

**Report 10381
Addendum 1
8 February 1996**

**Earth Observing System (EOS)/
Advanced Microwave Sounding Unit-A (AMSU-A)
Stress Analysis Report, A1 Module**

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Submitted to:

**National Aeronautics and Space Administration
Goddard Space Flight Center
Greenbelt, Maryland 20771**

Submitted by:

**Aerojet
1100 West Hollyvale Street
Azusa, California 91702**

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Section 1

INTRODUCTION

This *Addendum 1* to the *Stress Analysis Report* for the Earth Observing System (EOS) Advanced Microwave Sounding Unit-A (AMSU-A), A1 module, reports the structural margins of safety and natural frequency predictions for the design following the EOS AMSU-A1 Mechanical/Structural Subsystem Critical Design Review (CDR). This report is an addendum to the June 1995 submittal of Aerojet Report 10381. The report has been prepared in accordance with Section 3.4.3 of GSFC 420-05-01, Performance Assurance Requirements for EOS General Instruments.

1.1 Identification

This is *Addendum 1* to the *Stress Analysis Report* for the Earth Observing System (EOS)/Advanced Microwave Sounding Unit -A (AMSU-A), module A1. This report is submitted to fulfill the requirements of Contract NAS 5-32314 CDRL 113, *Stress Analysis Report*, for the EOS AMSU-A1 module. The *Stress Analysis Report* for the A2 module has been submitted under separate cover.

1.2 Purpose and Objectives

The purpose of this analysis is to show that the AMSU-A1 module exhibits positive structural margins of safety when subjected to the design loads given in GSFC 422-11-12-01, General Interface Requirements Document (GIRD) for EOS Common Spacecraft/Instruments EOS PM Project.

In addition, the dynamic analysis results are used to show that the A1 module natural frequencies are above 100 Hz and that the simplified test and analytical model requirements of Section 3.4.3 of GSFC 420-05-01, Performance Assurance Requirements for EOS General Instruments, can be applied to the A1 module.

1.3 Document Status and Schedule

This is the submittal of *Addendum 1* to the *Stress Analysis Report* for the A1 module following the EOS AMSU-A1 Mechanical/Structural Subsystem CDR, held 7 December 1995. *Addendum 1* is meant to be used in conjunction with the June 1995 submittal of the *Stress Analysis Report* for the Earth Observing System (EOS) Advanced Microwave Sounding Unit-A (AMSU-A), A1 module, Report No. 10381.

Section 2

SUMMARY OF RESULTS AND CONCLUSIONS

The updated analysis of *Addendum 1* shows all positive margins of safety for the EOS/AMSU-A1 Unit. Since publication of the June 1995 submittal of the *Stress Analysis Report*, various modifications have been made to the design and analysis. *Addendum 1* analysis reflects these changes. A list of the modifications and added analysis follows:

- (1) The 1356760 Power Control/Monitor Assy was redesigned (new weight 1.62 lb) and modeled in the NASTRAN model, replacing CONM2 point masses (.37 lb).
- (2) The 1331642 Upper Aft Panel was modified to contain two .05 x .50 ribs to help support the Power Control/Monitor Assy. The upper horizontal rib supporting the DC/DC Converter was also notched in three places for assembly purposes.
- (3) The 1356784 Transistor Assembly was added as CONM2 point masses (total weight .50 lb) to the Upper Front Panel.
- (4) Natural frequencies were re-calculated per the above three changes, with the NASTRAN lumped mass option used in place of the coupled mass option. All modes remained above 100 Hz, with the 1st mode now at 109 Hz.
- (5) Mass properties of the EOS/AMSU-A1 Addendum 1 updated configuration show a 109 lb (49.4 kg) unit.
- (6) The random vibration analysis was re-done using a Q of 7.1 to match NOAA test data of the A1 unit. Factors of safety of 1.25 (yield) and 1.4 (ultimate) were used on "3 σ " loads. Minimum margin of safety is now +.31 (was +.07 in Ref 1) at the Upper Right Front Support. In addition, a fatigue evaluation was performed at the June 1995 report most severe location (cumulative usage factor .14 at Upper Right Front Support), with results now showing a cumulative usage factor of .003.
- (7) Analysis is included on panel flange bending stresses resulting from panel tensile loads and offset flange attachment screws. Random vibration loads are used. Stress results required the following design changes:
 - (a) 1331652 Lower Aft Panel - Material change to 2024-T851 aluminum.
MS = +.07 Lower flange to t = .125 - .135 (was .050 - .060)
MS = +.12 Upper flange to t = .070 - .080 (was .050 - .060)
MS = +.16 Right flange to t = .070 - .080 (was .050 - .060)
 - (b) 1331650 Lower Right Panel -
MS = +.06 Lower flange to t = .100 - .110 (was .040 - .060)
 - (c) 1331401 Lower Front Panel -
MS = +.13 Lower flange to t = .090 - .100 (was .040 - .060)
MS = +.14 Upper flange to t = .060 - .070 (was .040 - .060)
 - (d) 1331642 Upper Aft Panel - Material change to 2024-T851 aluminum.
MS = +.11 Lower flange to t = .095 - .105 (was .060 - .070)
 - (e) 1331651 Upper Right Panel - Material change to 6061-T6 aluminum.
MS = +.08 Lower flange to t = .060 - .070 (was .040 - .060)

- (f) 1331447 Lower Right Front Support -
MS = +.18 Lower flange to t = .045 - .055 (was .040 - .060)

- (8) Analysis is included on lower baseplate beam cross-sections at panel attachments. Random vibration loads are used. Stress results required the following design change:
 - (a) 1356405 Lower Baseplate - Membrane under lower aft panel attachment thickened from .075 +/- .010 to .200 +/- .010 MS = +.09.

- (9) To demonstrate the mathematical soundness of the NASTRAN model, the model is subjected to the GSFC 422-11-12-01 Paragraph 11.1.4.i Deliverable Model Validity Check, where a rigid-body or stiffness-equilibrium check is performed. The model is shown to satisfy this check (see Appendix A).

- (10) Analysis added pertaining to the fasteners is as follows:
 - (a) The mounting screws and shear pins of the EOS/AMSU-A1 unit to the spacecraft mounting surface are evaluated for tensile and shear loadings along with thread shear. Loading conditions are the three static design loads, 15g's, independently in the global X, Y, and Z directions. In addition, bearing and shear tearout of the shear pins onto the baseplate are evaluated for the loading assumption of all shear reacted at the shear pins (no shear at mounting bolts). At the mounting bolts, member compression under preload and bearing and shear tearout in the baseplate are also calculated. Minimum overall MS in the mounting fasteners is a +.52 margin in the highest loaded screw under combined tensile and shear load.

 - (b) The fasteners mounting the panels to the baseplates and other panels are analyzed for tensile and shear loading and for thread shear. Thread shear stress calculations also consider the inserts and/or nutplates. Loading conditions are the three random vibration load cases. In addition, the panels' offset flange bending stresses are evaluated per the same random vibration loadings. Minimum MS's are +.06's in the Lower Right Panel lower flange and the Upper Aft Panel side flange, with a MS of +.10 in the screws attaching the Lower Aft Panel to the Lower Baseplate. The following locations are considered:
 - (1) 1331390 Upper Right Front Support
 - (2) 1331652 Lower Aft Panel
 - (3) 1331650 Lower Right Panel
 - (4) 1331352 Upper Front Panel
 - (5) 1331414 Lower Motor Mount Panel
 - (6) 1331389 Upper Motor Mount Panel
 - (7) 1331401 Lower Front Panel
 - (8) 1331642 Upper Aft Panel
 - (9) 1331651 Upper Right Panel
 - (10) 1331447 Lower Right Front Support

 - (c) The attachment hardware mounting the significant mass items to the A1 assembly are analyzed for tensile loads per the loading conditions of random vibration. Superpositioning of finite element model loads, derived from random vibration analysis, with preload effects, and over-turning moment effects is performed on the mounted hardware listed below. Minimum MS is +.68 in the screws attaching the 1331165 Bracket to the 1356409 A1-2 Receiver Assembly.

- (1) 1356010 DC/DC Converter
 - (2) 1331610 Detector Preamp
 - (3) 1356429 Receiver Assembly A1-1 Components
 - (a) 1348360 PLO Assemblies
 - (b) 1336610 Oscillators
 - (c) 1331592 Bracket and Components
 - (d) 1331582 Bracket and Components
 - (e) 1331595 Bracket and Components
 - (4) 1356409 Receiver Assembly A1-2 Components
 - (a) 1331165 Bracket and Components
 - (b) 1331482 Bracket and Components
 - (c) 1331481 Bracket and Components
 - (d) 1336610 Oscillators
- (11) Fastener length changes, required because of panel and baseplate modifications, are reflected on the 1356404 Antenna Subassembly Machined - A1 drawing. Modifications are to (1) the 1331652 Lower Aft Panel attachment to the 1356405 Lower Baseplate, where -9 (if available) or -10 NAS1352N06 fasteners replace the -6 screws, and (2) the 1331642 Upper Aft Panel attachment to the 1331356 Upper Baseplate, where -10 NAS1352N06 fasteners replace -8 screws. All other fastener lengths remain unchanged.
- (12) The following describes added analysis pertaining to the 1336405 Lower Baseplate.
- Baseplate added analysis consists of:
- (1) determining the magnitude of the stresses in the thin shell elements under the lower card cage,
 - (2) hand-calculating the localized stresses in the U-beam cap under the lower front panel, the lower aft panel, and the lower right panel,
 - (3) checking the shear stresses in the grooved section at the base of the integral rib, and
 - (4) calculating shear stresses in the threads for the inserts and nutplates.

All baseplate analysis is performed using the loadings attributed to random vibration. Minimum margins of safety are (1) +4.2 under the lower card cage, (2) +.09 at the lower aft panel, (3) +17 at the grooved section, and (4) +.33 at the internal threads of a baseplate penetration containing an MS51830-103 insert for attachment of the lower right panel to the lower baseplate.

Section 3

REFERENCE DOCUMENTS

The following documents were used in the preparation of this Report:

	SPECIFICATIONS
422-11-12-01 Rev. A January 1994	General Interface Requirements Document (GIRD) for EOS Common Spacecraft/Instruments EOS PM Project
420-05-01 Rev. A 2 Aug. 1991	Earth Observing System (EOS) Performance Assurance Requirements for EOS General Instruments
422-12-12-04 March 1993	Contract Documentation Requirements List for the Advanced Microwave Sounding Unit-A (AMSU-A) EOS PM Project
	<i>Aerojet Reports</i>
Report 9350 21 Dec 1988	Structural Analysis of the AMSU A1 Instrument Final Report
Report 10381 Preliminary Sept 1994	Earth Observing System (EOS)/ Advanced Microwave Sounding Unit-A (AMSU-A) Stress Analysis Report, A1 Module
Report 10381 June 1995	Earth Observing System (EOS)/ Advanced Microwave Sounding Unit-A (AMSU-A) Stress Analysis Report, A1 Module

Section 4

METHOD OF ANALYSIS

4.1 Finite Element Model

The NASTRAN finite element model prepared for EOS AMSU-A1 in the June 1995 report (Report 10381) is modified to a new and more refined model. With the primary changes the modeling of the re-designed Power Control/Monitor and the inclusion of the Transistor Assy mass, the *Addendum 1* model more accurately represents the EOS design (see Figure 3). The *Addendum 1* model statistics are:

6146	Grids
1081	Bar/Beam Elements
5493	Rectangular Plate Elements
523	Triangular Plate Elements
7	Material Types

The total mass of the model is now 49.4 Kg (109.0 pounds). Appendix A presents a detailed description of the NASTRAN finite element model, including the rigid-body validity check.

4.2 Boundary Conditions

The model was constrained along the three orthogonal axes at each of the 20 mounting bolt locations and along the two transverse axes (X and Y in Figure 1) at the 2 dowel pin locations. The constraints were imposed using NASTRAN single point constraint cards.

4.3 Load Application

For the static loads evaluations, the 15g load was uniformly applied over the entire model. Three load cases were run. Each load case represented the 15g load being applied in one of the axes shown in Figure 1.

Similarly for the random vibration loadings, the qualification level 9.97 Grms spectrum was applied along the three orthogonal axes. Three load cases were run. Each load case represented the random spectrum being applied in one of the axes shown in Figure 1. The Addendum 1 analysis is run with an amplification, Q, of 7.1, corresponding to the highest Q found in NOAA random vibration test results.

Section 5

RESULTS

The previous submittal of the AMSU-A1 EOS Stress Analysis Report (Report 10381) was presented in June 1995, prior to the July 26, 1995 initial Critical Design Review (CDR) on the EOS/AMSU-A1 Mechanical/Structural/Thermal Subsystem. With subsequent comments to the July 1995 presentation addressed, the EOS/AMSU-A1 Mechanical/Structural/Thermal Subsystem final CDR was presented on 7 December 1995. Addendum 1 is written to house the additional analysis performed due to the added scope to the analysis resulting from the action items of the July 1995 and December 1995 CDR's.

5.1 Natural Frequencies

The June 1995 submittal concluded that the minimum natural frequency of the EOS AMSU-A1 unit was 117.6 Hz, with the mode shape involving the flexing of the lower card cage circuit cards. Modes 1 through 4, with mode 4 at 118.6 Hz, all involved lower card cage circuit card and/or cage wall distortion. Mode 5, at 120.6 Hz identified the deformation of the upper aft and top panels.

Pursuant to the June 1995 report release, additional information on the 1356760 Power Control/Monitor (PC/M) Assembly, which mounts on the upper aft panel, became available. This data, a weight increase plus a new detailed design layout, allowed the modeling of the PC/M Assembly into the NASTRAN model (in place of CONM2 point masses). With this addition/modification, along with the addition of the 1356784 Transistor Assy via CONM2 point masses on the Upper Front Panel, the natural frequencies were re-evaluated, with results listed below. In addition, the NASTRAN analysis method option was changed from a coupled mass solution to a more conservative lumped mass solution. The new natural frequencies, per the NASTRAN model post rigid-body equilibrium check, are still above 100 Hz (eliminating the requirement of a detailed deliverable model), with the 1st mode at 108.9 Hz, mode shape lower card cage circuit cards flexing. The 1st mode involving the Upper Aft Panel/Power Control/Monitor is mode 5 at 116.3 Hz.

Mode No.	Natural Frequency Old PC/M (CONM2) No Trans Assy	Natural Frequency New PC/M Modeled W/Trans Assy
1	117.7 Hz	109.0 Hz
2	117.7	109.0
3	118.4	109.6
4	118.7	109.7
5	120.6	116.3
6	126.3	121.4
7	127.1	122.2
8	127.2	122.3
9	148.5	146.6
10	150.0	147.2

Figures 4 through 11 depict the new natural frequencies and modeshapes for the 1st 8 modes.

5.2 Random Vibration with Q = 7.1

Subsequent to the July 1995 presentation, the need was identified to re-evaluate random vibration analysis. The random vibration analysis of the June 1995 report was performed using the NASTRAN code with a type "G" structural damping value of 0.04. The critical damping percentage is 1/2 of this value, or 2%. For large Q, (Q>10), the amplification or quality factor, Q, is approximated by:

$$Q = 1/[2(c/c_c)] \quad c/c_c = \text{fraction of critical damping}$$

With c/c_c equal to 0.02, an amplification, Q , of 25 was used in the NASTRAN model. A Q of 25 was felt to be a conservative value and precluded the use of additional factors of safety in the random vibration analysis. Stresses derived from the NASTRAN solution were multiplied by an additional 3.0 factor to produce "3 σ " values.

The random vibration analysis of *Addendum 1* is re-done using a $Q = 7.14$ (NASTRAN type "G" structural damping value of 0.14), corresponding to the largest Q found in test data of the NOAA A1 unit. To the stresses derived from the NASTRAN random vibration stress output, a 3.0 factor is applied to produce "3 σ " values, plus an additional factor of safety (FS) of 1.25 on yield or 1.4 on ultimate is also employed.

Random vibration analysis in *Addendum 1* is presented similarly to the June 1995 submittal. Per structural component, margins of safety (MS) summary tables are given for each direction of vibration, along with the overall minimum MS table. A fatigue evaluation is performed again at the June 1995 report critical location.

Minimum MS attributed to random vibration "3 σ " loads, per the methods outlined above, is a +.31 at the 1331390 Upper Right Front Support. The fatigue evaluation at the Reference 1 critical location, the Upper Right Front Support, now identifies a cumulative usage factor of only .003, or <1 % of the allowed cycles are utilized.

Addendum 1 Tables 6 through 8 list the NASTRAN model random vibration results.

5.3 Panel Flange Bending Stresses

Addendum 1 analysis is concerned with panel flange bending stresses resulting from panel tensile loads and offset flange attachment screws. Random vibration loads, multiplied by an additional 3.0 factor to produce "3 σ " values, and then used with FS's of 1.25 yield and 1.4 ultimate, are more severe than the static 15g static design loads with FS's, and are thus used in the analysis.

The method employed for evaluation of a flange is to first determine the highest loaded plate finite element adjacent to the flange of interest. The (tensile) force in the panel perpendicular to the flange is the primary load reacted at the bolt in the form of a reacted force and a bending moment. This force is reacted in the flange attachment bolt and the bending moment produces bending in the flange. Both flange attachment bolts and the flanges themselves are evaluated per hand calculation methods. This data is summarized by itself in *Addendum 1*, Table 54, and is utilized in the overall random vibration minimum MS summary (Table 5). Note that no static design load flange bending stress calculations are performed, thus the overall static design load minimum MS summary (Table 1) contains no flange bending hand calculation results. Minimum margin of safety is at the 1331650 Lower Right Panel with MS = +.06.

5.4 Summary Tables

Margins of safety results, presented in *Addendum 1*, are the following tables. Tables 1 through 8 and 34 are modified June 1995 report Tables. Table 1 is the overall static loading (15g's in either X, Y, or Z directions) summary table. Tables 2, 3, and 4 present NASTRAN shell and beam results for static loads in the X, Y, and Z directions, respectively.

Table 5 is the overall random vibration ($Q = 7.1$) summary table. Tables 6, 7, and 8 present NASTRAN shell and beam results for random vibration loads in the X, Y, and Z directions, respectively.

Table 34 is a fatigue summary for the June 1995 report critical location at the Upper Right Front Support at element 2633.

Tables 54 through 59 are new Tables of *Addendum 1*. Panel flange bending stresses per random vibration loads are summarized in Table 54, with the results of the attachment screws of the panel flanges in Table 55.

Lower baseplate mounting bolts and associated fastener hardware stresses per static design loads (15g's in either X, Y, or Z directions) are summarized In Table 56.

Thread shear results in the attachment hardware connecting the panels to baseplates and other panels per random vibration loads are found in Table 57.

Large mass item attachment screw stresses per random vibration loads are found in Table 58.

Lower baseplate stresses per random vibration loads are shown in Table 59.

The Earth Observing System (EOS)/Advanced Microwave Sounding Unit-A (AMSU-A), A1 unit is shown in *Addendum 1* to exhibit all positive margins of safety and is therefore suitable for flight.

Hand written analyses on the above subjects follow the summary tables.

TABLE 1
AMSU-A1 MARGINS OF SAFETY
SUMMARY OF STATIC MINIMUM MARGINS

ITEM NO.*	DESCRIPTION	PART NUMBER	MATERIAL/ ALLOY	YIELD (PSI)	ULTIMATE (PSI)	MAXIMUM STRESS (PSI)	MARGINS OF SAFETY	
							YIELD	ULTIMATE
1	BASEPLATE ASSEMBLY, LOWER	1356405-1	ALUM/6061-T651	35000	42000	4925	4.69	5.09
2	PANEL, MOTOR MOUNT LOWER	1331414-1	ALUM/7075-T651	66000	75000	3055	16.28	16.54
3	PANEL, MOTOR MOUNT UPPER	1331389-1	ALUM/7075-T651	66000	75000	1944	26.16	26.56
4	PANEL, FRONT, LOWER	1331401-1	ALUM/6061-T651	35000	42000	4198	5.67	6.15
5	PANEL, AFT, LOWER	1331652-1	ALUM/2024-T851	58000	66000	5346	7.68	7.82
6	BASEPLATE, UPPER	1331356-1	ALUM/6061-T651	35000	42000	5136	4.45	4.84
7	PANEL, FRONT UPPER	1331352-1	ALUM/7075-T651	66000	75000	4706	10.22	10.38
8	PANEL, AFT WALL,UPPER	1331642-3	ALUM/2024-T851	58000	66000	3104	13.95	14.19
9	SHELF, RF, LOWER	1331556-1	BE/SR-200E	50000	70000	3018	12.25	15.57
10	SHELF, RF, UPPER	1331491-1	BE/SR-200E	50000	70000	2182	17.33	21.91
11	SUPPORT PANEL, LOWER RIGHT FRONT	1331447-1	ALUM/6061-T651	35000	42000	3451	7.11	7.69
12	PANEL, SIDEWALL, RIGHT LOWER	1331650-4	ALUM/6061-T6	35000	42000	10092	1.77	1.97
13	PANEL, SUPPORT, RIGHT FRONT UPPER	1331390-1	ALUM/6061-T651	35000	42000	6313	3.44	3.75
14	PANEL, SIDEWALL, RIGHT-UPPER	1331651-1	ALUM/6061-T6	35000	42000	830	32.73	35.14
15	PANEL, TOP	1356866-1	ALUM/6061-T6	35000	42000	627	43.66	46.85
16	PANEL, SIDEWALL, LEFT	1356826-1	ALUM/6061-T6	35000	42000	1363	19.54	21.01
17	MOTOR ROTOR SHAFT	1333645-1	303 CRES A COND	26000	73000	600	33.67	85.90
18	SHIELD, WARMLOAD, LOWER LEFT	1331445-1	ALUM/6061-T6	35000	42000	3085	8.08	8.72
19	SHIELD, WARMLOAD, LOWER RIGHT	1331405-1	ALUM/6061-T6	35000	42000	2633	9.63	10.39
20	SHIELD, WARMLOAD, UPPER LEFT	1331647-1	ALUM/6061-T6	35000	42000	2735	9.24	9.97
21	SHIELD, WARMLOAD, UPPER RIGHT	1331646-1	ALUM/6061-T6	35000	42000	2832	8.89	9.59
22	CARD CAGE ASSY (LOWER)	1331600-1	ALUM/6061-T6	35000	42000	1896	13.77	14.82
23	CARD CAGE ASSY, UPPER	1331162-8	ALUM/6061-T6	35000	42000	3665	6.64	7.19
23	CARD CAGE ASSY, UPPER	1331162-8	ALUM/6061-T4	16000	30000	2057	5.22	9.42
24	CALIBRATION SOURCE ASSY, WL (LOW)	1331380-1	ALUM/6061-T6	35000	42000	896	30.25	32.48
25	CALIBRATION SOURCE ASSY, WL (UP)	1331380-2	ALUM/7075-T6	66000	75000	942	55.05	55.87
26	BEAM SUPPORT	1331406-1	ALUM/7075-T6	66000	75000	4606	10.46	10.63

*SEE FIGURES 1 & 2

TABLE 2
AMSU-A1 MARGINS OF SAFETY
15 g's IN X - DIRECTION

ITEM NO.*	DESCRIPTION	PART NUMBER	MATERIAL/ ALLOY	YIELD (psi)	ULTIMATE (psi)	MAXIMUM STRESS (psi)	MARGINS OF SAFETY	
							YIELD	ULTIMATE
1	BASEPLATE ASSEMBLY, LOWER	1356405-1	ALUM/6061-T651	35000	42000	1728	15.20	16.36
2	PANEL, MOTOR MOUNT LOWER	1331414-1	ALUM/7075-T651	66000	75000	3055	16.28	16.54
3	PANEL, MOTOR MOUNT UPPER	1331389-1	ALUM/7075-T651	66000	75000	1944	26.16	26.56
4	PANEL, FRONT, LOWER	1331401-1	ALUM/6061-T651	35000	42000	2004	12.97	13.97
5	PANEL, AFT, LOWER	1331652-1	ALUM/2024-T851	58000	66000	3284	13.13	13.36
6	BASEPLATE, UPPER	1331356-1	ALUM/6061-T651	35000	42000	3019	8.27	8.94
7	PANEL, FRONT UPPER	1331352-1	ALUM/7075-T651	66000	75000	4072	11.97	12.16
8	PANEL, AFT WALL, UPPER	1331642-3	ALUM/2024-T851	58000	66000	3104	13.95	14.19
9	SHELF, RF, LOWER	1331556-1	BE/SR-200E	50000	70000	3018	12.25	15.57
10	SHELF, RF, UPPER	1331491-1	BE/SR-200E	50000	70000	372	106.53	133.41
11	SUPPORT PANEL, LOWER RIGHT FRONT	1331447-1	ALUM/6061-T651	35000	42000	1436	18.50	19.89
12	PANEL, SIDEWALL, RIGHT LOWER	1331650-4	ALUM/6061-T6	35000	42000	2526	10.08	10.88
13	PANEL, SUPPORT, RIGHT FRONT UPPER	1331390-1	ALUM/6061-T651	35000	42000	3805	6.36	6.88
14	PANEL, SIDEWALL, RIGHT-UPPER	1331651-1	ALUM/6061-T6	35000	42000	830	32.73	35.14
15	PANEL, TOP	1356866-1	ALUM/6061-T6	35000	42000	434	63.52	68.12
16	PANEL, SIDEWALL, LEFT	1356626-1	ALUM/6061-T6	35000	42000	1363	19.54	21.01
17	MOTOR ROTOR SHAFT	1333645-1	303 CRES A COND	26000	73000	82	252.66	634.89
18	SHIELD, WARMLOAD, LOWER LEFT	1331445-1	ALUM/6061-T6	35000	42000	3085	8.08	8.72
19	SHIELD, WARMLOAD, LOWER RIGHT	1331405-1	ALUM/6061-T6	35000	42000	2633	9.63	10.39
20	SHIELD, WARMLOAD, UPPER LEFT	1331647-1	ALUM/6061-T6	35000	42000	2735	9.24	9.97
21	SHIELD, WARMLOAD, UPPER RIGHT	1331646-1	ALUM/6061-T6	35000	42000	2832	8.89	9.59
22	CARD CAGE ASSY (LOWER)	1331600-1	ALUM/6061-T6	35000	42000	456	60.40	64.79
23	CARD CAGE ASSY, UPPER	1331162-8	ALUM/6061-T6	35000	42000	769	35.41	38.01
23	CARD CAGE ASSY, UPPER	1331162-8	ALUM/6061-T4	16000	30000	370	33.59	56.92
24	CALIBRATION SOURCE ASSY, WL (LOW)	1331380-1	ALUM/6061-T6	35000	42000	322	85.96	92.17
25	CALIBRATION SOURCE ASSY, WL (UP)	1331380-2	ALUM/7075-T6	66000	75000	394	133.01	134.97
26	BEAM SUPPORT	1331406-1	ALUM/7075-T6	66000	75000	4606	10.46	10.63

*SEE FIGURES 1 & 2

TABLE 3
AMSU-A1 MARGINS OF SAFETY
15 g's IN Y - DIRECTION

ITEM NO.*	DESCRIPTION	PART NUMBER	MATERIAL/ ALLOY	YIELD (psi)	ULTIMATE (psi)	MAXIMUM STRESS (psi)	MARGINS OF SAFETY	
							YIELD	ULTIMATE
1	BASEPLATE ASSEMBLY, LOWER	1356405-1	ALUM/6061-T651	35000	42000	4925	4.69	5.09
2	PANEL, MOTOR MOUNT LOWER	1331414-1	ALUM/7075-T651	66000	75000	1066	48.53	49.25
3	PANEL, MOTOR MOUNT UPPER	1331389-1	ALUM/7075-T651	66000	75000	1017	50.92	51.68
4	PANEL, FRONT, LOWER	1331401-1	ALUM/6061-T651	35000	42000	4198	5.67	6.15
5	PANEL, AFT, LOWER	1331652-1	ALUM/2024-T851	58000	66000	5346	7.68	7.82
6	BASEPLATE, UPPER	1331356-1	ALUM/6061-T651	35000	42000	5136	4.45	4.84
7	PANEL, FRONT UPPER	1331352-1	ALUM/7075-T651	66000	75000	4706	10.22	10.38
8	PANEL, AFT WALL, UPPER	1331642-3	ALUM/2024-T851	58000	66000	1171	38.62	39.26
9	SHELF, RF, LOWER	1331556-1	BE/SR-200E	50000	70000	1612	23.81	30.02
10	SHELF, RF, UPPER	1331491-1	BE/SR-200E	50000	70000	623	63.21	79.26
11	SUPPORT PANEL, LOWER RIGHT FRONT	1331447-1	ALUM/6061-T651	35000	42000	3451	7.11	7.69
12	PANEL, SIDEWALL, RIGHT LOWER	1331650-4	ALUM/6061-T6	35000	42000	10092	1.77	1.97
13	PANEL, SUPPORT, RIGHT FRONT UPPER	1331390-1	ALUM/6061-T651	35000	42000	6313	3.44	3.75
14	PANEL, SIDEWALL, RIGHT-UPPER	1331651-1	ALUM/6061-T6	35000	42000	703	38.83	41.67
15	PANEL, TOP	1356866-1	ALUM/6061-T6	35000	42000	278	99.72	106.91
16	PANEL, SIDEWALL, LEFT	1356626-1	ALUM/6061-T6	35000	42000	810	33.57	36.04
17	MOTOR ROTOR SHAFT	1333645-1	303 CRES A COND	26000	73000	600	33.67	85.90
18	SHIELD, WARMLOAD, LOWER LEFT	1331445-1	ALUM/6061-T6	35000	42000	2377	10.78	11.62
19	SHIELD, WARMLOAD, LOWER RIGHT	1331405-1	ALUM/6061-T6	35000	42000	847	32.06	34.42
20	SHIELD, WARMLOAD, UPPER LEFT	1331647-1	ALUM/6061-T6	35000	42000	365	75.71	81.19
21	SHIELD, WARMLOAD, UPPER RIGHT	1331646-1	ALUM/6061-T6	35000	42000	601	45.59	48.92
22	CARD CAGE ASSY (LOWER)	1331600-1	ALUM/6061-T6	35000	42000	1896	13.77	14.82
23	CARD CAGE ASSY, UPPER	1331162-8	ALUM/6061-T6	35000	42000	1179	22.75	24.45
24	CALIBRATION SOURCE ASSY, WL (LOW)	1331380-1	ALUM/6061-T6	35000	42000	746	36.53	39.21
25	CALIBRATION SOURCE ASSY, WL (UP)	1331380-2	ALUM/7075-T6	66000	75000	501	104.39	105.93
26	BEAM SUPPORT	1331406-1	ALUM/7075-T6	66000	75000	1044	49.57	50.31

*SEE FIGURES 1 & 2

TABLE 4
AMSU-A1 MARGINS OF SAFETY
15 g's IN Z - DIRECTION

ITEM NO.*	DESCRIPTION	PART NUMBER	MATERIAL/ ALLOY	YIELD (psi)	ULTIMATE (psi)	MAXIMUM STRESS (psi)	MARGINS OF SAFETY	
							YIELD	ULTIMATE
1	BASEPLATE ASSEMBLY, LOWER	1356405-1	ALUM/6061-T651	35000	42000	4310	5.50	5.96
2	PANEL, MOTOR MOUNT LOWER	1331414-1	ALUM/7075-T651	66000	75000	548	95.35	96.76
3	PANEL, MOTOR MOUNT UPPER	1331389-1	ALUM/7075-T651	66000	75000	942	55.05	55.87
4	PANEL, FRONT, LOWER	1331401-1	ALUM/6061-T651	35000	42000	2434	10.50	11.33
5	PANEL, AFT, LOWER	1331652-1	ALUM/2024-T851	58000	66000	3650	11.71	11.92
6	BASEPLATE, UPPER	1331356-1	ALUM/6061-T651	35000	42000	3940	6.11	6.61
7	PANEL, FRONT UPPER	1331352-1	ALUM/7075-T651	66000	75000	2240	22.57	22.92
8	PANEL, AFT WALL, UPPER	1331642-3	ALUM/2024-T851	58000	66000	1406	32.00	32.53
9	SHELF, RF, LOWER	1331556-1	BE/SR-200E	50000	70000	2843	13.07	16.59
10	SHELF, RF, UPPER	1331491-1	BE/SR-200E	50000	70000	2182	17.33	21.91
11	SUPPORT PANEL, LOWER RIGHT FRONT	1331447-1	ALUM/6061-T651	35000	42000	1258	21.26	22.85
12	PANEL, SIDEWALL, RIGHT LOWER	1331650-4	ALUM/6061-T6	35000	42000	5422	4.16	4.53
13	PANEL, SUPPORT, RIGHT FRONT UPPER	1331390-1	ALUM/6061-T651	35000	42000	5075	4.52	4.91
14	PANEL, SIDEWALL, RIGHT-UPPER	1331651-1	ALUM/6061-T6	35000	42000	445	61.92	66.42
15	PANEL, TOP	1356866-1	ALUM/6061-T6	35000	42000	627	43.66	46.85
16	PANEL, SIDEWALL, LEFT	1356626-1	ALUM/6061-T6	35000	42000	816	33.31	35.76
17	MOTOR ROTOR SHAFT	1333645-1	303 CRES A COND	26000	73000	600	33.67	85.90
18	SHIELD, WARMLoad, LOWER LEFT	1331445-1	ALUM/6061-T6	35000	42000	1939	13.44	14.47
19	SHIELD, WARMLoad, LOWER RIGHT	1331405-1	ALUM/6061-T6	35000	42000	744	36.63	39.32
20	SHIELD, WARMLoad, UPPER LEFT	1331647-1	ALUM/6061-T6	35000	42000	2093	12.38	13.33
21	SHIELD, WARMLoad, UPPER RIGHT	1331646-1	ALUM/6061-T6	35000	42000	602	45.51	48.83
22	CARD CAGE ASSY (LOWER)	1331600-1	ALUM/6061-T6	35000	42000	1588	16.63	17.89
23	CARD CAGE ASSY, UPPER	1331162-8	ALUM/6061-T6	35000	42000	3665	6.64	7.19
23	CARD CAGE ASSY, UPPER	1331162-8	ALUM/6061-T4	16000	30000	2057	5.22	9.42
24	CALIBRATION SOURCE ASSY, WL (LOW)	1331380-1	ALUM/6061-T6	35000	42000	896	30.25	32.48
25	CALIBRATION SOURCE ASSY, WL (UP)	1331380-2	ALUM/7075-T6	66000	75000	942	55.05	55.87
26	BEAM SUPPORT	1331406-1	ALUM/7075-T6	66000	75000	2671	18.77	19.06

*SEE FIGURE 1

TABLE 5

AMSU-A1 MARGINS OF SAFETY

SUMMARY OF RANDOM VIBRATION MINIMUM MARGINS

ITEM NO.*	DESCRIPTION	PART NUMBER	MATERIAL/ ALLOY	YIELD (PSI)	ULTIMATE (PSI)	3 SIGMA STRESS (PSI)	MARGINS OF SAFETY	
							YIELD	ULTIMATE
1	BASEPLATE ASSEMBLY, LOWER	1356405-1	ALUM/6061-T651	35000	42000	25654	0.09	0.17
2	PANEL, MOTOR MOUNT LOWER	1331414-1	ALUM/7075-T651	66000	75000	39937	0.32	0.34
3	PANEL, MOTOR MOUNT UPPER	1331389-1	ALUM/7075-T651	66000	75000	43788	0.21	0.22
4	PANEL, FRONT, LOWER	1331401-1	ALUM/6061-T651	35000	42000	24692	0.13	0.21
5	PANEL, AFT, LOWER	1331652-1	ALUM/2024-T851	58000	66000	43374	0.07	0.09
6	BASEPLATE, UPPER	1331356-1	ALUM/6061-T651	35000	42000	17148	0.63	0.75
7	PANEL, FRONT UPPER	1331352-1	ALUM/7075-T651	66000	75000	43260	0.22	0.24
8	PANEL, AFT WALL, UPPER	1331642-3	ALUM/2024-T851	58000	66000	43774	0.06	0.08
9	SHELF, RF, LOWER	1331556-1	BE/SR-200E	50000	70000	6841	4.85	6.31
10	SHELF, RF, UPPER	1331491-1	BE/SR-200E	50000	70000	7067	4.66	6.08
11	SUPPORT PANEL, LOWER RIGHT FRONT	1331447-1	ALUM/6061-T651	35000	42000	23766	0.18	0.26
12	PANEL, SIDEWALL, RIGHT LOWER	1331650-4	ALUM/6061-T6	35000	42000	26502	0.06	0.13
13	PANEL, SUPPORT, RIGHT FRONT UPPER	1331390-1	ALUM/6061-T651	35000	42000	21390	0.31	0.40
14	PANEL, SIDEWALL, RIGHT-UPPER	1331651-1	ALUM/6061-T6	35000	42000	25894	0.08	0.16
15	PANEL, TOP	1356866-1	ALUM/6061-T6	35000	42000	2215	11.64	12.54
16	PANEL, SIDEWALL, LEFT	1356626-1	ALUM/6061-T6	35000	42000	3432	7.16	7.74
18	SHIELD, WARMLOAD, LOWER LEFT	1331445-1	ALUM/6061-T6	35000	42000	5487	4.10	4.47
19	SHIELD, WARMLOAD, LOWER RIGHT	1331405-1	ALUM/6061-T6	35000	42000	6192	3.52	3.84
20	SHIELD, WARMLOAD, UPPER LEFT	1331647-1	ALUM/6061-T6	35000	42000	7674	2.65	2.91
21	SHIELD, WARMLOAD, UPPER RIGHT	1331646-1	ALUM/6061-T6	35000	42000	8841	2.17	2.39
22	CARD CAGE ASSY (LOWER)	1331600-1	ALUM/6061-T6	35000	42000	6810	3.11	3.41
23	CARD CAGE ASSY, UPPER	1331162-8	ALUM/6061-T6	35000	42000	11730	1.39	1.56
23	CARD CAGE ASSY, UPPER	1331162-8	ALUM/6061-T4	16000	30000	3076	3.16	5.97
24	CALIBRATION SOURCE ASSY, WL (LOW)	1331380-1	ALUM/6061-T6	35000	42000	4729	4.92	5.34
25	CALIBRATION SOURCE ASSY, WL (UP)	1331380-2	ALUM/6061-T6	35000	42000	3537	6.92	7.48
26	BEAM SUPPORT	1331406-1	ALUM/6061-T6	35000	42000	9174	2.05	2.27
27	REFLECTOR ASSY (LOWER)	1355777-1	ALUM/7075-T6	66000	75000	9393	4.62	4.70
28	REFLECTOR ASSY (UPPER)	1355777-1	ALUM/7075-T6	66000	75000	14595	2.62	2.67

*SEE FIGURES 1 & 2

TABLE 6
AMSU-A1 MARGINS OF SAFETY
RANDOM VIBRATION IN X - DIRECTION

ITEM NO.*	DESCRIPTION	PART NUMBER	MATERIAL/ ALLOY	YIELD (psi)	ULTIMATE (psi)	3 SIGMA STRESS (psi)	MARGINS OF SAFETY	
							YIELD	ULTIMATE
1	BASEPLATE ASSEMBLY, LOWER	1356405-1	ALUM/6061-T651	35000	42000	3474	7.06	7.64
2	PANEL, MOTOR MOUNT LOWER	1331414-1	ALUM/7075-T651	66000	75000	9108	4.80	4.88
3	PANEL, MOTOR MOUNT UPPER	1331389-1	ALUM/7075-T651	66000	75000	7155	6.38	6.49
4	PANEL, FRONT, LOWER	1331401-1	ALUM/6061-T651	35000	42000	8328	2.36	2.60
5	PANEL, AFT, LOWER	1331652-1	ALUM/2024-T851	58000	66000	6324	6.34	6.45
6	BASEPLATE, UPPER	1331356-1	ALUM/6061-T651	35000	42000	8112	2.45	2.70
7	PANEL, FRONT UPPER	1331352-1	ALUM/7075-T651	66000	75000	21998	1.40	1.44
8	PANEL, AFT WALL, UPPER	1331642-3	ALUM/2024-T851	58000	66000	5937	6.82	6.94
9	SHELF, RF, LOWER	1331556-1	BE/SR-200E	50000	70000	5630	6.10	7.88
10	SHELF, RF, UPPER	1331491-1	BE/SR-200E	50000	70000	1859	20.52	25.90
11	SUPPORT PANEL, LOWER RIGHT FRONT	1331447-1	ALUM/6061-T651	35000	42000	1254	21.33	22.92
12	PANEL, SIDEWALL, RIGHT LOWER	1331650-4	ALUM/6061-T6	35000	42000	6096	3.59	3.92
13	PANEL, SUPPORT, RIGHT FRONT UPPER	1331390-1	ALUM/6061-T651	35000	42000	10314	1.71	1.91
14	PANEL, SIDEWALL, RIGHT-UPPER	1331651-1	ALUM/6061-T6	35000	42000	3530	6.93	7.50
15	PANEL, TOP	1356866-1	ALUM/6061-T6	35000	42000	1034	26.08	28.01
16	PANEL, SIDEWALL, LEFT	1356626-1	ALUM/6061-T6	35000	42000	3432	7.16	7.74
18	SHIELD, WARMLOAD, LOWER LEFT	1331445-1	ALUM/6061-T6	35000	42000	5487	4.10	4.47
19	SHIELD, WARMLOAD, LOWER RIGHT	1331405-1	ALUM/6061-T6	35000	42000	6192	3.52	3.84
20	SHIELD, WARMLOAD, UPPER LEFT	1331647-1	ALUM/6061-T6	35000	42000	7674	2.65	2.91
21	SHIELD, WARMLOAD, UPPER RIGHT	1331646-1	ALUM/6061-T6	35000	42000	8841	2.17	2.39
22	CARD CAGE ASSY (LOWER)	1331600-1	ALUM/6061-T6	35000	42000	1913	13.64	14.68
23	CARD CAGE ASSY, UPPER	1331162-8	ALUM/6061-T6	35000	42000	4113	5.81	6.29
23	CARD CAGE ASSY, UPPER	1331162-8	ALUM/6061-T4	16000	30000	3076	3.16	5.97
24	CALIBRATION SOURCE ASSY, WL (LOW)	1331380-1	ALUM/6061-T6	35000	42000	1745	15.05	16.19
25	CALIBRATION SOURCE ASSY, WL (UP)	1331380-2	ALUM/6061-T6	35000	42000	3537	6.92	7.48
26	BEAM SUPPORT	1331406-1	ALUM/6061-T6	35000	42000	9174	2.05	2.27
27	REFLECTOR ASSY (LOWER)	1355777-1	ALUM/7075-T6	66000	75000	9393	4.62	4.70
28	REFLECTOR ASSY (UPPER)	1355777-1	ALUM/7075-T6	66000	75000	14595	2.62	2.67

*SEE FIGURES 1 & 2

TABLE 7
AMSU-A1 MARGINS OF SAFETY
RANDOM VIBRATION IN Y - DIRECTION

ITEM NO.*	DESCRIPTION	PART NUMBER	MATERIAL/ ALLOY	YIELD (psi)	ULTIMATE (psi)	3 SIGMA STRESS (psi)	MARGINS OF SAFETY	
							YIELD	ULTIMATE
1	BASEPLATE ASSEMBLY, LOWER	1356405-1	ALUM/6061-T651	35000	42000	9435	1.97	2.18
2	PANEL, MOTOR MOUNT LOWER	1331414-1	ALUM/7075-T651	66000	75000	1989	25.55	25.93
3	PANEL, MOTOR MOUNT UPPER	1331389-1	ALUM/7075-T651	66000	75000	5487	8.62	8.76
4	PANEL, FRONT, LOWER	1331401-1	ALUM/6061-T651	35000	42000	8853	2.16	2.39
5	PANEL, AFT, LOWER	1331652-1	ALUM/2024-T851	58000	66000	10845	3.28	3.35
6	BASEPLATE, UPPER	1331356-1	ALUM/6061-T651	35000	42000	17148	0.63	0.75
7	PANEL, FRONT UPPER	1331352-1	ALUM/7075-T651	66000	75000	14627	2.61	2.66
8	PANEL, AFT WALL, UPPER	1331642-3	ALUM/2024-T851	58000	66000	3939	10.78	10.97
9	SHELF, RF, LOWER	1331556-1	BE/SR-200E	50000	70000	3960	9.10	11.63
10	SHELF, RF, UPPER	1331491-1	BE/SR-200E	50000	70000	2517	14.89	18.86
11	SUPPORT PANEL, LOWER RIGHT FRONT	1331447-1	ALUM/6061-T651	35000	42000	6177	3.53	3.86
12	PANEL, SIDEWALL, RIGHT LOWER	1331650-4	ALUM/6061-T6	35000	42000	19551	0.43	0.53
13	PANEL, SUPPORT, RIGHT FRONT UPPER	1331390-1	ALUM/6061-T651	35000	42000	21390	0.31	0.40
14	PANEL, SIDEWALL, RIGHT-UPPER	1331651-1	ALUM/6061-T6	35000	42000	2557	9.95	10.73
15	PANEL, TOP	1356866-1	ALUM/6061-T6	35000	42000	1125	23.89	25.67
16	PANEL, SIDEWALL, LEFT	1356626-1	ALUM/6061-T6	35000	42000	2047	12.68	13.66
18	SHIELD, WARMLOAD, LOWER LEFT	1331445-1	ALUM/6061-T6	35000	42000	5085	4.51	4.90
19	SHIELD, WARMLOAD, LOWER RIGHT	1331405-1	ALUM/6061-T6	35000	42000	1212	22.10	23.75
20	SHIELD, WARMLOAD, UPPER LEFT	1331647-1	ALUM/6061-T6	35000	42000	5757	3.86	4.21
21	SHIELD, WARMLOAD, UPPER RIGHT	1331646-1	ALUM/6061-T6	35000	42000	8175	2.43	2.67
22	CARD CAGE ASSY (LOWER)	1331600-1	ALUM/6061-T6	35000	42000	5276	4.31	4.69
23	CARD CAGE ASSY, UPPER	1331162-8	ALUM/6061-T6	35000	42000	4554	5.15	5.59
23	CARD CAGE ASSY, UPPER	1331162-8	ALUM/6061-T4	16000	30000	915	12.99	22.42
24	CALIBRATION SOURCE ASSY, WL (LOW)	1331380-1	ALUM/6061-T6	35000	42000	2434	10.50	11.33
25	CALIBRATION SOURCE ASSY, WL (UP)	1331380-2	ALUM/6061-T6	35000	42000	2199	11.73	12.64
26	BEAM SUPPORT	1331406-1	ALUM/6061-T6	35000	42000	4638	5.04	5.47
27	REFLECTOR ASSY (LOWER)	1355777-1	ALUM/7075-T6	66000	75000	4368	11.09	11.26
28	REFLECTOR ASSY (UPPER)	1355777-1	ALUM/7075-T6	66000	75000	8229	5.42	5.51

*SEE FIGURES 1 & 2

TABLE 8
AMSU-A1 MARGINS OF SAFETY
RANDOM VIBRATION IN Z - DIRECTION

ITEM NO.*	DESCRIPTION	PART NUMBER	MATERIAL/ ALLOY	YIELD (psi)	ULTIMATE (psi)	3 SIGMA STRESS (psi)	MARGINS OF SAFETY	
							YIELD	ULTIMATE
1	BASEPLATE ASSEMBLY, LOWER	1356405-1	ALUM/6061-T651	35000	42000	9666	1.90	2.10
2	PANEL, MOTOR MOUNT LOWER	1331414-1	ALUM/7075-T651	66000	75000	1620	31.59	32.07
3	PANEL, MOTOR MOUNT UPPER	1331389-1	ALUM/7075-T651	66000	75000	1992	25.51	25.89
4	PANEL, FRONT, LOWER	1331401-1	ALUM/6061-T651	35000	42000	4539	5.17	5.61
5	PANEL, AFT, LOWER	1331652-1	ALUM/2024-T851	58000	66000	6204	6.48	6.60
6	BASEPLATE, UPPER	1331356-1	ALUM/6061-T651	35000	42000	7146	2.92	3.20
7	PANEL, FRONT UPPER	1331352-1	ALUM/7075-T651	66000	75000	5564	8.49	8.63
8	PANEL, AFT WALL, UPPER	1331642-3	ALUM/2024-T851	58000	66000	2586	16.94	17.23
9	SHELF, RF, LOWER	1331556-1	BE/SR-200E	50000	70000	6841	4.85	6.31
10	SHELF, RF, UPPER	1331491-1	BE/SR-200E	50000	70000	7067	4.66	6.08
11	SUPPORT PANEL, LOWER RIGHT FRONT	1331447-1	ALUM/6061-T651	35000	42000	2541	10.02	10.81
12	PANEL, SIDEWALL, RIGHT LOWER	1331650-4	ALUM/6061-T6	35000	42000	10035	1.79	1.99
13	PANEL, SUPPORT, RIGHT FRONT UPPER	1331390-1	ALUM/6061-T651	35000	42000	9174	2.05	2.27
14	PANEL, SIDEWALL, RIGHT-UPPER	1331651-1	ALUM/6061-T6	35000	42000	926	29.24	31.40
15	PANEL, TOP	1356866-1	ALUM/6061-T6	35000	42000	2215	11.64	12.54
16	PANEL, SIDEWALL, LEFT	1356626-1	ALUM/6061-T6	35000	42000	1852	14.12	15.20
18	SHIELD, WARMLOAD, LOWER LEFT	1331445-1	ALUM/6061-T6	35000	42000	1872	13.96	15.03
19	SHIELD, WARMLOAD, LOWER RIGHT	1331405-1	ALUM/6061-T6	35000	42000	1719	15.29	16.45
20	SHIELD, WARMLOAD, UPPER LEFT	1331647-1	ALUM/6061-T6	35000	42000	4911	4.70	5.11
21	SHIELD, WARMLOAD, UPPER RIGHT	1331646-1	ALUM/6061-T6	35000	42000	2202	11.72	12.62
22	CARD CAGE ASSY (LOWER)	1331600-1	ALUM/6061-T6	35000	42000	6810	3.11	3.41
23	CARD CAGE ASSY, UPPER	1331162-8	ALUM/6061-T6	35000	42000	11730	1.39	1.56
23	CARD CAGE ASSY, UPPER	1331162-8	ALUM/6061-T4	16000	30000	2161	4.92	8.92
24	CALIBRATION SOURCE ASSY, WL (LOW)	1331380-1	ALUM/6061-T6	35000	42000	4729	4.92	5.34
25	CALIBRATION SOURCE ASSY, WL (UP)	1331380-2	ALUM/6061-T6	35000	42000	3137	7.93	8.56
26	BEAM SUPPORT	1331406-1	ALUM/6061-T6	35000	42000	4452	5.29	5.74
27	REFLECTOR ASSY (LOWER)	1355777-1	ALUM/7075-T6	66000	75000	1998	25.43	25.81
28	REFLECTOR ASSY (UPPER)	1355777-1	ALUM/7075-T6	66000	75000	3825	12.80	13.01

*SEE FIGURES 1 & 2

Tables 9 through 33 not re-evaluated in *Addendum 1*.

FATIGUE EVALUATION				TABLE 34
RANDOM VIB STRESSES Q = 7.1				
QUALIFICATION LEVEL - 2 MIN/AXIS				
UPPER RIGHT FRONT				
SUPPORT PANEL				
BAR ELEMENT 2633	X - LOAD	Y - LOAD	Z - LOAD	
STRESS @ 1 SIGMA	3438	7138	3058	
STRESS @ 2 SIGMA	6876	14276	6116	
STRESS @ 3 SIGMA	10314	21414	9174	
EFFECTIVE FREQUENCY	217	184	283	
REQ'D CYCLES/STRESS	X - LOAD	Y - LOAD	Z - LOAD	
CYCLES @ 1 SIGMA	17707.2	15014.4	23092.8	
CYCLES @ 2 SIGMA	7161	6072	9339	
CYCLES @ 3 SIGMA	1171.8	993.6	1528.2	
TOTAL REQ'D CYCLES	26040	22080	33960	
MATERIAL 6061-T6				
MIL-HDBK-5F FIG 3.6.2.2.8, R = -1.0				
ENDUR LIMIT @ 100000000 CYCLES				
FATIGUE SUMMARY	STRESS	REQ'D	ALLOWED	USAGE
	LEVEL	CYCLES	CYCLES	FACTOR
X-STRESS @ 3 SIGMA	10314	1171.8	10000000	0.00001
X-STRESS @ 2 SIGMA	6876	7161	10000000	0.00007
X-STRESS @ 1 SIGMA	3438	17707.2	10000000	0.00018
Y-STRESS @ 3 SIGMA	21414	993.6	524552	0.00189
Y-STRESS @ 2 SIGMA	14276	6072	28348265	0.00021
Y-STRESS @ 1 SIGMA	7138	15014.4	10000000	0.00015
Z-STRESS @ 3 SIGMA	9174	1528.2	10000000	0.00002
Z-STRESS @ 2 SIGMA	6116	9339	10000000	0.00009
Z-STRESS @ 1 SIGMA	3058	23092.8	10000000	0.00023
CUMULATIVE USAGE				0.00286
ALLOWABLE USAGE				0.80000

Tables 35 through 53 not re-evaluated in *Addendum 1*.

5.4.1 Panel Flange Bending Stresses and Attachment Screw Stresses per Random Vibration Loads

The following pages contain a detailed analysis of panel flange bending stresses and attachment screw stresses per random vibration loads.

TABLE 54 A1-EOS PANEL FLANGE BENDING STRESS SUMMARY - RANDOM VIBRATION LOADS									
COMPONENT	PART NO.	FLANGE	MAT'RL	F _y	MIN t	STRESS	FS	MS	RANGE t
				PSI	IN	PSI			IN
UPPER RIGHT FRONT SUPPORT	1331390	ALL	6061-T6	35000	0.065	19776	1.25	0.42	.065-.075
LOWER AFT PANEL	1331652	LOWER	2024-T851	58000	0.125	43374	1.25	0.07	.125-.135
		UPPER	2024-T851	58000	0.07	41264	1.25	0.12	.070-.080
		RIGHT	2024-T851	58000	0.07	39839	1.25	0.16	.070-.080
LOWER RIGHT PANEL	1331650	LOWER	6061-T6	35000	0.1	26502	1.25	0.06	.100-.110
UPPER FRONT PANEL	1331352	LOWER	7075-T6	66000	0.04	43260	1.25	0.22	.040-.060
		UPPER	7075-T6	66000	0.04	<43260	1.25	>.22	.040-.060
		RIGHT	7075-T6	66000	0.04	22730	1.25	1.32	.040-.060
LOWER MOTOR MT PANEL	1331414	LOWER	7075-T6	66000	0.05	39937	1.25	0.32	.050-.060
		TOP	7076-T6	66000	0.05	15947	1.25	2.31	.050-.060
UPPER MOTOR MT PANEL	1331389	LOWER	7075-T6	66000	0.05	33345	1.25	0.58	.050-.060
		RIGHT	7075-T6	66000	0.05	43788	1.25	0.21	.050-.060
		TOP	7075-T6	66000	0.05	<33345	1.25	>0.58	.050-.060
LOWER FRONT PANEL	1331401	LOWER	6061-T6	35000	0.09	24692	1.25	0.13	.090-.100
		UPPER	6061-T6	35000	0.06	24476	1.25	0.14	.060-.070
UPPER AFT PANEL	1331642	LOWER	2024-T851	58000	0.095	41836	1.25	0.11	.095-.105
		UPPER	2024-T851	58000	0.05	37944	1.25	0.22	.050-.060
		SIDE	2024-T851	58000	0.05	43774	1.25	0.06	.050-.060
UPPER RIGHT PANEL	1331651	LOWER	6061-T6	35000	0.06	25894	1.25	0.08	.060-.070
LOWER RIGHT SUPPORT	1331447	LOWER	6061-T6	35000	0.045	23766	1.25	0.18	.045-.055

TABLE 55 A1-EOS PANEL FLANGE ATTACHMENT SCREW STRESS SUMMARY - RANDOM VIBRATION LOADS											
COMPONENT	PART NO.	TYPE	MATRL	FLANGE	F _{tu}	LENGTH	NO	FORCE	STRESS	FS	MS
					PSI	IN	BOLTS	LB/IN	PSI		
UPPER RIGHT FRONT SUPPORT	1331390	NAS1352N06	ALLOY STEEL	LOWER	160000	6.5	3	86.4	20605	1.4	4.55
		NAS1352N06	ALLOY STEEL	AFT	160000	6.2	3	70.65	16072	1.4	6.11
LOWER AFT PANEL	1331652	NAS1352N06	ALLOY STEEL	LOWER	160000	10.563	8	716.4	104119	1.4	0.10
		NAS1352N06	ALLOY STEEL	UPPER	160000	8.498	6	213.39	33267	1.4	2.44
		NAS1352N06	ALLOY STEEL	RIGHT	160000	8.77	7	206.82	28521	1.4	3.01
LOWER RIGHT PANEL	1331650	NAS1352N06	ALLOY STEEL	LOWER	160000	19.29	15	317.64	44963	1.4	1.54
UPPER FRONT PANEL	1331352	NAS1352N06	ALLOY STEEL	LOWER	160000	10.575	7	73.227	12177	1.4	8.39
		NAS1352N06	ALLOY STEEL	UPPER	160000	10.575	7	<73.227	<12.177	1.4	>8.39
		NAS1352N06	ALLOY STEEL	RIGHT	160000	11.5	8	37.665	5960	1.4	18.18
LOWER MOTOR MT PANEL	1331414	NAS1352N06	ALLOY STEEL	LOWER	160000	10.562	6	89.52	17346	1.4	5.59
UPPER MOTOR MT PANEL	1331389	NAS1352N06	ALLOY STEEL	LOWER	160000	10.563	6	76.713	14866	1.4	6.69
		NAS1352N06	ALLOY STEEL	RIGHT	160000	6.245	3	99.525	22804	1.4	4.01
		NAS1352N06	ALLOY STEEL	TOP	160000	10.563	6	<76.713	<14866	1.4	>6.69
LOWER FRONT PANEL	1331401	NAS1352N06	ALLOY STEEL	LOWER	160000	10.563	8	209.49	30446	1.4	2.75
		NAS1352N06	ALLOY STEEL	UPPER	160000	10.288	7	93.741	15165	1.4	6.54
UPPER AFT PANEL	1331642	NAS1352N06	ALLOY STEEL	LOWER	160000	11.7	9	383.49	54875	1.4	1.08
		NAS1352N06	ALLOY STEEL	UPPER	160000	9.8	7	111.12	17124	1.4	5.67
		NAS1352N06	ALLOY STEEL	SIDE	160000	11.6	8	128.721	20544	1.4	4.56
UPPER RIGHT PANEL	1331651	NAS1352N06	ALLOY STEEL	LOWER	160000	8.783	7	128.472	17743	1.4	5.44
LOWER RIGHT SUPPORT	1331447	NAS1352N06	ALLOY STEEL	LOWER	160000	6.5	3	50.532	12051	1.4	8.48

UPPER RIGHT FRONT SUPPORT PANEL LOWER FLANGE

RANDOM Y W/O_L = 7.1 "1Y" LOADS

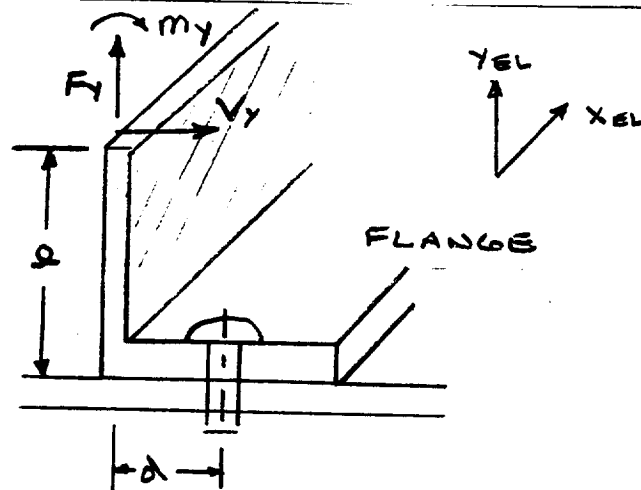
EL →	2589	2590	2591	2592	2593	
F _x	4.621	3.734	3.959	3.112	2.596	LB/IN
→ F _y	1.098	4.039	1.110	2.190	13.932	"
F _{xy}	4.641	4.917	5.086	4.390	4.710	"
M _x	.02107	.04215	.03439	.0886	.03597	IN-LB/IN
→ M _y	.03663	.1092	.1479	.2007	.1321	"
M _{xy}	.00616	.01483	.01294	.00854	.01441	"
V _x	.03292	.01364	.00332	.01037	.01848	LB/IN
→ V _y	.05322	.10674	.1473	.1981	.2623	"

$F_y = 13.932 \text{ LB/IN}$

$M_y = .1321 \text{ IN-LB/IN}$

$V_y = .2623 \text{ LB/IN}$

@ EL 2593 CENTROID

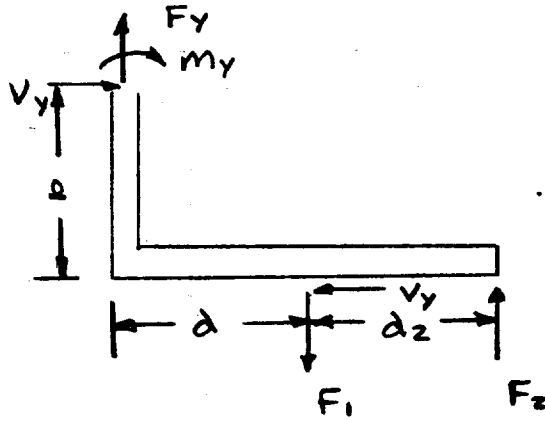


$d = .313$

$a = 1.125/2$

TO EL 2593 CENTROID

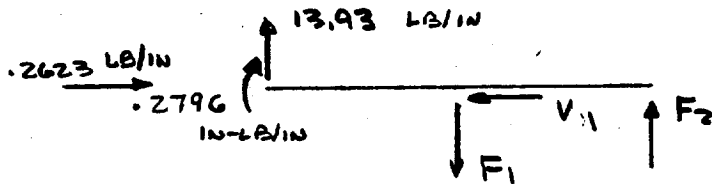
FLANGE STRESSES



$F_y = 13.93 \text{ LB/IN}$
 $M_y = -1321 \text{ IN-LB/IN}$
 $V_y = .2623 \text{ LB/IN}$

$t = .075 \pm .010 \text{ FLANGE}$

$d = 1.125/2$
 $a = .313$
 $a_2 = .312$

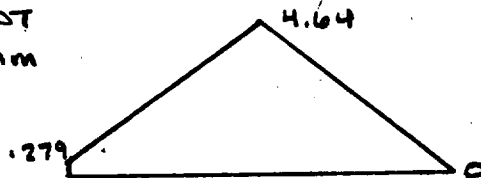


$\sum M_2 = 0 \quad F_1 (.312) = .2796 + 13.93 (.625)$

$F_1 = 28.80 \text{ LB/IN} \quad V_1 = .2623 \text{ LB/IN}$

$F_2 = 14.87 \text{ LB/IN}$

MOMENT
DIAGRAM



FLANGE TENSION (MEMBRANE + BENDING)

@ $t_{min} = .065$

$S_t = 3.0 \left(\frac{V_1}{.065} + \frac{M_1 (.065/2)}{(.065)^3/12} \right) \quad \text{"3\sigma \text{ LOADS"}$

$= 3(4 + 6589) = 19776 \text{ PSI}$

$MS = \frac{F_{ty}}{1.25 \times S_t} - 1$

$= \frac{35000}{(1.25)(19776)} - 1 = +.42$

$$MS = \frac{F_{tu}}{1.4 \times S_t} - 1 \quad F_{tu} = 42000 \text{ psi} \quad 6061-T651 \text{ ALUM}$$

$$= \frac{42000}{1.4(19776)} - 1 = +.52$$

CHECK RANDOM X W/Q=7.1 1T LOADS

EL	2589	2590	2591	2592	2593	
F _y	1.217	1.008	1.254	1.219	7.592	LB/IN
M _y	.0125	.0411	.0640	.0854	.0576	IN-LB/IN
V _y	.0166	.0412	.0622	.0822	.1161	LB/IN

CHECK RANDOM Z W/Q=7.1 1T LOADS

EL	2589	2590	2591	2592	2593	
F _y	.910	1.334	.739	1.236	6.425	LB/IN
M _y	.0162	.0485	.0750	.0890	.0552	IN-LB/IN
V _y	.0188	.0481	.0720	.0841	.1053	LB/IN

BOTH RANDOM X & RANDOM Z ARE LESS SEVERE THAN RANDOM Y

∴ t = .065 LOWER FLANGE OK
USING "3T LOADS"

BOLT STRESSES

Report 10381
Addendum 1

AT BOLT LINE

$$F = F_1 = 28.80 \text{ LB/IN}$$
$$V = V_1 = .26 \text{ LB/IN}$$

3 NAS1352N06-6 SCREWS IN 6.500 IN

.138-32UNC2-3A HEAT RESISTANT STEEL $F_{TU} = 160 \text{ KSI}$

TOTAL LOAD/BOLT

$$F_B = \frac{6.500}{3} (28.80) = 62.40 \text{ LB}$$

$$V_B = \frac{6.500}{3} (.26) = .568 \text{ LB}$$

"1 T LOADS"

$$S_t = (3) \frac{F_B}{A_s} = (3) \frac{62.40}{.009085} = 20605 \text{ PSI} \quad \text{"3 T STRESS"}$$

$$A_s = \pi/4 (D - .9743/n)^2$$
$$= .009085 \text{ IN}^2$$

$$D = .138$$
$$n = 32$$

$$FS = 1.4$$

$$S_t = 1.4 (20605) = 28847 \text{ PSI}$$

$$v_t = \frac{28847}{160000} = .180$$

$$f_s = \sim 0$$

$$R_t \sim 1.0$$

$$u = \frac{v_t}{R_t} = .180$$

$$MS = \frac{1}{u} - 1 = +4.5$$

WORST LOADED SCREW
UPPER RIGHT SUPPORT
PANEL LOWER FLANGE
"3 T LOADS"

• BOLTS OK ON LOWER FLANGE
USING "3 T LOADS"

UPPER RIGHT FRONT SUPPORT PANEL AFT FLANGE
RANDOM Y W/Q = 7.1 " 1σ LOADS "

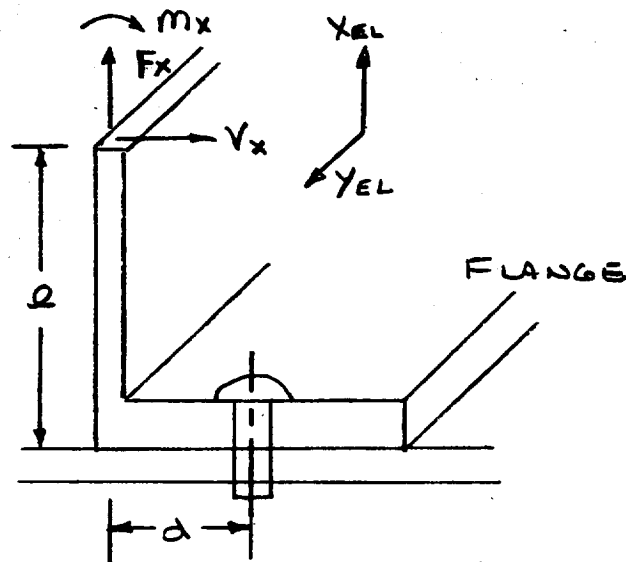
EL →	2589	2594	2599	2604	2609	
⇒ Fx	4.621	.802	.892	6.816	6.555	LB/IN
Fy	1.098	2.716	3.203	2.086	1.288	"
Fxy	4.641	6.023	6.529	7.083	7.736	"
⇒ Mx	.02107	.0570	.0740	.0680	.0317	IN-LB/IN
My	.03663	.0210	.0176	.0258	.0128	"
Mxy	.00616	.0236	.00918	.0117	.0135	"
⇒ Vx	.03292	.0506	.0761	.0681	.0333	LB/IN
Vy	.05388	.0156	.00593	.00680	.0137	"

$F_x = 6.816 \text{ LB/IN}$

$M_x = .0680 \text{ IN-LB/IN}$

$V_x = .0681 \text{ LB/IN}$

@ EL 2604 CENTROID

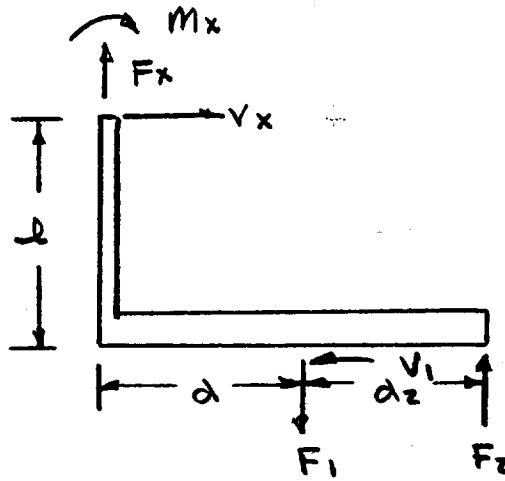


$d = .312$
 $L = .870/2$
TO ELEM
2604 CENTROID

FLANGE LENGTH 6.200 IN
SCREWS 3

NAS1352N06-6
.138-32UNCA-3A
HEAT-RESISTANT STEEL
W/FTU = 160000 PSI

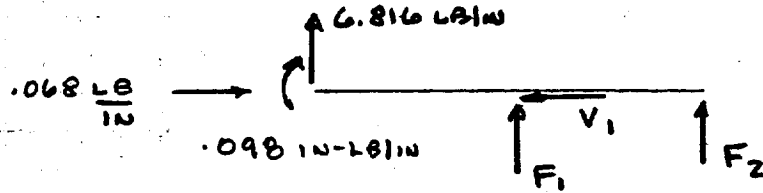
FLANGE STRESSES



$F_x = 6.816 \text{ LB/IN}$
 $M_x = .0680 \text{ IN-LB/IN}$
 $V_x = .0681 \text{ LB/IN}$

$t = .005 \text{ MIN FLANGE}$

$l = .870/2$
 $d = .312$
 $d_z = .313$

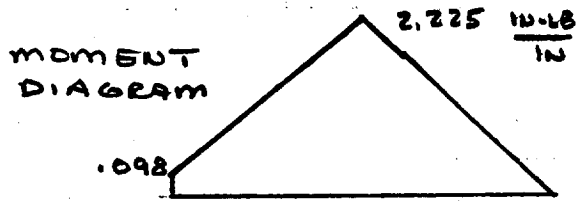


$$\sum M_2 = 0 \quad F_1 (.313) = .098 + 6.816 (.625)$$

$$F_1 = 13.92 \text{ LB/IN}$$

$$F_2 = 7.11 \text{ LB/IN}$$

$$V_1 = .07 \text{ LB/IN}$$



FLANGE TENSION (MEMB + BEND) @ $t_{min} = .065$

$$S_t = 3 \left[\frac{.07}{.065} + \frac{2.225 (.065/2)}{(.065)^3/12} \right] \quad \text{"3T LOADS"}$$

$$= 3 [1 + 3160]$$

$$= 9482 \text{ PSI}$$

$$MS = \frac{F_{ty}}{1.25 \times S_t} - 1$$

$$F_{ty} = 35000 \text{ PSI}$$

$$= \frac{35000}{1.25 (9482)} - 1 = + 2.0$$

6061-T6 ALUM
UPPER RIGHT
SUPPORT PANEL
AFT FLANGE
3T LOADS

$$MS = \frac{F_{tu}}{1.4 \times S_t} - 1$$

$$F_{tu} = 42000 \text{ PSI}$$

$$= \frac{42000}{1.4 (9482)} - 1 = + 2.2$$

6061-T6 ALUM
UPPER RIGHT
SUPPORT PANEL
AFT FLANGE
3T LOADS

$\therefore t = .065$ FLANGES OK
USING "3T LOADS"

CHECK RANDOM X W/Q=7.1 IT LOADS

EL	2589	2594	2599	2604	<u>2609</u>	
F _x	2.509	.741	.914	1.212	11.718	LB/IN
M _x	.0187	-.0527	.0706	.0684	.0326	IN-LB/IN
V _x	.0227	-.0501	.0658	.0597	.0333	LB/IN

CHECK RANDOM Z W/Q=7.1 IT LOADS

EL	2589	2594	2599	2604	2609	
F _x	1.425	.235	.833	3.688	4.290	LB/IN
M _x	.0166	.0495	.0730	.0626	.0272	IN-LB/IN
V _x	.0200	.0508	.0719	.0608	.0261	LB/IN

RANDOM X W/Q=7.1 @ EL 2609 IS MORE SEVERE THAN RANDOM Y.

CALCULATIONS FOR RANDOM X

FLANGE STRESSES

$$F_x = 11.718 \text{ LB/IN}$$

$$M_x = .0326 \text{ IN-LB/IN}$$

$$V_x = .0333 \text{ LB/IN}$$

$$F_1 = [.0326 + (.870/2)(.0333) + 11.718(.625)] / .315$$

$$= 23.55 \text{ LB/IN}$$

$$F_2 = 11.83 \text{ LB/IN}$$

$$V_1 = .033 \text{ LB/IN}$$

FLANGE TENSION (MEMB + BEND) @ $t_{min} = .065$

$$S_t = 3 \left[\frac{.033}{.065} + \frac{3,703 (.065/2)}{(.065)^{3/12}} \right] \quad 3T \text{ STRESS}$$
$$= 3 [1 + 5259]$$
$$= 15777 \text{ psi}$$

$$MS = \frac{35000}{1.25 \times 15777} - 1 = +.77$$

6061-T6 ALUM
UPPER RIGHT
SUPPORT PANEL
AFT FLANGE
3T STRESS

$$MS = \frac{42000}{1.4 \times 15777} - 1 = +.98$$

3T STRESS

$\therefore t = .065$ AFT FLANGE OK
USING "3T LOADS"

BOLT STRESSES

AT BOLT LINE

$$F = F_1 = 23.55 \text{ LB/IN}$$

$$V = V_1 = .033 \text{ LB/IN}$$

3 SCREWS IN 6.200 IN LENGTH

TOTAL LOAD / SCREW

$$F_B = \frac{6.200}{3} (23.55) = 48.67 \text{ LB}$$

$$V_B = \frac{6.200}{3} (.033) = .07 \text{ LB}$$

"IT LOADS"

$$S_t = (3) \frac{F_B}{A_s} = (3) \frac{48.67}{.00085}$$

"3T STRESS"

$$= 16072 \text{ PSI}$$

$$FS = 1.4$$

$$S_t = 1.4 \times S_t = 22500 \text{ PSI}$$

$$S_s = 1.4 \times S_s \Rightarrow \sim 0$$

$$R_t \sim 1.0$$

$$V_t = \frac{22500}{160000} = .141$$

$$U = \frac{V_t}{R_t} = .141$$

$$MS = \frac{1}{U} - 1 = + 6.1$$

WORST LOADED SCREW
UPPER RIGHT SUPPORT
PANEL AFT FLANGE
"3T LOADS"

∴ BOLTS OK ON AFT FLANGE
USING 3T LOADS

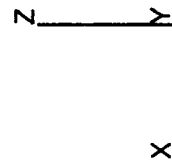
1116	2619	1946	2620	1947	2621	1948	2622	1949	2623	1950
2624	2609	2610	2611	2612	2613	2629	1945	2630	1940	2631
1115	1941	1942	1943	1944	1944	1944	1944	1944	1944	1945
2625	2604	2605	2606	2607	2608	2630	1940	2630	1940	2630
1114	1936	1937	1938	1939	1939	1940	1939	1939	1939	1940
2626	2599	2600	2601	2602	2603	2631	1935	2631	1935	2631
1113	1931	1932	1933	1934	1934	1935	1934	1934	1934	1935
2627	2594	2595	2596	2597	2598	2632	1930	2632	1930	2632
1112	1926	1927	1928	1929	1929	1930	1929	1929	1929	1930
2628	2589	2590	2591	2592	2593	2633	2633	2633	2633	2633
620	2614	2615	2616	2617	2618	670	660	660	660	670

UPPER RIGHT
FRONT SUPPORT

PANEL

CBAR
GRID

ART
FLANGE

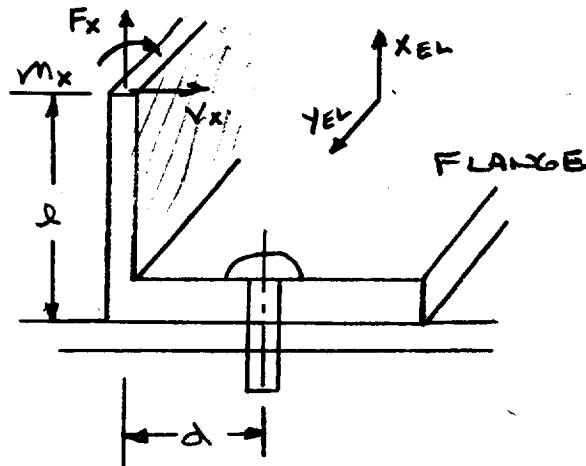


LOWER FLANGE

LOWER AFT PANEL - LOWER FLANGE
RANDOM Y W/Q=7.1 "1 T LOADS"

EL	575	485	565	
→ Fx	118.6	46.61	46.16	LB/IN
Fy	34.32	21.71	21.42	"
Fxy	60.45	27.40	37.79	"
→ Mx	.2462	.1311	.2658	IN-LB/IN
My	.0587	.0100	.0917	"
Mxy	.0364	.0159	.0406	"
→ Vx	.6860	.1873	.4319	LB/IN
Vy	.4446	.1285	.1806	"

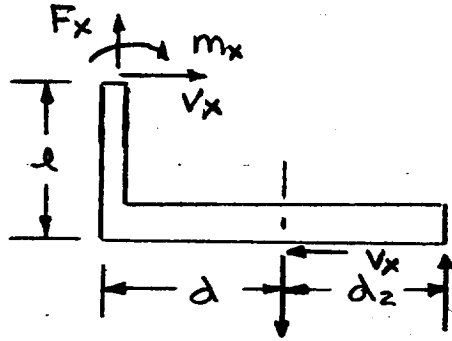
$F_x = 118.6 \text{ LB/IN}$
 $M_x = .2462 \text{ IN-LB/IN}$ @ EL 575 CENTROID
 $V_x = .6860 \text{ LB/IN}$



$d = .312$
 $l = 1.131/2 \text{ TO}$
 EL 575 CENTROID

FLANGE LENGTH $11.188 - .625 = 10.563 \text{ IN}$
 BOLTS 8 NAS1352N06-6
 .138-32UNC-3A
 HEAT-RESISTANT STEEL
 $w/F_{tu} = 160000 \text{ PSI}$

FLANGE STRESSES



$$F_x = 118.6 \text{ LB/IN}$$

$$M_x = .2462 \text{ IN-LB/IN}$$

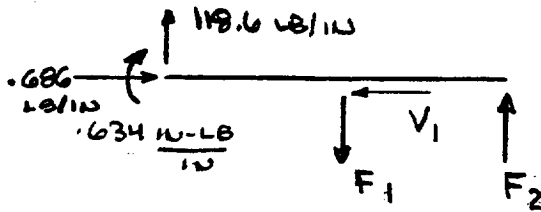
$$V_x = .686 \text{ LB/IN}$$

$$t = .050 \text{ FLANGE MIN T}$$

$$d = 1.131/2$$

$$d = .312$$

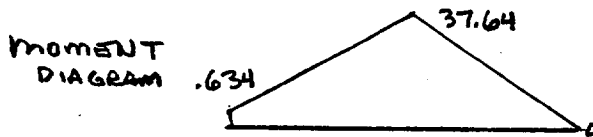
$$d_2 = .313$$



$$\sum M_2 = 0 \quad F_1 (.313) = .634 + 118.6 (.625)$$

$$F_1 = 238.8 \text{ LB/IN} \quad V_1 = .686 \text{ LB/IN}$$

$$F_2 = F_1 - 118.6 = 120.2 \text{ LB/IN}$$



$$M_1 = 37.64 \text{ IN-LB/IN}$$

FLANGE TENSION (MEMBRANE + BENDING)

$$S_t = 3 \left[\frac{V_1}{(.050)} + \frac{M_1 (.050/2)}{\frac{(.050)^3}{12}} \right] \text{ "3T LOADS"}$$

$$= 3 [14 + 90330]$$

$$= 271028 \text{ PSI}$$

$$MS = \frac{F_{ty}}{1.25 \times S_t} - 1$$

$$F_{ty} = 35000 \text{ PSI} \quad \text{ALUM 6061 T651}$$

$$= \frac{35000}{(1.25)(271028)} - 1 = -0.90 \quad \text{"3T LOADS"}$$

$$MS = \frac{F_{tu}}{1.4 \times S_t} - 1 \quad F_{tu} = 42000 \text{ PSI}$$

ALUM
6061-T651

$$= \frac{42000}{1.4(271078)} - 1 = -.89$$

CONSIDERABLY OVERSTRESSED

RAISE FLANGE t TO .160, ASSUMING SAME
PLATE ELEMENT LOADS

$$S_t = 3 \left[\frac{.686}{.160} + \frac{37.64(.160/2)}{(.160)^3/12} \right]$$

$$= 3 [4 + 8822]$$

3T LOADS

$$= 26476 \text{ PSI}$$

$$MS = \frac{35000}{1.25(26476)} - 1 = +.06$$

$t = .160$

$$MS = \frac{42000}{1.4(26476)} - 1 = +.13$$

$t = .160$

∴ RAISE LOWER FLANGE t TO .160
USING "3T LOADS"

TRY 2024-T851 MAT'RL

$$F_{Ty} = 58000 \text{ psi}$$

$$F_{Tx} = 66000 \text{ psi}$$

RAISE FLANGE t TO .125, WITH 2024-T851

$$S_t = 3 \left[\frac{.686}{.125} + \frac{37.64(6)}{(.125)^2} \right]$$

3T LOADS

$$= 3 [5 + 14453]$$

$$= 43374 \text{ psi}$$

$$MS = \frac{58000}{1.25(43374)} - 1 = +.07$$

$t = .125$

$$MS = \frac{66000}{1.4(43374)} - 1 = +.09$$

$t = .125$

∴ RAISE LOWER FLANGE t TO .125

USING "3T LOADS" & 2024-T851

BOLT STRESSES

Report 10381
Addendum 1

AT BOLT LINE

$$F = F_1 = 238.8 \text{ LB/IN}$$

$$V = V_1 = .686 \text{ LB/IN}$$

8 BOLTS IN 10.563 IN

TOTAL LOAD/BOLT

$$F_B = \frac{10.563}{8} (238.8) = 315.3 \text{ LB}$$

$$V_B = \frac{10.563}{8} (.686) = .91 \text{ LB}$$

"IT LOADS"

AT 3T LOADS

$$S_t = 3 \frac{F_B}{A_s} = \frac{(3)(315.3)}{(.009085)} = 104119 \text{ PSL}$$

$$S_s = 3 \frac{V_B}{A_s} = 300 \text{ PSL}$$

WITH FS=1.4

$$f_t = 1.4 \times S_t = 145767 \text{ PSL}$$

$$v_t = \frac{145767}{160000} = .911$$

$$f_s \rightarrow 0$$

$$R_t \sim 1.0$$

$$u = \frac{v_t}{R_t} = .911$$

$$MS = \frac{1}{u} - 1 = +.10$$

WORST LOADED SUBW
LOWER AFT PANEL
LOWER FLANGES
3T LOADS

•• BOLTS OK ON LOWER FLANGE
USING 3T LOADS

CHECK RANDOM X				W/Q=7.1	1 T LOADS
EL	575	485	565		
F _x	52.82	38.07	27.41		LB/IN
M _x	.1612	.1444	.2315		IN-LB/IN
V _x	.5458	.2074	.4429		LB/IN

RANDOM X IS LESS SEVERE THAN RANDOM Y

CHECK RANDOM Z				W/Q=7.1	1 T LOADS
EL	575	485	565		
F _x	52.01	16.81	20.57		LB/IN
M _x	.1332	.0796	.2137		IN-LB/IN
V _x	.5411	.1164	.4207		LB/IN

RANDOM Z IS LESS SEVERE THAN RANDOM Y

LOWER AFT PANEL - UPPER FLANGE

RANDOM Y W/Q=7.1 1 T LOADS

	EL	584	574	494	504	
⇒ Fx		25.68	19.54	15.37	5.31	LB/IN
Fy		4.12	1.75	2.16	3.08	"
Fxy		11.37	16.15	18.90	26.64	"
⇒ Mx		.1125	.1217	.0633	.0698	IN-LB/IN
My		.0569	.0425	.0213	.0219	"
Mxy		.0352	.0228	.0122	.0128	"
⇒ Vx		.4756	.1985	.1114	.1057	LB/IN
Vy		.0768	.0567	.0177	.0401	"

RANDOM X W/Q=7.1 1 T LOADS

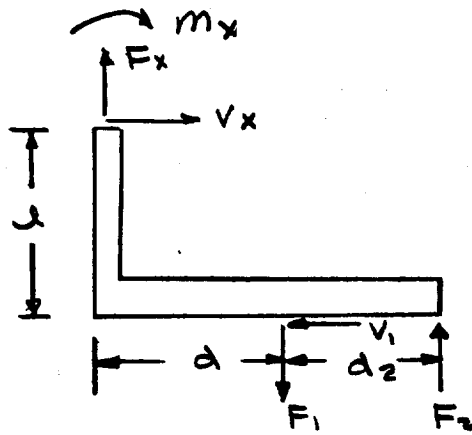
	EL	584	574	494	504	
⇒ Fx		29.08	15.16	35.24	12.09	LB/IN
Fy		7.19	3.98	8.71	2.45	"
Fxy		7.96	7.53	4.00	6.80	"
⇒ Mx		.1832	.2635	.1548	.2691	IN-LB/IN
My		.0381	.0773	.0282	.1058	"
Mxy		.0470	.0583	.0426	.0779	"
⇒ Vx		.7046	.4163	.2452	.2856	LB/IN
Vy		.1224	.1897	.0763	.0891	"

RANDOM Z W/Q=7.1 1 T LOADS

	EL	584	574	494	504	
⇒ Fx		18.27	11.92	17.11	6.79	LB/IN
Fy		3.86	2.46	3.88	1.51	"
Fxy		3.24	5.79	5.17	5.91	"
⇒ Mx		.0760	.1518	.0786	.1646	IN-LB/IN
My		.0168	.0504	.0310	.0606	"
Mxy		.0391	.0481	.0256	.0443	"
⇒ Vx		.3119	.1973	.0962	.1630	LB/IN
Vy		.2010	.1088	.0686	.0243	"

BASE UPPER FLANGE ANALYSIS ON EL 494
RANDOM X W/Q=7.1

FLANGE STRESSES

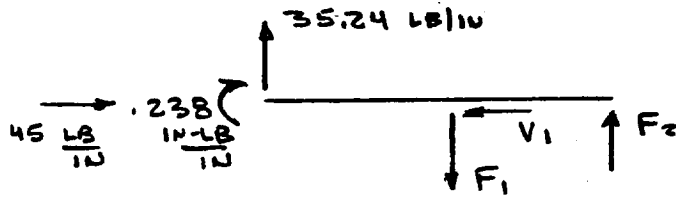


$F_x = 35.24 \text{ LB/IN}$
 $M_x = .1548 \text{ IN-LB/IN}$
 $V_x = .2452 \text{ LB/IN}$

