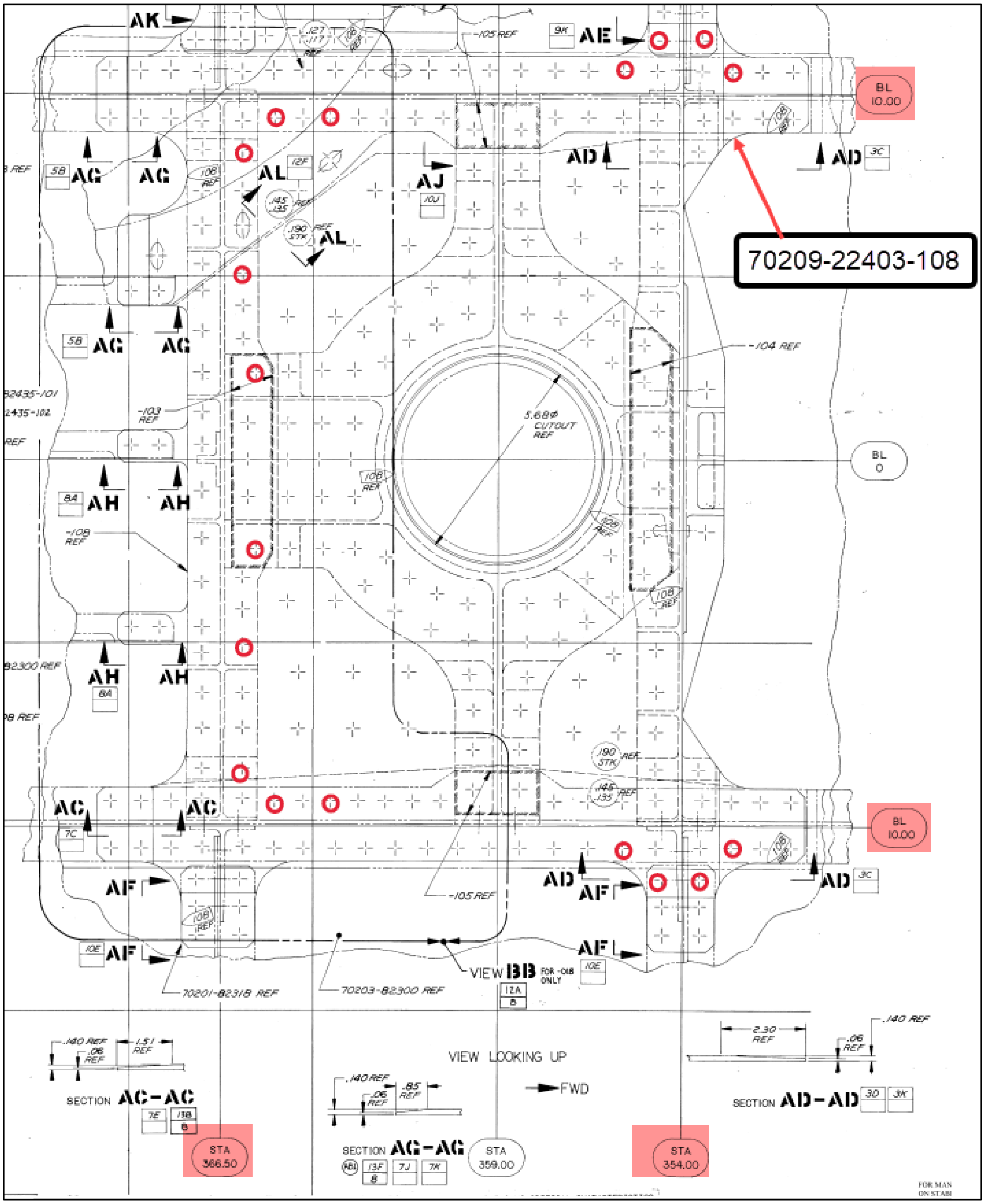


Figure 29, Interior Fastener Locations

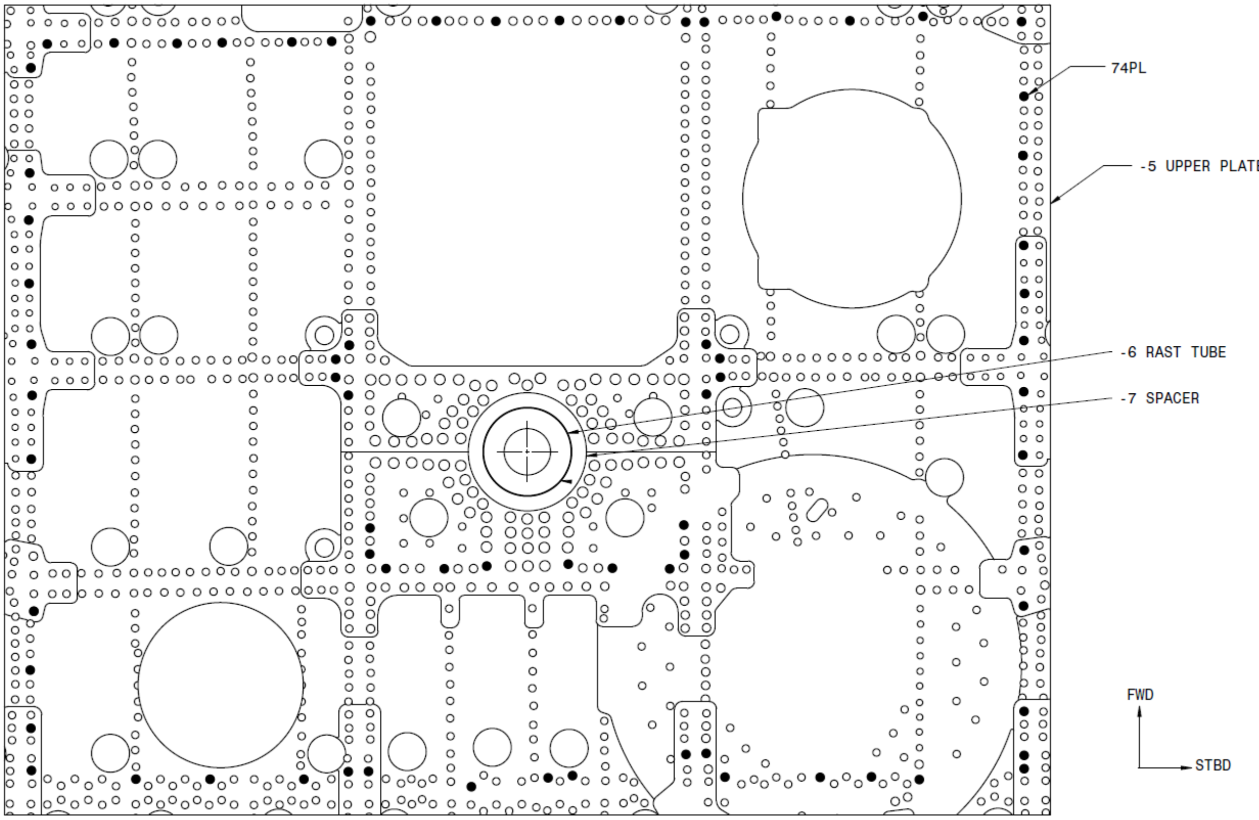


Figure 30, Identified Fasteners for Installation

Upper Plate

The plate has dimensions as shown in Figure 31. Numerous fasteners, doublers, and straps exist on the belly of the aircraft. These interference areas will be machined out of the plate to allow for good contact across the mating surface of the plate. Moment of inertia will be taken from the model, for the cross-section being analyzed.

Moments Mx and My will be assumed to cause a triangular distribution in the plate. The distribution will be from the center of the stanchion support tube going outboard. The plate will be evaluated separately in each direction as a cantilever beam. See Figure 32 below for FBD

The plate is supported by a 10" OD round HSS, centered about STA 359, BL 0. From ref (e), section 3.1.3 the yield line for a round HSS is 0.8 times diameter.