$t = .050 \text{ FLANGE MIN } t$

$l = .675/2$
 $d = .312$
 $d_2 = .313$

6 SCREWS IN 8.498 INCHES



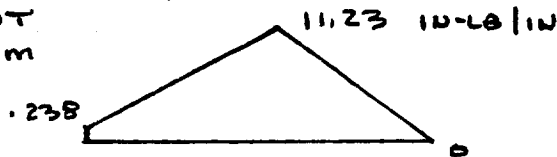
$\sum M_2 = 0 \quad F_1 (.313) = .238 + 35.24 (.625)$

$F_1 = 71.13 \text{ LB/IN}$

$F_2 = 35.89 \text{ LB/IN}$

$V_1 = .245 \text{ LB/IN}$

MOMENT
DIAGRAM



FLANGE TENSION (MEMBRANE + BENDING) @ $t = .050$

$$S_t = 3 \left[\frac{.245}{.050} + \frac{11.23 (.050/2)}{(.050)^3/12} \right] \text{ "3X LOADS"}$$

$$= 3 [5 + 26952]$$

$$= 80871 \text{ PSI}$$

$$MS = \frac{F_{ty}}{1.25 \times S_t} - 1 = \frac{35000}{1.25(80871)} - 1 = -.65$$

$$MS = \frac{F_{34}}{1.4 \times St} - 1 = \frac{42000}{1.4(80871)} - 1 = -.63$$

6061-T651
ALUM

∴ UPPER FLANGE BAD @ t = .055

RAISE FLANGE MIN t TO .085 IN

$$St = 3 \left[\frac{.245}{.085} + \frac{6(11,23)}{(.085)^2} \right]$$

$$= 3 [3 + 9326]$$

3 ∇ LOADS

$$= 27987 \text{ PSI}$$

$$MS = \frac{35000}{1.25(27987)} - 1 = +.0004$$

t = .085

$$MS = \frac{42000}{1.4(27987)} - 1 = +.07$$

t = .085

∴ RAISE UPPER FLANGE t TO .085 MIN

USING 3 ∇ LOADS

TRY 2024-T851

RAISE MIN FLANGE t TO .070, WITH 2024-T851

$$S_t = 3 \left[\frac{.245}{.070} + \frac{6(11.23)}{(.070)^2} \right]$$

$$= 3 [4 + 13751]$$

3T LOADS

$$= 41264 \text{ psi}$$

$$MS = \frac{58000}{1.25(41264)} - 1 = +.12$$

$t = .070$

$$MS = \frac{66000}{1.4(41264)} - 1 = +.14$$

$t = .070$

∴ RAISE UPPER FLANGE t TO .070

USING 3T LOADS & 2024-T851

BOLT STRESSES

AT BOLT LINE

$$F = F_1 = 71.13 \text{ LB/IN}$$

$$V = V_1 = .245 \text{ LB/IN}$$

6 BOLTS IN 8.498 INCHES

TOTAL FORCE/BOLT

$$F_B = \frac{8.498}{6} (71.13) = 100.7 \text{ LB}$$

$$V_B = \frac{8.498}{6} (.245) = .35 \text{ LB}$$

1 T LOADS

AT 3 T LOADS

$$S_t = 3 \frac{F_B}{A_s} = \frac{3(100.7)}{.009085} = 33267 \text{ PSI}$$

$$S_s = \frac{3V_B}{A_s} = 115 \text{ PSI}$$

WITH FS=1.4

$$S_t = 1.4 \times S_t = 46573 \text{ PSI}$$

$$r_t = \frac{46573}{160000} = .291$$

$$f_s \approx 0$$

$$R_t \sim 1.0$$

$$u = \frac{r_t}{R_t} = .291$$

$$MS = \frac{1}{u} - 1 = + 2.4$$

WORST LOADED SCREW
LOWER AFT PANEL
UPPER FLANGE
3 T LOADS

∴ BOLTS OK ON UPPER FLANGE

USING 3 T LOADS

LOWER ART PANEL - RIGHT FLANGE

Report 10381
Addendum 1

RANDOM Y w/Q=7.1 1 T LOADS

EL	575	576	584	583	
F _y	34.32	3.051	4.12	1.25	LB/IN
M _y	.0587	.1880	.0369	.0624	IN-LB/IN
V _y	.4446	.4108	.0768	.1904	LB/IN

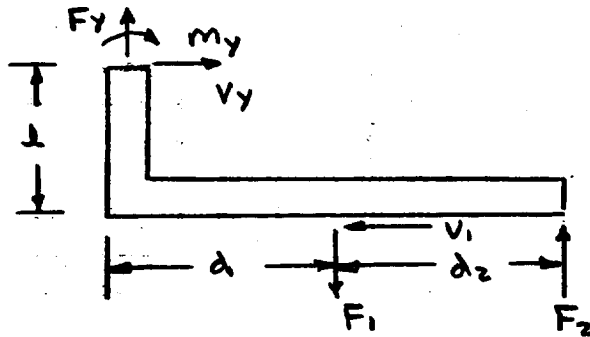
RANDOM X w/Q=7.1 1 T LOADS

EL	575	576	584	583	
F _y	13.26	.430	7.19	2.31	LB/IN
M _y	.0258	.1484	.0381	.1056	IN-LB/IN
V _y	.0302	.3042	.1224	.3321	LB/IN

RANDOM Z w/Q=7.1 1 T LOADS

EL	575	576	584	583	
F _y	20.48	1.54	3.26	.863	LB/IN
M _y	.0515	.0978	.0168	.0836	IN-LB/IN
V _y	.2260	.2551	.2010	.1588	LB/IN

BASE RIGHT FLANGE ANALYSIS ON EL 575
RANDOM Y w/Q=7.1

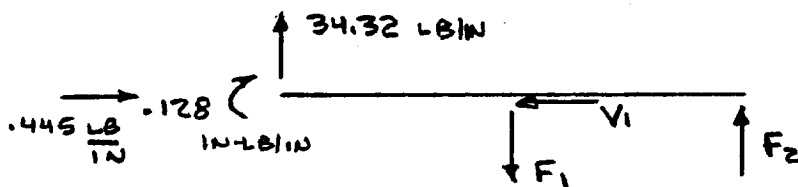


$F_y = 34.32 \text{ LB/IN}$
 $M_y = .0587 \text{ IN-LB/IN}$
 $V_y = .4446 \text{ LB/IN}$

t = .050 FLANGE MINIMUM

$l = .312/2$
 $a = .312$
 $a_2 = .313$

7 SCREWS IN 8.77 IN

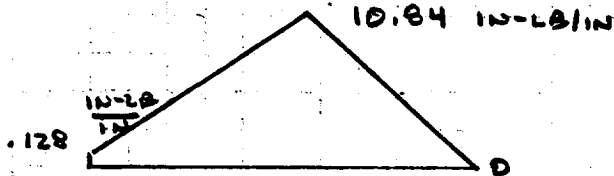


$$\sum M_z = 0 \quad F_1(.313) = .128 + 34.32(.625)$$

$$F_1 = 68.94 \text{ LB/IN}$$

$$F_2 = 34.62 \text{ LB/IN}$$

$$V_1 = .445 \text{ LB/IN}$$



FLANGE TENSION (MEMBRANE + BENDING) @ $t = .050$

$$S_t = 3 \left[\frac{.445}{.050} + \frac{10.84 (.050/2)}{(.050)^{3/12}} \right]$$

$$= 3 [9 + 26016]$$

$$= 78075 \text{ PSI}$$

3T LOADS

$$MS = \frac{F_{tv}}{1.25 \times S_t} - 1$$

$$= \frac{35000}{1.25(78075)} - 1 = -.64$$

6061-T651
ALUM

$$MS = \frac{F_{tu}}{1.4 \times S_t} - 1$$

$$= \frac{42000}{1.4(78075)} - 1 = -.62$$

6061-T651
ALUM

RIGHT FLANGE BAD @ $t = .050$

RAISE FLANGE MIN t TO .085 IN

$$S_t = 3 \left[\frac{.445}{.085} + \frac{6(10.84)}{(.085)^2} \right] \quad \text{3T LOADS}$$

$$= 27022 \text{ PSI}$$

$$MS = \frac{35000}{1.25(27022)} - 1 = +.04 \quad t = .085$$

$$MS = \frac{42000}{1.4(27022)} - 1 = +.11 \quad t = .085$$

∴ RAISE RIGHT FLANGE t TO .085 MIN
USING 3T LOADS

2024-T851

USE t MIN OF .070 IN

$$S_t = 3 \left[\frac{.445}{.070} + \frac{6(10.84)}{(.070)^2} \right] = 39839 \text{ PSI}$$

$$MS = \frac{58000}{1.25(39839)} - 1 = +.16 \quad t = .070$$

$$MS = \frac{66000}{1.4(39839)} - 1 = +.18 \quad t = .070$$

∴ RAISE RIGHT FLANGE t TO .070 MIN
USING 3T LOADS & 2024-T851

BOLT STRESSES

AT BOLT LINE

$$F = F_1 = 68.94 \text{ LB/IN}$$
$$V = V_1 = .445 \text{ LB/IN}$$

7 BOLTS IN 8.77 INCHES

TOTAL LOAD/BOLT

$$F_B = \frac{8.77}{7} (68.94) = 86.37 \text{ LB}$$

$$V_B = \frac{8.77}{7} (.445) = .558 \text{ LB}$$

1 T LOADS

AT 3 T LOADS

$$S_t = 3 \frac{F_B}{A_s} = \frac{(3)(86.37)}{.009085} = 28521 \text{ PSI}$$

$$S_s = 3 \frac{V_B}{A_s} = 184 \text{ PSI}$$

WITH FS=1.4

$$S_t = 1.4 \times 28521 = 39929 \text{ PSI}$$

$$r_t = \frac{39929}{160000} = .250$$

$$f_s = 70$$

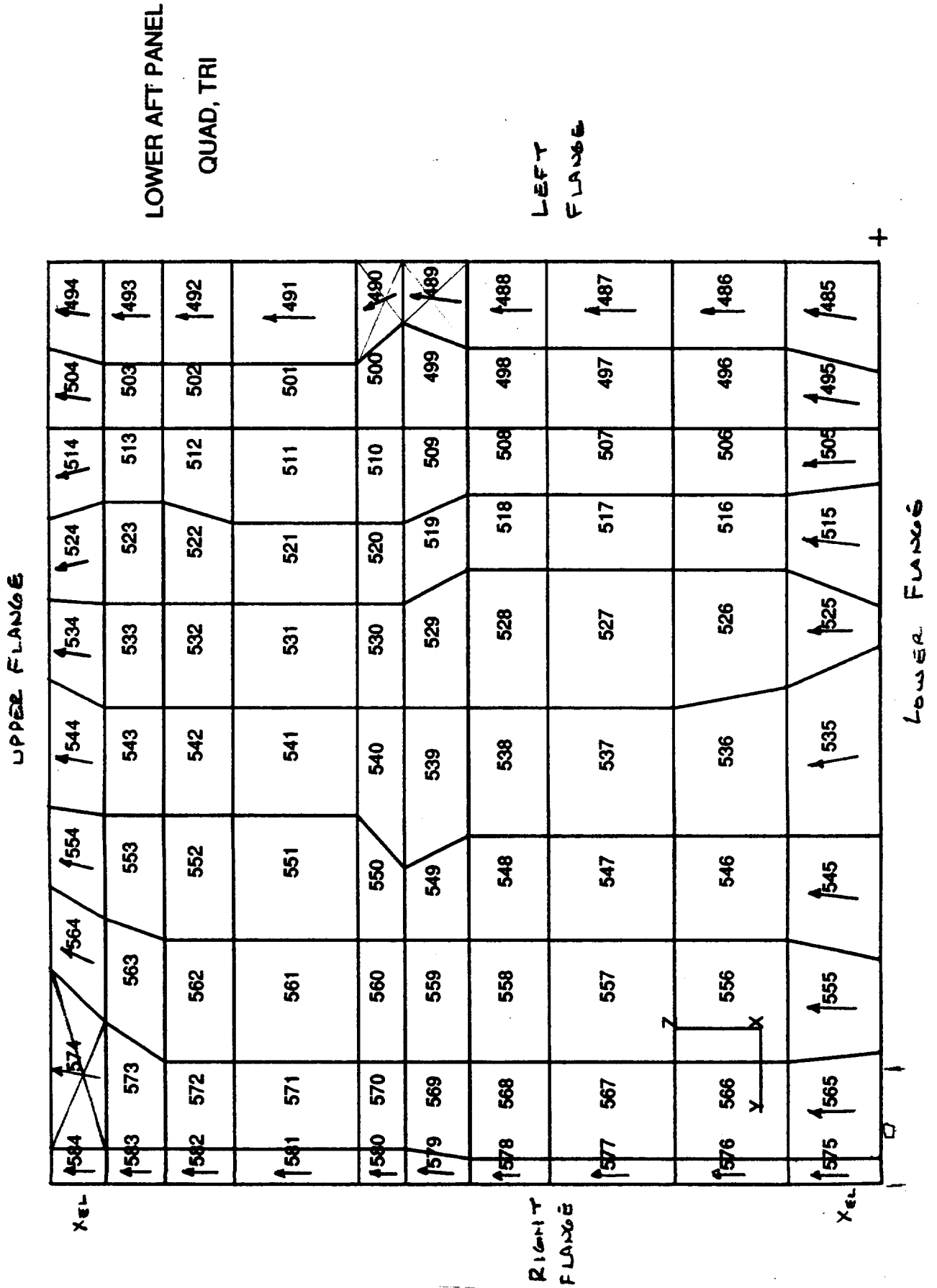
$$R_t \sim 1.0$$

$$u = \frac{r_t}{R_t} = .250$$

$$MS = \frac{1}{u} - 1 = +3.0$$

WORST LOADED SCREW
LOWER AFT PANEL
RIGHT FLANGE
3 T LOADS

∴ BOLTS OK ON RIGHT FLANGE
USING 3 T LOADS

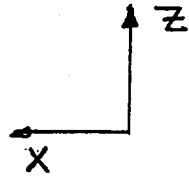
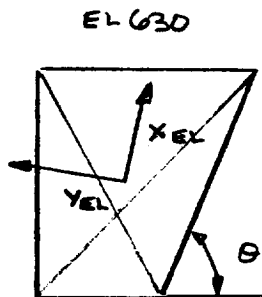


LOWER RIGHT PANEL - LOWER FLANGE

RANDOM Y W/Q = 7.1 IT LOADS

EL	630	760	
Fx	46.95	38.80	LB/IN
Fy	15.03	3.41	"
Fxy	3.13	4.40	"
Mx	.0463	.0615	IN-LB/IN
My	.0346	.0675	"
Mxy	.0241	.0133	"
Vx	.215	.274	LB/IN
Vy	.457	.115	"

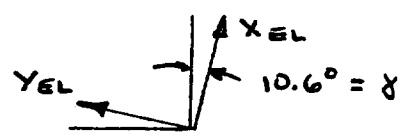
BOTH ELEMENTS HAVE SKEWED "ELEMENT X & Y" DIRECTIONS, ROTATING COMPONENTS TO HAVE "ELEMENT X" NORMAL TO FLANGE,



$$\tan \theta = \frac{\Delta Z}{\Delta X} = \frac{1.131}{.438}$$

$$\theta = 68.8^\circ$$

X_{EL} SKEWED +10.6°



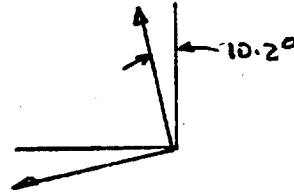
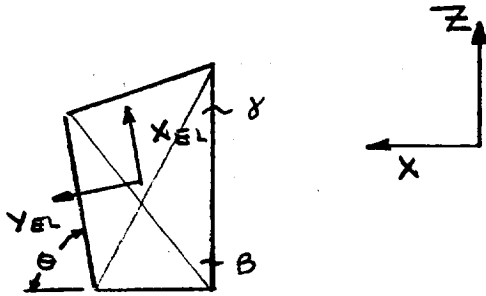
$$\begin{aligned}
 F_x' &= \frac{F_x + F_y}{2} + \frac{F_x - F_y}{2} \cos 2\gamma + F_{xy} \sin 2\gamma \\
 &= \frac{46.95 + 15.03}{2} + \frac{46.95 - 15.03}{2} \cos[2(10.6)] + 3.13 \sin[2(10.6)] \\
 &= 47.00 \text{ LB/IN}
 \end{aligned}$$

LIKEWISE M_x' = .055 IN-LB/IN

EL 760

$$\begin{aligned} \delta &= 12.0^\circ \\ \beta &= 32.4^\circ \end{aligned}$$

$$X_{EL} \ominus 32.4^\circ - \left(\frac{12.0 + 32.4}{2} \right) = 10.2^\circ$$



FOR $\theta = -10.2^\circ$

$$F_x' = \frac{F_x + F_y}{2} + \frac{F_x - F_y}{2} \cos 2\theta + F_{xy} \sin 2\theta$$

$$= 36.16 \text{ LB/IN}$$

$$M_x' = .065 \text{ IN-LB/IN}$$

RANDOM Y W/Q = 7.1 1 T LOADS

EL	630	760	
F_x'	47.00	36.16	LB/IN
M_x'	.055	.065	IN-LB/IN
V_x	.215	.274	LB/IN

RANDOM X W/Q = 7.1 1 T LOADS

EL	630	760	
F_x'	23.65	16.00	LB/IN
M_x'	.0073	.0124	IN-LB/IN
V_x	.0607	.0699	LB/IN

RANDOM Z W/Q = 7.1

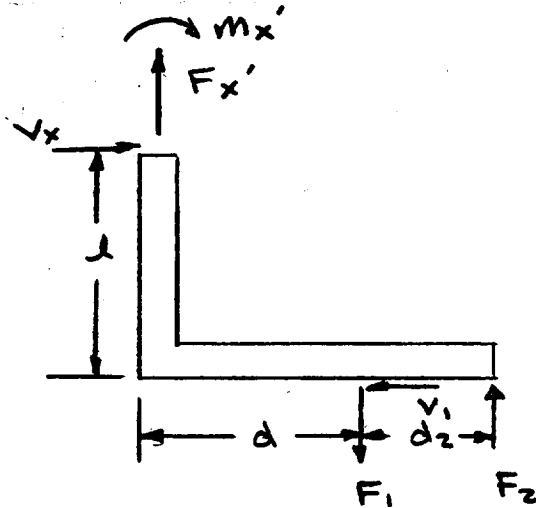
EL	630	760	1 T LOADS
F_x'	26.47	21.98	LB/IN
M_x'	.0142	.0206	IN-LB/IN
V_x	.137	.0521	LB/IN

$$F_x' = 47.00 \text{ LB/IN}$$

$$M_x' = .055 \text{ IN-LB/IN}$$

$$V_x = .215 \text{ LB/IN}$$

FLANGE STRESSES

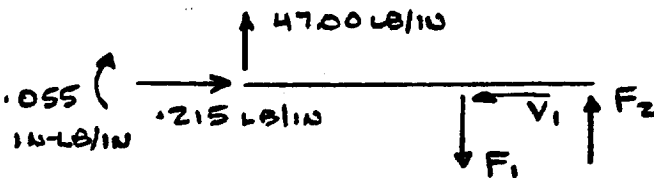


$$l = 1.331/2$$

$$d = .312$$

$$d_2 = .250$$

t = .040 FLANGE MIN t

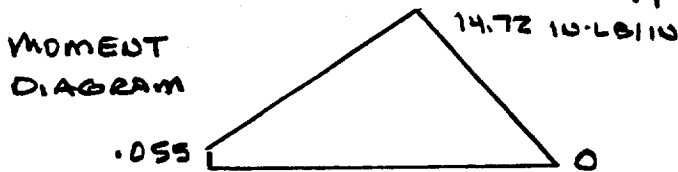


$$\sum M_2 = 0 \quad F_1 (.250) = 47.00 (.562) + .055$$

$$F_1 = 105.88 \text{ LB/IN}$$

$$F_2 = 58.88 \text{ LB/IN}$$

$$V_1 = .215 \text{ LB/IN}$$



FLANGE TENSION (MEMBER + BEND) @ t MIN = .040

$$S_t = 3 \left[\frac{V_1}{t} + \frac{6M_1}{t^2} \right] = 3 \left[\frac{.215}{.040} + \frac{6(14.72)}{(.040)^2} \right]$$

$$= 3 [5 + 55200]$$

$$= 165616 \text{ PSI}$$

3σ LOADS

MAT'L 6061-T651

$$F_{ty} = 35000 \text{ psi}$$

$$F_{tu} = 42000 \text{ psi}$$

$$MS = \frac{F_{ty}}{1.25 \times S_t} - 1$$

$$= \frac{35000}{1.25 (165616)} - 1 = -1.83$$

$$MS = \frac{F_{tu}}{1.4 \times S_t} - 1$$

$$= \frac{42000}{1.4 (165616)} - 1 = -0.82$$

OVERSTRESSED

RAISE FLANGE TO $t = .100$

$$S_t = 3 \left[\frac{.215}{.100} + \frac{6(14.72)}{(.100)^2} \right]$$

$$= 3 [2 + 8832] = 26502 \text{ psi}$$

$$MS = \frac{35000}{1.25 (26502)} - 1 = +.06 \quad t = .100$$

$$MS = \frac{42000}{1.40 (26502)} - 1 = +.13 \quad t = .100$$

∴ RAISE LOWER FLANGE TO $t = .100$ MIN

USING 3σ LOADS

BOLT STRESSES

AT BOLT

Report 10381
Addendum 1

$$F = F_1 = 105.88 \text{ LB/IN}$$

$$V = V_1 = .215 \text{ LB/IN}$$

15 BOLTS IN 19.29 INCHES

TOTAL LOAD / BOLT

$$F_B = 105.88 \left(\frac{19.29}{15} \right) = 136.2 \text{ LB}$$

$$V_B = .215 \left(\frac{19.29}{15} \right) = .28 \text{ LB}$$

1 ∇ LOADS

BOLTS ARE NAS1352N06-6, $F_{TU} = 160000 \text{ PSL}$

$$S_t = 3 \frac{F_B}{A_s} = 3 \frac{136.2}{.009085} = 44963 \text{ PSL}$$

3 ∇ LOADS

$$S_s = 3 \frac{V_B}{A_s} = 3 \frac{.28}{.009085} = 96 \text{ PSL}$$

$$S_t = 1.4 \times 44963 = 62948 \text{ PSL}$$

$$r_t = \frac{62948}{160000} = .393$$

$$S_s = 1.4 \times 96 = 134 \text{ PSL}$$

$$r_s = \frac{134}{(6)(160000)} = .0014 \approx 0$$

$$R_t \sim 1.0$$

$$U = \frac{r_t}{R_t} = .393$$

$$MS = \frac{1}{U} - 1 = +2.5$$

WORST LOADED BOLT
LOWER RIGHT PANEL
LOWER FLANGE
3 ∇ LOADS

\therefore BOLTS OK ON LOWER FLANGE

USING 3 ∇ LOADS

LOWER RIGHT PANEL - QUAD, TRI

639	649	659	669	679	689	699	709	719	729	739	749	759	769
638	648	658	668	678	688	698	708	718	728	738	748	758	768
637	647	657	667	677	687	697	707	717	727	737	747	757	767
636	646	656	666	676	686	696	706	716	726	736	746	756	766
635	645	655	665	675	685	695	705	715	725	735	745	755	765
634	644	654	664	674	684	694	704	714	724	734	744	754	764
633	643	653	663	673	683	693	703	713	723	733	743	753	763
632	642	652	662	672	682	692	702	712	722	732	742	752	762
631	641	651	661	671	681	691	701	711	721	731	741	751	761
x 630	640	650	660	670	680	690	700	710	720	730	740	750	760

UPPER FRONT PANEL - LOWER FLANGE

Report 10381
Addendum 1

RANDOM Y w/Q = 7.1 1 T LOADS.

EL	1652	1688	1760	1772	
Fx	12.125	12.561	10.33	10.083	LB/IN
Fy	5.468	15.213	5.625	2.575	"
Fxy	25.484	4.632	15.964	16.360	"
Mx	.0323	.0339	.0284	.0143	IN-LB/IN
My	.0213	.0257	.0256	.0155	"
Mxy	.0294	.0174	.0159	.0098	"
Vx	.0525	.0567	.0414	.0201	LB/IN
Vy	.3029	.0785	.0554	.0670	"

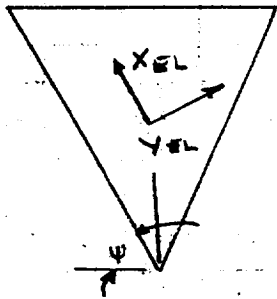
RANDOM X w/Q = 7.1 1 T LOADS

EL	1652	1688	1772	
Fx	8.903	4.143	3.228	LB/IN
Fy	2.235	4.422	.633	"
Fxy	6.105	2.256	4.193	"
Mx	.0179	.0405	.0256	IN-LB/IN
My	.0177	.0497	.0330	"
Mxy	.0189	.0223	.0165	"
Vx	.0367	.0688	.0243	LB/IN
Vy	.2350	.1797	.0733	"

RANDOM Z w/Q = 7.1 1 T LOADS

EL	1652	1688	1772	
Fx	5.525	4.268	4.607	LB/IN
Fy	1.698	5.029	1.600	"
Fxy	7.941	1.268	7.040	"
Mx	.0100	.0368	.0180	IN-LB/IN
My	.0094	.0411	.0242	"
Mxy	.0110	.0212	.0113	"
Vx	.0197	.0485	.0187	LB/IN
Vy	.1175	.1513	.0581	"

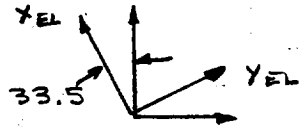
WORST CONDITION IS RANDOM Y @ EL 1652 WORST LOCATION.
EL 1688 HAS SKEWED "ELEMENT X & Y" DIRECTIONS.
ROTATING COMPONENTS TO HAVE "ELEM X" NORMAL
TO LOWER FLANGE IS LESS SEVERE THAN EL 1652



$$\tan \psi = \frac{\Delta Z}{\Delta Y} = \frac{1.125}{.746}$$

$$\psi = 56.5^\circ$$

$$90 - \psi = 33.5^\circ$$



$$\theta = -33.5^\circ$$

$$F_x' = \frac{F_x + F_y}{2} + \frac{F_x - F_y}{2} \cos 2\theta + F_{xy} \sin 2\theta$$

$$= 13.887 + (-1.326)(.3907) + (4.032)(-.9205) = 9.657 \text{ LB/IN}$$

∴ EL1652 WORST CASE

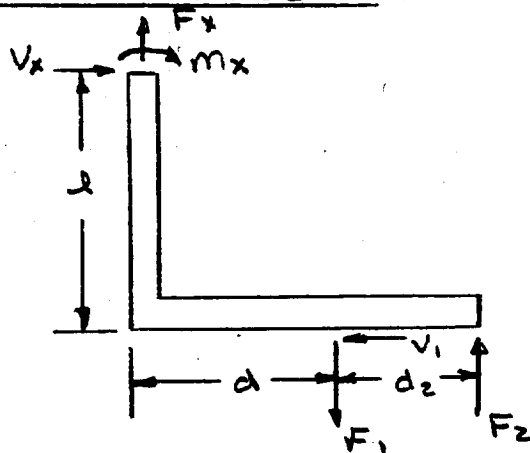
EL 1652

$$F_x = 12.125 \text{ LB/IN}$$

$$M_x = .0323 \text{ IN-LB/IN}$$

$$V_x = .0525 \text{ LB/IN}$$

FLANGE STRESSES

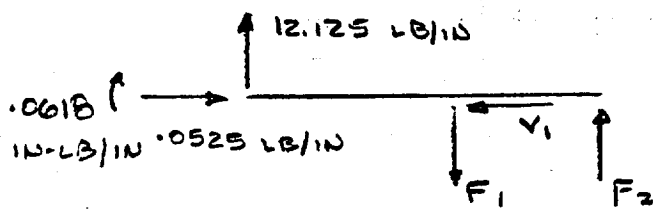


$$l = 1.125/2$$

$$d = .312$$

$$d_2 = .313$$

t = .040 FLANGE MINIMUM



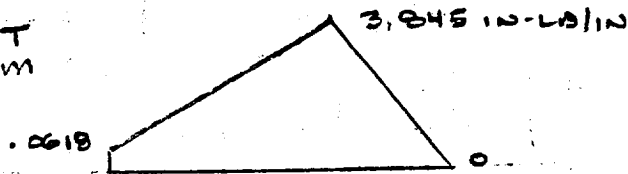
$$\sum M_2 = 0$$

$$F_1(.313) = 12.125(.625) + .0618$$

$$= 24.409 \text{ LB/IN}$$

$$F_2 = 12.284 \text{ LB/IN}$$

MOMENT
DIAGRAM



FLANGE TENSION (MEMBER + BEND) @ $t_{min} = .040$

$$S_t = 3 \left[\frac{V_1}{t} + \frac{6M_1}{t^2} \right]$$

$$= 3 \left[\frac{.0525}{.040} + \frac{6(3,845)}{(.040)^2} \right]$$

3 ∇ LOADS

$$= 3 [1 + 14419]$$

$$= 43260 \text{ PSI}$$

MAT'L 7075-T651

$$F_{ty} = 66000 \text{ PSI}$$

$$F_{tu} = 75000 \text{ PSI}$$

$$MS = \frac{F_{ty}}{1.25 \times S_t} - 1 = \frac{66000}{1.25(43260)} - 1 = +.22$$

$$MS = \frac{F_{tu}}{1.4 \times S_t} - 1 = \frac{75000}{1.4(43260)} - 1 = +.24$$

\therefore LOWER FLANGE OK @ $t = .040$

USING 3 ∇ LOADS

BOLT STRESSES

AT BOLT $F = F_1 = 24,409 \text{ LB/IN}$

$V = V_1 = .0525 \text{ LB/IN}$

7 BOLTS IN $11,200 - .625 = 10,575 \text{ IN}$

TOTAL LOAD/BOLT , 1 ∇ LOADS

$$F_B = \frac{10,575}{7} (24,409) = 36,875 \text{ LB}$$

$$V_B = \frac{10,575}{7} (.0525) = .08 \text{ LB}$$

BOLTS ARE NAS 1352 ND6-6 , $F_{tu} = 160000 \text{ PSI}$

④ 3T LOADS

$$S_t = 3 \frac{F_B}{A_s} = 3 \left(\frac{36,875}{.009085} \right) = 12177 \text{ psi}$$

$$S_s = 3 \frac{V_B}{A_s} = 3 \left(\frac{.08}{.009085} \right) = 27 \text{ psi}$$

3T LOADS

w/ FS = 1.4

$$S_t = 1.4 \times 12177 = 17048 \text{ psi}$$

$$v_t = \frac{17048}{160000} = .107$$

$$S_s = 1.4 \times 27 = 38 \text{ psi}$$

$$v_s = \frac{38}{(6)(160000)} = .0004 \approx 0$$

$$R_t \sim 1.0$$

$$u = \frac{v_t}{R_t} = .107$$

$$MS = \frac{1}{u} - 1 = + 8.3$$

WORST LOADED BOLT
UPPER FRONT PANEL
LOWER FLANGE

∴ BOLTS OK ON LOWER FLANGE
USING 3T LOADS

UPPER FRONT PANEL - UPPER FLANGE

Report 10381
Addendum 1

RANDOM Y w/Q=7.1 1 T LOADS

EL	1663	1783	
Fx	1.483	1.172	LB/IN
Mx	.0348	.0072	IN-LB/IN
Vx	.0102	.0001	LB/IN

RANDOM X w/Q=7.1 1 T LOADS

EL	1663	1783	
Fx	1.759	.905	LB/IN
Mx	.0101	.0199	IN-LB/IN
Vx	.0282	.0165	LB/IN

RANDOM Z w/Q=7.1 1 T LOADS

EL	1663	1711	1723	1783	
Fx	2.000	2.063	2.086	.820	LB/IN
Mx	.0048	.1248	.1618	.0121	IN-LB/IN
Vx	.0182	.1522	.1611	.0159	LB/IN

WORST LOAD IS FOR RANDOM Z @ EL 1723

COMPARE EL 1723 TO LOWER FLANGE EL 1652

EL 1723 < EL 1652

∴ UPPER FLANGE OK @ t=.50

MS > +.22 LIMIT

> +.24 ULT

PER 3T LOADS

∴ UPPER FLANGE BOLTS OK

MS > 8.3 ULT

PER 3T LOADS

UPPER FRONT PANEL - RIGHT FLANGE

Report 10381
Addendum 1

RANDOM Y w/Q=7.1 I T LOADS

EL	1652	1653	
F _y	5.468	6.116	LB/IN
M _y	.0213	.0277	IN-LB/IN
V _y	.3029	.6723	LB/IN

RANDOM X w/Q=7.1 I T LOADS

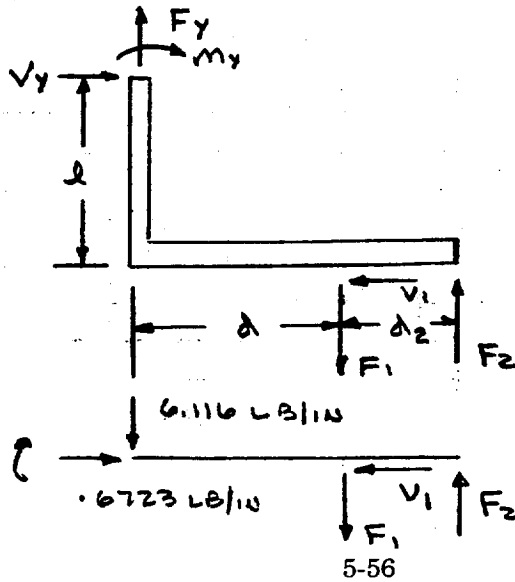
EL	1652	1653	1655	1656	
F _y	2.235	2.374	3.592	3.589	LB/IN
M _y	.0177	.0371	.1664	.2256	IN-LB/IN
V _y	.2350	.5163	1.081	1.711	LB/IN

RANDOM Z w/Q=7.1 I T LOADS

EL	1652	1653	
F _y	1.698	2.492	LB/IN
M _y	.0094	.0207	IN-LB/IN
V _y	.1175	.2337	LB/IN

WORST CASE IS EL 1653 RANDOM Y

$F_y = 6.116 \text{ LB/IN}$
 $M_y = .0277 \text{ IN-LB/IN}$
 $V_y = .6723 \text{ LB/IN}$



$l = .937/2$
 $d = .312$
 $d_2 = .313$

FLANGE $t = .040 \text{ IN MIN}$

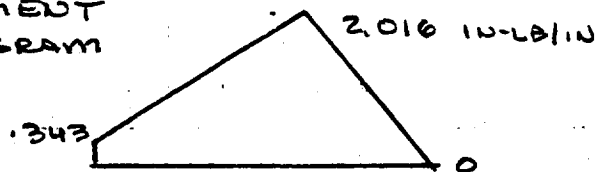
$$\sum M_2 = 0 \quad F_1 (.313) = 6.116 (.625) + .343$$

$$F_1 = 12.555 \text{ LB/IN}$$

$$F_2 = 6.439 \text{ LB/IN}$$

$$V_1 = .672 \text{ LB/IN}$$

MOMENT
DIAGRAM



FLANGE TENSION (MEMBER + BEND) @ t = .040

$$S_t = 3 \left[\frac{V_1}{t} + \frac{6M_1}{t^2} \right]$$

3T LOADS

$$= 3 \left[\frac{.672}{.040} + \frac{6(2.016)}{(.040)^2} \right]$$

$$= 3 [17 + 7560] = 22730 \text{ PSI}$$

$$MS = \frac{F_{tu}}{1.25 \times S_t} - 1$$

$$= \frac{66000}{1.25(22730)} - 1 = +1.3$$

$$MS = \frac{F_{tu}}{1.4 \times S_t} - 1$$

$$= \frac{75000}{1.4(22730)} - 1 = +1.4$$

∴ RIGHT FLANGE OK @ t = .040
USING 3T LOADS

BOLT STRESSES

AT BOLT

$$F = F_1 = 12.555 \text{ LB/IN}$$

$$V = V_1 = .672 \text{ LB/IN}$$

$$8 \text{ BOLTS IN } 12.500 - 1.000 = 11.500 \text{ IN}$$

TOTAL LOAD / BOLT

$$F_B = \left(\frac{11,500}{8}\right)(12.555) = 18.05 \text{ LB}$$

$$V_B = \left(\frac{11,500}{8}\right)(.672) = .97 \text{ LB}$$

1 T LOADS

BOLTS ARE NAS1352N06-6, $F_{tu} = 160000 \text{ psi}$

$$S_t = 3 \frac{F_B}{A_s} = 3 \frac{18.05}{.009085} = 5960 \text{ psi}$$

3 T LOADS

$$S_s = 3 \frac{V_B}{A_s} = 3 \frac{.97}{.009085} = 317 \text{ psi}$$

$$S_t = 1.4 \times 5960 = 8345 \text{ psi}$$

$$r_t = \frac{8345}{160000} = .052$$

$$S_s = 1.4 \times 317 = 443 \text{ psi}$$

$$r_s = \frac{443}{(6)(160000)} = .005 \approx 0$$

$$R_t \sim 1.0$$

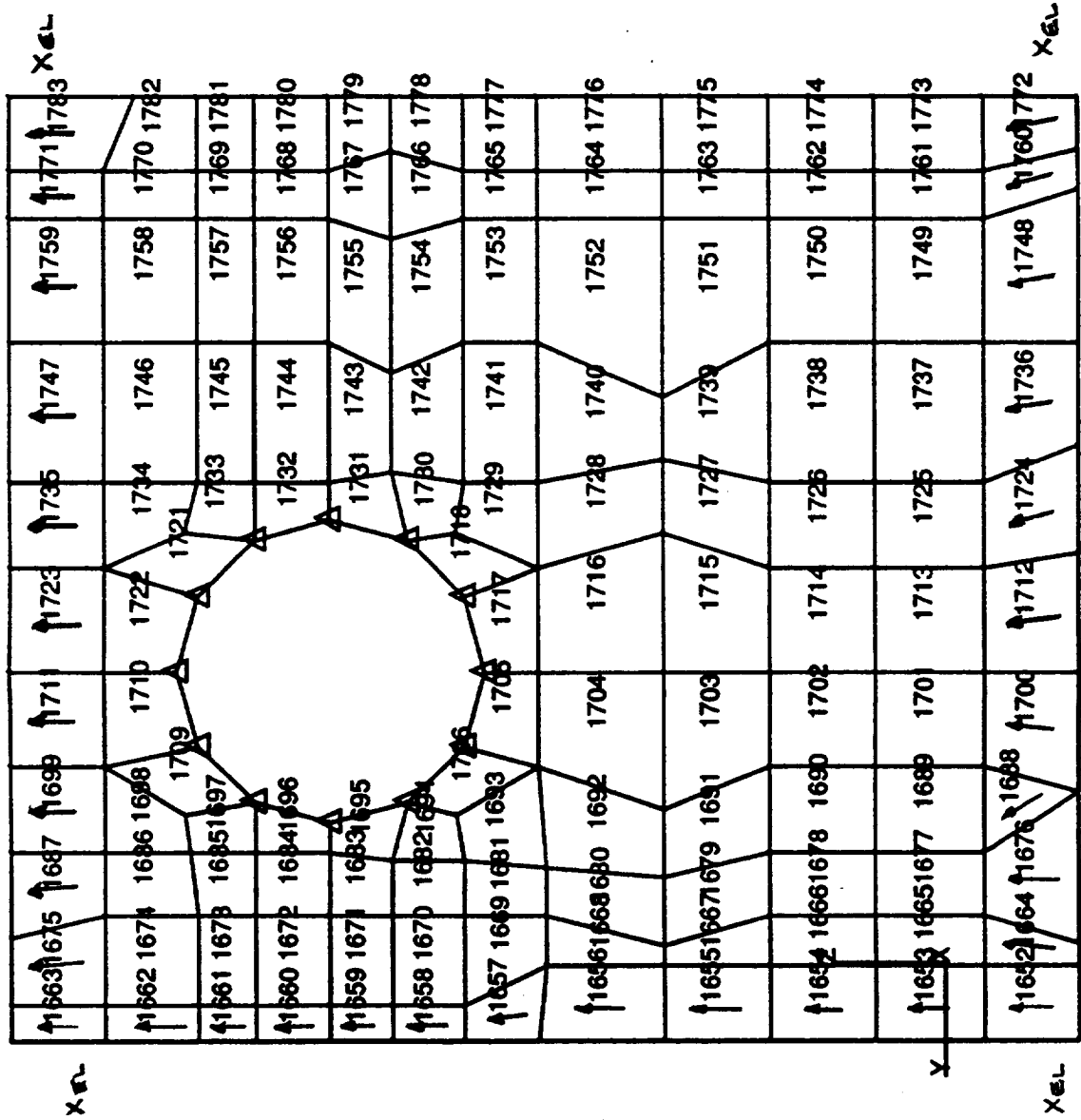
$$u = \frac{r_t}{R_t} = .052$$

$$MS = \frac{1}{u} - 1 = +18$$

WORST LOADED BOLT
UPPER FRONT PANEL
RIGHT FLANGE
3 T LOADS

∴ BOLTS OK ON RIGHT FLANGE
WITH 3 T LOADS

UPPER FRONT PANEL
QUAD, TRI



LOWER MOTOR MOUNT PANEL - LOWER FLANGE

RANDOM Y w/Q=7.1 1 T LOADS

EL	2810	2812*	2813	2819	
Fy	4.904	17.18	7.542	4.094	LB/IN
My	.0241	.114	.1022	.0086	IN-LB/IN
Vy	.0490	.0958	.0516	.0229	LB/IN

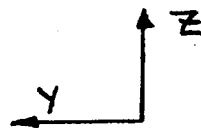
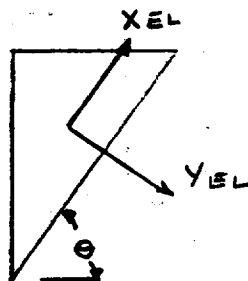
RANDOM X w/Q=7.1 1 T LOADS

EL	2810	2811	2812*	2813	2817	
Fy	2.608	5.970	15.47	7.311	7.513	LB/IN
My	.0220	.0116	.090	.0735	.0463	IN-LB/IN
Vy	.0536	.1363	.1235	.1165	.1143	LB/IN

RANDOM Z w/Q=7.1 1 T LOADS

EL	2810	2812*	2813	2816	
Fy	2.227	4.82	4.826	4.132	LB/IN
My	.0098	.178	.0913	.1370	IN-LB/IN
Vy	.0184	.1373	.0374	.1197	LB/IN

* EL 2812 HAS SKEWED "ELEMENT X & Y" DIRECTIONS ROTATING COMPONENTS TO MAKE "ELEM X" NORMAL TO FLANGE



$$\tan \theta = \frac{\Delta Z}{\Delta Y} = \frac{1.131}{.811}$$

$$\theta = 54.4^\circ$$

$$90 - \theta = 35.6^\circ = \gamma$$



RANDOM Y - EL 2812

$$F_x' = \frac{F_x + F_y}{2} + \frac{F_x - F_y}{2} \cos 2\delta + F_{xy} \sin 2\delta$$

$$= \frac{10.83 + 12.66}{2} + \frac{10.83 - 12.66}{2} \cos 71.2^\circ + 6.36 \sin 71.2^\circ$$

$$= 17.18 \text{ LB/IN}$$

$$M_x' = \frac{.0847 + .0453}{2} + \frac{.0847 - .0453}{2} \cos 71.2^\circ + .0384 \sin 71.2^\circ$$

$$= .114 \text{ IN-LB/IN}$$

$$V_x' = V_x = .0958 \text{ LB/IN}$$

RANDOM X - EL 2812

$$F_x' = \frac{7.827 + 14.811}{2} + \frac{7.827 - 14.811}{2} \cos 71.2^\circ + 6.76 \sin 71.2^\circ$$

$$= 15.47 \text{ LB/IN}$$

$$M_x' = \frac{.0605 + .0666}{2} + \frac{.0605 - .0666}{2} \cos 71.2^\circ + .0295 \sin 71.2^\circ$$

$$= .090 \text{ IN-LB/IN}$$

$$V_x' = V_x = .1235 \text{ LB/IN}$$

RANDOM Z - EL 2812

$$F_x' = \frac{3.899 + 3.049}{2} + \frac{3.899 - 3.049}{2} \cos 71.2^\circ + 1.133 \sin 71.2^\circ$$

$$= 4.82 \text{ LB/IN}$$

$$M_x' = \frac{.1242 + .1046}{2} + \frac{.1242 - .1046}{2} \cos 71.2^\circ + .0643 \sin 71.2^\circ$$

$$= .178 \text{ IN-LB/IN}$$

$$V_x' = V_x = .1373 \text{ LB/IN}$$

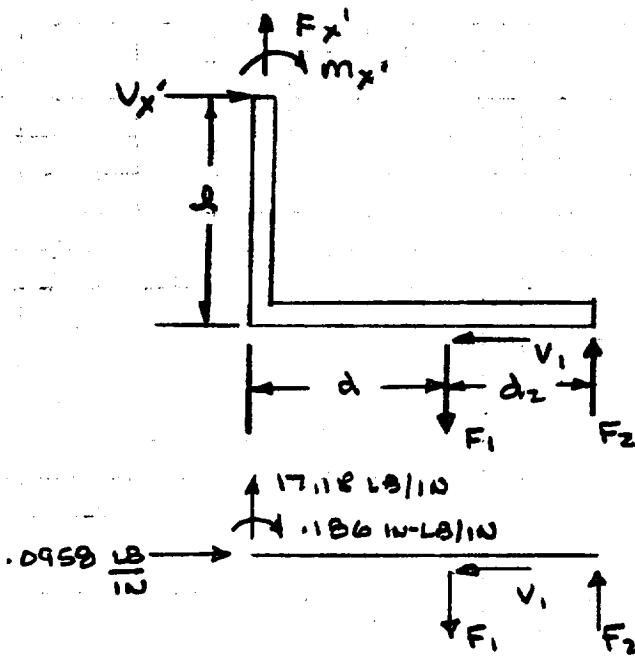
WORST CASE IS RANDOM Y @ EL 2812

$$F_x' = 17.18 \text{ LB/IN}$$

$$M_x' = .114 \text{ IN-LB/IN}$$

$$V_x' = .0958 \text{ LB/IN}$$

FLANGE STRESSES



$$l = \frac{2}{3}(1.131) = .754$$

$$d = .312$$

$$d_2 = .438$$

$t = .050$ FLANGE MINIMUM

$$\sum M_2 = 0 \quad F_1(.438) = 17.18(.750) + .186$$

$$F_1 = 29.84 \text{ LB/IN}$$

$$F_2 = 12.66 \text{ LB/IN}$$

$$V_1 = .096 \text{ LB/IN}$$

MOMENT DIAGRAM



FLANGE TENSION (MEMB + BEND) @ $t = .050$ MIN

$$S_t = 3 \left[\frac{V_1}{t} + \frac{6 M_1}{t^2} \right] = 3 \left[\frac{.096}{.050} + \frac{6(5.546)}{(.050)^2} \right]$$

$$= 3 [2 + 13310]$$

$$= 39937 \text{ PSI}$$

3 ∇ LOADS

MAT'RL 7075-T651

$$F_{Ty} = 66000 \text{ PSI}$$

$$F_{Tu} = 75000 \text{ PSI}$$

W/F S = 1.25 LIMIT, 1.4 ULTIMATE

$$MS = \frac{F_{ty}}{1.25 \times S_t} - 1$$

$$= \frac{66000}{1.25(39937)} - 1 = + .32$$

$$MS = \frac{F_{tu}}{1.40 \times S_t} - 1 =$$

$$= \frac{75000}{1.40(39937)} - 1 = + .34$$

∴ LOWER FLANGE OK @ t = .050
USING 3T LOADS

BOLT STRESSES

AT BOLT $F = F_1 = 29.84 \text{ LB/IN}$

$V = V_1 = .096 \text{ LB/IN}$

6 BOLTS IN 10.562 IN

TOTAL LOAD/BOLT @ 1T LOAD

$$F_B = \frac{10.562}{6} (29.84) = 52.53 \text{ LB}$$

$$V_B = \frac{10.562}{6} (.096) = .17 \text{ LB}$$

BOLTS ARE NAS1352N06-6, $F_{tu} = 160000 \text{ PSI}$
@ 3T LOADS

$$S_t = 3 \frac{F_B}{A_s} = 3 \frac{52.53}{.009085} = 17346 \text{ PSI}$$

$$S_s = 3 \frac{V_B}{A_s} = 3 \frac{.17}{.009085} = 56 \text{ PSI}$$

3T LOADS

$$W/FS = 1.4$$

$$S_t = 1.4 \times 17346 = 24284 \text{ PSL}$$

$$r_t = \frac{24284}{160000} = .152$$

$$S_s = 1.4 \times 56 = 79 \text{ PSL}$$

$$r_s = \frac{79}{(6)(160000)} = .0008 \approx 0$$

$$R_t \sim 1.0$$

$$U = \frac{r_t}{R_t} = .152$$

$$MS = \frac{1}{U} - 1 = +5.6$$

WORST LOADED BOLT
LOWER MOTOR MT PANEL
LOWER FLANGE
USING 3T LOADS

00 BOLTS OK ON LOWER FLANGE

USING 3T LOADS

LOWER MOTOR MOUNT PANEL - TOP FLANGE

THE "TOP FLANGE" IS DEFINED AS THE $t=.055$ THICK FLANGES ABOVE THE MOTOR.

RANDOM Y $w/Q=7.1$ | ∇ LOADS

	2878	2882	2884	2886	
EL	2878	2882	2884	2886	
F _x	1.624				LB/IN
F _y	1.999	.446	1.243	1.094	"
F _{xy}	1.281				"
M _x	.0124				IN-LB/IN
M _y	.0072	.0091	.0225	.0300	"
M _{xy}	.0067				"
V _x	.0339				LB/IN
V _y	.0332	.0241	.0715	.0698	"

RANDOM X $w/Q=7.1$ | ∇ LOADS

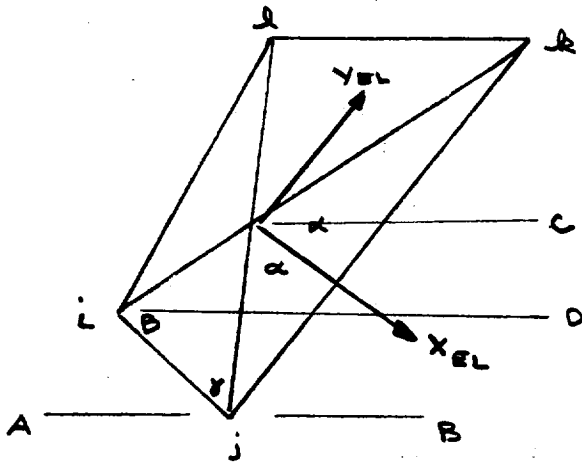
	2878	2882	2884	2886	
EL	2878	2882	2884	2886	
F _x	7.493				LB/IN
F _y	3.193	2.626	1.236	5.100	"
F _{xy}	2.547				"
M _x	.0493				IN-LB/IN
M _y	.0160	.0295	.1300	.1771	"
M _{xy}	.0325				"
V _x	.2168				LB/IN
V _y	.1489	.1224	.3743	.5323	"

RANDOM Z $w/Q=7.1$ | ∇ LOADS

	2878	2882	2884	2886	
EL	2878	2882	2884	2886	
F _x	1.141				LB/IN
F _y	1.101	.496	.552	.968	"
F _{xy}	1.295				"
M _x	.0123				IN-LB/IN
M _y	.0057	.0100	.0241	.0327	"
M _{xy}	.0052				"
V _x	.0462	.0076	.0250	.0658	LB/IN
V _y	.0270				"

WORST CONDITION IS RANDOM X @ EL 2878
RIGHT SIDE

AT EL 2878 THE "X_{ELEM}" DIRECTION IS SLIGHTLY
SKEWED FROM THE I-J SIDE NORMAL



	Y	Z
i	9.021	9.313
j	8.751	9.073
k	7.796	10.221
l	8.646	10.221



$$\angle A_j i \quad \tan^{-1} \frac{.240}{.270} = 41.63^\circ$$

$$\angle B_j l \quad \tan^{-1} \frac{1.148}{.105} = 84.77^\circ$$

$$\angle B_j k \quad \tan^{-1} \frac{1.148}{.955} = 50.24^\circ$$

$$\angle D_l k \quad \tan^{-1} \frac{.908}{1.225} = 36.55^\circ$$

$$\angle D_l i \quad \tan^{-1} \frac{.908}{.375} = 67.56^\circ$$

$$\perp \text{ TO } i j \quad \angle = 67.56 - 40 = -22.44^\circ$$

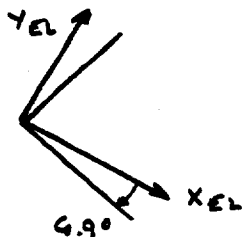
$$\gamma = 180 - 84.77 - 41.63 = 53.60^\circ$$

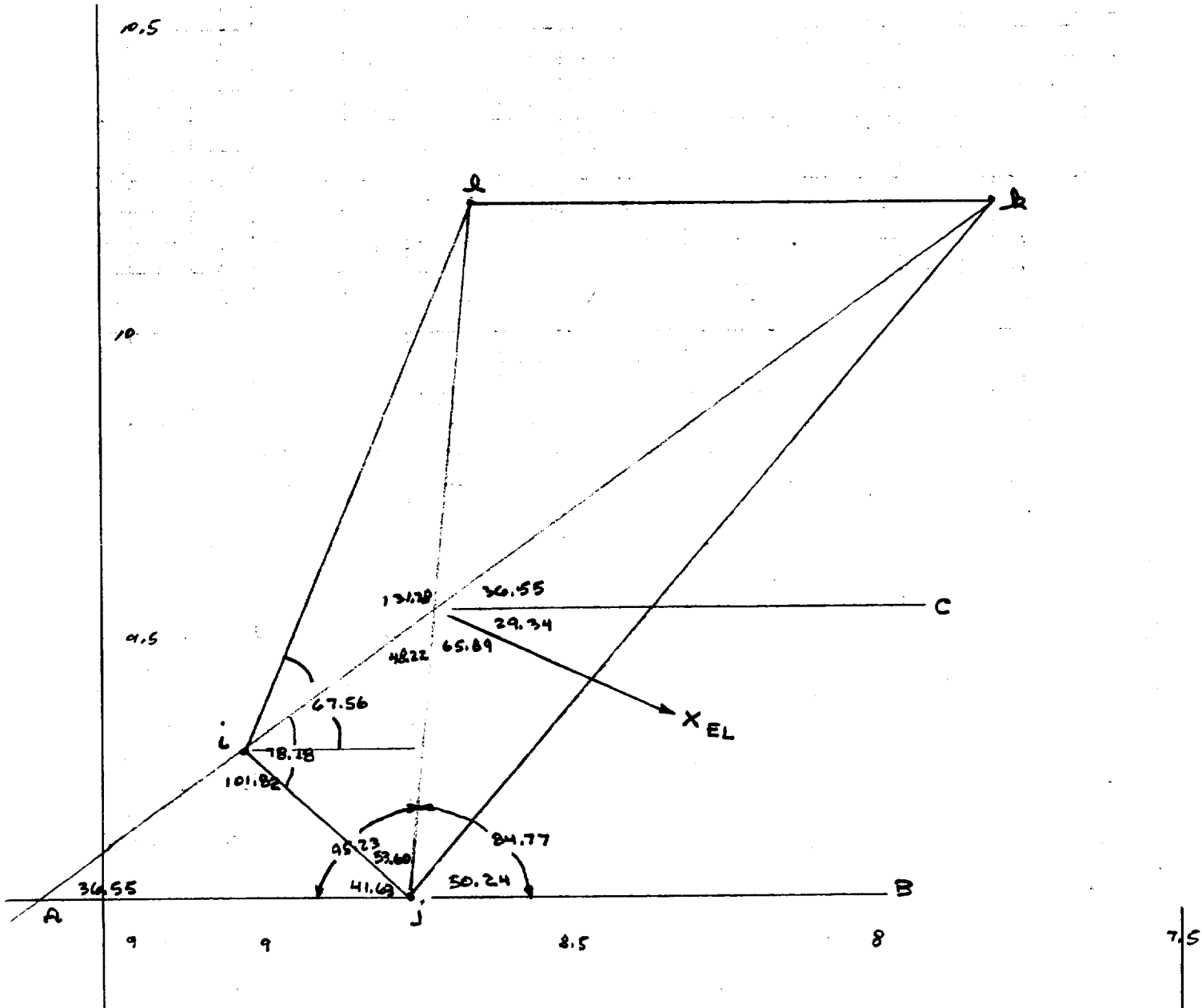
$$\beta = 41.63 + 36.55 = 78.18^\circ$$

$$\alpha = (53.60 + 78.18) / 2 = 65.89$$

$$X_{EL} @ -(65.89 - 36.55) = -29.34$$

ROTATE X_{EL} 29.34 - 22.44 = 6.9 CW





$\angle A_j L \quad \tan^{-1} \frac{.240}{.270} = 41.63^\circ$
 $\angle B_j L \quad \tan^{-1} \frac{1.148}{.105} = 84.77^\circ$
 $\angle B_j E \quad \tan^{-1} \frac{1.148}{.955} = 50.24$
 $\angle B A_j L \quad \tan^{-1} \frac{.908}{1.225} = 36.55$
 $\angle L E \quad \tan^{-1} \frac{.908}{.375} = 67.56$

$\perp L E \quad 67.56 - 90 = -22.44$
 $\angle E L \quad -29.34$
 ROTATE 6.9° CW

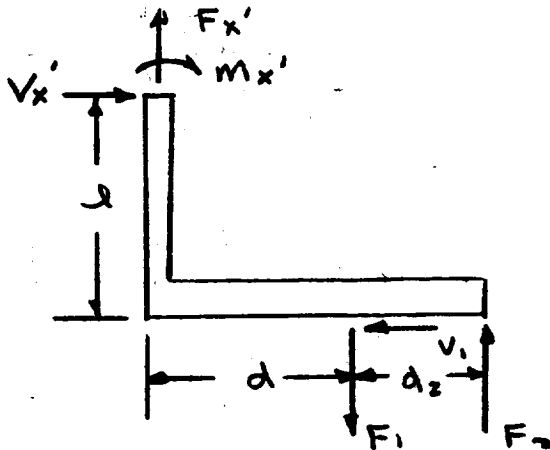
$$F_x' = \frac{7.493 + 3.193}{2} + \frac{7.493 - 3.193}{2} \cos(-13.8^\circ) + 2.547 \sin(-13.8^\circ)$$

$$= 6.823 \text{ LB/IN}$$

$$m_x' = .041 \text{ IN-LB/IN}$$

$$V_x' = V_x = .2168 \text{ LB/IN}$$

FLANGE STRESSES

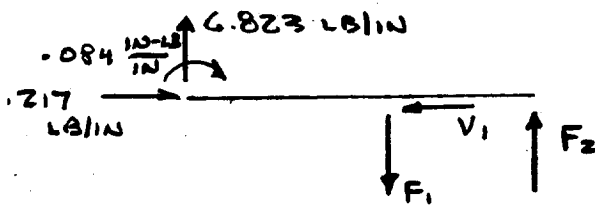


$$l = .2$$

$$d = .312$$

$$d_2 = .438$$

$t = .050$ FLANGE MINIMUM



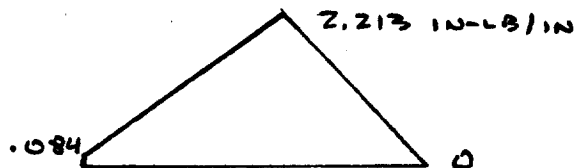
$$\sum M_2 = 0 \quad F_1 (.438) = 6.823 (.750) + .084$$

$$F_1 = 11.876 \text{ LB/IN}$$

$$F_2 = 5.053 \text{ LB/IN}$$

$$V_1 = .217 \text{ LB/IN}$$

MOMENT DIAGRAM



FLANGE TENSION (MEMB + BEND) @ $t_{min} = .050$

$$S_t = 3 \left[\frac{V_1}{t} + \frac{6m_1}{t^2} \right]$$

@ 3T LOADS

$$= 3 \left[\frac{.217}{.050} + \frac{6(2.213)}{(1.050)^2} \right]$$

$$= 3 [4 + 5311]$$

② 3T L0405

$$= 15946 \text{ psi}$$

w/ FS = 1.25 LIMIT, 1.4 ULT

$$MS = \frac{F_{ty}}{1.25 \times S_t} - 1$$

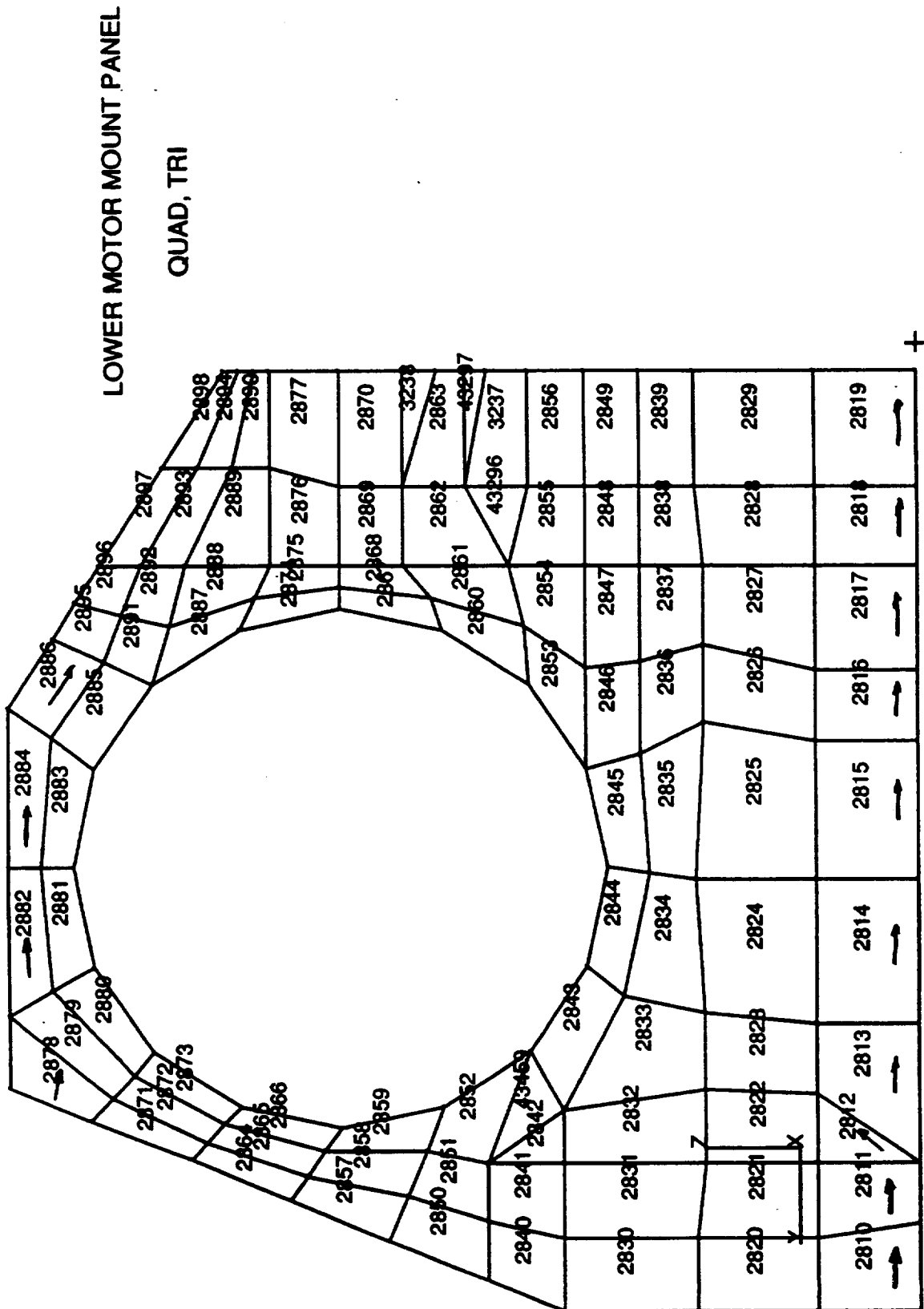
$$= \frac{66000}{1.25(15946)} - 1 = + 2.3$$

$$MS = \frac{F_{tu}}{1.4 \times S_t} - 1$$

$$= \frac{75000}{1.4(15946)} - 1 = + 2.4$$

∴ TOP FLANGE OK @ t = .050

USING 3T L0405



UPPER MOTOR MOUNT PANEL - LOWER FLANGE

RANDOM Y W/Q=7.1 IT LOADS

EL	2634	2635	2642	
F _y	9.448	13.795	9.675	LB/IN
M _y	.0177	.0217	.0201	IN-LB/IN
V _y	.0847	.0367	.0442	LB/IN

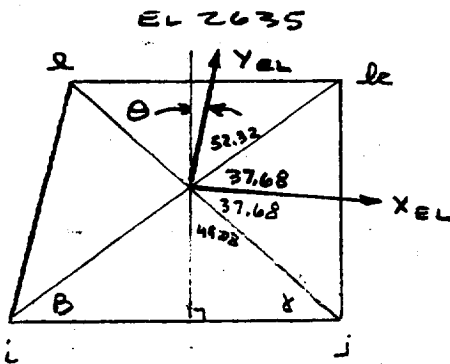
RANDOM X W/Q=7.1 IT LOADS

EL	2634	2635	2642	
F _y	4.000	8.365	14.176	LB/IN
M _y	.0211	.0263	.0166	IN-LB/IN
V _y	.0979	.0572	.0645	LB/IN

RANDOM Z W/Q=7.1 IT LOADS

EL	2634	2635	2642	
F _y	3.611	6.151	7.878	LB/IN
M _y	.0118	.0131	.0148	IN-LB/IN
V _y	.0631	.0451	.0206	LB/IN

WORST CASE IS EL 2635 WHOSE SKEWED "ELEMENT X & Y" DIRECTIONS LEAD TO NORMAL COMPONENTS F_y', M_y', V_y' OF



$$\beta = \tan^{-1} \frac{1.125}{1.640} = 34.45^\circ$$

$$\gamma = \tan^{-1} \frac{1.125}{1.298} = 40.92^\circ$$

$$90 - \gamma = 49.08$$

$$\alpha = \frac{\gamma + \beta}{2} = 37.68^\circ$$

$$\theta = 180 - 52.32 - 2(37.68) - 49.08$$

$$= 3.2^\circ \text{ CCW}$$

ROTATE EL 2635 $\theta = 3.2^\circ$

Report 10381
Addendum 1

$$F_y' = \frac{13.795 + 2.476}{2} + \frac{13.795 - 2.476}{2} \cos(2 \times 3.2^\circ) + 8.414 \sin(2 \times 3.2^\circ)$$

$$= 14.698 \text{ LB/IN}$$

$$M_y' = \frac{.0217 + .0278}{2} + \frac{.0217 - .0278}{2} \cos(2 \times 3.2^\circ) + .0219 \sin(2 \times 3.2^\circ)$$

$$= .0242 \text{ IN-LB/IN}$$

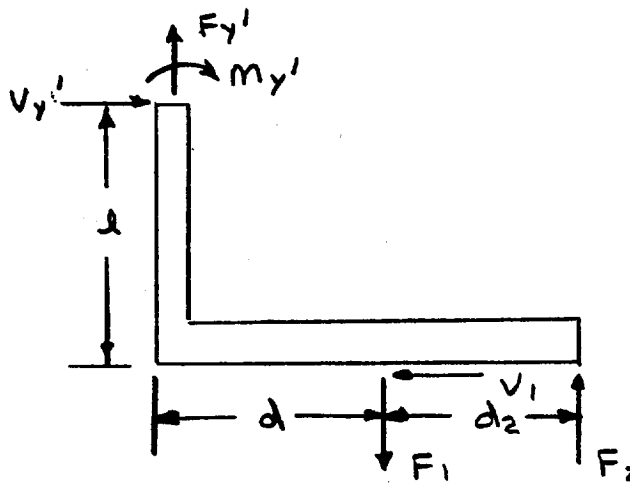
$$V_y' = V_y = .0367 \text{ LB/IN}$$

$$F_y' = 14.698 \text{ LB/IN}$$

$$M_y' = .0242 \text{ IN-LB/IN}$$

$$V_y' = .0367 \text{ LB/IN}$$

FLANGE STRESSES

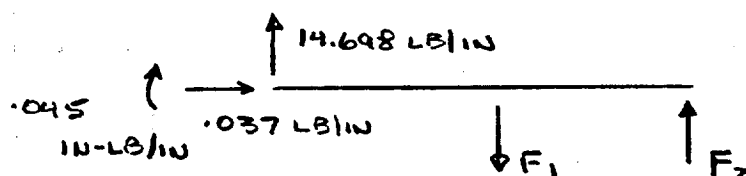


$$d = .312$$

$$d_2 = .438$$

$$l = 1.125/2$$

FLANGE $t = .050$
MINIMUM



$$\Sigma M_2 = 0$$

$$F_1(.438) = 14.698(.750) + .045$$

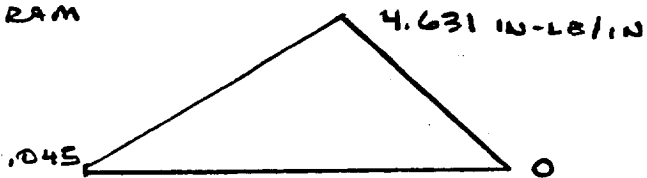
$$F_1 = 25.271 \text{ LB/IN}$$

$$F_2 = 10.573 \text{ LB/IN}$$

$$V_1 = .037 \text{ LB/IN}$$

Report 10381
Addendum 1

MOMENT
DIAGRAM



FLANGE TENSION (MEMB + BEND) @ $t = .050$ MIN

$$S_t = 3 \left[\frac{V_1}{t} + \frac{6M_1}{t^2} \right]$$

$$= 3 \left[\frac{.037}{.050} + \frac{6(4.631)}{(.050)^2} \right]$$

3T LOADS

$$= 3 [1 + 11114]$$

$$= 33345 \text{ PSI}$$

MAT'L 7075-T651

$$F_{ty} = 66000 \text{ PSI}$$

$$F_{tu} = 75000 \text{ PSI}$$

W/F 1.25 LIMIT, 1.4 VLT

$$MS = \frac{F_{ty}}{1.25 \times S_t} - 1$$

$$= \frac{66000}{1.25(33345)} - 1 = +.58$$

$$MS = \frac{F_{tu}}{1.4 \times S_t} - 1$$

$$= \frac{75000}{1.4(33345)} - 1 = +.61$$

• • LOWER FLANGE OK @ $t = .050$

USING 3T LOADS

BOLT STRESSES

Report 10381
Addendum 1

AT BOLT

$$F = F_1 = 25.571 \text{ LB/IN}$$

$$V = V_1 = .037 \text{ LB/IN}$$

6 BOLTS IN 10.563 IN

TOTAL LOAD/BOLT

$$F_B = \frac{10.563}{6} (25.571) = 45.02 \text{ LB}$$

$$V_B = \frac{10.563}{6} (.037) = .065 \text{ LB}$$

BOLTS ARE NAS 1352ND6, $F_{TU} = 160000 \text{ PSI}$
② 3T LOADS

$$S_t = 3 \frac{F_B}{A_s} = 3 \frac{45.02}{.009085} = 14866 \text{ PSI}$$

$$S_s = 3 \frac{V_B}{A_s} = 3 \frac{.065}{.009085} = 21 \text{ PSI}$$

3T LOADS

$$FS = 1.4$$

$$S_t = 1.4 \times 14866 = 20812 \text{ PSI}$$

$$V_t = \frac{20812}{160000} = .130$$

$$S_s = 1.4 \times 21 = 30 \text{ PSI}$$

$$V_s = \frac{30}{(6)(160000)} = .0003 \Rightarrow 0$$

$$R_t \sim 1.0$$

$$u = \frac{V_t}{R_t} = .130$$

$$MS = \frac{1}{u} - 1 = + 6.7$$

WORST LOADED BOLT
UPPER MOTOR MI PANEL
LOWER FLANGE
USING 3T LOADS

∴ BOLTS OK ON LOWER FLANGE

USING 3T LOADS

UPPER MOTOR MOUNT PANEL - RIGHT FLANGE

RANDOM Y w/Q=7.1 1σ LOADS

EL	2634	2643	2652	
F _x	10.565	19.290	3.786	LB/IN
M _x	.0322	.0596	.0346	IN-LB/IN
V _x	.0842	.0788	.0349	LB/IN

RANDOM X w/Q=7.1 1σ LOADS

EL	2634	2643	2652	
F _x	6.362	10.206	5.221	LB/IN
M _x	.0237	.0492	.0261	IN-LB/IN
V _x	.1305	.1088	.3170	LB/IN

RANDOM Z w/Q=7.1 1σ LOADS

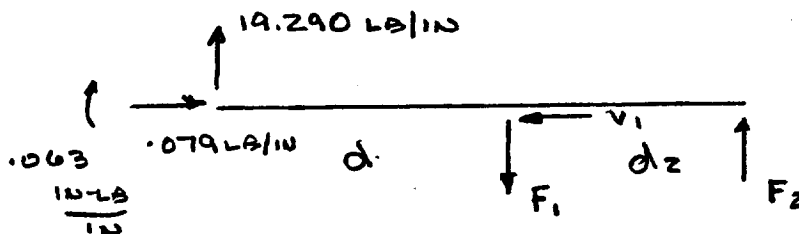
EL	2634	2643	2652	
F _x	4.810	8.451	1.537	LB/IN
M _x	.0164	.0346	.0259	IN-LB/IN
V _x	.0773	.0589	.3079	LB/IN

WORST CASE IS RANDOM Y @ EL 2643

F_x = 19.290 LB/IN
M_x = .0596 IN-LB/IN
V_x = .0788 LB/IN

FLANGE STRESSES

SIMILAR TO LOWER FLANGE



d = .312
d₂ = .438
L = .595/2

FLANGE t = .050
MINIMUM

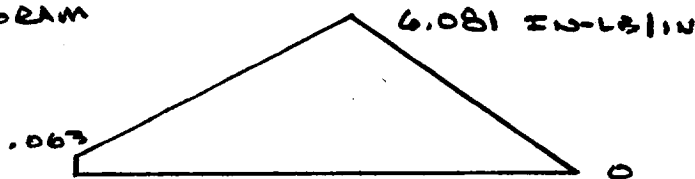
$$\sum M_2 = 0 \quad F_1(.438) = 19,290(.750) + .063$$

$$F_1 = 33.175 \text{ LB/IN}$$

$$F_2 = 13.885 \text{ LB/IN}$$

$$V_1 = .079 \text{ LB/IN}$$

MOMENT
DIAGRAM



FLANGE TENSION (MEMB + BEND) @ MIN $t = .050$

$$S_t = 3 \left[\frac{V_1}{t} + \frac{6M_1}{t^2} \right]$$

$$= 3 \left[\frac{.079}{.050} + \frac{6(6.081)}{(.050)^2} \right]$$

@ 3 ∇ LOADS

$$= [2 + 14594]$$

$$= 43788 \text{ PSL}$$

$$MS = \frac{66000}{1.25(43788)} - 1 = +.21$$

$$MS = \frac{75000}{1.4(43788)} - 1 = +.22$$

∴ RIGHT FLANGE OK @ $t = .050$

USING 3 ∇ LOADS

BOLT STRESSES

AT BOLT

$$F = F_1 = 33.175 \text{ LB/IN}$$

$$V = V_1 = .08 \text{ LB/IN}$$

3 BOLTS IN 6.245 IN

TOTAL LOAD/BOLT

$$F_B = \frac{6.245}{3} (33.175) = 69.06 \text{ LB}$$

$$V_B = \frac{6.245}{3} (1.08) = .17 \text{ LB}$$

BOLTS ARE NAS1352N06, $F_{TU} = 160000 \text{ PSI}$

$$S_t = 3 \frac{F_B}{A_s} = 3 \frac{69.06}{.009085} = 22804 \text{ PSI}$$

$$S_s = 3 \frac{V_B}{A_s} = 3 \frac{.17}{.009085} = 56 \text{ PSI}$$

© 3T LOADS

$$F_S = 1.4$$

$$S_t = 1.4 \times 22804 = 31926$$

$$r_t = \frac{31926}{160000} = .200$$

$$S_s = 1.4 \times 56 = 79 \text{ PSI}$$

$$r_s = \frac{79}{(6)(160000)} = .0008 \Rightarrow 0$$

$$R_t \sim 1.0$$

$$u = \frac{r_t}{R_t} = .200$$

$$MS = \frac{1}{u} - 1 = +4.0$$

WORST LOADED BOLT
UPPER MOTOR MOUNT PANEL
RIGHT FLANGE
USING 3T LOADS

∴ BOLTS OK ON RIGHT FLANGE

USING 3T LOADS

UPPER MOTOR MOUNT PANEL - TOP FLANGE

Report 10381
Addendum 1

THE "TOP FLANGE" IS DEFINED AS THE t=.055 THICK FLANGES ABOVE THE MOTOR

RANDOM Y W/Q=7.1 1 V LOADS

EL	2700	2706	2708	2720	2722	2724	2727	
F _x	2.668	1.992	1.908	1.450	12.583	5.441	9.386	LB/IN
F _y	10.402	11.187	5.600	1.746	2.768	1.802	2.723	"
F _{xy}	14.836	3.392	1.508	1.531	4.418	6.550	4.165	"
M _x	.7180	.152	.109	.0028	.0018	.0175	.0323	IN-LB/IN
M _y	.2098	.0848	.0374	.0120	.0647	.0887	.0541	"
M _{xy}	.2478	.1788	.156	.0109	.0152	.0191	.0101	"
V _x	7.843	1.168	.461	.0180	.0274	.0833	.2003	LB/IN
V _y	2.017	.1869	.0524	.0312	.2143	.3327	.0937	"

RANDOM X W/Q=7.1 1 V LOADS

EL	2700	2706	2708	2720	2722	2724	2727	
F _x	3.158	2.287	2.126	2.073	21.826	4.077	13.081	LB/IN
F _y	13.105	14.451	7.696	2.562	3.137	2.007	4.085	"
F _{xy}	18.454	4.006	1.654	1.376	6.375	8.781	5.128	"
M _x	.711	.1832	.1264	.0032	.0033	.0221	.0456	IN-LB/IN
M _y	.194	.1049	.0658	.0159	.0744	.1043	.0659	"
M _{xy}	.292	.2168	.1890	.0133	.0184	.0191	.0128	"
V _x	9.222	1.566	.703	.0279	.0404	.1072	.2467	LB/IN
V _y	2.480	.2698	.0650	.0546	.2441	.4811	.1086	"

RANDOM Z W/Q=7.1 1 V LOADS

EL	2700	2706	2708	2720	2722	2724	2727	
F _x	.930	1.615	.850	1.965	5.069	2.978	5.081	LB/IN
F _y	4.819	3.240	2.478	.647	.823	.575	1.156	"
F _{xy}	4.160	1.210	1.165	.0977	1.598	2.078	1.219	"
M _x	.184	.0633	.0462	.0013	.0009	.0056	.0128	IN-LB/IN
M _y	.0642	.0349	.0389	.0049	.0187	.0255	.0156	"
M _{xy}	.156	.0498	.0471	.0034	.0040	.0058	.0040	"
V _x	1.999	.360	.212	.0067	.0157	.0246	.0566	IN
V _y	.535	.149	.0466	.0137	.0614	.0931	.0263	"

NOTE "ELEM-X" IS APPROXIMATELY PERPENDICULAR TO FLANGE IN EL 2700, 2706, 2708. "ELEM-Y" IS IN EL 2720, 2722, 2724, AND 2727.

WORST CASE IS RANDOM X @ BL 2727

$$\begin{aligned} F_y &= 4.085 \text{ LB/IN} \\ M_y &= .0659 \text{ IN-LB/IN} \\ V_y &= .1086 \text{ LB/IN} \end{aligned} \quad 1 \nabla \text{ LOADS}$$

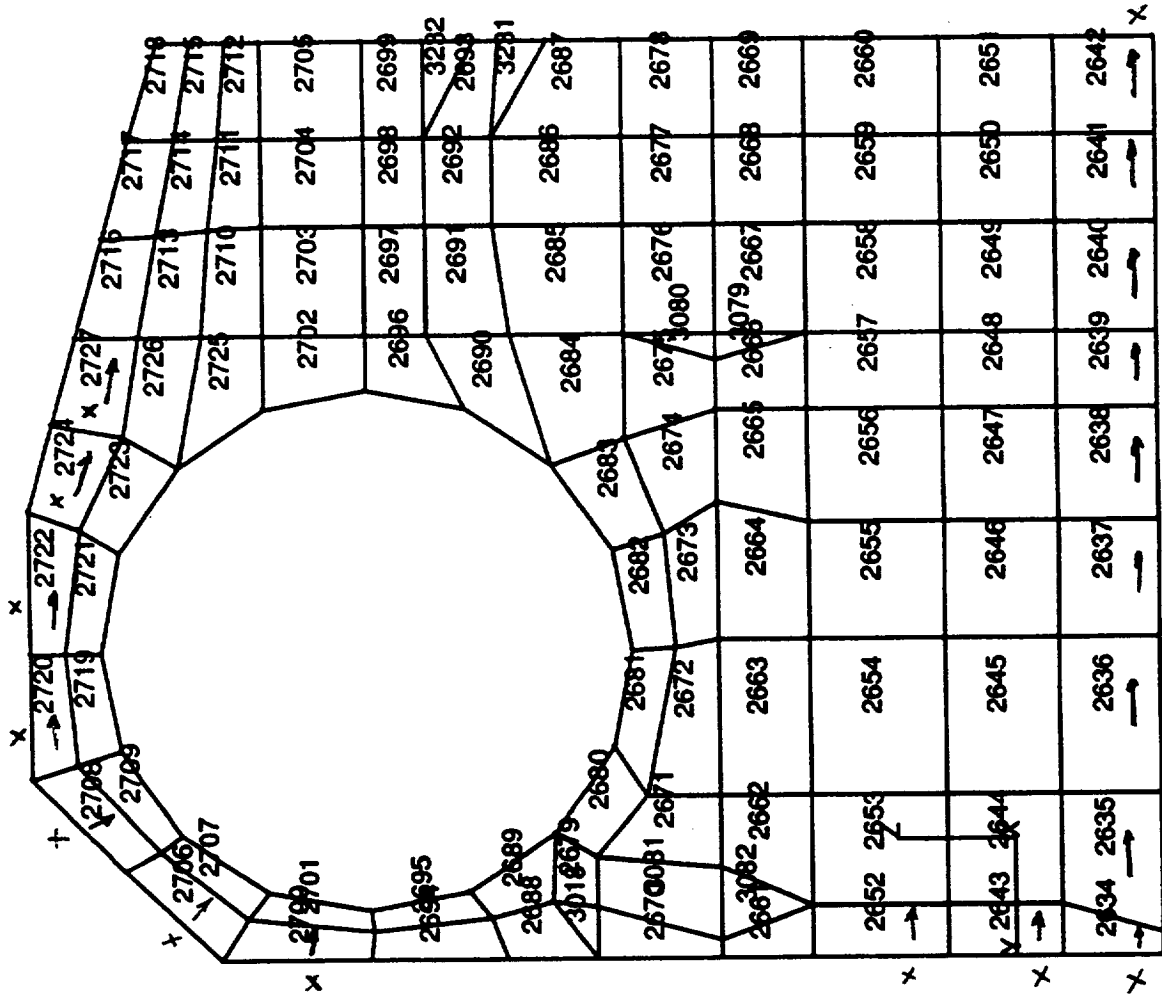
THESE LOADS << LOWER FLANGE ($F_y' = 14.648 \text{ LB/IN}$)
AND RIGHT FLANGE ($F_x = 19.290 \text{ LB/IN}$) THEREFORE
BY COMPARISON

FLANGE STRESSES

$$\begin{aligned} MS > + .21 & \quad \text{LIMIT} \\ MS > + .22 & \quad \text{ULTIMATE} \end{aligned} \quad 3 \nabla \text{ LOADS}$$

∴ TOP FLANGE OK @ $E = .050$
USING 3 ∇ LOADS

UPPER MOTOR MOUNT PANEL
QUAD, TRI



LOWER FRONT PANEL - LOWER FLANGE

RANDOM Y - W/Q=7.1 1 T LOADS

EL	1435	1445	1475	1503	1547	
F _x	12.694	11.462	13.066	14.183	4.526	LB/IN
F _y	8.847	15.037	13.761	22.265	28.357	"
F _{xy}	17.828	11.104	12.167	2.028	51.844	"
M _x	.0845	.1070	.0513	.0491	.0449	IN-LB/IN
M _y	.0704	.0540	.0395	.0220	.0121	"
M _{xy}	.0393	.0220	.0237	.0410	.0125	"
V _x	.4041	.3688	.0823	.0701	.5882	LB/IN
V _y	.1927	.2629	.0774	.0887	.5548	"

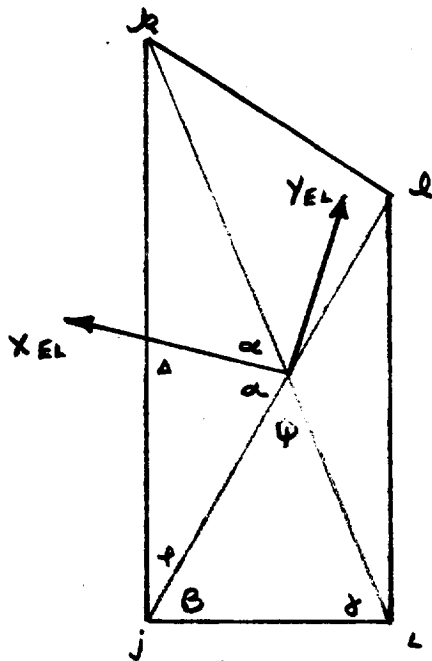
RANDOM X - W/Q=7.1 1 T LOADS

EL	1435	1445	1475	1503	1547	
F _x	2.380	4.856	3.713	5.100	1.181	LB/IN
F _y	9.004	7.217	3.547	5.689	11.649	"
F _{xy}	7.575	3.470	4.028	1.905	8.993	"
M _x	.2550	.3024	.0780	.0880	.0256	IN-LB/IN
M _y	.2191	.0763	.0429	.0698	.0077	"
M _{xy}	.1223	.0282	.0219	.0385	.0096	"
V _x	1.170	.9037	.2663	.1545	.2745	LB/IN
V _y	.5665	.8035	.1890	.1903	.2289	"

RANDOM Z - W/Q=7.1 1 T LOADS

EL	1435	1445	1475	1503	1547	
F _x	8.598	5.068	7.457	3.715	1.321	LB/IN
F _y	4.634	12.670	3.716	5.298	12.974	"
F _{xy}	7.599	3.849	5.260	1.366	24.039	"
M _x	.0425	.0565	.1794	.0855	.0578	IN-LB/IN
M _y	.0432	.0984	.1173	.0476	.0056	"
M _{xy}	.0177	.0127	.0782	.0703	.0087	"
V _x	.1572	.1446	.1552	.1231	.3921	LB/IN
V _y	.0816	.1303	.1706	.1584	.3526	"

WORST CASE IS RANDOM Y @ EL 1547, WHICH IS A SLIGHTLY SKEWED ELEMENT. "ELEM Y" IS TO BE ROTATED 3.4° CCW TO BE NORMAL TO THE LOWER FLANGE



	Y	Z
L	11.222	0
J	11.846	0
K	11.846	1.531
L	11.222	1.131

$$\delta = \tan^{-1} \frac{1.531}{.624} = 67.83^\circ$$

$$\theta = \tan^{-1} \frac{1.131}{.624} = 61.11^\circ$$

$$\phi = 180 - \delta - \theta = 51.06^\circ$$

$$\frac{\delta + \theta}{2} = \alpha = 64.47^\circ$$

$$\theta = 90 - \theta = 28.89^\circ$$

$$\Delta = 180 - \alpha - \phi = 86.64^\circ$$

X_{EL} is 90 - 86.64 = 3.36° CW OF NORMAL
 Y_{EL} " " " " " "

ROTATE Y_{EL} + 3.36° (CCW)

EL 1547

$$F_y' = \frac{28.357 + 4.526}{2} + \frac{28.357 - 4.526}{2} \cos(2 \times 3.36^\circ) + 51.044 \sin(2 \times 3.36^\circ)$$

$$= 34.248 \text{ LB/IN}$$

$$M_y' = \frac{.0121 + .0949}{2} + \frac{.0121 - .0949}{2} \cos(2 \times 3.36^\circ) + .0125 \sin(2 \times 3.36^\circ)$$

$$= .014 \text{ IN-LB/IN}$$

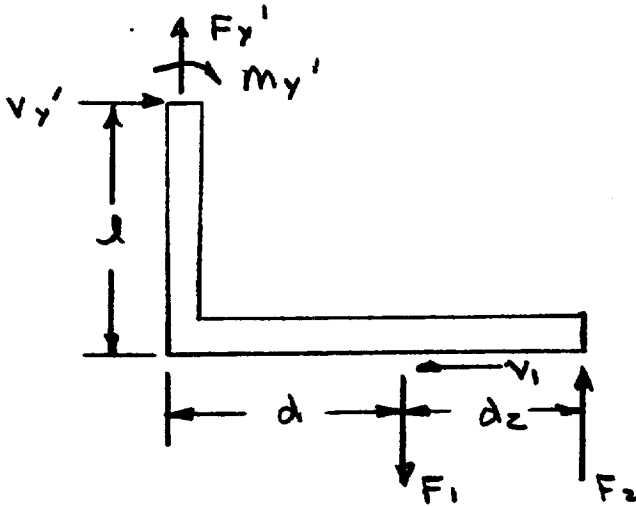
$$V_y' = V_y = .5548 \text{ LB/IN}$$

$$F_y' = 34.248 \text{ LB/IN}$$

$$M_y' = .014 \text{ IN-LB/IN}$$

$$V_y' = .555 \text{ LB/IN}$$

FLANGE STRESSES

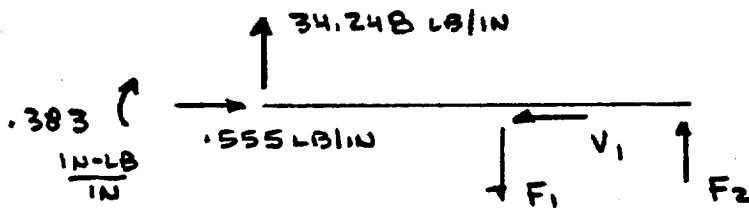


$$d = .313$$

$$d_2 = .312$$

$$l = 1.331/2$$

FLANGE $t = .040$
MINIMUM



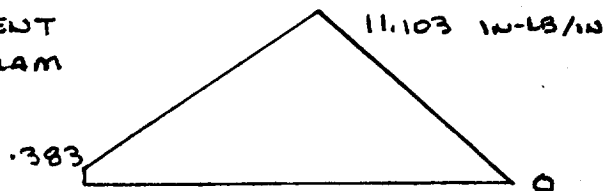
$$\sum M_2 = 0 \quad F_1 (.312) = 34.248 (.625) + .383$$

$$F_1 = 69.83 \text{ LB/IN}$$

$$F_2 = 35.59 \text{ LB/IN}$$

$$V_1 = .555 \text{ LB/IN}$$

MOMENT
DIAGRAM



FLANGE TENSION (MEMB + BEND) @ $t_{min} = .040$

$$S_t = 3 \left[\frac{V_1}{t} + \frac{6M_1}{t^2} \right] = \frac{.555}{.04} + \frac{6(11.103)}{(.040)^2}$$

$$= 3 [14 + 41636]$$

$$= 124950 \text{ psi}$$

@ 37 LOADS

W/FS 1.25 LIMIT, 1.4 ULTIMATE

$$MS = \frac{F_{TY}}{1.25 \times S_t} - 1$$

$$= \frac{35000}{1.25(124950)} - 1 = -.78$$

$$MS = \frac{F_{TU}}{1.4 \times S_t} - 1$$

$$= \frac{42000}{1.4(124950)} - 1 = -.76$$

∴ FLANGE BAD @ $t = .040$ (LOWER FLANGE)

SEE RECOMMENDATION

BOLT STRESSES

AT BOLT

$$F = F_1 = 69.83 \text{ LB/IN}$$

$$V = V_1 = .555 \text{ LB/IN}$$

8 NAS1352ND6 BOLTS ($F_{TU} = 160000 \text{ psi}$) IN

$$11.188 - .625 = 10.563 \text{ IN}$$

TOTAL LOADS

$$F_B = \frac{10.563}{8} (69.83) = 92.2 \text{ LB}$$

$$V_B = \frac{10.563}{8} (.555) = .73 \text{ LB}$$

③ ST LOADS

$$S_s = 3 \frac{F_B}{A_s} = 3 \frac{92.2}{.009085} = 30445 \text{ psi}$$

$$S_s = 3 \frac{V_B}{A_s} = 3 \frac{.73}{.009085} = 241 \text{ psi}$$

$$FS = 1.4$$

$$S_t = 1.4 \times 30445 = 42623 \text{ psi}$$

$$r_t = \frac{42623}{160000} = .266$$

$$S_s = 1.4 \times 241 = 337 \text{ psi}$$

$$r_s = \frac{337}{(.6)(160000)} = .003 \approx 0$$

$$R_t \sim 1.0$$

$$u = \frac{r_t}{R_t} = .266$$

$$MS = \frac{1}{u} - 1 = + 2.8$$

WORST LOADED BOLT
LOWER FRONT PANEL
LOWER FLANGE
USING 3T LOADS

∴ BOLTS OK ON LOWER FLANGE

USING 3T LOADS

DUE TO LOW MS ON FLANGE, RECOMMEND A THICKNESS INCREASE TO .090 (FROM .040)

@ $t = .090$, w/ 3T LOADS

$$S_t = 3 \left[\frac{.555}{.090} + \frac{6(11,103)}{(.090)^2} \right]$$

FLANGE
STRESSES

$$= 3 [6 + 8224]$$

$$= 24692 \text{ psi}$$

$$MS = \frac{35000}{1.25(24692)} - 1 = +.13$$

$$t = .090$$

$$MS = \frac{42000}{1.4(24692)} - 1 = +.21$$

$$t = .090$$

∴ w/ $t = .090$ LOWER FLANGE OK

USING 3T LOADS

LOWER FRONT PANEL - UPPER FLANGE

RANDOM Y W/Q=7.1 I T LOADS

EL	1454	1516	1526	1556	
F _x	8.270	5.185	1.767	2.517	LB/IN
F _y	9.043	7.708	8.068	7.965	"
F _{xy}	13.420	18.987	13.420	11.165	"
M _x	.0082	.0203	.0459	.0314	IN-LB/IN
M _y	.0147	.0954	.0920	.0100	"
M _{xy}	.0088	.0075	.0110	.0058	"
V _x	.0149	.0270	.0361	.0282	LB/IN
V _y	.0206	.1585	.1362	.0160	"

RANDOM X W/Q=7.1 I T LOADS

EL	1546	
F _x	1.492	LB/IN
F _y	4.259	"
F _{xy}	4.086	"
M _x	.0137	IN-LB/IN
M _y	.0405	"
M _{xy}	.0180	"
V _x	.0128	LB/IN
V _y	.0781	"

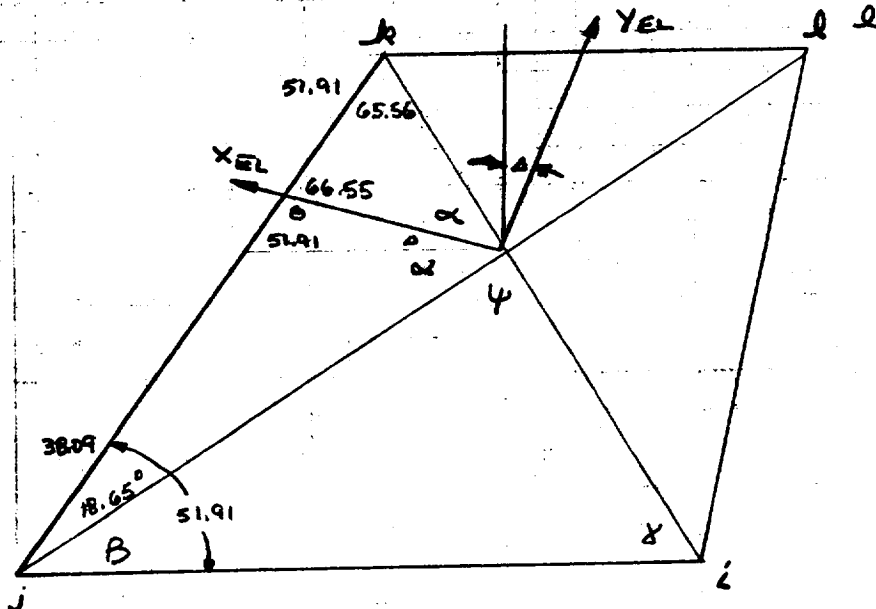
RANDOM Z W/Q=7.1 I T LOADS

EL	1546	
F _x	.414	LB/IN
F _y	3.628	"
F _{xy}	2.445	"
M _x	.0088	IN-LB/IN
M _y	.0239	"
M _{xy}	.0094	"
V _x	.0108	LB/IN
V _y	.0342	LB/IN

WORST CASE IS RANDOM Y AT EL 1454, WHICH IS SLIGHTLY SKEWED. "ELEM Y" NEED BE ROTATED CCW 14.64 TO BE NORMAL TO THE UPPER FLANGE

EL 1454

	Y	Z
i	1.12	9.421
j	2.0	9.421
k	1.471	10.096
l	.971	10.096



$$\angle jlk \quad \tan^{-1} \frac{.675}{.351} = 62.53^\circ = \gamma$$

$$\angle lji \quad \tan^{-1} \frac{.675}{1.029} = 33.26^\circ = \beta$$

$$\angle \psi = 180 - \gamma - \beta = 84.21^\circ$$

$$\alpha = \frac{\gamma + \beta}{2} = 47.89^\circ$$

$$\angle ljk \quad \tan^{-1} \frac{.675}{.529} = 51.91^\circ$$

$$\theta = 180 - 18.65 - \alpha = 113.45^\circ$$

$$\Delta = 14.64^\circ$$

Y_{EL} IS 14.64° CW OF NORMAL TO UPPER FLANGE

ROTATE F_y 14.64° CCW

$$F_y' = \frac{9.043 + 8.270}{2} + \frac{9.043 - 8.270}{2} \cos(2 \times 14.64^\circ) + 13.420 \sin(2 \times 14.64^\circ)$$

$$= 15.557 \text{ LB/IN}$$

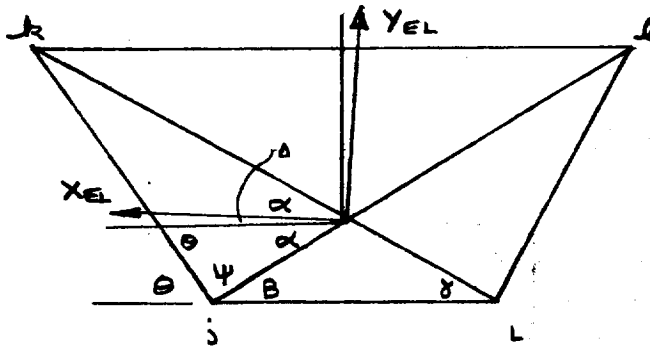
$$M_y' = .0186 \text{ IN-LB/IN}$$

$$V_y' = V_y = .0206 \text{ LB/IN}$$

Report 10381
Addendum 1

EL 1516

	Y	Z
L	7.6	9.421
J	8.326	9.421
K	8.8	10.046
L	7.246	10.046



$$\angle jk \quad \tan^{-1} \frac{.675}{1.2} = 29.36^\circ = \gamma$$

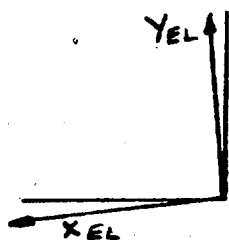
$$\angle lj \quad \tan^{-1} \frac{.675}{1.08} = 32.01^\circ = \beta$$

$$\alpha = \frac{\gamma + \beta}{2} = 30.68^\circ$$

$$\angle jk = \theta = \tan^{-1} \frac{.675}{.474} = 54.92^\circ$$

$$\psi = 180 - \beta - \theta = 93.07^\circ$$

$$180 = \theta + \psi + (\alpha - \delta) \quad \delta = -1.33^\circ$$



ROTATE YEL 1.33° CW TO
ACHIEVE NORMAL

$$F_y' = \frac{7.708 + 5.185}{2} + \frac{7.708 - 5.185}{2} \cos(2\alpha - 1.33^\circ) + 18.987 \sin(-2.66^\circ)$$

$$= 6.825 \text{ LB/IN}$$

LESS SEVERE THAN EL 1454

$$F_y' = 15.557 \text{ LB/IN}$$

$$M_y' = .0186 \text{ IN-LB/IN}$$

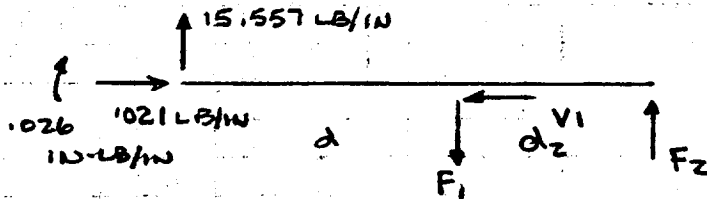
$$V_y' = .0206 \text{ LB/IN}$$

© ELI 54 RANDOMY

Report 10381
Addendum 1

FLANGE STRESSES

SIMILAR TO LOWER FLANGE



$$d = .675/2$$

$$d = .313$$

$$d_2 = .312$$

FLANGE $t = .040$
MINIMUM

$$\sum M_2 = 0 \quad F_1(.312) = 15.557(.625) + .026$$

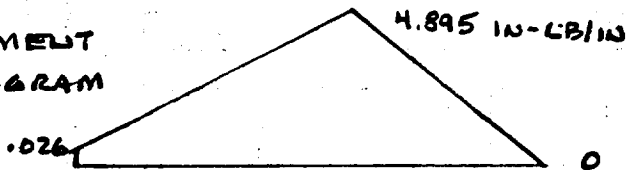
$$F_1 = 31.247 \text{ LB/IN}$$

$$F_2 = 15.690 \text{ LB/IN}$$

$$V_1 = .021 \text{ LB/IN}$$

3D LOADS

MOMENT
DIAGRAM



FLANGE TENSION (MEMB + BEND) @ $t_{min} = .040$

$$S_t = 3 \left[\frac{V_1}{t} + \frac{6M_1}{t^2} \right]$$

© 3D LOADS

$$= 3 \left[\frac{.021}{.040} + \frac{6(4.895)}{(.040)^2} \right] = 55070 \text{ psi}$$

$$MS = \frac{35000}{1.25(55070)} - 1 = -.49$$

$$MS = \frac{42000}{1.4(55070)} - 1 = -.45$$

∴ UPPER FLANGE BAD @ $t = .040$

USING 3D LOADS

REQUIRE $t = .060$ MINIMUM , @ 3T LOADS

$$S_t = 3 \left[\frac{.021}{.060} + \frac{6(4.895)}{(.060)^2} \right] = 24476 \text{ PSI}$$

$$MS = \frac{35000}{1.25(24476)} - 1 = +.14$$

3T LOADS

$$MS = \frac{42000}{1.4(24476)} - 1 = +.23$$

∴ UPPER FLANGE OK @ $t = .060$
USING 3T LOADS

BOLT STRESSES

AT BOLT

$$F = F_1 = 31.247 \text{ LB/IN}$$

$$V = V_1 = .021 \text{ LB/IN}$$

7 BOLTS IN $11.188 - .9 = 10.288 \text{ IN}$
 A51352N06 W/ FTU = 160000 PSU

TOTAL LOAD/BOLT

$$F_B = \frac{10.288}{7} (31.247) = 45.924 \text{ LB}$$

$$V_B = \frac{10.288}{7} (.021) = .031 \text{ LB}$$

1 ∇ LOADS

$$S_t = 3 \frac{F_B}{A_s} = 3 \frac{45.924}{.009085} = 15165 \text{ PSU}$$

$$S_s = 3 \frac{V_B}{A_s} \Rightarrow 0$$

3 ∇ LOADS

$$S_t = 1.4 \times 15165 = 21230 \text{ PSU}$$

$$v_t = \frac{21230}{160000} = .133$$

$$R_t = 1.0$$

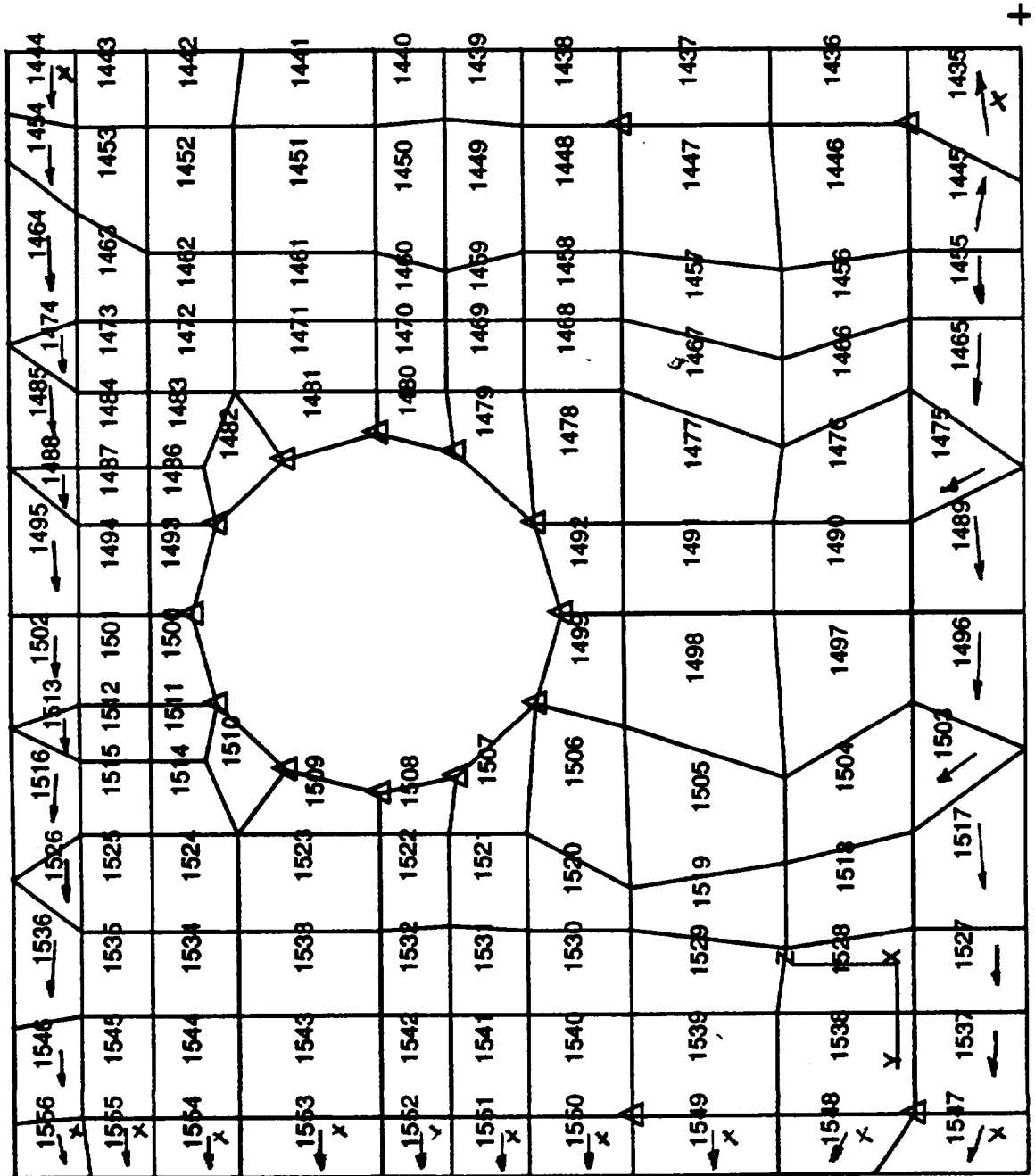
$$u = \frac{v_t}{R_t} = .133$$

$$MS = \frac{1}{u} - 1 = +6.5$$

WORST LOADED BOLT
 LOWER FRONT PANEL
 UPPER FLANGE
 USING 3 ∇ LOADS

0 BOLTS OK ON UPPER FLANGE
USING 3 ∇ LOADS

LOWER FRONT PANEL
QUAD. TRI



UPPER AFT PANEL - LOWER FLANGE

Report 10381
Addendum 1

RANDOM Y w/Q=7.1 1 ∇ LOADS

EL	44328	44326	44339	
F _x			11.542	LB/IN
F _y	14.738	10.261		"
F _{xy}				"
M _x			1.426	IN-LB/IN
M _y	1.395	1.125		"
M _{xy}				"
V _x			2.512	LB/IN
V _y	.964	.517		"

RANDOM X w/Q=7.1 1 ∇ LOADS

EL	44323	44329	44336	
F _x				LB/IN
F _y	16.378	17.394	17.282	"
F _{xy}				"
M _x				IN-LB/IN
M _y	1.228	10.041	10.496	"
M _{xy}				"
V _x				LB/IN
V _y	2.710	5.700	5.892	"

RANDOM Z w/Q=7.1 1 ∇ LOADS

EL	44328			
F _x				LB/IN
F _y	10.544			"
F _{xy}				"
M _x				IN-LB/IN
M _y	1.519			"
M _{xy}				"
V _x				LB/IN
V _y	3.874			"

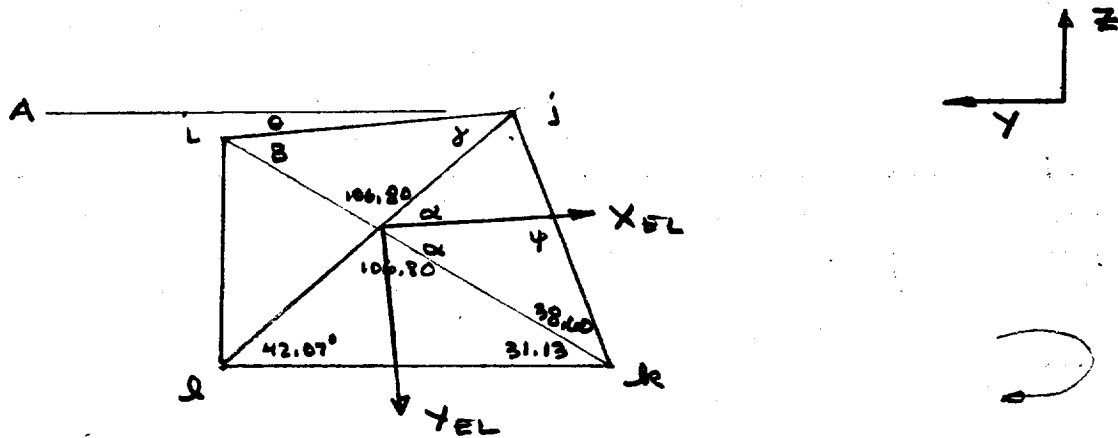
WORST CASE IS RANDOM X @ EL 44329

F_y = 17.394 LB/IN
 M_y = 10.041 IN-LB/IN
 V_y = 5.700 LB/IN

ELEMENT 44329 IS SLIGHTLY SKEWED

Report 10381
Addendum 1

	Y	Z
L	8.15	10.7
J	17.40	10.773
Jr	7.15	10.096
Q	8.15	10.096



$$\angle \theta = \tan^{-1} \frac{.073}{.75} = 5.56^\circ$$

$$\angle A_j Q = \tan^{-1} \frac{.677}{.75} = 42.07^\circ$$

$$\gamma = 42.07 - 5.56 = 36.51^\circ$$

$$\angle Q Jr Q = \tan^{-1} \frac{.604}{1} = 31.13^\circ$$

$$\beta = 180 - 106.80 - 36.51 = 36.69$$

$$\alpha = \frac{\gamma + \beta}{2} = 36.60$$

$$\angle Jr J = \tan^{-1} \frac{.677}{.25} = 69.73^\circ$$

$$\phi = 180 - \alpha - 36.60 = 104.80$$

ROTATE Y_{EL} $42.07 - 36.60 = 5.47^\circ$ CW TO ACHIEVE NORMAL

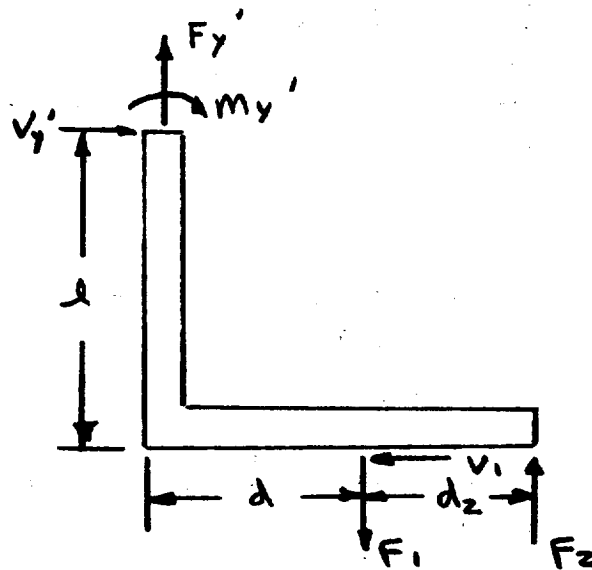
$$F_y' = \frac{17.394 + 14.673}{2} + \frac{17.394 - 14.673}{2} \cos(2 \times -5.47^\circ) + 3.360 \sin(2 \times -5.47^\circ)$$

$$F_y' = 16.732 \text{ LB/IN}$$

$$M_y' = \frac{10.041 + 3.332}{2} + \frac{10.041 - 3.332}{2} \cos(2 \times -5.47^\circ) + 1.695 \sin(2 \times -5.47^\circ) = 9.658 \text{ IN-LB/IN}$$

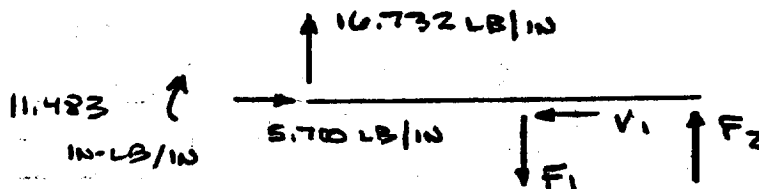
$$V_y' = V_y = 5.700 \text{ LB/IN}$$

$$\begin{aligned} F_y' &= 16.732 \text{ LB/IN} \\ M_y' &= 9.658 \text{ IN-LB/IN} \\ V_y' &= 5.700 \text{ LB/IN} \end{aligned}$$

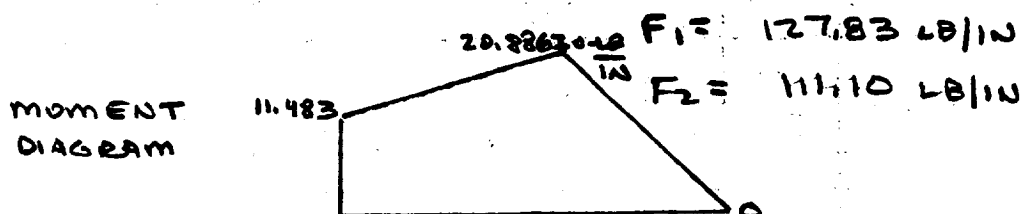


$$\begin{aligned} d &= .562 \\ d_2 &= .188 \\ l &= .6405/2 \end{aligned}$$

FLANGE $t = .060$
MINIMUM



$$\sum M_2 = 0 \quad F_1 (.188) = 16.732 (.750) + 11.483$$



FLANGE STRESSES

Report 10381
Addendum 1

MEMB + BEND @ 3T LOADS FOR $t_{min} = .060$ IN

$$\begin{aligned} S_t &= 3 \left[\frac{V_1}{t} + \frac{6M_1}{t^2} \right] \\ &= 3 \left[\frac{5.780}{.060} + \frac{6(20.886)}{(.060)^2} \right] \\ &= 3 [95 + 34810] \\ &= 104715 \text{ PSI} \end{aligned}$$

MAT'L 6061-T651

$$F_{ty} = 35000 \text{ PSI}$$

$$F_{tu} = 42000 \text{ PSI}$$

W/F S 1.25 LIMIT, 1.4 ULTIMATE

$$\begin{aligned} MS &= \frac{F_{ty}}{1.25 \times S_t} - 1 \\ &= \frac{35000}{1.25(104715)} - 1 = -.73 \end{aligned}$$

$$\begin{aligned} MS &= \frac{F_{tu}}{1.4 \times S_t} - 1 \\ &= \frac{42000}{1.4(104715)} - 1 = -.71 \end{aligned}$$

∴ LOWER FLANGE OVERSTRESSED @ $t = .060$

RAISE t TO $t = .120$

$$\begin{aligned} S_t &= 3 \left[\frac{5.700}{.120} + \frac{6(20.886)}{(.120)^2} \right] \\ &= 3 [48 + 8703] = 26250 \text{ PSI} \end{aligned}$$

$$MS = \frac{35000}{1.25(26250)} - 1 = +.07 \quad t = .120$$

$$MS = \frac{42000}{1.4(26250)} - 1 = +.14 \quad t = .120$$

∴ LOWER FLANGE OK @ t = .120 IN
USING 3 T LOADS

CONSIDER HIGHER STRENGTHENED 2024-T851 ALUM

$$F_{Ty} = 58000 \text{ psi}$$

$$F_{Tu} = 66000 \text{ psi}$$

RAISE t TO .095 IN MINIMUM WITH 2024-T851

$$S_t = 3 \left[\frac{5.700}{.095} + \frac{6(20.886)}{(.095)^2} \right]$$

$$= 41836 \text{ psi}$$

3 T LOADS

$$MS = \frac{58000}{1.25(41836)} - 1 = +.11 \quad t = .095$$

$$MS = \frac{66000}{1.4(41836)} - 1 = +.13 \quad t = .095$$

∴ LOWER FLANGE OK @ t = .095 IN
USING 3 T LOADS ON 2024-T851 MAT'L

BOLT STRESSES

AT BOLT LINE

$$F = F_1 = 127.83 \text{ LB/IN}$$

$$V = V_1 = 5.70 \text{ LB/IN}$$

9 NAS 1352N06 BOLTS ($F_{TU} = 160000 \text{ PSI}$) IN 11.700 IN

TOTAL LOAD/BOLT

$$F_B = \frac{11.700}{9} (127.83) = 166.17 \text{ LB}$$

$$V_B = \frac{11.700}{9} (5.70) = 7.41 \text{ LB}$$

$$S_t = 3 \frac{F_B}{A_s} = 3 \frac{166.17}{.009085} = 54870 \text{ PSI}$$

3T LOADS

$$S_s = 3 \frac{V_B}{A_s} = 3 \frac{7.41}{.009085} = 2447 \text{ PSI}$$

$$F_S = 1.4$$

$$S_t = 1.4 \times 54870 = 76818 \text{ PSI}$$

$$r_t = \frac{76818}{160000} = .480$$

$$f_s = 1.4 (2447) = 3426 \text{ PSI}$$

$$r_s = \frac{3426}{(.6)(160000)} = .036 \sim 0$$

$$R_t \sim 1.0$$

$$u = \frac{r_t}{R_t} = .480$$

$$MS = \frac{1}{u} - 1 = +1.1$$

WORST LOADED BOLT
UPPER AFT PANEL
LOWER FLANGE
USING 3T LOADS

∴ BOLTS OK ON LOWER FLANGE

USING 3T LOADS

UPPER AFT PANEL - UPPER FLANGE

RANDOM Y W/Q=7.1 1σ LOADS

EL	<u>44206</u>	44207
F _x	5.700	2.214
F _y	6.148	2.347
F _{xy}	4.136	4.712
M _x	.0947	.1050
M _y	.0511	.0325
M _{xy}	.0370	.0300
V _x	.1176	.1515
V _y	.0945	.0153

RANDOM X W/Q=7.1 1σ LOADS

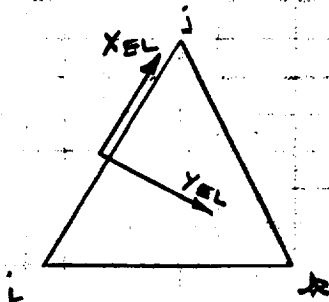
EL	44200	44211
F _x	4.224	3.963
F _y	4.162	3.433
F _{xy}	1.086	.7783
M _x	.2401	.2593
M _y	.2735	.2349
M _{xy}	.2060	.2051
V _x	.0832	.0961
V _y	.1819	.0955

RANDOM Z W/Q=7.1 1σ LOADS

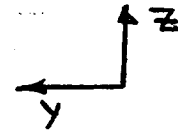
EL	44206
F _x	2.729
F _y	2.226
F _{xy}	1.955
M _x	.2549
M _y	.1680
M _{xy}	.0780
V _x	.3493
V _y	.1866

WORST CASE IS RANDOM Y AT SKEWED
ELEMENT 44206

EL 44206



	Y	Z
L	6.196	21.781
j	5.7	22.752
K	5.216	21.777



$$\angle X_{EL} j = \tan^{-1} \frac{.971}{.996} = 62.94^\circ$$

ROTATE X_{EL} $90 - 62.94 = 27.06^\circ$ CCW

$$F_x' = \frac{5.700 + 6.148}{2} + \frac{5.700 - 6.148}{2} \cos(2 \times 27.06)^\circ + 4.136 \sin(2 \times 27.06)^\circ = 9.013 \text{ LB/IN}$$

$$M_x' = \frac{.0947 + .0511}{2} + \frac{.0947 - .0511}{2} \cos(2 \times 27.06)^\circ + .0370 \sin(2 \times 27.06)^\circ = .128 \text{ IN-LB/IN}$$

$$V_x' = V_x = .1176 \text{ LB/IN}$$

$$F_x' = 9.013 \text{ LB/IN}$$

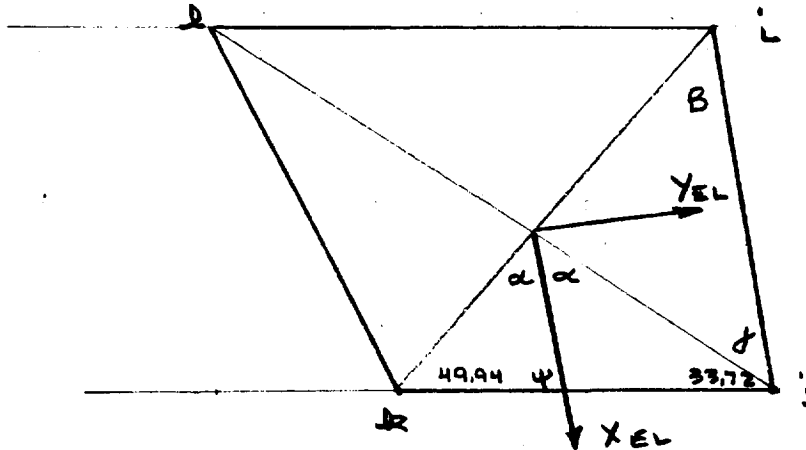
$$M_x' = .128 \text{ IN-LB/IN}$$

$$V_x' = .1176 \text{ LB/IN}$$

EL 44207

Report 10381
Addendum 1

	y	z
i	4.396	22.752
j	4.236	21.775
k	5.216	21.777
	5.7	22.752



$$\angle ijk = \tan^{-1} \frac{.975}{1.820} = 49.94^\circ$$

$$\angle jkl = \tan^{-1} \frac{.977}{1.464} = 33.72^\circ$$

$$\angle kji = \tan^{-1} \frac{.977}{.160} = 80.70^\circ$$

$$\delta = 80.70 - 33.72 = 46.98^\circ$$

$$B = 180 - 49.94 - 80.70 = 49.36^\circ$$

$$\alpha = \frac{\delta + B}{2} = 48.17$$

$$180 - 49.94 - 48.17 = 81.89 = \psi$$

X_{EL} is 90 - 81.89 = 8.11° CCW OF NORMAL

ROTATE X_{EL} CW 8.11° TO ACHIEVE NORMAL

$$F_x' = \frac{2.214 + 2.347}{2} + \frac{2.214 - 2.347}{2} \cos(2 \times 8.11)^\circ + 4.712 \sin(2 \times 8.11)^\circ$$

$$= .278 \text{ Lb/in}$$

MUCH LESS SEVERE THAN EL 44206

FLANGE STRESSES

Report 10381
Addendum 1

SIMILAR TO LOWER FLANGE, WITH

$$F_x' = 9.013 \text{ LB/IN}$$

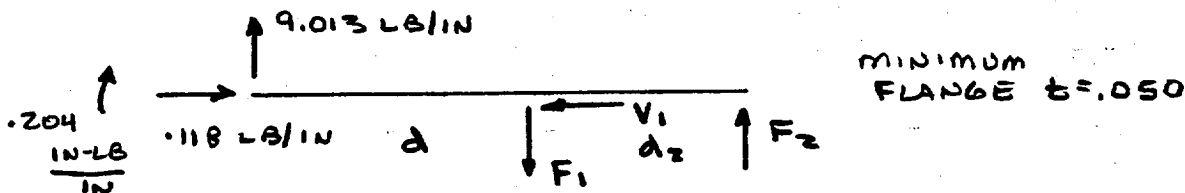
$$M_x' = .128 \text{ IN-LB/IN}$$

$$V_x' = .1176 \text{ LB/IN}$$

$$d = 2/3 (.972)$$

$$d = .562$$

$$d_2 = .188$$



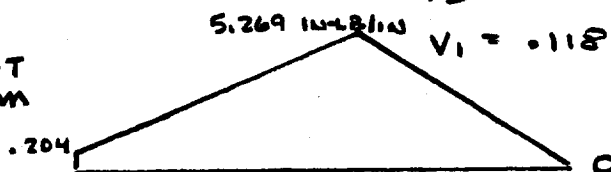
$$\sum M_2 = 0 \quad F_1 (.188) = 9.013 (.750) + .204$$

$$F_1 = 37.04 \text{ LB/IN}$$

$$F_2 = 28.03 \text{ LB/IN}$$

$$V_1 = .118 \text{ LB/IN}$$

MOMENT
DIAGRAM



FLANGE TENSION (MEMBER + BEND) @ $t_{min} = .050$

$$S_t = 3 \left[\frac{V_1}{t} + \frac{6M_1}{t^2} \right]$$

@ 3T LOADS

$$= 3 \left[\frac{.118}{.050} + \frac{6(5.269)}{(.050)^2} \right]$$

$$= 3 [2 + 12646] = 37944 \text{ PSI}$$

$$MS = \frac{35000}{1.25(37944)} - 1 = -.26$$

$$MS = \frac{42000}{1.4(37944)} - 1 = -.21$$

∴ UPPER FLANGE BAR @ $t = .05$

USING 3T LOADS

RAISE t TO .060 MIN , @ 3T LOADS

$$S_t = 3 \left[\frac{.118}{.060} + \frac{6(5.269)}{(.060)^2} \right] = 26351 \text{ psi}$$

$$MS = \frac{35000}{1.25(26351)} - 1 = +.06 \quad t = .060$$

$$MS = \frac{42000}{1.4(26351)} - 1 = +.14 \quad t = .060$$

∴ FLANGE OK @ $t = .060$
USING 3T LOADS

CONSIDER HIGHER STRENGTHED 2024-T851
THEN t_{MIN} CAN REMAIN @ .050

$$S_t = 37944 \text{ psi} \quad @ 3T \text{ LOADS}$$

$$MS = \frac{58000}{1.25(37944)} - 1 = +.22 \quad t = .050$$

$$MS = \frac{66000}{1.4(37944)} - 1 = +.24 \quad t = .050$$

∴ FLANGE OK @ $t = .050$
USING 3T LOADS, USING 2024-T851

BOLT STRESSES

AT BOLT

$$F = F_1 = 37.04 \text{ LB/IN}$$

$$V = V_1 = .118 \text{ LB/IN}$$

7 BOLTS (NAS1352N06, $F_{TU} = 160000 \text{ PSL}$)
IN $11.700 - 2(1.950) = 9.800 \text{ IN}$

TOTAL LOAD/BOLT

$$F_B = \frac{9.800}{7} (37.04) = 51.856 \text{ LB}$$

$$V_B = \frac{9.800}{7} (.118) = .165 \text{ LB}$$

$$S_t = 3 \frac{F_B}{A_s} = 3 \frac{51.856}{.009085} = 17123 \text{ PSL}$$

$$S_s = 3 \frac{V_B}{A_s} = 3 \frac{.165}{.009085} = 54 \text{ PSL}$$

⊙ 3T LOADS

$$FS = 1.4$$

$$S_t = 1.4 \times 17123 = 23972 \text{ PSL}$$

$$r_t = \frac{23972}{160000} = .150$$

$$S_s = 1.4 \times 54 = 76 \text{ PSL}$$

$$r_s = \frac{76}{(6)(160000)} = .0008 \Rightarrow 0$$

$$R_t \sim 1.0$$

$$U = \frac{r_t}{R_t} = .150$$

$$MS = \frac{1}{U} - 1 = +5.7$$

WORST LOADED BOLT
UPPER AFT PANEL
UPPER FLANGE
USING 3T LOADS

∴ BOLTS OK ON UPPER FLANGES

USING 3T LOADS

UPPER AFT PANEL - SIDE FLANGES

RANDOM Y W/Q=7.1 1T LOADS

EL	44344	44303	44345	44314	
Fx	5.191	4.931	.9843	8.913	LB/IN
Fy	6.417	17.088	14.568	5.542	"
Fxy	6.876	2.891	2.508	9.751	"
Mx	.0875	.1208	.1625	.0682	IN-LB/IN
My	.0602	.0536	.0664	.0634	"
Mxy	.0380	.0346	.0286	.0332	"
Vx	.0838	.1530	.1200	.0817	LB/IN
Vy	.1068	.0715	.0996	.1355	"

RANDOM X W/Q=7.1 1T LOADS

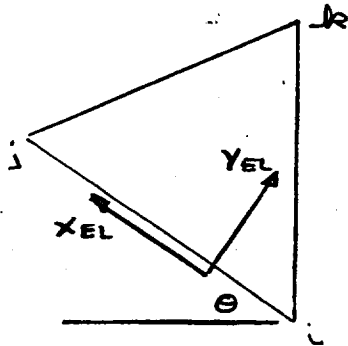
EL	44339	44303	44314	
Fx	14.481	3.925	5.501	LB/IN
Fy	5.088	14.671	8.150	"
Fxy	6.341	5.586	4.590	"
Mx	1.187	.3694	.3466	IN-LB/IN
My	.3179	.3466	.3986	"
Mxy	1.867	.3050	.2940	"
Vx	1.989	.3366	.1216	LB/IN
Vy	.766	.3135	.3499	"

RANDOM Z W/Q=7.1 1T LOADS

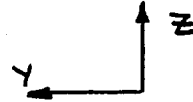
EL	44303	44314	
Fx	2.231	4.291	LB/IN
Fy	10.125	5.053	"
Fxy	1.188	4.474	"
Mx	.0854	.0356	IN-LB/IN
My	.0367	.0378	"
Mxy	.0259	.0265	"
Ux	.1224	.0866	LB/IN
Vy	.0785	.1075	"

WORST CASE IS RANDOM Y @ EL44344, A SKEWED ELEMENT.

EL 44344



	Y	Z
L	.346	18.249
J	1.363	18.710
R	.346	18.971



$$\angle L_j = \theta = \tan^{-1} \frac{.461}{1.017} = 24.38^\circ$$

ROTATE X_{EL} CCW 24.38° TO ACHIEVE NORMAL

RANDOM Y

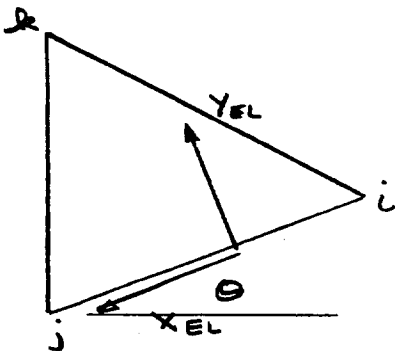
$$F_x' = \frac{5.191 + 6.417}{2} + \frac{5.191 - 6.417}{2} \cos(2 \times 24.38^\circ) + 6.876 \sin(2 \times 24.38^\circ)$$

$$= 10.570 \text{ LB/IN}$$

$$M_x' = .111 \text{ IN-LB/IN}$$

$$V_x' = V_x = .0838 \text{ LB/IN}$$

EL 44303



	Y	Z
L	.346	12.95
J	1.497	12.45
R	1.497	13.45



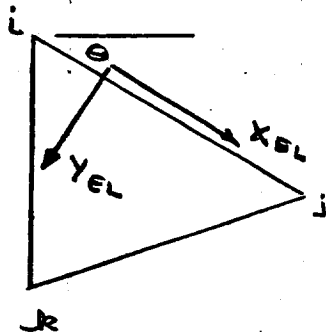
$$\angle L_j = \theta = \tan^{-1} \frac{.50}{1.151} = 23.48^\circ$$

ROTATE X_{EL} CW 23.48° TO ACHIEVE NORMAL

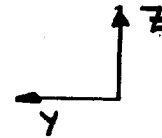
CW ROTATION IS A -23.48° ANGLE

\therefore EL 44303 LESS SEVERE THAN EL 44344 RANDOM Y

EL 44345



	Y	Z
L	11.846	18.971
J	10.925	18.665
Jr	11.846	18.249



$$\angle L_j = \theta = \tan^{-1} \frac{.306}{.921} = 18.38^\circ$$

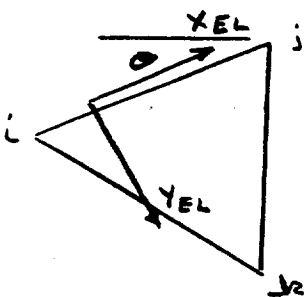
ROTATE X_{EL} CCW 18.38° TO ACHIEVE NORMAL

RANDOM Y

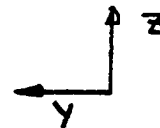
$$F_x' = \frac{.9843 + 14.568}{2} + \frac{.9843 - 14.568}{2} \cos(2 \times 18.38^\circ) + 2.508 \sin(2 \times 18.38^\circ) = 3.905 \text{ LB/IN}$$

∴ EL 44345 LESS SEVERE THAN EL 44344 RANDOM Y

EL 44314



	Y	Z
L	11.846	12.95
J	10.864	13.45
Jr	10.864	12.45



$$\angle L_j = \theta = \tan^{-1} \frac{.50}{.982} = 26.98^\circ$$

ROTATE X_{EL} CW 26.98° TO ACHIEVE NORMAL

CW ROTATION IS A -26.98° ANGLE

∴ EL 44314 LESS SEVERE THAN EL 44344 RANDOM Y

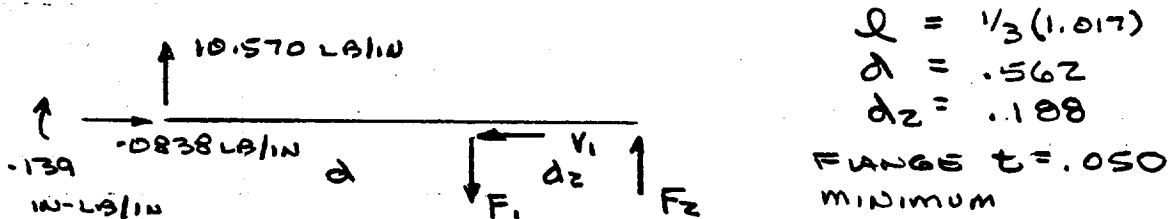
$$F_x' = 10.570 \text{ LB/IN}$$

$$M_x' = .111 \text{ IN-LB/IN}$$

$$V_x' = .0838 \text{ LB/IN}$$

FLANGE STRESSES

SIMILAR TO LOWER FLANGE



$$\sum M_2 = 0 \quad F_1(.188) = 10.570(.750) + .139$$

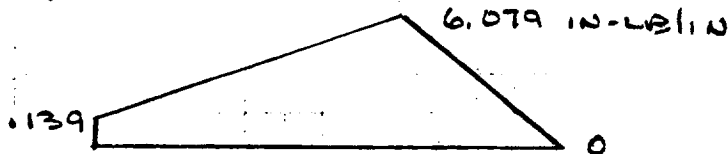
$$F_1 = 42.907 \text{ LB/IN}$$

$$F_2 = 32.337 \text{ LB/IN}$$

$$V_1 = .0838 \text{ LB/IN}$$

3T LOADS

MOMENT
DIAGRAM



FLANGE TENSION (MEMB + BEND) @ t = .050 MIN

$$S_t = 3 \left[\frac{V_1}{t} + \frac{6M_1}{t^2} \right] = 3 \left[\frac{.0838}{.050} + \frac{6(6.079)}{(.050)^2} \right] \text{ @ 3T LOADS}$$

$$= 3 [2 + 14590] = 43774 \text{ PSI}$$

$$MS = \frac{35000}{1.25(43774)} - 1 = -.36$$

$$MS = \frac{42000}{1.4(43774)} - 1 = -.31$$

∴ SIDE FLANGES BAD @ t = .050

USING 3T LOADS

RAISE t TO .065 MIN , @ 3T LOADS

$$S_t = 3 \left[\frac{.0838}{.065} + \frac{6(6.079)}{(.065)^2} \right] = 25903 \text{ psi}$$

$$MS = \frac{35000}{1.25(25903)} - 1 = +.08 \quad t = .065$$

$$MS = \frac{42000}{1.4(25903)} - 1 = +.16 \quad t = .065$$

∴ FLANGE OK @ $t = .065$
USING 3T LOADS

CONSIDER HIGHER STRENGTHED 2024-T851
THEN t_{min} CAN REMAIN AT $t = .050$

$$S_t = 43774 \text{ psi}$$

$$MS = \frac{58000}{1.25(43774)} - 1 = +.06 \quad t = .050$$

$$MS = \frac{66000}{1.4(43774)} - 1 = +.08 \quad t = .050$$

∴ FLANGE OK @ $t = .050$
USING 3T LOADS & 2024-T851 ALUM

BOLT STRESSES

AT BOLT

$$F = F_1 = 42.907 \text{ LB/IN}$$

$$V = V_1 = .0838 \text{ LB/IN}$$

8 BOLTS (NAS1352N06, FTU=160000 PSL)
IN 12.500 - .900 = 11.600 IN

TOTAL LOAD/BOLT

$$F_B = \frac{11.600}{8} 42.907 = 62.215 \text{ LB}$$

$$V_B = \frac{11.600}{8} .0838 = .12 \text{ LB}$$

$$S_t = 3 \frac{F_B}{A_s} = 3 \frac{62.215}{.009085} = 20543 \text{ PSL}$$

$$S_s = 3 \frac{V_B}{A_s} = 3 \frac{.12}{.009085} = 40 \text{ PSL}$$

@ 3T LOADS

$$FS = 1.4$$

$$S_t = 1.4 \times 20543 = 28762 \text{ PSL}$$

$$r_t = \frac{28762}{160000} = .180$$

$$S_s = 1.4 \times 40 = 55 \text{ PSL}$$

$$r_s = \frac{55}{(106)(160000)} = .0006 \approx 0$$

$$R_t \sim 1.0$$

$$u = \frac{r_t}{R_t} = .180$$

$$MS = \frac{1}{u} - 1 = +4.6$$

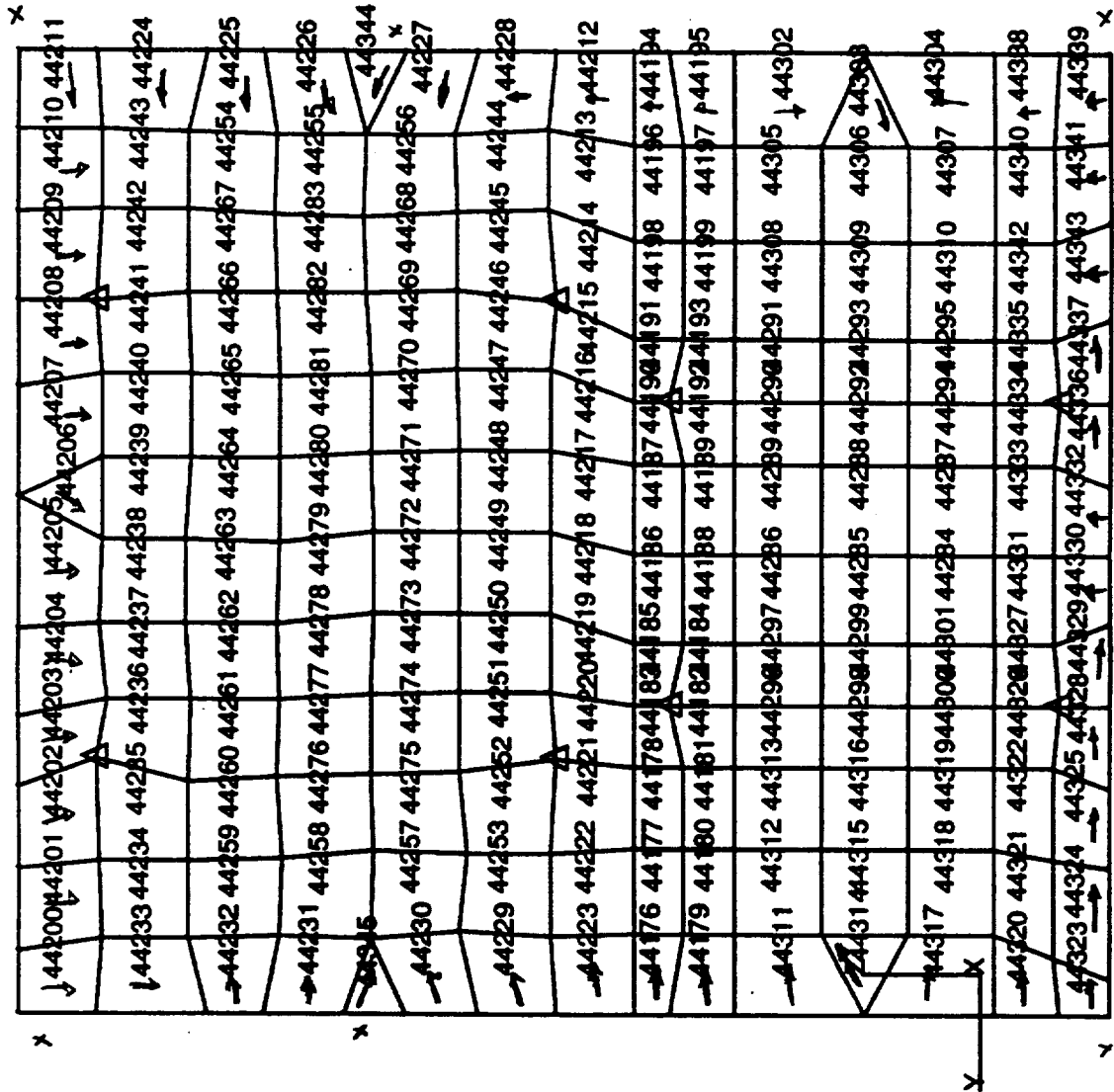
WORST LOADED SCREW
UPPER AFT PANEL
SIDE FLANGES
USING 3T LOADS

∴ BOLTS OK ON SIDE FLANGES

USING 3T LOADS

UPPER AFT PANEL

QUAD, TRI



UPPER RIGHT PANEL - LOWER FLANGE

RANDOM Y w/Q=7.1 1T LOADS

EL	1801	1813	1825	
F _x	16.715	15.460	15.294	LB/IN
F _y	2.502	1.895	1.479	"
F _{xy}	7.034	3.940	3.706	"
M _x	.0575	.1563	.2430	IN-LB/IN
M _y	.0511	.0363	.0641	"
M _{xy}	.0239	.0272	.0094	"
V _x	.0437	.2148	.2859	LB/IN
V _y	.4898	.0378	.0094	"

RANDOM X w/Q=7.1 1T LOADS

EL	1861	1873	
F _x	12.662	16.519	LB/IN
F _y	1.775	9.735	"
F _{xy}	12.724	3.842	"
M _x	.0544	.0293	IN-LB/IN
M _y	.0238	.0169	"
M _{xy}	.0191	.0137	"
V _x	.1285	.2530	LB/IN
V _y	.16565	.2800	"

RANDOM Z w/Q=7.1 1T LOADS

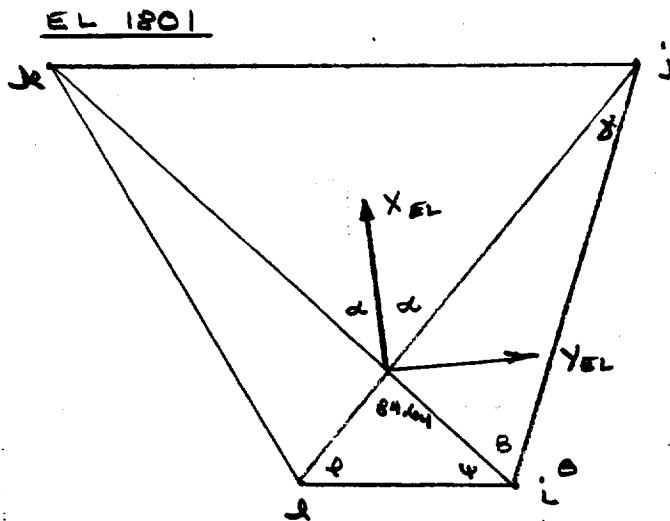
EL	1873	
F _x	9.791	LB/IN
F _y	4.921	"
F _{xy}	2.159	"
M _x	.0067	IN-LB/IN
M _y	.0194	"
M _{xy}	.0047	"
V _x	.1000	LB/IN
V _y	.0763	"

EL 1825 RANDOM Y IS WORST CASE USING F_x, M_x, V_x

$$F_x = 15.294 \text{ LB/IN}$$

$$M_x = .2430 \text{ IN-LB/IN}$$

$$V_x = .2859 \text{ LB/IN}$$



	X	Z
L	17.472	10.096
J	17.157	11.221
K	18.082	11.221
l	18.022	10.096

$\begin{matrix} \uparrow Z \\ X \rightarrow \end{matrix}$

$$\angle L_j = \theta = \tan^{-1} \frac{1.125}{.315} = 74.36^\circ$$

$$\angle l_j = \psi = \tan^{-1} \frac{1.125}{1.210} = 42.92$$

$$\angle l_j = \tan^{-1} \frac{1.125}{1.865} = 52.44 = \phi$$

$$\alpha = (180 - \phi - \psi) / 2 = 42.32$$

ROTATE X_{EL} CW $(90 - 42.92) - 42.32 = 4.76^\circ$

RANDOM Y

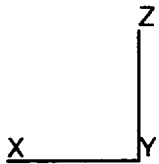
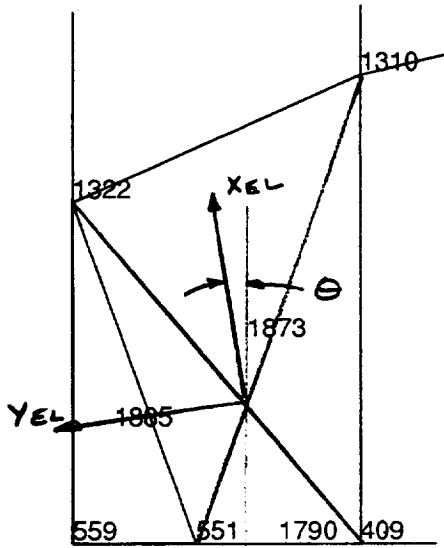
$$F_x' = \frac{(16.715 + 2.502)}{2} + \frac{(16.715 - 2.502)}{2} \cos(2x - 4.76)^\circ + 7.034 \sin(2x - 4.76)^\circ$$

$$= 15.454 \text{ LB/IN}$$

$$M_x' = .0567 \text{ IN-LB/IN}$$

$$V_x' = V_x = .0437 \text{ LB/IN}$$

EL 1873



RANDOM X

ROTATE XEL CW 10° , THUS $\theta = -10^\circ$,
TO ACHIEVE NORMAL

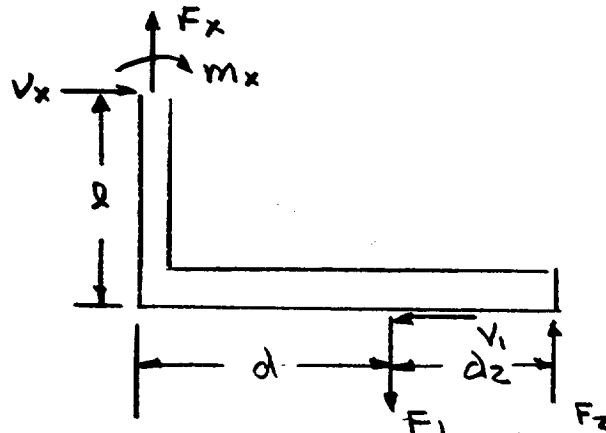
$$F_x' = \frac{16.519 + 9.735}{2} + \frac{16.519 - 9.735}{2} \cos(-20^\circ) + 3.842 \sin(-20^\circ)$$

$$= 15.000 \text{ LB/IN}$$

$$M_x' = .0242 \text{ IN-LB/IN}$$

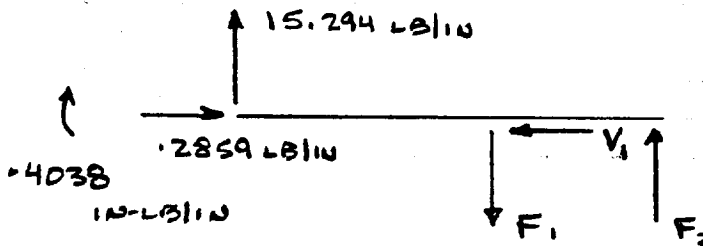
$$V_x' = V_x = 1.2530 \text{ LB/IN}$$

FLANGE STRESSES



$l = 1.125/2$
 $d = .312$
 $d_2 = .188$

$t = .040$ FLANGE
MINIMUM



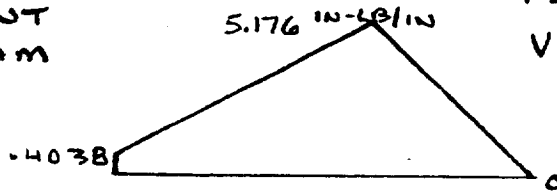
$\sum M_2 = 0 \quad F_1(.188) = 15.294(.5) + .4038$

$F_1 = 42.824 \text{ LB/IN}$

$F_2 = 27.530 \text{ LB/IN}$

$V_1 = .2859 \text{ LB/IN}$

MOMENT
DIAGRAM



FLANGE TENSION (MEMB + BEND) @ $t = .040$

$S_t = 3 \left[\frac{V_1}{t} + \frac{6M_1}{t^2} \right]$

$= 3 \left[\frac{.2859}{.040} + \frac{6(5.176)}{(.040)^2} \right]$

$= 3 [7 + 19410]$

$= 58251 \text{ PSI}$

⑥ 3T LOADS

MAT'RL 6061-T4

$F_{TY} = 16000 \text{ PSI}$
 $F_{TU} = 30000 \text{ PSI}$

W/FS 1.25 YIELD, 1.14 ULTIMATE

Report 10381
Addendum 1

$$MS = \frac{F_{ty}}{1.25 \times S_t} - 1$$
$$= \frac{16000}{1.25(58251)} - 1 = -0.78$$

$$MS = \frac{F_{tu}}{1.14 \times S_t} - 1$$
$$= \frac{30000}{1.14(58251)} - 1 = -0.63$$

∴ LOWER FLANGE IS BAD @ t = .040

RECOMMEND

1) CHANGE MATERIAL TO 6061-T6

2) RAISE T6 t TO .060

W/ t = .060 6061-T6 F_{ty} 35000 psi
 F_{tu} 42000 psi

$$MS = \frac{35000}{1.25(25894)} - 1 = +0.08 \quad t = .060$$

$$MS = \frac{42000}{1.4(25894)} - 1 = +0.16 \quad t = .060$$

∴ LOWER FLANGE OK @ t = .060 6061-T6

USING 3T LOADS

w/t = .090 6061-T4

Report 10381
Addendum 1

$$S_t = 3 \left[\frac{2859}{.090} + \frac{6(51176)}{(1.090)^2} \right]$$

⊙ 3T LOADS

$$= 3 [3 + 3834]$$

$$= 11512 \text{ psi}$$

$$MS = \frac{16000}{1.25(11512)} - 1 = +.11$$

$$MS = \frac{30000}{1.4(11512)} - 1 = +.86$$

∴ LOWER FLANGE OK @ t = .090 6061-T4

USING 3T LOADS

BOLT STRESSES

$$F_B = \frac{4.783}{7} (42.824) = 53.73 \text{ LB}$$

7 NAS1352N06 BOLTS, $F_{t4} = 160000 \text{ psi}$ IN 0.783 IN.

$$S_t = 3 \frac{F_B}{A_s} = 3 \frac{53.73}{1009085} = 17742 \text{ psi} \quad \text{⊙ 3T LOADS}$$

$$f_t = 1.4 \times S_t = 24839 \text{ psi}$$

$$r_t = \frac{24839}{160000} = .155$$

$$f_s \rightarrow 0$$

$$R_t = 1.0$$

$$u = r_t / R_t = .155$$

$$MS = \frac{1}{u} - 1 = +5.4$$

WORST LOADED BOLT
UPPER RIGHT PANEL
LOWER FLANGE @ 3T LOADS

∴ BOLTS OK ON LOWER FLANGE @ 3T LOADS

UPPER RIGHT PANEL - QUAD, TRI

1884 1872	1860	1848 1836	1824	1812
1883 1871	1859	1847 1835	1823	1811
1882 1870	1858	1846 1834	1822	1810
1881 1869	1857	1845 1833	1821	1809
1880 1868	1856 1844	1832 1787	1820 1799	1808 1797
1879 1867	1855 1843	1831 1788	1819 1798	1807 1789
1878 1866	1854	1842 1830	1818	1806
44124 1877 1865	1853	1841 1829	1817	1805
44123 1876 1864	1852	1840 1828	1816	1804
441744128 1875 1863	1851	1839 1827	1815	1803
1874 1862	1850	1838 1826	1814	1802
44173 1873 1861	1849	1837 1825	1813	1801 800

LOWER RIGHT SUPPORT PANEL- LOWER FLANGE, AFT FLANGE

RANDOM Y w/Q=7.1 1 T LOADS

EL	2565	
F _x		
F _y	8.277	LB/IN
F _{xy}		
M _x		
M _y	.0475	IN-LB/IN
M _{xy}		
V _x		
V _y	.0903	LB/IN

RANDOM X w/Q=7.1 1 T LOADS

EL	2566	
F _y	3.334	LB/IN
M _y	.0044	IN-LB/IN
V _y	.0095	LB/IN

RANDOM Z w/Q=7.1 1 T LOADS

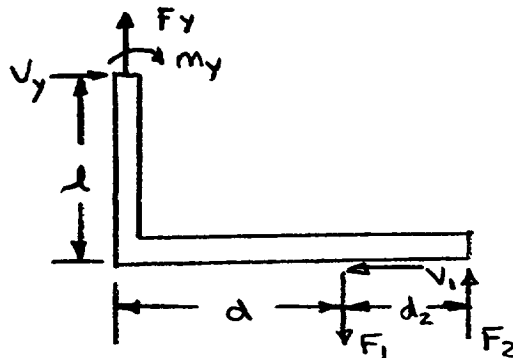
EL	2565	
F _y	5.195	LB/IN
M _y	.0126	IN-LB/IN
V _y	.0144	LB/IN

WORST CASE IS RANDOM Y @ EL 2565

$$F_y = 8.277 \text{ LB/IN}$$

$$M_y = .0475 \text{ IN-LB/IN}$$

$$V_y = .0903 \text{ LB/IN}$$



$$l = 1.131/2$$

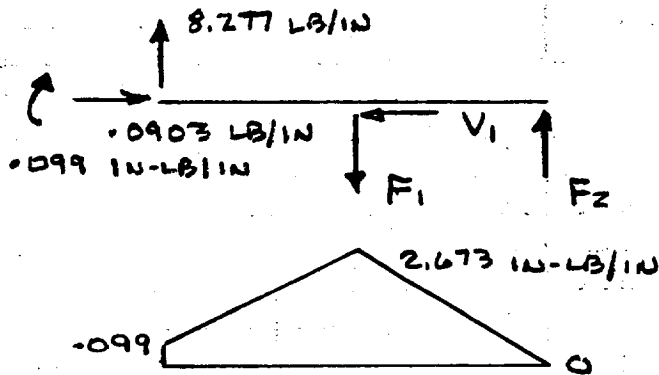
$$d = .312$$

$$d_2 = .313$$

FLANGE $t = .040$
MINIMUM

FLANGE STRESSES

Report 10381
Addendum 1



$$\sum M_2 = 0$$

$$F_1 (.313) = 8.277 (.625) + .099$$

$$F_1 = 16.844 \text{ LB/IN}$$

$$F_2 = 8.567 \text{ LB/IN}$$

$$V_1 = .0903 \text{ LB/IN}$$

FLANGE TENSION (MEMB + BEND) @ $t_{min} = .040$

$$S_t = 3 \left[\frac{V_1}{t} + \frac{6M_1}{t^2} \right]$$

@ 3T LOADS

$$= 3 \left[\frac{.0903}{.040} + \frac{6(2.673)}{(.040)^2} \right]$$

$$= 3 [2 + 10024]$$

$$= 30078 \text{ PSI}$$

MAT'L 6061-T651

$$F_{ty} = 35000 \text{ PSI}$$

$$F_{tu} = 42000 \text{ PSI}$$

$$F_S = 1.25, 1.4$$

$$MS = \frac{F_{ty}}{1.25 \times S_t} - 1$$

$$= \frac{35000}{(1.25)(30078)} - 1 = -.07$$

$$MS = \frac{F_{tu}}{1.4 \times S_t} - 1$$

$$= \frac{42000}{(1.4)(30078)} - 1 = -.003$$

∴ FLANGES BAD @ $t = .040$

USING 3T LOADS

RECOMMEND TIGHTENING TOLERANCE TO

$$t = .050 \pm .005$$

THEN ① $t_{\min} = .045$, ② 3Y LOADS

$$S_t = 3 \left[\frac{.0903}{.045} + \frac{6(2.673)}{(.045)^2} \right] = 23766 \text{ psi}$$

$$MS = \frac{35000}{1.25(23766)} - 1 = +.18 \quad t = .045$$

$$MS = \frac{42000}{1.4(23766)} - 1 = +.26 \quad t = .045$$

∴ FLANGES OK @ $t = .045$

USING 3Y LOADS

BOLT STRESSES

3 A325 SCREWS, $F_{tu} = 160000 \text{ psi}$ IN 6.500 IN

$$F_B = \frac{6.500}{3} 16.844 = 36.50 \text{ LB}$$

$$S_t = 3 \frac{F_B}{A_s} = 3 \frac{36.50}{.009085} = 12052 \text{ psi} \quad \text{② 3T LOADS}$$

$$S_t = 1.4 \times 12052 = 16874 \text{ psi}$$

$$r_t = \frac{16874}{160000} = .105$$

$$S_s \sim 0$$

$$R_t \sim 1.0$$

$$u = \frac{r_t}{R_t} = .105$$

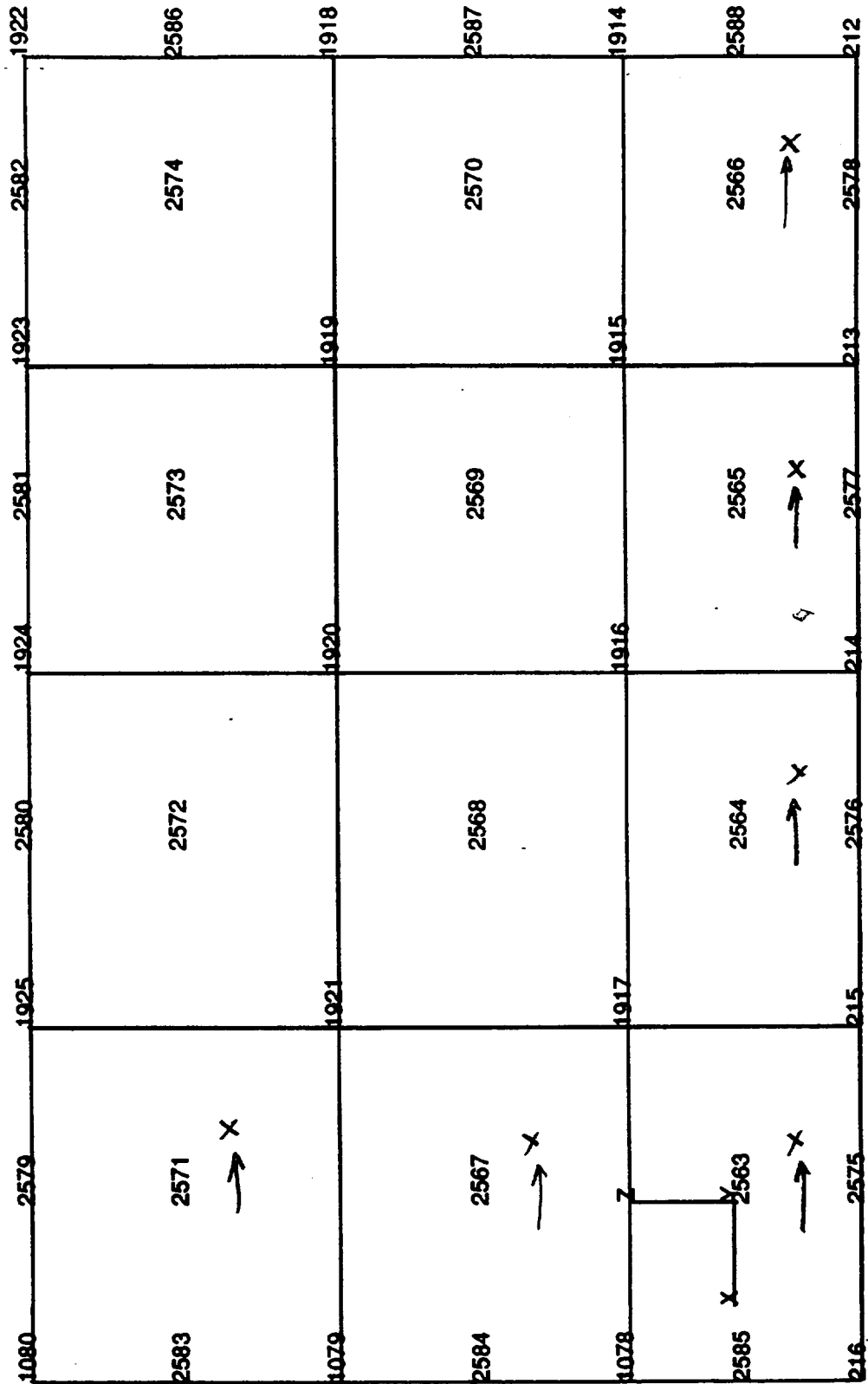
$$ms = \frac{1}{u} - 1 = +8.5$$

WORST LOADED SCREW
LOWER RIGHT SUPPORT
LOWER FLANGE
USING 3T LOADS

∴ BOLTS OK ON LOWER & AFT FLANGES

USING 3T LOADS

LOWER RIGHT SUPPORT PANEL - QUAD, TRI, BARS, BEAMS, GRID



5.4.2 Lower Baseplate Mounting Bolts and Pins Stresses per 15g Static Design Loads

The following pages contain a detailed analysis of lower baseplate mounting bolts and pin stresses per 15g static design loads.

TABLE 56 AMSU A1-EOS LOWER BASEPLATE MOUNTING BOLTS MARGINS OF SAFETY

LOAD CASE	BOLT GRID	APPLIED TENSION T3 (LB)	T3 FS	PRELOAD TENSION (LB)	TOTAL TENSION (LB)	TENSION ALLOW (LB)	APPLIED SHEAR T1 (LB)	APPLIED SHEAR T2 (LB)	SHEAR FS	TOTAL SHEAR (LB)	SHEAR ALLOW (LB)	MARGIN OF SAFETY
GX = 15	1	158.4	1.4	1315	1536.8	2800	125.9	19.3	1.4	178.3	1273	0.81
	4	43.2	1.4	1315	1375.5	2800	89.4	3.4	1.4	125.3	1273	
	7	160.5	1.4	1315	1539.7	2800	155.5	16.4	1.4	218.9	1273	0.79
	9	57.5	1.4	1315	1395.5	2800	119.8	2.3	1.4	167.8	1273	
	12	19.9	1.4	1315	1342.9	2800	111.8	1.1	1.4	156.5	1273	
	15	18.8	1.4	1315	1341.3	2800	104.9	0.2	1.4	146.9	1273	
	17	152.7	1.4	1315	1528.8	2800	57.8	6.0	1.4	81.4	1273	0.83
	21	205.6	1.4	1315	1602.8	2800	113.0	57.4	1.4	177.4	1273	0.73
	85	58.1	1.4	1315	1396.3	2800	39.5	5.3	1.4	55.8	1273	
	105	112.1	1.4	1315	1471.9	2800	8.7	17.6	1.4	27.5	1273	
	169	7.3	1.4	1315	1325.2	2800	23.2	21.4	1.4	44.2	1273	
	189	95.3	1.4	1315	1448.4	2800	8.0	31.9	1.4	46.0	1273	
	254	27.1	1.4	1315	1352.9	2800	44.2	13.4	1.4	64.7	1273	
	257	31.1	1.4	1315	1358.5	2800	90.0	5.6	1.4	126.2	1273	
	261	123.9	1.4	1315	1488.5	2800	55.0	9.6	1.4	78.2	1273	
	263	36.1	1.4	1315	1365.5	2800	103.5	7.5	1.4	145.3	1273	
	266	11.8	1.4	1315	1331.5	2800	102.3	2.7	1.4	143.3	1273	
	269	5.4	1.4	1315	1322.6	2800	95.8	3.3	1.4	134.2	1273	
	271	85.0	1.4	1315	1434.0	2800	52.6	6.7	1.4	74.2	1273	
	275	60.0	1.4	1315	1399.0	2800	76.4	24.0	1.4	112.1	1273	

TABLE 56 AMSU A1-EOS LOWER BASEPLATE MOUNTING BOLTS MARGINS OF SAFETY													
LOAD CASE	BOLT GRID	APPLIED TENSION T3 (LB)	T3 FS	PRELOAD TENSION (LB)	TOTAL TENSION (LB)	TENSION ALLOW (LB)	APPLIED SHEAR T1 (LB)	APPLIED SHEAR T2 (LB)	SHEAR FS	TOTAL SHEAR (LB)	SHEAR ALLOW (LB)	MARGIN OF SAFETY	
GY - 15	1	108.7	1.4	1315	1467.18	2800	49.2	57.8	1.4	106.3	1273		
	4	41	1.4	1315	1372.4	2800	43.5	17.9	1.4	65.9	1273		
	7	263	1.4	1315	1683.2	2800	8.5	108.7	1.4	152.6	1273	0.66	
	9	75.8	1.4	1315	1421.12	2800	16.1	42	1.4	63.0	1273		
	12	68.4	1.4	1315	1410.76	2800	8.1	27.4	1.4	40.0	1273		
	15	79.8	1.4	1315	1426.72	2800	15	23.3	1.4	38.8	1273		
	17	216.7	1.4	1315	1618.38	2800	29.9	16.6	1.4	47.9	1273		
	21	308.3	1.4	1315	1746.62	2800	86.3	164.1	1.4	259.6	1273	0.58	
	85	7.4	1.4	1315	1325.36	2800	3.6	66.4	1.4	93.1	1273		
	105	81.7	1.4	1315	1429.38	2800	11.3	124.6	1.4	175.2	1273	0.94	
	169	36.6	1.4	1315	1366.24	2800	6.6	50.3	1.4	71.0	1273		
	189	190.7	1.4	1315	1581.98	2800	8.8	78.6	1.4	110.7	1273		
	254	20	1.4	1315	1343	2800	35.2	52.2	1.4	88.1	1273		
	257	70.9	1.4	1315	1414.26	2800	20.8	14.3	1.4	35.3	1273		
	261	298.4	1.4	1315	1732.76	2800	13.9	283.9	1.4	397.9	1273	0.53	
	263	95.7	1.4	1315	1448.98	2800	19.6	37.6	1.4	59.4	1273		
	266	64.9	1.4	1315	1405.86	2800	7.2	25.2	1.4	36.7	1273		
	269	67.2	1.4	1315	1409.08	2800	12.4	23.9	1.4	37.7	1273		
	271	222.5	1.4	1315	1626.5	2800	68	20.5	1.4	99.4	1273	0.72	
	275	183.8	1.4	1315	1572.32	2800	93	183.9	1.4	288.5	1273	0.72	

TABLE 56 AMSU A1-EOS LOWER BASEPLATE MOUNTING BOLTS MARGINS OF SAFETY

LOAD CASE	BOLT GRID	APPLIED TENSION T3 (LB)	T3 FS	PRELOAD TENSION (LB)	TOTAL TENSION (LB)	TENSION ALLOW (LB)	APPLIED SHEAR T1 (LB)	APPLIED SHEAR T2 (LB)	SHEAR FS	TOTAL SHEAR (LB)	SHEAR ALLOW (LB)	MARGIN OF SAFETY
GZ = 15	1	55.3	1.4	1315	1392.4	2800	19.4	10.3	1.4	30.8	1273	
	4	31.9	1.4	1315	1359.7	2800	21.1	5.2	1.4	30.4	1273	
	7	199.2	1.4	1315	1593.9	2800	2.1	24.1	1.4	33.9	1273	0.76
	9	61.3	1.4	1315	1400.8	2800	25.6	3.2	1.4	36.1	1273	
	12	46.1	1.4	1315	1379.5	2800	8.6	4.4	1.4	13.5	1273	
	15	48.8	1.4	1315	1383.3	2800	2.6	8.9	1.4	13.0	1273	
	17	139.8	1.4	1315	1510.7	2800	40.5	4.7	1.4	57.1	1273	
	21	58.8	1.4	1315	1397.3	2800	61.7	59.2	1.4	119.7	1273	
	85	53.6	1.4	1315	1390.0	2800	16.3	1.5	1.4	22.9	1273	
	105	123.6	1.4	1315	1488.0	2800	7	42.9	1.4	60.9	1273	
	169	57.1	1.4	1315	1394.9	2800	11.4	12.8	1.4	24.0	1273	
	189	171.2	1.4	1315	1554.7	2800	3.7	48.5	1.4	68.1	1273	0.80
	254	1.3	1.4	1315	1316.8	2800	7.9	15.8	1.4	24.7	1273	
	257	63	1.4	1315	1403.2	2800	20.7	5.1	1.4	29.8	1273	
	261	146.9	1.4	1315	1520.7	2800	7.4	53.9	1.4	76.2	1273	
	263	66.5	1.4	1315	1408.1	2800	19.7	3.1	1.4	27.9	1273	
	266	39.9	1.4	1315	1370.9	2800	3.6	8.2	1.4	12.5	1273	
	269	40.3	1.4	1315	1371.4	2800	8.8	10.4	1.4	19.1	1273	
	271	154.7	1.4	1315	1531.6	2800	59.6	0.4	1.4	83.4	1273	
	275	45.7	1.4	1315	1379.0	2800	48.1	56.6	1.4	104.0	1273	

TABLE 56 AMSU A1-EOS LOWER BASEPLATE SHEAR PINS SHEAR TEAROUT MARGINS OF SAFETY										
LOAD CASE	BOLT GRID	COMP	APPLIED SHEAR T1 (LB)	APPLIED SHEAR T2 (LB)	TOTAL SHEAR (LB)	SHEAR TEAROUT (PSI)	FS	SHEAR Fsu (PSI)	MS	
GX = 15	127	BASEPL	984.8	2	985	7473	1.4	27000	1.58	
TABLE 56 AMSU A1-EOS LOWER BASEPLATE SHEAR PINS BEARING MARGINS OF SAFETY										
LOAD CASE	BOLT GRID	COMP	APPLIED LOAD T1 (LB)	APPLIED LOAD T2 (LB)	TOTAL LOAD (LB)	BEARING STRESS (PSI)	FS	ALLOW Fcy/Flu (PSI)	MS	
GX = 15	127	BASEPL	984.8	2	985	8379	1.25	35000	2.34	
	127	BASEPL	984.8	2	985	8379	1.4	42000	2.58	

TABLE 56 AMSU A1-EOS LOWER BASEPLATE MOUNTING BOLTS MEMBER COMPRESSION MARGINS OF SAFETY

LOAD CASE	MEMBER 1	MEMBER 2	APPLIED LOAD (LB)	BEARING AREA (IN ²)	BEARING STRESS (PSI)	FS	ALLOW Fu (PSI)	MS
PRELOAD	BOLT	WASHER	1315	0.036	36290	1.40	140000	1.76
	WASHER	.435 ISO	1315	0.112	11781	1.40	60000	2.64
	.435 ISO	BASEPL	1315	0.083	15928	1.25	35000	0.76
	ISOLATOR	BASEPL	1315	0.083	15928	1.40	42000	0.88
	BASEPL	.590 ISO	1315	0.156	8433	1.25	35000	2.32
	BASEPL	.590 ISO	1315	0.156	8433	1.40	42000	2.56
	.590 ISO	SPCCR	1315	0.234	5620	1.40	60000	6.63

TABLE 56 AMSU A1-EOS LOWER BASEPLATE MOUNTING BOLTS SHEAR TEAROUT MARGINS OF SAFETY									
LOAD CASE	BOLT GRID	COMP	APPLIED SHEAR T1 (LB)	APPLIED SHEAR T2 (LB)	TOTAL SHEAR (LB)	SHEAR TEAROUT (PSI)	FS	SHEAR Fu (PSI)	MS
GY = 15	261	BASEPL	13.9	283.9	284	3207	1.4	27000	5.01

TABLE 56 AMSU A1-EOS LOWER BASEPLATE MOUNTING BOLTS BEARING MARGINS OF SAFETY									
LOAD CASE	BOLT GRID	COMP	APPLIED LOAD T1 (LB)	APPLIED LOAD T2 (LB)	TOTAL LOAD (LB)	BEARING STRESS (PSI)	FS	ALLOW Fcy/Ftu (PSI)	MS
GY = 15	261	BASEPL	13.9	283.9	284	1927	1.25	35000	13.53
	261	BASEPL	13.9	283.9	284	1927	1.4	42000	14.57
	261	.590 ISO	13.9	283.9	284	1927	1.4	35000	11.97

TABLE 56 AMSU A1-EOS THREAD SHEAR RANDOM VIBRATION 3S LOADING										
LOAD CASE	INT/EXT THREAD	PRELOAD	APPLIED LOAD LB	APPLIED LOAD FS	JOINT STIFFNESS FACTOR	TOTAL LOAD LB	SHEAR AREA SQ.IN	THREAD SHEAR PSI	ALLOWABLE Fu PSI	MARGIN OF SAFETY
GY = 15	EXTERNAL .190-32UNF SCREW A-286	1315	308.3	1.4	1	1746.62	0.05065	34484	84000	1.44

11-11-95

AMSU A1 EOS 1356405 LOWER BASEPLATE MOUNTING BOLTS STRESSES PER STATIC LOADS

STATIC LOADS 15g INDEPENDENTLY ACTING IN
GLOBAL X, Y, Z DIRECTIONS

FACTOR'S OF SAFETY 1.4 ULTIMATE

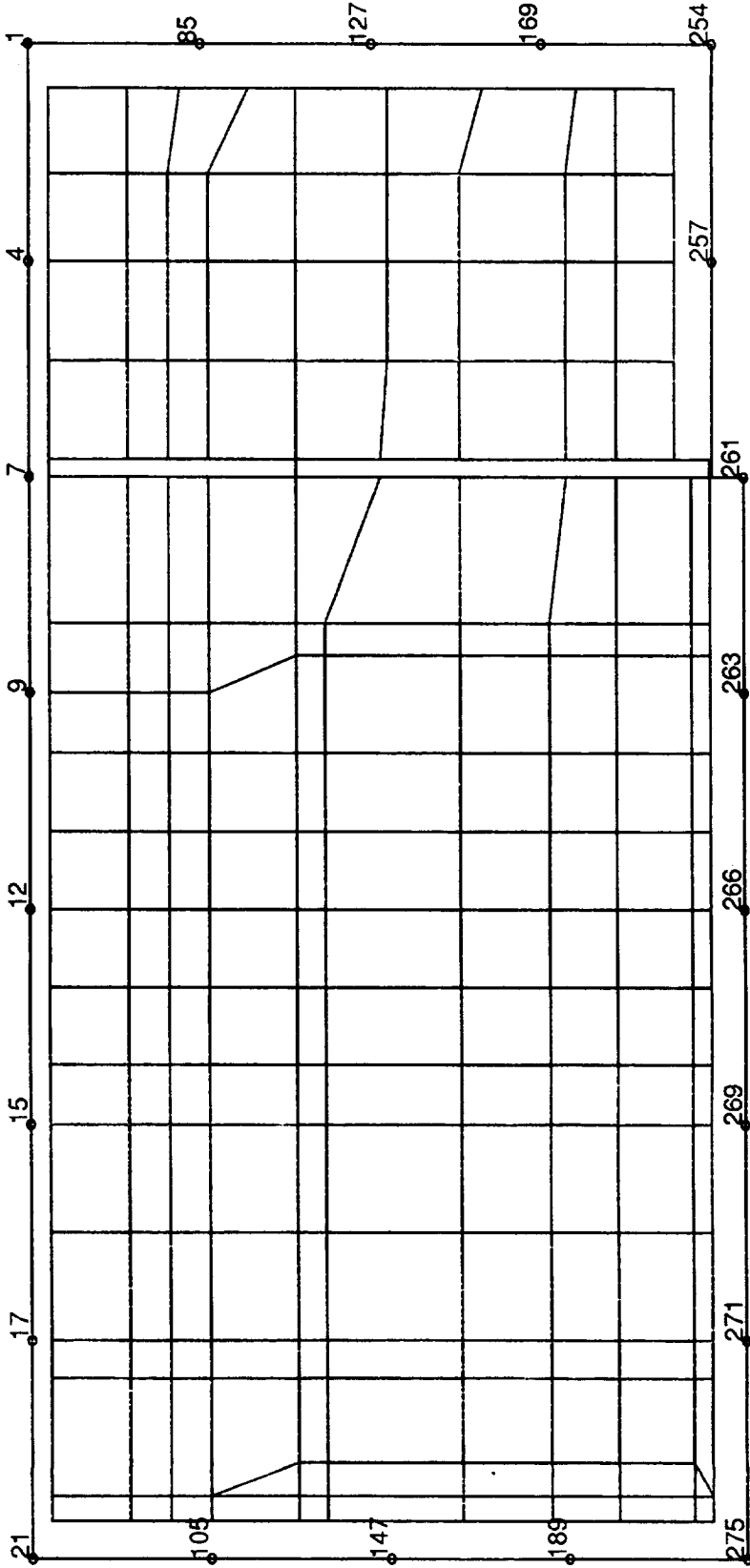
ASSUMPTIONS

- 1) STRESSES IN BOLTS DERIVED FROM NASTRAN
SPC FORCES PER UNI-DIRECTION LOAD CASE
PLUS BOLT PRELOAD TORQUE (50 IN-LB)
- 2) 20 BOLTS PLUS 2 DOWEL PINS PER
FIGURE 1 SKETCH, WITH NOTED NASTRAN
GRID NUMBER. GRIDS 127 & 147 ARE THE
DOWEL PINS.
- 3) BOLT GRIDS (1, 4, 7, 9, 12, 15, 17, 21, 25, 105,
169, 189, 254, 257, 261, 263, 266, 269, 271, 275)
REACT TENSION/COMPRESSION (NASTRAN
T3 SPC FORCES) PLUS SHEAR (NASTRAN
T1 & T2 SPC FORCES).
- 4) PIN GRIDS (127, 147) REACT ONLY SHEAR
(NASTRAN T1 & T2 SPC FORCES).
- 5) INTERACTIVE TENSION PLUS SHEAR
CONSIDERED PER MIL-HDBK-5E FIG 1.5.3.5
 $R_s^3 + R_t^2 = 1$ CURVE.
- 6) ALLOWABLES ARE PER MS16997 (UNC-3A)
TENSILE LOAD 2800 # 10-32
SHEAR LOAD 1273 LB SCREWS

TENSILE LOAD ALLOWABLE BASED ON F_{TU}
(140000 PSL) AND TENSILE AREA ($A_s = .019991 \text{ IN}^2$)
SHEAR LOAD ALLOWABLE BASED OF $F_{SH} = .6 \times F_{TU}$
AREA PER MINOR ϕ ($\pi/4 (.1389 \text{ IN}^2)$).