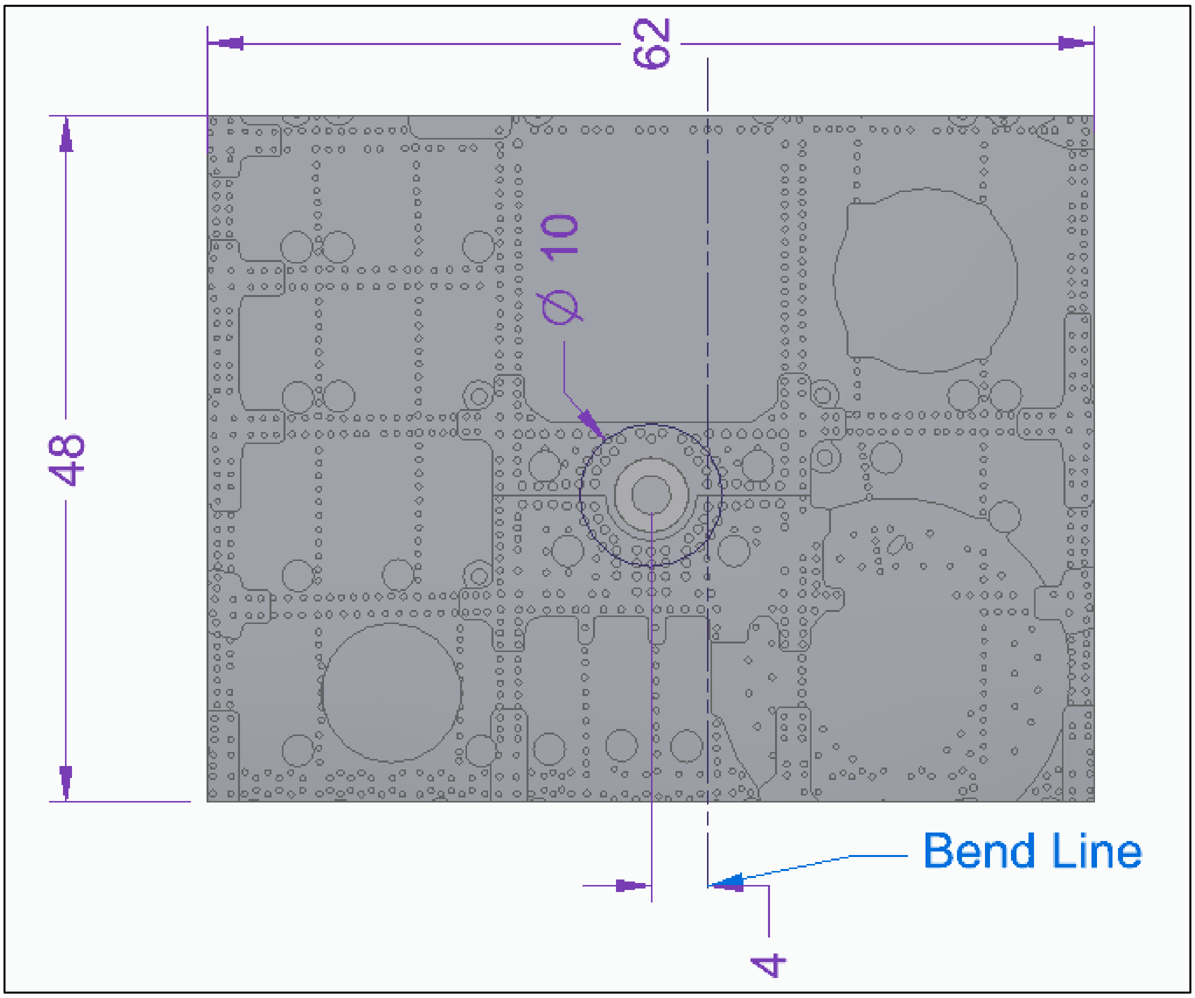


Figure 31, Upper Plate

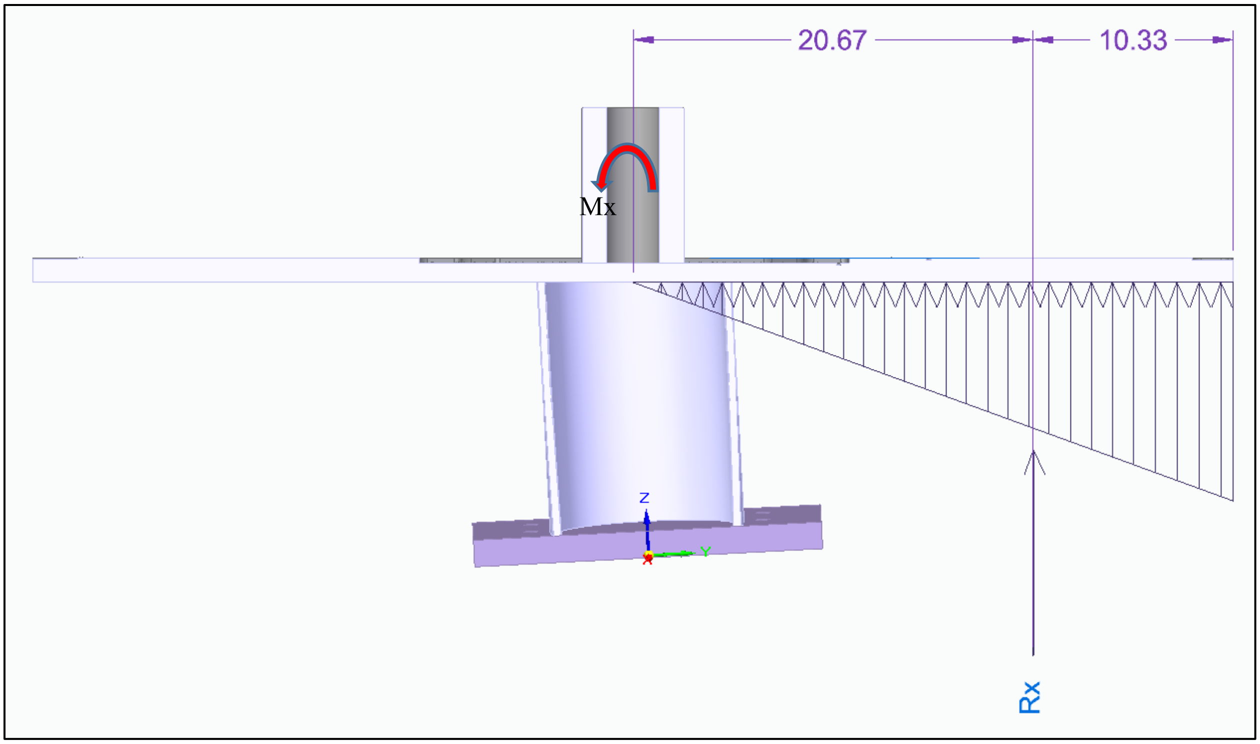


Figure 32, Upper Plate Free Body Diagram

Plate Bending about X-axis

Max M_x from enclosure (1) Table 5, M_x = -656,446 in lb

Applying load sharing ratio from enclosure (2), Table 8

$M_{x\ plate}$ = 0.24 * -656,446 in lb = -157,547 in lb

$R_x = \frac{M_{x\,plate}}{20.66\ in} = 7{,}624$ lb

I_{yy} = 6.8 in^4, taken from model.

$$\sigma_B = \frac{(20.66 - 4) * R_x * (\frac{1.25}{2})}{Iy} = 11{,}679\ psi$$

Following guidance from ref (e), the yield strength of the plate (Fy) and resistance factor (Φ) are used for flexure checks of the plate.

Fy = 36 KSI

Φ = 0.9

$$MS = \frac{\phi \text{Fy}}{\sigma_B} - 1 = \frac{.9 * 36KSI}{11{,}679\ psi} - 1 = +1.7$$

Plate Bending about Y-axis

Max M_y from enclosure (1) Table 5, My = 81,602 in lb

Applying load sharing ratio from enclosure (2), ***Table 8***

$M_{y\ plate}$ = 0.26 * 81,602 in lb = 21,217 in lb

$R_x = \frac{M_{y\,plate}}{26.5\ in} = 801$ lb

I_{xx} = 7.8 in^4, taken from model.

$$\sigma_B = \frac{(26.5 - 4) * R_x * (\frac{1.25}{2})}{Ix} = 1{,}445\ psi$$

$$MS = \frac{\phi Fy}{\sigma_B} - 1 = \frac{.9 * 36KSI}{1{,}445\ psi} - 1 = +21.4$$

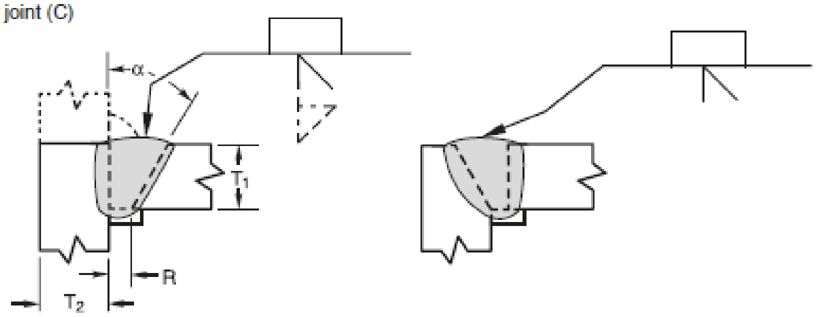
RAST Tube

The RAST tube is 5.25" OD x 2.75" ID ASTM A106 Grade B.

F_{tu} = 60 KSI
F_{ty} = 35 KSI

The RAST Tube will be welded to the top of the upper plate using a prequalified weld from ref (f). Weld shall be a complete joint penetration (CJP) TC-U4a, as shown below, with T1 as the RAST Tube.

Single-bevel-groove weld (4)
T-joint (T)
Corner joint (C)



Tolerances	
As Detailed (see 5.4.1.1)	As Fit-Up (see 5.4.1.8)
R = +1/16, –0	+1/4, –1/16
α = +10°, –0°	+10°, –5°

Welding Process	Joint Designation	Base Metal Thickness (U – unlimited)		Groove Preparation		Allowed Welding Positions	Gas Shielding for FCAW	Notes
		T_1	T_2	Root Opening	Groove Angle			
SMAW	TC-U4a	U	U	R = 1/4	α = 45°	All	—	e, g, k, o
				R = 3/8	α = 30°	F, V, OH	—	e, g, k, o
GMAW FCAW	TC-U4a-GF	U	U	R = 3/16	α = 30°	All	Required	a, g, k, o
				R = 3/8	α = 30°	F	Not req.	a, g, k, o
				R = 1/4	α = 45°	All	Not req.	a, g, k, o
SAW	TC-U4a-S	U	U	R = 3/8	α = 30°	F	—	g, k, o
				R = 1/4	α = 45°			

Figure 33, Weld from ref (f)

Stress at base RAST Tube

The critical case load case from enclosure (1), Table 5, Load Case 9

Fx = -1,284 lb
Fy = 13,173 lb
Mx = -656,446 in lb
My = 55,730 in lb

Load ratios applied from enclosure (2), ***Table 8***

$$M_{total} = \sqrt{{M_x}^2 + {M_y}^2} = \sqrt{(0.77 * -656{,}446)^2 + (0.75 * 55{,}730)^2} = 507{,}189 \ in \ lb$$

$$\sigma_{bending} = \frac{M_{total} * c}{I} = \frac{507{,}189 * \frac{5.25}{2}}{\frac{\pi}{4}(2.625^4 - 1.375^4)} = 38{,}613 \ psi$$

$$R_b = \frac{38{,}613}{60 \ KSI} = 0.643$$

$$F_{total} = \sqrt{{F_x}^2 + {F_y}^2} = \sqrt{(0.1 * -1{,}284)^2 + (0.1 * 13{,}173)^2} = 1{,}324 \ lb$$

$$\sigma_{shear} = \frac{F_{total}}{A} = \frac{1{,}324}{\pi(2.625^2 - 1.375^2)} = 85\ psi$$

$$R_s = \frac{85}{.577 * 60\ KSI} = 0.0024$$

The combined bending and shear MS is given by:

$$MS = \frac{1}{\sqrt{R_b^2 + R_s^2}} - 1 = +0.55$$, ref (j), section 7.10

Stress at top of RAST Tube

The function of the RAST tube is to react out of plane moments (Mx, My) into the inner frame cap. This results in a large lateral load acting on the tube. Stresses will be checked using ring analysis from ref (g) table 9.2.