- 7) THE FACTOR OF SAFETY, 1.4, IS APPLIED
ONLY TO THE APPLIED LOADS, NOT TO PRELOAD.

BASEPLATE SCREWS & PINS



THE FOLLOWING TABLES LIST BOLT LOADS (LB)
PER EACH OF THE 3 159 STATIC LOAD CASES.
(REF NASTRAN OUTPUT).

EOS AMSU-A1 STATIC ANALYSIS
LAUNCH_SHOCK_LOAD_GX=15

TABLE 1

MAY 11, 1995

FORCES OF SINGLE-POINT CONSTRAINT

POINT ID.	TYPE	T1	T2	T3
1	G	-1.258689E+02	-1.925428E+01	-1.583812E+02
4	G	-8.936213E+01	-3.449354E+00	-4.321259E+01
7	G	-1.555324E+02	-1.639825E+01	-1.604990E+02
9	G	-1.198174E+02	-2.323261E+00	-5.753431E+01
12	G	-1.117775E+02	-1.102563E+00	-1.990412E+01
15	G	-1.049295E+02	2.357800E-01	1.884999E+01
17	G	-5.776802E+01	-5.988444E+00	1.526645E+02
21	G	-1.129670E+02	5.739198E+01	2.055744E+02
85	G	-3.954858E+01	5.255445E+00	-5.809161E+01
105	G	-8.667003E+00	-1.759135E+01	1.121176E+02
127	G	-1.453382E+01	-7.860929E+00	0.0
147	G	-1.358557E+01	1.389905E+01	0.0
169	G	-2.319088E+01	-2.135475E+01	-7.277608E+00
189	G	-8.034056E+00	3.189130E+01	9.530946E+01
254	G	-4.417500E+01	1.340856E+01	-2.712557E+01
257	G	-9.000320E+01	-5.570083E+00	-3.113841E+C1
261	G	-5.496064E+01	9.612906E+00	-1.239343E+02
263	G	-1.035119E+02	-7.489269E+00	-3.609636E+01
266	G	-1.022560E+02	-2.693850E+00	-1.180209E+01
269	G	-9.576151E+01	-3.327263E+00	5.448496E+00
271	G	-5.261657E+01	6.668529E+00	8.500832E+01
275	G	-7.635905E+01	-2.395988E+01	6.002437E+01

EOS AMSU-A1 STATIC ANALYSIS
LAUNCH_SHOCK_LOAD_GY=15

TABLE 2

MAY 11, 1995

FORCES OF SINGLE-POINT CONSTRAINT

POINT ID.	TYPE	T1	T2	T3
1	G	-4.922646E+01	-5.776447E+01	-1.086544E+02
4	G	-4.347932E+01	-1.792556E+01	-4.098786E+01
7	G	-8.491455E+00	-1.087068E+02	-2.630446E+02
9	G	1.610494E+01	-4.199586E+01	-7.578282E+01
12	G	8.147963E+00	-2.741898E+01	-6.838016E+01
15	G	1.503447E+01	-2.332141E+01	-7.976778E+01
17	G	-2.994038E+01	-1.656991E+01	-2.166770E+02
21	G	8.626559E+01	-1.640731E+02	-3.082957E+02
85	G	-3.598199E+00	-6.635413E+01	-7.431519E+00
105	G	-1.125033E+01	-1.246174E+02	-8.174689E+01
127	G	3.137108E+00	-5.558894E+01	0.0
147	G	-3.884206E+00	-1.303475E+02	0.0
169	G	6.632992E+00	-5.031898E+01	3.664951E+01
189	G	8.759583E+00	-7.864672E+01	1.907108E+02
254	G	3.523089E+01	-5.222286E+01	2.000888E+01
257	G	2.078536E+01	-1.434851E+01	7.093593E+01
261	G	1.390133E+01	-2.838523E+02	2.983871E+02
263	G	-1.958684E+01	-3.764598E+01	9.571375E+01
266	G	-7.217860E+00	-2.524164E+01	6.485027E+01
269	G	-1.238178E+01	-2.386706E+01	6.723901E+01
271	G	6.803258E+01	-2.047393E+01	2.224868E+02
275	G	-9.297598E+01	-1.839245E+C2	1.837866E+02

EOS AMSU-A1 STATIC ANALYSIS
LAUNCH_SHOCK_LOAD_GZ=15

TABLE 3

MAY 11, 1995

FORCES OF SINGLE-POINT CONSTRAINT

POINT ID.	TYPE	T1	T2	T3
1	G	-1.938496E+01	-1.031298E+01	-5.532035E+01
4	G	-2.114051E+01	-5.205739E+00	-3.193669E+01
7	G	-2.123874E+00	-2.408677E+01	-1.992273E+02
9	G	2.555438E+01	3.230314E+00	-6.137473E+01
12	G	8.647001E+00	4.380313E+00	-4.614014E+01
15	G	-2.639420E+00	8.850567E+00	-4.880497E+01
17	G	-4.054764E+01	4.674185E+00	-1.398236E+02
21	G	6.168258E+01	-5.916256E+01	-5.882284E+01
85	G	-1.630356E+01	-1.521022E+00	-5.358508E+01
105	G	7.041644E+00	4.292433E+01	-1.235561E+02
127	G	-3.645182E+00	-8.849172E-01	0.0
147	G	1.124046E+01	-1.528708E+00	0.0
169	G	-1.144201E+01	-1.275482E+01	-5.711489E+01
189	G	3.653283E+00	-4.854662E+01	-1.712159E+02
254	G	-7.883881E+00	1.581296E+01	-1.267313E+00
257	G	-2.067689E+01	-5.077182E+00	-6.299686E+01
261	G	7.427674E+00	5.385385E+01	-1.468824E+02
263	G	1.966401E+01	-3.097493E+00	-6.651685E+01
266	G	3.598240E+00	-8.165441E+00	-3.990044E+01
269	G	8.849655E+00	-1.037084E+01	-4.030917E+01
271	G	-5.964692E+01	3.574720E-01	-1.547499E+02
275	G	4.807593E+01	5.663111E+01	-4.568103E+01

DETAILED CALCULATIONS ARE PERFORMED FOR THE MOST SEVERE CASE, LAUNCH SHOCK LOAD GY=15, GRID 261. SUMMARIZED RESULTS FOR SELECTED BOLTS AND PINS AND LOAD CASES IS IN TABLE 4.

CASE GY=15g GRID 261 BOLT

$$F_t = T_3 = 298.4 \text{ LB} \quad \text{APPLIED TENSION}$$

$$F_s = \sqrt{T_1^2 + T_2^2} = \sqrt{(13.9)^2 + (283.9)^2} = 284.2 \text{ LB} \quad \text{APPLIED SHEAR}$$

$$\text{PRELOAD TORQUE, } T = .2 F_L d$$

$$F_L = \text{PRELOAD}$$

$$d = \text{NOMINAL } \phi, .190 \text{ IN } \quad \#10 \text{ SCREW}$$

$$T = 50 \text{ IN-LB} \quad F_L = 1315 \text{ LB}$$

ASSUMING $F_i = 1315 \text{ LB}$ PRELOAD

TOTAL BOLT TENSILE LOAD, F_b , IS A FUNCTION OF PRELOAD, APPLIED TENSION, & JOINT STIFFNESS.

$$F_b = F_i + \frac{k_b F_t}{k_b + k_m}$$

$$F_i = 421 \text{ LB}$$

$$F_t = 298.4 \text{ LB}$$

k_b = BOLT STIFFNESS

k_m = MEMBER STIFFNESS

$$k_b = \frac{EA}{l}$$

$$= .9126 \times 10^6 \text{ LB/IN}$$

$$E_b = 28 \times 10^6 \text{ PSI}$$

$$A = \pi/4 (1.190)^2 = .02835 \text{ IN}^2$$

l = GRIP OF THERMAL SPACERS + BP LEDGES
.25 + .25 + .31 + .06

$$k_m = \frac{\pi E_m d}{2 \ln \left[\frac{5(l+d/2)}{d+2.5d} \right]}$$

$$= 58409 \text{ LB/IN}$$

FOR 6-10 SPACER ONLY
W/ FIBERS \perp THICKNESS
USE EPOXY ONLY PROP

$$E_m = 250000 \text{ PSI}$$

$$d = .87 \text{ IN}$$

$$d = .190 \text{ IN}$$

WITH $k_m \ll k_b$ USE $\frac{k_b}{(k_b + k_m)} = 1.0$ & APPLY THE APPLIED LOAD DIRECTLY TO PRELOAD.

TENSILE LOAD W/FS

$$F_t = 1315 + 1.4(298.4) = 1733 \text{ LB}$$

SHEAR LOAD W/FS

$$F_s = 1.4(284.2) = 398 \text{ LB}$$

$$r_t = \frac{1733}{2800} = .619$$

$$r_s = \frac{398}{1273} = .313$$

PER FIG 1.5.3.5 MIL-HDBK-5E $R_t^2 + R_s^3 = 1$
CURVE FOR COMBINED TENSION & SHEAR

$$R_t = .944$$

$$R_s = .477$$

$$u = \frac{V_t}{R_t} = \frac{V_s}{R_s} = .656$$

$$MS = \frac{1}{u} - 1 = +.52$$

COMBINED TENSION
PLUS SHEAR ULTIMATE
GRID 261 SCREW
Gy = 15g

CASE Gy = 15g GRID 21 BOLT

$$F_t = T_3 = 308.3 \text{ LB} \quad \text{APPLIED TENSION}$$

$$F_s = \sqrt{T_1^2 + T_2^2} = \sqrt{86.3^2 + 164.1^2} = 185.4 \text{ LB} \quad \text{APPLIED SHEAR}$$

$$F_L = 1315 \text{ LB PRELOAD}$$

$$S_t = 1315 + 1.4(308.3) = 1747 \text{ LB}$$

$$S_s = 1.4(185.4) = 259.6 \text{ LB}$$

$$v_t = \frac{1747}{2800} = .624$$

$$v_s = \frac{259.6}{1273} = .204$$

$$R_t = .983$$

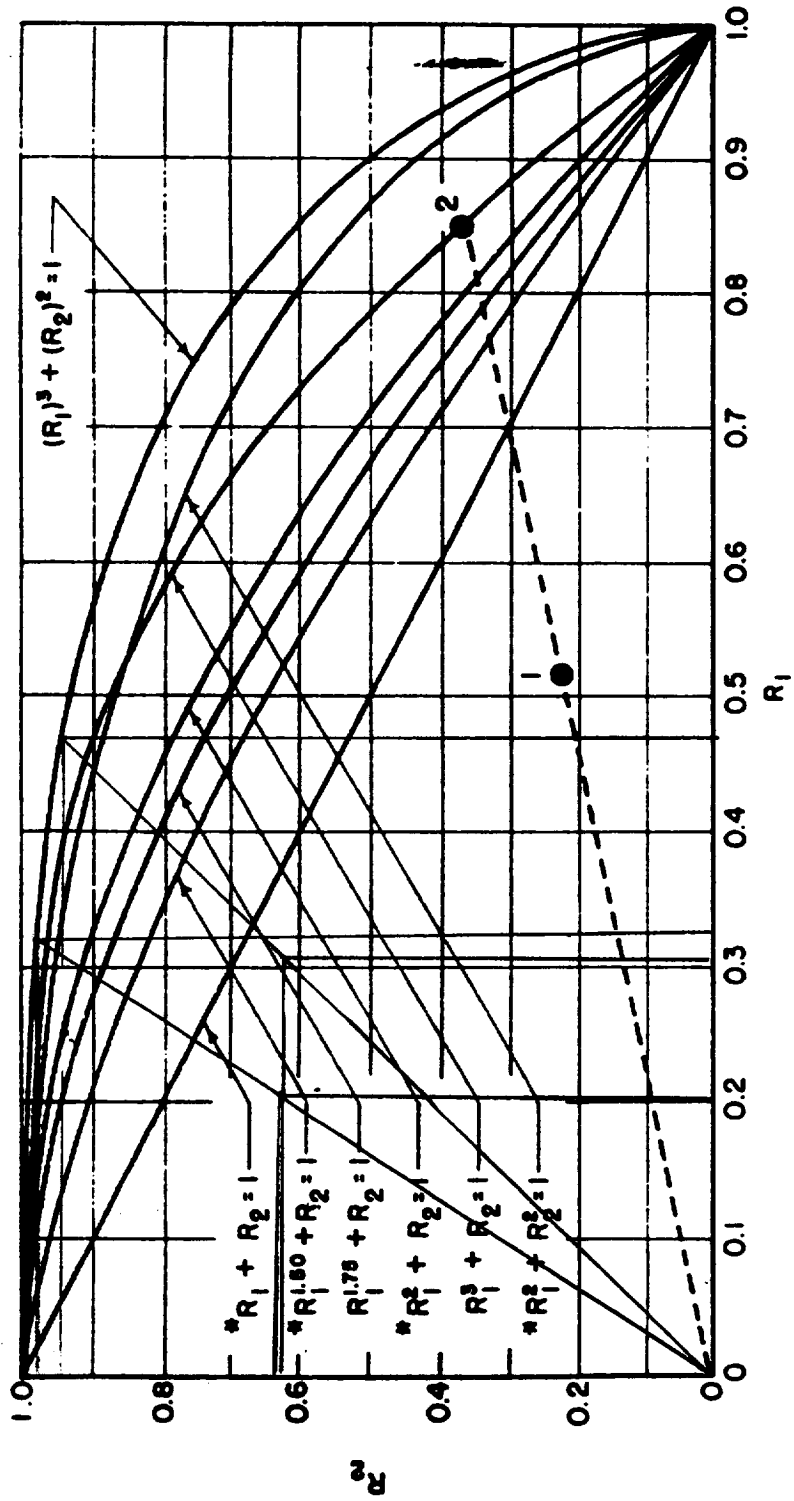
$$R_s = .320$$

$$u = \frac{v_t}{R_t} = \frac{v_s}{R_s} = .635$$

$$MS = \frac{1}{u} - 1 = +.57$$

COMBINED TENSION
PLUS SHEAR ULTIMATE
GRID 21 SCREW
Gy = 15g

MIL-HDBK-5E
1 June 1987



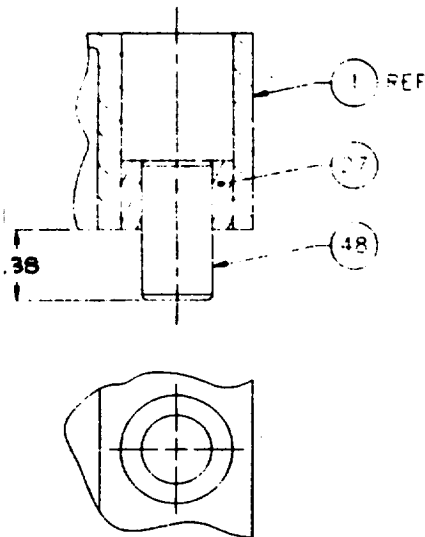
Typical interaction curves for combined loading conditions. *Refer to Section 1.5.3.5 for analytical margin of safety.

THE 2 SHEAR PIN HOLES ARE PER 1356405

Report 10381
Addendum 1

.5964 ϕ HOLES W/ ASSUMED TITANIUM BUSHINGS
.5960 ϕ HOLES W/ ASSUMED TITANIUM BUSHINGS & ALLOY STEEL PINS

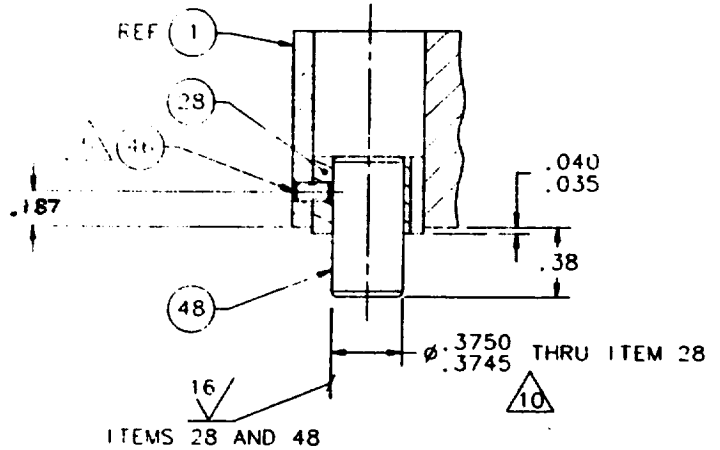
ASSUME 1333395-2 & -3 TITANIUM BUSHINGS W/.375 ϕ
ALLOY STEEL PINS. PER 1356404 THE PIN JOINTS
ARE VIEW P & VIEW N



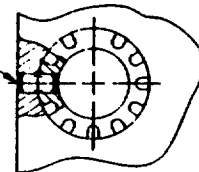
VIEW P

4	4
	C

SCALE: 2/1



.086-56UNC-2B THRU ONE WALL
ITEMS 1 AND 28

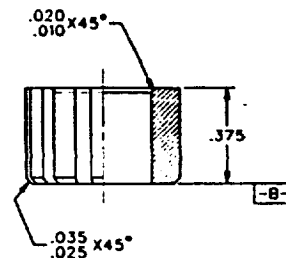
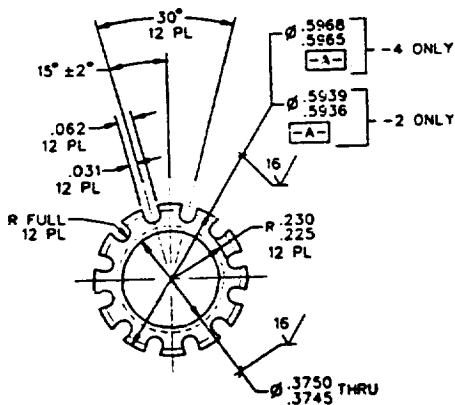


VIEW N

4	8
	C

SCALE: 2/1

1333395 TI-6AL-4V BUSHINGS ARE SCALLOPED ALONG
THE OD, THUS REDUCING THE BEARING AREA TO THE
6061-T6 ALUMINUM BASEPLATE.



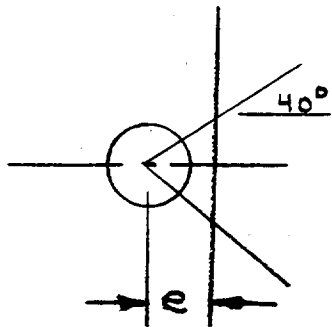
SHEAR-TEAROUT OF ALUMINUM BASEPLATE

THE SHEAR LOAD ORIGINATES FROM THE UNIT 15g STATIC SOLUTIONS WITH ALL SHEAR LOAD REACTED ONLY AT THE 2 PINS (NO SPL RESTRAINT IN T1 OR T2 DIRECTIONS FOR THE 20 SCREWS)

MAXIMUM SHEAR LOAD IS AT GR127 PIN FOR GX=15g LOAD

$$F = \sqrt{984.8^2 + 2.0^2} = 985 \text{ LB}$$

THE SHEAR TEAROUT OF THE ALUMINUM LOWER BASEPLATE FOR DIMENSIONS AS NOTED, PER BRUNN, "ANALYSIS AND DESIGN OF AIRPLANE STRUCTURES", 1973, P D1.4 - D1.5



$$e = .404 \quad \frac{e}{d} = 0.68$$

$$d = .5960$$

$$t = .375$$

$$AS = (e - \frac{d}{2} \cos 40)(t)(2)$$

$$= .132 \text{ IN}^2$$

PER ULTIMATE SF 1.4

$$\tau = \frac{1.4 \times 985}{.132} = 10464 \text{ PSI}$$

SHEAR ALLOWABLE FOR LOWER BASEPLATE (1356405)
6061-T6

$$F_{su} = 27000 \text{ PSI}$$

$$MS = \frac{27000}{10464} - 1 = +1.6 \quad \text{BASEPLATE}$$

BEARING OF 1333395-2 BUSHING ONTO ALUMINIUM BASEPLATE

WITH PREVIOUSLY DETERMINED MAXIMUM BOLT SHEAR OF

$$F = 985 \text{ LB}$$

BEARING AREA W/O CONSIDERING SCALLOPS IN
1333395-2 BUSHING

$$A = (.375 - .010 - .035)(.5936) = .196 \text{ IN}^2$$

SCALLOPS EXIST AROUND 40% OF CIRCUMFERENCE

$$\pi d = \pi(.5936) = 1.865$$

$$\text{REMOVE } 12 \times .062 = .744$$

$$(.744/1.865) \times 100 = 40\%$$

BEARING AREA W/ SCALLOPS

$$A = (.6)(.196) = .118 \text{ IN}^2$$

BEARING STRESS

$$\sigma = \frac{1.25 \times 985}{.118} = 10476 \text{ PSI}$$

LIMIT LOAD
W/ 1.25 FS

WITH $e/D = .68 \ll 1.5$ USE $F_{br} = F_{cy}$
6061-T6 ALUMINIUM

$$F_{cy} = 35000 \text{ PSI}$$

$$MS = \frac{35000}{10476} - 1 = +2.3$$

BASEPLATE

$$\sigma = \frac{1.4 \times 985}{.118} = 11733 \text{ PSI}$$

ULTIMATE LOAD
W/ 1.4 FS

WITH $e/D = .68 \ll 1.5$ USE $F_{br} = F_{tu} = 42000 \text{ PSI}$

$$MS = \frac{42000}{11733} - 1 = +2.6$$

BASEPLATE

RESULTS FOR ALL SHEAR (T1 & T2 FORCES) REACTED
AT SHEAR PINS (GRIDS 127, 147).

EOS AMSU-A1 STATIC ANALYSIS
LAUNCH_SHOCK_LOAD_GX=15

FORCES OF SINGLE - POINT						
POINT ID.	TYPE	T1	T2	T3		
1	G	0.0	0.0	-1.485400E+02		
4	G	0.0	0.0	-3.155964E+01		
7	G	0.0	0.0	-1.606117E+02		
9	G	0.0	0.0	-5.649572E+01		
12	G	0.0	0.0	-1.992761E+01		
15	G	0.0	0.0	1.712983E+01		
17	G	0.0	0.0	1.595522E+02		
21	G	0.0	0.0	1.940879E+02		
85	G	0.0	0.0	-8.084093E+01		
105	G	0.0	0.0	1.166457E+02		
127	G	-9.848364E+02	-1.957444E+00	0.0		
147	G	-6.203901E+02	1.957444E+00	0.0		
169	G	0.0	0.0	-2.474701E+01		
189	G	0.0	0.0	1.065255E+02		
254	G	0.0	0.0	-1.448587E+01		
257	G	0.0	0.0	-3.174564E+01		
261	G	0.0	0.0	-1.137115E+02		
263	G	0.0	0.0	-3.900265E+01		
266	G	0.0	0.0	-1.144709E+01		
269	G	0.0	0.0	5.779668E+00		
271	G	0.0	0.0	8.338869E+01		
275	G	0.0	0.0	5.000587E+01		

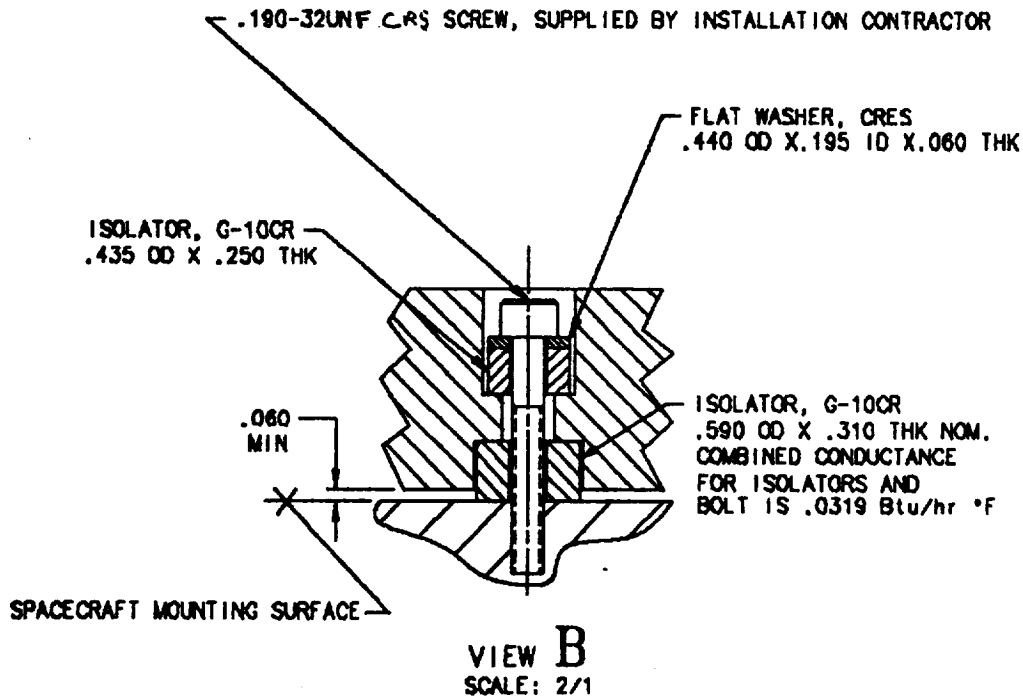
EOS AMSU-A1 STATIC ANALYSIS
LAUNCH_SHOCK_LOAD_GY=15

FORCES OF SINGLE - POINT						
POINT ID.	TYPE	T1	T2	T3		
1	G	0.0	0.0	-7.765912E+01		
4	G	0.0	0.0	-3.411418E+01		
7	G	0.0	0.0	-2.643308E+02		
9	G	0.0	0.0	-8.226789E+01		
12	G	0.0	0.0	-7.924261E+01		
15	G	0.0	0.0	-8.992119E+01		
17	G	0.0	0.0	-2.211956E+02		
21	G	0.0	0.0	-2.993695E+02		
85	G	0.0	0.0	-1.207610E+01		
105	G	0.0	0.0	-1.094637E+02		
127	G	8.818773E+00	-6.744928E+02	0.0		
147	G	-8.818773E+00	-9.307338E+02	0.0		
169	G	0.0	0.0	4.529426E+01		
189	G	0.0	0.0	2.281156E+02		
254	G	0.0	0.0	1.687144E+01		
257	G	0.0	0.0	7.181385E+01		
261	G	0.0	0.0	2.525800E+02		
263	G	0.0	0.0	9.802837E+01		
266	G	0.0	0.0	7.032902E+01		
269	G	0.0	0.0	7.296421E+01		
271	G	0.0	0.0	2.327888E+02		
275	G	0.0	0.0	1.808551E+02		

EOS AMSU-A1 STATIC ANALYSIS
LAUNCH_SHOCK_LOAD_GZ=15

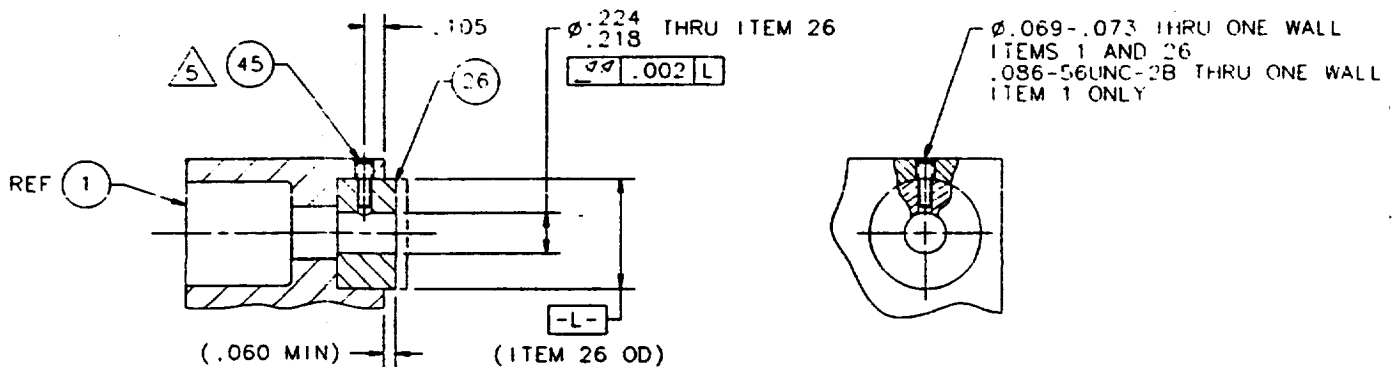
FORCES OF SINGLE - P O I					
POINT ID.	TYPE	T1	T2	T3	
1	G	0.0	0.0	-5.179372E+01	
4	G	0.0	0.0	-3.265757E+01	
7	G	0.0	0.0	-2.059886E+02	
9	G	0.0	0.0	-6.171374E+01	
12	G	0.0	0.0	-4.586198E+01	
15	G	0.0	0.0	-4.759489E+01	
17	G	0.0	0.0	-1.416723E+02	
21	G	0.0	0.0	-5.164100E+01	
85	G	0.0	0.0	-5.265801E+01	
105	G	0.0	0.0	-1.266990E+02	
127	G	-1.271475E+01	2.596414E-02	0.0	
147	G	1.271475E+01	-2.596429E-02	0.0	
169	G	0.0	0.0	-5.745068E+01	
189	G	0.0	0.0	-1.748955E+02	
254	G	0.0	0.0	2.310870E-01	
257	G	0.0	0.0	-6.460750E+01	
261	G	0.0	0.0	-1.454034E+02	
263	G	0.0	0.0	-6.695461E+01	
266	G	0.0	0.0	-3.945700E+01	
269	G	0.0	0.0	-3.842529E+01	
271	G	0.0	0.0	-1.582297E+02	
275	G	0.0	0.0	-4.175319E+01	

FROM 1356863 THERMAL INTERFACE CONTROL DWG,
THE BOLT JOINT IS AS FOLLOWS



WHERE THE .435 Ø X .250 THK ISOLATOR IS A
G-10CR SPACER, AND THE .590 OD X .310 THK
ISOLATOR IS A 133395-G SPACER, ALSO G-10CR

THE BASEPLATE HOLE DIMENSIONS ARE PER 1356405
W/SKETCH PER 1356404 VIEW R



COMPRESSION OF G-10/CR ISOLATORS UNDER BOLT PRELOAD

MAXIMUM LOAD AS DETERMINED ABOVE FOR 50 IN-LB
PRELOAD TORQUE ($F_L = 1315 \text{ LB}$)

$$F = 1315 \text{ LB}$$

APPLY A FS = 1.4 (ULTIMATE) (1.25 LIMIT FOR 6061-T6)

MINIMUM BOLT JOINT BEARING AREAS WITH

BOLT ASSUMED A-286 STEEL	$F_{TU} = 140000 \text{ PSI}$
WASHER ASSUMED ALLOY STEEL	$F_{TU} = 160000 \text{ PSI}$
G-10/CR ISOLATORS (LAMINATES \perp TO CENTERLINE)	$F_{TU} = 60000 \text{ PSI}$
BASEPLATE 6061-T6 ALUM	$F_{TU} = 42000 \text{ PSI}$ $F_{TY} = 35000 \text{ PSI}$

BOLT HEAD TO WASHER

ASSUME MS 16775 .190-32UNC SCREW
ASSUME NAS 1149E0363P WASHER

$$\begin{aligned} \text{HEAD OD} & .3125 - 2(.005) = .3025 \text{ MIN} \\ \text{WASHER ID} & .203 + .010 = .213 \text{ MAX} \end{aligned}$$

$$A = \pi/4 (.3025^2 - .213^2) = .0362 \text{ IN}^2 \text{ MIN}$$

$$F/A = \frac{1315}{.0362} = 36290 \text{ PSI}$$

$$MS = \frac{140000}{1.4 \times 36290} - 1 = +1.8 \quad \text{BOLT/WASHER}$$

WASHER TO .435 OD X .250 THK ISOLATOR

ASSUME NAS 1149E0363P WASHER

$$\begin{aligned} \text{WASHER OD} & .438 - .005 = .433 \text{ MIN ID } .213 \text{ MAX} \\ \text{ISOLATOR OD} & .435 - .002 = .433 \text{ MIN (ASSUMED)} \end{aligned}$$

$$A = \pi/4 (.433^2 - .213^2) = .112 \text{ IN}^2 \text{ MIN}$$

$$F/A = \frac{1315}{.112} = 11781 \text{ PSI}$$

$$MS = \frac{60000}{1.4 \times 11781} - 1 = +2.6 \quad \text{ISOLATOR}$$

.435 OD ISOLATOR TO BASEPLATE LEDGE

ISOLATOR OD .433 MIN (ASSUMED)
BASEPLATE ID .287 MAX

$$A = \pi/4 (.433^2 - .287^2) = .083 \text{ IN}^2$$

$$F/A = \frac{1315}{.083} = 15928 \text{ PSL}$$

$$MS = \frac{42000}{1.4 \times 15928} - 1 = +0.88 \quad \text{BASEPLATE}$$

$$MS = \frac{35000}{1.25 \times 15928} - 1 = +0.76 \quad \text{BASEPLATE}$$

BASEPLATE LEDGE TO 1333395-6 .540 OD ISOLATOR

ISOLATOR OD $.540 - 2(.030) = .530$ MIN
BASEPLATE ID .287 MAX

$$A = \pi/4 (.530^2 - .287^2) = .156 \text{ IN}^2$$

$$F/A = \frac{1315}{.156} = 8433 \text{ PSL}$$

$$MS = \frac{42000}{1.4 \times 8433} - 1 = +2.6 \quad \text{BASEPLATE}$$

$$MS = \frac{35000}{1.25 \times 8433} - 1 = +2.3 \quad \text{BASEPLATE}$$

.590 OD ISOLATOR TO SPACECRAFT

ISOLATOR OD .590 MIN
ISOLATOR ID .224 MAX (ASSUMED)

$$A = \pi/4 (.590^2 - .224^2) = .234 \text{ IN}^2$$

$$F/A = \frac{1315}{.234} = 5620 \text{ PSI}$$

$$MS = \frac{60000}{1.4 \times 5620} - 1 = +6.6 \quad \text{ISOLATOR}$$

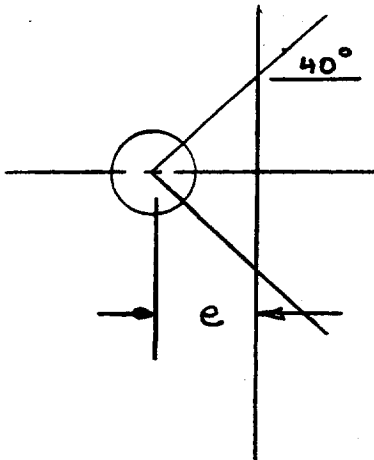
SHEAR-TEAROUT OF ALUMINUM BASEPLATE

THE MAXIMUM .190-32UNC SCREW SHEAR LOAD ORIGINATES FROM THE UNIT 15g STATIC SOLUTIONS WITH SHEAR LOAD REACTED AT BOTH THE 20 SCREWS AND 2 SHEAR PINS.

MAXIMUM SHEAR LOAD IS AT GR261 FOR 6Y=15g LOAD

$$F = \sqrt{13.9^2 + 283.9^2} = 284 \text{ LB}$$

THE SHEAR TEAROUT OF THE ALUMINUM LOWER BASEPLATE AT THE LOWER .590 OD ISOLATOR (THIS IS THE ISOLATOR/HOLE WITH THE CLOSE TOLERANCE FIT) PER BRUHN, "ANALYSIS AND DESIGN OF AIRPLANE STRUCTURES", 1973, PD1.4-D1.5



$$e = .404 \quad \frac{e}{d} = 0.68$$

$$d = .5920$$

$$t = .250$$

$$AS = (e - \frac{d}{2} \cos 40) (t) (2)$$

$$= .089 \text{ IN}^2$$

$$\gamma = \frac{1.4 \times 284}{.089} = 4486 \text{ PSI}$$

SHEAR ALLOWABLE FOR 1356405 6061-T6 LOWER
BASEPLATE

$$F_{su} = 27000 \text{ psi}$$

$$MS = \frac{27000}{4486} - 1 = +5.0 \quad \text{BASEPLATE}$$

BEARING OF .590 OD ISOLATOR ONTO BASEPLATE
HOLE PER MAXIMUM SHEAR LOAD.

MAXIMUM BOLT SHEAR

$$F = 284 \text{ LB}$$

BEARING AREA

$$A = (.590)(.250) = .148 \text{ IN}^2$$

BEARING STRESS

$$\tau = \frac{1.25 \times 284}{.148} = 2407 \text{ psi} \quad \begin{array}{l} \text{LIMIT LOAD} \\ \text{w/ 1.25 FS} \end{array}$$

WITH $e/D = .68 < 1.5$ USE $F_{ory} = F_{cy}$

$$F_{cy} = 35000 \text{ psi} \quad \text{6061-T6 ALUM}$$

$$MS = \frac{35000}{2407} - 1 = +13 \quad \text{BASEPLATE}$$

WITH $e/D = .68 < 1.5$ USE $F_{bru} = F_{bu}$

$$F_{bu} = 42000 \text{ psi} \quad \text{6061-T6 ALUM}$$

$$\tau = \frac{1.4 \times 284}{.148} = 2696 \text{ psi}$$

$$MS = \frac{42000}{2696} - 1 = +14 \quad \text{BASEPLATE}$$

FOR ISOLATOR USE $F_{bru} = F_{cu} \text{ EDGE} = 35000 \text{ psi}$

$$MS = \frac{35000}{2696} - 1 = +11 \quad \begin{array}{l} .590 \text{ OD} \\ \text{ISOLATOR} \end{array}$$

THREAD SHEAR OF .190-32UNF SCREW INTO
SPACECRAFT MOUNTING SURFACE

ASSUMPTIONS

- 1) SCREW MAT'L HAS $F_{TU} = 140000 \text{ PSI}$
- 2) -3A SCREW THREAD
- 3) SPACECRAFT HAS INSERT ALSO WITH $F_{TU} = 140000 \text{ PSI}$
- 3) LENGTH OF ENGAGEMENT $2 \times \text{DIA}$ ($\approx .190 \text{ IN}$)

SHEAR LOAD 1747 LB (REF GRID 21 Gy=15g CASE)

SHEAR AREA

$$AS = \frac{\pi E L_e}{2}$$

$$E = .1697$$
$$L_e = .190$$

$$= .05065 \text{ IN}$$

WITH FS=1.4

$$\gamma = \frac{1747}{.05065} = 34484 \text{ PSI}$$

$$F_{Su} = .6 F_{Tu} = .6(140000) = 84000 \text{ PSI}$$

$$MS = \frac{84000}{34484} - 1 = +1.4$$

∴ SPACECRAFT MOUNTING JOINT OK
PER ASSUMPTIONS

5.4.3 Thread Shear Stresses in Attachment Hardware per Random Vibration Loads

The following pages contain a detailed analysis of thread shear stresses in attachment hardware per random vibration loads.

TABLE 57 AMSU EOS-A1 THREAD SHEAR PER RANDOM VIBRATION LOADS										
1331650 LOWER RIGHT PANEL TO 1356405 LOWER BASEPLATE										
LOAD CASE	INT/EXT THREADS	PRELOAD LB	APPLIED LOAD LB	APPLIED LOAD FS	JOINT STIFFNESS FACTOR	TOTAL LOAD LB	SHEAR AREA SQ. IN	THREAD SHEAR PSI	ALLOWABLE Fsu PSI	MARGIN OF SAFETY
RANDOM	INTERNAL	399	408	1.4	0.565	722	0.0355	20330	27000	0.33
Y	.216-28UNF-2B									
	BASEPLATE									
	6061-T6									
	EXTERNAL	399	408	1.4	0.565	722	0.025	28869	48000	0.66
	.216-28UNF-2A									
	MS51830-103									
	INSERT									
	CRES 303									
	INTERNAL	399	408	1.4	0.513	692	0.0344	20117	48000	1.39
	.138-32UNRC-3A									
	MS51830-103									
	INSERT									
	CRES 303									
	EXTERNAL	399	408	1.4	0.513	692	0.0287	24112	96000	2.98
	.138-32UNJC-3B									
	MS1352N06-6									
	SCREW									
	ALLOY STEEL									

TABLE 57 AMSU EOS-A1 THREAD SHEAR PER RANDOM VIBRATION LOADS										
1331414 LOWER MOTOR MOUNT PANEL TO 1356405 LOWER BASEPLATE										
LOAD CASE	INT/EXT THREADS	PRELOAD LB	APPLIED LOAD LB	APPLIED LOAD FS	JOINT STIFFNESS FACTOR	TOTAL LOAD LB	SHEAR AREA SQ. IN	THREAD SHEAR PSI	ALLOWABLE Fsu PSI	MARGIN OF SAFETY
RANDOM Y	INTERNAL	399	158	1.4	0.602	532	0.0355	14990	27000	0.80
	.216-28UNF-2B BASEPLATE									
	6061-T6									
	EXTERNAL	399	158	1.4	0.602	532	0.025	21286	48000	1.25
	.216-28UNF-2A MS51830-103 INSERT CRES 303									
	INTERNAL	399	158	1.4	0.56	523	0.0344	15200	48000	2.16
	.138-32UNRC-3A MS51830-103 INSERT CRES 303									
	EXTERNAL	399	158	1.4	0.56	523	0.0287	18219	96000	4.27
	.138-32UNJC-3B MS1352N06-6 SCREW ALLOY STEEL									

TABLE 57 AMSU EOS-A1 THREAD SHEAR PER RANDOM VIBRATION LOADS										
1331447 LOWER RIGHT FRONT SUPPORT PANEL TO 1356405 LOWER BASEPLATE										
LOAD CASE	INT/EXT THREADS	PRELOAD LB	APPLIED LOAD LB	APPLIED LOAD FS	JOINT STIFFNESS FACTOR	TOTAL LOAD LB	SHEAR AREA SQ. IN	THREAD SHEAR PSI	ALLOWABLE Fsu PSI	MARGIN OF SAFETY
RANDOM	INTERNAL	399	110	1.4	0.606	492	0.0355	13868	27000	0.95
Y	.216-28UNF-2B									
	BASEPLATE									
	6061-T6									
	EXTERNAL	399	110	1.4	0.606	492	0.025	19693	48000	1.44
	.216-28UNF-2A									
	MS51830-103									
	INSERT									
	CRES 303									
	INTERNAL	399	110	1.4	0.565	486	0.0344	14128	48000	2.40
	.138-32UNRC-3A									
	MS51830-103									
	INSERT									
	CRES 303									
	EXTERNAL	399	110	1.4	0.565	486	0.0287	16934	96000	4.67
	.138-32UNJC-3B									
	MS1352N06-6									
	SCREW									
	ALLOY STEEL									

TABLE 57 AMSU EOS-A1 THREAD SHEAR PER RANDOM VIBRATION LOADS										
1331652 LOWER AFT PANEL TO 1356405 LOWER BASEPLATE										
LOAD CASE	INT/EXT THREADS	PRELOAD LB	APPLIED LOAD LB	APPLIED LOAD FS	JOINT STIFFNESS FACTOR	TOTAL LOAD LB	SHEAR AREA SQ. IN	THREAD SHEAR PSI	ALLOWABLE Fsu PSI	MARGIN OF SAFETY
RANDOM	INTERNAL	399	946	1.4	0.434	974	0.0341	28557	84000	1.94
Y	.138-32UNJC-3B									
	MF1331-06									
	ANCHOR NUT									
	A286 STEEL									
	EXTERNAL	399	946	1.4	0.434	974	0.0208	46817	96000	1.05
	.138-32UNRC-3A									
	NAS1352N06-8									
	SCREW									
	ALLOY STEEL									
1331642 UPPER AFT PANEL TO 1331356 UPPER BASEPLATE										
		LB	LB	FS	FACTOR	LB	SQ. IN	PSI	PSI	SAFETY
RANDOM	INTERNAL	399	499	1.4	0.362	652	0.0341	19117	84000	3.39
X	.138-32UNJC-3B									
	MF1331-06									
	ANCHOR NUT									
	A286 STEEL									
	EXTERNAL	399	499	1.4	0.362	652	0.0208	31341	96000	2.06
	.138-32UNRC-3A									
	NAS1352N06-10									
	SCREW									
	ALLOY STEEL									

TABLE 57 AMSU EOS-A1 THREAD SHEAR PER RANDOM VIBRATION LOADS										
1331651 UPPER RIGHT PANEL TO 1331356 UPPER BASEPLATE										
LOAD CASE	INT/EXT THREADS	PRELOAD LB	APPLIED LOAD LB	APPLIED LOAD FS	JOINT STIFFNESS FACTOR	TOTAL LOAD LB	SHEAR AREA SQ. IN	THREAD SHEAR PSI	ALLOWABLE Fsu PSI	MARGIN OF SAFETY
RANDOM	INTERNAL	399	161	1.4	0.322	472	0.0341	13829	84000	5.07
Y	.138-32UNJC-3B									
	MF1331-06									
	ANCHOR NUT									
	A286 STEEL									
	EXTERNAL	399	161	1.4	0.322	472	0.0208	22672	96000	3.23
	.138-32UNRC-3A									
	NAS1352N06-10									
	SCREW									
	ALLOY STEEL									
1331389 UPPER MOTOR MOUNT PANEL TO 1331390 UPPER RIGHT FRONT SUPPORT PANEL										
		LB	LB	FS	FACTOR	LB	SQ. IN	PSI	PSI	SAFETY
RANDOM	INTERNAL	399	207	1.4	0.505	545	0.0341	15993	84000	4.25
Y	.138-32UNJC-3B									
	MF1331-06									
	ANCHOR NUT									
	A286 STEEL									
	EXTERNAL	399	207	1.4	0.505	545	0.0208	26219	96000	2.66
	.138-32UNRC-3A									
	NAS1352N06-6									
	SCREW									
	ALLOY STEEL									

TABLE 57 AMSU EOS-A1 THREAD SHEAR PER RANDOM VIBRATION LOADS										
1331401 LOWER FRONT PANEL TO 1356405 LOWER BASEPLATE										
LOAD CASE	INT/EXT THREADS	PRELOAD LB	APPLIED LOAD LB	APPLIED LOAD FS	JOINT STIFFNESS FACTOR	TOTAL LOAD LB	SHEAR AREA SQ. IN	THREAD SHEAR PSI	ALLOWABLE Fsu PSI	MARGIN OF SAFETY
RANDOM	INTERNAL	399	277	1.4	0.457	576	0.0341	16898	84000	3.97
Y	.138-32UNJC-3B									
	MF1331-06									
	ANCHOR NUT									
	A286 STEEL									
	EXTERNAL	399	277	1.4	0.457	576	0.0208	27703	96000	2.47
	.138-32UNRC-3A									
	NAS1352N06-6									
	SCREW									
	ALLOY STEEL									
TABLE 57 AMSU EOS-A1 THREAD SHEAR PER RANDOM VIBRATION LOADS										
1331401 LOWER FRONT PANEL TO 1356405 LOWER BASEPLATE										
RANDOM	INTERNAL	399	277	1.4	0.586	626	0.0355	17641	27000	0.53
Y	.216-28UNF-2B									
	PANEL									
	6061-T6									
	EXTERNAL	399	277	1.4	0.586	626	0.025	25050	48000	0.92
	.216-28UNF-2A									
	MS51830-103									
	INSERT									
	CRES 303									
	INTERNAL	399	277	1.4	0.541	609	0.0344	17698	48000	1.71
	.138-32UNRC-3A									
	MS51830-103									
	INSERT									
	CRES 303									
	EXTERNAL	399	277	1.4	0.541	609	0.0287	21213	96000	3.53
	.138-32UNJC-3B									
	MS1352N06-6									
	SCREW									
	ALLOY STEEL									

TABLE 57 AMSU EOS-A1 THREAD SHEAR PER RANDOM VIBRATION LOADS										
1331389 UPPER MOTOR MOUNT PANEL TO 1331356 UPPER BASEPLATE										
LOAD CASE	INT/EXT THREADS	PRELOAD LB	APPLIED LOAD LB	APPLIED LOAD FS	JOINT STIFFNESS FACTOR	TOTAL LOAD LB	SHEAR AREA SQ. IN	THREAD SHEAR PSI	ALLOWABLE Fsu PSI	MARGIN OF SAFETY
RANDOM	INTERNAL	399	134	1.4	0.601	512	0.0355	14415	27000	0.87
Y	.216-28UNF-2B									
	BASEPLATE									
	6061-T6									
	EXTERNAL	399	134	1.4	0.601	512	0.025	20470	48000	1.34
	.216-28UNF-2A									
	MS51830-103									
	INSERT									
	CRES 303									
	INTERNAL	399	134	1.4	0.561	504	0.0344	14658	48000	2.27
	.138-32UNRC-3A									
	MS51830-103									
	INSERT									
	CRES 303									
	EXTERNAL	399	134	1.4	0.561	504	0.0287	17569	96000	4.46
	.138-32UNJC-3B									
	MS1352N06-6									
	SCREW									
	ALLOY STEEL									

TABLE 57 AMSU EOS-A1 THREAD SHEAR PER RANDOM VIBRATION LOADS										
1331352 UPPER FRONT PANEL TO 1331356 UPPER BASEPLATE										
LOAD CASE	INT/EXT THREADS	PRELOAD LB	APPLIED LOAD LB	APPLIED LOAD FS	JOINT STIFFNESS FACTOR	TOTAL LOAD LB	SHEAR AREA SQ. IN	THREAD SHEAR PSI	ALLOWABLE Fsu PSI	MARGIN OF SAFETY
RANDOM	INTERNAL	399	111	1.4	0.605	493	0.0355	13888	27000	0.94
Y	.216-28UNF-2B									
	BASEPLATE									
	6061-T6									
	EXTERNAL	399	111	1.4	0.605	493	0.025	19721	48000	1.43
	.216-28UNF-2A									
	MS51830-103									
	INSERT									
	CRES 303									
	INTERNAL	399	111	1.4	0.566	487	0.0344	14156	48000	2.39
	.138-32UNRC-3A									
	MS51830-103									
	INSERT									
	CRES 303									
	EXTERNAL	399	111	1.4	0.566	487	0.0287	16967	96000	4.66
	.138-32UNJC-3B									
	MS1352N06-6									
	SCREW									
	ALLOY STEEL									

TABLE 57 AMSU EOS-A1 THREAD SHEAR PER RANDOM VIBRATION LOADS										
1331390 UPPER RIGHT FRONT SUPPORT PANEL TO 1331356 UPPER BASEPLATE										
LOAD CASE	INT/EXT THREADS	PRELOAD LB	APPLIED LOAD LB	APPLIED LOAD FS	JOINT STIFFNESS FACTOR	TOTAL LOAD LB	SHEAR AREA SQ. IN	THREAD SHEAR PSI	ALLOWABLE Fsu PSI	MARGIN OF SAFETY
RANDOM	INTERNAL	399	187	1.4	0.586	552	0.0355	15561	27000	0.74
Y	.216-28UNF-2B									
	BASEPLATE									
	6061-T6									
	EXTERNAL	399	187	1.4	0.586	552	0.025	22097	48000	1.17
	.216-28UNF-2A									
	MS51830-103									
	INSERT									
	CRES 303									
	INTERNAL	399	187	1.4	0.541	541	0.0344	15716	48000	2.05
	.138-32UNRC-3A									
	MS51830-103									
	INSERT									
	CRES 303									
	EXTERNAL	399	187	1.4	0.541	541	0.0287	18837	96000	4.10
	.138-32UNJC-3B									
	MS1352N06-6									
	SCREW									
	ALLOY STEEL									

12-6-95

THREAD SHEAR - MS 51830-103 INSERTS
1331650 LOWER RIGHT PANEL TO
1356405 LOWER BASEPLATE

USE RANDOM VIBRATION NASTRAN "ELFORC" DATA AS LOAD. PER LOWER FLANGE BENDING STRESS / BOLT TENSILE STRESS EVALUATION, THE FORCE @ THE NAS 1352NØ6-6 SCREW IS:

$$F_1 = 3 \times 105.88 \text{ LB/IN} = 317.64 \text{ LB/IN} \quad "3T"$$

W/15 SCREWS IN 19.29 INCHES

LOAD PER SCREW, P

$$P = \frac{19.29}{15} (317.64) = 408 \text{ LB}$$

FACTOR OF SAFETY ON P

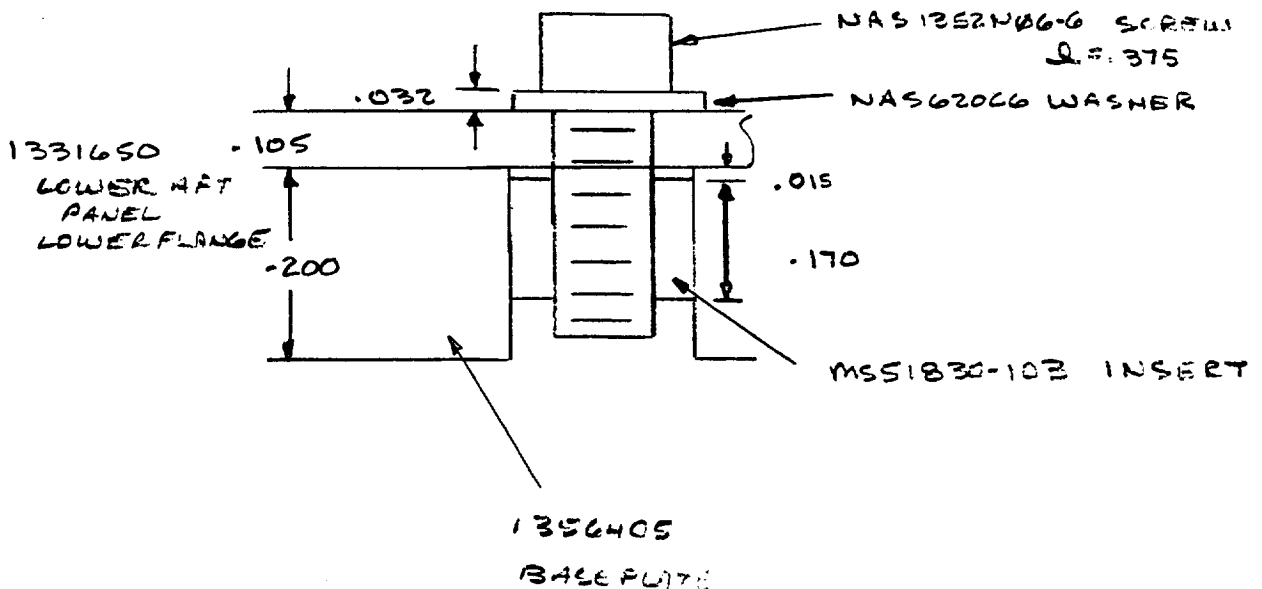
$$FS = 1.4$$

PRELOAD (9-11 IN-LB TORQUE)

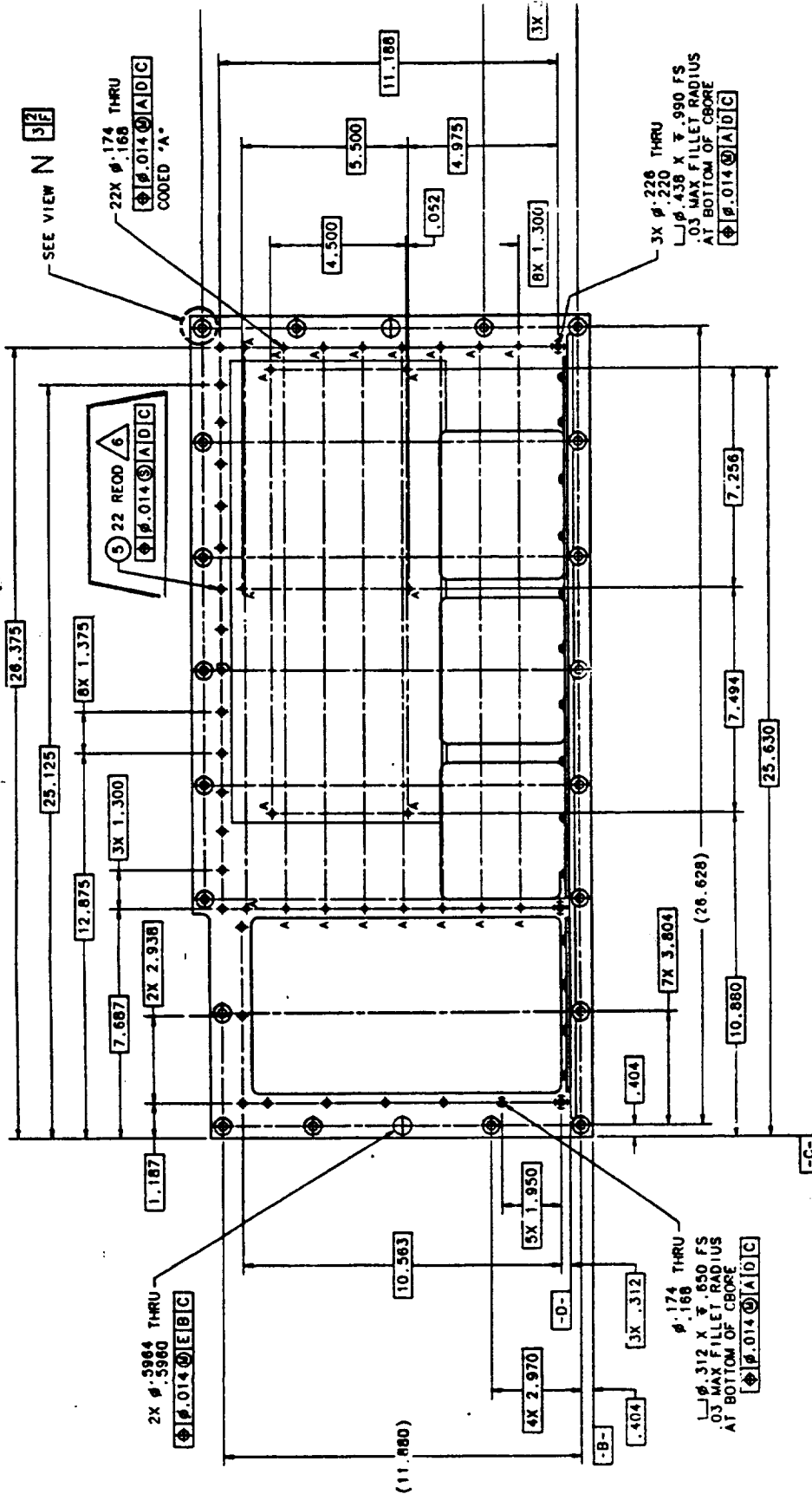
$$T = .2 F_L d$$

$$d = .138$$

$$F_L = 11 / (.2)(.138) = 399 \text{ LB}$$



1356405 LOWER BASE PLATE
MS51830-103 INSERTS - ITEM 5



VIEW M-M 1 E

MS51830-103
 15 TO 1331650 LOWER RIGHT PANEL
 4 1331414 LOWER MOTOR MOUNT PANEL
 3 1331447 LOWER RIGHT FRONT SUPPORT PANEL

FOR NAS1352NØ6 SCREW TO EXTEND BEYOND
INSERT REQUIRES A -6 SCREW OF $\phi = .375$ IN.
A -6 SCREW OF .375 IN. LENGTH IS ADEQUATE WITH
THE MS51830-103 INSERT

BASEPLATE INT THD TO INSERT EXT THD

- . 216-28UNF-2A EXT THD IN MS51830-103
- . 216-28UNF-2B INT THD IN BPLATE

ENGAGEMENT LENGTH

$$l_e = .125 - .010 - \frac{1}{n} \quad n = 28$$

$$= .1079 \text{ IN}$$

MAT'RL

- GRES 302 $F_{su} = .6(80000) = 48000 \text{ PSI}$ INSERT
- 6061-T6 $F_{su} = 27000 \text{ PSI}$ BASEPLATE

THREAD SHEAR AREA (H-28 APP A5)

INT THD

$$A_{S_n} = \pi n l_e D_{s_{min}} \left[\frac{1}{2} n + 1.57735 (D_{s_{min}} - E_{n_{max}}) \right]$$

- $n = 28$
- $l_e = .1079$
- $D_{s_{min}} = .2085$ MIN MAJOR EXT
- $E_{n_{max}} = .1970$ MAX PITCH INT

$$A_{S_n} = .0355 \text{ IN}^2$$

EXT THD

$$A_{S_s} = \pi n l_e K_{n_{max}} \left[\frac{1}{2} n + 1.57735 (E_{s_{min}} - K_{n_{max}}) \right]$$

- $K_{n_{max}} = .186$ MAX MINOR INT
- $E_{s_{min}} = .1886$ MIN PITCH EXT

$$A_{S_s} = .0250 \text{ IN}^2$$

JOINT STIFFNESS

PER SHIGLEY, MECHANICAL ENGINEERING DESIGN,
4TH EDITION, 1983, P 371-376, WITH ASSUMPTIONS
USE $d =$ INSERT NOMINAL ϕ , .216 IN

$$F_b = \frac{k_b P}{k_b + k_m} + F_L$$

b = BOLT
m = MEMBER

$$k_b = \frac{EA}{l}$$

$$E = 29 \times 10^6 \text{ PSL}$$

$$A = \pi/4 (.216)^2 = .0366 \text{ IN}^2$$

$$l = .032 + .105 + .015 = .152 \text{ IN}$$

GRIP LENGTH

$$= 6.991 \times 10^6 \text{ LB/IN}$$

$$k_m = \frac{\pi E d}{2 \ln \left[5 \frac{l + d/2}{l + 2.5d} \right]}$$

$$E = 10 \times 10^6 \text{ PSL}$$

$$d = .216 \text{ IN}$$

$$l = .152 \text{ IN}$$

$$= 5.381 \times 10^6 \text{ LB/IN}$$

$$w/E = 10 \times 10^6 \text{ PSL}$$

WHOLE GRIP LENGTH

TOTAL SCREW TENSILE LOAD

$$P = 1.4 F = 1.4(408) = 571 \text{ LB}$$

$$F_L = 399 \text{ LB}$$

$$F_b = (.565)(571) + 399 = 722 \text{ LB}$$

SHEAR STRESS

BASEPLATE 6061-T6 INT THD

$$\tau = \frac{F_b}{A_{S_n}} = \frac{722}{.0355} = 20335 \text{ PSL}$$

$$MS = \frac{27000}{20335} - 1 = +.33 \quad \text{BASEPLATE}$$

•• THREAD SHEAR OK IN BASEPLATE ID THDS

MS51830-103 INSERT CRES EXT THD

$$\gamma = \frac{F_b}{A_{S_3}} = \frac{722}{.0250} = 28880 \text{ psi}$$

$$MS = \frac{48000}{28880} - 1 = +.66 \quad \text{INSERT}$$

∴ THREAD SHEAR OK IN INSERT OD THDS

MS51830-103 INT THD TO MS1352NØ6-6 SCREW EXT THD

- .138-32UNRL-3A EXT THD MS1352NØ6
- .138-32UNJL-3B INT THD MS51830-103

ENGAGEMENT LENGTH

$$l_e = .170 - .015 - 1/n \quad n = 32$$

$$= .124 \text{ IN}$$

MATERIAL

ALLOY STEEL $F_{Su} = .6(160000) = 96000 \text{ psi}$ SCREW

CRES 303 $F_{Su} = .6(80000) = 48000 \text{ psi}$ INSERT

THREAD SHEAR AREA (H-28 APPAS)

INT THD

$$A_{S_m} = \pi E \frac{3l_e}{4}$$

$$= 1.0344 \text{ IN}^2$$

$$l_e = .124$$

$$E = \text{BASIC PITCH } \phi .1177 \text{ IN}$$

$$A_{S_3} = \pi E \frac{5l_e}{8}$$

$$= .0287 \text{ IN}^2$$

JOINT STIFFNESS

$$F_b = \frac{k_b}{k_b + k_m} P + F_i$$

b = BOLT
m = MEMBER

$$k_b = \frac{EA}{L_{GRIP}}$$

$$= 2.854 \times 10^6 \text{ LB/IN}$$

$$E = 29 \times 10^6 \text{ PSI}$$

$$A = \pi/4 (.138)^2 = .0150 \text{ IN}^2$$

$$L = .032 + .105 + .015 = .152 \text{ IN}$$

GRIP LENGTH

$$k_m = \frac{\pi E d}{2.1n \left[5 \frac{d+d/2}{L+2.5d} \right]}$$

$$= 2.713 \times 10^6 \text{ LB/IN}$$

$$E = 10 \times 10^6 \text{ PSI}$$

$$d = .138 \text{ IN}$$

$$L = .152 \text{ IN}$$

W/B = 10 x 10⁶ PSI ASSUMED
ENTIRE GRIP LENGTH

TOTAL SCREW TENSILE LOAD

$$P = 1.4 F = 1.4(408) = 571 \text{ LB}$$

$$F_L = 399 \text{ LB}$$

$$F_b = (.513)(571) + 399 = 692 \text{ LB}$$

SHEAR STRESS

MS51830-102 INSERT LRES INT THD

$$\tau = \frac{F_b}{A_{Sn}} = \frac{692}{.0344} = 20108 \text{ PSI}$$

$$MS = \frac{48000}{20108} - 1 = +1.4 \quad \text{INSERT}$$

∴ THREAD SHEAR OK IN INSERT ID THD

MS1352N06 SCREW STEEL EXT THD (NEXT RESIST)

$$\tau = \frac{F_b}{A_{Ss}} = \frac{692}{.0287} = 24111 \text{ PSI}$$

$$MS = \frac{96000}{24111} - 1 = +3.0 \quad \text{SCREW}$$

∴ THREAD SHEAR OK IN SCREW EXT THD

12-7-45

1331414 LOWER MOTOR MOUNT PANEL TO
1356405 LOWER BASEPLATE

FORCE @ NAS1352NØ6-6 SCREW IS

$$F_1 = 3 \times 29.84 \text{ LB/IN} = 89.52 \text{ LB/IN} \quad \text{"3Ø RANDOM"}$$

W/ 6 SCREWS IN 10.562 IN

LOAD PER SCREW, P

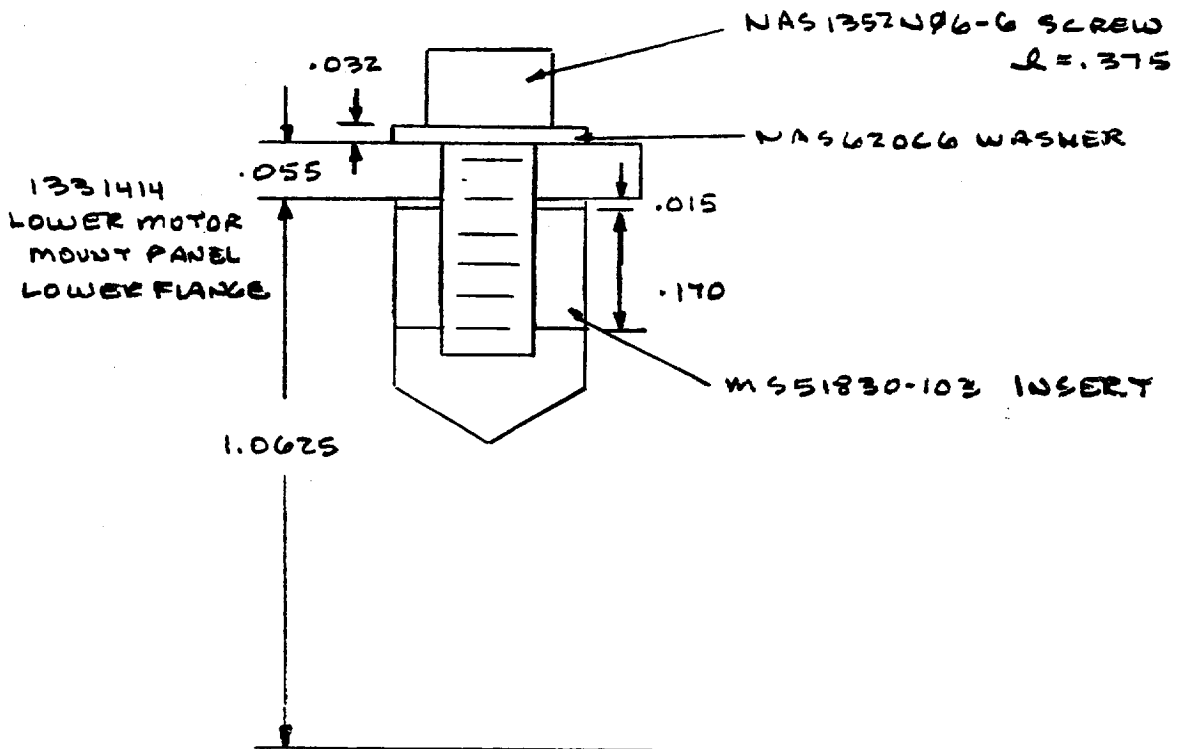
$$P = \frac{10.562}{6} (89.52) = 157.6 \text{ LB}$$

FACTOR OF SAFETY ON P

$$FS = 1.4$$

PRELOAD (9-11 IN-LB TORQUE)

$$F_L = 11 / (62) (1.38) = 399 \text{ LB}$$



THE NAS1352NØ6-6 SCREW (L=.375 IN) WILL EXTEND BEYOND INSERT THREADS. FULL L OF INSERT ID LENGTH IS MADE.

BASEPLATE INT THD TO INSERT EXT THD

.216-28UNF-2A INSERT MSS51830-103
.216-28UNF-2A BASEPLATE

$$L_e = .125 - .010 - \frac{1}{n} = .079 \text{ IN} \quad n = 28$$

$$F_{su} = 48000 \text{ PSI INSERT}$$

$$F_{su} = 27000 \text{ PSI BASEPLATE}$$

$$A_{S_n} = .0355 \text{ IN}^2$$

$$A_{S_s} = .0250 \text{ IN}^2$$

JOINT STIFFNESS

$$F_b = \frac{k_b}{k_b + k_m} P + F_L$$

$$k_b = \frac{EA}{L_{GRIP}}$$

$$= 10.418 \times 10^6 \text{ LB/IN}$$

$$E = 29 \times 10^6 \text{ PSI}$$

$$A = \pi/4 (.216)^2 = .0366 \text{ IN}^2$$

$$L = .032 + .055 + .015$$

$$= .102 \text{ IN}$$

GRIP LENGTH

$$k_m = \frac{\pi E d}{2 \ln \left[5 \frac{L + d/2}{L + 2.5d} \right]}$$

$$= 6.897 \times 10^6 \text{ LB/IN}$$

$$E = 10 \times 10^6 \text{ PSI}$$

$$d = .216 \text{ IN}$$

$$L = .102 \text{ IN}$$

TOTAL SCREW TENSILE LOAD

$$F_b = (.602)(1.4)(157.6) + 399 = 532 \text{ LB}$$

SHEAR STRESSBASEPLATE LOG1-T6 INT THD

$$\tau = \frac{F_b}{A_{S_n}} = \frac{532}{.0355} = 14980 \text{ PSI}$$

$$MS = \frac{27000}{14980} - 1 = +.80 \text{ BASEPLATE}$$

∴ THREAD SHEAR OK IN BASEPLATE

MS51830-103 INSERT CRES EXT THD

$$\gamma = \frac{F_b}{AS_s} = \frac{532}{.0250} = 21280 \text{ PSI}$$

$$MS = \frac{48000}{21280} - 1 = +1.3 \quad \text{INSERT}$$

∴ THREAD SHEAR OK IN INSERT EXT THDS

MS51830-103 INT THD TO MS1352ND6-6 SCREW EXT THD

.138-32UNRC-3A EXT THD MS1352ND6
.138-32UNJC-3B INT THD MS51830-103

$$L_e = .170 - .015 - \frac{1}{16} \quad n = 32$$

$$= .124 \text{ IN}$$

$$F_{su} = 96000 \text{ PSI} \quad \text{SCREW}$$

$$F_{su} = 48000 \text{ PSI} \quad \text{INSERT}$$

$$AS_n = .0344 \text{ IN}^2$$

$$AS_s = .10287 \text{ IN}^2$$

$$k_b = \frac{EA}{L} \quad L = .102 \text{ IN}$$

$$= 4.253 \times 10^6 \text{ LB/IN} \quad A = .10150 \text{ IN}^2$$

$$E = 29 \times 10^6 \text{ PSI}$$

$$k_m = 3.342 \times 10^6 \text{ LB/IN}$$

$$F_b = (.560)(1.4)(157.6) + 399 = 523 \text{ LB}$$

SHEAR STRESS

MS51830-103 INSERT CRES INT THD

$$\gamma = \frac{F_b}{AS_n} = \frac{523}{.0344} = 15191 \text{ PSI}$$

$$MS = \frac{48000}{15191} - 1 = +2.2 \quad \text{INSERT}$$

∴ THREAD SHEAR OK IN INSERT ID THDS

NAS1352NØ6 SCREW STEEL EXT THD (HEAT RESISTANT)

$$\gamma = \frac{F_b}{A_s} = \frac{523}{.0287} = 18223 \text{ PSI}$$

$$MS = \frac{96000}{18223} - 1 = +4.3 \quad \text{SCREW}$$

∴ THREAD SHEAR OK IN SCREW EXT THDS

1331447 LOWER RIGHT FRONT SUPPORT PANEL TO
1356405 LOWER BASEPLATE

FORCE IN NAS1352NØ6-6 SCREW IS

$$F = 3 \times 16.844 = 50.53 \text{ LB/IN} \quad \text{"3 RANDOM"}$$

W/ 3 SCREWS IN 6.500 IN, LOAD PER SCREW

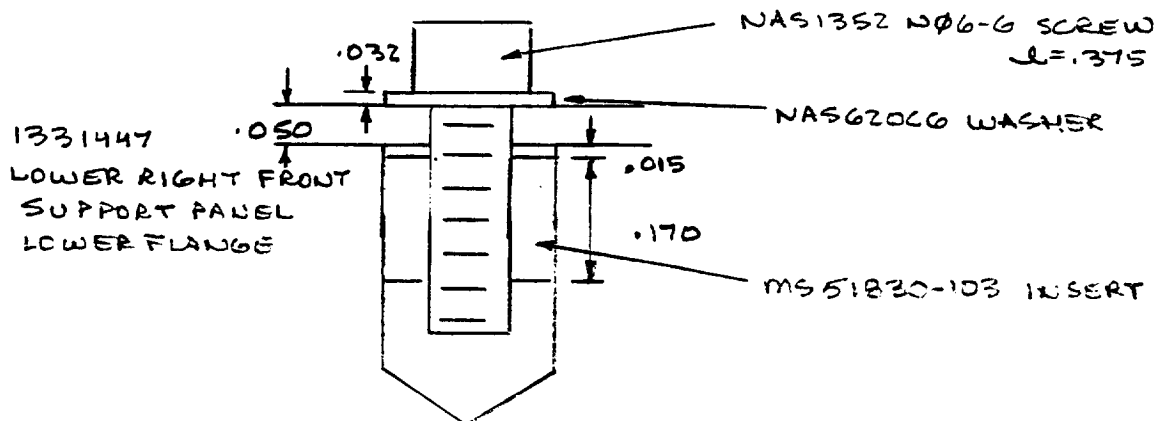
$$P = \frac{6.500}{3} (50.53) = 109.5 \text{ LB}$$

FACTOR OF SAFETY ON P, 1.4

PRELOAD @ 110-LB TORQUE

$$F_L = 11 / (.2)(.138) = 399 \text{ LB}$$

THE NAS1352NØ6-6 SCREW LENGTH, .375, IS ADEQUATE TO ENGAGE ENTIRE INSERT THREADS.



BASEPLATE INT THD TO INSERT EXT THD

$$L_e = .125 - .010 - 1/n = .079 \text{ IN} \quad n = 28$$

$$A_{S_n} = .0355 \text{ IN}^2$$

$$A_{S_s} = .0250 \text{ IN}^2$$

JOINT STIFFNESS

$$F_b = \frac{k_b}{k_b + k_m} P + F_i$$

$$k_b = \frac{EA}{L}$$

$$= 10.955 \times 10^6 \text{ LB/IN}$$

$$k_m = \frac{\pi E d}{2 \ln \left[5 \frac{R+d/2}{R+2.5d} \right]}$$

$$= 7.133 \times 10^6 \text{ LB/IN}$$

$$E = 29 \times 10^6 \text{ PSI}$$

$$A = \pi/4 (.216)^2 = .0366 \text{ IN}^2$$

$$L = .032 + .050 + .015 = .097 \text{ IN}$$

$$E = 10 \times 10^6 \text{ PSI}$$

$$d = .216 \text{ IN}$$

$$L = .097 \text{ IN}$$

TOTAL SCREW TENSILE LOAD

$$F_b = (.606)(1.4)(109.5) + 399 = 492 \text{ LB}$$

SHEAR STRESSBASEPLATE 6061-T6 INT THD

$$\tau = \frac{F_b}{A_{S_n}} = \frac{492}{.0355} = 13855 \text{ PSI}$$

$$MS = \frac{27000}{13855} - 1 = +.95 \quad \text{BASEPLATE}$$

∴ THREAD SHEAR OK IN BASEPLATE

MS 51830-103 INSERT CREW EXT THD

$$\tau = \frac{F_b}{A_{S_s}} = \frac{492}{.0250} = 19680 \text{ PSI}$$

$$MS = \frac{48000}{19680} - 1 = +1.4 \quad \text{INSERT}$$

∴ THREAD SHEAR OK IN INSERT EXT THD

MSS1830 INT THD TO MS1352NØ6 SCREW EXT THD

$$d_e = .175 - .015 - \frac{1}{16} = .124 \text{ IN} \quad n = 22$$

$$A_{S_n} = .0344 \text{ IN}^2$$

$$A_{S_s} = .0287 \text{ IN}^2$$

$$k_{10} = 4.471 \times 10^6 \text{ LB/IN}$$

$$k_{21} = 3.440 \times 10^6 \text{ LB/IN}$$

$$F_b = (.565)(1.4)(109.5) + 399 = 486 \text{ LB}$$

SHEAR STRESS

MSS1830 INSERT CPES INT THD

$$\gamma = \frac{F_b}{A_{S_n}} = \frac{486}{.0344} = 14117 \text{ PSI}$$

$$MS = \frac{48000}{14117} - 1 = +2.4 \quad \text{INSERT}$$

∴ THREAD SHEAR OK IN INSERT INT THDS

MS1352NØ6 SCREW HEAT RESISTANT STEEL EXT THD

$$\gamma = \frac{F_b}{A_{S_s}} = \frac{486}{.0287} - 1 = 16934 \text{ PSI}$$

$$MS = \frac{96000}{16934} - 1 = +4.7 \quad \text{SCREW}$$

∴ THREAD SHEAR OK IN SCREW EXT THDS

THREAD SHEAR - MF1301 ANCHOR NUTS

1331652 LOWER AFT PANEL TO
1356405 LOWER BASEPLATE VIA MF1331-06 ANCHORS

USE RANDOM VIBRATION NASTRAN "ELFORCS" DATA AS LOAD. PER LOWER AFT PANEL LOWER FLANGE BENDING STRESS/ BOLT TENSILE STRESS EVALUATION, THE FORCE @ THE NAS 1352 NØ6-8 SCREW IS:

$$F_1 = 3 \times 238.8 = 716.4 \text{ LB/IN} \quad "3T"$$

WITH 8 SCREWS IN 10.563 IN, THE LOAD PER SCREW, P, IS

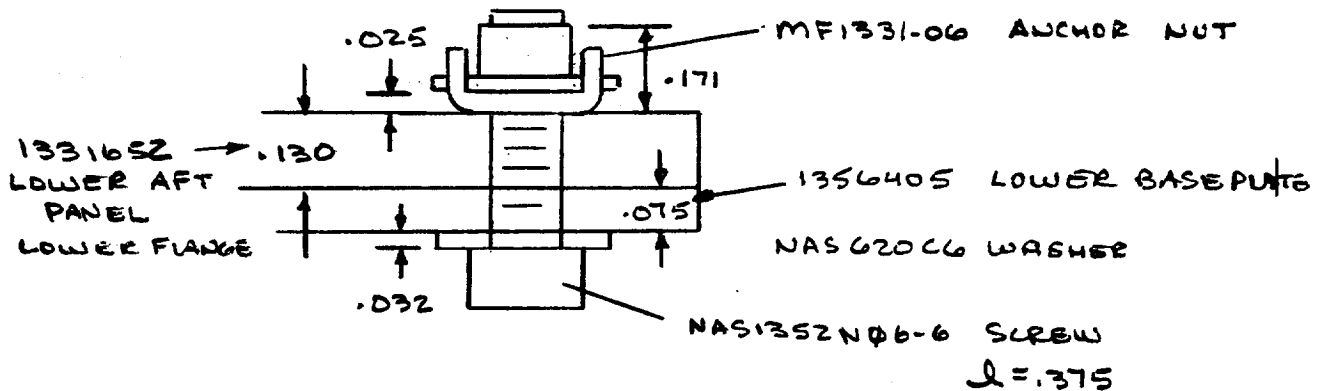
$$P = \frac{10.563}{8} (716.4) = 946 \text{ LB}$$

FACTOR OF SAFETY ON EXTERNAL LOAD, P, IS 1.4

PRELOAD (11 IN-LB MAX TORQUE)

$$F_L = T / .2d \quad d = .138$$

$$F_L = 11 / (.2)(.138) = 399 \text{ LB}$$



FOR THE NAS 1352NØ6 SCREW TO EXTEND BEYOND THE NUT PLATE, UTILIZING THE FULL COMPLIMENT OF NUTPLATE THREADS, ITS LENGTH MUST EXCEED

$$l = .032 + .075 + .130 + .171 = .408 \text{ IN}$$

THUS A -8 $l = .500$ IN SCREW IS REQ'D.