The critical load for the top of the RAST tube is same as for the inner frame. Load was derived in enclosure (3)

$F_{inner} = 89{,}383\ lb$, ref enclosure (3)

The pressure distribution on the tube is assumed to vary linearly, as shown below, ref (g) table 9.2, case 13. With θ = 90^0

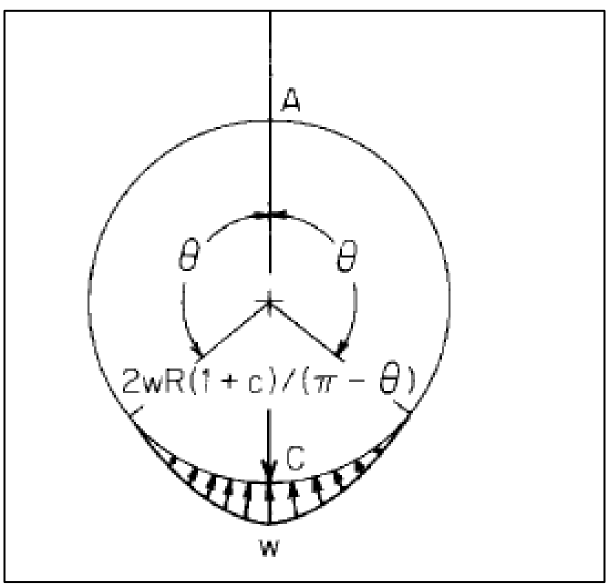


Figure 34, Assumed Load Distribution from ref (g)

The moment, hoop load, and radial shear equations from ref (g), are given below in Figure 35.

$$M = M_A - N_A R(1-u) + V_A R z + LT_M$$
$$N = N_A u + V_A z + LT_N$$
$$V = -N_A z + V_A u + LT_V$$

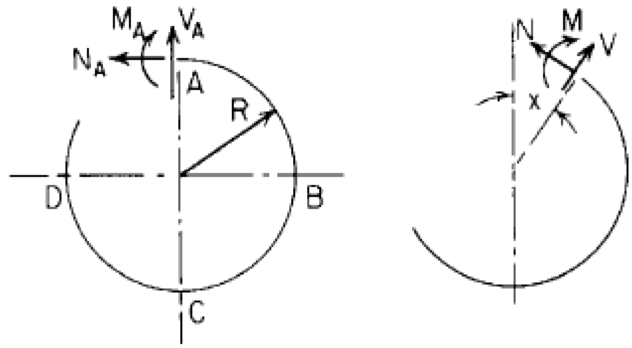


Figure 35, Moment, Hoop, and Radial Shear forces from ref (g)

The unit load (ω), is found from the equation in Figure 34, and setting equal to $F_{\_inner}$.

ω = 35, 101 lb/in
R = 2.125 in, radius to centroid of cross-section

Location of maximum stress is found at x= 118.4 degrees.

This results in the following loads at the critical cross-section

M = 10,665 in lb
N = 2,008 lb
V = 0

The effective area of the RAST tube is determined using the load distribution shown below in Figure 36. A spacer is used to provide contact between the RAST tube and inner frame, this is necessary due to the diameter of the lower/outboard opening smaller than the upper/inner dimeter in the airframe structure.

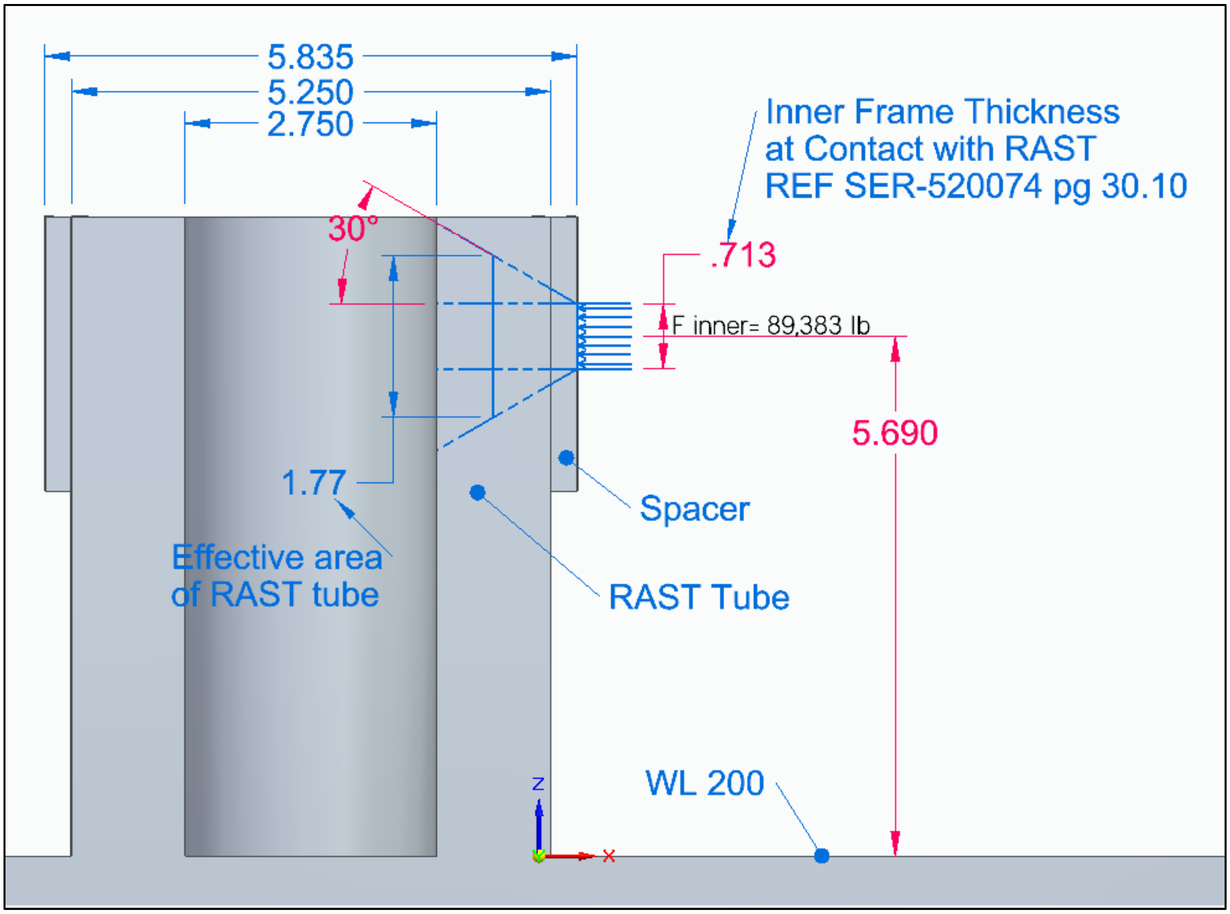


Figure 36, Effective RAST Tube Area

$$\sigma_{bending} = \frac{Mc}{I} = \frac{10{,}665 * \frac{1.25}{2}}{\frac{1.77 * 1.25^3}{12}} = \frac{6{,}666\ lb}{0.288\ in^4} = 23{,}146\ psi$$

$$\sigma_{hoop} = \frac{N}{A_{effective}} = \frac{2{,}008\ lb}{1.77in * 1.25in} = 907\ psi$$

$$\sigma_{tensile\ inner\ surface} = 907 + 23{,}146 = 24{,}053\ psi$$

$$R_T = \frac{24{,}053\ psi}{60\ KSI} = 0.40$$

$$\sigma_{shear} = \frac{F_{inner}}{A} = \frac{89{,}383\ lb}{15.708\ in^2} = 5{,}690\ psi$$

$$R_s = \frac{5{,}690}{0.577 * 60\ KSI} = 0.164$$

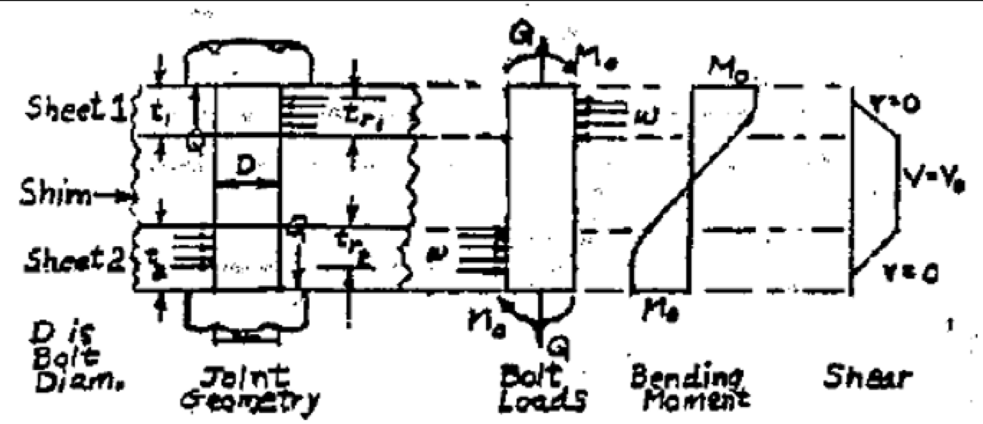
The combined tension and shear MS is given by:

$$MS = \frac{1}{\sqrt{R_T^2 + R_s^2}} - 1 \ = +1.3$$, ref (j), section 7.10

Fastener Analysis

- Load reacted by the fasteners is based on load sharing between the RAST tube and the upper plate, see enclosure (2).
- Individual fastener loading is found using a rigid body distribution, calculations are performed within ref (h).
- All fasteners used for attaching plate to aircraft are NAS6604, Alloy Steel Tension bolt, 160 KSI Ftu.
- Perimeter fasteners are analyzed for a spacing of ≤ 5 inches/fastener.
- Interior fasteners have been specifically identified as shown in Figure 29 , due to limited accessibility.
- Conservatively, highest shear and tensile load is assumed to occur on same fastener, and checked for MS. All other fasteners are less critical by inspection.
    - $F_{S\ max} = F_{S14,\ Load\ Case\ 5} = 716$ lb (same as Vo, in ref (i) notation used below in Figure 37)
    - $F_{A\ max} = F_{A1,\ Load\ Case\ 12} = 42$ lb

- Based on coordinate system (+Z-up), negative axial load, is tension in bolt. Axial loads are predominantly compression and carried by bearing against the upper plate (distributed).
- Bending moment is determined using methods from ref (i) section D3.5A, provided in Figure 37.



The sheet bearing stresses generate a bending moment in the bolt which is, from statics

$$M_o = V_o(t_{s1}/2 + t_{s2}/2 + t_f)/2$$

where t_s is the required thickness of the sheet to develope the applied shear load, V_o, and t_f is the thickness of the filler (shim).

$t_{s1} = V_o/F_{bru_1}D$ $\quad$ $t_{s2} = V_o/F_{bru_2}D$

Figure 37, Fastener Free Body Diagram from ref (i)

The lower bearing strength for the airframe is 7075-T73 extrusion, F_{bru} = 88 KSI ref (c), Table 3.7.10.0(f2)

$t_{s1} = \frac{V_o}{F_{bru}*D} = \frac{716\ lb}{88\ KSI*0.25\ in} = 0.033\ in$ < Thickness of skin and frame cap

Aircraft plate A36 Steel F_{bru} = 1.6 * Ftu = 1.6 * 58 KSI = 92.8 KSI, ref (1.6 is scaling factor $\frac{F_{bru}}{F_{tu}}$ for similar carbon steel from ref (c)).

$t_{s2} = \frac{V_o}{F_{bru}*D} = \frac{716\ lb}{92.8\ KSI*0.25\ in} = 0.031\ in \ll$ Thickness of plate

$M_o = \frac{716\left(\frac{.033}{2}+\frac{.031}{2}+0\right)}{2} = 11.5$ in lb

Fastener allowable for tension, shear, and bending taken from ref (j)(k), and provided below in Figure 38.

TABLE 2.2.2.1 ULTIMATE STRENGTHS OF TENSION BOLTS

MATERIAL	HEAD TYPE \ F_{tu} (KSI)	125	150	160			180	220
STEEL	HEXAGON HEAD	AN 3-20 AN 173-186[1] MS 20073		NAS 1303-1320[1]				
	INTERNAL WRENCHING			MS 20004-20024	NAS 144-158			
	12 POINT EXTERNAL WRENCHING						NAS 624-644	SPS EWB-22
TITANIUM	HEXAGON HEAD	SS 5021	NAS 673-678[1,2]			NAS 1266-1270[1] NAS 673-678[1,2]		
	INTERNAL WRENCHING		SS 5027[2]			SS 5027[2]		
	12 POINT EXTERNAL WRENCHING		SS 5029[3]			NAS 1271-1280		
10-32	TENSION - LB. SHEAR - LB. BENDING - IN. LB.	2210 2125 131	2980 2690 168	3620 2690 177		3180 2690 180		
$\frac{1}{4}$-28	TENSION - LB. SHEAR - LB. BENDING - IN. LB.	4080 3680 304	5430 4650 380	6190 4650 402	5000 4650 394	5820 4650 406	6960 5280 455	8800 6300 554

Figure 38, Fastener Allowable Loads from ref (j)

Failure criteria from ref (k), with fastener bending included will be used. Criteria provided below.

$$\left(\frac{V}{V_{\text{allow}}}\right)^{2.5} + \left(\frac{P}{P_{\text{allow}}}\right)^{1.5} + \left(\frac{M}{M_{\text{allow}}}\right) \leq 1 \text{ ,}$$

$$\left(\frac{716}{4650}\right)^{2.5} + \left(\frac{42}{6190}\right)^{1.5} + \left(\frac{11.5}{.88(402)}\right) \leq 1$$

$$0.057 \leq 1$$

Re-writing as MS for consistency

$$MS = \frac{1}{0.057} - 1 = +16$$

Fastener locations used for analysis and load case results provided below, in Figure 39 through Figure 43.

					Coords				Orientation				
		Fastener #		x	y	z		x	y	z		Diameter	Strength
Perimeter Fasteners	FWD Row	1		334	30	200		0	0	1		0.25	1
		2		334	25	200		0	0	1		0.25	1
		3		334	20	200		0	0	1		0.25	1
		4		334	15	200		0	0	1		0.25	1
		5		334	10	200		0	0	1		0.25	1
		6		334	5	200		0	0	1		0.25	1
		7		334	0	200		0	0	1		0.25	1
		8		334	-5	200		0	0	1		0.25	1
		9		334	-10	200		0	0	1		0.25	1
		10		334	-15	200		0	0	1		0.25	1
		11		334	-20	200		0	0	1		0.25	1
		12		334	-25	200		0	0	1		0.25	1
		13		334	-30	200		0	0	1		0.25	1
	AFT Row	14		379	30	200		0	0	1		0.25	1
		15		379	25	200		0	0	1		0.25	1
		16		379	20	200		0	0	1		0.25	1
		17		379	15	200		0	0	1		0.25	1
		18		379	10	200		0	0	1		0.25	1
		19		379	5	200		0	0	1		0.25	1
		20		379	0	200		0	0	1		0.25	1
		21		379	-5	200		0	0	1		0.25	1
		22		379	-10	200		0	0	1		0.25	1
		23		379	-15	200		0	0	1		0.25	1
		24		379	-20	200		0	0	1		0.25	1
		25		379	-25	200		0	0	1		0.25	1
		26		379	-30	200		0	0	1		0.25	1
	STBD Side	27		339	30	200		0	0	1		0.25	1
		28		344	30	200		0	0	1		0.25	1
		29		349	30	200		0	0	1		0.25	1
		30		354	30	200		0	0	1		0.25	1
		31		359	30	200		0	0	1		0.25	1
		32		364	30	200		0	0	1		0.25	1
		33		369	30	200		0	0	1		0.25	1
		34		374	30	200		0	0	1		0.25	1
	Port Side	35		339	-30	200		0	0	1		0.25	1
		36		344	-30	200		0	0	1		0.25	1
		37		349	-30	200		0	0	1		0.25	1
		38		354	-30	200		0	0	1		0.25	1
		39		359	-30	200		0	0	1		0.25	1
		40		364	-30	200		0	0	1		0.25	1
		41		369	-30	200		0	0	1		0.25	1
		42		374	-30	200		0	0	1		0.25	1
Interior Fasteners	FWD STBD corner	43		352	11	200		0	0	1		0.25	1
		44		353	12	200		0	0	1		0.25	1
		45		355	12	200		0	0	1		0.25	1
		46		356	11	200		0	0	1		0.25	1
	FWD Port corner	47		352	-11	200		0	0	1		0.25	1
		48		353	-12	200		0	0	1		0.25	1
		49		355	-12	200		0	0	1		0.25	1
		50		356	-11	200		0	0	1		0.25	1
	Aft STBD corner	51		363	9	200		0	0	1		0.25	1
		52		365.5	9	200		0	0	1		0.25	1
		53		366	8	200		0	0	1		0.25	1
		54		366	5	200		0	0	1		0.25	1
		55		366	2.5	200		0	0	1		0.25	1
	Aft Port corner	56		363	-9	200		0	0	1		0.25	1
		57		365.5	-9	200		0	0	1		0.25	1
		58		366	-8	200		0	0	1		0.25	1
		59		366	-5	200		0	0	1		0.25	1
		60		366	-2.5	200		0	0	1		0.25	1