MF1331-06 NUT PLATE INT THREADS TO NAS1352N06-8 SCREW

.1380-32 UNJC-3B MF1331-06 INT THD
.1380-32 UNRL-3A NAS1352N06-8 EXT THD

ENGAGEMENT LENGTH

$$l_e = .171 - .025 - \frac{1}{n} = .115 \text{ IN} \quad n = 32$$

MAT'RL

A286 STEEL	$F_{su} = .6(140000) = 84000 \text{ psi}$	ASSUMED
HEAT TREATED	(REF MSS1830 A-286 $F_{tu} = 140000 \text{ psi}$)	NUT PLATE
ALLOY STEEL	$F_{su} = .6(160000) = 96000 \text{ psi}$	SCREW

THREAD SHEAR AREA (H-28)

INT THD

$$A_{S_n} = \pi n l_e D_{smin} \left[\frac{1}{2}n + .57735 (D_{smin} - E_{nmax}) \right]$$

$$\begin{aligned} n &= 32 \\ l_e &= .115 \\ D_{smin} &= .1320 \\ E_{nmax} &= .1204 \end{aligned}$$

$$A_{S_n} = .0341 \text{ IN}^2$$

$$A_{S_g} = \pi n l_e K_{nmax} \left[\frac{1}{2}n + .57735 (E_{smin} - K_{nmax}) \right]$$

$$\begin{aligned} K_{nmax} &= .1157 \text{ IN} \\ E_{smin} &= .1156 \text{ IN} \end{aligned}$$

$$A_{S_g} = .0208 \text{ IN}^2$$

JOINT STIFFNESS

PER SNIGLEY, MECHANICAL ENGINEERING DESIGN, 4TH ED, 1983, P371-376, WITH ASSUMPTIONS,

$$F_b = \frac{b P}{k_b + k_m} + F_i$$

b = BOLT
m = MEMBER

$$k_b = \frac{EA}{l}$$

$$= 1.656 \times 10^6 \text{ LB/IN}$$

$$E = 29 \times 10^6 \text{ PSL}$$

$$A = \pi/4 (.138)^2 = .0150 \text{ IN}^2$$

$$l = \text{GRIP LENGTH}$$

$$= .032 + .075 + .130 + .025 = .262 \text{ IN}$$

$$k_m = \frac{\pi E d}{2 \ln \left[5 \frac{l+d/2}{l+2.5d} \right]}$$

$$= 2.161 \times 10^6 \text{ LB/IN}$$

$$E = 10 \times 10^6 \text{ PSL}$$

$$d = .138 \text{ IN}$$

$$l = .262 \text{ IN}$$

TOTAL SCREW TENSILE LOAD

$$F_b = (F_s)(P) + (F_i)$$

$$P_b = \frac{k_b}{k_b + k_m} P = (0.434)(946) = 410 \text{ LB}$$

$$F_b = (1.4)(410) + 399 = 974 \text{ LB}$$

SHEAR STRESS

NUT PLATE A-286 INT THD

$$\tau = \frac{F_b}{A_{S_n}} = \frac{974}{.0341} = 28600 \text{ PSL}$$

$$MS = \frac{84000}{28600} - 1 = +1.9 \quad \text{NUT PLATE}$$

SCREW HEAT RESIST STEEL EXT THD

$$\tau = \frac{F_b}{A_{S_s}} = \frac{974}{.0208} = 46775 \text{ PSL}$$

$$MS = \frac{96000}{46775} - 1 = +1.1 \quad \text{SCREW}$$

∴ BOTH NUT PLATE & SCREW ARE OK FOR
THREAD SHEAR

1331642 UPPER AFT PANEL TO
1331356 UPPER BASEPLATE VIA MF1331-06 ANCHOR NUTS

FORUS @ MF1331-06 NOT PLATE / NAS1352N06-10 SCREW

$$F_1 = 3 \times 127.83 = 383.49 \text{ LB/IN} \quad \text{"39 LOADS"}$$

W/ 9 SCREWS IN 11.7 IN

LOAD PER SCREW, P

$$P = \left(\frac{11.7}{9}\right)(383.49) = 498.5 \text{ LB}$$

FS \Rightarrow 1.4 ON P

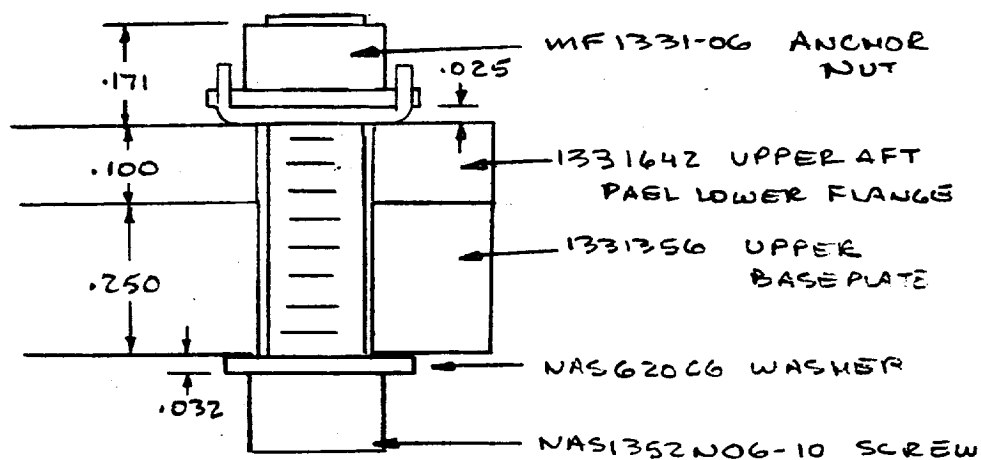
PRELOAD @ 11 IN-LB TORQUE

$$F_L = 11(.2)(.138) = 399 \text{ LB}$$

FOR THE NAS1352N06 SCREW TO EXTEND BEYOND NOT PLATE, UTILIZING FULL COMPLIMENT OF NOTPLATE THREADS, ITS LENGTH MUST EXCEED

$$L = .032 + .250 + .100 + .171 = .553$$

THUS A -10 (L=.625) IS REQ'D



PREVIOUS 1331642 FLANGET WAS .065 (NOW .100)
@ .065, THE REQ'D SCREW LENGTH WOULD BE

$$L = .032 + .250 + .065 + .171 = .518$$

THUS PREVIOUS -8 (L=.500) WOULD HAVE BEEN TOO SHORT

MF1331-06 NUT PLATE INT THD TO NAS135ZN06-10 SCREW

Report 10381
Addendum 1

.1380-32UNJC-3B

MF1331-06 NUT PLATE

.1380-32UNRL-3A

NAS135ZN06-6 SCREW

ENGAGEMENT LENGTH

$$l_e = .171 - .025 - 1/4$$

n = 32

$$= .115 \text{ IN}$$

$$F_{Su} = 84000 \text{ PSI}$$

NUT PLATE

$$F_{Su} = 96000 \text{ PSI}$$

SCREW

$$A_{Sn} = .0341 \text{ IN}^2$$

$$A_{Ss} = .0208 \text{ IN}^2$$

JOINT STIFFNESS

$$F_b = \frac{k_b}{k_b + k_m} P + F_i$$

$$k_b = \frac{EA}{L_{GRIP}}$$

$$= 1.066 \times 10^6 \text{ LB/IN}$$

$$k_m = \frac{\pi E d}{2 \ln \left[5 \frac{l + d/2}{l + 2.5d} \right]}$$

$$= 1.881 \times 10^6 \text{ LB/IN}$$

$$E = 29 \times 10^6 \text{ PSI}$$

$$A = \pi/4 (.138)^2 = .0150 \text{ IN}^2$$

$$L = .032 + .250 + .100$$

$$+ .025 = .407 \text{ IN}$$

$$E = 10 \times 10^6 \text{ PSI}$$

$$d = .138 \text{ IN}$$

$$L = .407 \text{ IN}$$

TOTAL SCREW LOAD

$$F_b = (F_s)(P) + F_i$$

$$P_b = \frac{k_b}{k_b + k_m} P = (.362)(498.5) = 180.3 \text{ LB}$$

$$F_b = (1.4)(180.3) + 399 = 651.4$$

SHEAR STRESS

NUT PLATE A-286 INT THD

$$\gamma = \frac{F_b}{A_{Sn}} = \frac{651.4}{.0341} = 19102 \text{ PSI}$$

$$MS = \frac{84000}{19102} - 1 = + 3.4 \quad \text{NUTPLATE}$$

SCREW HEAT RESISTANT STEEL EXT TND

$$\gamma = \frac{F_b}{A_s} = \frac{651.4}{.0208} = 31317 \text{ PSI}$$

$$MS = \frac{96000}{31317} - 1 = + 2.1 \quad \text{SCREW}$$

∴ BOTH NUTPLATE & SCREW ARE OK FOR
THREAD SHEAR

ADDITIONAL PANEL ATTACHMENTS

Report 10381
Addendum 1

1331051 UPPER RIGHT PANEL TO
1331356 UPPER BASEPLATE

MF1331-06 NUT PLATES

$F_1 = 3 \times 42.82 = 128.46 \text{ LB/IN}$ "3T"

w/ 7 SCREWS NAS1352N06-10 IN 8.783 IN

$P = \frac{8.783}{7} 128.46 = 161.18 \text{ LB}$

$F_S = 1.4 \text{ ON P}$

$F_L = 399 \text{ LB (PRELOAD)}$

USES NAS1352N06-10 SCREWS ($d = .625 \text{ IN}$)

$d_{GRIP} = .250$	t	UPPER BASEPLATE
.065	t	UPPER RIGHT PANEL FLANGE
.171	t	NUTPLATE MF1331-06
.037	t	NAS62066 WASHER
<u>.518</u>		

$l_e = .171 - .025 - \frac{1}{2}n = .115 \text{ IN}$

$AS_n = .0341 \text{ IN}^2$

$AS_s = .0208 \text{ IN}^2$

$k_b = \frac{(29 \times 10^6)(.0150)}{(.518)} = 840 \times 10^3 \text{ LB/IN}$

$k_{em} = \frac{\pi^2 (10 \times 10^6)(.138)}{2 \ln \left[5 \frac{.518 + .138/2}{.518 + 2.4(.138)} \right]} = 1771 \times 10^3 \text{ LB/IN}$

$F^* = (1.4)(.322)(161.18) + 399 = 472 \text{ LB}$

$\gamma = \frac{472}{.0341} = 13829 \text{ PSL}$

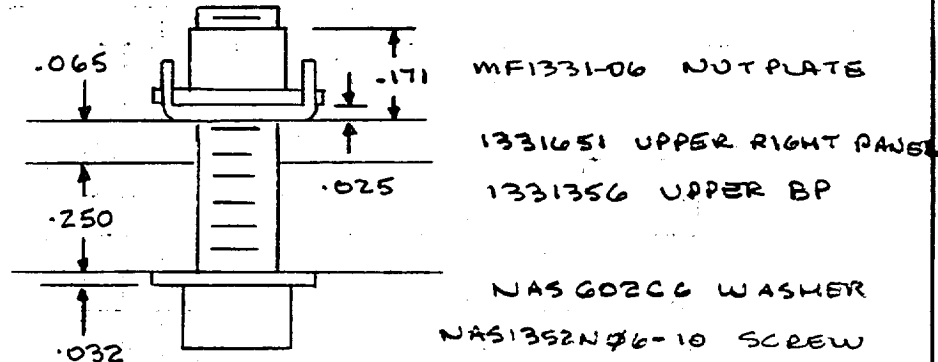
$MS = \frac{84000}{13829} - 1 = +5.1 \quad \text{NUTPLATE}$

$\gamma = \frac{472}{.0208} = 22692 \text{ PSL}$

$MS = \frac{96000}{22692} - 1 = +3.2 \quad \text{SCREW}$

∴ BOTH NUT PLATE & SCREW ARE OK FOR TMO SHEAR

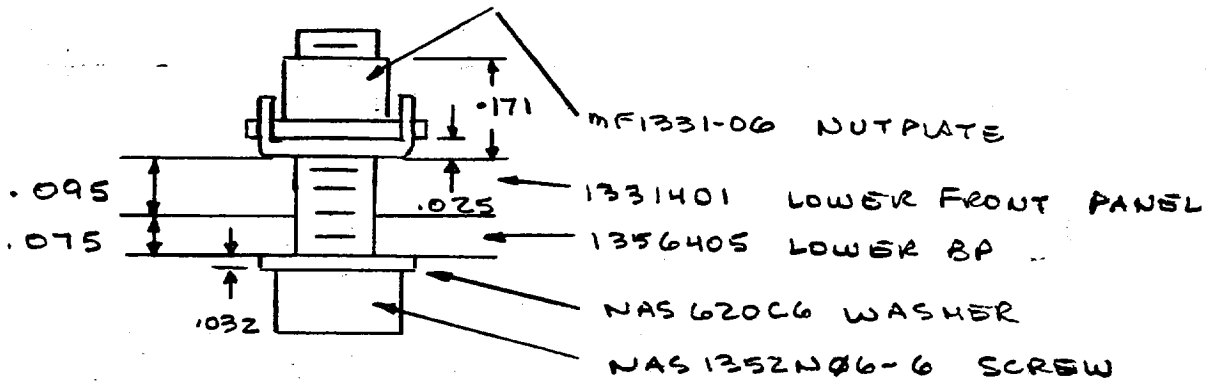
1331651 UPPER RIGHT PANEL - 1331356 UPPER BASEPLATE



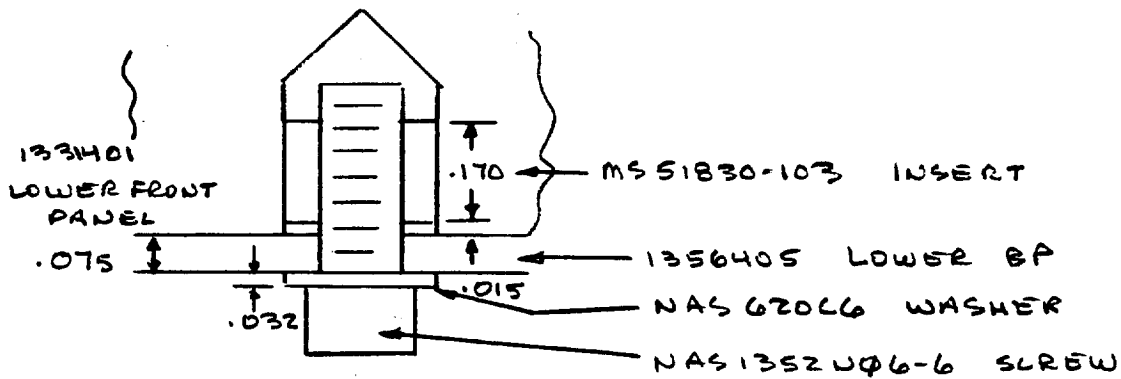
1331401 LOWER FRONT PANEL TO
1356405 LOWER BASEPLATE VIA

5 MF1331-06 NUTPLATES
3 MS51830-103 INSERTS

JOINT W/ NUTPLATES



JOINT W/ INSERT



$$F_1 = 3 \times 69.83 = 209.49 \text{ LB/IN} \quad \text{"3T"}$$

w/ 8 SCREWS IN 10.563 IN

$$P = \frac{10.563}{8} (209.49) = 277 \text{ LB}$$

$$FS = 1.4 \text{ ON } P$$

$$FL = 399 \text{ LB (PRELOAD)}$$

$$L_{GRIP} = .032 + .075 + .095 + .025 = .227 \text{ IN} \quad \text{w/ NUTPLATE}$$

$$L_{GRIP} = .032 + .075 + .015 = .122 \text{ IN} \quad \text{w/ INSERT}$$

REQ'D NAS 1352 NØ6-6 SCREW. ($l = .375$ IN)

SCREW $l = .032 + .075 + .095 + .171 = .373$ IN W/NUTPLATE

SCREW $l = .032 + .075 + .015 + .170 = .292$ IN W/INSERT

\therefore -6 SCREW $l = .375 > \begin{matrix} .373 \text{ IN} \\ .292 \text{ IN} \end{matrix}$

$l_e = .171 - .025 - 1/n = .115$ IN W/NUTPLATE

$l_e = .125 - .010 - 1/n = .079$ IN PANEL-INSERT
 $n = 28$
 $= .170 - .015 - 1/n = .124$ IN INSERT/SCREW
 $n = 32$

$A_{Sn} = .0341$ IN² W/NUTPLATE
 $A_{Ss} = .0208$ IN²

$A_{Sn} = .0355$ IN² PANEL-INSERT
 $A_{Ss} = .0250$ IN² .216-28UNF

$A_{Sn} = .0344$ IN² INSERT-SCREW
 $A_{Ss} = .0287$ IN² 1138-32UNRC

W/NUTPLATE

$J_{2b} = 1.916 \times 10^6$ LB/IN

$J_{2m} = \frac{\pi (10 \times 10^6 \times .138)}{2 \ln \left[5 \frac{.227 + .138/2}{.227 + 2.5(.138)} \right]} = 2.280 \times 10^6 \frac{\text{LB}}{\text{IN}}$

$F_b = (1.4)(.457)(277) + 399 = 576$ LB

$\gamma = \frac{576}{.0341} = 16894$ PSI

$MS = \frac{84000}{16894} - 1 = +4.0$ NUTPLATE

$\gamma = \frac{576}{.0208} = 27692$ PSI

$MS = \frac{96000}{27692} - 1 = +2.5$ SCREW

∴ BOTH NUTPLATE & SCREW OK FOR TND SHEAR

W/INSERT

PANEL/INSERT OD

PANEL 6061-T6 $F_{su} = 27000 \text{ psi}$

$$J_b = \frac{(29 \times 10^6)(.0306)}{(.122)} = 8.700 \times 10^6 \text{ LB/IN}$$

$$J_m = \frac{\pi(10 \times 10^6)(.216)}{2 \ln \left[5 \frac{.122 + .216/2}{.122 + 2.5(.216)} \right]} = 6.144 \times 10^6 \text{ LB/IN}$$

$$F_b = (1.4)(.586)(277) + 399 = 626 \text{ LB}$$

$$\tau = \frac{626}{.0355} = 17642 \text{ psi}$$

$$MS = \frac{27000}{17642} - 1 = +.53 \quad \text{LOWER FRONT PANEL}$$

$$\tau = \frac{626}{.0250} = 25040 \text{ psi}$$

$$MS = \frac{48000}{25040} - 1 = +.92 \quad \text{INSERT OD TND}$$

∴ THREAD SHEAR OK IN PANEL/INSERT JOINT

INSERT ID/SCREW

$$J_b = \frac{(29 \times 10^6)(.0150)}{.122} = 3.566 \times 10^6 \text{ LB/IN}$$

$$J_m = \frac{\pi(10 \times 10^6)(.138)}{2 \ln \left[5 \frac{.122 + .138/2}{.122 + 2.5(.138)} \right]} = 3.030 \times 10^6 \text{ LB/IN}$$

$$F_b = (1.4)(1.541)(277) + 399 = 609 \text{ LB}$$

$$\tau = \frac{609}{0.344} = 17693 \text{ psi}$$

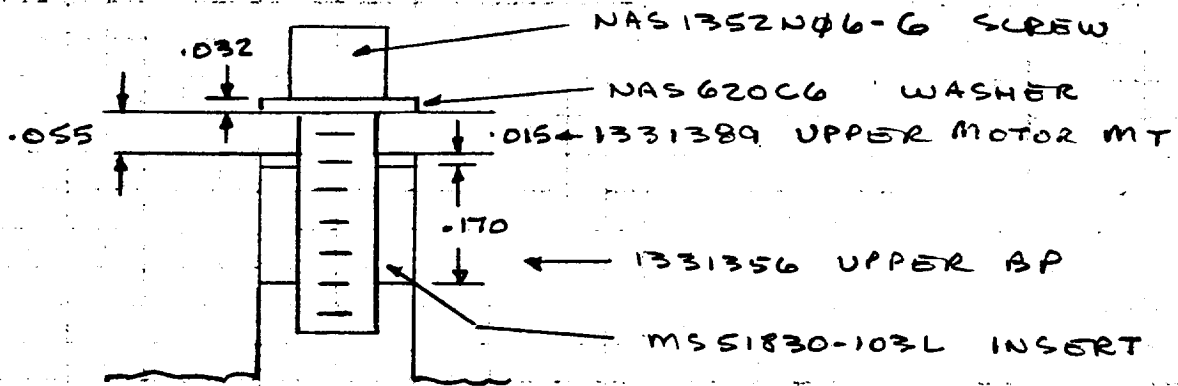
$$MS = \frac{48000}{17693} - 1 = +1.7 \quad \text{INSERT ID THDS}$$

$$\tau = \frac{609}{0.287} = 21220 \text{ psi}$$

$$MS = \frac{96000}{21220} - 1 = +3.5 \quad \text{SCREW}$$

∴ THREAD SHEAR OK IN INSERT/SCREW THDS

1331389 UPPER MOTOR MT PANEL TO
1331356 UPPER BASEPLATE VIA MSS1830-103L INSERTS



$F_1 = 3 \times 25.271 = 75.813 \text{ LB/IN}$ "34"

W/G SCREWS IN 10.563 IN

$P = \frac{10.563}{6} (75.813) = 133.5 \text{ LB}$

$R_S = 1.4 \text{ ON } P$

$F_L = 399 \text{ LB PRELOAD}$

$L_{GRIP} = .032 + .055 + .015 = .102 \text{ IN}$

REQ'D. NAS1352NØ6 LENGTH .375 - 6 OK

SCREW $L > .032 + .055 + .015 + .170 = .272 \text{ IN}$

$l_e = .125 - .010 - \frac{1}{n} = .079 \text{ IN}$ BP-INSERT
.216-28UNF
n=28

$l_e = .170 - .015 - \frac{1}{n} = .124 \text{ IN}$ INSERT-SCREW
.138-32UNR
n=32

$A_{Sn} = .0355 \text{ IN}^2$ UPPER BP-INSERT
 $A_{Ss} = .0250 \text{ IN}^2$

$A_{Sn} = .0344 \text{ IN}^2$ INSERT-SCREW
 $A_{Ss} = .0287 \text{ IN}^2$

UPPER BASEPLATE 6061-T6 $F_{su} = 27000 \text{ psi}$

$$J_{rb} = \frac{(29 \times 10^6)(.0366)}{.102} = 10.406 \times 10^6 \text{ LB/IN}$$

$$J_{em} = \frac{\pi(10 \times 10^6)(.216)}{2 \ln \left[5 \frac{.102 + .216/2}{.102 + 2.5(.216)} \right]} = 6.897 \times 10^6 \text{ LB/IN}$$

$$F_b = (1.4)(.601)(133.5) + 399 = 511 \text{ LB}$$

$$\tau = \frac{511}{.0355} = 14406 \text{ psi}$$

$$MS = \frac{27000}{14406} - 1 = +.87 \quad \text{UPPER BP}$$

$$\tau = \frac{511}{.0250} = 20456 \text{ psi}$$

$$MS = \frac{48000}{20456} - 1 = +1.3 \quad \text{INSERT OD THD}$$

\therefore THREAD SHEAR OK IN UPPER BP/INSERT JOINT

INSERT ID - SCREW

$$J_{rb} = \frac{(29 \times 10^6)(.0150)}{.102} = 4.265 \times 10^6 \text{ LB/IN}$$

$$J_{em} = \frac{\pi(10 \times 10^6)(.138)}{2 \ln \left[5 \frac{.102 + .138/2}{.102 + 2.5(.138)} \right]} = 3.342 \times 10^6 \text{ LB/IN}$$

$$F_b = (1.4)(.561)(133.5) + 399 = 504 \text{ LB}$$

$$\tau = \frac{504}{.0344} = 14645 \text{ psi}$$

$$MS = \frac{48000}{14645} - 1 = +2.3$$

INSERT ID THDS

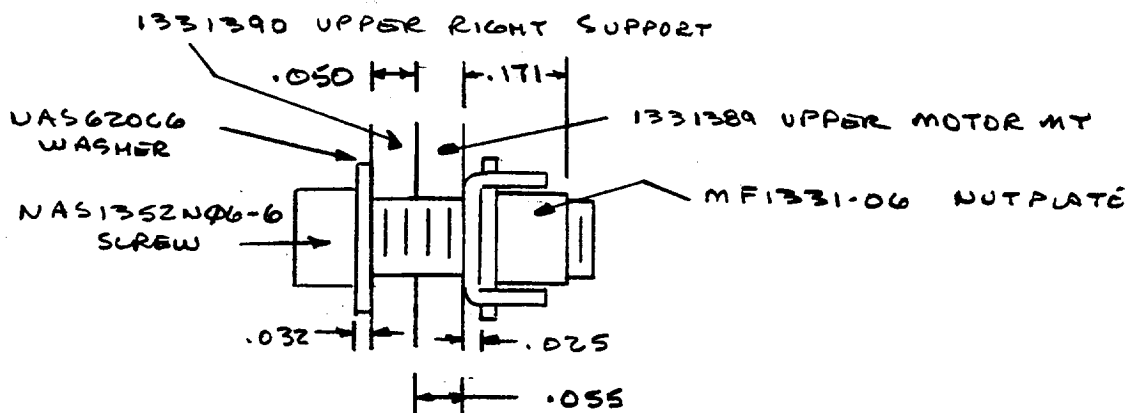
$$\tau = \frac{504}{.0287} = 17561 \text{ psi}$$

$$MS = \frac{96000}{17561} - 1 = +4.5$$

SCREW

∴ THREAD SHEAR OK IN INSERT/SCREW THDS

1331389 UPPER MOTOR MT PANEL TO
1331390 UPPER RIGHT FRONT SUPPORT PANEL
VIA MF1331-06 NUTPLATE



$$F_1 = 3 \times 33.175 = 99.525 \text{ LB/IN}$$

"3T"

W/3 SCREWS IN 6.245 IN

$$P = \frac{6.245}{3} (99.525) = 207 \text{ LB}$$

$$FS = 1.4 \text{ ON } P$$

$$F_L = 399 \text{ LB (PRELOAD)}$$

$$\text{REQ'D NAS1352 } L = .032 + .050 + .055 + .171 = .308 \text{ IN}$$

$$\therefore -6 \text{ } L = .375 \text{ IS OK}$$

$$L_{GRIP} = .032 + .050 + .055 + .025 = .162 \text{ IN}$$

$$l_e = .171 - .025 - \frac{1}{4} = .115$$

$$A_{Sn} = .0341 \text{ IN}^2$$

$$A_{Ss} = .0208 \text{ IN}^2$$

$$k_b = \frac{(29 \times 10^6)(.0150)}{.162} = 2.685 \times 10^6 \text{ LB/IN}$$

$$k_m = \frac{8(10 \times 10^6)(.138)}{2 \ln \left[5 \frac{.162 + .138/2}{.162 + 2.5(.138)} \right]} = 2.633 \times 10^6 \text{ LB/IN}$$

$$F_b = (1.4)(.505)(207) + 399 = 545 \text{ LB}$$

$$\gamma = \frac{545}{.0341} = 15992 \text{ PSI}$$

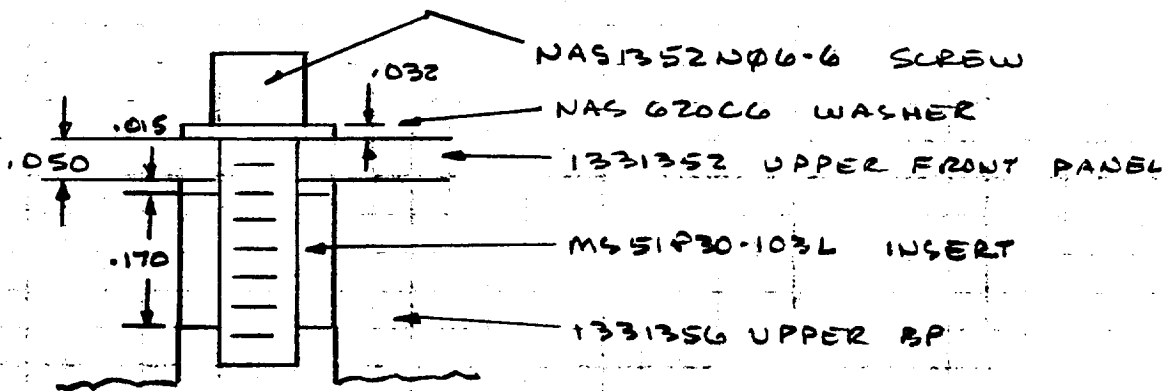
$$MS = \frac{84000}{15992} - 1 = +4.3 \quad \text{NUT PLATE}$$

$$\gamma = \frac{545}{.0208} = 26202 \text{ PSI}$$

$$MS = \frac{96000}{26202} - 1 = +2.7 \quad \text{SCREW}$$

∴ THREAD SHEAR OK IN JOINT

1331352 UPPER FRONT PANEL TO
1331356 UPPER BASEPLATE VIA MS51830-103L INSERTS



$$F_1 = 3 \times 24.409 = 73.227 \text{ LB/IN}$$

7 SCREWS IN 10.575 IN

$$P = \frac{10.575}{7} (73.227) = 111 \text{ LB}$$

$$F_S = 1.4 \text{ ON } P$$

$$F_L = 399 \text{ LB (PRELOAD)}$$

$$L_{GRIP} = .032 + .050 + .015 = .097 \text{ IN}$$

REQ'D NAS1352 NØ6 LENGTH .375 -6 OK

$$\text{SCREW } L > .032 + .050 + .015 + .170 = .267 \text{ IN}$$

$$L_e = .125 - .010 - \frac{1}{n} = .079 \text{ IN}$$

BP-INSERT
1216-28UNF
n=28

$$L_e = .170 - .015 - \frac{1}{n} = .124 \text{ IN}$$

INSERT-SCREW
1138-32UNEL
N=32

$$A_{S_n} = .0355 \text{ IN}^2$$

$$A_{S_s} = .0250 \text{ IN}^2$$

BP-INSERT

$$A_{S_n} = .0344 \text{ IN}^2$$

$$A_{S_s} = .0287 \text{ IN}^2$$

INSERT-SCREW

BP - INSERT OD TMD

$$J_{eb} = \frac{(29 \times 10^6)(.0306)}{.097} = 10.942 \times 10^6 \text{ LB/IN}$$

$$J_{em} = \frac{\pi(10 \times 10^6)(.216)}{2.1n \left[5 \frac{.097 + .216/2}{.097 + 2.5(.216)} \right]} = 7.133 \times 10^6 \text{ LB/IN}$$

$$F_b = (1.4)(.605)(111) + 399 = 493 \text{ LB}$$

$$\gamma = \frac{493}{.0355} = 13889 \text{ PSL}$$

$$MS = \frac{27000}{13889} - 1 = +.94 \quad \text{UPPER BP}$$

$$\gamma = \frac{493}{.0250} = 19720 \text{ PSL}$$

$$MS = \frac{48000}{19720} - 1 = +1.4 \quad \text{INSERT OD TMD}$$

∴ THREAD SHEAR OK IN UPPER BP/INSERT JOINT

INSERT ID - SCREW

$$J_{eb} = \frac{(29 \times 10^6)(.0150)}{.097} = 4.485 \times 10^6 \text{ LB/IN}$$

$$J_{em} = \frac{\pi(10 \times 10^6)(.138)}{2.1n \left[5 \frac{.097 + .138/2}{.097 + 2.5(.138)} \right]} = 3.440 \times 10^6 \text{ LB/IN}$$

$$F_b = (1.4)(.566)(111) + 399 = 487 \text{ LB}$$

$$\gamma = \frac{487}{.0344} = 14155 \text{ PSL}$$

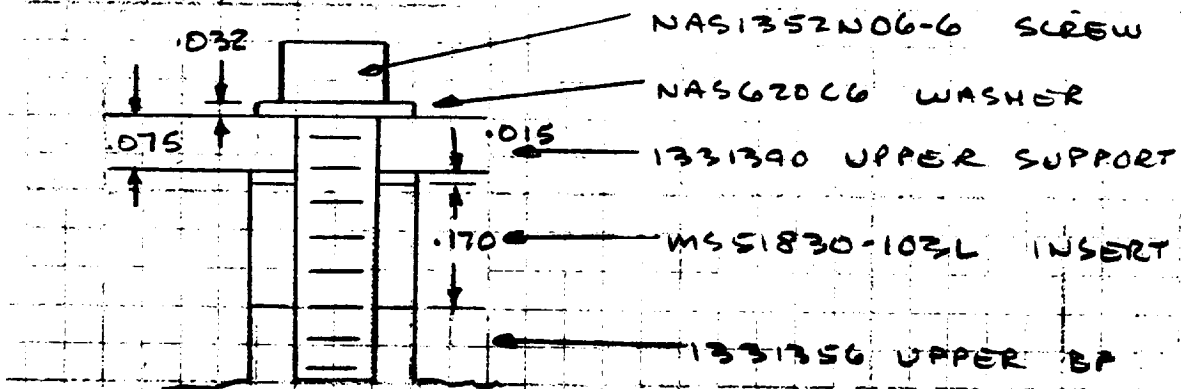
$$MS = \frac{48000}{14155} - 1 = +2.4 \quad \text{INSERT ID THD}$$

$$\gamma = \frac{487}{.0287} = 16969 \text{ PSI}$$

$$MS = \frac{96000}{16969} - 1 = +4.7 \quad \text{SCREW}$$

∴ THREAD SHEAR OK IN INSERT/SCREW THDS

1331390 UPPER RIGHT FRONT SUPPORT PANEL TO
1331356 UPPER BASE PLATE VIA MS51830-103L INSERTS



$$F_1 = 3 \times 28.80 = 86.40 \text{ LB/IN} \quad "3\text{T}"$$

W/ 3 SCREWS IN 6.500 IN

$$P = \frac{6.500}{3} (86.40) = 187.2 \text{ LB}$$

$$FS = 1.4 \text{ ON } P$$

$$F_L = 399 \text{ LB (PRELOAD)}$$

$$L_{GRIP} = .032 + .075 + .015 = .122 \text{ IN}$$

REQ'D NAS1352N06 LENGTH .375 -6 OK

$$\text{SCREW } L > .032 + .075 + .015 + .170 = .292 \text{ IN}$$

$$L_e = .125 - .010 - \frac{1}{n} = .079 \text{ IN} \quad \begin{array}{l} \text{BP-INSERT} \\ .216-28\text{UNF} \\ n=28 \end{array}$$

$$L_e = .170 - .015 - \frac{1}{n} = .124 \text{ IN} \quad \begin{array}{l} \text{INSERT-SCREW} \\ .138-32\text{UNRC} \\ n=32 \end{array}$$

$$\begin{array}{l} A_{Sn} = .0355 \text{ IN}^2 \\ A_{Ss} = .0250 \text{ IN}^2 \end{array}$$

UPPER BP-INSERT

$$\begin{array}{l} A_{Sn} = .0344 \text{ IN}^2 \\ A_{Ss} = .0287 \text{ IN}^2 \end{array}$$

INSERT-SCREW

BP - INSERT OD TND

$$k_b = \frac{(29 \times 10^6)(.0366)}{.122} = 8.700 \times 10^6 \text{ LB/IN}$$

$$k_{em} = \frac{27(10 \times 10^6)(.216)}{2 \ln \left[5 \frac{.122 + .216/2}{.122 + 2.5(.216)} \right]} = 6.144 \times 10^6 \text{ LB/IN}$$

$$F_b = (1.4)(.586)(187.2) + 399 = 553 \text{ LB}$$

$$\gamma = \frac{553}{.0355} = 15566 \text{ PSI}$$

$$MS = \frac{27000}{15566} - 1 = +.73 \quad \text{UPPER BP}$$

$$\gamma = \frac{553}{.0250} = 22120 \text{ PSI}$$

$$MS = \frac{48000}{22120} - 1 = +1.2 \quad \text{INSERT OD}$$

∴ THREAD SHEAR OK IN UPPER BP/INSERT OD TND

INSERT ID - SUREW

$$k_b = \frac{(29 \times 10^6)(.0150)}{.122} = 3.566 \times 10^6 \text{ LB/IN}$$

$$k_{em} = \frac{27(10 \times 10^6)(.138)}{2 \ln \left[5 \frac{.122 + .138/2}{.122 + 2.5(.138)} \right]} = 3.030 \times 10^6 \text{ LB/IN}$$

$$F_b = (1.4)(.541)(187.2) + 399 = 541 \text{ LB}$$

$$\gamma = \frac{541}{.0344} = 15718 \text{ PSI}$$

$$MS = \frac{48000}{15718} - 1 = +2.1$$

INSERT TO THD

$$\tau = \frac{541}{10287} = 18850 \text{ PSI}$$

$$MS = \frac{96000}{18850} - 1 = +4.1$$

SCREW

∴ THREAD SHEAR OK IN INSERT/SCREW JOINT

5.4.4 Large Masses Attachment Screw Stresses per Random Vibration Loads

The following pages contain a detailed analysis of large masses attachment screw stresses per random vibration loads.

TABLE 58. A1-EOS LARGE MASS ITEMS ATTACHMENT SCREW STRESS SUMMARY - RANDOM VIBRATION LOADS													
COMPONENT	PART NO.	SCREW	PRELOAD LB	POINT MASS LB	GRMS G	GRID PT 3s LOAD LB	O-TURN 3s LOAD LB	JOINT STIFFNESS	FS	TOTAL TENSION LB	ALLOW LOAD LB	MARGIN OF SAFETY	
DC/DC CONVERTER	1356010	NAS1352N08	792.7	0.91	17.98	49.1	36.3	0.384	1.4	838.6	2240	1.67	
DETECTOR PREAMP	1331610	NAS1352N06	507.2	0.7225	24.25	52.6	56.9	1	1.4	660.4	1458	1.21	
LOWER SHELF PLO ASSY 1	1331555 1348360	NAS1352N04	246	0.529	15.56	24.7	56.8	1	1.4	360.1	966	1.68	
PLO ASSY 2	1348360	NAS1352N04	246	0.532	16.26	26.0	59.7	1	1.4	365.9	966	1.64	
OSCILLATOR 1	1336610	NAS1352N04	246	0.393	19.31	22.8	38	1	1.4	331.1	966	1.92	
OSCILLATOR 2	1336610	NAS1352N04	246	0.39	14.52	17.0	28.3	1	1.4	309.4	966	2.12	
OSCILLATOR 2	1336610	NAS1352N04	246	0.34	21.73	22.2	37	1	1.4	328.8	966	1.94	
BRACKET	1331592	NAS1352N04	246	0.248	16.71	12.4	40.9	1	1.4	320.7	966	2.01	
BRACKET	1331562	NAS1352N04	246	0.292	21.15	18.5	68.3	1	1.4	367.6	966	1.63	
BRACKET	1331562	NAS1352N04	246	0.194	22.15	12.9	61.3	1	1.4	349.9	966	1.76	
UPPER SHELF BRACKET	1331490 1331165	MS24693-C27	362	0.403	16.27	19.7	28.7	1	1.4	429.7	725	0.69	
BRACKET	1331481	NAS1352N04	246	0.222	26.73	17.8	75.2	1	1.4	376.2	966	1.57	
BRACKET	1331482	NAS1352N04	246	0.237	19.09	13.6	98.3	1	1.4	402.6	966	1.40	
OSCILLATOR 1	1336610	NAS1352N04	246	0.3966	22.1	26.3	43.9	1	1.4	344.3	966	1.81	

REF 1356010 DC/DC CONVERTER
 1356008 EOYAMSU A1 TOP ASSEMBLY
 NAS1352 SCREW
 NAS1149 WASHER
 MS21043 NUT

LOADING CONDITION RANDOM VIBRATION (9.97 GRMS)

METHOD - TENSILE LOAD DEVELOPED IN SCREW DUE TO:

- 1) MASS @ NASTRAN MODEL GRIDPOINTS
 X ACCELERATION DUE TO RANDOM VIB
 (@ GRID POINT 1403)
- 2) PRELOAD (T=24-26 IN-LB, REF 1356008)
- 3) ADDITIONAL OVERTURNING MOMENT EFFECTS
 ON DC/DC CONVERTOR

RANDOM VIBRATION RESULTS WITH Q=7.1

RESPONSE OF LARGE MASSES Q=7.1											
COMPONENT	GRID	LOAD DIRECTION	X-RESPONSE			Y-RESPONSE			Z-RESPONSE		
			RMS	GRMS	Q	RMS	GRMS	Q	RMS	GRMS	Q
LARGE MASS	65050	X	3897	10.09585	1.0	0	0	0.0	0	0	0.0
		Y	0	0	0.0	3897	10.09585	1.0	0	0	0.0
		Z	0	0	0.0	0	0	0.0	3897	10.0959	1.0
DC/DC CONVERTER	1403	X	6940	17.97927	1.8	1116	2.891192	0.3	3074	7.96373	0.8
		Y	948	2.455959	0.2	4254	11.02073	1.1	787	2.03886	0.2
		Z	1338	3.466321	0.3	2832	7.336788	0.7	5789	14.9456	1.5
	1400	X	3911	10.13212	1.0	863	2.235751	0.2	3000	7.77202	0.8
		Y	1239	3.209845	0.3	3998	10.35751	1.0	785	2.03368	0.2
		Z	3503	9.07513	0.9	1825	4.727979	0.5	5616	14.5482	1.4
	1364	X	3742	9.694301	1.0	843	2.183938	0.2	3065	7.94041	0.8
		Y	846	2.19171	0.2	4005	10.37565	1.0	1235	3.19948	0.3
		Z	3256	8.435233	0.8	1847	4.784974	0.5	5317	13.7746	1.4
	1367	X	6298	16.31606	1.6	1142	2.958549	0.3	3170	8.21244	0.8
		Y	819	2.121762	0.2	4263	11.04404	1.1	1318	3.41451	0.3
		Z	1310	3.393782	0.3	2858	7.404145	0.7	5474	14.1813	1.4

THE ABOVE TABLE IDENTIFIES THE 4 GRID POINTS (1403, 1400, 1364, 1367) OF THE NASTRAN MODEL USED TO APPLY PT MASSES (CONM2 43365-43368) REPRESENTING THE DC/DC CONVERTER. EACH PT MASS IS 0.91 LB.

LARGEST RESPONSE PER X-LOAD, X-RESPONSE IS A 17 GRMS LEVEL OF 17.98 G AT GR1403.

STATISTICAL ST LOAD AT GR 1403

$$F_L = 3 (17.98) (0.91) = 49.1 \text{ LB}$$

PRELOAD TORQUE, $T = .2 F_i d$

$F_i = \text{PRELOAD}$

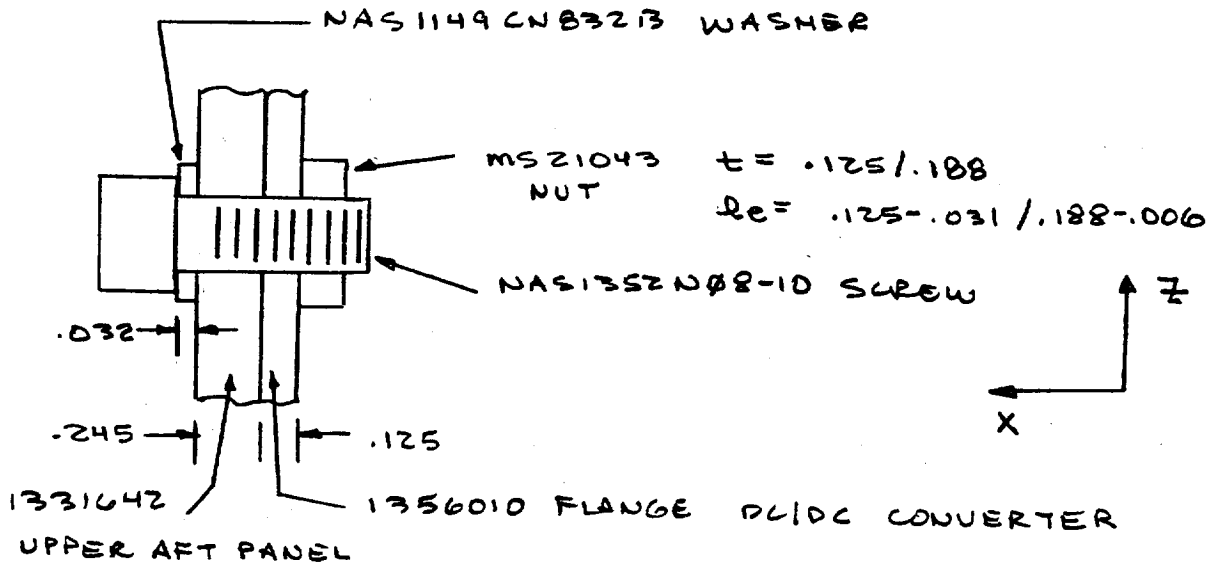
$d = \text{NOMINAL SCREW } \phi \text{ NAS1352N}\phi 8-10$
.1640-32UNRC-3A

$= .164$

$T = 26 \text{ IN-LB MAX}$

$$F_i = \frac{26}{(.2 \times .164)} = 792.7 \text{ LB}$$

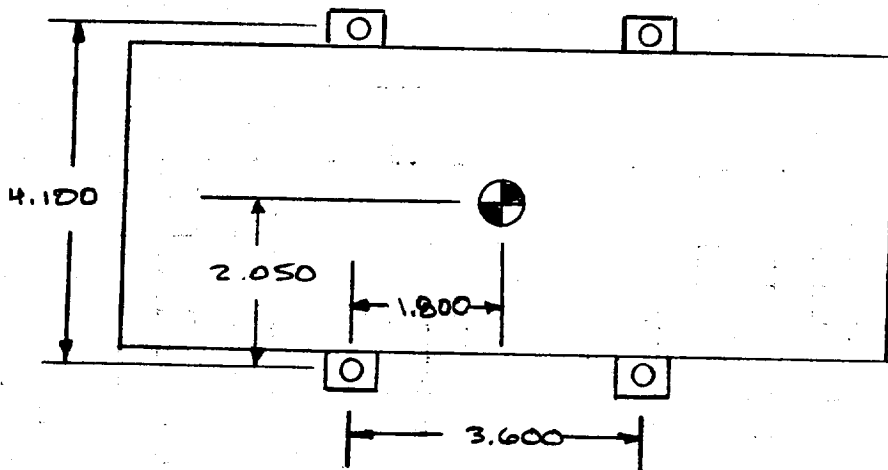
JOINT SKETCH



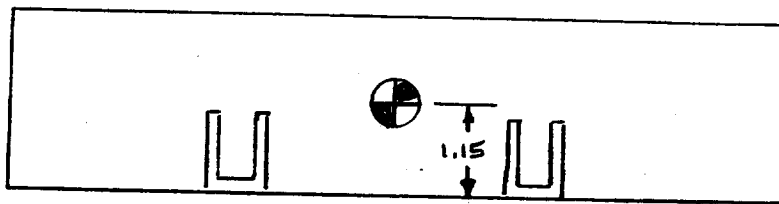
OVERTURNING MOMENT

USING "3T" LOADS. LARGEST

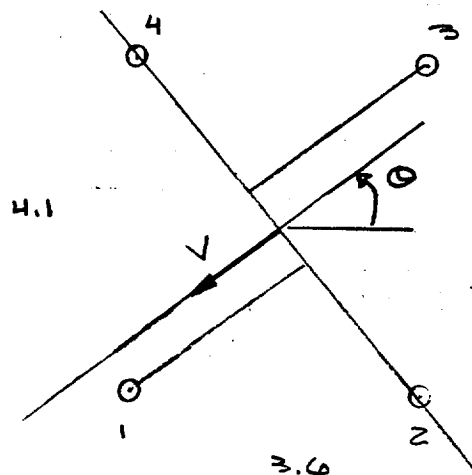
RESPONSE (17.98 GRMS @ 19) IS USED IRRESPECTIVE OF DIRECTION TO CONSERVATIVELY FIND THE OVERTURNING MOMENT.



ASSUMED CG @ CENTER OF ATTACHMENT BOLT PATTERN. HEIGHT ASSUMED AT MID HEIGHT OF ENCLOSURE



ASSUMED LOAD DIRECTION THROUGH SCREW #4



$$V = (4)(.91)(3)(17.98)$$

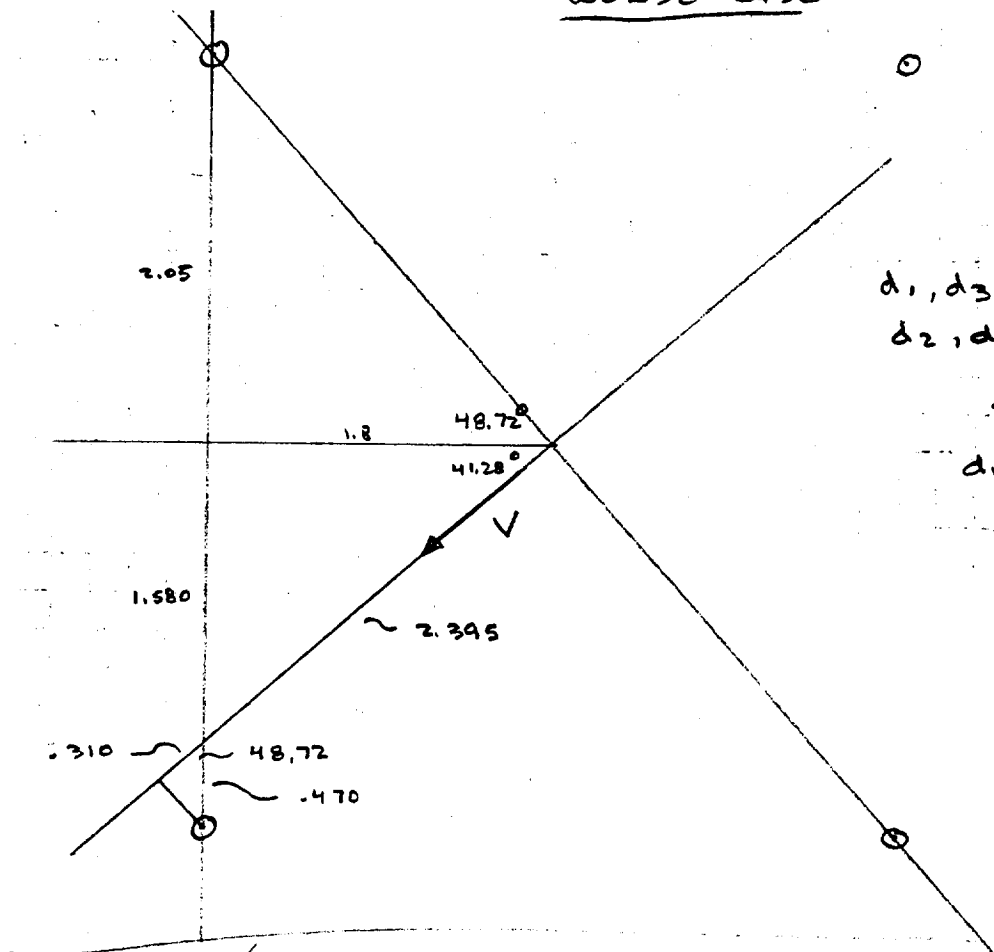
$$= 196.3 \text{ LB}$$

$$M_t = 1.15(V)$$

$$= 225.8 \text{ IN-LB}$$

$$\theta = 48.72^\circ$$

WORSE CASE

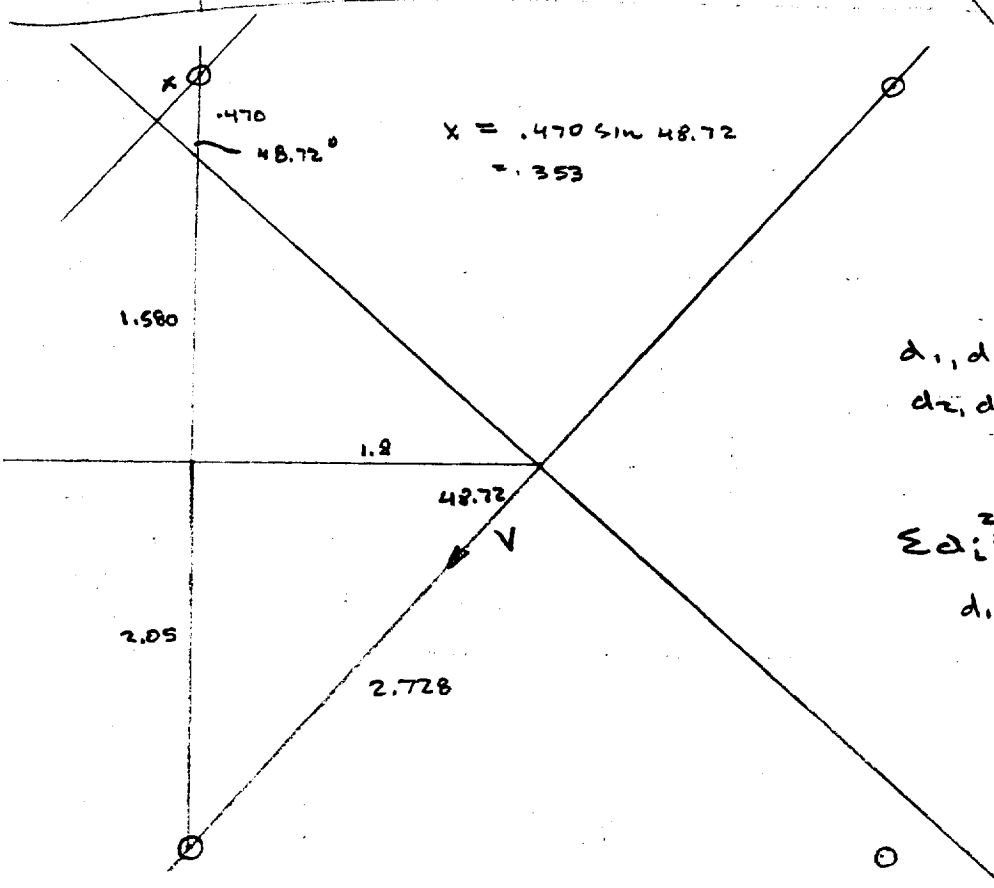


$$d_1, d_3 = 2.705$$

$$d_2, d_4 = 0$$

$$\sum d_i^2 = 14.634$$

$$d_i / \sum d_i^2 = \underline{\underline{.185}}$$



$$X = .470 \sin 48.72 = .353$$

$$d_1, d_3 = 2.728$$

$$d_2, d_4 = .353$$

$$\sum d_i^2 = 15.133$$

$$d_i / \sum d_i^2 = \underline{\underline{.180}}$$

TENSILE DISTANCES ALONG SKEWED AXES

$$d_2 = 0$$

$$d_4 = 0$$

$$d_3 = 2.395 + .310 = 2.705$$

$$d_1 = 2.705$$

$$\sum d_i^2 = 2.705^2 + 2.705^2 + 0^2 + 0^2 = 14.634 \text{ IN}^2$$

TENSILE FORCE AT SCREW #2

$$F_{t_2} = \frac{M d_2}{\sum d_i^2} = \frac{196.3 \cdot 2.705}{14.634}$$

$$= 36.3 \text{ LB}$$

TOTAL TENSILE LOAD, F_b

$$F_L = 792.7 \text{ LB PRELOAD}$$

$$F_t = F_{t_1} + F_{t_2} = 49.1 + 36.3 = 85.4 \text{ LB}$$

PER SHIGLEY "MECHANICAL ENGINEERING DESIGN", 4TH EDITION, P371, THE TOTAL TENSILE LOAD DEVELOPED IN THE SCREW IS A FUNCTION OF JOINT STIFFNESS

$$F_b = F_L + \left(\frac{k_b F_t}{k_b + k_m} \right) FS$$

FS = 1.4 ON
APPLIED
LOAD ONLY

$$k_b = \frac{EA}{l}$$

$$E = 28 \times 10^6 \text{ PSI}$$

$$A = \pi/4 (.164)^2 = .02112 \text{ IN}^2$$

$$l = \text{GRIP LENGTH}$$

$$= 1.471 \times 10^6 \text{ LB/IN} \quad = .032 + .245 + .125 = .402 \text{ IN}$$

$$k_m = \frac{\pi E d}{2 \ln \left[\frac{5(l + d/2)}{(l + 2.5d)} \right]}$$

$$= 2.359 \times 10^6 \text{ LB/IN}$$

$$E = 10 \times 10^6 \text{ PSI}$$

$$d = .164 \text{ IN}$$

$$l = .402 \text{ IN}$$

$$\frac{k_b}{k_b + k_m} = .384$$

$$F_D = 792.7 + .384(1.4)(85.4) = 839 \text{ LB}$$

PER NAS1352 FOR A -08 SCREW OF HEAT RESISTING STEEL, THE MINIMUM BREAKING STRENGTH IS

$$F_{Tu} = 2240 \text{ LB}$$

$$MS = \frac{2240}{839} - 1 = + 1.7$$

∴ DC/DC CONVERTER ATTACHMENT SCREWS ARE OK IN TENSION

METHOD 2 - INSURE LOAD DEVELOPED FROM RANDOM VIBRATION NASTRAN RUNS PLUS THE OVERTURNING MOMENT IS LESS THAN THE SCREW BREAKING STRENGTH. USE "3σ" RANDOM VIBRATION LOADS & A 1.4 FS.

APPLIED LOAD, F,

$$F = 1.4 (49.1 + 36.3) = 120 \text{ LB}$$

BREAKING STRENGTH, F_{Tu} ,

$$F_{Tu} = 2240 \text{ LB}$$

$$MS = \frac{2240}{120} - 1 = + 17 \quad \therefore \text{OK}$$

DETECTOR PREAMP ATTACHMENT

Report 10381
Addendum 1

REF	1331610	DETECTOR PREAMP ASSY
	1356008	EOS/AMSU A-1 TOP ASSY
	1331081	INSULATOR RF SHOULDER WASHER
	1331614	PREAMP BASE
	NAS1352	SCREW
	NAS620	WASHER
	MS51830	INSERT
	1331401	PANEL, LOWER FRONT

LOADING CONDITION RANDOM VIBRATION (9.97 GRMS)

FIND TENSILE LOAD DEVELOPED IN SCREW DUE TO:

- 1) MASS @ NASTRAN MODEL GRID POINTS X ACCEL DUE TO RANDOM VIBRATION (@ GRIDPT 999)
- 2) PRELOAD (T = 12 - 14 IN-LB)
- 3) ADDITIONAL OVERTURNING MOMENT EFFECTS ON DETECTOR PREAMP

RANDOM VIBRATION RESULTS WITH Q = 7.1

COMPONENT	GRID	LOAD DIRECTION	X-RESPONSE			Y-RESPONSE			Z-RESPONSE		
			RMS	GRMS	Q	RMS	GRMS	Q	RMS	GRMS	Q
	999	X	9362	24.25389	2.4	618	1.601036	0.2	709	1.83679	0.2
		Y	3219	8.339378	0.8	3327	8.619171	0.9	580	1.50259	0.1
		Z	1045	2.707254	0.3	690	1.787565	0.2	3727	9.65544	1.0
DETECTOR PREAMP	1078	X	3708	9.606218	1.0	725	1.878238	0.2	1420	3.67876	0.4
		Y	550	1.42487	0.1	3402	8.813472	0.9	1390	3.60104	0.4
		Z	804	2.082902	0.2	892	2.310881	0.2	4537	11.7539	1.2
	1080	X	3900	10.10363	1.0	1238	3.207254	0.3	1600	4.14508	0.4
		Y	1808	4.683938	0.5	3428	8.880829	0.9	1571	4.06995	0.4
		Z	2434	6.305699	0.6	1387	3.593264	0.4	4776	12.3731	1.2
	1001	X	6150	15.93264	1.6	1387	3.593264	0.4	789	2.04404	0.2
		Y	1190	3.082902	0.3	3556	9.212435	0.9	657	1.70207	0.2
		Z	813	2.106218	0.2	1476	3.823834	0.4	3764	9.7513	1.0

THE 4 GRID PTS (999, 1078, 1080, 1001) OF THE NASTRAN MODEL USED TO APPLY PT MASSES (CONM2 43373 - 43376) REPRESENT THE DETECTOR PREAMP. EACH PT MASS IS .7225 LB. LARGEST RESPONSE PER X-LOAD, X-RESPONSE AT GR 999 FOR "1" LOAD IS 24.25 G.

STATISTICAL 3T LOAD AT GR 999

$$F_{L1} = 3(24.25)(0.7225) = 52.6 \text{ LB}$$

PRELOAD TORQUE, $T = .2 F_i d$

F_i = PRELOAD

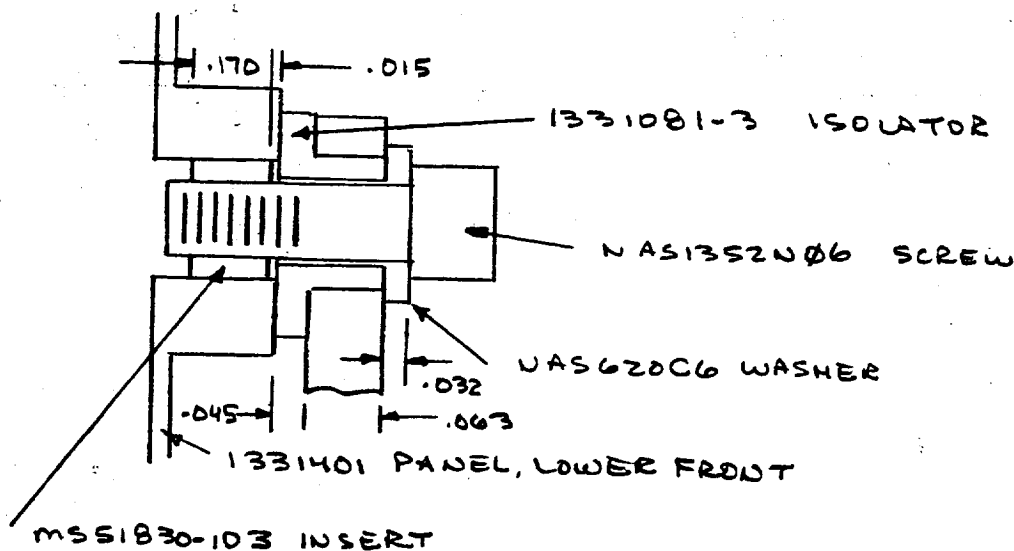
d = .138 IN

T = 14 IN-LB

NOM SCREW ϕ NAS1352N06-6
MAX .138-32UNRC-3A

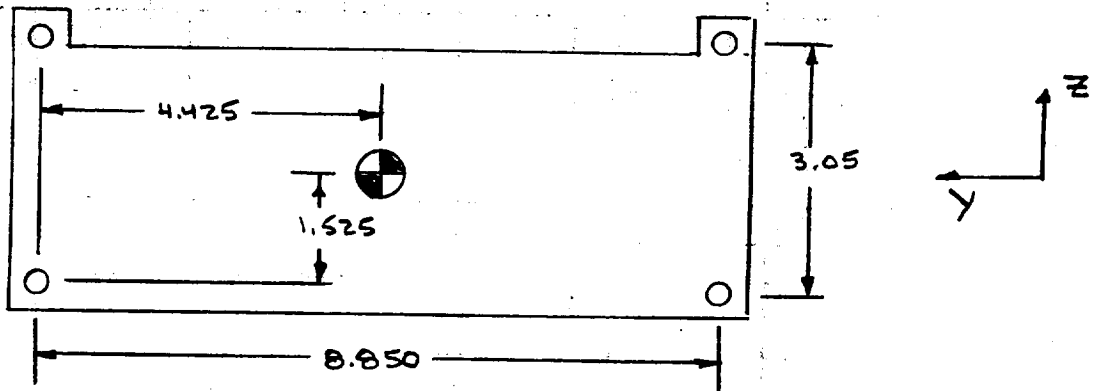
$$F_i = \frac{14}{(.2)(.138)} = 507.2 \text{ LB}$$

SKETCH OF JOINT

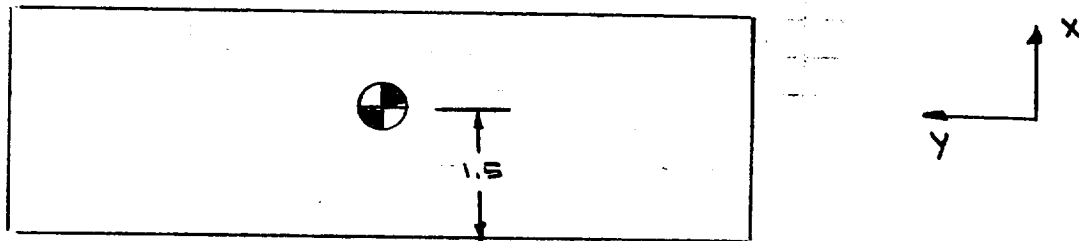


OVERTURNING MOMENT

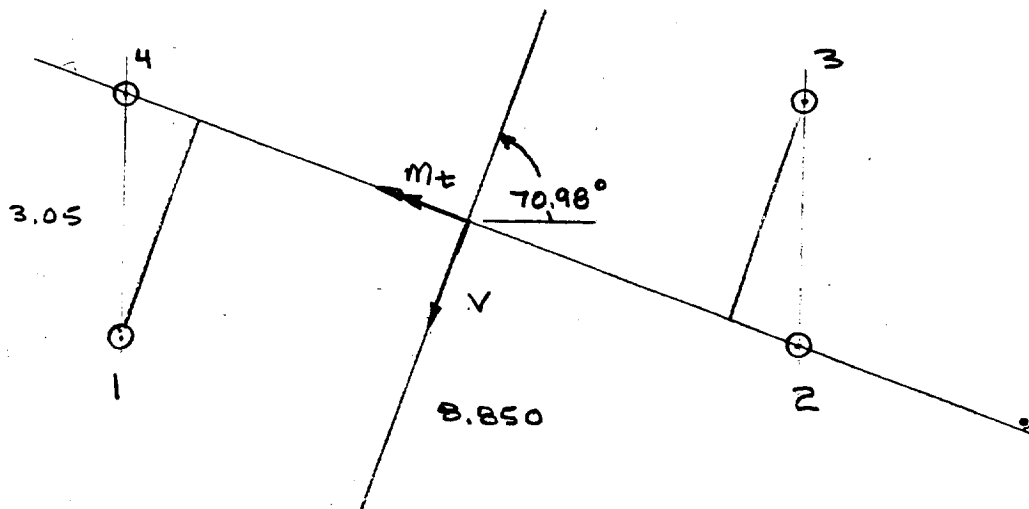
USING "3T" LOADS FROM RANDOM VIBRATION, THE LARGEST RESPONSE (24.25 GRMS @ 1T) IS APPLIED WITHOUT REGARD TO DIRECTION, AS A FORCE THROUGH THE ASSUMED PREAMP DETECTOR CG TO DEVELOP THE LARGEST POSSIBLE OVERTURNING MOMENT BOLT TENSILE LOAD.



ASSUMED CG @ CENTER OF ATTACHMENT BOLT
PATTERN. HEIGHT OF CG ASSUMED AT 1.5 INCHES



ASSUMED LOAD DIRECTION IS \Rightarrow \perp TO SCREW #4



$$V = 4(.7225)(3)/(24.25) = 218.9 \text{ LB}$$

$$M_t = (1.5)(V) = 328.4 \text{ IN-LB}$$

TENSILE LOAD DISTANCES ALONG SKEWED AXIS

$$d_2 = d_4 = 0$$

$$d_1 = d_3 = 3.050 \cos(19.02) = 2.884 \text{ IN}$$

$$\sum d_i^2 = 16.629 \text{ IN}^2$$

TENSILE FORCE AT SCREW # 2

$$F_{t2} = \frac{W_t d_2}{\sum d_i^2} = \frac{(328.4)(2.884)}{16.629} = 56.9 \text{ LB}$$

TOTAL TENSILE LOAD, F_b

$$F_L = 507.2 \text{ LB} \quad \text{PRELOAD}$$

$$F_b = F_{t1} + F_{t2} = 52.6 + 56.9 = 109.5 \text{ LB}$$

WITH $FS = 1.4$ APPLIED TO F_t ONLY

$$F_b = F_L + (FS) \frac{k_b}{k_b + k_m} F_t$$

$$k_b = \frac{EA}{l}$$

$$= 2.702 \times 10^6 \text{ LB/IN}$$

$$E = 28 \times 10^6 \text{ PSI}$$

$$A = \pi/4 (1.138)^2 = .01496 \text{ IN}^2$$

$$l = \text{GRIP LENGTH}$$

$$= .032 + .063 + .045 + .015$$

$$= .155$$

WITH A LOW E FIBERGLAS ISOLATORS WASHER IN THE MEMBER STACK-UP, CONSERVATIVELY ASSUME

$$k_m \rightarrow 0$$

THEN

$$\frac{k_b}{k_b + k_m} = 1.0$$

$$k_b + k_m$$

$$F_t = F_L + (FS) F_t = 507.2 + (1.4)(109.5) = 661 \text{ LB}$$

PER NAS1352 FOR -06 SCREW OF HEAT RESISTANT STEEL, MINIMUM BREAKING STRENGTH IS

$$F_{TU} = 1458 \text{ LB}$$

$$MS = \frac{1458}{661} - 1 = +1.2$$

∴ DETECTOR PREAMP ATTACHMENT SCREWS ARE OK IN TENSION

METHOD 2 INSURE LOAD DEVELOPED FROM RANDOM VIBRATION NASTRAN RUNS PLUS THE OVERTURNING MOMENT + SCREW BREAKING STRENGTH. USE "3T" LOADS & A 1.4 FS

APPLIED LOAD, F

$$F = 1.4(52.6 + 56.9) = 153.3 \text{ LB}$$

BREAKING STRENGTH, F_{TU} ,

$$F_{TU} = 1458 \text{ LB}$$

$$MS = \frac{1458}{153.3} - 1 = +8.5 \quad \therefore \text{OK}$$

1-8-96

LOWER SHELF (A1-1) LARGE MASS ATTACHMENTS

REF	1331556	LOWER RF SHELF
	1331555	LOWER RF SHELF ASSY
	1356429	RECEIVER ASSY, A1-1
	1348360	PLO ASSY
	NAS1352	SCREW
	NAS620	WASHER
	1331081	INSULATOR RF SHOULDER WASHER
	1336610	OSCILLATOR
	1331592	BRACKET
	1331562	MIXER

LOADING CONDITION RANDOM VIBRATION (9.97 GRMS)

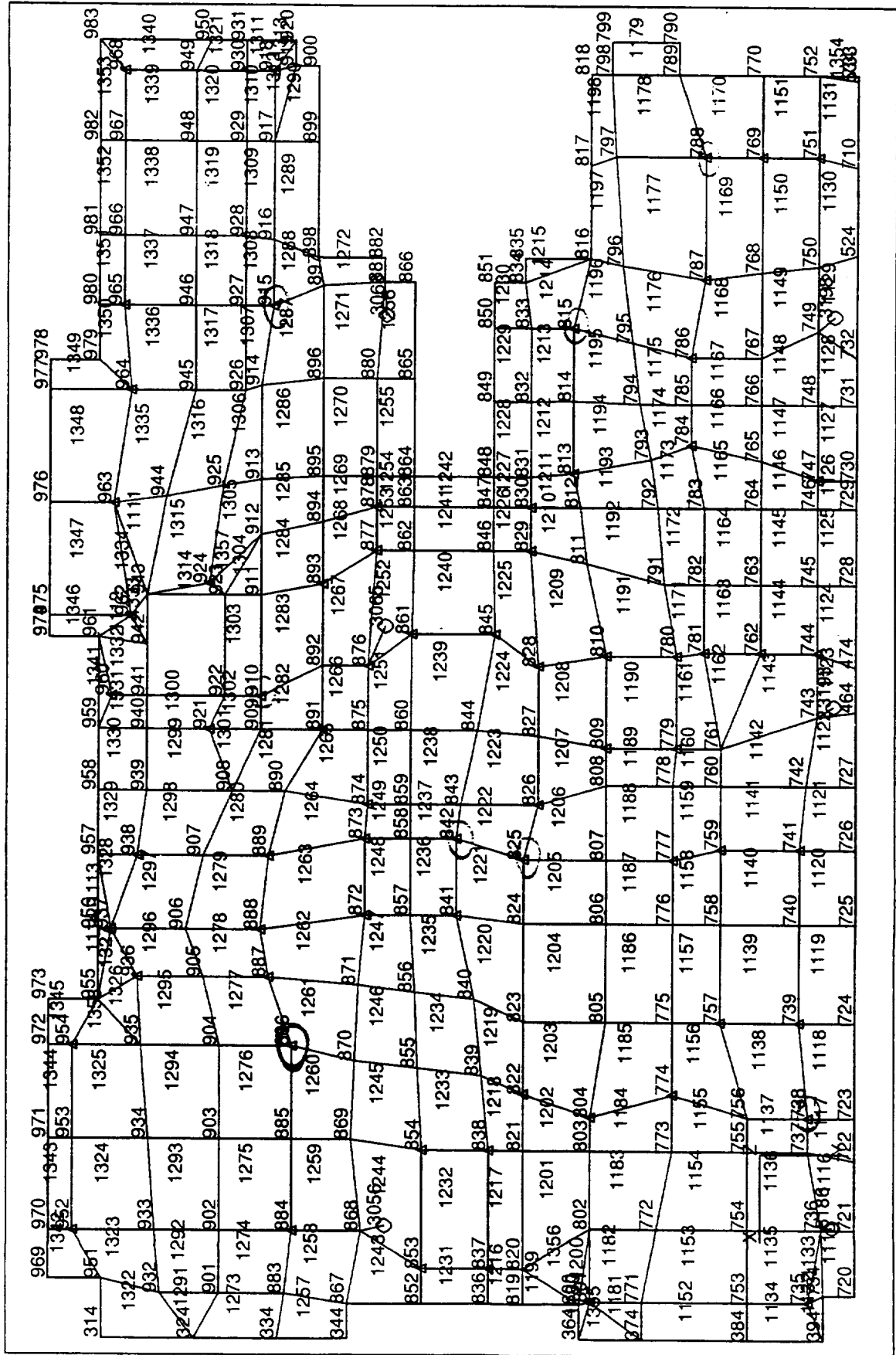
METHOD 1 - TENSILE LOAD DEVELOPED IN SCREW DUE TO:

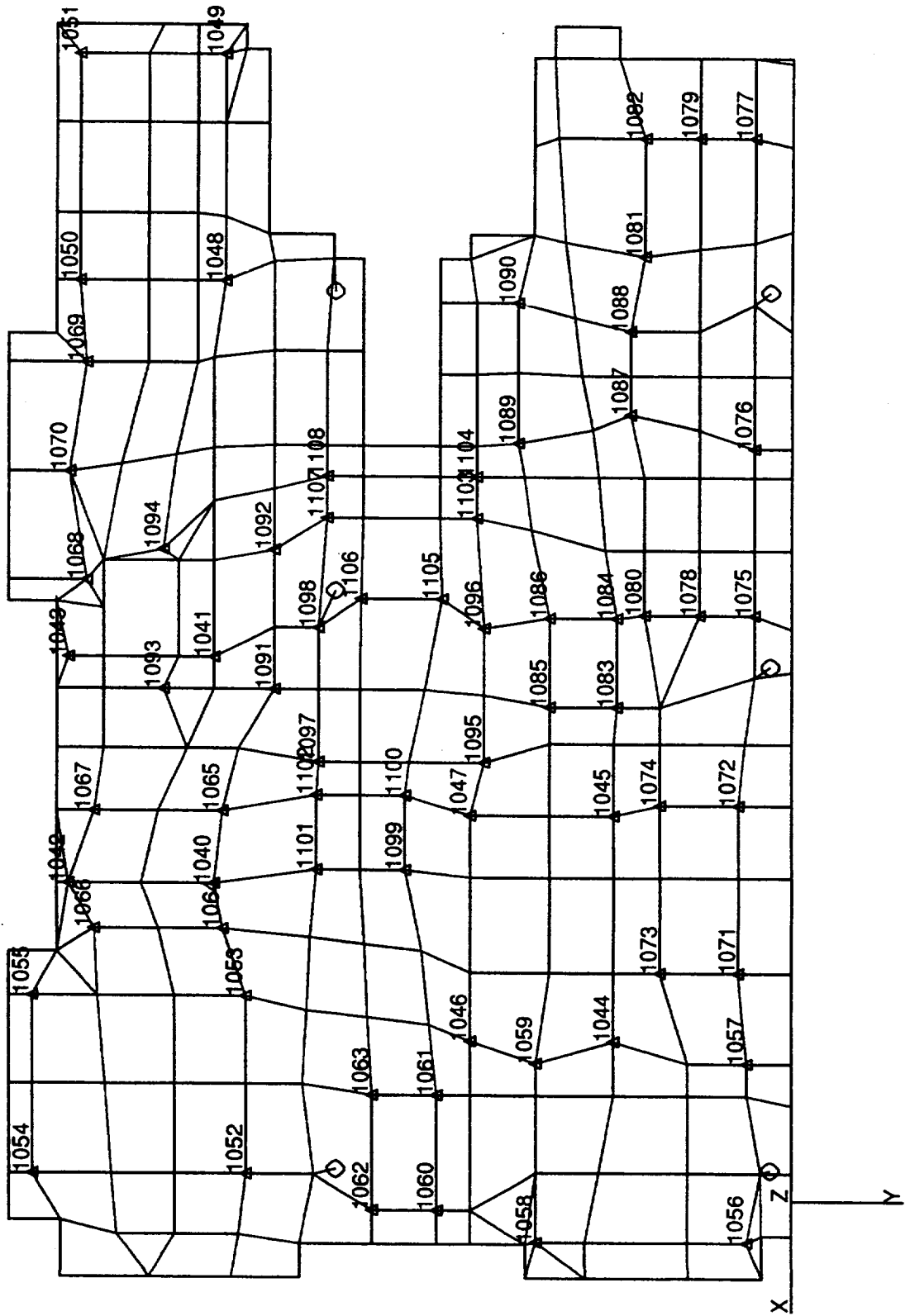
- 1) MASS @ NASTRAN MODEL GRIDPOINTS Z-ACCEL DUE TO RANDOM VIBRATION
- 2) PRELOAD (REF 1356429)
- 3) ADDITIONAL OVERTURNING MOMENT EFFECTS

1348360 PLO'S ATTACHMENT

2 PLO UNITS ARE ATTACHED TO THE 1331555 LOWER RF SHELF ASSY. FOR THE PLO IN THE +X-Y CORNER OF THE MODEL, 4 GRID POINTS (735, 738, 801, 804) OF THE NASTRAN MODEL ARE USED TO APPLY PT MASSES (LOUM2 1056-1059) TO REPRESENT THE PLO. EACH PT MASS IS 0.529 LB.

LARGEST RESPONSE PER Z-LOAD, Z-RESPONSE IS A 19 GRMS LEVEL OF 15.56 GRMS. AT GR 738





RANDOM VIBRATION RESULTS WITH Q=7.1

COMPONENT	GRID	LOAD DIRECTION	RESPONSE OF LARGE MASSES Q=7.1								
			X-RESPONSE			Y-RESPONSE			Z-RESPONSE		
			RMS	GRMS	Q	RMS	GRMS	Q	RMS	GRMS	Q
PLO +X-Y	735	X	4591	11.89378	1.2	915	2.370466	0.2	1540	3.98964	0.4
		Y	1688	4.373057	0.4	3839	9.945596	1.0	1385	3.58808	0.4
		Z	833	2.158031	0.2	755	1.955959	0.2	3733	9.67098	1.0
	738	X	4588	11.88601	1.2	1119	2.898964	0.3	3810	9.87047	1.0
		Y	1648	4.26943	0.4	4164	10.78756	1.1	2573	6.6658	0.7
		Z	847	2.194301	0.2	837	2.168394	0.2	6007	15.5622	1.5
	801	X	4448	11.52332	1.1	931	2.411917	0.2	1651	4.2772	0.4
		Y	1344	3.481865	0.3	3866	10.01554	1.0	676	1.7513	0.2
		Z	1188	3.07772	0.3	756	1.958549	0.2	3621	9.38083	0.9
804	X	4428	11.4715	1.1	1117	2.893782	0.3	2687	6.96114	0.7	
	Y	1352	3.502591	0.3	4160	10.7772	1.1	2170	5.62176	0.6	
	Z	1170	3.031088	0.3	835	2.163212	0.2	5112	13.2435	1.3	

STATISTICAL 3σ LOAD AT 62738

$$F_{t1} = 3(15.56)(0.529) = 24.7 \text{ LB}$$

PRELOAD TORQUE $T = .2 F_i d$

$F_i = \text{PRELOAD}$

$d = \text{NOMINAL SCREW } \phi = .112$

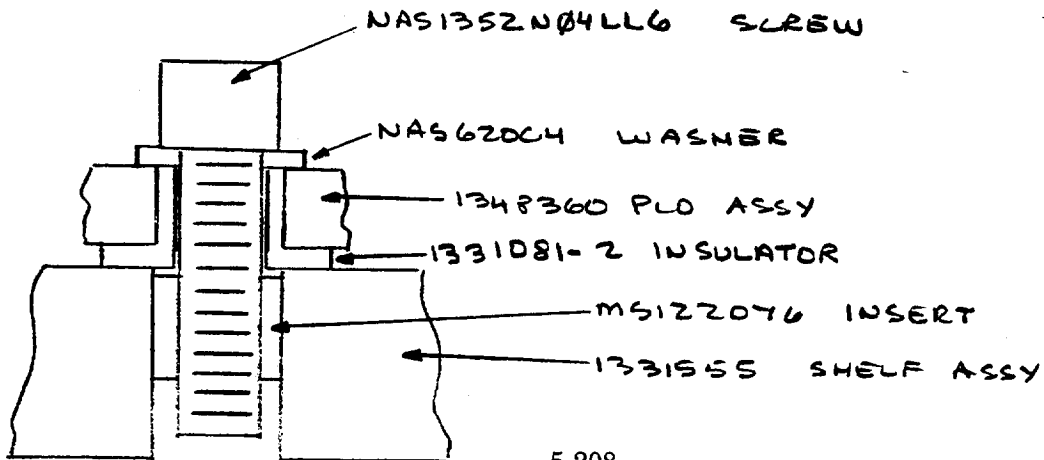
ATTACHMENT SCREWS ARE (4) NAS1352NØ4LL6

.112-40UNRC-3A #4 SCREWS

T = 4.5 TO 5.5 IN-LB (1356429 SH1)

$$F_i = \frac{5.5}{12(.112)} = 246 \text{ LB}$$

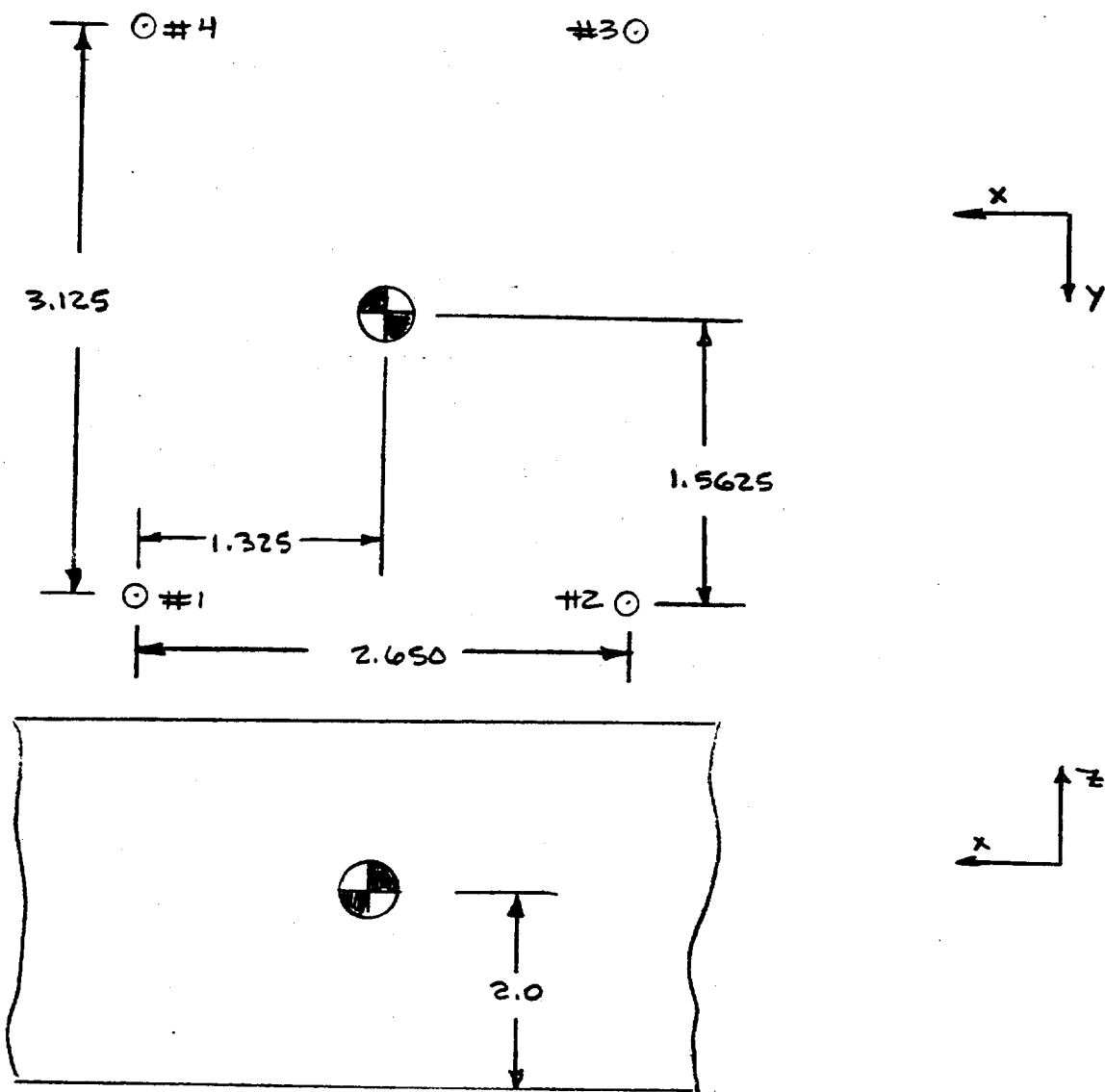
SKETCH OF JOINT



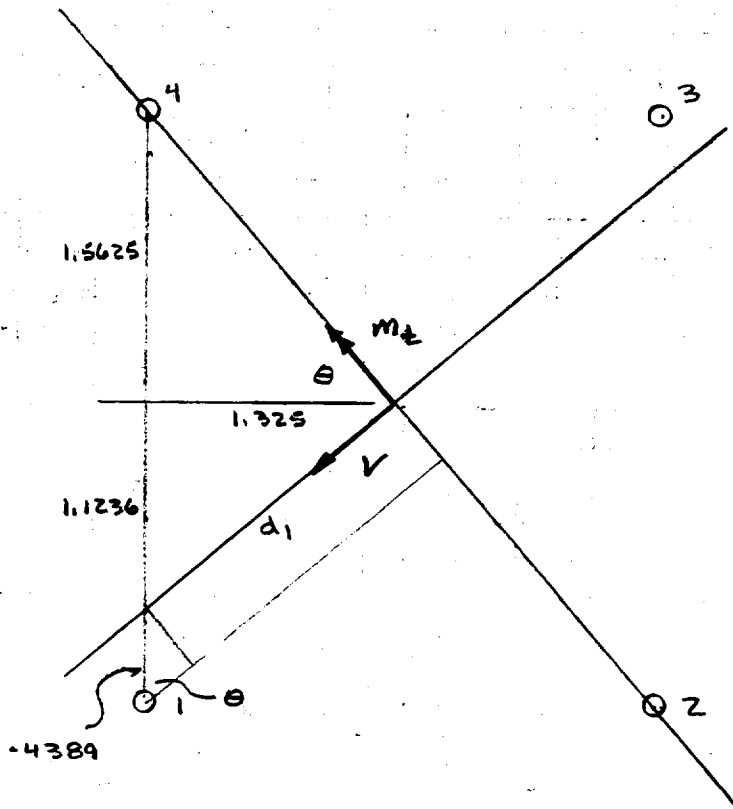
OVERTURNING MOMENT

USING "3σ" LOADS FROM RANDOM VIBRATION WITH A Q=7.1, THE LARGEST RESPONSE (15.56 GRMS @ 17 AT 62738) IS APPLIED WITHOUT REGARD TO DIRECTION, AS A FORCE THROUGH THE ASSUMED PLO ASSY CG TO DEVELOP THE LARGEST POSSIBLE OVERTURNING MOMENT BOLT TENSILE LOAD.