Figure 39, Fastener Locations

Load Case 1					Load Case 2					Load Case 3				
		Reaction					Reaction					Reaction		
x	y	z	shear	axial	x	y	z	shear	axial	x	y	z	shear	axial
28.490	-6.092	226.634	29.13444	226.6337	24.420	-5.222	194.257	24.97238	194.2574	261.757	102.517	262.481	281.1165	262.4812
27.166	-6.092	222.921	27.84056	222.9206	23.285	-5.222	191.075	23.86334	191.0748	221.005	102.517	248.256	243.6247	248.2563
25.841	-6.092	219.208	26.54971	219.2076	22.150	-5.222	187.892	22.7569	187.8922	180.253	102.517	234.031	207.3666	234.0313
24.517	-6.092	215.495	25.26235	215.4946	21.014	-5.222	184.710	21.65344	184.7097	139.501	102.517	219.806	173.1193	219.8063
23.192	-6.092	211.782	23.97904	211.7816	19.879	-5.222	181.527	20.55346	181.5271	98.749	102.517	205.581	142.3416	205.5814
21.868	-6.092	208.069	22.70046	208.0685	18.744	-5.222	178.344	19.45754	178.3445	57.997	102.517	191.356	117.7854	191.3564
20.543	-6.092	204.356	21.42746	204.3555	17.608	-5.222	175.162	18.3664	175.1619	17.245	102.517	177.131	103.9573	177.1314
19.219	-6.092	200.643	20.16111	200.6425	16.473	-5.222	171.979	17.28095	171.9793	-23.507	102.517	162.906	105.1774	162.9064
17.894	-6.092	196.929	18.90273	196.9295	15.338	-5.222	168.797	16.20234	168.7967	-64.259	102.517	148.681	120.9914	148.6815
16.570	-6.092	193.216	17.65404	193.2165	14.202	-5.222	165.614	15.13203	165.6141	-105.011	102.517	134.457	146.7548	134.4565
15.245	-6.092	189.503	16.41724	189.5034	13.067	-5.222	162.432	14.07192	162.4315	-145.763	102.517	120.232	178.2035	120.2315
13.920	-6.092	185.790	15.19523	185.7904	11.932	-5.222	159.249	13.02448	159.2489	-186.515	102.517	106.007	212.8319	106.0066
12.596	-6.092	182.077	13.99189	182.0774	10.797	-5.222	156.066	11.99305	156.0663	-227.267	102.517	91.782	249.3188	91.78161
28.490	-18.013	328.839	33.70711	328.839	24.420	-15.440	281.862	28.89181	281.862	261.757	-264.251	337.649	371.9479	337.6492
27.166	-18.013	325.126	32.59526	325.1259	23.285	-15.440	278.679	27.93879	278.6794	221.005	-264.251	323.424	344.4876	323.4242
25.841	-18.013	321.413	31.49986	321.4129	22.150	-15.440	275.497	26.99988	275.4968	180.253	-264.251	309.199	319.8744	309.1992
24.517	-18.013	317.700	30.42269	317.6999	21.014	-15.440	272.314	26.07659	272.3142	139.501	-264.251	294.974	298.8127	294.9743
23.192	-18.013	313.987	29.36576	313.9869	19.879	-15.440	269.132	25.17065	269.1316	98.749	-264.251	280.749	282.0991	280.7493
21.868	-18.013	310.274	28.33134	310.2738	18.744	-15.440	265.949	24.284	265.949	57.997	-264.251	266.524	270.5405	266.5243
20.543	-18.013	306.561	27.32197	306.5608	17.608	-15.440	262.766	23.41883	262.7664	17.245	-264.251	252.299	264.8129	252.2994
19.219	-18.013	302.848	26.34054	302.8478	16.473	-15.440	259.584	22.57761	259.5838	-23.507	-264.251	238.074	265.2943	238.0744
17.894	-18.013	299.135	25.3903	299.1348	15.338	-15.440	256.401	21.76311	256.4012	-64.259	-264.251	223.849	271.9516	223.8494
16.570	-18.013	295.422	24.47486	295.4217	14.202	-15.440	253.219	20.97845	253.2186	-105.011	-264.251	209.624	284.3514	209.6245
15.245	-18.013	291.709	23.59829	291.7087	13.067	-15.440	250.036	20.22711	250.036	-145.763	-264.251	195.400	301.7867	195.3995
13.920	-18.013	287.996	22.76508	287.9957	11.932	-15.440	246.853	19.51292	246.8535	-186.515	-264.251	181.175	323.4443	181.1745
12.596	-18.013	284.283	21.98014	284.2827	10.797	-15.440	243.671	18.84012	243.6709	-227.267	-264.251	166.950	348.5378	166.9496
28.490	-7.417	237.990	29.43992	237.9898	24.420	-6.357	203.991	25.23421	203.9913	261.757	61.765	270.833	268.9455	270.8332
28.490	-8.741	249.346	29.80118	249.346	24.420	-7.493	213.725	25.54387	213.7251	261.757	21.013	279.185	262.5991	279.1852
28.490	-10.066	260.702	30.21624	260.7021	24.420	-8.628	223.459	25.89963	223.4589	261.757	-19.739	287.537	262.5002	287.5372
28.490	-11.390	272.058	30.6829	272.0582	24.420	-9.763	233.193	26.29963	233.1928	261.757	-60.491	295.889	268.6557	295.8892
28.490	-12.715	283.414	31.19886	283.4144	24.420	-10.898	242.927	26.74188	242.9266	261.757	-101.243	304.241	280.6544	304.2412
28.490	-14.039	294.771	31.7617	294.7705	24.420	-12.034	252.660	27.22432	252.6605	261.757	-141.995	312.593	297.7907	312.5932
28.490	-15.364	306.127	32.36899	306.1267	24.420	-13.169	262.394	27.74485	262.3943	261.757	-182.747	320.945	319.2384	320.9452
28.490	-16.688	317.483	33.01827	317.4828	24.420	-14.304	272.128	28.30137	272.1281	261.757	-223.499	329.297	344.1925	329.2972
12.596	-7.417	193.434	14.61732	193.4335	10.797	-6.357	165.800	12.52913	165.8002	-227.267	61.765	100.134	235.5101	100.1336
12.596	-8.741	204.790	15.33193	204.7897	10.797	-7.493	175.534	13.14165	175.534	-227.267	21.013	108.486	228.236	108.4856
12.596	-10.066	216.146	16.12385	216.1458	10.797	-8.628	185.268	13.82044	185.2678	-227.267	-19.739	116.838	228.1222	116.8376
12.596	-11.390	227.502	16.98228	227.502	10.797	-9.763	195.002	14.55624	195.0017	-227.267	-60.491	125.190	235.1792	125.1896
12.596	-12.715	238.858	17.89766	238.8581	10.797	-10.898	204.736	15.34085	204.7355	-227.267	-101.243	133.542	248.7976	133.5416
12.596	-14.039	250.214	18.86168	250.2142	10.797	-12.034	214.469	16.16716	214.4693	-227.267	-141.995	141.894	267.9788	141.8936
12.596	-15.364	261.570	19.86728	261.5704	10.797	-13.169	224.203	17.0291	224.2032	-227.267	-182.747	150.246	291.6274	150.2456
12.596	-16.688	272.927	20.90845	272.9265	10.797	-14.304	233.937	17.92153	233.937	-227.267	-223.499	158.598	318.7504	158.5976
23.457	-10.861	253.406	25.84933	253.4063	20.106	-9.309	217.205	22.15657	217.2054	106.900	-44.190	238.494	115.6732	238.4935
23.722	-11.125	256.420	26.20134	256.4201	20.333	-9.536	219.789	22.45829	219.7887	115.050	-52.341	243.009	126.3963	243.0089
23.722	-11.655	260.963	26.43066	260.9626	20.333	-9.990	223.682	22.65485	223.6822	115.050	-68.641	246.350	133.9706	246.3497
23.457	-11.920	262.491	26.31211	262.4912	20.106	-10.217	224.992	22.55324	224.9925	106.900	-76.792	245.175	131.6225	245.1751
17.629	-10.861	237.069	20.70602	237.069	15.111	-9.309	203.202	17.74802	203.202	-72.409	-44.190	175.904	84.82835	175.9037
17.364	-11.125	238.598	20.62264	238.5976	14.884	-9.536	204.512	17.67655	204.5122	-80.560	-52.341	174.729	96.06959	174.7291
17.364	-11.655	243.140	20.91322	243.1401	14.884	-9.990	208.406	17.92562	208.4058	-80.560	-68.641	178.070	105.837	178.0699
17.629	-11.920	246.154	21.28094	246.1539	15.111	-10.217	210.989	18.2408	210.9891	-72.409	-76.792	182.585	105.5464	182.5853
22.927	-13.775	276.905	26.74694	276.9046	19.652	-11.807	237.347	22.92595	237.3468	90.599	-133.844	251.178	161.6245	251.1779
22.927	-14.437	282.583	27.09395	282.5827	19.652	-12.374	242.214	23.22339	242.2137	90.599	-154.220	255.354	178.8633	255.3539
22.662	-14.569	282.976	26.94155	282.9757	19.425	-12.488	242.551	23.09276	242.5506	82.448	-158.296	253.344	178.4804	253.3441
21.868	-14.569	280.748	26.27657	280.7479	18.744	-12.488	240.641	22.52278	240.641	57.997	-158.296	244.809	168.5859	244.8092
21.205	-14.569	278.891	25.72805	278.8914	18.176	-12.488	239.050	22.05261	239.0497	37.621	-158.296	237.697	162.7049	237.6967
18.159	-13.775	263.538	22.79224	263.5377	15.565	-11.807	225.889	19.5362	225.8895	-56.108	-133.844	199.968	145.1292	199.968
18.159	-14.437	269.216	23.19848	269.2158	15.565	-12.374	230.756	19.88441	230.7564	-56.108	-154.220	204.144	164.11	204.144
18.424	-14.569	271.094	23.48835	271.094	15.792	-12.488	232.366	20.13287	232.3663	-47.958	-158.296	207.824	165.401	207.8242
19.219	-14.569	273.322	24.11675	273.3218	16.473	-12.488	234.276	20.6715	234.2758	-23.507	-158.296	216.359	160.0315	216.3592
19.881	-14.569	275.178	24.64776	275.1783	17.041	-12.488	235.867	21.12665	235.8671	-3.131	-158.296	223.472	158.3266	223.4717

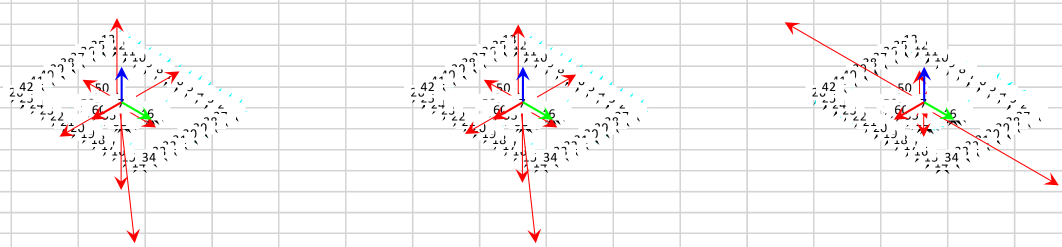


Figure 40, Fastener Loads, Load Case 1,2, and 3

Load Case 4				
		Reaction		
x	y	z	shear	axial
-212.916	-112.961	126.034	241.026	126.0336
-174.435	-112.961	133.893	207.8166	133.8934
-135.954	-112.961	141.753	176.7585	141.7532
-97.472	-112.961	149.613	149.2012	149.613
-58.991	-112.961	157.473	127.4366	157.4728
-20.510	-112.961	165.333	114.8076	165.3326
17.972	-112.961	173.192	114.3814	173.1923
56.453	-112.961	181.052	126.2817	181.0521
94.934	-112.961	188.912	147.5556	188.9119
133.416	-112.961	196.772	174.8138	196.7717
171.897	-112.961	204.631	205.6908	204.6315
210.378	-112.961	212.491	238.7869	212.4913
248.860	-112.961	220.351	273.297	220.351
-212.916	233.371	226.075	315.9044	226.0748
-174.435	233.371	233.935	291.3585	233.9345
-135.954	233.371	241.794	270.0844	241.7943
-97.472	233.371	249.654	252.9092	249.6541
-58.991	233.371	257.514	240.7117	257.5139
-20.510	233.371	265.374	234.2708	265.3737
17.972	233.371	273.233	234.0623	273.2335
56.453	233.371	281.093	240.1023	281.0932
94.934	233.371	288.953	251.9419	288.953
133.416	233.371	296.813	268.8158	296.8128
171.897	233.371	304.673	289.8461	304.6726
210.378	233.371	312.532	314.1993	312.5324
248.860	233.371	320.392	341.1646	320.3922
-212.916	-74.479	137.149	225.5673	137.1493
-212.916	-35.998	148.265	215.9381	148.265
-212.916	2.483	159.381	212.9309	159.3807
-212.916	40.965	170.496	216.8214	170.4964
-212.916	79.446	181.612	227.2555	181.612
-212.916	117.927	192.728	243.3932	192.7277
-212.916	156.409	203.843	264.1914	203.8434
-212.916	194.890	214.959	288.6443	214.9591
248.860	-74.479	231.467	259.7659	231.4667
248.860	-35.998	242.582	251.4498	242.5824
248.860	2.483	253.698	248.8721	253.6981
248.860	40.965	264.814	252.2087	264.8138
248.860	79.446	275.929	261.2332	275.9294
248.860	117.927	287.045	275.387	287.0451
248.860	156.409	298.161	293.9299	298.1608
248.860	194.890	309.276	316.0906	309.2765
-66.687	25.572	195.917	71.42221	195.9173
-74.384	33.268	196.568	81.48438	196.5684
-74.384	48.661	201.015	88.88646	201.0147
-66.687	56.357	204.810	87.31168	204.8098
102.631	25.572	230.500	105.7685	230.5003
110.327	33.268	234.295	115.2337	234.2954
110.327	48.661	238.742	120.5815	238.7417
102.631	56.357	239.393	117.0861	239.3929
-51.295	110.231	223.516	121.5814	223.5157
-51.295	129.472	229.074	139.2626	229.0735
-43.599	133.320	231.757	140.2676	231.757
-20.510	133.320	236.473	134.8882	236.4729
-1.269	133.320	240.403	133.3259	240.4028
87.238	110.231	251.811	140.5751	251.8109
87.238	129.472	257.369	156.1198	257.3687
79.542	133.320	256.908	155.2452	256.9083
56.453	133.320	252.192	144.7795	252.1925
37.212	133.320	248.263	138.4158	248.2626

Load Case 5				
		Reaction		
x	y	z	shear	axial
499.094	210.256	330.705	541.5737	330.705
418.725	210.256	305.438	468.5491	305.4377
338.357	210.256	280.170	398.3625	280.1703
257.988	210.256	254.903	332.8142	254.903
177.619	210.256	229.636	275.2383	229.6356
97.251	210.256	204.368	231.6575	204.3683
16.882	210.256	179.101	210.9325	179.101
-63.487	210.256	153.834	219.6316	153.8336
-143.855	210.256	128.566	254.7584	128.5663
-224.224	210.256	103.299	307.3823	103.2989
-304.592	210.256	78.032	370.1136	78.03158
-384.961	210.256	52.764	438.6372	52.76424
-465.330	210.256	27.497	510.6264	27.49689
499.094	-513.062	393.436	715.7703	393.4364
418.725	-513.062	368.169	662.2411	368.169
338.357	-513.062	342.902	614.5873	342.9017
257.988	-513.062	317.634	574.2736	317.6344
177.619	-513.062	292.367	542.9374	292.367
97.251	-513.062	267.100	522.1974	267.0997
16.882	-513.062	241.832	513.3395	241.8323
-63.487	-513.062	216.565	516.9749	216.565
-143.855	-513.062	191.298	532.8478	191.2976
-224.224	-513.062	166.030	559.9186	166.0303
-304.592	-513.062	140.763	596.6649	140.763
-384.961	-513.062	115.496	641.4262	115.4956
-465.330	-513.062	90.228	692.6502	90.22827
499.094	129.887	337.675	515.7182	337.6752
499.094	49.519	344.645	501.5443	344.6453
499.094	-30.850	351.615	500.0463	351.6155
499.094	-111.219	358.586	511.3357	358.5856
499.094	-191.587	365.556	534.603	365.5558
499.094	-271.956	372.526	568.379	372.5259
499.094	-352.325	379.496	610.9233	379.4961
499.094	-432.693	386.466	660.5437	386.4662
-465.330	129.887	34.467	483.1174	34.46705
-465.330	49.519	41.437	467.9571	41.4372
-465.330	-30.850	48.407	466.3513	48.40735
-465.330	-111.219	55.378	478.4364	55.37751
-465.330	-191.587	62.348	503.2271	62.34766
-465.330	-271.956	69.318	538.9729	69.31781
-465.330	-352.325	76.288	583.6646	76.28796
-465.330	-432.693	83.258	635.4173	83.25812
193.693	-79.071	259.782	209.211	259.7817
209.767	-95.145	266.229	230.3359	266.2292
209.767	-127.292	269.017	245.368	269.0172
193.693	-143.366	265.358	240.9789	265.3578
-159.929	-79.071	148.605	178.4083	148.6053
-176.003	-95.145	144.946	200.0738	144.9459
-176.003	-127.292	147.734	217.2103	147.734
-159.929	-143.366	154.181	214.7816	154.1815
161.546	-255.882	265.009	302.6098	265.0091
161.546	-296.067	268.494	337.2719	268.4941
145.472	-304.103	264.138	337.1067	264.1377
97.251	-304.103	248.977	319.2751	248.9773
57.066	-304.103	236.344	309.4115	236.3436
-127.782	-255.882	174.047	286.0137	174.0466
-127.782	-296.067	177.532	322.4648	177.5317
-111.708	-304.103	183.282	323.9715	183.2822
-63.487	-304.103	198.443	310.6597	198.4426
-23.302	-304.103	211.076	304.9949	211.0763

Load Case 6				
		Reaction		
x	y	z	shear	axial
-450.253	-220.700	57.810	501.4342	57.80985
-372.155	-220.700	76.712	432.6752	76.71201
-294.057	-220.700	95.614	367.6655	95.61417
-215.959	-220.700	114.516	308.7826	114.5163
-137.861	-220.700	133.418	260.2192	133.4185
-59.763	-220.700	152.321	228.6481	152.3206
18.335	-220.700	171.223	221.4599	171.2228
96.433	-220.700	190.125	240.8477	190.125
174.531	-220.700	209.027	281.3704	209.0271
252.629	-220.700	227.929	335.4544	227.9293
330.727	-220.700	246.831	397.6035	246.8314
408.825	-220.700	265.734	464.5923	265.7336
486.923	-220.700	284.636	534.6047	284.6358
-450.253	482.182	170.288	659.718	170.2875
-372.155	482.182	189.190	609.0971	189.1897
-294.057	482.182	208.092	564.7738	208.0919
-215.959	482.182	226.994	528.3353	226.994
-137.861	482.182	245.896	501.5033	245.8962
-59.763	482.182	264.798	485.8719	264.7983
18.335	482.182	283.701	482.5308	283.7005
96.433	482.182	302.603	491.7308	302.6027
174.531	482.182	321.505	512.7971	321.5048
252.629	482.182	340.407	544.3539	340.407
330.727	482.182	359.309	584.7051	359.3091
408.825	482.182	378.211	632.169	378.2113
486.923	482.182	397.113	685.2691	397.1135
-450.253	-142.602	70.307	472.2956	70.30737
-450.253	-64.504	82.805	454.8501	82.80489
-450.253	13.594	95.302	450.4584	95.30242
-450.253	91.692	107.800	459.4947	107.7999
-450.253	169.790	120.297	481.2034	120.2975
-450.253	247.888	132.795	513.9811	132.795
-450.253	325.986	145.293	555.8732	145.2925
-450.253	404.084	157.790	604.9894	157.79
486.923	-142.602	297.133	507.3747	297.1333
486.923	-64.504	309.631	491.1767	309.6308
486.923	13.594	322.128	487.1125	322.1283
486.923	91.692	334.626	495.4809	334.6258
486.923	169.790	347.123	515.6768	347.1234
486.923	247.888	359.621	546.3904	359.6209
486.923	325.986	372.118	585.9701	372.1184
486.923	404.084	384.616	632.7543	384.6159
-153.481	60.453	174.629	164.9574	174.6291
-169.100	76.073	173.348	185.4239	173.3482
-169.100	107.312	178.347	200.2768	178.3472
-153.481	122.932	184.627	196.6431	184.6271
190.150	60.453	257.799	199.5289	257.7986
205.770	76.073	264.079	219.3818	264.0786
205.770	107.312	269.078	232.0715	269.0776
190.150	122.932	267.797	226.4274	267.7966
-122.242	232.269	209.685	262.4725	209.6845
-122.242	271.318	215.933	297.5842	215.9333
-106.622	279.128	220.963	298.7984	220.9635
-59.763	279.128	232.305	285.4538	232.3048
-20.714	279.128	241.756	279.8951	241.7559
158.911	232.269	277.732	281.4277	277.7323
158.911	271.318	283.981	314.4298	283.9811
143.292	279.128	281.450	313.759	281.4504
96.433	279.128	270.109	295.3159	270.1091
57.384	279.128	260.658	284.9651	260.658