ASSUMED IN-PLANE CG IS @ CENTER OF ATTACHMENT BOLT PATTERN. HEIGHT OF CG ASSUMED AT 2.0 INCHES.



ASSUMED LOAD DIRECTION IS \perp TO SCREW #4-#2



$$\theta = \tan^{-1} \frac{1.5625}{1.325}$$

$$= 49.702^\circ$$

$$90 - \theta = 40.298^\circ$$

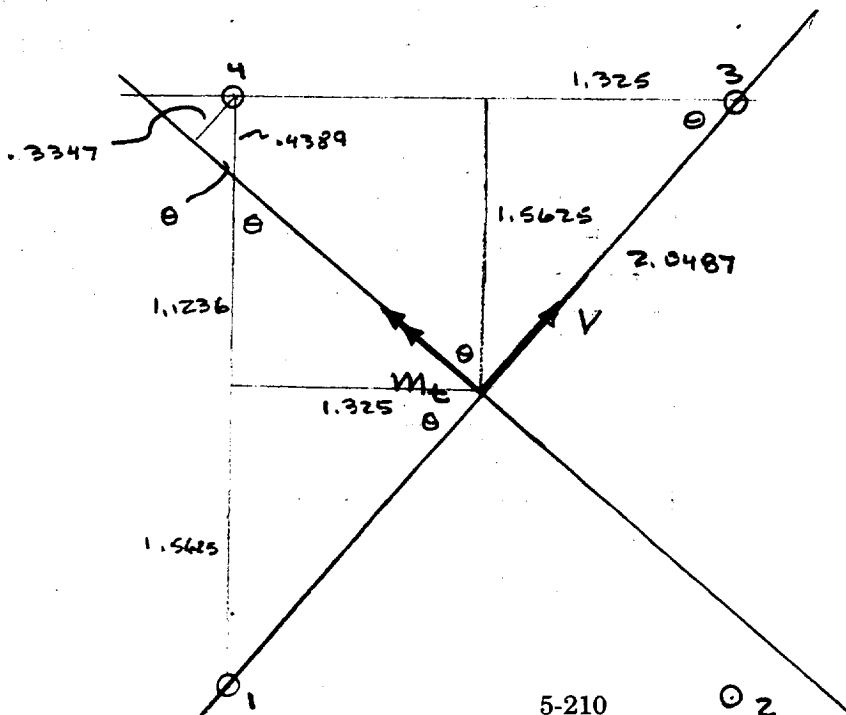
$$d_3 = d_1 = 1.737$$

$$d_2 = d_4 = 0$$

$$\sum d_i^2 = 6.036$$

$$d_1 / \sum d_i^2 = \underline{\underline{.288}}$$

ASSUMED LOAD DIRECTION IS \parallel TO SCREW #3-#1



$$\theta = \tan^{-1} \frac{1.5625}{1.325}$$

$$= 49.702^\circ$$

$$90 - \theta = 40.298^\circ$$

$$d_1 = d_3 = 2.0487$$

$$d_2 = d_4 = .3347$$

$$\sum d_i^2 = 8.618$$

$$d_1 / \sum d_i^2 = .238$$

\therefore LESS SEVERE CASE

$$V = 4(.529)(3)(15.56) = 98.8 \text{ LB}$$

$$M_t = (2.0)V = 197.5 \text{ IN-LB}$$

TENSILE FORCE AT SCREW #1

$$F_{t2} = \frac{M_t d_1}{\sum d_i^2} = \frac{(197.5)(1.737)}{6.036} = 56.8 \text{ LB}$$

TOTAL TENSILE LOAD, F_b

$$F_b = F_L + F_S \frac{J_{2b}}{J_{2b} + J_{2m}} F_t$$

$$F_t = F_{t1} + F_{t2} = 24.7 + 56.8 = 81.5 \text{ LB}$$

WITH $F_S = 1.4$ APPLIED TO F_t ONLY

$$F_b = F_L + (F_S) \frac{J_{2b}}{J_{2b} + J_{2m}} (F_t)$$

WORST CASE SCENARIO IS

$$J_{2b} \gg J_{2m}$$

THEN

$$F_b = F_L + (F_S)(F_t)$$

$$= 246 + 1.4(81.5) = 360 \text{ LB}$$

PER NAS1352 FOR UNF SCREW OF HEAT RESISTANT STEEL, MIN BREAKING STRENGTH

$$F_{tu} = 960 \text{ LB}$$

$$MS = \frac{960}{360} - 1 = +1.7$$

∴ PLO MOUNTING SCREWS ARE OK IN TENSION FOR +X-Y PLO.

FOR THE PLO IN THE +X+Y CORNER OF THE NASTRAN MODEL, 4 GRID POINTS (884, 886, 952, 954) ARE USED TO APPLY PT MASSES (CONM2 1052-1055) TO REPRESENT THE PLO, WITH EACH PT MASS AT 0.532 LB

LARGEST RESPONSE PER 3-LOAD, Z-RESPONSE IS A 17 GRMS LEVEL OF 16.26 GRMS AT GR 886.

RANDOM VIBRATION RESULTS WITH Q=7.1

RESPONSE OF LARGE MASSES Q=7.1											
COMPONENT	GRID	LOAD DIRECTION	X-RESPONSE			Y-RESPONSE			Z-RESPONSE		
			RMS	GRMS	Q	RMS	GRMS	Q	RMS	GRMS	Q
LOWER SHELF PLO +X+Y	884	X	4185	10.84197	1.1	1003	2.598446	0.3	2102	5.4456	0.5
		Y	1189	3.080311	0.3	3972	10.29016	1.0	1352	3.50259	0.3
		Z	1614	4.181347	0.4	765	1.981865	0.2	4286	11.1036	1.1
	886	X	4184	10.83938	1.1	1192	3.088083	0.3	2916	7.5544	0.7
		Y	1188	3.07772	0.3	4262	11.04145	1.1	1988	5.15026	0.5
		Z	1613	4.178756	0.4	897	2.323834	0.2	6276	16.2591	1.6
	952	X	3959	10.25648	1.0	1004	2.601036	0.3	1365	3.53627	0.4
		Y	1210	3.134715	0.3	3963	10.26684	1.0	873	2.26166	0.2
		Z	1946	5.041451	0.5	764	1.979275	0.2	4021	10.4171	1.0
954	X	3958	10.25389	1.0	1192	3.088083	0.3	1146	2.96891	0.3	
	Y	1203	3.11658	0.3	4263	11.04404	1.1	859	2.22539	0.2	
	Z	1934	5.010363	0.5	895	2.318653	0.2	3829	9.91969	1.0	

STATISTICAL 3T LOAD AT GR 886

$$F_{t1} = 3(16.26)(.532) = 25.9 \text{ LB}$$

PRELOAD

$$F_L = 240 \text{ LB}$$

SKETCH OF JOINT

SEE OTHER PLO ON LOWER SHELF.

OVERTURNING MOMENT

SEE OTHER PLO ON LOWER SHELF

$$V = 4(.532)(3)(16.26) = 103.8 \text{ LB}$$

$$M_{t2} = (2.0)V = 207.6 \text{ IN-LB}$$

TENSILE FORCE AT SCREW # 1

$$F_{t2} = \frac{M_{t2} d_1}{\sum d_i^2} = \frac{(207.6)(1.737)}{6.036} = 59.7 \text{ LB}$$

TOTAL TENSILE LOAD, F_b

$$F_b = F_L + FS \frac{d_b}{d_b + d_m} F_t$$

$$F_t = F_{t_1} + F_{t_2} = 25.9 + 59.7 = 85.6 \text{ LB}$$

WORST CASE SCENARIO

$$d_b \gg d_m$$

THEN

$$F_b = F_L + (FS)(F_t)$$

$$= 246 + 1.4(85.6) = 366 \text{ LB}$$

PER NAS1352

$$F_{tu} = 966 \text{ LB}$$

$$MS = \frac{966}{366} - 1 = +1.6$$

∴ PLO MOUNTING SCREWS ARE OK IN TENSION FOR TX4Y PLO.

1336610 OSCILLATORS ATTACHMENT

3 OSCILLATORS ARE ATTACHED TO THE 1331555 LOWER RF SHELF ASSY. FOR THE OSCILLATOR MOUNTED ON THE BOTTOM OF THE SHELF, 4 GRID PTS (888, 910, 937, 940) OF THE NASTRAN MODEL ARE USED TO APPLY PT MASSES (CONM2 1040-1043) TO REPRESENT THE UNDERSIDE OSCILLATOR. EACH PT MASS IS 0.393 LB.

LARGEST RESPONSE PER Z-LOAD, Z-RESPONSE IS A 1T GRMS LEVEL OF 19.31 GRMS AT GR 910.

RANDOM VIBRATION RESULTS WITH Q=7.1

RESPONSE OF LARGE MASSES Q=7.1											
COMPONENT	GRID	LOAD DIRECTION	X-RESPONSE			Y-RESPONSE			Z-RESPONSE		
			RMS	GRMS	Q	RMS	GRMS	Q	RMS	GRMS	Q
ORO (BOTTOM MT)	960	X	4002	10.36788	1.0	1568	4.062176	0.4	1963	5.08549	0.5
		Y	1196	3.098446	0.3	4725	12.24093	1.2	2514	6.51295	0.6
		Z	1820	4.715026	0.5	1384	3.585492	0.4	5833	15.1114	1.5
	888	X	4149	10.7487	1.1	1322	3.42487	0.3	2398	6.21244	0.6
		Y	1184	3.067358	0.3	4434	11.48705	1.1	2862	7.41451	0.7
		Z	1652	4.279793	0.4	1035	2.681347	0.3	6407	16.5984	1.6
	910	X	4137	10.71762	1.1	1566	4.056995	0.4	1792	4.64249	0.5
		Y	1191	3.085492	0.3	4714	12.21244	1.2	2863	7.4171	0.7
		Z	1630	4.222798	0.4	1364	3.533679	0.4	7454	19.3109	1.9
	937	X	4044	10.47668	1.0	1325	3.432642	0.3	1960	5.07772	0.5
		Y	1210	3.134715	0.3	4437	11.49482	1.1	2598	6.73057	0.7
		Z	1899	4.919689	0.5	1032	2.673575	0.3	5252	13.6062	1.3

STATISTICAL 3σ LOAD AT GR 910

$$F_{E1} = 3(19.31)(0.393) = 22.8 \text{ LB}$$

PRELOAD TORQUE

ATTACHMENT SCREWS ARE, NAS135ZNDØ4LL6 (SAME AS USED WITH PLOS) #4 SCREWS

$$F_L = \frac{5.5}{(2)(6.112)} = 246 \text{ LB}$$

SKETCH OF JOINT

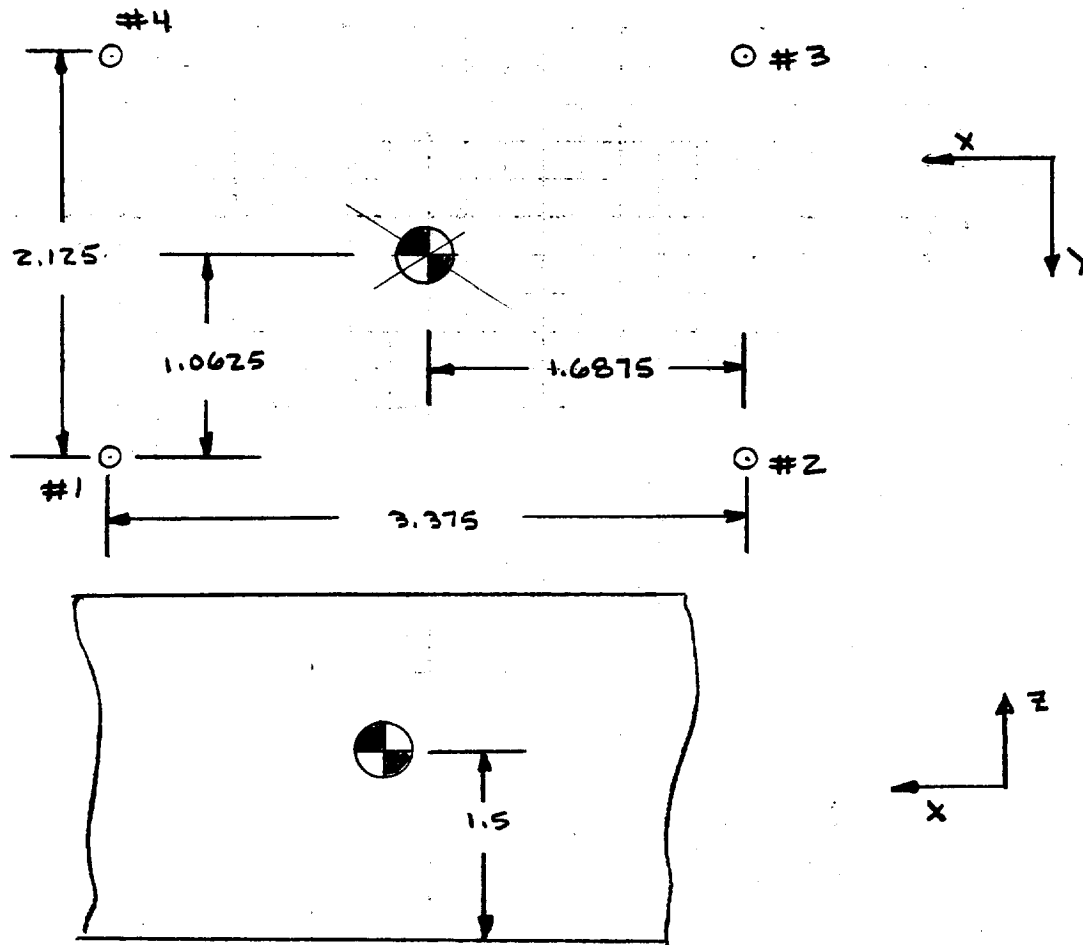
SEE PLO JOINT SKETCH, SUBSTITUTE 1336610 FOR 1348360.

1-8-95

OVERTURNING MOMENT

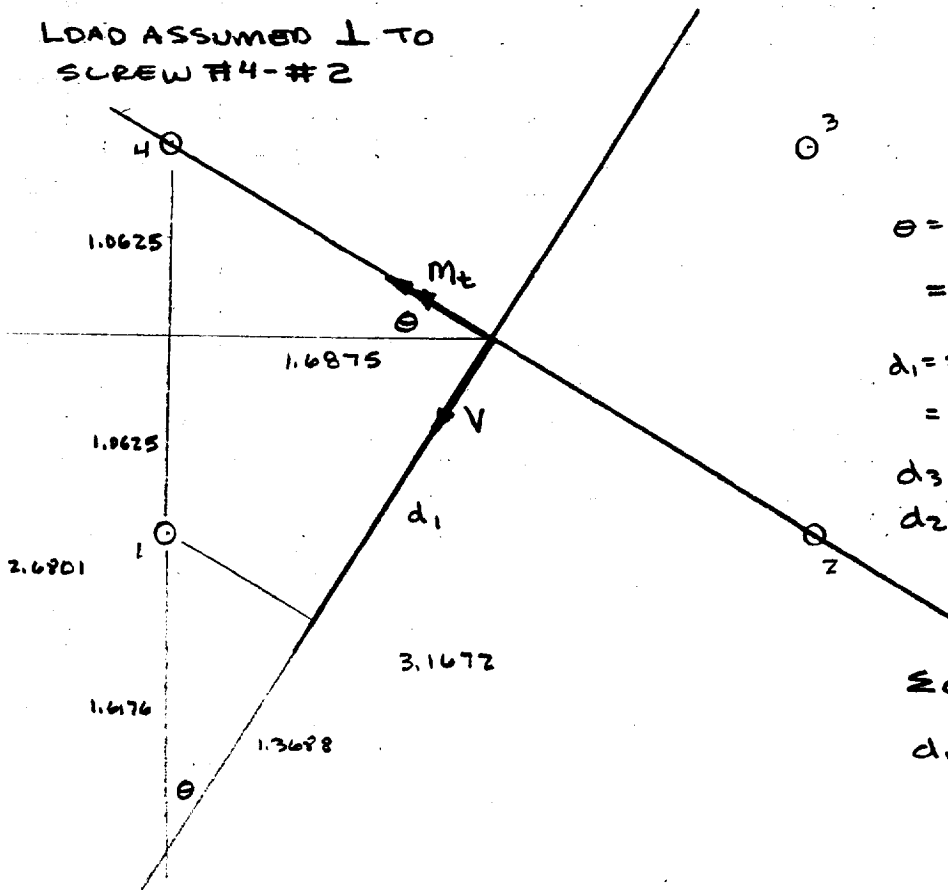
USING "3σ" LOADS FROM RANDOM VIBRATION $Q=7.1$ WITH LARGEST RESPONSE (19.31 GRMS @ 17 AT GR 910) APPLIED WITHOUT REGARD TO DIRECTION, AS A FORCE THROUGH THE ASSUMED DRO ASSY CG, DEVELOPING THE LARGEST POSSIBLE OVERTURNING MOMENT BOLT TENSIVE LOAD

ASSUMED IN-PLANE CG @ CENTER OF ATTACHMENT BOLT PATTERN. HEIGHT OF CG ASSUMED AT 1.5 INCHES.



LOAD ASSUMED \perp TO
SCREW #4-#2

Report 10381
Addendum 1



$$\theta = \tan^{-1} \frac{1.0625}{1.6875}$$

$$= 32.20^\circ$$

$$d_1 = 3.1672 - 1.3688$$

$$= 1.7983$$

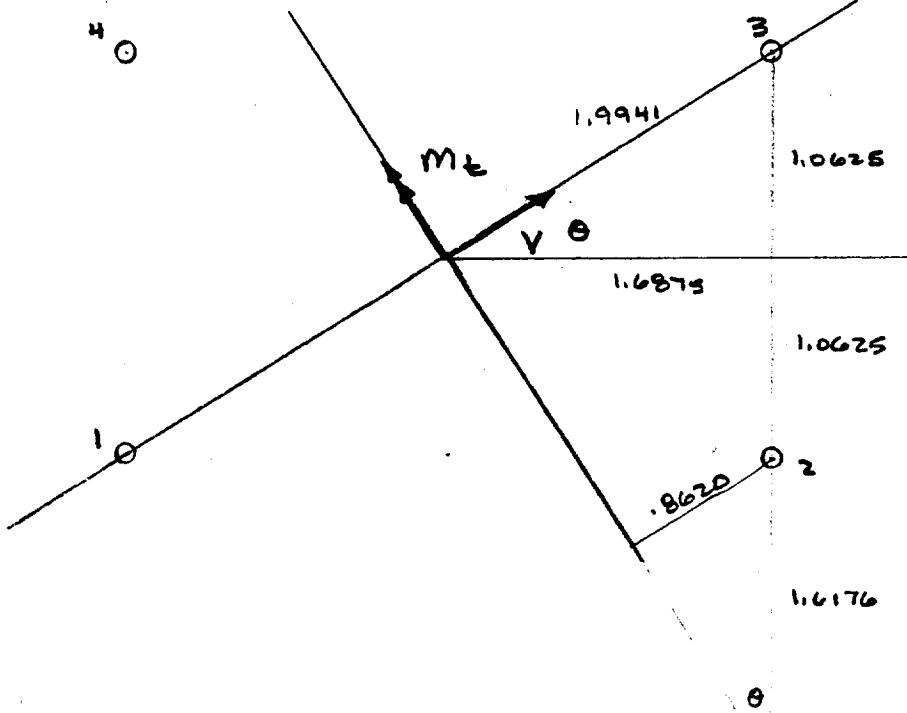
$$d_3 = d_1$$

$$d_2 = d_4 = 0$$

$$\sum d_i^2 = 6.468$$

$$d_1 / \sum d_i^2 = \underline{\underline{.2780}}$$

LOAD ASSUMED \parallel
TO SCREW #3-#1



$$\theta = 32.20^\circ$$

$$d_1 = d_3 = 1.9941$$

$$d_2 = d_4 = .8620$$

$$\sum d_i^2 = 9.439$$

$$d_1 / \sum d_i^2 = .2113$$

\therefore LESS
SEVERE
THAN
ABOVE
CASE

$$V = 4(.393)(3)(19.31) = 91.1 \text{ LB}$$

$$M_t = 1.5 V = 136.6 \text{ IN-LB}$$

TENSILE FORCS @ SCREW #3

$$F_{t2} = \frac{M_t d_3}{\sum d_i^2} = \frac{(136.6)(1.7983)}{(6.468)} = 38.0 \text{ LB}$$

TOTAL TENSILE LOAD, F_b

$$F_b = F_L + FS \frac{l_{eb}}{l_{eb} + l_{em}} F_t$$

$$F_t = F_{t1} + F_{t2} = 22.8 + 38.0 = 60.8 \text{ LB}$$

ASSUME WORST CASE SCENARIO

$$l_{eb} \gg l_{em}$$

$$l_{eb} / (l_{eb} + l_{em}) = 1.0$$

USE $FS = 1.4$, THEN

$$F_b = 246 + (1.4)(1.0)(60.8) = 331 \text{ LB}$$

PER NAS1352 N04LL6 SCREW, #4, HEAT RESISTANT STEEL, MIN BREAKING STRENGTH

$$F_{tu} = 966 \text{ LB}$$

$$MS = \frac{966}{331} - 1 = +1.9$$

° UNDERSIDE MOUNTED DRO MOUNTING SCREWS OK IN TENSION.

DRO MOUNTED AT THE -X, -Y CORNER OF THE 1331555 LOWER SHELF ASSY ATTACHES AT GRIDS 915, 918, 965, 968 IN THE NASTRAN MODEL VIA PT MASSES (CONM2 1048-1051). EACH PT MASS IS .390 LB

LARGEST RESPONSE PER Z-LOAD, Z-RESPONSE IS A 1G GRMS LEVEL OF 14.5Z GRMS AT GRID 915.

RANDOM VIBRATION RESULTS w/ Q=7.1

Report 10381
Addendum 1

RESPONSE OF LARGE MASSES Q=7.1											
COMPONENT	GRID	LOAD DIRECTION	X-RESPONSE			Y-RESPONSE			Z-RESPONSE		
			RMS	GRMS	Q	RMS	GRMS	Q	RMS	GRMS	Q
968		X	3976	10.30052	1.0	1744	4.518135	0.4	1235	3.19948	0.3
		Y	1332	3.450777	0.3	4130	10.69948	1.1	934	2.41969	0.2
		Z	1618	4.19171	0.4	1855	4.805699	0.5	3877	10.044	1.0
915		X	4062	10.52332	1.0	1859	4.816062	0.5	3018	7.81865	0.8
		Y	1145	2.966321	0.3	4762	12.33679	1.2	1966	5.09326	0.5
		Z	1586	4.108808	0.4	1766	4.57513	0.5	5603	14.5155	1.4
918		X	4014	10.39896	1.0	1755	4.546632	0.5	1436	3.72021	0.4
		Y	1107	2.867876	0.3	4136	10.71503	1.1	940	2.43523	0.2
		Z	1618	4.19171	0.4	1858	4.813472	0.5	3975	10.2979	1.0
965		X	3973	10.29275	1.0	1871	4.84715	0.5	2610	6.76166	0.7
		Y	1250	3.238342	0.3	4770	12.35751	1.2	2106	5.45596	0.5
		Z	1680	4.352332	0.4	1761	4.562176	0.5	5280	13.6788	1.4

STATISTICAL 3σ LOAD @ GR 915

$$F_{t1} = 3(14.52)(.390) = 17.0 \text{ LB}$$

PRELOAD

$$F_i = 246 \text{ LB}$$

SKETCH OF JOINT

SEE PLO JOINT SKETCH, SUBSTITUTE 1336610
DRO FOR 1348360 PLO

OVERTURNING MOMENT

SEE OTHER DRO ABOVE FOR GEOMETRY

$$V = (4)(.390)(3)(14.52) = 68.0 \text{ LB}$$

$$M_t = (1.5)V = 101.9 \text{ IN-LB}$$

TENSILE FORCE AT SCREW #3

$$F_{t2} = \frac{M_t d_3}{\sum d_i^2} = \frac{(101.9)(1.7983)}{(4.468)} = 28.3 \text{ LB}$$

TOTAL TENSILE LOAD, F_{t3}

$$w/ k_b \gg k_m \quad k_b / (k_b + k_m) = 1.0$$

$$F_t = F_{t1} + F_{t2} = 17.0 + 28.3 = 45.3 \text{ LB}$$

FS = 1.4 ON Ft ONLY,

$$F_D = 246 + (1.4)(1.0)(45.3) = 310 \text{ LB}$$

ALLOWABLE, NAS135ZNØ4LL6

$$F_{t4} = 966 \text{ LB}$$

$$MS = \frac{966}{310} - 1 = + 2.1$$

∴ OSCILLATOR @ SHELF -X,-Y CORNER
MOUNTING SCREWS OK IN TENSION

THE GDO MOUNTED TOWARDS THE CENTER OF THE SHELF (ON THE TOP) ATTACHES AT GRIDS 774, 777, 822, AND 825 WITH PT MASSES 1044-1047 (CONM2). EACH PT MASS IS .34 LB.

LARGEST RESPONSE PER Z-LOAD, Z-RESPONSE IS A 1T GRMS LOAD OF 21.73 GRMS AT GRID 825.

RANDOM VIBRATION RESULTS w/Q=7.1

RESPONSE OF LARGE MASSES Q=7.1											
COMPONENT	GRID	LOAD DIRECTION	X-RESPONSE			Y-RESPONSE			Z-RESPONSE		
			RMS	GRMS	Q	RMS	GRMS	Q	RMS	GRMS	Q
LOWER SHELF	825	X	4354	11.27879	1.1	1396	3.61658	0.4	2179	5.84508	0.6
		Y	1286	3.331608	0.3	4525	11.7228	1.2	1832	4.74811	0.5
		Z	1262	3.26943	0.3	1133	2.935233	0.3	8389	21.7332	2.2
	774	X	4480	11.60622	1.1	1142	2.958549	0.3	2876	7.45078	0.7
		Y	1436	3.720207	0.4	4197	10.87306	1.1	1854	4.80311	0.5
		Z	1044	2.704663	0.3	856	2.217617	0.2	5162	13.3731	1.3
	777	X	4443	11.51036	1.1	1400	3.626943	0.4	2355	6.10104	0.6
		Y	1393	3.608808	0.4	4532	11.74093	1.2	1716	4.4456	0.4
		Z	1044	2.704663	0.3	1134	2.937824	0.3	7141	18.5	1.8
	822	X	4374	11.33161	1.1	1140	2.953368	0.3	2576	6.67358	0.7
		Y	1296	3.357513	0.3	4190	10.85492	1.1	2265	5.86788	0.6
		Z	1269	3.287565	0.3	853	2.209845	0.2	5771	14.9508	1.5

STATISTICAL 3T LOAD @ GRID 825

$$F_{t1} = (3)(21.73)(.34) = 22.2 \text{ LB}$$

PRELOAD

$$F_L = 246 \text{ LB}$$

JOINT SKETCH

SEE PLO JOINT SKETCH, REPLACE 1348360 PLO WITH 1336610 GDO.

OVERTURNING MOMENT

SEE SKETCHES AT 1ST DRO EVALUATED FOR GEOMETRY

$$V = (4)(1.34)(3)(21.73) = 88.7 \text{ LB}$$

$$M_t = (1.5)V = 133.0 \text{ IN-LB}$$

TENSILE FORCE @ SCREW # 3

$$F_{t2} = \frac{M_t d_3}{\sum d_i^2} = \frac{(133.0)(1.7983)}{(6.468)} = 37.0 \text{ LB}$$

TOTAL TENSILE LOAD, F_b

$$w/ \ell_{2b} \gg \ell_{2m} \quad \therefore \ell_{2b} / (\ell_{2b} + \ell_{2m}) = 1.0$$

$$F_t = F_{t1} + F_{t2} = 22.2 + 37.0 = 59.2 \text{ LB}$$

$$F_S = 1.4$$

$$F_b = F_L + F_S \frac{\ell_{2b}}{\ell_{2b} + \ell_{2m}} F_t$$

$$= 246 + (1.4)(1.0)(59.2)$$

$$= 329 \text{ LB}$$

PER MS1352 NØ4LL6 SCREW, $F_{tu} = 966 \text{ LB}$

$$MS = \frac{966}{329} - 1 = + 1.9$$

∴ GDO MOUNTING SCREWS OK IN TENSION.

1331592 BRACKET W/ 1331579 IF AMPLIFIERS,
1331576 SAW FILTERS, AND 1356886 ATTENUATOR

THE 1331592 BRACKET W/ 1331579 IF AMPS, 1331576 SAW FILTERS, AND 1356886 ATTENUATOR IS MOUNTED VIA 8 ATTACHMENT SCREWS TO THE 1331555 LOWER SHELF. GRID PTS 744, 747, 751, 762, 769, 781, 787, AND 788 ARE USED IN THE LASTRAN MODEL TO APPLY PT MASSES (CONMZ 1075-1082) TO REPRESENT THIS ASSY. EACH PT MASS IS .248 LB.

LARGEST RESPONSE PER Z-LOAD, Z-RESPONSE IS A 17 GRMS LOAD OF 16.71 GRMS AT GRID 788.

RANDOM VIBRATION RESULTS WITH Q=7.1

COMPONENT	GRID	LOAD DIRECTION	RESPONSE OF LARGE MASSES Q=7.1								
			X-RESPONSE			Y-RESPONSE			Z-RESPONSE		
			RMS	GRMS	Q	RMS	GRMS	Q	RMS	GRMS	Q
	788	X	4366	11.31088	1.1	1674	4.336788	0.4	2545	6.59326	0.7
		Y	1296	3.357513	0.3	4526	11.72539	1.2	2425	6.28238	0.6
		Z	1013	2.624352	0.3	1959	5.07513	0.5	6449	16.7073	1.7
	744	X	4423	11.45855	1.1	1594	4.129534	0.4	1311	3.39637	0.3
		Y	1397	3.619171	0.4	4741	12.28238	1.2	1536	3.97927	0.4
		Z	848	2.196891	0.2	1428	3.699482	0.4	3981	10.3135	1.0
	747	X	4390	11.37306	1.1	1720	4.455959	0.4	3594	9.31088	0.9
		Y	1305	3.380829	0.3	4834	12.52332	1.2	3049	7.89896	0.8
		Z	869	2.251295	0.2	1665	4.313472	0.4	5418	14.0363	1.4
	751	X	4248	11.00518	1.1	1667	4.318653	0.4	1680	4.35233	0.4
		Y	1122	2.906736	0.3	4517	11.70207	1.2	1652	4.27979	0.4
		Z	899	2.329016	0.2	1956	5.067358	0.5	5172	13.399	1.3
	762	X	4428	11.4715	1.1	1600	4.145078	0.4	1691	4.38083	0.4
		Y	1383	3.582902	0.4	4747	12.29793	1.2	2031	5.26166	0.5
		Z	926	2.398964	0.2	1427	3.696891	0.4	4715	12.215	1.2
	769	X	4318	11.18653	1.1	1666	4.316062	0.4	2229	5.77461	0.6
		Y	1205	3.121762	0.3	4514	11.6943	1.2	2104	5.45078	0.5
		Z	961	2.489637	0.2	1954	5.062176	0.5	6252	16.1969	1.6
	781	X	4420	11.45078	1.1	1601	4.147668	0.4	1807	4.68135	0.5
		Y	1363	3.531088	0.3	4747	12.29793	1.2	2383	6.17358	0.6
		Z	1005	2.603627	0.3	1426	3.694301	0.4	5480	14.1969	1.4
	787	X	4371	11.32383	1.1	1745	4.520725	0.4	2849	7.38083	0.7
		Y	1313	3.401554	0.3	4739	12.2772	1.2	2886	7.47668	0.7
		Z	1006	2.606218	0.3	1884	4.880829	0.5	5421	14.044	1.4

STATISTICAL 3σ LOAD @ GR 788

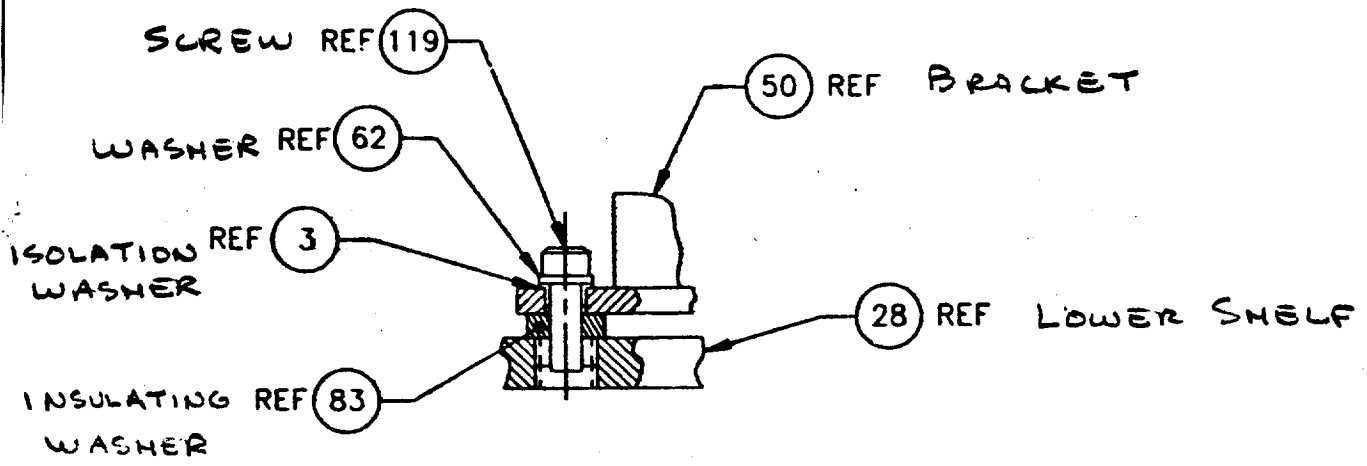
$$F_{E1} = 3(16.71)(.248) = 12.4 \text{ LB}$$

PRELOAD TORQUE

ATTACHMENT SCREWS ARE NAS1352 NØ477 (#4)
WITH T=5.5 IN-LB MAX

$$F_L = \frac{5.5}{(.2)(.112)} = 246 \text{ LB}$$

SKETCH OF JOINT (REF 1356429 VIEW F)



VIEW F

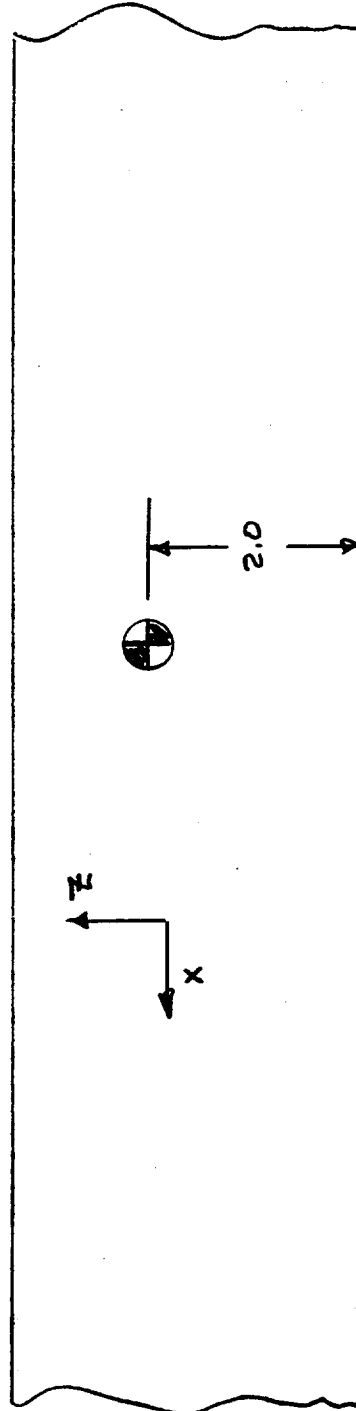
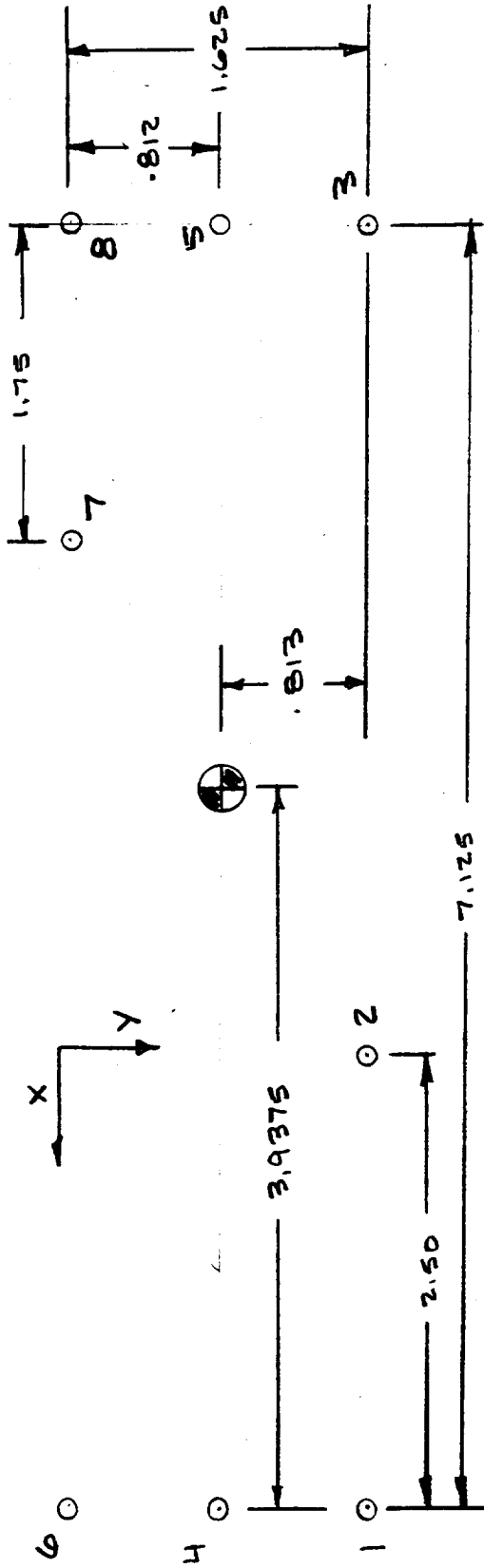
4	2
	E

HARDWARE USAGE, 8 PL (REF)
SCALE: 2/1

OVERTURNING MOMENT

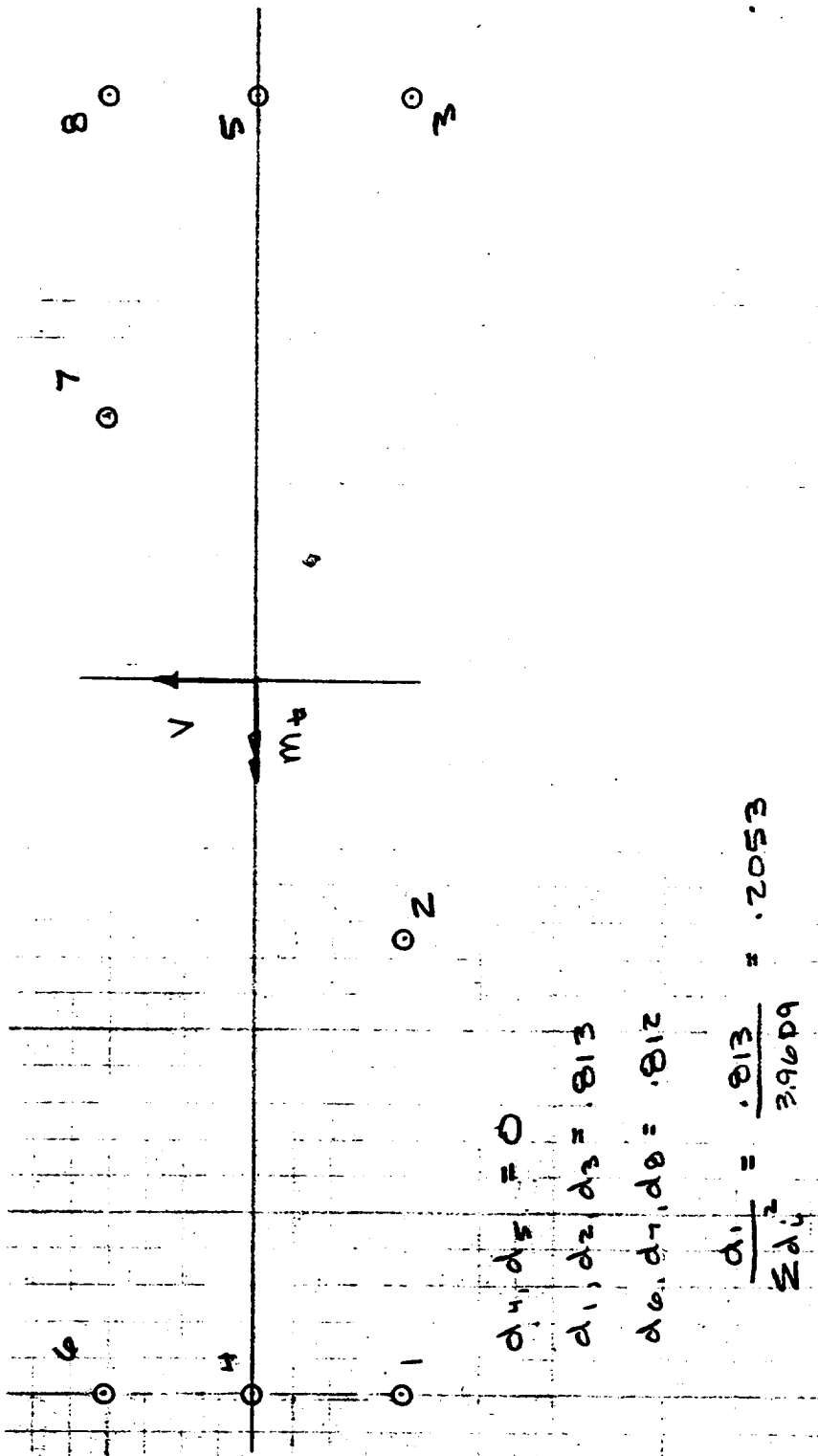
USING "3σ" LOADS FROM RANDOM VIBRATION, Q=7.1, WITH LARGEST RESPONSE (16.71 GRMS @ 1σ @ GRID 788) APPLIED WITHOUT REGARD TO DIRECTION OR LOCATION. LOAD IS APPLIED AS A FORCE THROUGH THE BOLT PATTERN CG TO DEVELOP THE LARGEST POSSIBLE OVERTURNING MOMENT BOLT TENSILE LOAD.

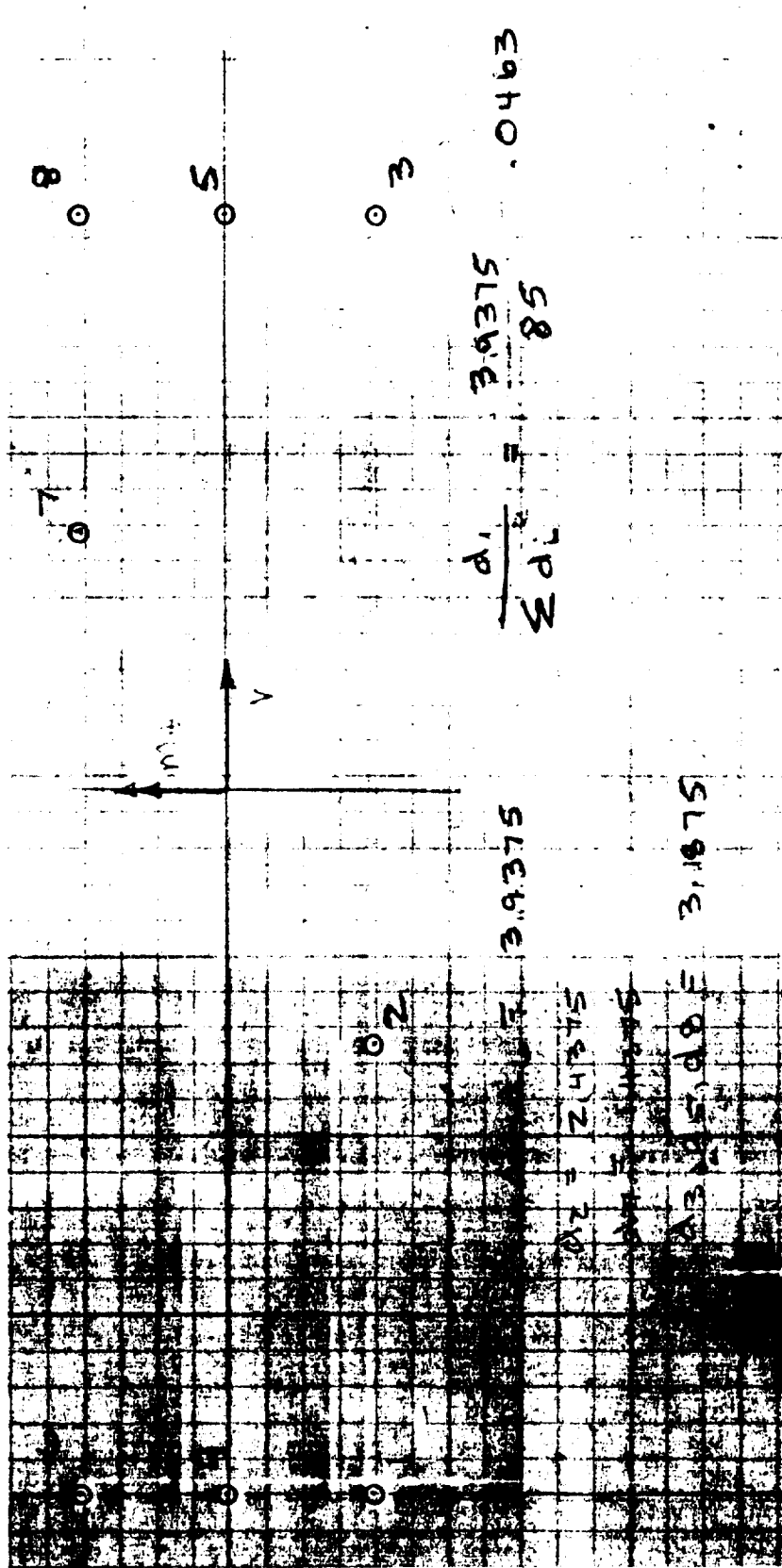
ASSUMED IN-PLANE CG IS @ ATTACHMENT BOLT PATTERN CENTER. HEIGHT OF CG ASSUMED AT 2.0 INCHES



CG ② X = 20.432
Y = 10.483
Z = 7.781

IF SCREW 1 X = 16.076
Y = 11.296
Z = 6.781





APPLYING V IN -Y DIRECTION

$$V = 8(.248375)(3)(16.71) = 99.6 \text{ LB}$$

$$M_t = (2.0)V = 199.2 \text{ IN-LB}$$

TENSILE FORCE @ SCREW #1

$$F_{t2} = \frac{m \cdot d_1}{\sum d_i^2} = \frac{(199.2)(.813)}{(3.9609)} = 40.9 \text{ LB}$$

TOTAL TENSILE LOAD, F_b

$$F_b = F_t + FS \frac{l_b}{l_b + l_m} F_t$$

$$F_t = F_{t1} + F_{t2} = 12.4 + 40.9 = 53.3 \text{ LB}$$

$$FS = 1.4$$

ASSUME $l_b \gg l_m$

$$\text{THEN } \frac{l_b}{l_b + l_m} = 1.0$$

$$F_t = 246 \text{ LB}$$

$$F_b = 246 + (1.4)(1.0)(53.3) = 321 \text{ LB}$$

PER NAS1352 NØ4LLT SCREW, #4, HEAT RESISTANT STEEL

$$F_{tu} = 966 \text{ LB}$$

$$MS = \frac{966}{321} - 1 = +2.0$$

∴ MOUNTING SCREWS OK IN TENSION ON 1331592 BRACKET

1331562 MIXER ON 1331582 BRACKET WITH 1331559 FILTERS

THE 1331562 MIXER W/1331582 BRACKET & 1331559 FILTERS IS MOUNTED VIA 4 LONG #4 NAS1352N04-16 ATTACHMENT SCREWS TO THE 1331555 LOWER SHELF. GRIDS 784, 786, 813, 815 ARE USED IN THE NASTRAN MODEL TO APPLY PT MASSES (CONM2 1087-1090) OF .292 LB EACH.

LARGEST RESPONSE TO 3T LOAD Z-RESPONSE IS A 1T GRMS LOAD OF 21.15 GRMS AT GRID 815.

RESPONSE OF LARGE MASSES Q=7.1											
COMPONENT	GRID	LOAD DIRECTION	X-RESPONSE			Y-RESPONSE			Z-RESPONSE		
			RMS	GRMS	Q	RMS	GRMS	Q	RMS	GRMS	Q
	784	X	4388	11.36788	1.1	1738	4.502591	0.4	2205	5.71244	0.6
		Y	1330	3.445596	0.3	4840	12.53886	1.2	2910	7.53886	0.7
		Z	1025	2.65544	0.3	1707	4.42228	0.4	5180	13.4197	1.3
	786	X	4383	11.35492	1.1	1755	4.546632	0.5	2778	7.19689	0.7
		Y	1329	3.443005	0.3	4811	12.46373	1.2	3085	7.99223	0.8
		Z	1023	2.650259	0.3	1809	4.686528	0.5	5399	13.987	1.4
	813	X	4387	11.36528	1.1	1737	4.5	0.4	2759	7.14767	0.7
		Y	1346	3.487047	0.3	4852	12.56995	1.2	3062	7.93264	0.8
		Z	1183	3.064767	0.3	1667	4.318653	0.4	7058	18.285	1.8
	815	X	4410	11.42487	1.1	1755	4.546632	0.5	4159	10.7746	1.1
		Y	1402	3.632124	0.4	4791	12.41192	1.2	4086	10.5855	1.0
		Z	1169	3.028497	0.3	1838	4.761658	0.5	8164	21.1503	2.1

STATISTICAL 3T LOAD @ GRID 815

$$F_{t1} = 3(21.15)(.292) = 18.5 \text{ LB}$$

PRELOAD

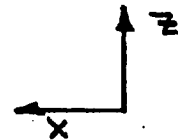
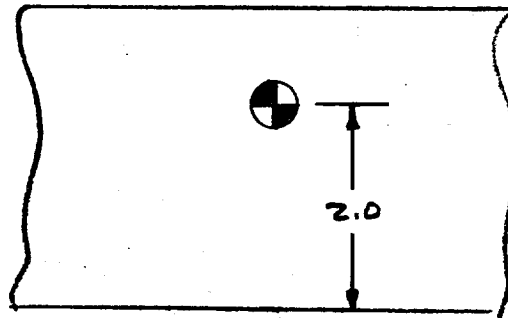
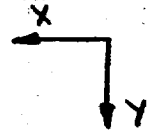
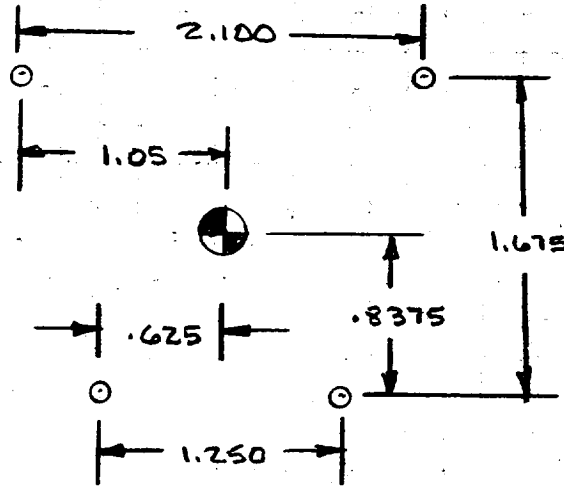
#4 ATTACHMENT SCREWS WITH T = 5.5 IN-LB MAX TORQUE PER 1356429

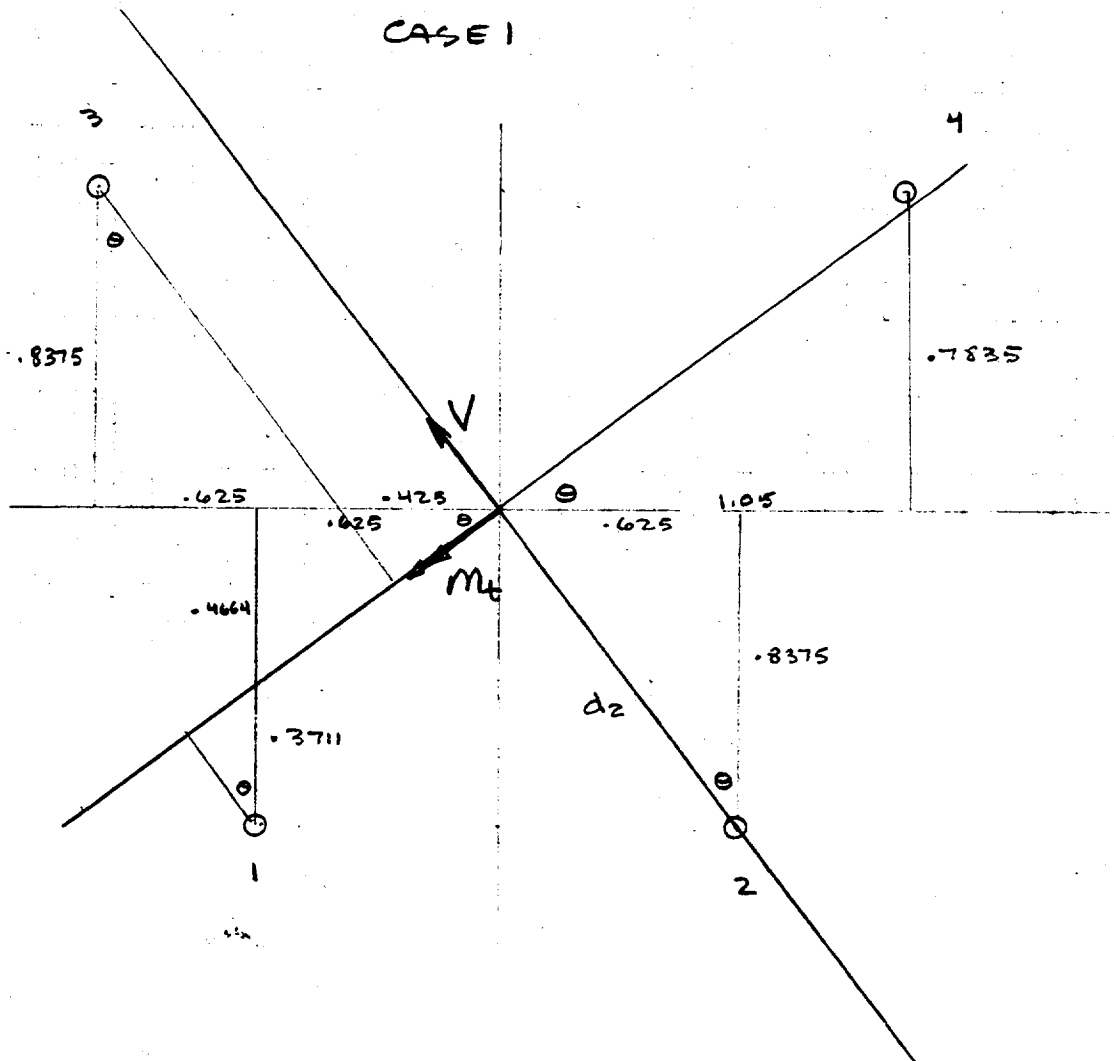
$$F_{t2} = \frac{5.5}{(.2)(.112)} = 246 \text{ LB}$$

OVERTURNING MOMENT

"3T" LOADS FROM RANDOM VIBRATION, Q=7.1, WITH LARGEST RESPONSE (21.15 GRMS @ 1T @ GRID 815) APPLIED WITHOUT REGARD TO DIRECTION OR LOCATION. LOAD IS APPLIED AS A FORCE THROUGH ATTACHMENT BOLT PATTERN CG TO FIND LARGEST POSSIBLE OVERTURNING MOMENT AND BOLT TENSILE LOAD.

ASSUMED IN-PLANE CG @ ATTACHMENT BOLT PATTERN CENTER, HEIGHT OF CG ASSUMED AT 2.0 INCHES.





$$\theta = \tan^{-1} \frac{.625}{.8375} = 36.73^\circ$$

$$d_2 = .8375 / \cos \theta = 1.0450$$

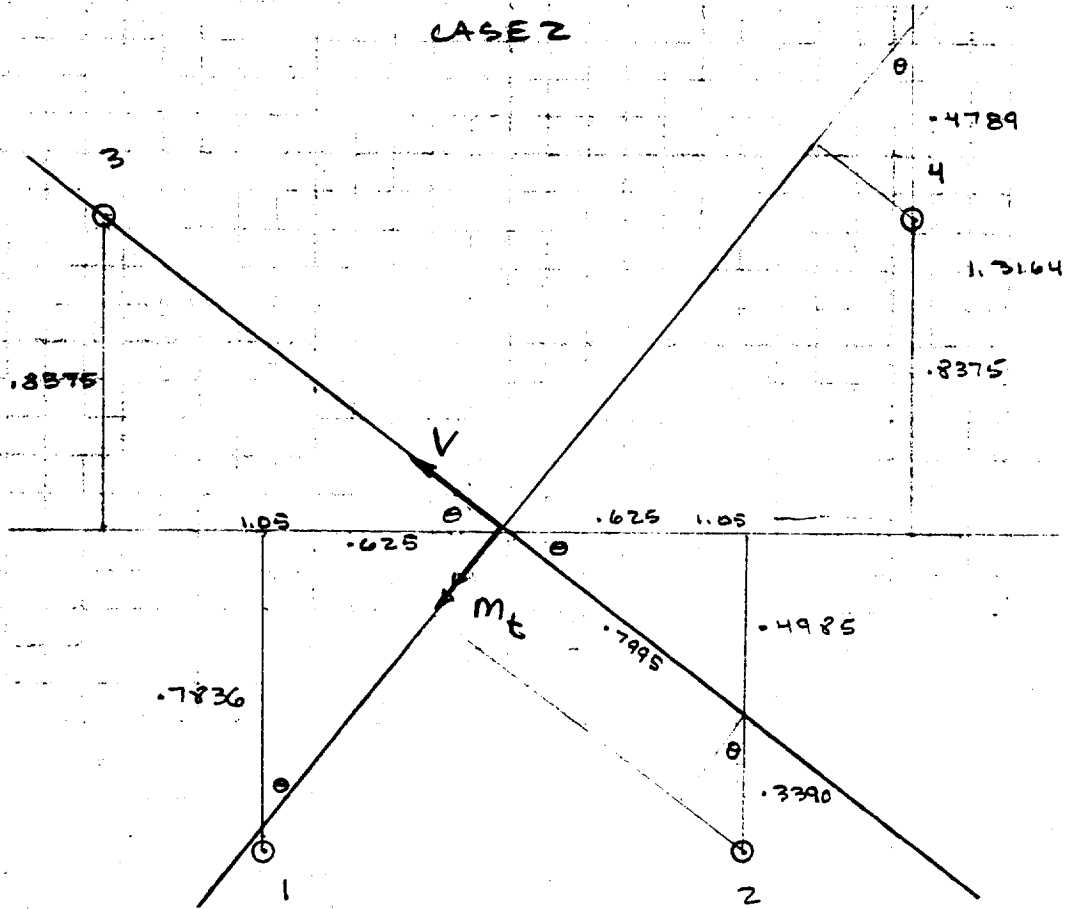
$$d_4 = (.8375 - .7835) \cos \theta = .0433$$

$$d_3 = .8375 / \cos \theta + .425 \sin \theta = 1.2991$$

$$d_1 = .3711 \cos \theta = .2974$$

$$\frac{d_3}{\sum d_i^2} = \frac{1.2991}{2.8701} = .4526$$

CASE 2



$$\theta = \tan^{-1} \frac{.8375}{1.05} = 38.58^\circ$$

$$d_3 = .8375 / \sin \theta = 1.3431$$

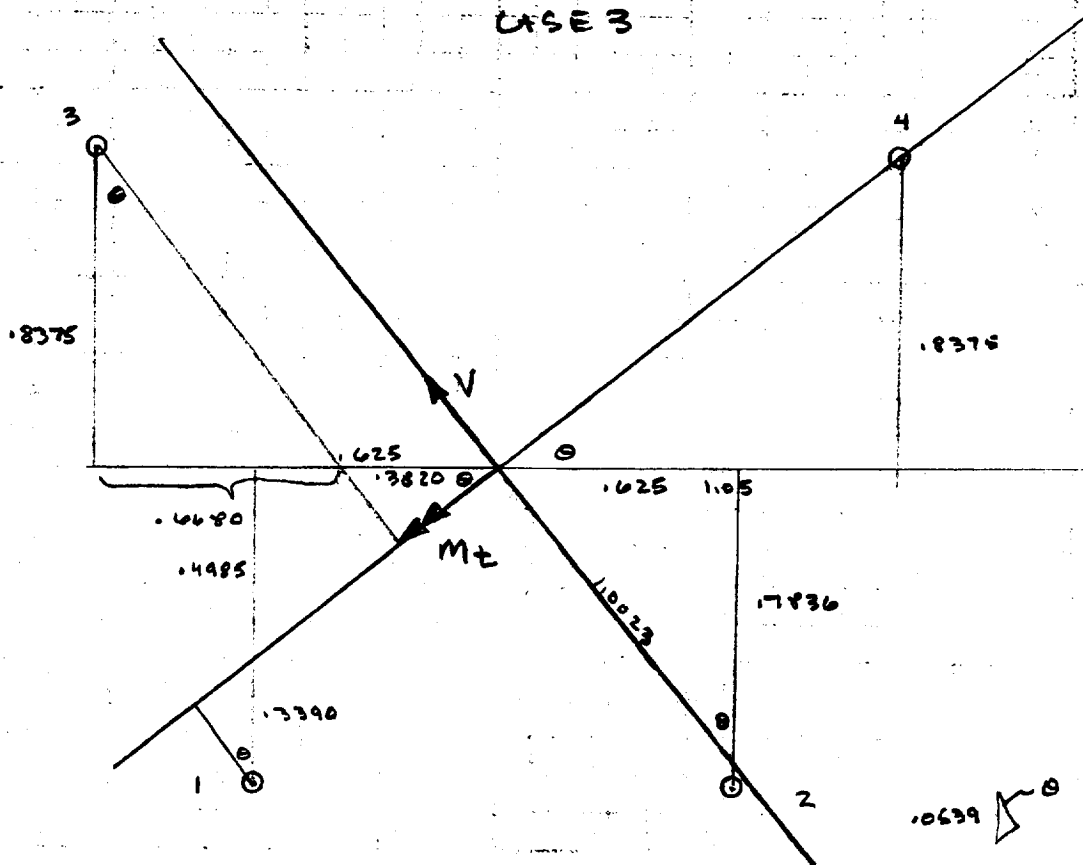
$$d_1 = (.8375 - .7836) \sin \theta = .0336$$

$$d_2 = .7995 + .3390 \sin \theta = 1.0108$$

$$d_4 = .4789 \sin \theta = .2986$$

$$\frac{d_3}{\sum d_i^2} = \frac{1.3431}{2.9160} = \underline{\underline{.4606}}$$

WORST
CASE



$$\theta = \tan^{-1} \frac{.8375}{1.105} = 38.58^\circ$$

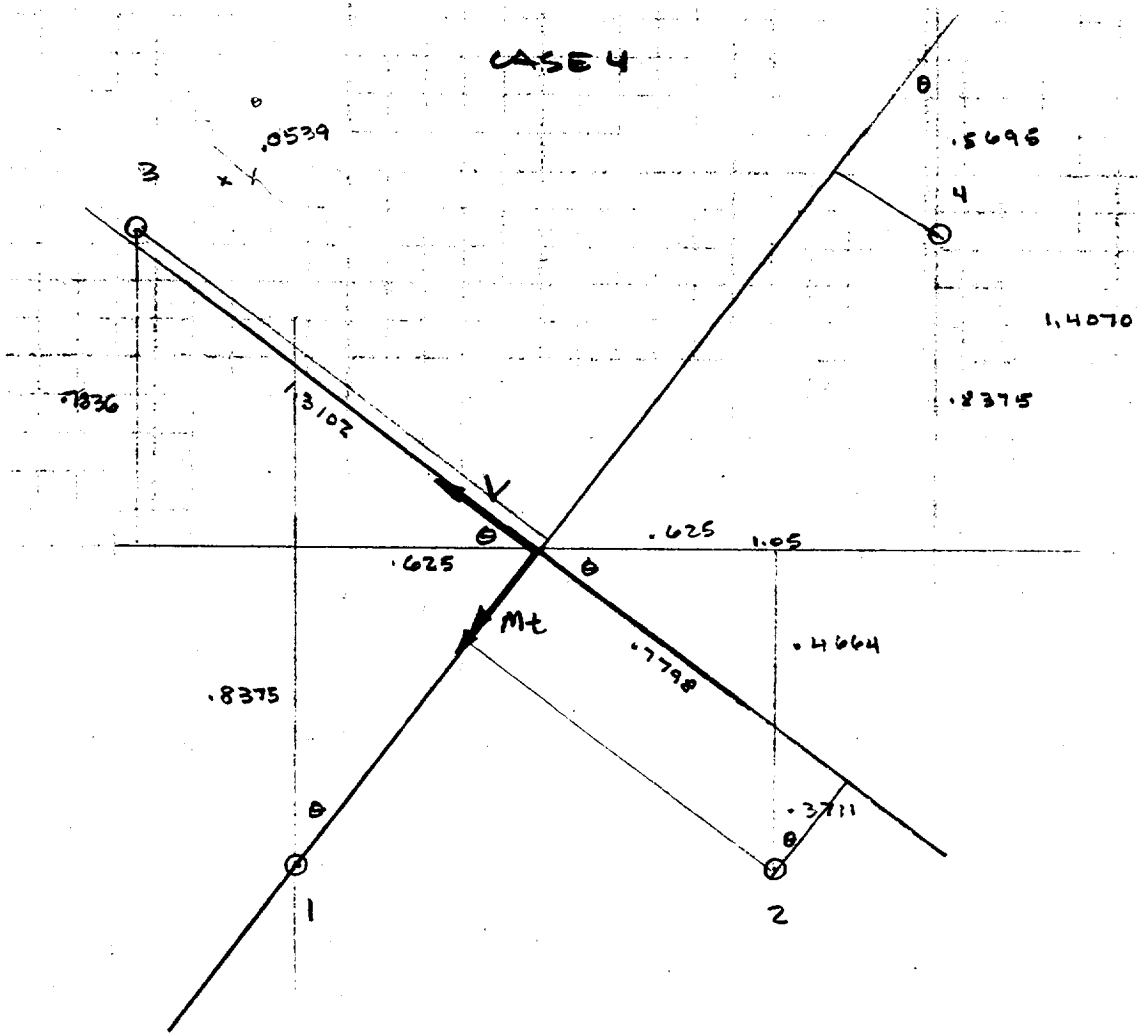
$$d_4 = 0$$

$$d_1 = .3390 \cos \theta = .2650$$

$$d_3 = .8375 / \cos \theta + .3820 \sin \theta = 1.3095$$

$$d_2 = 1.0023 + .0539 \cos \theta = 1.0444$$

$$\frac{d_3}{\sum d_i} = \frac{1.3095}{2.8759} = .4553$$



$$\theta = \tan^{-1} \frac{.625}{.8375} = 36.73^\circ$$

$$d_1 = 0$$

$$d_3 = 1.3102 + .0539 \sin \theta = 1.3424$$

$$d_2 = .7798 + .3711 \tan \theta = 1.0568$$

$$d_4 = .5695 \sin \theta = .3406$$

$$\frac{d_3}{\sum d_i^2} = \frac{1.3424}{3.0348} = .4423$$

APPLYING V IN CASE 2

$$V = 4(.292)(3)(21.15) = 74.1 \text{ LB}$$

$$M = (2.0)V = 148.2 \text{ IN-LB}$$

TENSILE FORCE AT SCREW #3

$$F_{t2} = \frac{M \cdot d_3}{\sum d_i^2} = \frac{(148.2)(1.3431)}{(2.9160)} = 68.3 \text{ LB}$$

TOTAL TENSILE LOAD F_b

$$F_b = F_L + FS \frac{k_b}{k_b + k_m} F_t$$

$$F_t = F_{t1} + F_{t2} = 18.5 + 68.3 = 86.8 \text{ LB}$$

$$FS = 1.4$$

ASSUME $k_b \gg k_m$

$$\frac{k_b}{k_b + k_m} = 1.0$$

$$F_L = 246 \text{ LB}$$

$$F_b = 246 + 1.4(1.0)(86.8) = 367 \text{ LB}$$

NAS1352NØ4-16 SCREWS ALLOWABLE LOAD IS

$$F_{tu} = 966 \text{ LB}$$

$$MS = \frac{966}{367} - 1 = +1.6$$

∴ MOUNTING BOLTS OK IN TENSION
ON 1331582 BKT

1331562 MIXER ON 1331595 BRACKET
W/ 1331501 ISOLATOR

THE 1331562 MIXER ON THE 1331595 BRACKET IS MOUNTED VIA 4 NAS1352-N04-15 #4 SCREWS TO THE 1331555 LOWER SHELF. GRIDS 841, 842, 872, 873 ARE USED IN THE NASTRAN MODEL TO APPLY PT MASSES (CONM2 1099-1102.) OF .194 LB EACH

LARGEST RESPONSE TO Z-LOAD Z-RESPONSE IS A 1T GRMS LOAD OF 22.15 GRMS AT GP 842.

RANDOM VIBRATION RESULTS W/ Q=7.1

COMPONENT	GRID	LOAD DIRECTION	RESPONSE OF LARGE MASSES Q=7.1								
			X-RESPONSE			Y-RESPONSE			Z-RESPONSE		
			RMS	GRMS	Q	RMS	GRMS	Q	RMS	GRMS	Q
841	X	Y	4307	11.15803	1.1	1336	3.46114	0.3	2398	6.21503	0.6
		Z	1249	3.235751	0.3	4450	11.5285	1.1	2103	5.44818	0.5
		X	1380	3.523318	0.3	1057	2.738342	0.3	7942	20.5751	2.0
842	X	Y	4303	11.14767	1.1	1417	3.670984	0.4	2116	5.48187	0.5
		Z	1248	3.233161	0.3	4549	11.78497	1.2	2115	5.47927	0.5
		X	1358	3.518135	0.3	1160	3.005181	0.3	8550	22.1503	2.2
872	X	Y	4234	10.96891	1.1	1337	3.463731	0.3	2445	6.3342	0.6
		Z	1208	3.129534	0.3	4450	11.5285	1.1	2529	6.55181	0.6
		X	1493	3.867876	0.4	1056	2.735751	0.3	7504	19.4404	1.9
873	X	Y	4232	10.96373	1.1	1418	3.673575	0.4	2178	5.64249	0.6
		Z	1210	3.134715	0.3	4550	11.78756	1.2	2701	6.99741	0.7
		X	1490	3.860104	0.4	1160	3.005181	0.3	8045	20.842	2.1

STATISTICAL 3T LOAD @ GR 842

$$F_{L1} = 3(22.15)(.194) = 12.9 \text{ LB}$$

PRELOAD

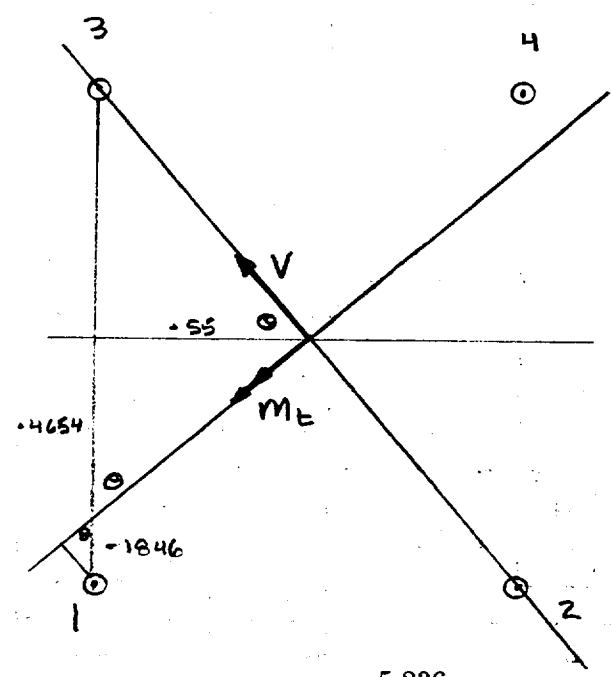
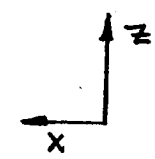
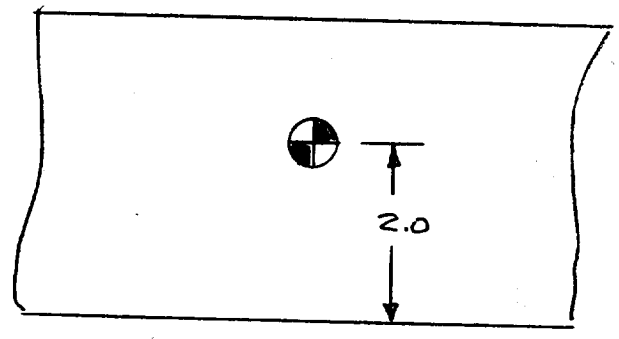
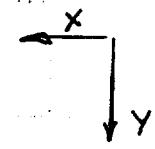
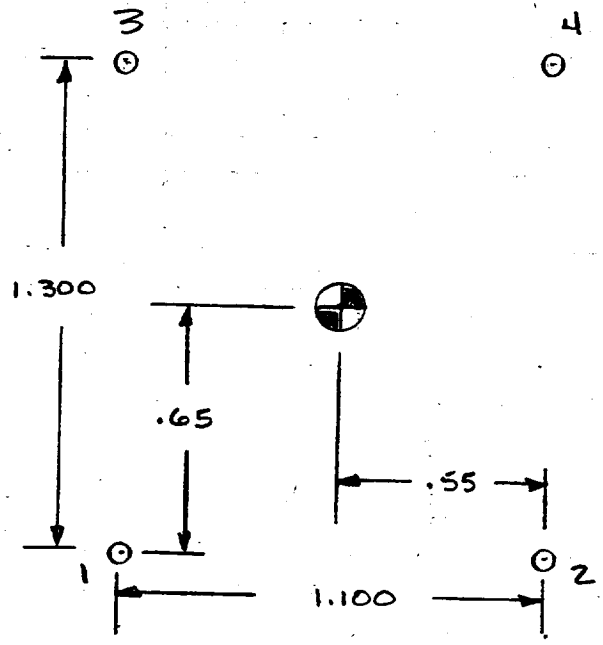
PER 1356429 FOR #4 SCREWS W/ 5.5 IN-LB T_{MAX}

$$F_L = \frac{5.5}{(.2)(.112)} = 246 \text{ LB}$$

OVERTURNING MOMENT

"3T" LOADS FROM RANDOM VIBRATION, Q=7.1 WITH LARGEST RESPONSE. (22.15 GRMS @ 1T @ GR 842) APPLIED WITHOUT REGARD TO DIRECTION OR LOCATION. APPLY LOAD THROUGH ATTACHMENT BOLT PATTERN CG TO FIND LARGEST POSSIBLE OVERTURNING MOMENT BOLT TENSILE LOAD.

ASSUMED IN-PLANE CG @ ATTACHMENT BOLT PATTERN CENTER. HEIGHT OF CG ASSUMED AT 2.0 INCHES



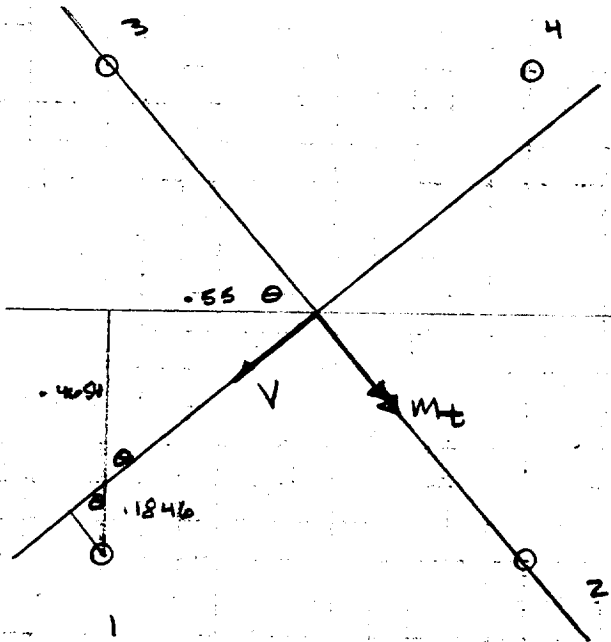
$$\theta = \text{TAN}^{-1} \frac{.65}{.55} = 49.76^\circ$$

$$d_2 = d_3 = \frac{.65}{\sin \theta} = .8515$$

$$d_1 = d_4 = .1846 \sin \theta = .1409$$

$$\frac{d_2}{\sum d_i^2} = \frac{.8515}{1.4897} = .5716$$

NOT WORST CASE



$$\theta = \tan^{-1} \frac{.65}{.55} = 49.76^\circ$$

$$d_2 = d_3 = 0$$

$$d_1 = d_4 = .4654 / \cos \theta + .1846 \cos \theta = .8397$$

$$\frac{d_1}{\sum d_i^2} = \frac{.8397}{1.4103} = .5954$$

WORST
CASE

$$V = 4(.194)(3)(22.15) = 51.5 \text{ LB}$$

$$M = (2.0)V = 103 \text{ IN-LB}$$

$$F_{t2} = \frac{M d_4}{\sum d_i^2} = \frac{(103)(.8397)}{(1.4103)} = 61.3 \text{ LB}$$

$$F_t = F_{t1} + F_{t2} = 129 + 61.3 = 190.3 \text{ LB}$$

$$FS = 1.4$$

$$k_b \gg k_m$$

$$F_b = F_t + FS \frac{k_b}{k_b + k_m} F_t = 190.3 + (1.4)(1.0)(190.3) = 466 \text{ LB}$$

$$\text{NAS1352N } \phi 4.15 \text{ SCREW, } F_t = 966 \text{ LB}$$

$$MS = \frac{966}{466} - 1 = +1.08$$

∴ MOUNTING BOLTS OK IN TENSION ON 1331595 BKT

UPPER SHELF (A1-2) LARGE MASS ATTACHMENTS

REF 1331491 UPPER RF SHELF
 1331490 UPPER RF SHELF ASSY
 1356409 RECEIVER ASSY, A1-2
 1331471 BAND PASS FILTER BRACKET
 1331559 BP FILTER
 1331165 BRACKET
 MS24693 SCREW
 1336610 OSCILLATOR
 1331562 MIXER/AMP
 1331481 BRACKET
 1331482 BRACKET

1331165 BRACKET ATTACHMENT

THE 1331165 BRACKET ATTACHES TO THE UPPER SHELF (1331490) VIA 3 MS24693-C27 SCREWS. ATTACHED TO THE OTHER END OF THE 1331165 BRACKET IS THE 1331471 BRACKET WITH MOUNTED 1331559 BP FILTERS & OTHER HARDWARE. 3 GRID PTS (1806, 1808, 1810) ARE USED IN THE NASTRAN MODEL TO APPLY PT MASSES (CONM2 2102, 2103, 2104) OF .403 LB EACH.