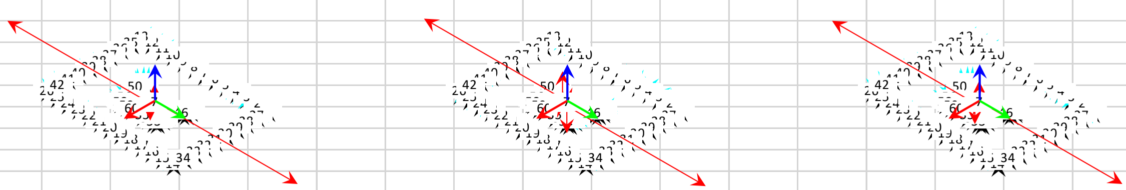


Figure 41, Fastener Loads, Load Case 4, 5, and 6

Load Case 7					Load Case 8					Load Case 9				
		Reaction					Reaction					Reaction		
x	y	z	shear	axial	x	y	z	shear	axial	x	y	z	shear	axial
492.989	211.561	282.141	536.4663	282.1407	-456.358	-219.394	9.245	506.3562	9.245491	109.818	-128.619	382.285	169.1235	382.2848
412.904	211.561	257.669	463.9481	257.669	-377.976	-219.394	28.943	437.0354	28.9433	94.762	-128.619	350.869	159.7579	350.869
332.819	211.561	233.197	394.3688	233.1973	-299.595	-219.394	48.641	371.3364	48.6411	79.706	-128.619	319.453	151.3134	319.4532
252.734	211.561	208.726	329.5949	208.7256	-221.213	-219.394	68.339	311.5588	68.33891	64.650	-128.619	288.037	143.9525	288.0374
172.650	211.561	184.254	273.0678	184.2539	-142.831	-219.394	88.037	261.7909	88.03672	49.593	-128.619	256.622	137.8487	256.6216
92.565	211.561	159.782	230.9251	159.7822	-64.449	-219.394	107.735	228.6645	107.7345	34.537	-128.619	225.206	133.175	225.2058
12.480	211.561	135.310	211.9291	135.3105	13.933	-219.394	127.432	219.8361	127.4323	19.481	-128.619	193.790	130.0856	193.79
-67.605	211.561	110.839	222.1004	110.8388	92.315	-219.394	147.130	238.0247	147.1301	4.425	-128.619	162.374	128.6947	162.3742
-147.690	211.561	86.367	258.0124	86.36709	170.696	-219.394	166.828	277.9767	166.8279	-10.631	-128.619	130.958	129.0573	130.9584
-227.774	211.561	61.895	310.8688	61.8954	249.078	-219.394	186.526	331.9243	186.5258	-25.687	-128.619	99.543	131.1587	99.5426
-307.859	211.561	37.424	373.5445	37.4237	327.460	-219.394	206.224	394.1622	206.2236	-40.744	-128.619	68.127	134.9177	68.1268
-387.944	211.561	12.952	441.881	12.95201	405.842	-219.394	225.921	461.3474	225.9214	-55.800	-128.619	36.711	140.2012	36.711
-468.029	211.561	-11.520	513.6236	-11.5197	484.224	-219.394	245.619	531.6073	245.6192	-70.856	-128.619	5.295	146.8446	5.295193
492.989	-509.202	322.971	708.7485	322.9709	-456.358	486.042	99.822	666.7083	99.82206	109.818	-264.124	479.206	286.0448	479.2059
412.904	-509.202	298.499	655.5732	298.4992	-377.976	486.042	119.520	615.7137	119.5199	94.762	-264.124	447.790	280.609	447.7901
332.819	-509.202	274.028	608.3216	274.0275	-299.595	486.042	139.218	570.9589	139.2177	79.706	-264.124	416.374	275.8888	416.3743
252.734	-509.202	249.556	568.4727	249.5558	-221.213	486.042	158.915	534.0152	158.9155	64.650	-264.124	384.959	271.9212	384.9585
172.650	-509.202	225.084	537.675	225.0841	-142.831	486.042	178.613	506.5943	178.6133	49.593	-264.124	353.543	268.7398	353.5427
92.565	-509.202	200.612	517.5469	200.6124	-64.449	486.042	198.311	490.2967	198.3111	34.537	-264.124	322.127	266.3727	322.1269
12.480	-509.202	176.141	509.3548	176.1407	13.933	486.042	218.009	486.242	218.0089	19.481	-264.124	290.711	264.8417	290.7111
-67.605	-509.202	151.669	513.6701	151.669	92.315	486.042	237.707	494.7314	237.7067	4.425	-264.124	259.295	264.1613	259.2953
-147.690	-509.202	127.197	530.1875	127.1973	170.696	486.042	257.405	515.145	257.4045	-10.631	-264.124	227.880	264.3381	227.8795
-227.774	-509.202	102.726	557.8242	102.7256	249.078	486.042	277.102	546.1475	277.1023	-25.687	-264.124	196.464	265.3704	196.4637
-307.859	-509.202	78.254	595.0327	78.25394	327.460	486.042	296.800	586.0608	296.8001	-40.744	-264.124	165.048	267.2483	165.0479
-387.944	-509.202	53.782	640.1462	53.78225	405.842	486.042	316.498	633.202	316.4979	-55.800	-264.124	133.632	269.9541	133.6321
-468.029	-509.202	29.311	691.6196	29.31055	484.224	486.042	336.196	686.0829	336.1957	-70.856	-264.124	102.216	273.4633	102.2163
492.989	131.476	286.677	510.2195	286.6773	-456.358	-141.012	19.310	477.6477	19.30955	109.818	-143.675	393.054	180.8382	393.0538
492.989	51.392	291.214	495.6601	291.214	-456.358	-62.630	29.374	460.6359	29.37362	109.818	-158.731	403.823	193.0169	403.8229
492.989	-28.693	295.751	493.823	295.7507	-456.358	15.751	39.438	456.63	39.43768	109.818	-173.787	414.592	205.5772	414.5919
492.989	-108.778	300.287	504.847	300.2874	-456.358	94.133	49.502	465.9656	49.50174	109.818	-188.843	425.361	218.4532	425.3609
492.989	-188.863	304.824	527.9271	304.8241	-456.358	172.515	59.566	487.8773	59.5658	109.818	-203.900	436.130	231.5924	436.1299
492.989	-268.948	309.361	561.5787	309.3608	-456.358	250.897	69.630	520.7803	69.62987	109.818	-218.956	446.899	244.9523	446.8989
492.989	-349.032	313.898	604.0376	313.8975	-456.358	329.279	79.694	562.7498	79.69393	109.818	-234.012	457.668	258.4987	457.6679
492.989	-429.117	318.434	653.5896	318.4342	-456.358	407.660	89.758	611.9231	89.75799	109.818	-249.068	468.437	272.2038	468.4369
-468.029	131.476	-6.983	486.1452	-6.98299	484.224	-141.012	255.683	504.3382	255.6832	-70.856	-143.675	16.064	160.1968	16.06421
-468.029	51.392	-2.446	470.842	-2.4463	484.224	-62.630	265.747	488.2573	265.7473	-70.856	-158.731	26.833	173.8278	26.83322
-468.029	-28.693	2.090	468.9076	2.090393	484.224	15.751	275.811	484.4798	275.8114	-70.856	-173.787	37.602	187.6767	37.60223
-468.029	-108.778	6.627	480.5036	6.627087	484.224	94.133	285.875	493.2886	285.8754	-70.856	-188.843	48.371	201.6987	48.37124
-468.029	-188.863	11.164	504.6981	11.16378	484.224	172.515	295.939	514.037	295.9395	-70.856	-203.900	59.140	215.8601	59.14026
-468.029	-268.948	15.700	539.7998	15.70047	484.224	250.897	306.004	545.3639	306.0036	-70.856	-218.956	69.909	230.1351	69.90927
-468.029	-349.032	20.237	583.8447	20.23717	484.224	329.279	316.068	585.5741	316.0676	-70.856	-234.012	80.678	244.5038	80.67828
-468.029	-429.117	24.774	634.9744	24.77386	484.224	407.660	326.132	632.9768	326.1317	-70.856	-249.068	91.447	258.9507	91.44729
188.666	-76.744	205.480	203.6779	205.4803	-158.507	62.780	120.328	170.4874	120.3278	52.605	-182.821	301.673	190.2386	301.6732
204.683	-92.761	211.282	224.7218	211.282	-174.184	78.457	118.401	191.0378	118.401	55.616	-185.832	310.110	193.976	310.1102
204.683	-124.795	213.097	239.7271	213.0967	-174.184	109.810	122.427	205.908	122.4267	55.616	-191.855	314.418	199.7531	314.4178
188.666	-140.812	209.110	235.4209	209.1097	-158.507	125.486	128.379	202.1665	128.379	52.605	-194.866	310.288	201.8413	310.2884
-163.707	-76.744	97.805	180.8024	97.80485	186.373	62.780	206.998	196.6626	206.9981	-13.643	-182.821	163.444	183.3292	163.4437
-179.724	-92.761	93.818	202.2503	93.81785	202.049	78.457	212.951	216.7471	212.9505	-16.654	-185.832	159.314	186.5768	159.3143
-179.724	-124.795	95.633	218.802	95.63253	202.049	109.810	216.976	229.9608	216.9761	-16.654	-191.855	163.622	192.576	163.6219
-163.707	-140.812	101.434	215.9348	101.4342	186.373	125.486	215.049	224.6809	215.0494	-13.643	-194.866	172.059	195.3428	172.0589
156.633	-252.931	205.672	297.5023	205.6724	-127.155	235.220	150.348	267.3891	150.3478	46.582	-215.944	312.799	220.9115	312.7987
156.633	-292.973	207.941	332.2152	207.9407	-127.155	274.411	155.380	302.4399	155.3799	46.582	-223.473	318.183	228.2759	318.1832
140.616	-300.981	203.500	332.2086	203.5	-111.478	282.250	160.326	303.467	160.3258	43.571	-224.978	312.977	229.1585	312.977
92.565	-300.981	188.817	314.8937	188.817	-64.449	282.250	172.145	289.5143	172.1445	34.537	-224.978	294.127	227.6137	294.1275
52.522	-300.981	176.581	305.5297	176.5812	-25.258	282.250	181.993	283.3775	181.9934	27.009	-224.978	278.420	226.5936	278.4196
-131.673	-252.931	117.574	285.1518	117.5743	155.020	235.220	221.260	281.7088	221.2599	-7.620	-215.944	199.702	216.0789	199.7018
-131.673	-292.973	119.843	321.2022	119.8426	155.020	274.411	226.292	315.1711	226.292	-7.620	-223.473	205.086	223.6024	205.0863
-115.656	-300.981	125.191	322.4377	125.1906	139.344	282.250	223.359	314.7721	223.3588	-4.609	-224.978	212.446	225.0254	212.4464
-67.605	-300.981	139.874	308.4805	139.8736	92.315	282.250	211.540	296.9626	211.5401	4.425	-224.978	231.296	225.0217	231.2959
-27.562	-300.981	152.109	302.2408	152.1095	53.124	282.250	201.691	287.2054	201.6912	11.953	-224.978	247.004	225.2955	247.0038