LARGEST RESPONSE PER Z LOAD Z RESPONSE IS A 1G GRMS LOAD OF 16.27 GRMS AT GR 1806

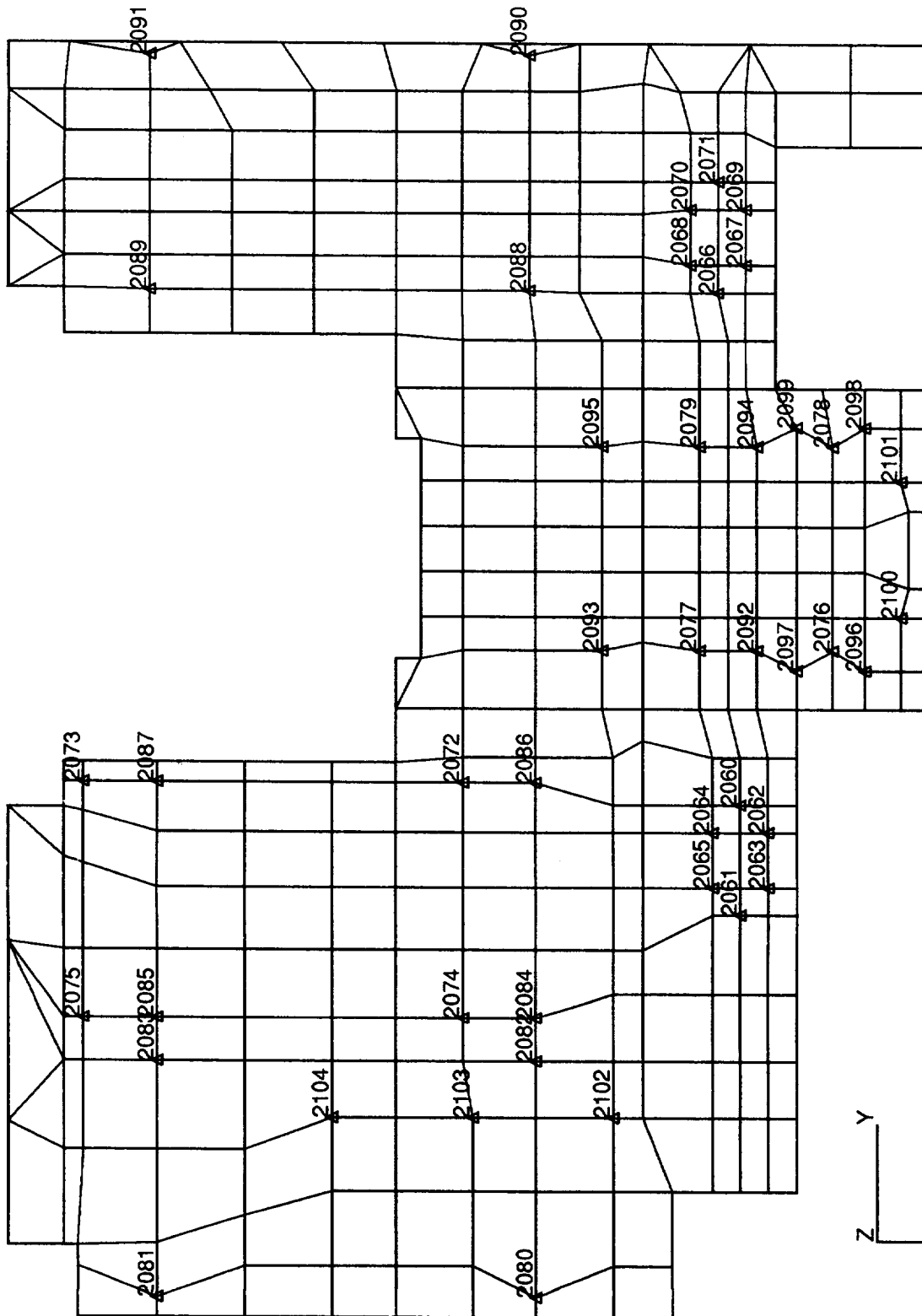
RANDOM VIBRATION RESULTS, Q=7.1

RESPONSE OF LARGE MASSES Q=7.1												
COMPONENT	GRID	LOAD DIRECTION	X-RESPONSE			Y-RESPONSE			Z-RESPONSE			
			RMS	GRMS	Q	RMS	GRMS	Q	RMS	GRMS	Q	
UPPER SHELF	1808	X	4125	10.68653	1.1	1106	2.865285	0.3	1900	4.92228	0.5	
		Y	924	2.393782	0.2	1542	3.994819	0.4	1542	3.99482	0.4	
		Z	1142	2.956549	0.3	1600	4.145078	0.4	5838	15.1244	1.5	
	1806	X	4129	10.69689	1.1	1189	3.080311	0.3	2172	5.62694	0.6	
		Y	924	2.393782	0.2	1524	3.948187	0.4	1524	3.94819	0.4	
		Z	1144	2.963731	0.3	1726	4.471503	0.4	6282	16.2746	1.6	
	1810	X	4122	10.67876	1.1	1067	2.764249	0.3	1578	4.08808	0.4	
		Y	925	2.396373	0.2	1428	3.699482	0.4	1429	3.70207	0.4	
		Z	1141	2.955959	0.3	1517	3.930052	0.4	5536	14.342	1.4	

STATISTICAL 3σ LOAD AT GR 1806

$$F_{E1} = 3(16.27)(.403) = 19.7 \text{ LB}$$

1846	1828	1814	1202	1190	1142	1130	1118	1106
1845	1827	1813	1797	1785	1772	1758	1744	1730
1844	1826	1812	1796	1784	1770	1756	1742	1728
1843	1825	1811	1795	1783	1769	1755	1741	1727
1842	1824	1810	1794	1782	1768	1754	1740	1726
1841	1823	1809	1793	1781	1767	1753	1739	1725
1840	1822	1808	1792	1780	1766	1752	1738	1724
1839	1821	1807	1791	1779	1765	1751	1737	1723
1838	1820	1806	1790	1778	1764	1750	1736	1722
1837	1819	1805	1789	1777	1763	1749	1735	1721
1836	1818	1804	1788	1776	1762	1748	1734	1720
1835	1817	1803	1787	1775	1761	1747	1733	1719
1834	1816	1802	1786	1774	1760	1746	1732	1718
1833	1815	1801	1785	1773	1759	1745	1731	1717
1832	1814	1800	1784	1772	1758	1744	1730	1716
1831	1813	1799	1783	1771	1757	1743	1729	1715
1830	1812	1798	1782	1770	1756	1742	1728	1714
1829	1811	1797	1781	1769	1755	1741	1727	1713
1828	1810	1796	1780	1768	1754	1740	1726	1712
1827	1809	1795	1779	1767	1753	1739	1725	1711
1826	1808	1794	1778	1766	1752	1738	1724	1710
1825	1807	1793	1777	1765	1751	1737	1723	1709
1824	1806	1792	1776	1764	1750	1736	1722	1708
1823	1805	1791	1775	1763	1749	1735	1721	1707
1822	1804	1790	1774	1762	1748	1734	1720	1706
1821	1803	1789	1773	1761	1747	1733	1719	1705
1820	1802	1788	1772	1760	1746	1732	1718	1704
1819	1801	1787	1771	1759	1745	1731	1717	1703
1818	1800	1786	1770	1758	1744	1730	1716	1702
1817	1799	1785	1769	1757	1743	1729	1715	1701
1816	1798	1784	1768	1756	1742	1728	1714	1700
1815	1797	1783	1767	1755	1741	1727	1713	1699
1814	1796	1782	1766	1754	1740	1726	1712	1698
1813	1795	1781	1765	1753	1739	1725	1711	1697
1812	1794	1780	1764	1752	1738	1724	1710	1696
1811	1793	1779	1763	1751	1737	1723	1709	1695
1810	1792	1778	1762	1750	1736	1722	1708	1694
1809	1791	1777	1761	1749	1735	1721	1707	1693
1808	1790	1776	1760	1748	1734	1720	1706	1692
1807	1789	1775	1759	1747	1733	1719	1705	1691
1806	1788	1774	1758	1746	1732	1718	1704	1690
1805	1787	1773	1757	1745	1731	1717	1703	1689
1804	1786	1772	1756	1744	1730	1716	1702	1688
1803	1785	1771	1755	1743	1729	1715	1701	1687
1802	1784	1770	1754	1742	1728	1714	1700	1686
1801	1783	1769	1753	1741	1727	1713	1699	1685
1800	1782	1768	1752	1740	1726	1712	1698	1684
1799	1781	1767	1751	1739	1725	1711	1697	1683
1798	1780	1766	1750	1738	1724	1710	1696	1682
1797	1779	1765	1749	1737	1723	1709	1695	1681
1796	1778	1764	1748	1736	1722	1708	1694	1680
1795	1777	1763	1747	1735	1721	1707	1693	1679
1794	1776	1762	1746	1734	1720	1706	1692	1678
1793	1775	1761	1745	1733	1719	1705	1691	1677
1792	1774	1760	1744	1732	1718	1704	1690	1676
1791	1773	1759	1743	1731	1717	1703	1689	1675
1790	1772	1758	1742	1730	1716	1702	1688	1674
1789	1771	1757	1741	1729	1715	1701	1687	1673
1788	1770	1756	1740	1728	1714	1700	1686	1672
1787	1769	1755	1739	1727	1713	1699	1685	1671
1786	1768	1754	1738	1726	1712	1698	1684	1670
1785	1767	1753	1737	1725	1711	1697	1683	1669
1784	1766	1752	1736	1724	1710	1696	1682	1668
1783	1765	1751	1735	1723	1709	1695	1681	1667
1782	1764	1750	1734	1722	1708	1694	1680	1666
1781	1763	1749	1733	1721	1707	1693	1679	1665
1780	1762	1748	1732	1720	1706	1692	1678	1664
1779	1761	1747	1731	1719	1705	1691	1677	1663
1778	1760	1746	1730	1718	1704	1690	1676	1662
1777	1759	1745	1729	1717	1703	1689	1675	1661
1776	1758	1744	1728	1716	1702	1688	1674	1660
1775	1757	1743	1727	1715	1701	1687	1673	1659
1774	1756	1742	1726	1714	1700	1686	1672	1658
1773	1755	1741	1725	1713	1699	1685	1671	1657
1772	1754	1740	1724	1712	1698	1684	1670	1656
1771	1753	1739	1723	1711	1697	1683	1669	1655
1770	1752	1738	1722	1710	1696	1682	1668	1654
1769	1751	1737	1721	1709	1695	1681	1667	1653
1768	1750	1736	1720	1708	1694	1680	1666	1652
1767	1749	1735	1719	1707	1693	1679	1665	1651
1766	1748	1734	1718	1706	1692	1678	1664	1650
1765	1747	1733	1717	1705	1691	1677	1663	1649
1764	1746	1732	1716	1704	1690	1676	1662	1648
1763	1745	1731	1715	1703	1689	1675	1661	1647
1762	1744	1730	1714	1702	1688	1674	1660	1646
1761	1743	1729	1713	1701	1687	1673	1659	1645
1760	1742	1728	1712	1700	1686	1672	1658	1644
1759	1741	1727	1711	1699	1685	1671	1657	1643
1758	1740	1726	1710	1698	1684	1670	1656	1642
1757	1739	1725	1709	1697	1683	1669	1655	1641
1756	1738	1724	1708	1696	1682	1668	1654	1640
1755	1737	1723	1707	1695	1681	1667	1653	1639
1754	1736	1722	1706	1694	1680	1666	1652	1638
1753	1735	1721	1705	1693	1679	1665	1651	1637
1752	1734	1720	1704	1692	1678	1664	1650	1636
1751	1733	1719	1703	1691	1677	1663	1649	1635
1750	1732	1718	1702	1690	1676	1662	1648	1634
1749	1731	1717	1701	1689	1675	1661	1647	1633
1748	1730	1716	1700	1688	1674	1660	1646	1632
1747	1729	1715	1699	1687	1673	1659	1645	1631
1746	1728	1714	1698	1686	1672	1658	1644	1630
1745	1727	1713	1697	1685	1671	1657	1643	1629
1744	1726	1712	1696	1684	1670	1656	1642	1628
1743	1725	1711	1695	1683	1669	1655	1641	1627
1742	1724	1710	1694	1682	1668	1654	1640	1626
1741	1723	1709	1693	1681	1667	1653	1639	1625
1740	1722	1708	1692	1680	1666	1652	1638	1624
1739	1721	1707	1691	1679	1665	1651	1637	1623
1738	1720	1706	1690	1678	1664	1650	1636	1622
1737	1719	1705	1689	1677	1663	1649	1635	1621
1736	1718	1704	1688	1676	1662	1648	1634	1620
1735	1717	1703	1687	1675	1661	1647	1633	1619
1734	1716	1702	1686	1674	1660	1646	1632	1618
1733	1715	1701	1685	1673	1659	1645	1631	1617
1732	1714	1700	1684	1672	1658	1644	1630	1616
1731	1713	1699	1683	1671	1657	1643	1629	1615
1730	1712	1698	1682	1670	1656	1642	1628	1614
1729	1711	1697	1681	1669	1655	1641	1627	1613
1728	1710	1696	1680	1668	1654	1640	1626	1612
1727	1709	1695	1679	1667	1653	1639	1625	1611
1726	1708	1694	1678	1666	1652	1638	1624	1610
1725	1707	1693	1677	1665	1651	1637	1623	1609
1724	1706	1692	1676	1664	1650	1636	1622	1608
1723	1705	1691	1675	1663	1649	1635	1621	1607
1722	1704	1690	1674	1662	1648	1634	1620	1606
1721	1703	1689	1673	1661	1647	1633	1619	1605
1720	1702	1688	1672	1660	1646	1632		



PRELOAD TORQUE

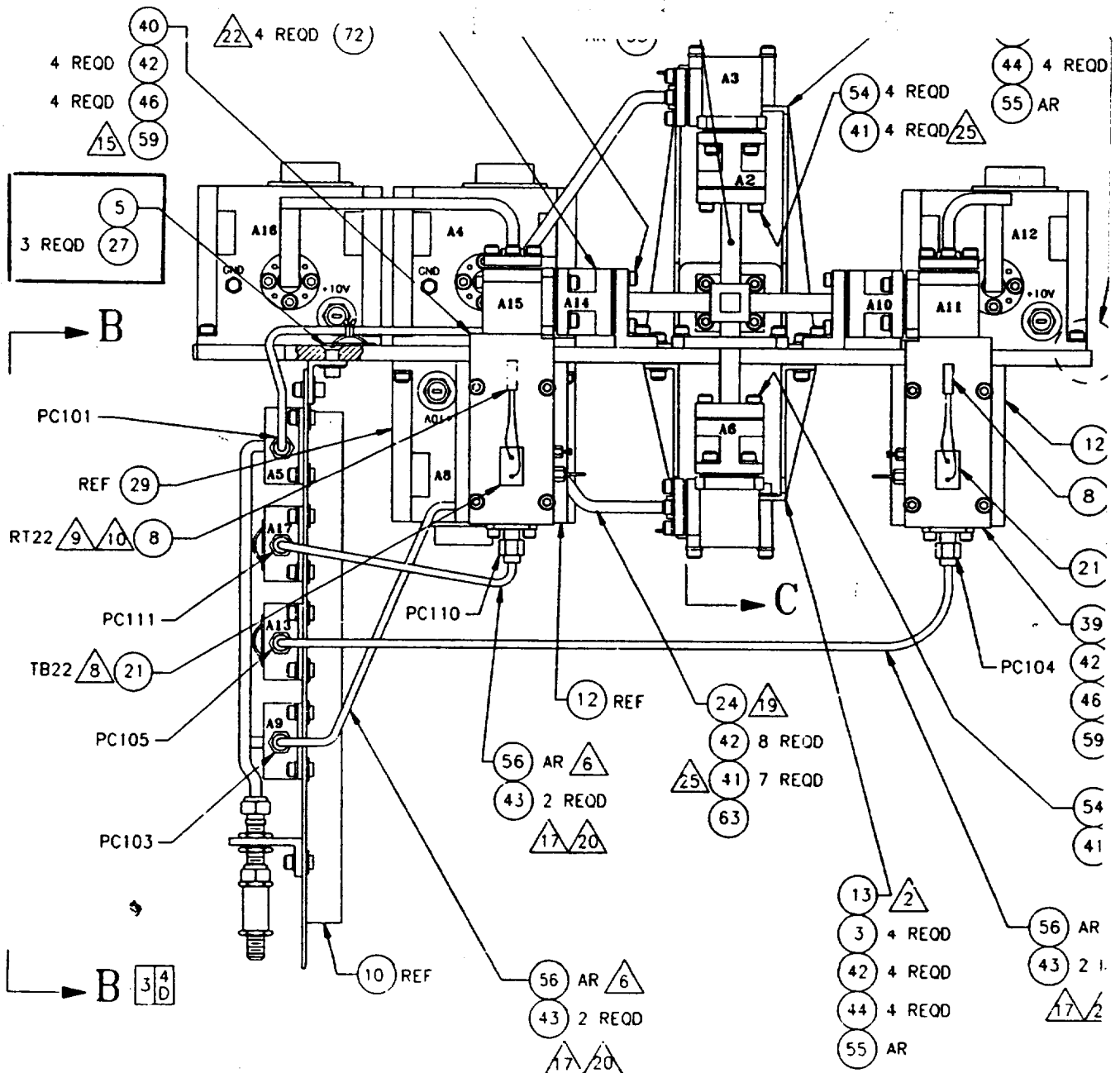
1-10-96

Report 10381
Addendum 1

ATTACHMENT SCREWS 1331165 BRACKET TO SHELF ARE MS24693-C27 WHICH ARE #6-32UNC-2A SCREWS OF CORROSION RESISTING STEEL WITH MINIMUM TENSILE STRENGTH OF 725 LB. PER 1356409 TABLE 1, THE PRELOAD TORQUE IS 8 TO 10 IN-LB. MAXIMUM PRELOAD IS THEN

$$F_L = \frac{T}{(2)(d)} = \frac{10}{(2)(.138)} = 362 \text{ LB}$$

JOINT SKETCH

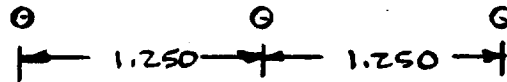


THE JOINT IN QUESTION IS A LINE OF 3 SCREWS. CONNECTING THE ITEM (5) 1331165 BRACKET WITH THE ITEM (27) SCREWS TO THE ITEM (15) SHELF.

OVERTURNING MOMENT

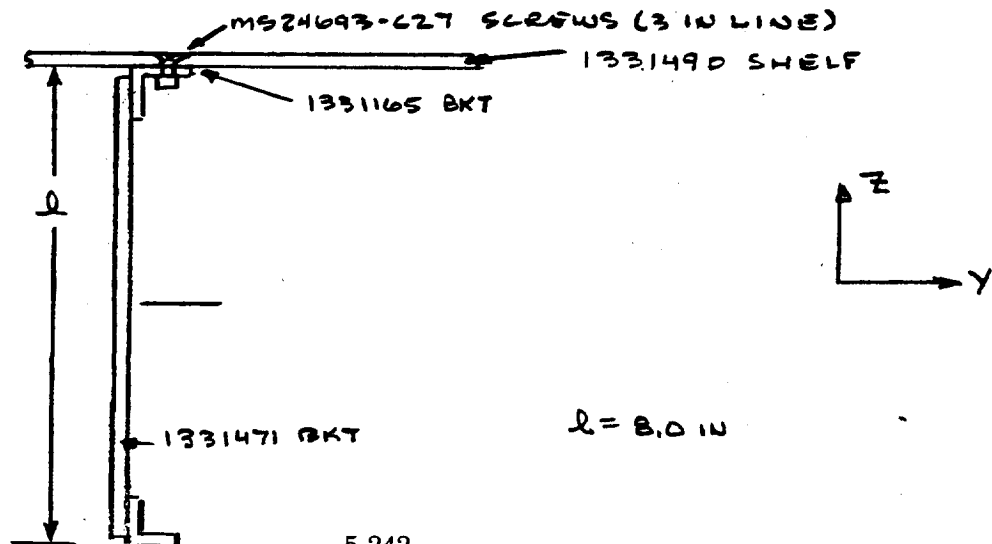
BECAUSE THE PRESENT BOLT PATTERN OF INTEREST IS ARRANGED IN A LINE AND NOT A PLAINR PATTERN, THE PROCEDURE USED IN DETERMINING ADDITIONAL TENSILE LOADS IN THE ATTACHMENT SCREWS, AS UTILIZED ABOVE FOR OTHER COMPONENT MOUNTINGS, NEED BE MODIFIED.

THE PATTERN IS 3 SCREWS SPALED 1.250 INCHES APART. THUS THE PATTERN CG IS AT THE MIDDLE SCREW.



AS SHOWN ON THE PREVIOUS PAGE SKETCH, THE ITEM (10) 1331471 BRACKET ATTACHES TO THE ITEM (5) 1331165 BRACKET. MOUNTED ON THE 1331471 BKT ARE FILTERS AND CONNECTORS, SUCH THAT THE HARDWARE ATTACHED TO THE SHELF AT THE 3 MS24693-C27 SCREWS (ITEM (27)) WEIGHS APPROXIMATELY 1.21 LB.

OF INTEREST IS A LOAD IN THE Y-DIRECTION, NORMAL TO THE 1331471 BRACKET FACE, PRODUCING A MOMENT ALONG THE X-AXIS WHICH WOULD REACT THROUGH THE 1331165 BKT TO PRODUCE ADDED BOLT TENSION AND ALSO FLANGE BENDING IN THE 1331165 BKT.



PER THE PREVIOUS RANDOM VIBRATION RESULTS, $Q=7.1$
TABLE, THE LARGEST Y-RESPONSE IS 4.47 GRMS AT
GRID 1806. THUS, FOR A "3Y" LOAD

$$F_y = (3)(.4033)(3)(4.47) = 16.2 \text{ LB}$$

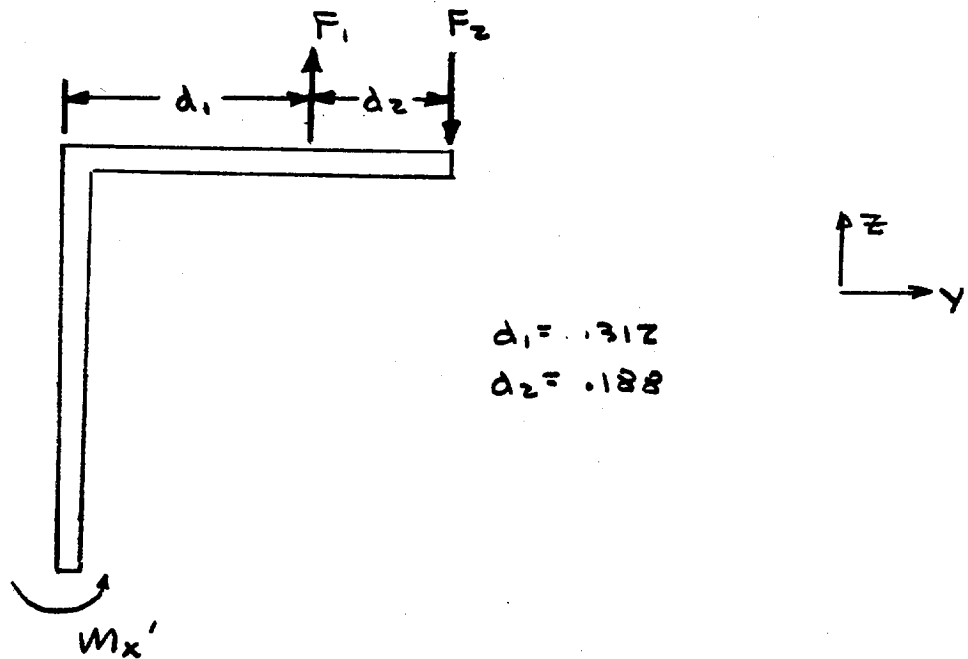
$$M_x = \frac{F_y (L)}{8} = (16.2)(1) = 16.2 \text{ IN-LB}$$

FIXED ENDS
W/CENTER
LOAD

ON A PER INCH BASIS USING THE 1331165 BKT SPACING
BETWEEN THE SCREWS, $1.250 + 1.250 = 2.500$

$$M_x' = \frac{16.2}{2.50} = 6.5 \frac{\text{IN-LB}}{\text{IN}}$$

1331165 BRACKET



$$d_1 = .312$$

$$d_2 = .188$$

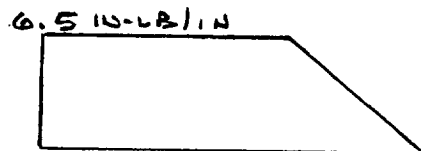
$$\sum M_2 = 0$$

$$F_1 (.188) = 6.5$$

$$F_1 = 34.5 \text{ LB/IN}$$

$$F_2 = 34.5 \text{ LB/IN}$$

MOMENT
DIAGRAM



BOLT LOAD/BOLT 3 BOLTS SHARE LOAD

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Addendum 1

$$F_{t2} = (34.5)(2.500)/3 = 28.7 \text{ LB}$$

TOTAL TENSILE LOAD, F_b , IN SCREW

$$F_b = F_L + F_S \frac{J_{cb}}{J_{cb} + J_{cm}} F_t$$

$$F_t = F_{t1} + F_{t2} = 19.7 + 28.7 = 48.4 \text{ LB}$$

WITH $F_S = 1.4$ APPLIED TO F_t ONLY, AND $F_L = 362 \text{ LB}$

USING WORST CASE SCENARIO $J_{cb} \gg J_{cm}$

$$F_b = F_L + F_S (1) F_t$$

$$= 362 + (1.4)(1.0)(48.4) = 430 \text{ LB}$$

ALLOWABLE MS24693-C27

$$F_{tu} = 725 \text{ LB}$$

$$MS = \frac{725}{430} - 1 = +.68$$

∴ 1331165 BKT MOUNTING SCREWS TO SHELF
ARE OK IN TENSION

1331165-1 BRACKET FLANGE BENDING

THE BRACKET FLANGE MUST REACT THE ABOVE
DETERMINED $M = 6.5 \text{ IN-LB/IN}$ MOMENT. A
BENDING STRESS IS SET UP IN THE 1331165-1 BKT

$$S = \frac{6M}{t^2}$$

$$M = 6.5 \text{ IN-LB/IN}$$

$$t = .062 - .010 \text{ MIN}$$

$$= \frac{6(6.5)}{(.052)^2}$$

$$= 14423 \text{ PSI}$$

MAT'L 6061-T6 ALUM (1331165-1 BKT)

$$F_{ty} = 35000 \text{ psi}$$

$$F_{tu} = 42000 \text{ psi}$$

WITH FS = 1.25 YIELD, 1.4 ULTIMATE

$$MS = \frac{F_{ty}}{1.25 \times S_t} - 1 = \frac{35000}{1.25(14423)} - 1$$

$$= +.94$$

$$MS = \frac{F_{tu}}{1.4 \times S_t} - 1 = \frac{42000}{1.4(14423)} - 1$$

$$= +1.1$$

∴ FLANGE ON 1331165 OK.

1331482

1331481 BRACKETS W/1331562 MIXERS & OTHER HARDWARE

THE 1331481 BRACKET MOUNTS BELOW THE 1331490 SHELF WITH 4 NAS1352NØ4LL4 #4 SCREWS. ATTACHED TO THE BRACKET ARE THE 1331562 MIXER & VARIOUS OTHER HARDWARE. 4 GRID PTS (1613,1615,1679,1681) ARE USED IN THE NASTRAN MODEL TO APPLY PT MASSES (CONM2 2076,2078,2092,2094) OF .222 LB EACH.

LARGEST RESPONSE PER Z-LOAD Z-RESPONSE IS A 17 GRMS LOAD OF 26.728 GRMS AT GR 1613.

THE 1331482 BRACKET MOUNTS ABOVE THE 1331490 SHELF WITH 4 NAS1352NØ4LL6 #4 SCREWS. ATTACHED TO THE BRACKET ARE A 1331562 MIXER & VARIOUS OTHER HARDWARE. 4 GRIDS (1615,1619,1681,1685) ARE USED IN THE NASTRAN MODEL TO APPLY PT MASSES (CONM2 2096-2098) OF .237 LB EACH

LARGEST RESPONSE PER Z-LOAD Z-RESPONSE IS A 17 GRMS LOAD OF 19.09 GRMS AT GR 1681.

RESPONSE OF LARGE MASSES Q=7.1											
COMPONENT	GRID	LOAD DIRECTION	X-RESPONSE			Y-RESPONSE			Z-RESPONSE		
			RMS	GRMS	Q	RMS	GRMS	Q	RMS	GRMS	Q
	1681	X	4444	11.51295	1.1	1274	3.300518	0.3	2691	6.9715	0.7
		Y	751	1.945596	0.2	1162	3.010363	0.3	1162	3.01036	0.3
		Z	736	1.906736	0.2	1888	4.891192	0.5	7370	19.0933	1.9
	1685	X	4447	11.52073	1.1	1175	3.044041	0.3	2241	5.8057	0.6
		Y	750	1.943005	0.2	1080	2.797927	0.3	1080	2.79793	0.3
		Z	736	1.906736	0.2	1720	4.455959	0.4	7183	18.6088	1.8
	1615	X	4562	11.81865	1.2	1263	3.272021	0.3	2309	5.98187	0.6
		Y	897	2.323834	0.2	1805	4.676166	0.5	1805	4.67617	0.5
		Z	924	2.393782	0.2	1890	4.896373	0.5	6861	17.7746	1.8
	1619	X	4561	11.81606	1.2	1176	3.046632	0.3	2173	5.62953	0.6
		Y	897	2.323834	0.2	1424	3.689119	0.4	1424	3.68912	0.4
		Z	919	2.380829	0.2	1728	4.476684	0.4	5271	13.6554	1.4
	1679	X	4443	11.51036	1.1	1327	3.437824	0.3	3456	8.95337	0.9
		Y	751	1.945596	0.2	1818	4.709845	0.5	1818	4.70984	0.5
		Z	736	1.906736	0.2	1983	5.137306	0.5	8986	23.2798	2.3
	1683	X	4445	11.51554	1.1	1234	3.196891	0.3	2328	6.03109	0.6
		Y	750	1.943005	0.2	907	2.349741	0.2	907	2.34974	0.2
		Z	736	1.906736	0.2	1820	4.715026	0.5	6888	17.8446	1.8
	1613	X	4562	11.81865	1.2	1319	3.417098	0.3	2929	7.58808	0.8
		Y	897	2.323834	0.2	2475	6.411917	0.6	2475	6.41192	0.6
		Z	924	2.393782	0.2	1983	5.137306	0.5	10317	26.728	2.6
	1617	X	4562	11.81865	1.2	1226	3.176166	0.3	2097	5.43264	0.5
		Y	897	2.323834	0.2	1503	3.893782	0.4	1503	3.89378	0.4
		Z	923	2.391192	0.2	1825	4.727979	0.5	5326	13.7979	1.4

1331481 LOWER BRACKET MOUNTING BOLTS
STATISTICAL 3σ LOAD @ GR 1013

$$F_{01} = 3(26.728)(.222) = 17.8 \text{ LB}$$

PRELOAD

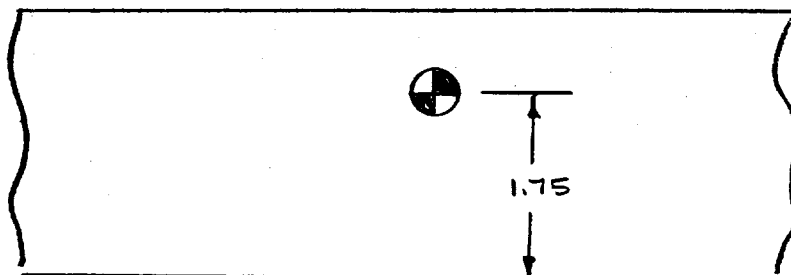
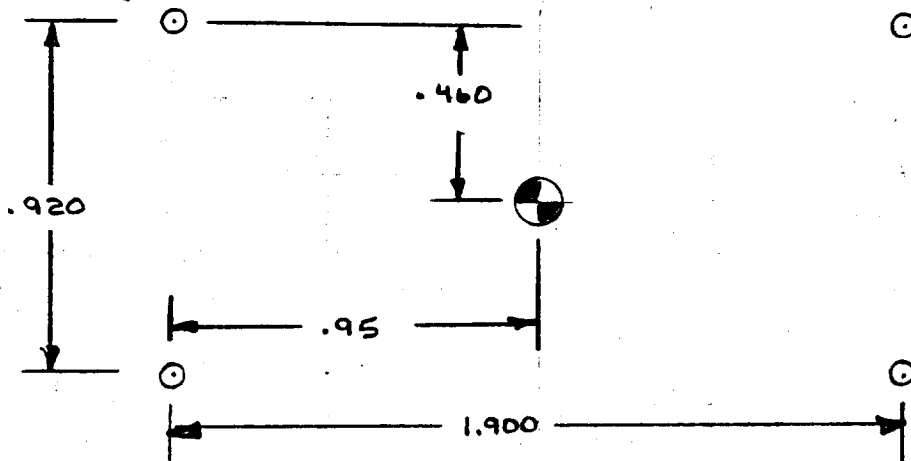
#4 SCREWS NAS1352N0444, REF 1356409

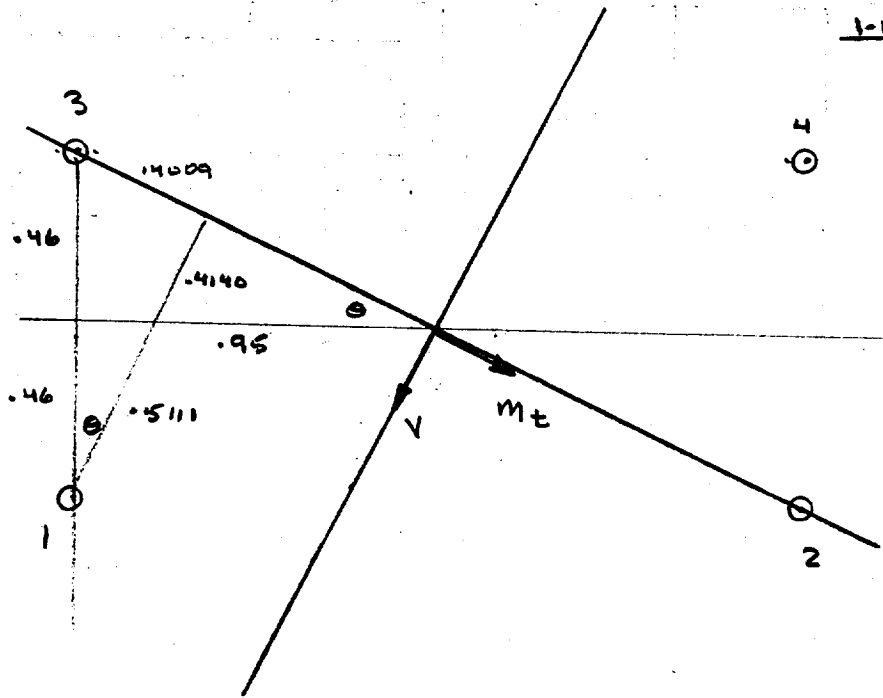
$$F_L = \frac{5.5}{(12)(.112)} = 246 \text{ LB}$$

OVERTURNING MOMENT

RANDOM VIBRATION "3σ" LOADS (Q=7.1) LARGEST RESPONSE (26.728 GRAMS @ 1T @ GR 1013) ARE APPLIED WITHOUT REGARD TO DIRECTION. A FORCE THROUGH THE ASSUMED MOUNTING BOLT CG IS USED TO FIND THE LARGEST POSSIBLE OVERTURNING MOMENT BOLT TENSILE LOAD.

ASSUMED IN-PLANE CG IS @ CENTER OF ATTACHMENT BOLT PATTERN, HEIGHT OF CG ASSUMED AT 1.75 INCHES.





$$\theta = \tan^{-1} \frac{.460}{.950} = 25.84^\circ$$

$$d_1 = .92 \cos \theta = .8280$$

$$d_2 = d_3 = 0$$

$$d_4 = d_1$$

$$\frac{d_4}{\sum d_i^2} = .6038$$

$$V = 4(.222)(3)(26.728) = 71.2 \text{ LB}$$

$$M_t = (1.75)V = 124.6 \text{ IN-LB}$$

TENSILE FORCE @ SCREW # 4

$$F_{t2} = \frac{M_t d_4}{\sum d_i^2} = \frac{(124.6)(.8280)}{(1.3711)} = 75.2 \text{ LB}$$

TOTAL TENSILE FORCE, F_b

$$F_b = F_L + F_S \frac{d_{2b}}{d_{2b} + d_{2m}} F_t$$

$$F_{t1} = F_{t1} + F_{t2} = 17.8 + 75.2 = 93.0 \text{ LB}$$

$$FS = 1.4$$

226 >> 22m ASSUMED

$$F_b = 246 + (1.4)(1.0)(93.0) = 376 \text{ LB}$$

FOR NAS1352 NØ4 SCREWS

$$F_{t4} = 966 \text{ LB}$$

$$MS = \frac{966}{376} - 1 = +1.6$$

∴ MOUNTING SCREWS OK @ 1331481 LOWER BKT.

1331482 UPPER BKT MOUNTING BOLTS

$$F_{t1} = 3(19.09)(.237) = 13.6 \text{ LB}$$

$$F_L = 246 \text{ LB} \quad \text{NAS1352NØ4LL6}$$

OVERTURNING MOMENT

WITH SAME BOLT PATTERN AS THE 1331481 LOWER BRACKET, ASSUME IN-PLANE CG IS @ CENTER OF ATTACHMENT BOLT PATTERN, BUT NOW, THE HEIGHT OF THE CG IS INCREASE TO A CONSERVATIVE 3.0 INCHES

$$V = 4(.237)(3)(19.09) = 54.3 \text{ LB}$$

$$M_t = (3.0)V = 162.9 \text{ IN-LB}$$

$$F_{t2} = \frac{(162.9)(.8280)}{(1.3711)} = 98.3 \text{ LB}$$

$$F_t = F_{t1} + F_{t2} = 13.6 + 98.3 = 111.9 \text{ LB}$$

$$F_b = 246 + (1.4)(1.0)(111.9) = 403 \text{ LB}$$

$$F_{tu} = 966 \text{ LB}$$

$$MS = \frac{966}{403} - 1 = +1.4$$

∴ MOUNTING SCREWS OK @ 1331482 UPPER BKT

4 1336610 MOUNT TO THE 1331440 UPPER SHELF, 3 ABOVE THE 6 SHELF AND 1 BELOW. ALL USE 4 NAS1352NØ4 LLL #4 SCREWS. 4 GRID PTS ARE USED PER DRD TO APPLY PT MASS.

DRD	GRIDS	CONM2	UNIT WTS
-3	1723, 1728, 1779, 1784	2084-2087	.3966 LB
-4	1724, 1729, 1780, 1785	2072-2075	.3966
-5	1500, 1501, 1577, 1582	2088-2091	.3966
-8	1793, 1798, 1831, 1836	2080-2083	.3966

LARGEST RESPONSE PER Z LOAD Z RESPONSE IS A 17 GRMS LOAD OF 22.10 GRMS AT GR 1724.

STATISTICAL 3σ LOAD @ GR 1724

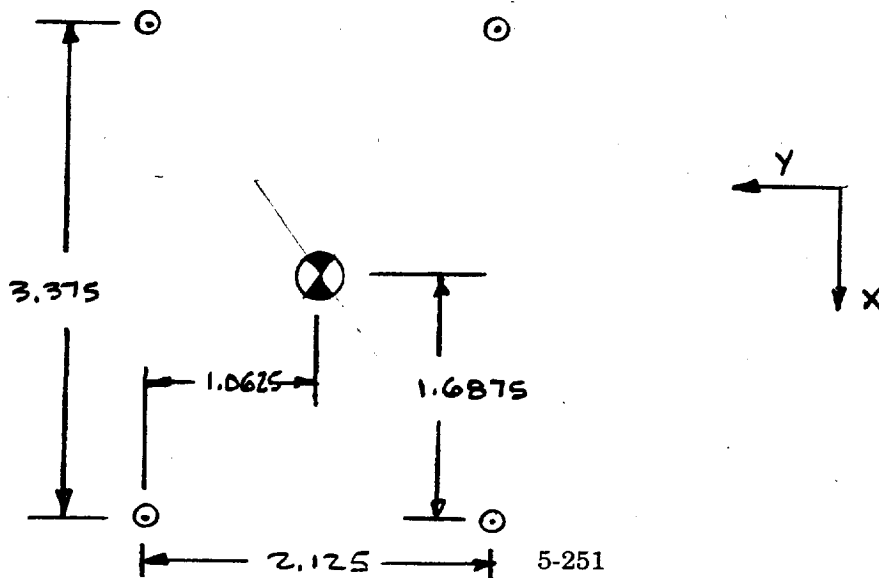
$$F_{E1} = 3(22.10)(.3966) = 26.3 \text{ LB}$$

PRELOAD

$$F_i = 246 \text{ LB} \quad \#4 \text{ SCREW}$$

OVERTURNING MOMENT

USING "3σ" LOAD FROM RANDOM VIB, Q=7.1, THE LARGEST RESPONSE (22.10 GRMS @ 1σ @ GR 1724) IS APPLIED WITHOUT REGARD TO DIRECTION, AS A FORCE THROUGH THE ASSUMED CG TO DEVELOP THE LARGEST POSSIBLE OVERTURNING MOMENT BOLT TENSILE LOAD.



COMPONENT	GRID	LOAD DIRECTION	RESPONSE OF LARGE MASSES Q=7.1								
			X-RESPONSE			Y-RESPONSE			Z-RESPONSE		
			RMS	GRMS	Q	RMS	GRMS	Q	RMS	GRMS	Q
1831		X	4012	10.39378	1.0	1138	2.948187	0.3	1479	3.83161	0.4
		Y	1131	2.930052	0.3	1192	3.088083	0.3	1192	3.08808	0.3
		Z	1459	3.779793	0.4	1652	4.279793	0.4	5008	12.9741	1.3
1836		X	4004	10.37306	1.0	1093	2.831606	0.3	777	2.01295	0.2
		Y	1137	2.945596	0.3	1307	3.38601	0.3	1307	3.38601	0.3
		Z	1454	3.766839	0.4	1498	3.880829	0.4	4848	12.5596	1.2
1793		X	4166	10.79275	1.1	1139	2.950777	0.3	2116	5.48187	0.5
		Y	869	2.251295	0.2	1687	4.370466	0.4	1687	4.37047	0.4
		Z	1050	2.720207	0.3	1653	4.282383	0.4	6387	16.5466	1.6
1798		X	4159	10.77461	1.1	1093	2.831606	0.3	1207	3.12694	0.3
		Y	868	2.248705	0.2	1110	2.875648	0.3	1110	2.87565	0.3
		Z	1049	2.717617	0.3	1499	3.88342	0.4	5108	13.2332	1.3
1779		X	4196	10.87047	1.1	1139	2.950777	0.3	2095	5.42746	0.5
		Y	829	2.147668	0.2	1700	4.404145	0.4	1700	4.40415	0.4
		Z	980	2.53886	0.3	1654	4.284974	0.4	6551	16.9715	1.7
1784		X	4191	10.85751	1.1	1093	2.831606	0.3	1313	3.40155	0.3
		Y	828	2.145078	0.2	1057	2.738342	0.3	1057	2.73834	0.3
		Z	980	2.53886	0.3	1499	3.88342	0.4	5100	13.2124	1.3
1723		X	4363	11.30311	1.1	1142	2.958549	0.3	2420	6.26943	0.6
		Y	722	1.870466	0.2	1328	3.440415	0.3	1328	3.44041	0.3
		Z	735	1.904145	0.2	1661	4.303109	0.4	8147	21.1062	2.1
1728		X	4378	11.34197	1.1	1092	2.829016	0.3	2724	7.05699	0.7
		Y	727	1.88342	0.2	1072	2.777202	0.3	1072	2.7772	0.3
		Z	727	1.88342	0.2	1499	3.88342	0.4	6558	16.9896	1.7

COMPONENT	GRID	LOAD DIRECTION	RESPONSE OF LARGE MASSES Q=7.1								
			X-RESPONSE			Y-RESPONSE			Z-RESPONSE		
			RMS	GRMS	Q	RMS	GRMS	Q	RMS	GRMS	Q
1577		X	4633	12.00259	1.2	1152	2.984456	0.3	2436	6.31088	0.6
		Y	1064	2.756477	0.3	1914	4.958549	0.5	1914	4.95855	0.5
		Z	1150	2.979275	0.3	1673	4.334197	0.4	5613	14.5415	1.4
1582		X	4621	11.9715	1.2	1082	2.803109	0.3	2180	5.64767	0.6
		Y	1073	2.779793	0.3	2500	6.476684	0.6	2500	6.47668	0.6
		Z	1132	2.932642	0.3	1520	3.937824	0.4	8141	21.0907	2.1
1500		X	4744	12.29016	1.2	1154	2.989637	0.3	2100	5.44041	0.5
		Y	1363	3.531088	0.3	2251	5.831606	0.6	2251	5.83161	0.6
		Z	1595	4.132124	0.4	1675	4.339378	0.4	4813	12.4689	1.2
1501		X	4751	12.30829	1.2	1082	2.803109	0.3	1582	4.09845	0.4
		Y	1374	3.59585	0.4	2186	5.663212	0.6	2186	5.66321	0.6
		Z	1620	4.196891	0.4	1520	3.937824	0.4	4667	12.0907	1.2
1724		X	4365	11.30829	1.1	1113	2.88342	0.3	2562	6.63731	0.7
		Y	722	1.870466	0.2	1512	3.917098	0.4	1512	3.9171	0.4
		Z	734	1.901554	0.2	1610	4.170984	0.4	8530	22.0984	2.2
1729		X	4379	11.34456	1.1	1129	2.92487	0.3	2003	5.18912	0.5
		Y	729	1.888601	0.2	710	1.839378	0.2	710	1.83938	0.2
		Z	726	1.880829	0.2	1522	3.943005	0.4	4922	12.7513	1.3
1785		X	4191	10.85751	1.1	1128	2.92228	0.3	927	2.40155	0.2
		Y	829	2.147668	0.2	811	2.101036	0.2	811	2.10104	0.2
		Z	983	2.546632	0.3	1520	3.937824	0.4	4604	11.9275	1.2
1780		X	4195	10.86788	1.1	1104	2.860104	0.3	1104	2.8601	0.3
		Y	829	2.147668	0.2	1701	4.406736	0.4	1701	4.40674	0.4
		Z	979	2.536269	0.3	1595	4.132124	0.4	6540	16.943	1.7

ASSUME IN-PLANE CG @ CENTER OF ATTACHMENT
BOLT PATTERN. HEIGHT OF CG ASSUMED AT 1.5 IN.

PER 1336610 EVALUATION OF LOWER SHELF

$$\frac{d_1}{\sum d_i^2} = .2780$$

$$V = 4(.3966)(3)(22.10) = 105.2 \text{ LB}$$

$$M_t = (1.5)(V) = 157.8 \text{ IN-LB}$$

TENSILE FORCE @ SCREW

$$F_{t2} = \frac{M_t d_3}{\sum d_i^2} = (157.8)(.2780) = 43.9 \text{ LB}$$

$$F_t = F_{t1} + F_{t2} = 26.3 + 43.9 = 70.2 \text{ LB}$$

TOTAL TENSILE LOAD

$$F_b = F_c + F_s \frac{J_{kb}}{J_{kb} + J_{km}} F_t$$

$$= 246 + (1.4)(1.0)(70.2) = 344 \text{ LB}$$

FOR NAS1352NØ4LL6 SCREW

$$F_{t4} = 966 \text{ LB}$$

$$MS = \frac{966}{344} - 1 = +1.8$$

∴ ALL 1331610 OSCILLATOR MOUNTING BOLTS
ARE ADEQUATE IN TENSION.

5.4.5 Lower Baseplate Stresses per Random Vibration Loads

The following pages contain a detailed analysis of lower baseplate stresses per random vibration loads.

TABLE 59 A1-EOS 1356405 LOWER BASEPLATE STRESSES - RANDOM VIBRATION LOADS							
STRESS CATEGORY	LOAD CASE	LOCATION	MATERIAL	3s STRESS PSI	F _{ty} /F _{tu} PSI	FS	MARGIN OF SAFETY
STRESSES UNDER LOWER CARD CAGE	RANDOM Z	EL 289	6061-T6	5755	35000	1.25	3.87
				5755	42000	1.4	4.21
STRESS CATEGORY	LOAD CASE	LOCATION	MATERIAL	3s STRESS PSI	F _{ty} /F _{tu} PSI	FS	MARGIN OF SAFETY
STRESSES UNDER PANEL ATTACHMENTS	RANDOM Y	LOWER FRONT PANEL	6061-T6	18594	35000	1.25	0.51
				18594	42000	1.4	0.61
	RANDOM Y	LOWER AFT PANEL	6061-T6	25654	35000	1.25	0.09
				25654	42000	1.4	0.17
	RANDOM Y	LOWER RIGHT PANEL	6061-T6	8737	35000	1.25	2.20
				8737	42000	1.4	2.43
STRESS CATEGORY	LOAD CASE	LOCATION	MATERIAL	3s STRESS PSI	F _{su} PSI	FS	MARGIN OF SAFETY
SHEAR STRESS IN LEFT PANEL FLANGE GROOVE	RANDOM Y	EL 3256	6061-T6	1023	27000	1.4	17.85

LOWER BASEPLATE (1356405)

5.4.5.1 STRESSES IN THIN SHELL ELEMENTS UNDER CARD CAGE

PER RANDOM VIBRATION (9.97 GRMS) $w/Q = 7.1$

REF NASTRAN MODEL

- 1) LOWER BASEPLATE GRIDS
- 2) LOWER CARD CAGE BASE GRIDS
- 3) LOWER BASEPLATE ENLARGEMENT
w/ LOWER CARD CAGE SILHOUETTE
w/ BASEPLATE GRIDS & SHELLS

METHOD - EVALUATE STRESSES AT SHELLS IN THE
BASEPLATE BELOW THE LOWER CARD CAGE
FOOTPRINT FOR 3 UNIDIRECTIONAL
RANDOM VIBRATION CASES, X, Y, Z.

GRIDS CONNECTING LOWER BASEPLATE & CARD CAGE

GR 2928-2933
GR 119, 140, 161, 182, 203, 224
GR 114, 135, 156, 177, 198, 219

ELEMENT ON BASEPLATE EVALUATED

CQUAD4/	259-271
TRIA3	277-289
ELEMENTS	295-307
	313-325
	331-343
	349-361
	363-375
	3968-3974

REF 3 SPREAD SHEETS FOR X-LOAD, Y-LOAD,
Z-LOAD, RESPECTIVELY. MOST SEVERE CASE
AND CONDITION

Z-LOAD

ELEMENT 289

3T STRESS 5755 PSL

MATERIAL 6061-T6

$F_{ty} = 35000 \text{ PSL}$

$F_{tu} = 42000 \text{ PSL}$

1-8-96

FACTORS OF SAFETY

1.25 YIELD
1.4 ULTIMATE

MARGINS OF SAFETY

YIELD

$$MS = \frac{35000}{1.25 \times 5755} - 1 = + 3.8$$

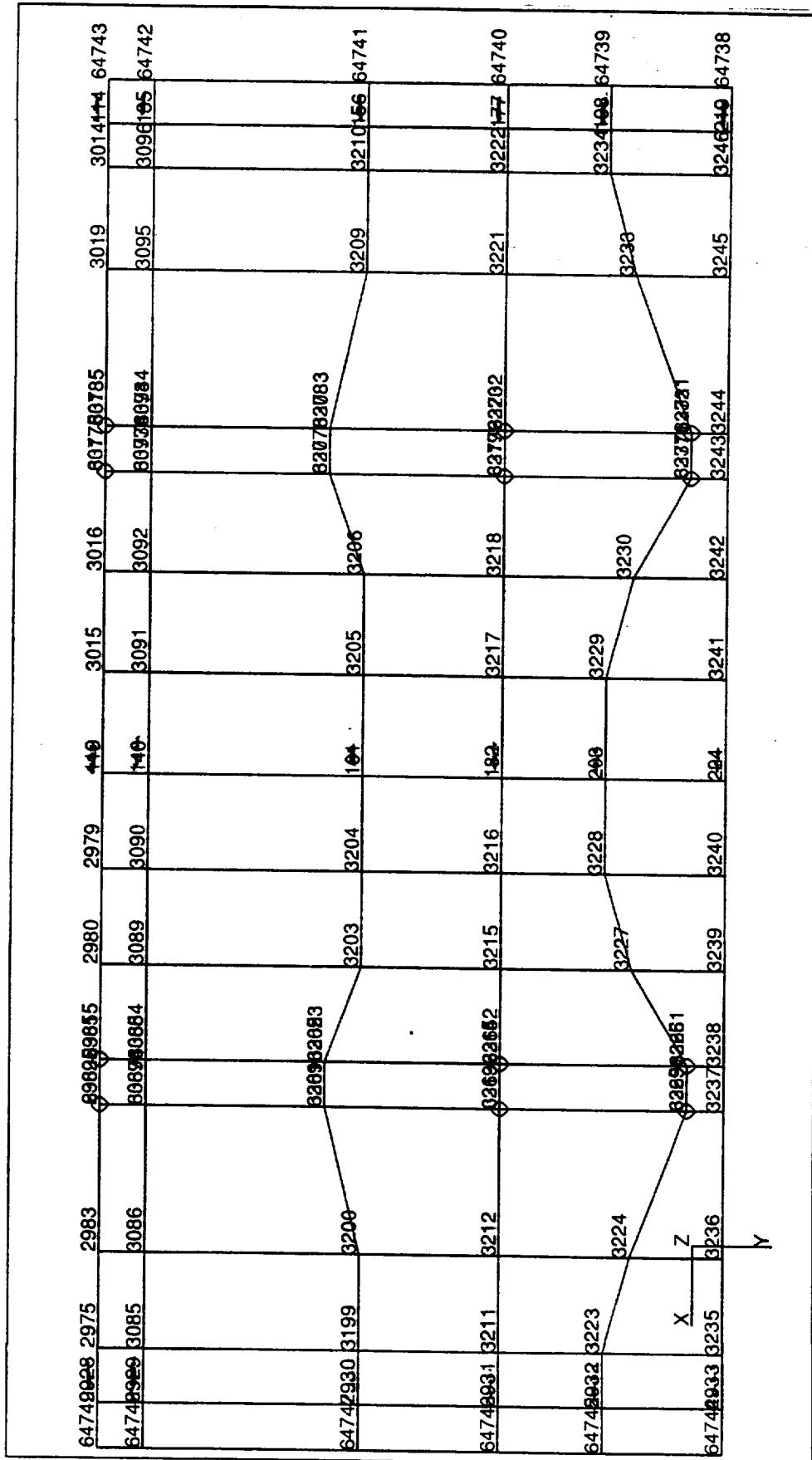
ULTIMATE

$$MS = \frac{42000}{1.4 \times 5755} - 1 = + 4.2$$

∴ MAGNITUDES OF STRESSES IN THIN SHELLS OF LOWER BASEPLATE UNDER THE CARD CAGE ARE ACCEPTABLE FOR RANDOM VIBRATION "3σ" STRESSES

BOTTOM PLATE OF LOWER CARD CASE
GRIDS

GRIDS ON LOWER EP



LOWER SP CARBONS

1-4-96

21 2019	18 17	16	15	14	13	12	11	10	9	8	7 6	5	4	3	2	1
82 4140	69 38	67	36 65	64	63	33	32	31 30	29	28 7	27	26	25	24	23	22
63 6261	60 59	58	57 56	55	54	53	52 51	50	49 18	48	47	46	45	44	43	
84 8382	81 80	79	78 77	76	75	74	73 72	71	70 69	68	67	66	65	64	63	
105 10403	102 101	100	99 98	97	96	95	94 93	92	91 90	89	88	87	86	85	84	
126 1252	123 122	121	120 119	118	117	116	115 114	113	112 111	110	109	108	107	106	105	
146 452	144 143	142	141 140	139	138	137	136 135	134	133 132	131	130	129	128	127	126	
147																
168 1676	165 164	163	162 161	160	159	158	157 156	155	154 153	152	151	150	149	148	147	
189	188 185	184	183 182	181	180	179	178 177	176	175 174	173	172	171	170	169	168	
210 208	207 206	205	204 203	202	201	200	199 198	197	196 195	194	193	192	191	190	189	
231 230	228 227	226	225 224	223	222	221	220 219	218	217 216	215	214	213	212	211	210	
252 251	249 248	247	246 245	244	243	242	241 240	239	238 237	236	235	234	233	232	231	
275 273	272 271	270	269 268	267	266	265	264 263	262	261 260	259	258	257	256	255	254	

LOWER BP GRIDS
SQUAD
SERIES



LOWER CC

105	104103	102	101	100	99	98	97	96	95	94	93	92	
	271 3968	270	269	268	267	266	265	264	263	262	261	260	259
126	125124 2928	123	122	121	120	119	118	117	116	115	114	113	
	289 3969	288	287	285	284	283	282	281	280	279	278	277	
	146 145	144	143	142	141	140	139	138	137	136	135	134	277
147	3073970	306	305	304	303	302	301	300	299	298	297	296	295
168	167166	165	164	163	162	161	160	159	158	157	156	155	
	3253971	324	323	322	321	320	319	318	317	316	315	314	313
189	188187	186	185	184	183	182	181	180	179	178	177	176	
	3433972	342	341	340	339	338	337	336	335	334	333	332	331
210	209208	207	206	205	204	203	202	201	200	199	198	197	
	3613973	360	359	358	357	356	355	354	353	352	351	350	349
231	230229	228	227	226	225	224	223	222	221	220	219	218	217
	251230	249	248	247	246	245	244	243	242	241	240	239	238
252	251230	249	248	247	246	245	244	243	242	241	240	239	238
275	274273	272	271	270	269	268	267	266	265	264	263	262	

LOWER BASEPLATE GRID

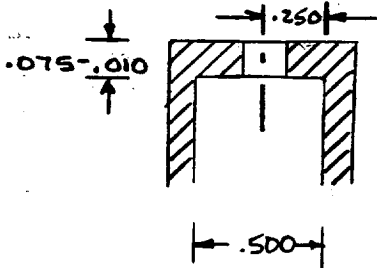
LOWER CARD CARDS
FOOTPRINT SILHOUETTE

TEMPZ

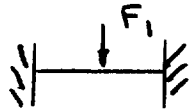
LOWER BASEPLATE SHELL ELEMENTS RANDOM VIBRATION RMS STRESSES Q=7.1			
Z - LOAD			
ELEMENT	1 SIGMA COMPONENT RMS STRESS (PSI)	3 SIGMA PRINCIPAL RMS STRESS (PSI)	1ST MODE FREQUENCY (HZ)
285(3)	156	963	403
285(5)	314		666
285(7)	33		436
285(10)	82	905	675
285(12)	295		672
285(14)	37		415
286(3)	106	855	533
286(5)	254		678
286(7)	75		344
286(10)	109	726	496
286(12)	236		673
286(14)	29		725
287(3)	43	327	638
287(5)	70		528
287(7)	51		308
287(10)	157	489	228
287(12)	59		432
287(14)	24		615
288(3)	389	1172	167
288(5)	234		179
288(7)	19		455
288(10)	153	561	219
288(12)	57		389
288(14)	66		302
289(3)	1901	5755	221
289(5)	766		243
289(7)	143		254
289(10)	1783	5353	221
289(12)	846		215
289(14)	40		518
295(3)	40	244	319
295(5)	56		247
295(7)	32		263
295(10)	17	146	505
295(12)	43		208
295(14)	13		406

LOWER BASEPLATE - LOCALIZED STRESSES UNDER
PANEL ATTACHMENTS

EVALUATED ARE THE THIN SECTIONS UNDER THE ATTACHMENTS OF THE LOWER FRONT, LOWER AFT, AND LOWER RIGHT PANELS, WHOSE CROSS SECTIONS ARE AS FOLLOWS.

LOWER FRONT PANEL ATTACHMENT TO LOWER BASEPLATE

CONSIDER TOP SECTION AS A FIXED END BEAM W/ CENTER LOAD.



PER FLANGE BENDING ANALYSIS OF THE LOWER FRONT PANEL LOWER FLANGE PER RANDOM VIBRATION, $Q=7.1$ THE MAXIMUM FORCE IN LBS/IN WAS DETERMINED FROM RANDOM Y LOAD AS

$$F_1 = 69.83 \text{ LB/IN} \quad \begin{array}{l} \text{"1"} \\ \text{"3"} \end{array} \text{ LOAD}$$

$$= 209.5 \text{ LB/IN} \quad \text{"3"} \text{ LOAD}$$

MAXIMUM BENDING MOMENT IS

$$M = \frac{F_1 l}{8} \quad \text{② ENDS OF BEAM \& AT CENTER}$$

$$= \frac{(209.5)(.500)}{8} = 13.09 \text{ IN-LB/IN}$$

BENDING STRESS IN BEAM

$$\sigma = \frac{6M}{t^2} = \frac{6(13.09)}{(0.075-.010)^2} = 18594 \text{ PSI}$$

APPLY $FS = 1.25$ YIELD, 1.4 ULTIMATE
ALLOWABLE, 6061-T6 ALUMINUM

$$F_{TY} = 35000 \text{ PSI}$$

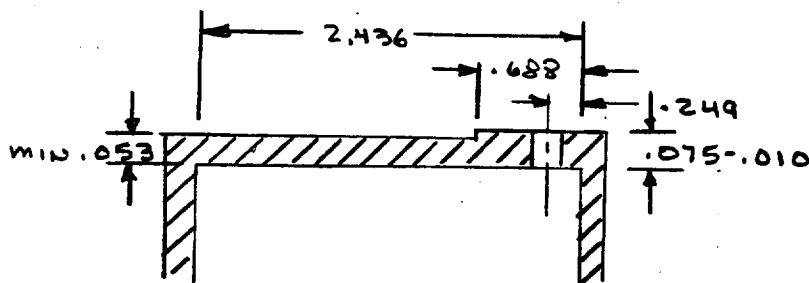
$$F_{TU} = 42000 \text{ PSI}$$

$$MS = \frac{35000}{1.25(18594)} - 1 = +.51$$

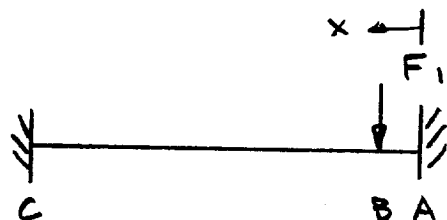
$$MS = \frac{42000}{1.4(18594)} - 1 = +.61$$

∴ LOWER BASEPLATE "U-BEAM CAP" OK
UNDER LOWER FRONT PANEL

LOWER AFT PANEL ATTACHMENT TO LOWER BASEPLATE



CONSIDER TOP SECTION AS A FIXED END BEAM
WITH OFFSET LOAD.



PER FLANGE BENDING ANALYSIS OF THE LOWER AFT
PANEL LOWER FLANGE PER RANDOM VIBRATION, $Q = 7.1$,
THE MAXIMUM FORCE IN LB/IN WAS DETERMINED
FROM RANDOM Y LOAD AS

$$F_1 = 238.8 \text{ LB/IN}$$

$$= 716.4 \text{ LB/IN}$$

"15" LOAD
"35" LOAD

MAXIMUM BENDING MOMENT IS FOUND FROM

Report 10381
Addendum 1

$$R_A = \frac{F_1 b^2}{L^3} (3a+b) = .97079 F_1 = 695.5 \text{ LB/IN}$$

$$R_B = \frac{F_1 a^2}{L^3} (3b+a) = .02921 F_1 = 20.9 \text{ LB/IN}$$

$$a = .249$$

$$b = 2.187$$

$$L = 2.436$$

$$M = -\frac{F_1 ab^2}{L^2} + R_A x \quad \text{A to B}$$

$$= -\frac{F_1 ab^2}{L^2} + R_A x - F_1 (x-a) \quad \text{B to C}$$

MAXIMUM M @ END A (X=0)

$$M = -143.78 \text{ IN-LBS/IN}$$

BENDING STRESS (@ X=0)

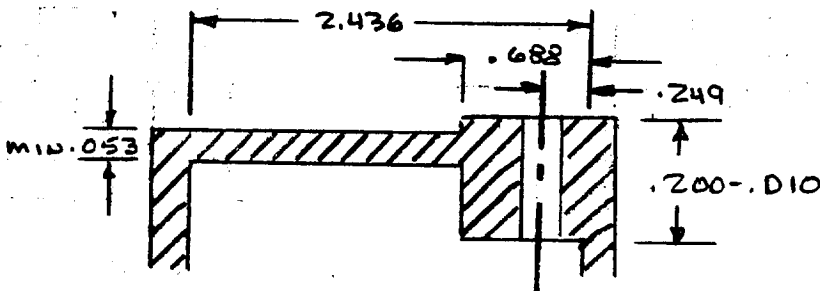
$$\sigma = \frac{6M}{t^2} = \frac{6(143.78)}{(0.075 \cdot 0.010)^2} = 204184 \text{ PSI}$$

YIELD MS

$$MS = \frac{35000}{1.25 \times 204184} - 1 = -.86$$

∴ CONSIDERABLY OVERSTRESSED

MODIFY THICKNESS TO $t = .200 - .010$ FOR .688 IN



BENDING STRESS $w/t = .200 - .010$ @ END A

$$\sigma = \frac{6M}{t^2} = \frac{6(143.78)}{(.200 - .010)^2} = 23897 \text{ PSI}$$

$$MS = \frac{35000}{1.25 \times 23897} - 1 = +.17$$

$$MS = \frac{42000}{1.4 \times 23897} - 1 = +.26$$

PRELIMINARY INDICATIONS SHOW ACCEPTABLE REDESIGN WITH $t = .200 - .010$ BELOW PANEL ATTACHMENT.

A FINITE ELEMENT MODEL IS CONSTRUCTED TO VERIFY THE HAND CALCULATED RESULTS

A 2.436 INCH WIDE PLATE (OF ARBITRARY LENGTH) IS CONSTRUCTED WITH ALL ENDS FIXED.

MODEL 1 IS A CONSTANT $t = .065$ LOADED .249 IN FROM END BY A 716.4 LB/IN VERTICAL LOAD. RESULT SHOULD AGREE WITH ORIGINAL HAND CALC.

MODEL	MAX MAJOR STRESS	MAX VON MISES STRESS
1	201999 PSI	178275 PSI

201999 PSI ~ HAND CALC 204184 PSI (1% ERROR)

MODEL 2 CONSIDERS THE RECESS TO $t = .053$ IN IN THE UPPER HALF OF THE MODEL FROM $x = .688$ TO 2.436 (SURFACE 1). RESULTS WITH SAME LOAD

MODEL	MAX MAJOR STRESS	MAX VON MISES STRESS
2	206879 PSI	182582 PSI

MODEL 3, THE REDESIGN, CONSIDERS THE $t = .053$ RECESS IN SURFACE 1 AND RAISES THE THICKNESS TO $t = .190$ FROM $x = 0$ TO $.688$. (SURFACES 2, 3, 5, 6) RESULTS WITH SAME LOAD.

MODEL	MAX MADE STRESS	MAX VON MISES STRESS
3	28781 psl	25400 psl

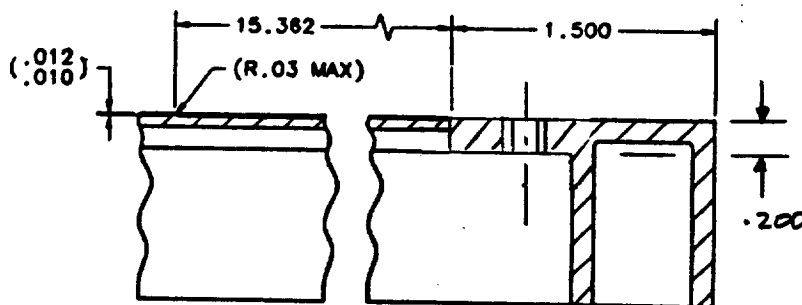
ADJUST MAX VON MISES STRESS BY 1% AND APPLY FACTORS OF SAFETY

$$\sigma = (1.01)(25400) = 25654 \text{ psl}$$

$$MS = \frac{35000}{1.25 \times 25654} - 1 = +.09$$

$$MS = \frac{42000}{1.4 \times 25654} - 1 = +.17$$

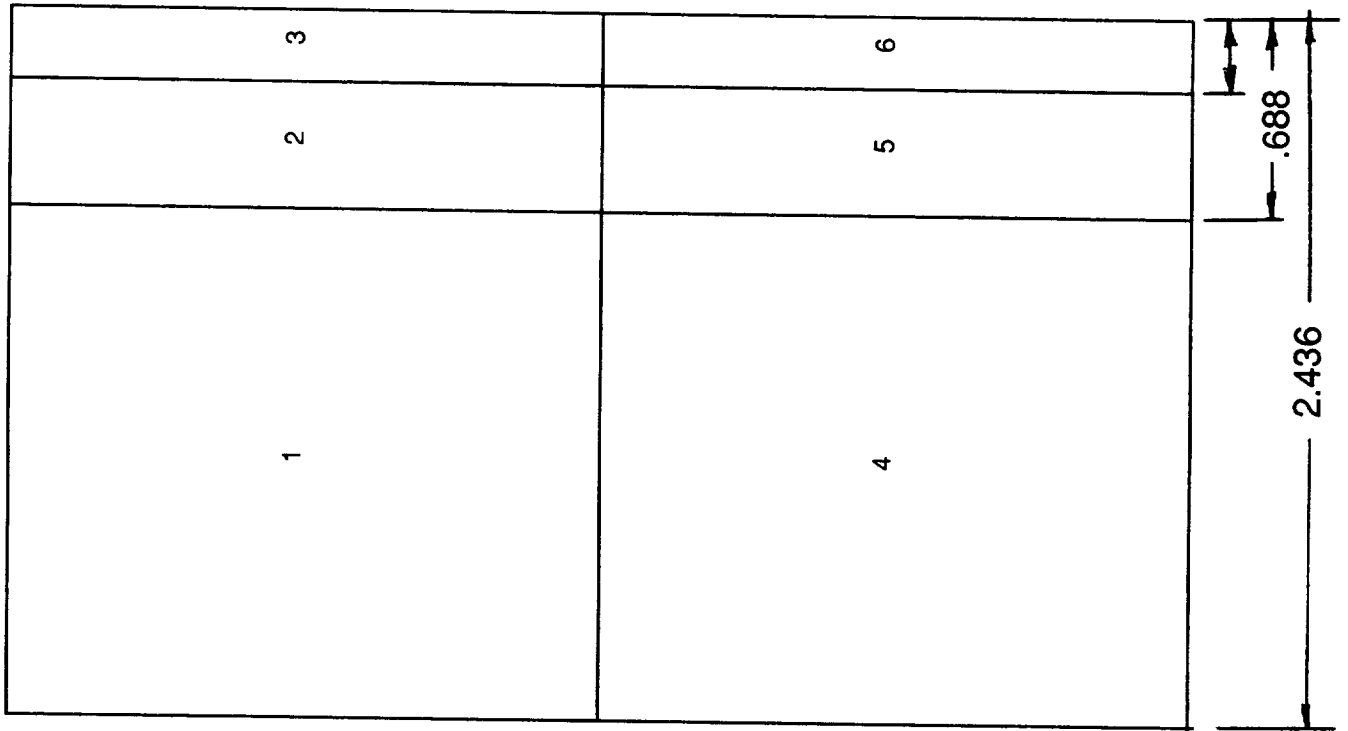
∴ INCREASING t TO $.200 - .010$ BELOW LOWER AFT PANEL SOLVES STRESS PROBLEM.



SECTION B-B 12
SCALE: 2/1

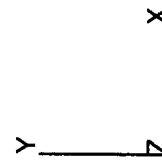
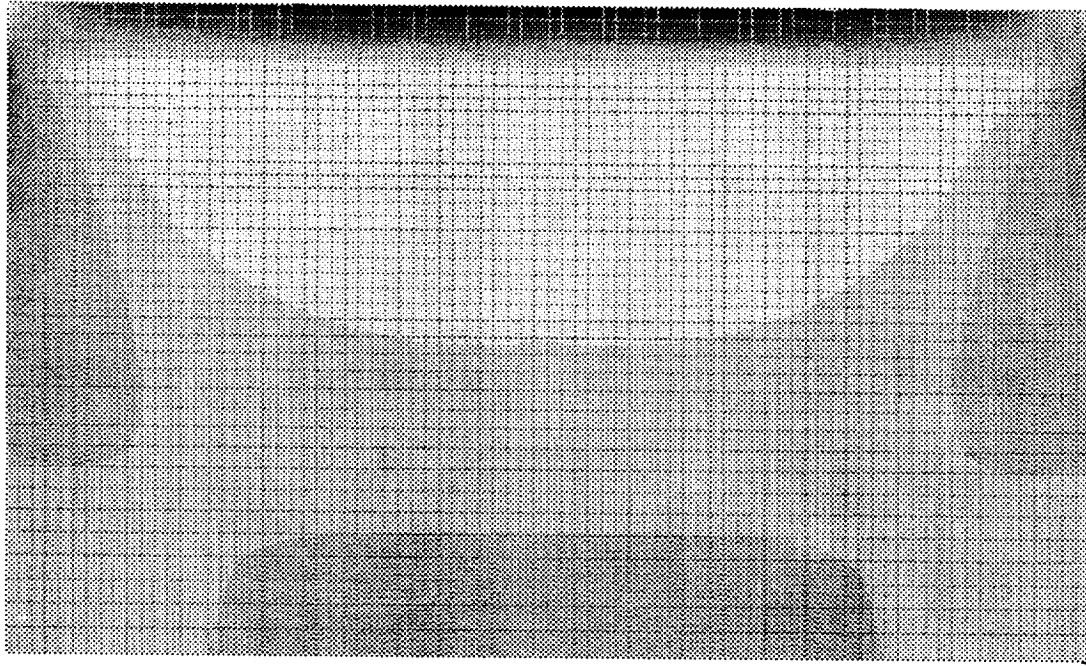
REVISED LOWER BASEPLATE

Lower Baseplate @ Lower Aft Panel



Thickness	Surface
.053	1
.065	4
.190	2, 3, 5, 6

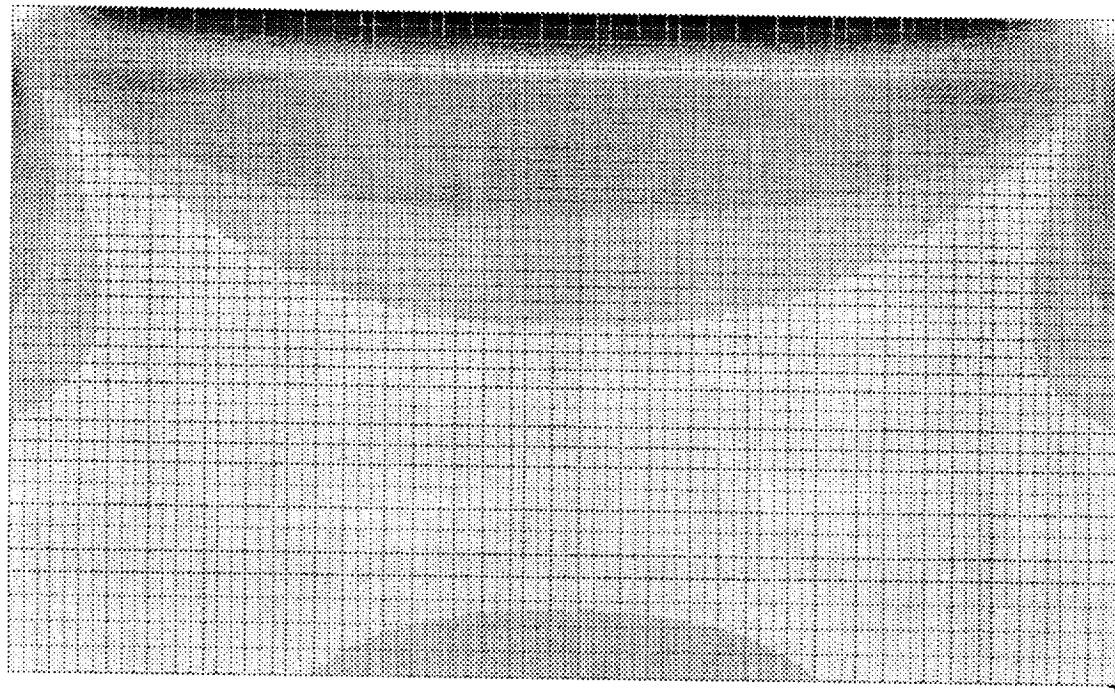
FRINGE PLOT LC=1.7 RES=2.1(MAJOR) MSC/PATRAN R-1.4 P3/FEA 11-Jan-96 14:52:10



201999.
187047.
172095.
157144.
142192.
127240.
112288.
97336.
82385.
67433.
52481.
37529.
22578.
7626.
-7326.
-22278.

major prin stress - top surf
t=.065 constant

FRINGE PLOT LC=1.14 RES=2.1(VON-MISES) MSC/PATRAN R-1.4 P3/FEA 12-Jan-96 11:09:54

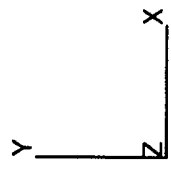
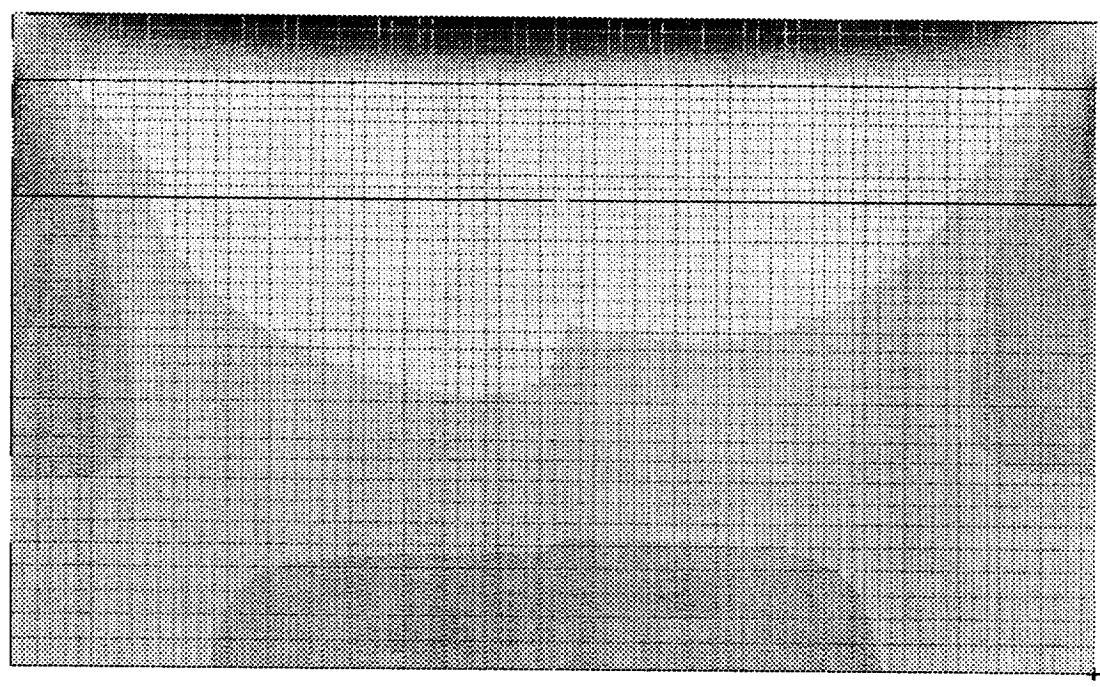


von Mises stress - top surf

t=.065

178275.
166391.
154507.
142623.
130739.
118855.
106971.
95087.
83203.
71319.
59435.
47551.
35667.
23783.
11899.
15.28

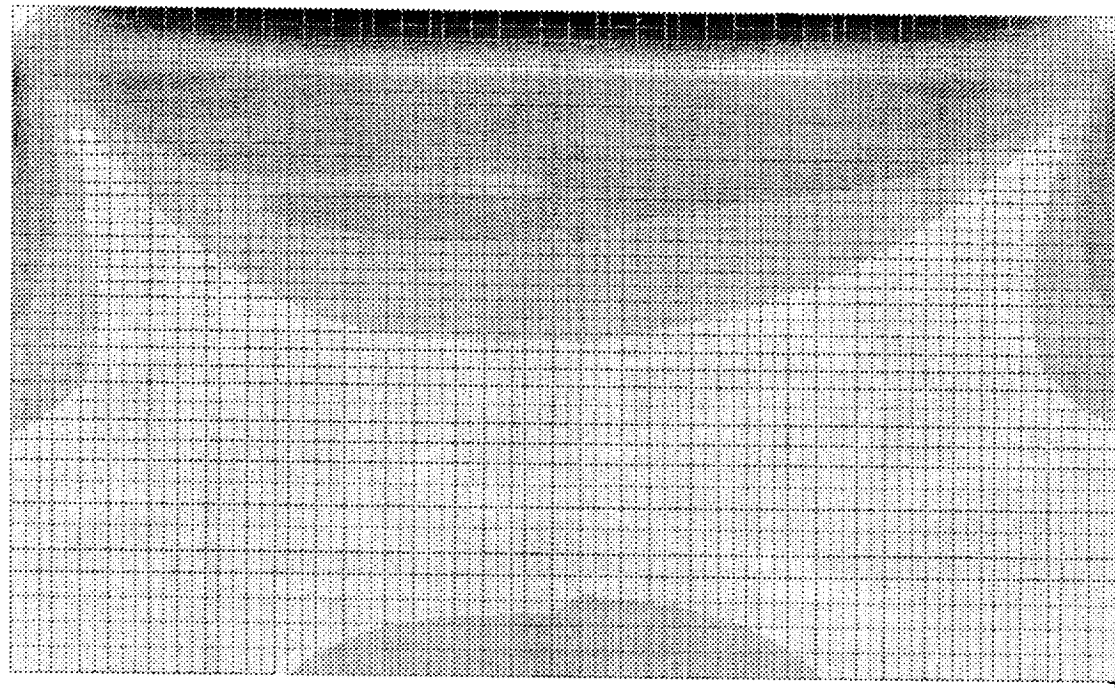
FRINGE PLOT LC=1.6 RES=2.1(MAJOR) MSC/PATRAN R-1.4 P3/FEA 11-Jan-96 14:48:18



206879.
191609.
176339.
161069.
145799.
130529.
115258.
99988.
84718.
69448.
54178.
38908.
23638.
8368.
-6903.
-22173.

major prin stress - top surf
t=.065 with .053 recess

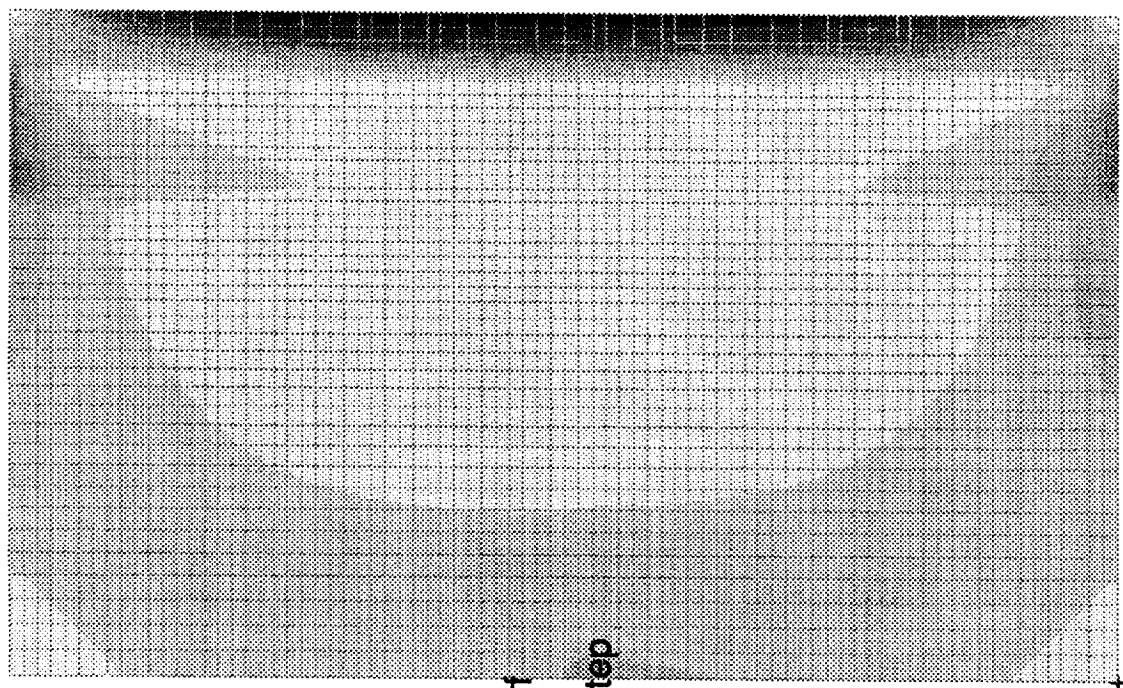
FRINGE PLOT LC=1.13 RES=2.1(VON-MISES) MSC/PATRAN R-1.4 P3/FEA 12-Jan-96 11:08:49



von Mises stress - top surf
t=.065 w/ .053 recess

182582.
170411.
158240.
146069.
133898.
121726.
109555.
97384.
85213.
73042.
60871.
48700.
36529.
24358.
12187.
15.45

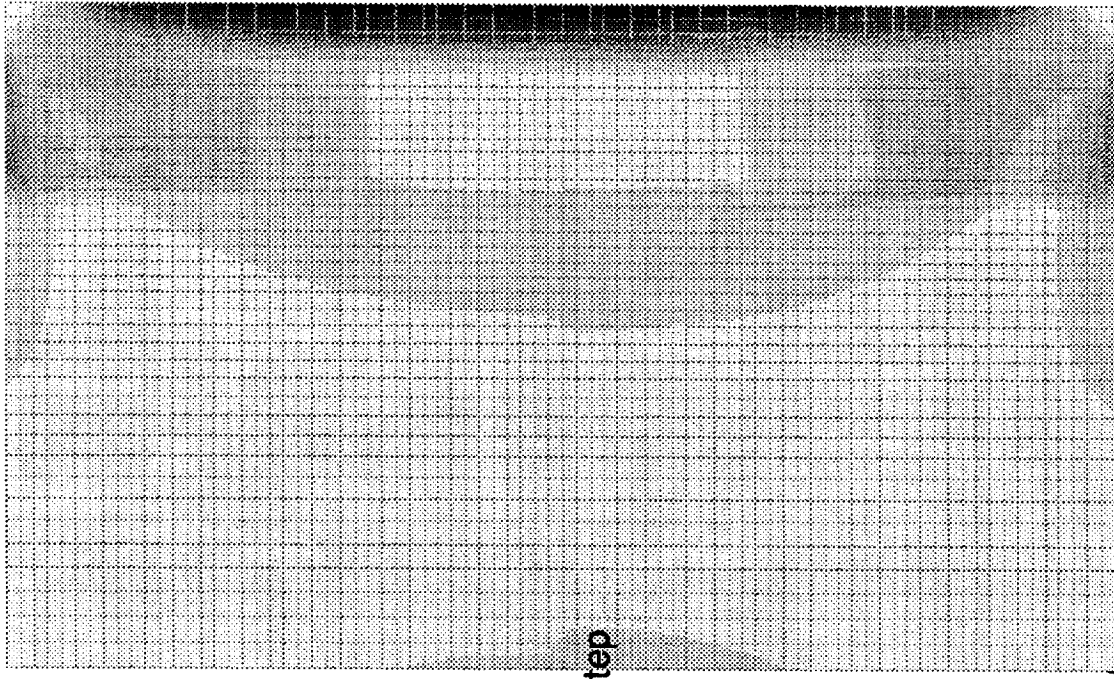
FRINGE PLOT LC=1.12 RES=2.1(MAJOR) MSC/PATRAN R-1.4 P3/FEA 12-Jan-96 10:56:03



major principal stress - top surf
t=.065 w/ .053 recess & .190 step

28781.
26741.
24702.
22662.
20623.
18583.
16544.
14504.
12464.
10425.
8385.
6346.
4306.
2267.
227.4
-1812.

FRINGE PLOT LC=1.12 RES=2.1(VON-MISES) MSC/PATRAN R-1.4 P3/FEA 12-Jan-96 10:54:57



von Mises stress - top surf

t=.065 w/ .053 recess & .190 step

25400.

23707.

22014.

20321.

18627.

16934.

15241.

13548.

11855.

10161.

8468.

6775.

5082.

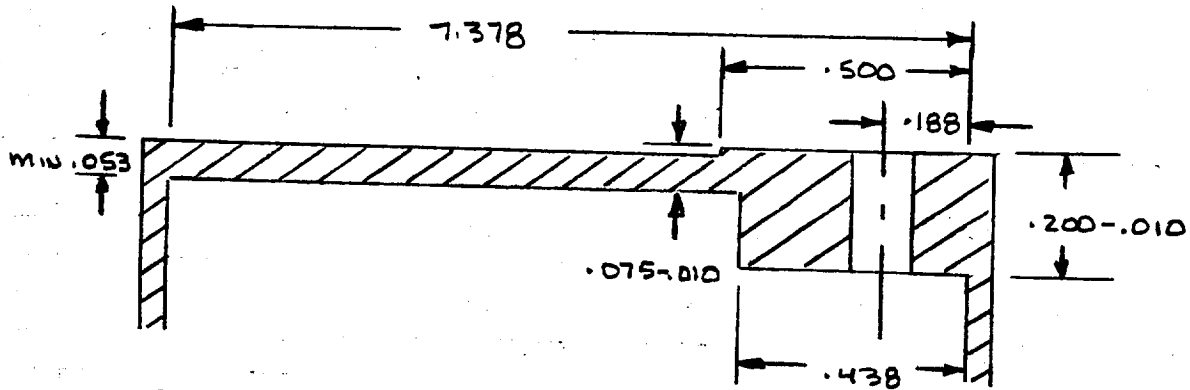
3388.

1695.

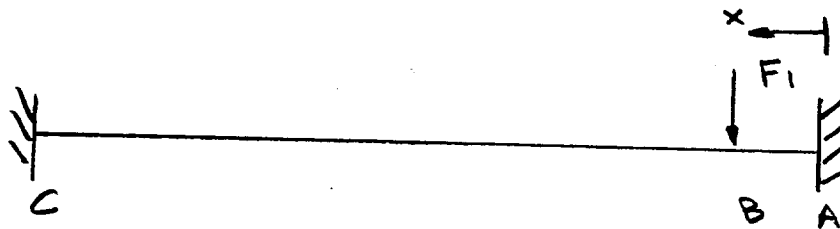
1.867

LOWER RIGHT PANEL ATTACHMENT TO LOWER BASEPLATE

THIS CROSS SECTION IS SIMILAR TO THE REVISED DESIGN UNDER THE LOWER AFT PANEL, AT THE LOWER RIGHT PANEL



CONSIDER TOP SECTION AS A FIXED END BEAM WITH OFFSET LOAD



PER FLANGE BENDING ANALYSIS OF THE LOWER RIGHT PANEL LOWER FLANGE PER RANDOM VIBRATION, $Q = 7.1$, THE MAXIMUM FORCE IN LB/IN WAS DETERMINED FROM RANDOM Y LOAD AS.

$$F_1 = 105.9 \text{ LB/IN} \quad \text{"1G" LOAD}$$

$$= 317.6 \text{ LB/IN} \quad \text{"3G" LOAD}$$

MAXIMUM M

$$R_A = \frac{F_1 b^2}{l^3} (3a+b) = .998 F_1 = 317.0 \text{ LB/IN}$$

$$R_B = .6 \text{ LB/IN}$$

$$a = .188$$

$$b = 7.190$$

$$l = 7.378$$

$$M = -\frac{F_1 a b^2}{l^2} + R_A x \quad \text{A to B}$$

$$= -\frac{F_1 a b^2}{l^2} + R_A x - F_1 (x-a) \quad \text{B to C}$$

MAXIMUM M @ END A (x=0)

$$M = -56.71 \text{ IN-LB/IN}$$

BENDING STRESS (@ x=0)

$$\sigma = \frac{6M}{t^2} = \frac{6(56.71)}{(-.200-.010)^2} = 9426 \text{ psi}$$

$$\text{YIELD MS} = \frac{35000}{1.25(9426)} - 1 = +2.0$$

VERIFY VIA FINITE ELEMENT MODEL, 7.378 IN WIDE
WITH ALLOYS FIXED. $t = .190$ AT LOAD, 317.6 LB/IN,
.065 FOR $.500-.438 = .062$ IN, THEN .053.