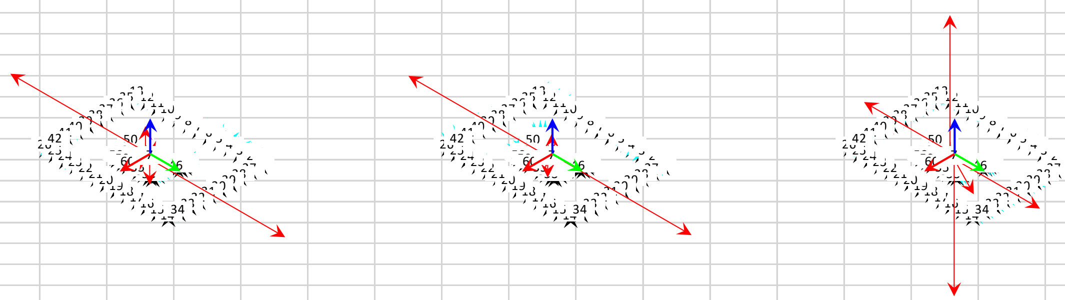


Figure 42, Fastener Loads, Load Case 7, 8, and 9

Load Case 10						Load Case 11						Load Case 12				
		Reaction						Reaction						Reaction		
x	y	z	shear	axial		x	y	z	shear	axial		x	y	z	shear	axial
-60.977	118.175	6.230	132.9795	6.23003		103.713	-127.313	333.720	164.2103	333.7205		-67.083	119.480	-42.334	137.0241	-42.3343
-48.192	118.175	31.281	127.6235	31.28065		88.941	-127.313	303.100	155.3032	303.1003		-54.013	119.480	-16.488	131.122	-16.4881
-35.406	118.175	56.331	123.3649	56.33127		74.168	-127.313	272.480	147.3417	272.4802		-40.944	119.480	9.358	126.301	9.358206
-22.621	118.175	81.382	120.3204	81.38189		59.396	-127.313	241.860	140.4867	241.86		-27.874	119.480	35.204	122.6887	35.20447
-9.835	118.175	106.433	118.5834	106.4325		44.624	-127.313	211.240	134.907	211.2399		-14.805	119.480	61.051	120.3941	61.05074
2.950	118.175	131.483	118.2117	131.4831		29.851	-127.313	180.620	130.766	180.6197		-1.736	119.480	86.897	119.4929	86.89701
15.736	118.175	156.534	119.2179	156.5337		15.079	-127.313	150.000	128.203	149.9995		11.334	119.480	112.743	120.0167	112.7433
28.521	118.175	181.584	121.5679	181.5844		0.307	-127.313	119.379	127.3135	119.3794		24.403	119.480	138.590	121.9469	138.5895
41.307	118.175	206.635	125.1861	206.635		-14.466	-127.313	88.759	128.1323	88.75923		37.472	119.480	164.436	125.2187	164.4358
54.092	118.175	231.686	129.9665	231.6856		-29.238	-127.313	58.139	130.6274	58.13908		50.542	119.480	190.282	129.7306	190.2821
66.878	118.175	256.736	135.7864	256.7362		-44.010	-127.313	27.519	134.7055	27.51892		63.611	119.480	216.128	135.3585	216.1283
79.664	118.175	281.787	142.5187	281.7868		-58.783	-127.313	-3.101	140.2286	-3.10123		76.681	119.480	241.975	141.9699	241.9746
92.449	118.175	306.837	150.0404	306.8375		-73.555	-127.313	-33.721	147.034	-33.7214		89.750	119.480	267.821	149.4343	267.8209
-60.977	233.245	84.518	241.0837	84.51799		103.713	-260.264	408.740	280.1676	408.7405		-67.083	237.105	14.052	246.4117	14.0525
-48.192	233.245	109.569	238.1713	109.5686		88.941	-260.264	378.120	275.0417	378.1203		-54.013	237.105	39.899	243.1791	39.89876
-35.406	233.245	134.619	235.9168	134.6192		74.168	-260.264	347.500	270.626	347.5001		-40.944	237.105	65.745	240.6139	65.74503
-22.621	233.245	159.670	234.3391	159.6698		59.396	-260.264	316.880	266.9558	316.88		-27.874	237.105	91.591	238.7375	91.5913
-9.835	233.245	184.720	233.452	184.7205		44.624	-260.264	286.260	264.062	286.2598		-14.805	237.105	117.438	237.5665	117.4376
2.950	233.245	209.771	233.2634	209.7711		29.851	-260.264	255.640	261.9706	255.6397		-1.736	237.105	143.284	237.111	143.2838
15.736	233.245	234.822	233.775	234.8217		15.079	-260.264	225.020	260.7007	225.0195		11.334	237.105	169.130	237.3754	169.1301
28.521	233.245	259.872	234.9821	259.8723		0.307	-260.264	194.399	260.2645	194.3994		24.403	237.105	194.976	238.3572	194.9764
41.307	233.245	284.923	236.8742	284.9229		-14.466	-260.264	163.779	260.666	163.7792		37.472	237.105	220.823	240.0475	220.8226
54.092	233.245	309.974	239.435	309.9736		-29.238	-260.264	133.159	261.9014	133.1591		50.542	237.105	246.669	242.4317	246.6689
66.878	233.245	335.024	242.6433	335.0242		-44.010	-260.264	102.539	263.9591	102.5389		63.611	237.105	272.515	245.4893	272.5152
79.664	233.245	360.075	246.4739	360.0748		-58.783	-260.264	71.919	266.82	71.91875		76.681	237.105	298.361	249.1958	298.3614
92.449	233.245	385.125	250.8983	385.1254		-73.555	-260.264	41.299	270.4586	41.29859		89.750	237.105	324.208	253.5226	324.2077
-60.977	130.960	14.929	144.4606	14.92869		103.713	-142.086	342.056	175.911	342.056		-67.083	132.550	-36.069	148.558	-36.0691
-60.977	143.746	23.627	156.1446	23.62735		103.713	-156.858	350.392	188.0446	350.3916		-67.083	145.619	-29.804	160.3277	-29.8039
-60.977	156.531	32.326	167.9892	32.32602		103.713	-171.630	358.727	200.5326	358.7271		-67.083	158.688	-23.539	172.2849	-23.5387
-60.977	169.317	41.025	179.9625	41.02468		103.713	-186.403	367.063	213.3127	367.0627		-67.083	171.758	-17.274	184.3931	-17.2735
-60.977	182.103	49.723	192.0406	49.72334		103.713	-201.175	375.398	226.3354	375.3982		-67.083	184.827	-11.008	196.6244	-11.0083
-60.977	194.888	58.422	204.2049	58.422		103.713	-215.947	383.734	239.5613	383.7338		-67.083	197.897	-4.743	208.9572	-4.74311
-60.977	207.674	67.121	216.4408	67.12066		103.713	-230.720	392.069	252.9583	392.0693		-67.083	210.966	1.522	221.3746	1.522091
-60.977	220.459	75.819	228.7368	75.81933		103.713	-245.492	400.405	266.5008	400.4049		-67.083	224.035	7.787	233.863	7.787294
92.449	130.960	315.536	160.3043	315.5361		-73.555	-142.086	-25.386	159.9958	-25.3858		89.750	132.550	274.086	160.0765	274.0861
92.449	143.746	324.235	170.9085	324.2348		-73.555	-156.858	-17.050	173.2476	-17.0503		89.750	145.619	280.351	171.0554	280.3513
92.449	156.531	332.933	181.7937	332.9334		-73.555	-171.630	-8.715	186.7278	-8.71473		89.750	158.688	286.616	182.3104	286.6165
92.449	169.317	341.632	192.9121	341.6321		-73.555	-186.403	-0.379	200.3903	-0.37917		89.750	171.758	292.882	193.7932	292.8817
92.449	182.103	350.331	204.2258	350.3308		-73.555	-201.175	7.956	214.2001	7.956378		89.750	184.827	299.147	205.4657	299.1469
92.449	194.888	359.029	215.704	359.0294		-73.555	-215.947	16.292	228.1306	16.29193		89.750	197.897	305.412	217.2973	305.4121
92.449	207.674	367.728	227.3218	367.7281		-73.555	-230.720	24.627	242.1609	24.62748		89.750	210.966	311.677	229.2633	311.6773
92.449	220.459	376.427	239.0588	376.4268		-73.555	-245.492	32.963	256.2746	32.96304		89.750	224.035	317.942	241.3439	317.9425
-12.392	164.203	132.738	164.6698	132.7376		47.578	-180.494	247.372	186.6591	247.3719		-17.419	166.530	78.436	167.4386	78.43622
-14.950	166.760	129.467	167.4287	129.4672		50.533	-183.448	255.163	190.2807	255.163		-20.033	169.144	74.520	170.3261	74.52
-14.950	171.874	132.947	172.5231	132.9466		50.533	-189.357	258.497	195.9837	258.4972		-20.033	174.372	77.026	175.5187	77.02608
-12.392	174.431	139.696	174.8709	139.6965		47.578	-192.311	254.040	198.1095	254.0403		-17.419	176.986	83.448	177.8407	83.44838
43.864	164.203	242.960	169.9606	242.9603		-17.420	-180.494	112.643	181.3323	112.6432		40.086	166.530	192.160	171.2868	192.1598
46.421	166.760	249.710	173.1005	249.7101		-20.375	-183.448	108.186	184.5761	108.1863		42.700	169.144	198.582	174.4505	198.5821
46.421	171.874	253.190	178.0327	253.1896		-20.375	-189.357	111.520	190.45	111.5205		42.700	174.372	201.088	179.5238	201.0882
43.864	174.431	249.919	179.8619	249.9192		-17.420	-192.311	119.312	193.0989	119.3116		40.086	176.986	197.172	181.4685	197.172
-7.278	192.331	161.895	192.4687	161.8949		41.669	-212.993	253.462	217.0305	253.462		-12.191	195.283	102.558	195.6629	102.5582
-7.278	198.724	166.244	198.857	166.2442		41.669	-220.379	257.630	224.2837	257.6298		-12.191	201.817	105.691	202.1853	105.6908
-4.721	200.002	172.124	200.058	172.1242		38.715	-221.856	252.339	225.2088	252.3393		-9.577	203.124	111.487	203.35	111.4865
2.950	200.002	187.155	200.0241	187.1546		29.851	-221.856	233.967	223.8555	233.9672		-1.736	203.124	126.994	203.1317	126.9943
9.343	200.002	199.680	200.2204	199.6799		22.465	-221.856	218.657	222.9907	218.6572		4.799	203.124	139.917	203.181	139.9174
38.750	192.331	252.077	196.1957	252.0771		-11.511	-212.993	143.229	213.3036	143.2295		34.859	195.283	195.605	198.3695	195.6047
38.750	198.724	256.426	202.4665	256.4264		-11.511	-220.379	147.397	220.6794	147.3972		34.859	201.817	198.737	204.8057	198.7373
36.193	200.002	252.286	203.2507	252.2862		-8.557	-221.856	154.355	222.0211	154.3548		32.245	203.124	194.195	205.6677	194.1946
28.521	200.002	237.256	202.0257	237.2558		0.307	-221.856	172.727	221.8564	172.7269		24.403	203.124	178.687	204.5849	178.6868
22.129	200.002	224.730	201.2228	224.7305		7.693	-221.856	188.037	221.9895	188.037		17.868	203.124	165.764	203.9087	165.7637

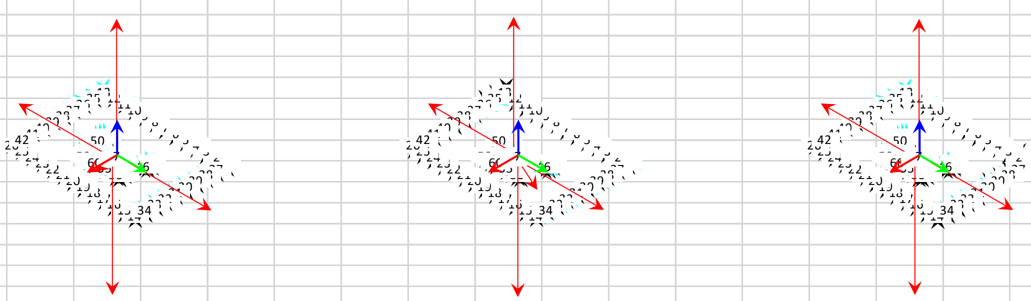


Figure 43, Fastener Loads, Load Case 10, 11, and 12