MODEL	MAX MAJOR STRESS	MAX VON MISES STRESS
1	9899 psi	8737 psi

PER FINITE ELEMENT MODEL VON MISES STRESS

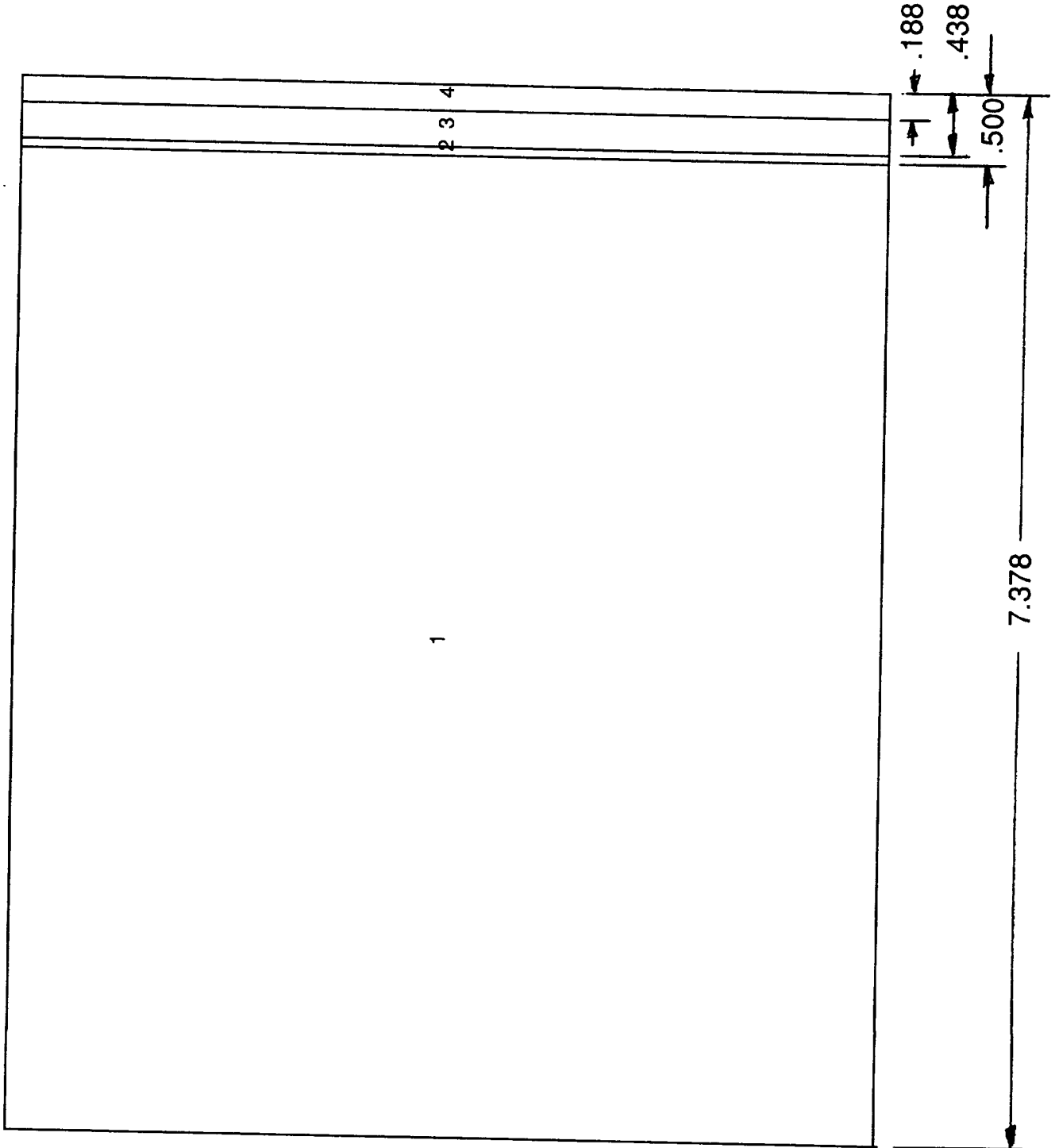
$$\text{MS} = \frac{35000}{1.25 \times 8737} - 1 = +2.2$$

$$\text{MS} = \frac{42000}{1.4 \times 8737} - 1 = +2.4$$

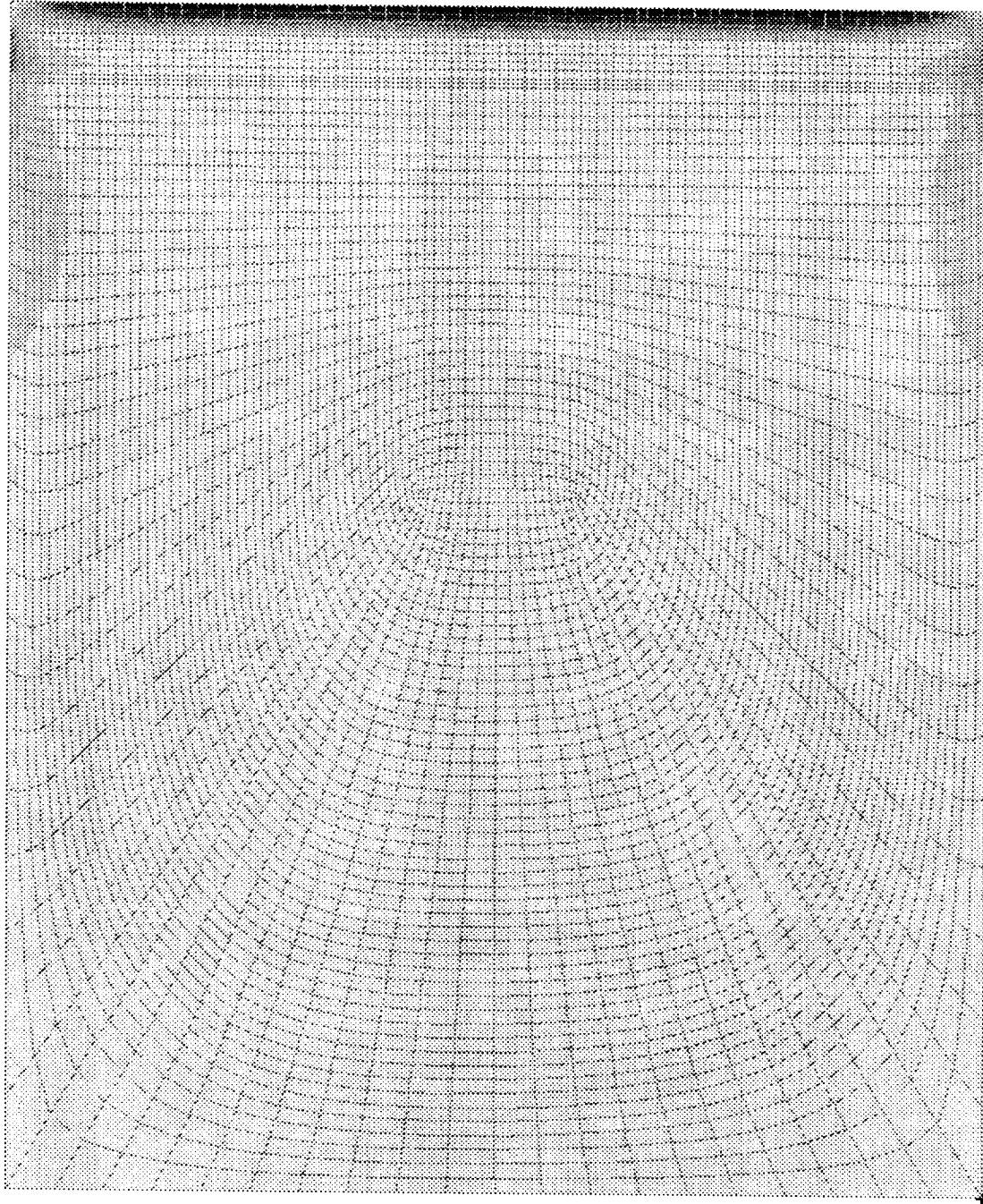
∴ LOWER BASEPLATE CROSS SECTION OK
UNDER LOWER RIGHT PANEL.

Lower Baseplate
@ Lower Right Panel

Thickness	Surface
.053	1
.075	2
.190	3, 4



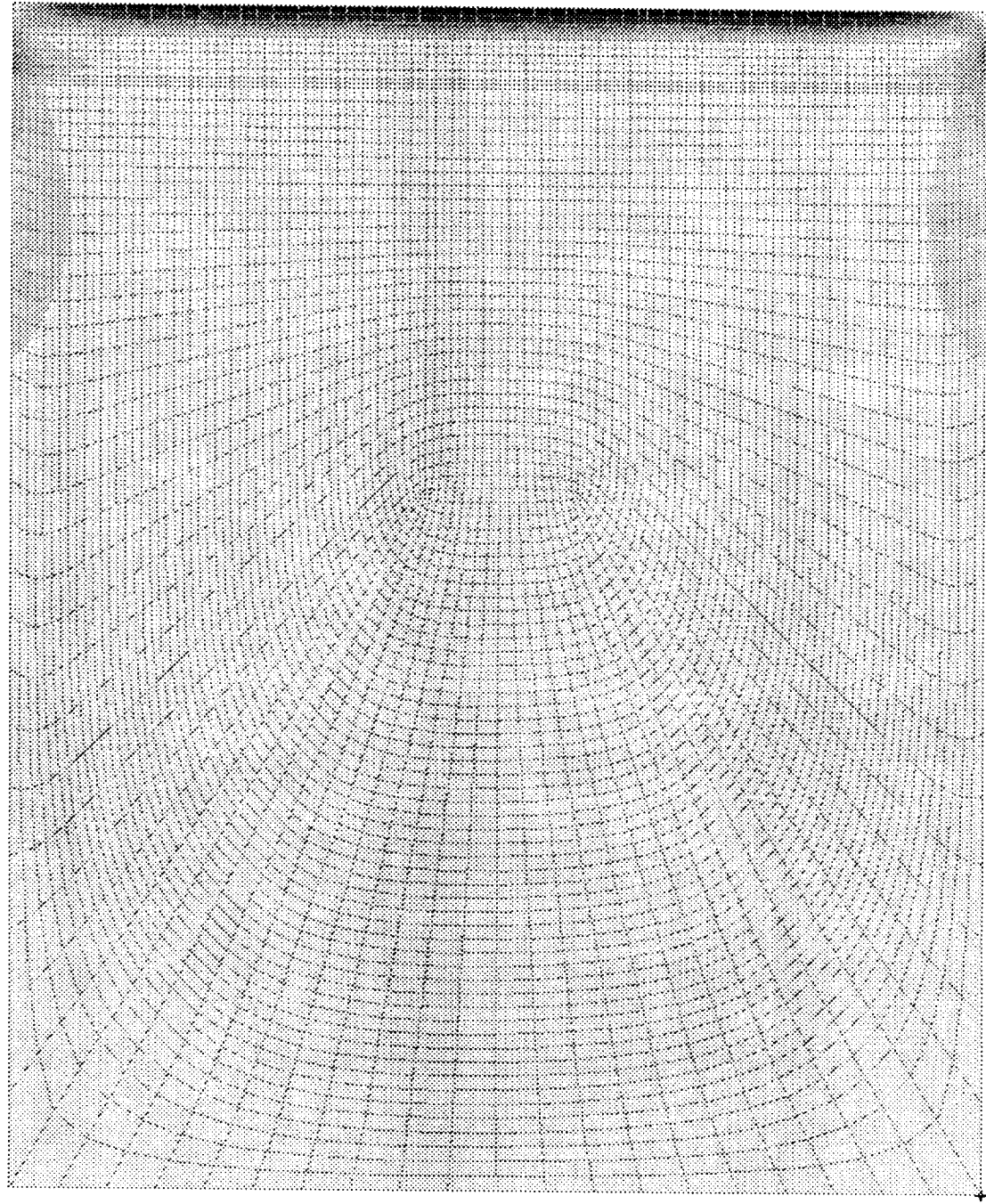
FRINGE PLOT LC=1.15 RES=2.1(MAJOR) MSC/PATRAN R-1.4 P3/FEA 12-Jan-96 12:35:42



9899.
9210.
8521.
7831.
7142.
6453.
5763.
5074.
4385.
3695.
3006.
2317.
1627.
938.0
248.7
-440.6

major prin stress - top surf t=.065 w/.053 recess & .190 step

FRINGE PLOT LC=1.15 RES=2.1(MAJOR) MSC/PATRAN R-1.4 P3/FEA 12-Jan-96 12:36:37



9899.
9210.
8521.
7831.
7142.
6453.
5763.
5074.
4385.
3695.
3006.
2317.
1627.
938.0
248.7
-440.6

von Mises stress - top surf t=.065 w/.053 recess & .190 step

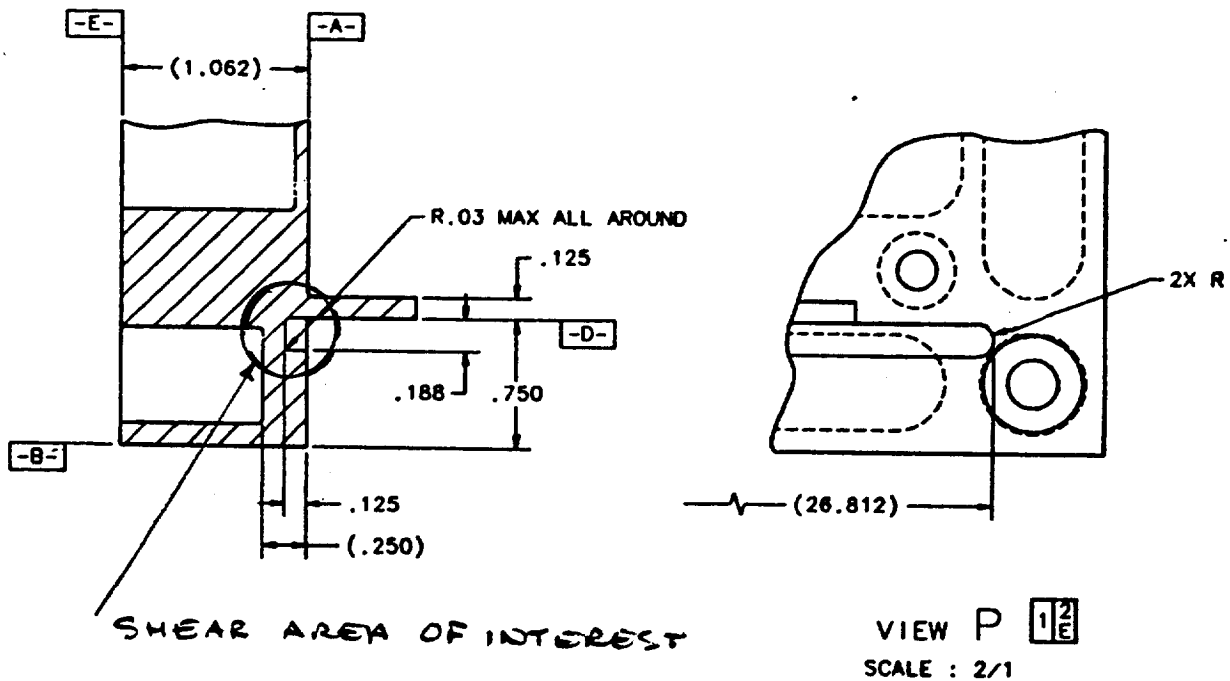
1-12-96

5.4.5.3
LOWER BASEPLATE - SHEAR STRESS @ LEFT PANEL
FLANGE GROOVED CROSS SECTION

USING RANDOM VIBRATION RESULTS, Q=7.1, THE WORST CASE VERTICAL LBS/INCH LOAD IS DERIVED FROM LEFT PANEL SHELL ELEMENTS NASTRAN MODEL DATA. AS SHOWN ON FOLLOWING PAGES

$F = 127.9 \text{ LB/IN}$ "3T" LOAD

THE GROOVED SECTION AT THE LEFT PANEL FLANGE ON THE LOWER BASEPLATE (1356405 VIEW P) IS SHOWN IN THE SKETCH BELOW



RANDOM VIBRATION DATA FOR THE "3T" CONDITION IS USED IN THE EVALUATION ALONG WITH A FACTOR OF SAFETY, FS OF 1.4.

RANDOM VIBRATION RESULTS - LEFT PANEL

1T LOADS, Q=7.1

		<u>RANDOM X</u>		
EL	3243	3256		
F _X	5.90	16.50		LB/IN
F _Y	23.56	33.73		"
F _{XY}	0.61	6.25		"

		<u>RANDOM Y</u>				
EL	3243	3253	3254	3255	3256	
F _X	5.39	8.24	11.17	11.80	21.28	LB/IN
F _Y	22.25	25.39	24.63	23.36	44.51	"
F _{XY}	4.54	4.23	6.21	7.35	5.39	"

		<u>RANDOM Z</u>	
EL	3243	3256	
F _X	4.58	10.54	LB/IN
F _Y	16.00	18.55	"
F _Z	3.51	3.92	"

CRITICAL LOAD CASE IS RANDOM Y, CRITICAL ELEMENT IS EL 3256, WHICH IS A SLIGHTLY SKEWED ELEMENT, AT $\theta = -7.80^\circ$. ROTATING -7.80° GIVES A FORCE $F_{y'}$ OF

$$F_{y'} = 42.63 \text{ LB/IN} \quad 1T \text{ LOAD}$$

$$= 127.9 \text{ LB/IN} \quad 3T \text{ LOAD}$$

THIS FORCE IS REACTED IN SHEAR ACROSS THE MINIMUM SECTION OF THE LOWER BASEPLATE LEFT PANEL FLANGE GROOVE (SEE SKETCH). SHEAR STRESS WITH 1.4 FACTOR OF SAFETY APPLIED TO "3T" LOAD

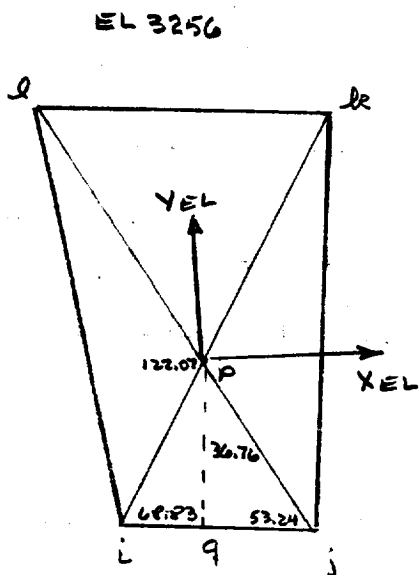
$$\tau = \left(\frac{127.9}{.125} \right) \frac{\text{LB/IN}}{\text{IN}} = 1023 \text{ PSL}$$

MATERIAL, 6061-T6 ALUMINUM,

$$F_{su} = 27000 \text{ psi}$$

$$MS = \frac{27000}{1.14(1023)} - 1 = +17$$

∴ SHEAR STRESS IN GROOVED SECTION AT
LEFT PANEL FLANGE IS OK



GRID	X	Z
l	40	25.532
j	41	25.970
k	300	25.970
l	2352	25.125



$$\angle k_l j = \tan^{-1} \frac{1.131}{-0.438} = 68.83^\circ$$

$$\angle l_j i = \tan^{-1} \frac{1.131}{0.845} = 53.24^\circ$$

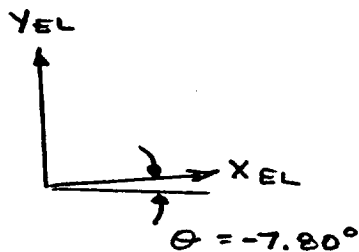
$$\angle l_j k = \tan^{-1} \frac{1.131}{0} = 90^\circ$$

$$\angle l_k j = 180 - 90 - 68.83 = 21.17^\circ$$

$$\angle l_j k = 90 - 53.24 = 36.76^\circ$$

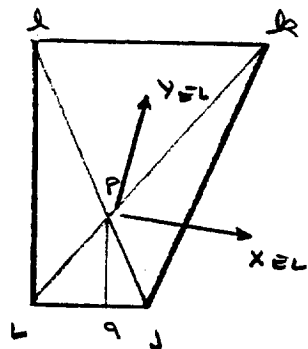
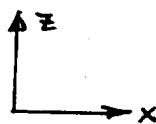
$$\angle k_p j = 180 - 21.17 - 36.76 = 122.07^\circ$$

$$\angle q_p j = 90 - 53.24 = 36.76^\circ$$



$$F_y' = \frac{F_x + F_y}{2} + \frac{F_x - F_y}{2} \cos(2(-7.80)) + F_{xy} \sin(2(-7.80))$$

EL3243



	6210	X	Z
L	27	7.282	0
J	28	7.408	0
K	2369	8.100	1.131
P	990	7.282	1.131

$$\angle L_P J \quad \tan^{-1} \frac{1.131}{.818} = 54.12^\circ$$

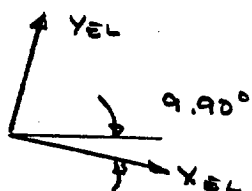
$$\angle J_P L \quad \tan^{-1} \frac{1.131}{.326} = 73.92^\circ$$

$$\angle L_P P = 90 - 54.12 = 35.88^\circ$$

$$\angle J_P P = 90 - 73.92 = 16.08^\circ$$

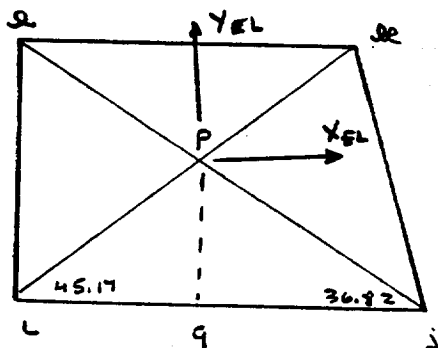
$$\angle J_P K = 180 - 35.88 - 16.08 = 128.04^\circ$$

$$X_{EL} \text{ axis } \odot \quad 16.08 + (54.12 + 73.92) / 2 = 30.10^\circ$$



$$F_y' = \frac{F_x + F_y}{2} + \frac{F_x - F_y}{2} \cos(2(9.90^\circ)) + F_{xy} \sin(2(9.90^\circ))$$

EL 3239



	6210	X	Z
L	23	.782	0
J	24	2.293	0
R	2338	1.9065	1.131
Q	2057	.782	1.131



$$\angle L_{JQ} \quad \text{TAN}^{-1} \frac{1.131}{1.511} = 36.82^\circ$$

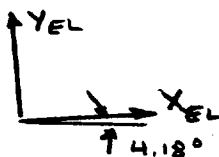
$$\angle R_{LJ} \quad \text{TAN}^{-1} \frac{1.131}{1.1245} = 45.17$$

$$\angle LQP = 90 - 45.17 = 44.83^\circ$$

$$\angle QPJ = 90 - 36.82 = 53.18^\circ$$

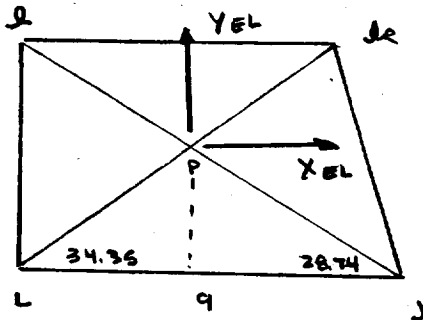
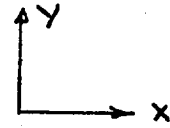
$$\angle JPQ = 180 - 44.83 - 53.18 = 81.98^\circ$$

$$\text{X}_{EL} \text{ AXIS} \quad \odot \quad 53.18 + (45.17 + 36.82)/2 = 94.18^\circ$$



$$F_{y'} = \frac{F_x + F_y}{2} + \frac{F_x - F_y}{2} \cos(2(-4.18)) + F_{xy} \sin(2(-4.18))$$

EL 3255



	Qr10	X	Z
L	39	23.470	0
J	40	25.532	0
Jr	2352	25.125	1.131
Q	2351	23.470	1.131

$$\angle JrLj \text{ TAN}^{-1} \frac{1.131}{1.655} = 34.35^\circ$$

$$\angle LjJr \text{ TAN}^{-1} \frac{1.131}{.407} = 70.21^\circ$$

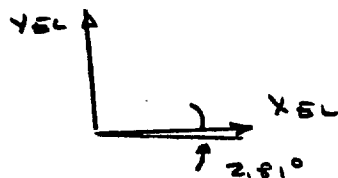
$$\angle LjL \text{ TAN}^{-1} \frac{1.131}{2.062} = 28.74^\circ$$

$$\angle Pqj = 180 - 90 - 28.74 = 61.26^\circ$$

$$\angle LqP = 180 - 90 - 34.35 = 55.65^\circ$$

$$\angle QPj = 180 - 61.26 - 55.65 = 63.09^\circ$$

$$X_{EL} \text{ AXIS } \odot 61.26 + (34.35 + 28.74)/2 = 92.81^\circ$$



$$Fy' = \frac{Fx + Fy}{2} + \frac{Fx - Fy}{2} \cos(2(-2.81)) + Fxy \sin(2(-2.81)) =$$

LEFT PANEL

3566	3567	3568	3569	3570	3571	3572	3573	3574	3575	3576	3577	3578
3552	3553	3554	3555	3556	3557	3558	3559	3560	3561	3562	3563	3564
3534	3535	3536	3537	3538	3539	3540	3541	3542	3543	3544	3545	3546
3516	3517	3518	3519	3520	3521	3522	3523	3524	3525	3526	3527	3528
3502	3503	3504	3505	3506	3507	3508	3509	3510	3511	3512	3513	3514
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2623	2624	2625	2626	2627	2628	2629	2630	2631	2632	2633	2634	2635
2601	2602	2603	2604	2605	2606	2607	2608	2609	2610	2611	2612	2613
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2557	2558	2559	2560	2561	2562	2563	2564	2565	2566	2567	2568	2569
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2513	2514	2515	2516	2517	2518	2519	2520	2521	2522	2523	2524	2525
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2337	2338	2339	2340	2341	2342	2343	2344	2345	2346	2347	2348	2349
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2271	2272	2273	2274	2275	2276	2277	2278	2279	2280	2281	2282	2283
2249	2250	2251	2252	2253	2254	2255	2256	2257	2258	2259	2260	2261
2227	2228	2229	2230	2231	2232	2233	2234	2235	2236	2237	2238	2239
2205	2206	2207	2208	2209	2210	2211	2212	2213	2214	2215	2216	2217
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2095	2096	2097	2098	2099	2100	2101	2102	2103	2104	2105	2106	2107
2073	2074	2075	2076	2077	2078	2079	2080	2081	2082	2083	2084	2085
2051	2052	2053	2054	2055	2056	2057	2058	2059	2060	2061	2062	2063
2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041
2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997
1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975
1941	1942	1943	1944	1945	1946	1947	1948	1949	1950	1951	1952	1953
1919	1920	1921	1922	1923	1924	1925	1926	1927	1928	1929	1930	1931
1897	1898	1899	1900	1901	1902	1903	1904	1905	1906	1907	1908	1909
1875	1876	1877	1878	1879	1880	1881	1882	1883	1884	1885	1886	1887
1853	1854	1855	1856	1857	1858	1859	1860	1861	1862	1863	1864	1865
1831	1832	1833	1834	1835	1836	1837	1838	1839	1840	1841	1842	1843
1809	1810	1811	1812	1813	1814	1815	1816	1817	1818	1819	1820	1821
1787	1788	1789	1790	1791	1792	1793	1794	1795	1796	1797	1798	1799
1765	1766	1767	1768	1769	1770							

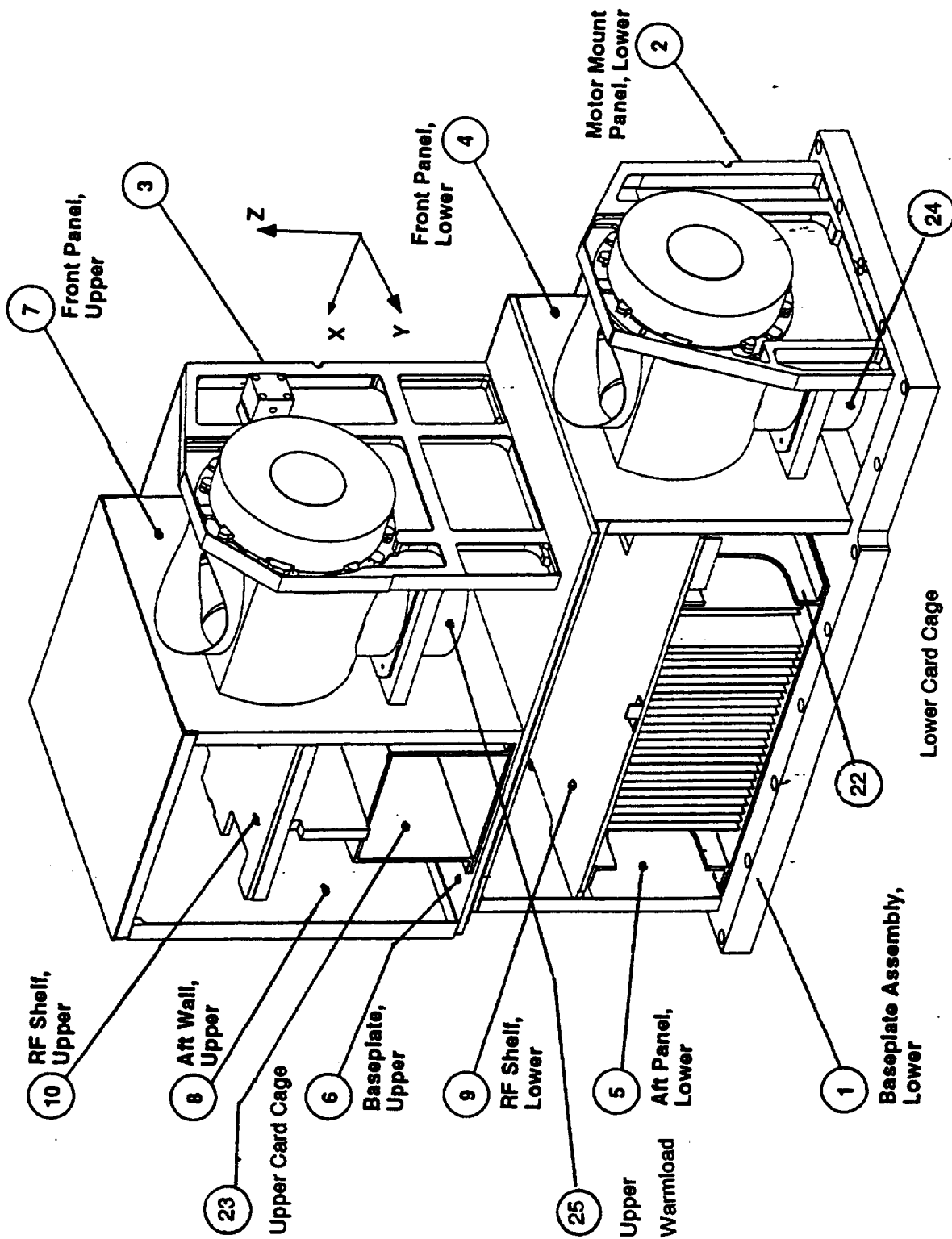


Figure 1 AMSU A1 Axes And Parts Identification Lower Warmload

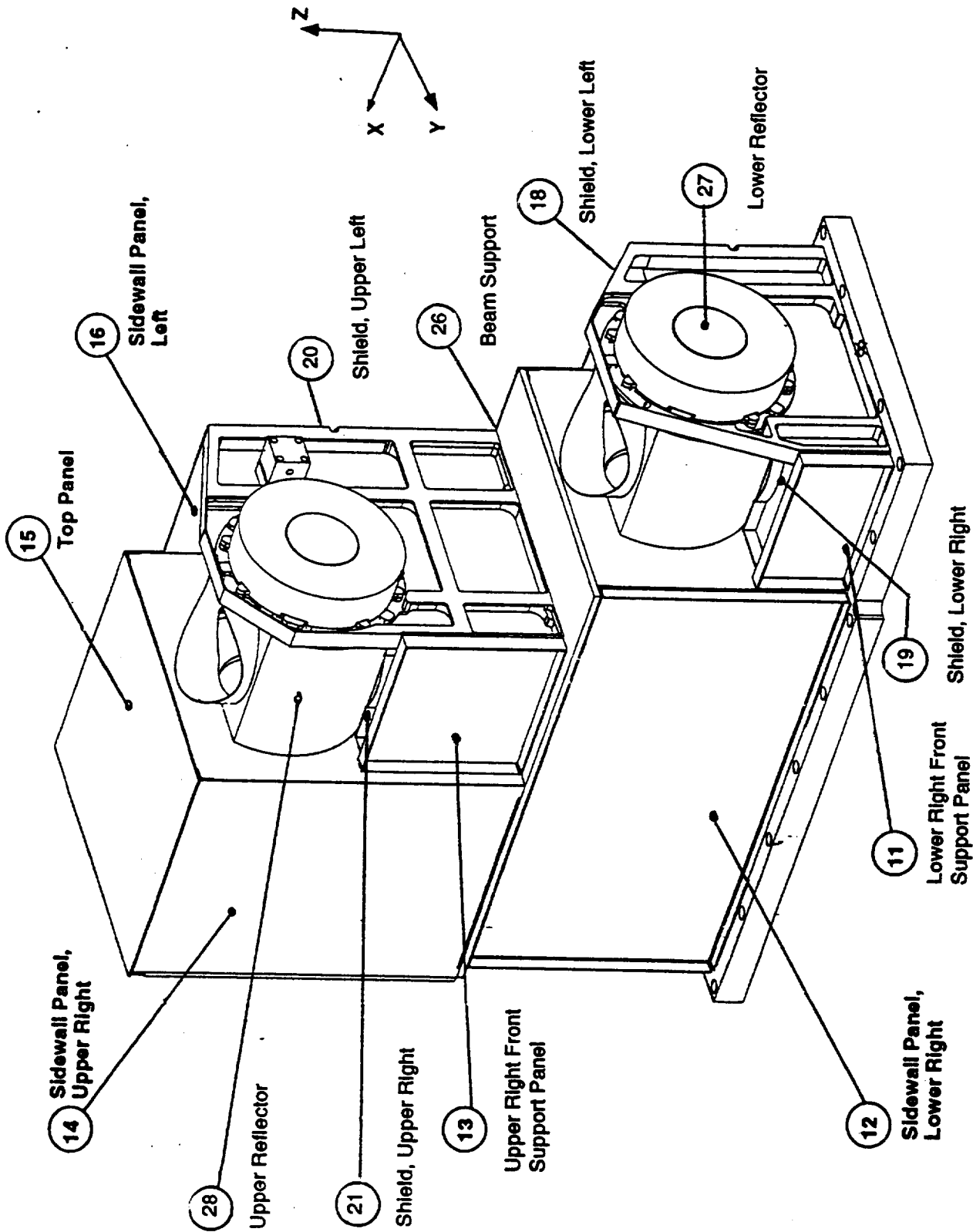
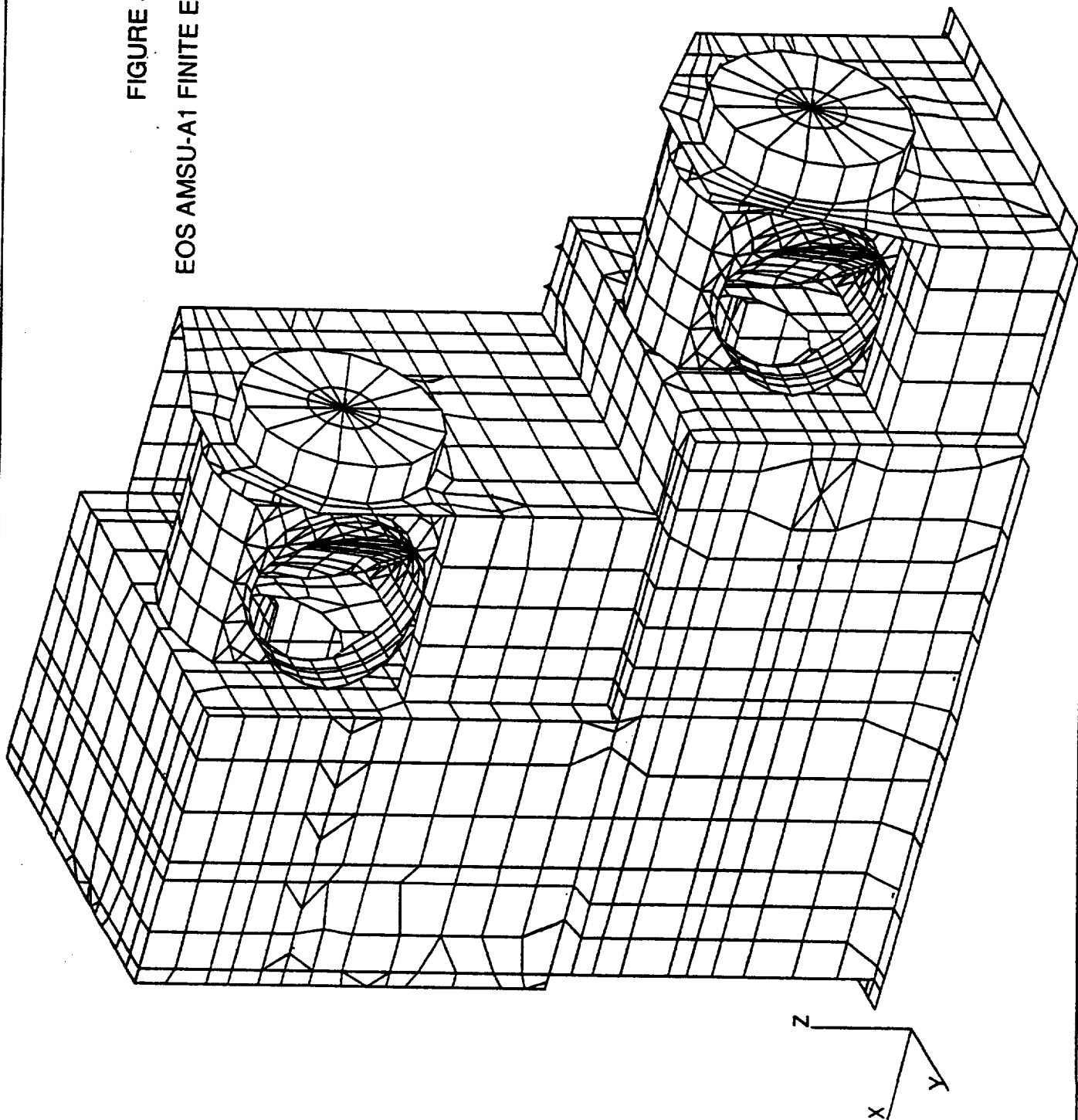


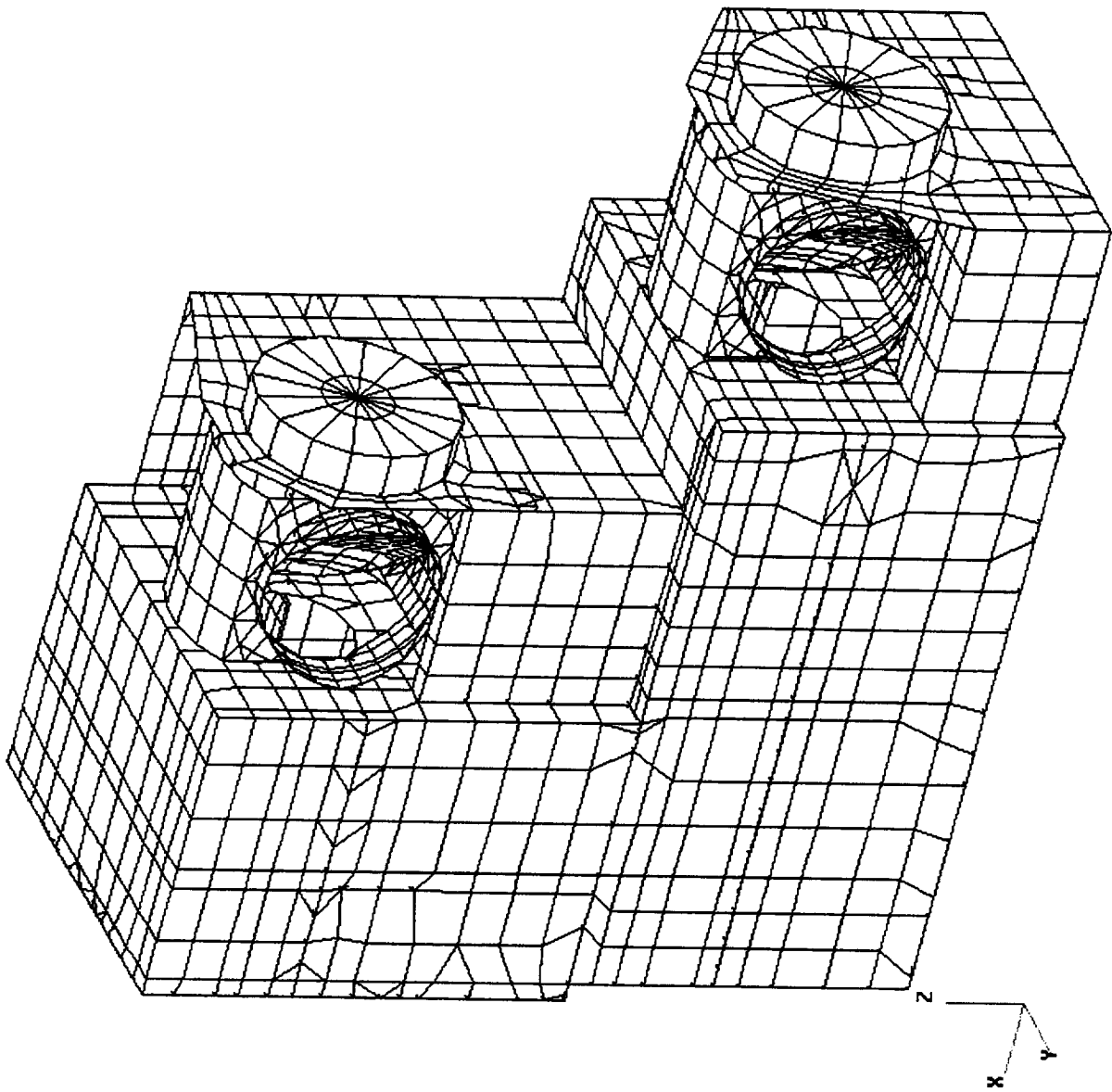
Figure 2 AMSU A1 External Parts Identification

FIGURE 3
EOS AMSU-A1 FINITE ELEMENT MODEL



Time: 15:38:09
Date: 01/23/96
Eigenvectors
Translational
modal
Mode 1 : Frequency = 108.9
Max. Deformation =
4.337412E+01
@Node 63688

FIGURE 4 EOS AMSU-A1
1ST NON-RIGID BODY
MODESHAPE 109.0 HZ



Time: 15:40:59
Date: 01/23/96
EigenVectors
Translational
modal
Mode 1 : Frequency = 100.9
Max. Deformation =
4.337412E+01
@Node 63688

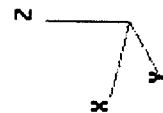
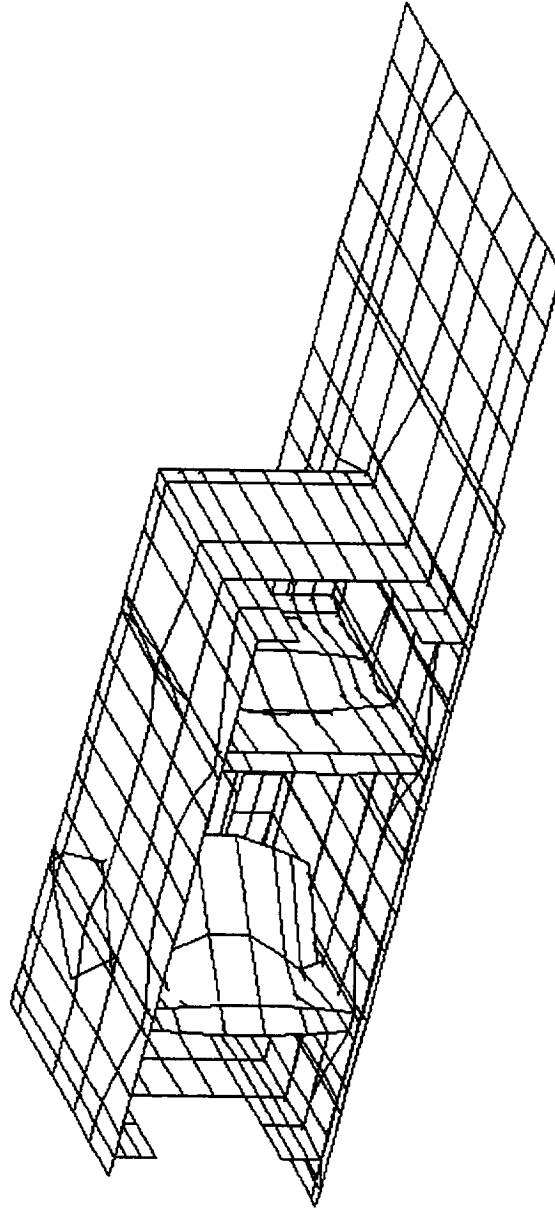
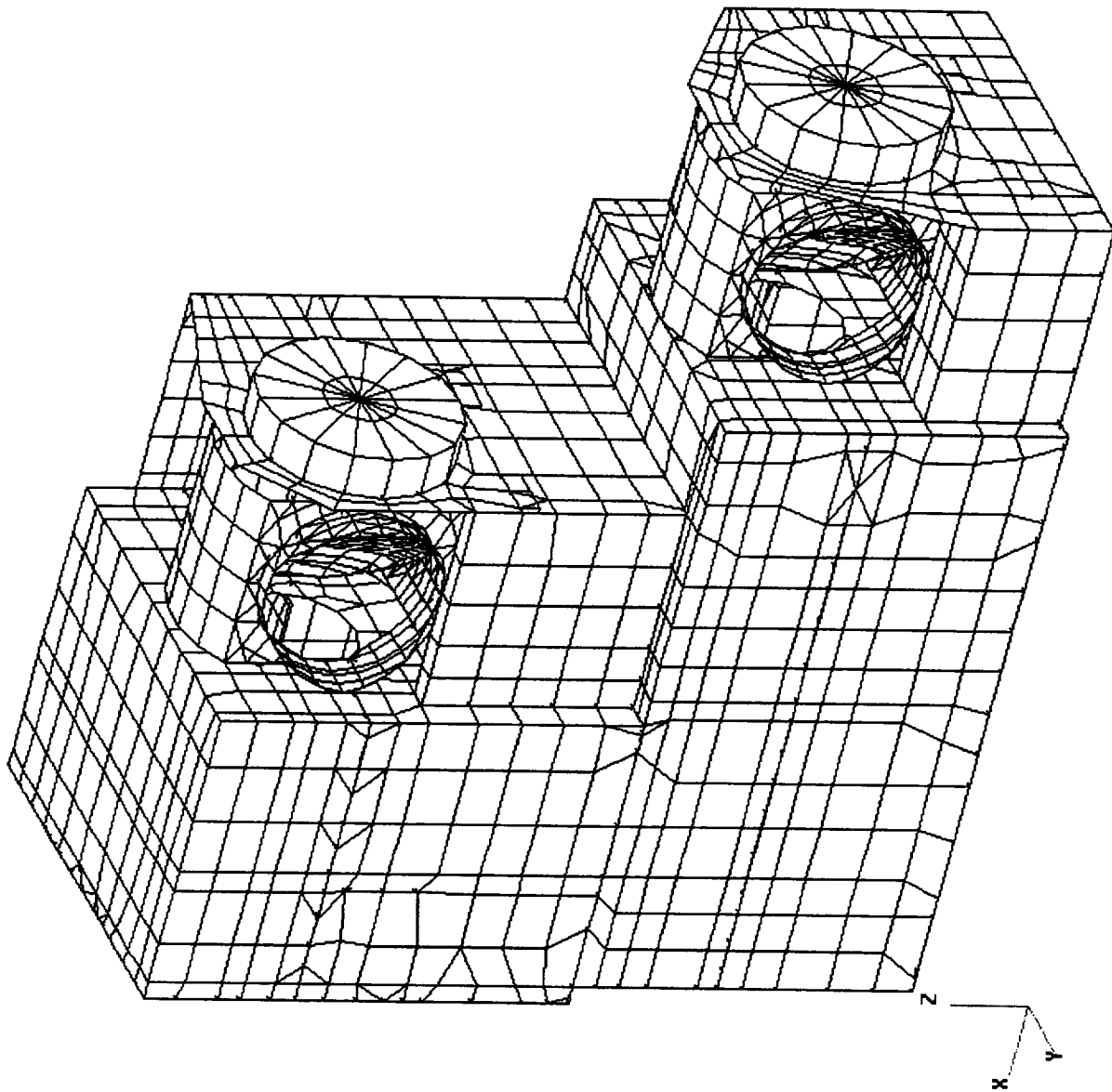


FIGURE 4a EOS AMSU-A1
1ST NON-RIGID BODY
MODESHAPE 100.0 HZ
LOWER CARD CAGE

Time: 15:37:24
Date: 01/23/96
Eigenvalues
Translational
modal
Mode 2 : Frequency = 108.9
Max. Deformation =
4.287141E+01
@Node 63808

FIGURE 5 EOS AMSU-A1
2ND NON-RIGID BODY
MODESHAPE 109.0 HZ



Time: 15:34:59
Date: 01/23/96
Eigenvalues
Translational
modal
Mode 2 : Frequency = 108.9
Max. Deformation =
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@Node 63808

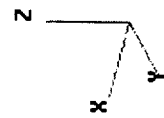
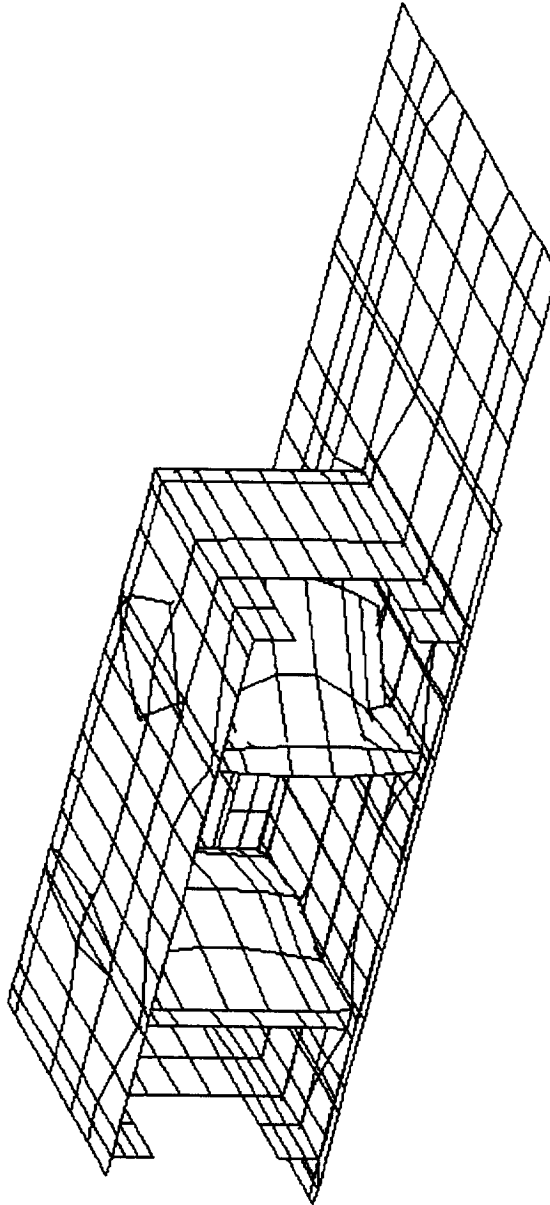
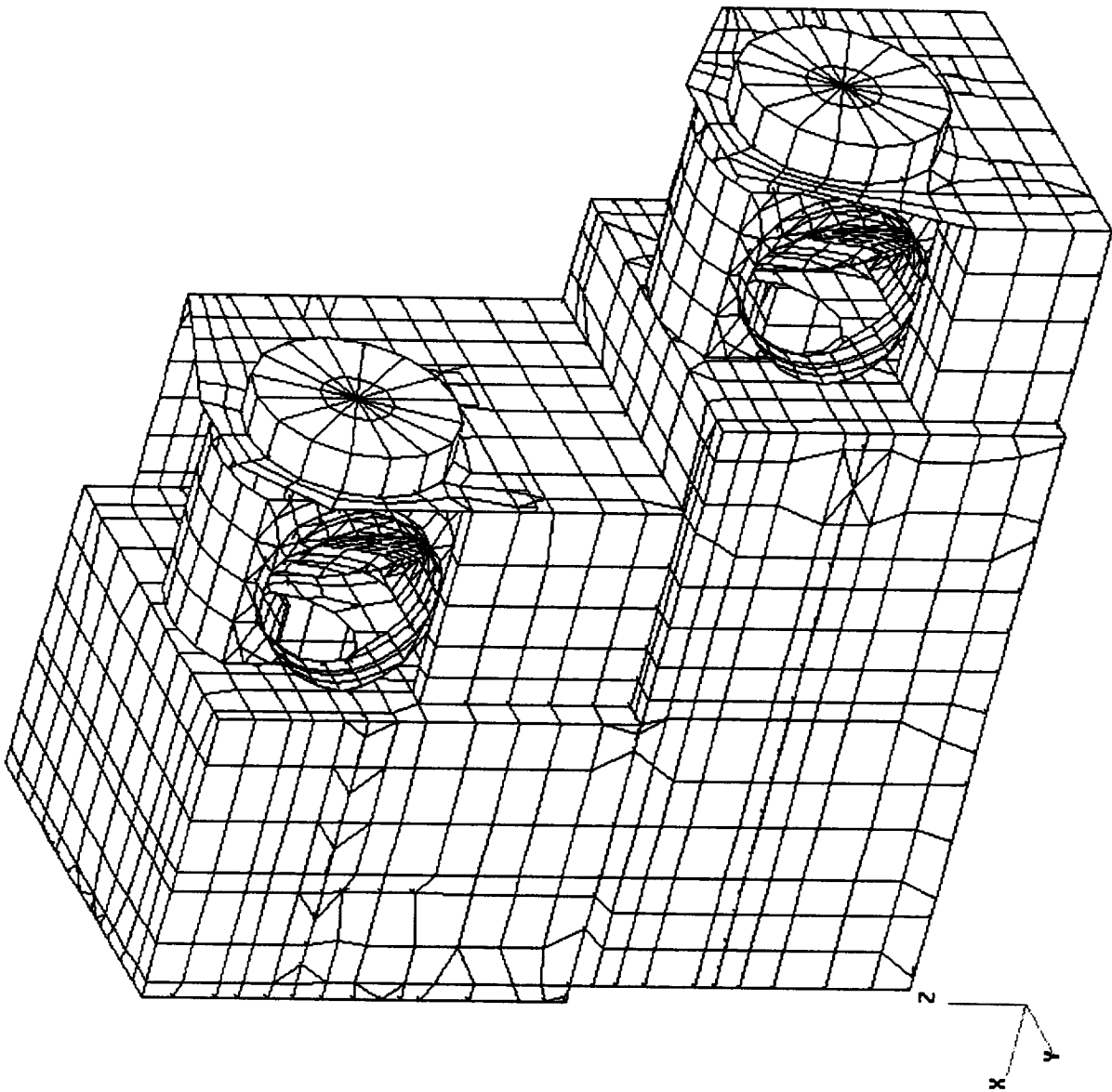


FIGURE 5a EOS AMSU-A1
2ND NON-RIGID BODY
MODESHAPE 109.0 HZ
LOWER CARD CAGE

Time: 15:29:40
Date: 01/23/96
Eigenvectors
Translational
modal
Mode 3 : Frequency = 109.5
Max. Deformation =
3.212686E+01
@Node 63728

FIGURE 6 EOS AMSU-A1
3rd NON-RIGID BODY
MODESHAPE 109.6 HZ



Time: 15:33:05
Date: 01/23/96
Eigenvalues
Translational
modal
Mode 3 : Frequency = 109.5
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@Node 63728

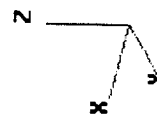
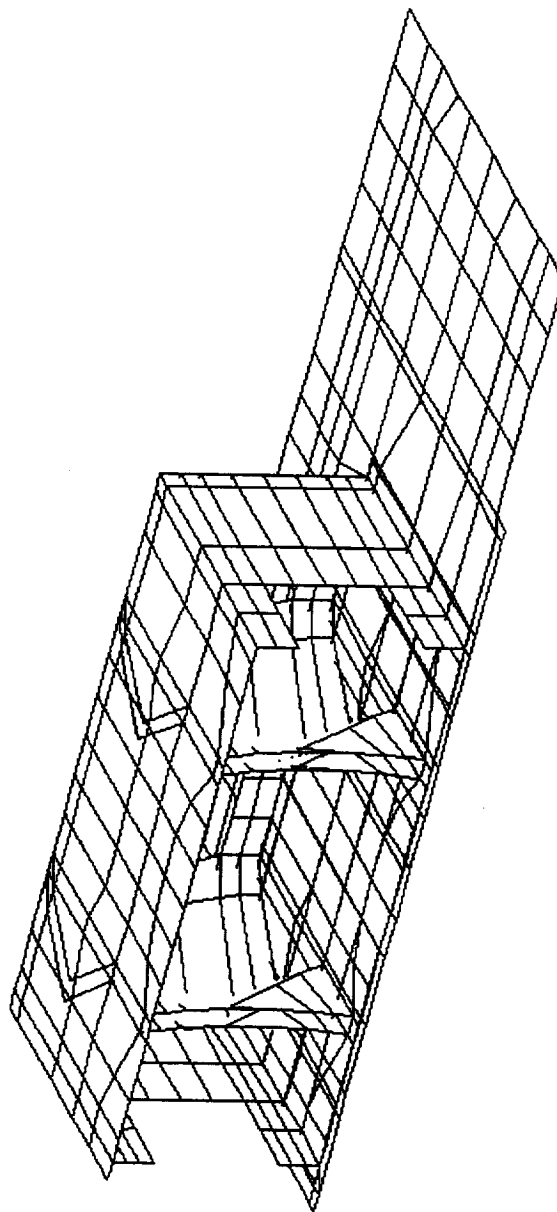
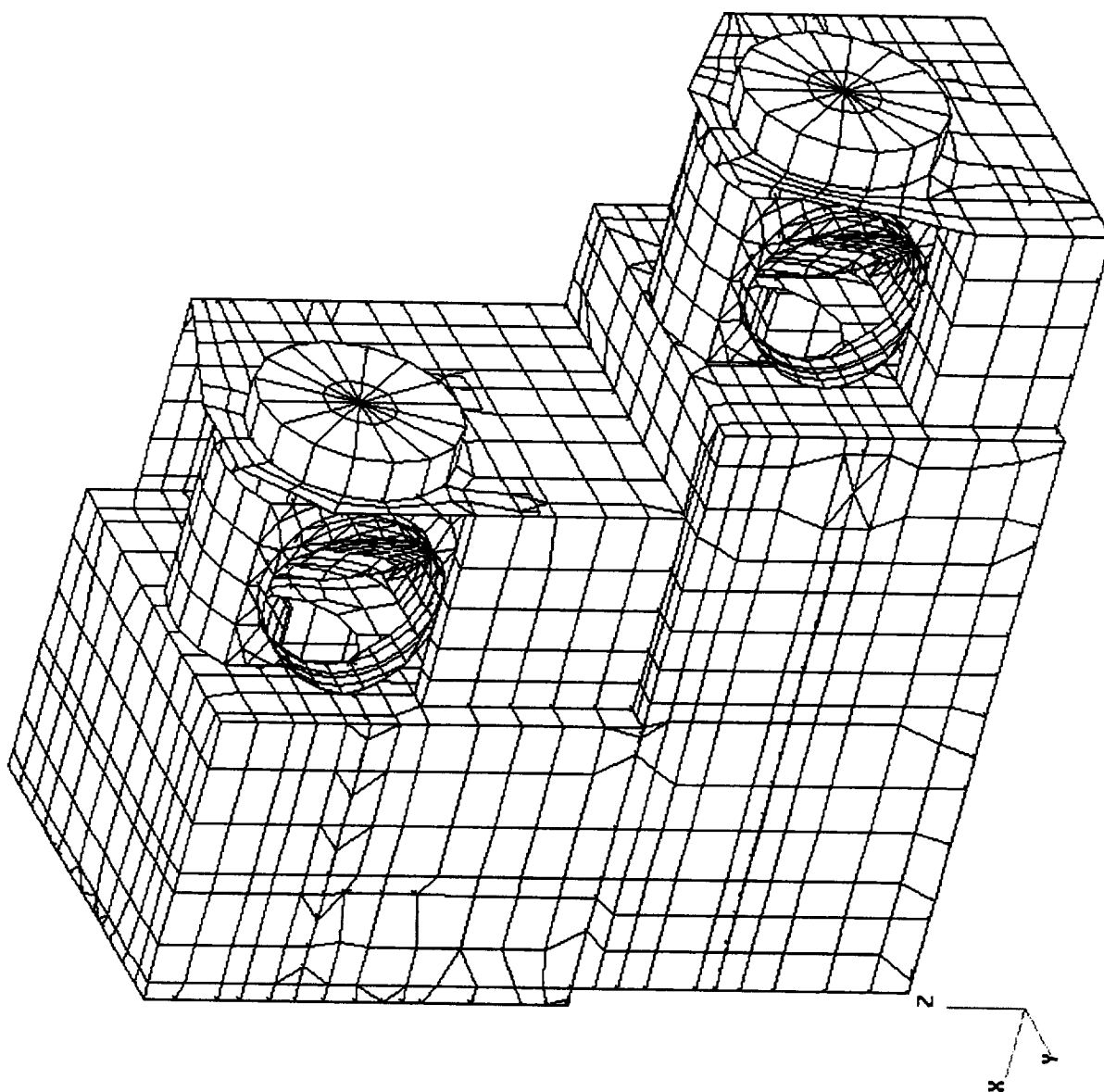


FIGURE 6a EOS AMSU-A1
3rd NON-RIGID BODY
MODESHAPE 109.6 HZ
LOWER CARD CAGE

Time: 15:27:31
Date: 01/23/96
Eigenvectors
Translational
modal
Mode 4 : Frequency = 109.7
Max. Deformation =
3.191910E+01
@Node 63768

FIGURE 7 EOS AMSU-A1
4TH NON-RIGID BODY
MODESHAPE 109.7 HZ



Time: 15:13:59
Date: 01/23/96
Eigenvectors
Translational
modal
Mode 4 : Frequency = 109.7
Max. Deformation =
3.191910E+01
@Node 63768

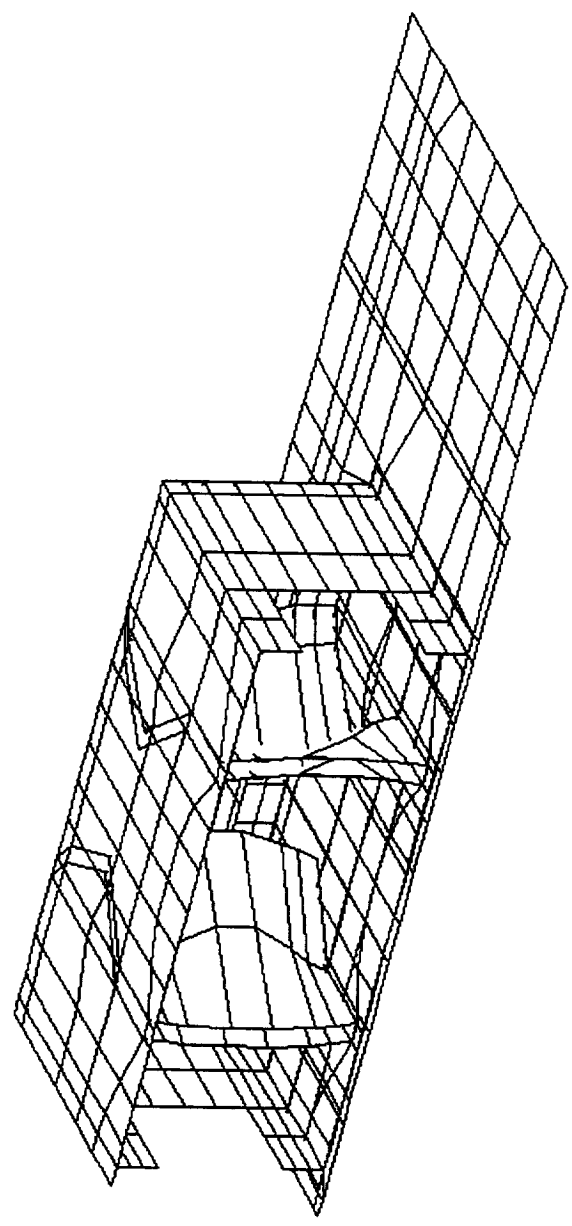
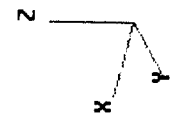
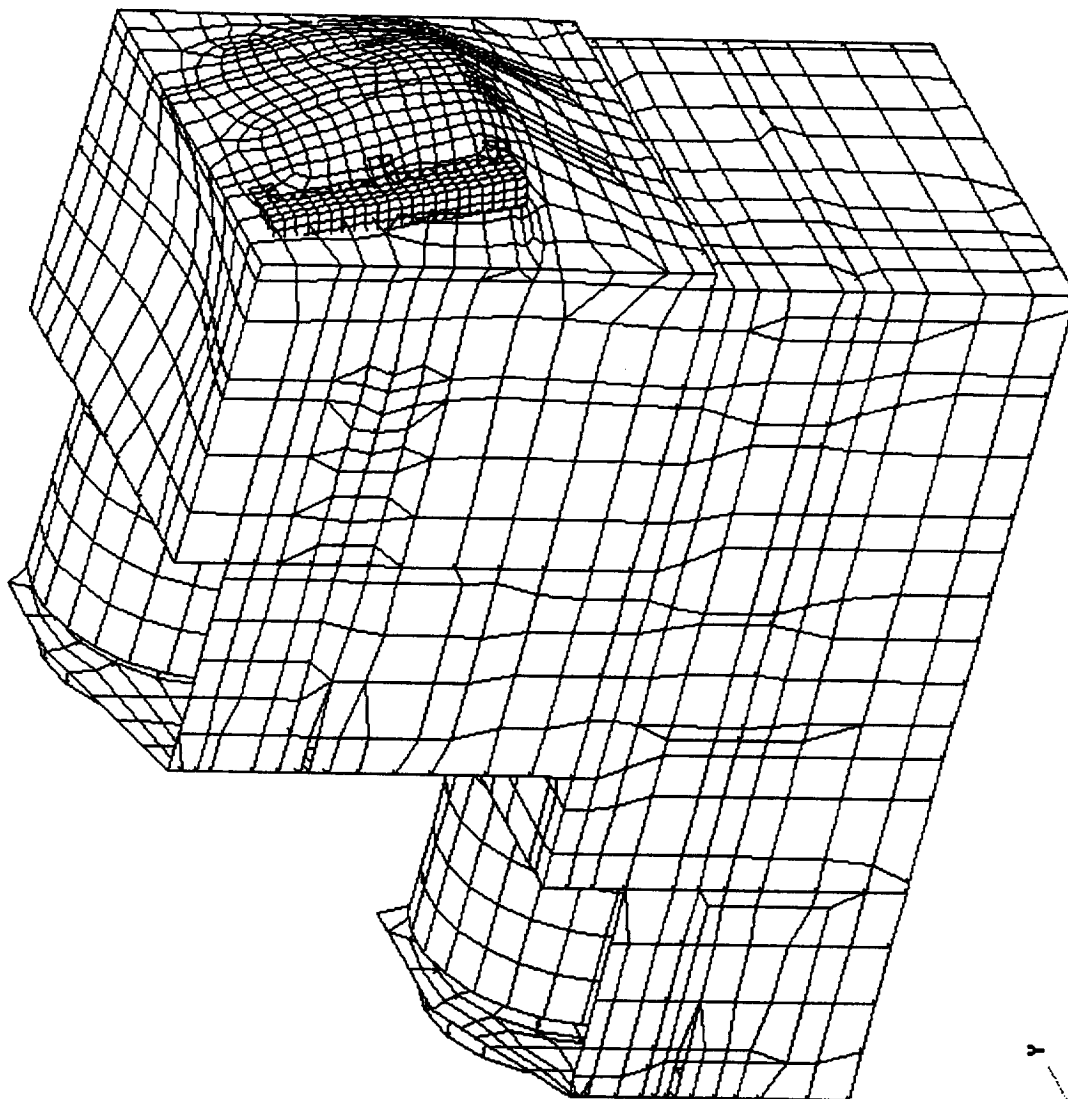


FIGURE 7a EOS AMSU-A1
4TH NON-RIGID BODY
MODESHAPE 109.7 HZ
LOWER CARD CAGE



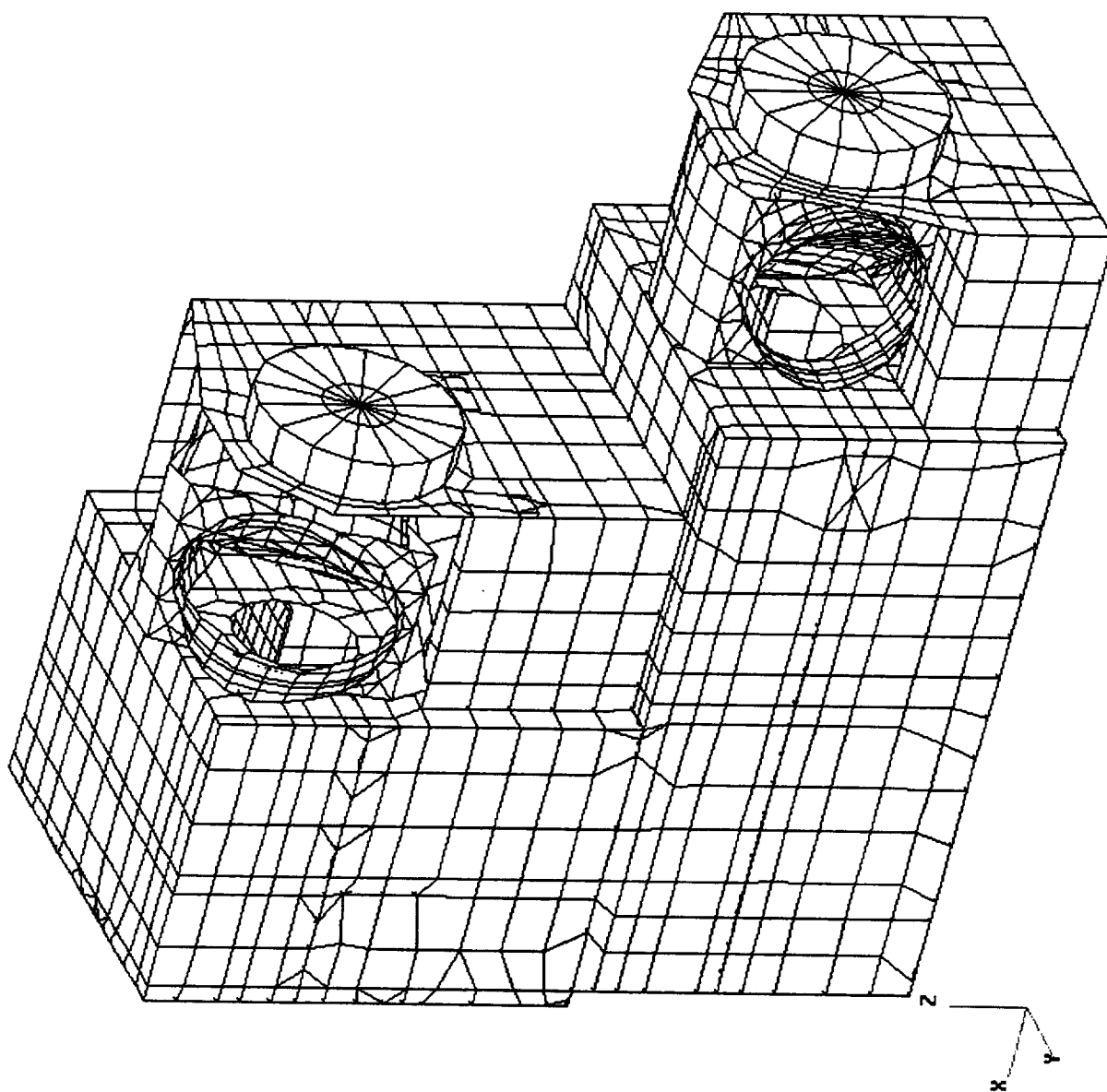
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Date: 01/23/96
Eigenvectors
Translational
moda1
Mode 5 : Frequency = 116.2
Max. Deformation =
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@Node 66848

FIGURE 8 EOS AMSU-A1
5TH NON-RIGID BODY
MODESHAPE 116.3 HZ



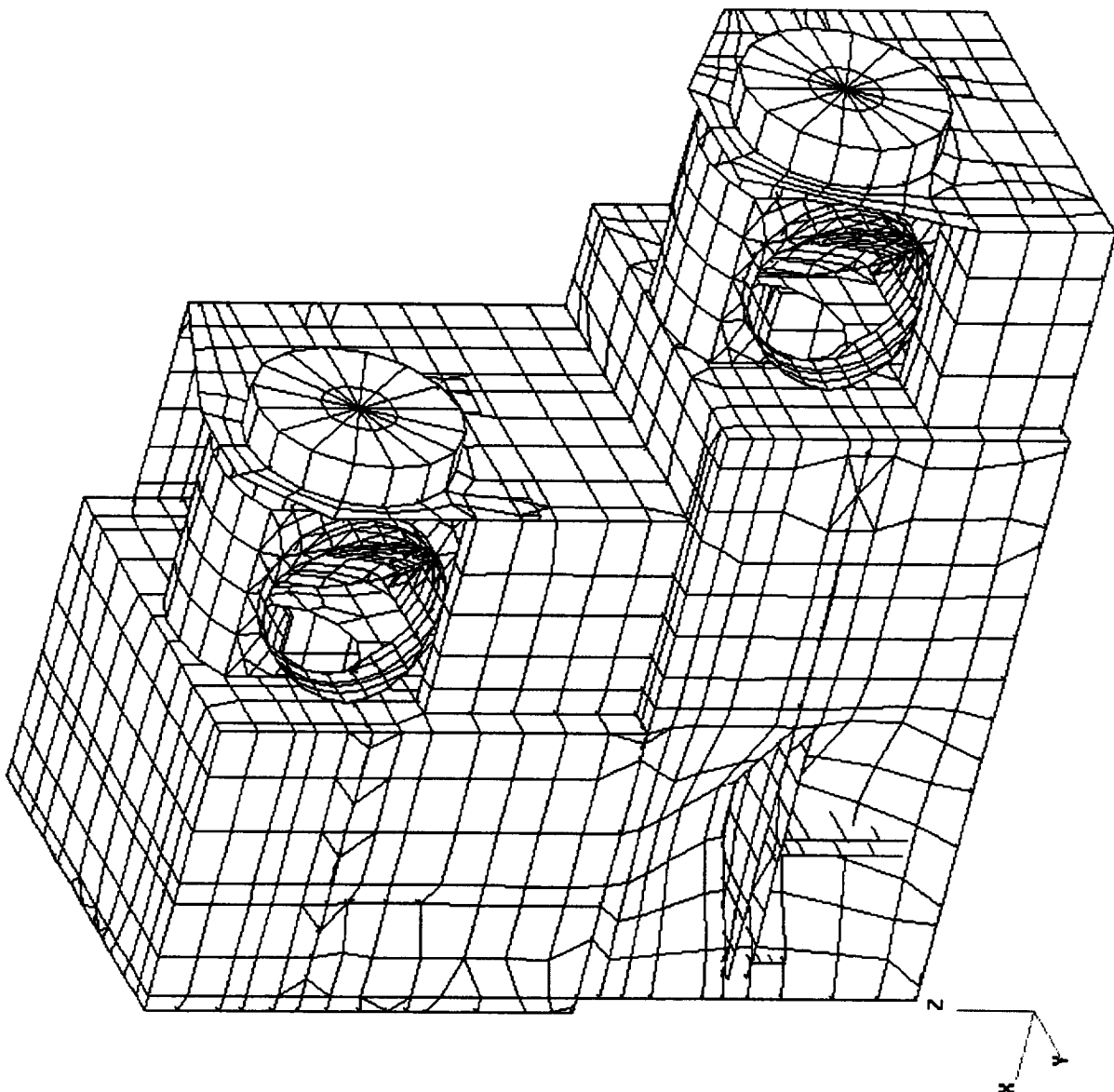
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EigenVectors
Translational
modal
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Max. Deformation =
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@Node 34517

FIGURE 9 EOS AMSU-A1
6TH NON-RIGID BODY
MODESHAPE 121.4 HZ



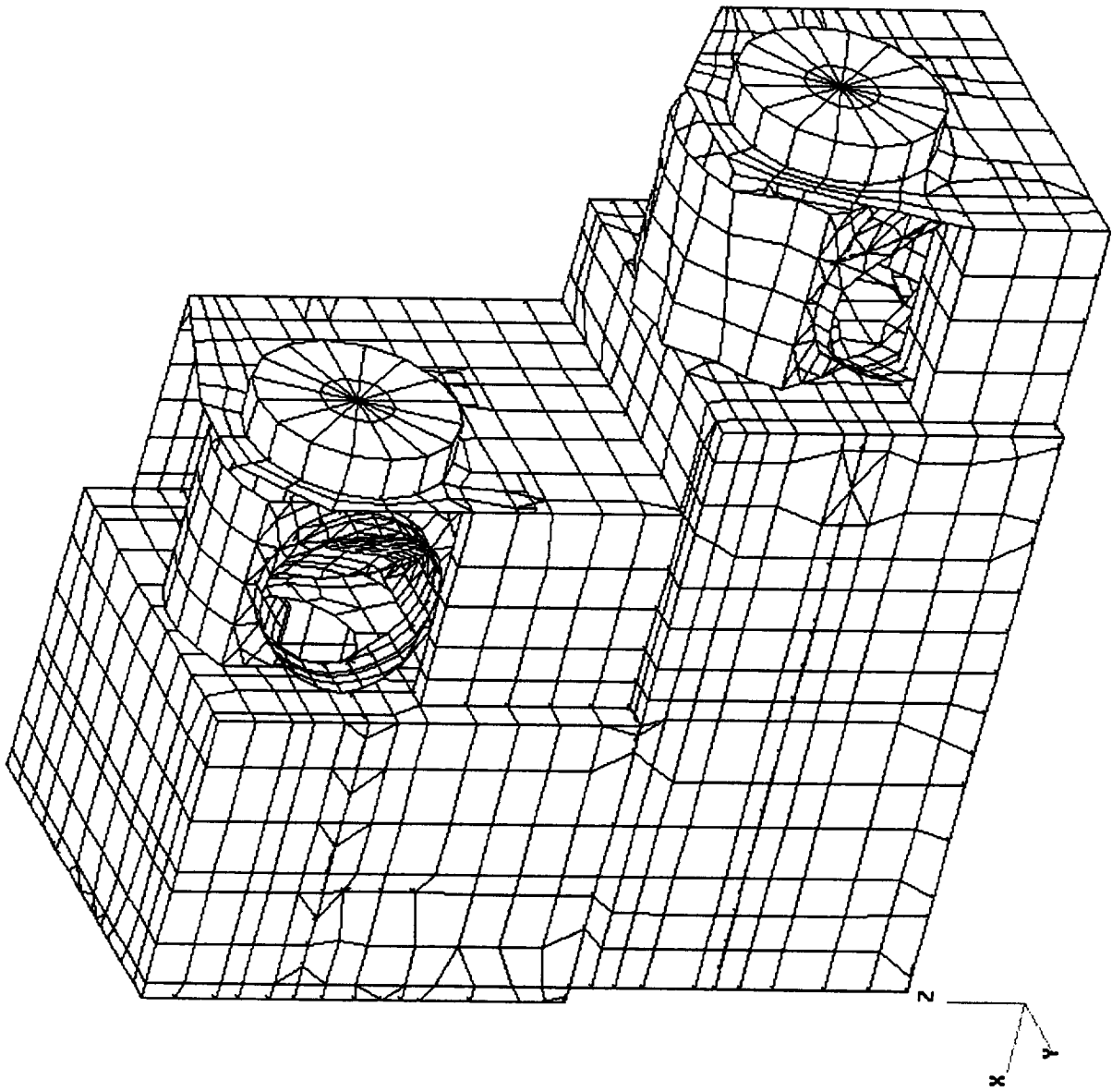
Time: 15:54:18
Date: 01/23/96
Eigenvalues
Translational
modal
Mode 7 : Frequency = 122.1
Max. Deformation =
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@Node 443

FIGURE 10 EOS AMSU-A1
7TH NON-RIGID BODY
MODESHAPE 122.2 HZ



Time: 15:56:47
Date: 01/23/96
Eigenvectors
Translational
modal
Mode 8 : Frequency = 122.3
Max. Deformation =
4.744259E+01
QNode 32017

FIGURE 11 EOS AMSU-A1
BTH NON-RIGID BODY
MODESHAPE 122.3 HZ



Figures 12 through 45 not re-evaluated in *Addendum 1*.

Appendix A

NASTRAN FINITE ELEMENT MODEL

NASTRAN Mathematical Validity Check

To demonstrate the mathematical soundness of the NASTRAN model, the model is subjected to the GSFC 422-11-12-01 Paragraph 11.1.4.i Deliverable Model Validity Check, where a rigid-body or stiffness-equilibrium check is performed. Using NASTRAN Solution 3, a DIAG 64 ALTER 126 DMAP is run. The NASTRAN Executive Control Data Deck consists of:

```

ID AMSU1,RANDOM
TIME 60
SOL 3
$
DIAG 64
$
COMPILE SOL3,SOUIN=MSCSOU
ALTER 126
VECPLOT, ,BGPDT,EQEXIN,CSTM,,,/RBGLOBAL/GRDPNT=0//4 $
VEC USET/V1/G/F/COMP' $
PARTN RBGLOBAL,V1/RBFF,,,/0 $
TRNSP RBFF/RBFFT $
MPYAD KFF,RBFFT/KFFR/ $
MATGPR GPL,USET,SIL,KFFR/'F'///1.E-2 $
DIAGONAL KFF/KFFD/OPT='SQUARE'/POWER=-1. $
MPYAD KFFD,KFFR,/KFFRN/ $
MATGPR GPL,USET,SIL,KFFRN/'F'///SMALL=1.E-5 $
ENDALTER
CEND

```

A NASTRAN correspondence on the rigid-body check describes the requirements of the test.

“The basic function of this check is to multiply through a cross product the free stiffness matrix by the model rigid body matrix. The matrix which results from this multiplication can be thought of as the internal forces which must be applied to the structure to overcome any model internal constraint to achieve the desired rigid body motion. This matrix is titled the KFFR matrix. The smaller the magnitude of the numbers in the matrix, the less internal constraint present in the model. The DMAP will print any values larger than 1.0E-2. In an attempt to evaluate the effect of any internal constraint, the KFFR matrix is divided by the diagonal stiffness term of each respective row. The resulting matrix is considered ‘normalized’ and is titled the KFFRN matrix. A satisfactory KFFRN matrix . . . will generally have terms less than 1.0E-5.”

Thus terms of the KFFRN matrix need be less than 1.0E-5.

The NASTRAN EOS/AMSU-A1 finite element model has been checked and modified to conform to GSFC 422-11-12-01 Paragraph 11.1.4.i requirements. All terms of the KFFRN matrix are less than 1.0E-5. There were, however, modifications to the model required to reach satisfactory equilibrium. These corrections consisted of:

- (1) Using large field data transfer from PATRAN to NASTRAN. This eliminated truncation errors at several GRID cards and out-of-plane elements.
- (2) Modifying GRIDs slightly to insure all GRIDs of an element lie in a plane (i.e. Power Control Module and the Warmload Housings).
- (3) Constructing several massless, stiffless, CBAR elements in the Reflector Shrouds.

Upon making the above changes, the KFFRN matrix became null. A check of the 1st ten non-rigid-body modes before and after the model modifications demonstrated no significant change in natural frequencies or mode shapes. A comparison table of “before changes” and “after changes” follows.

Mode No.	Natural Frequency Before Changes	Natural Frequency After Changes
1	108.9 Hz	109.0 Hz
2	109.0	109.0
3	109.6	109.6
4	109.7	109.7
5	115.9	116.3
6	121.4	121.4
7	122.2	122.2
8	122.3	122.3
9	146.6	146.6
10	147.2	147.2

The NASTRAN finite element model of the EOS AMSU-A1 module is shown in its entirety in Figure 3 and again in Figure A1 in this appendix. Figure A2 is a section view of the model, showing the components modeled in the interior (i.e. shelves, card cages, warmload structures). Elements and grids are highlighted in the piece part models of Figures A3 through A58 that are combined to form the A1 module model. The following components are identified:

Component	Figures
Lower Baseplate	A3-A6
Upper Baseplate	A7-A10
Top Panel	A11-A13
Lower Shelf	A14-A16
Upper Shelf	A17-A19
Lower Aft Panel	A20-A22
Upper Aft Panel	A23-A25
Lower Front Panel	A26-A28
Upper Front Panel	A29-A31
Lower Motor Mount Panel	A32-A34
Upper Motor Mount Panel	A35-A37
Left Panel/Beam Support	A38-A39
Lower Right Panel	A40-A42
Upper Right Panel	A43-A45
Lower Right Front Support	A46
Upper Right Front Support	A47
Lower Left Shield	A48
Lower Right Shield	A49
Upper Left Shield	A50
Upper Right Shield	A51
Lower Card Cage Assembly	A52
Upper Card Cage Assembly	A53
Lower Reflector Assembly	A54
Upper Reflector Assembly	A55
Lower Warmload	StructureA56
Upper Warmload	StructureA57
Upper Aft Panel w/PCM	A58

Addendum 1 shows only the components modified from the June 1995 submittal. These are Figures A23-A25 (Upper Aft Panel), Figure A30 (Upper Front Panel Bars, Beams, and Masses), and new Figure A58 (Upper Aft Panel w/PCM).

FIGURE A1
EOS AMSU-A1 FINITE ELEMENT MODEL

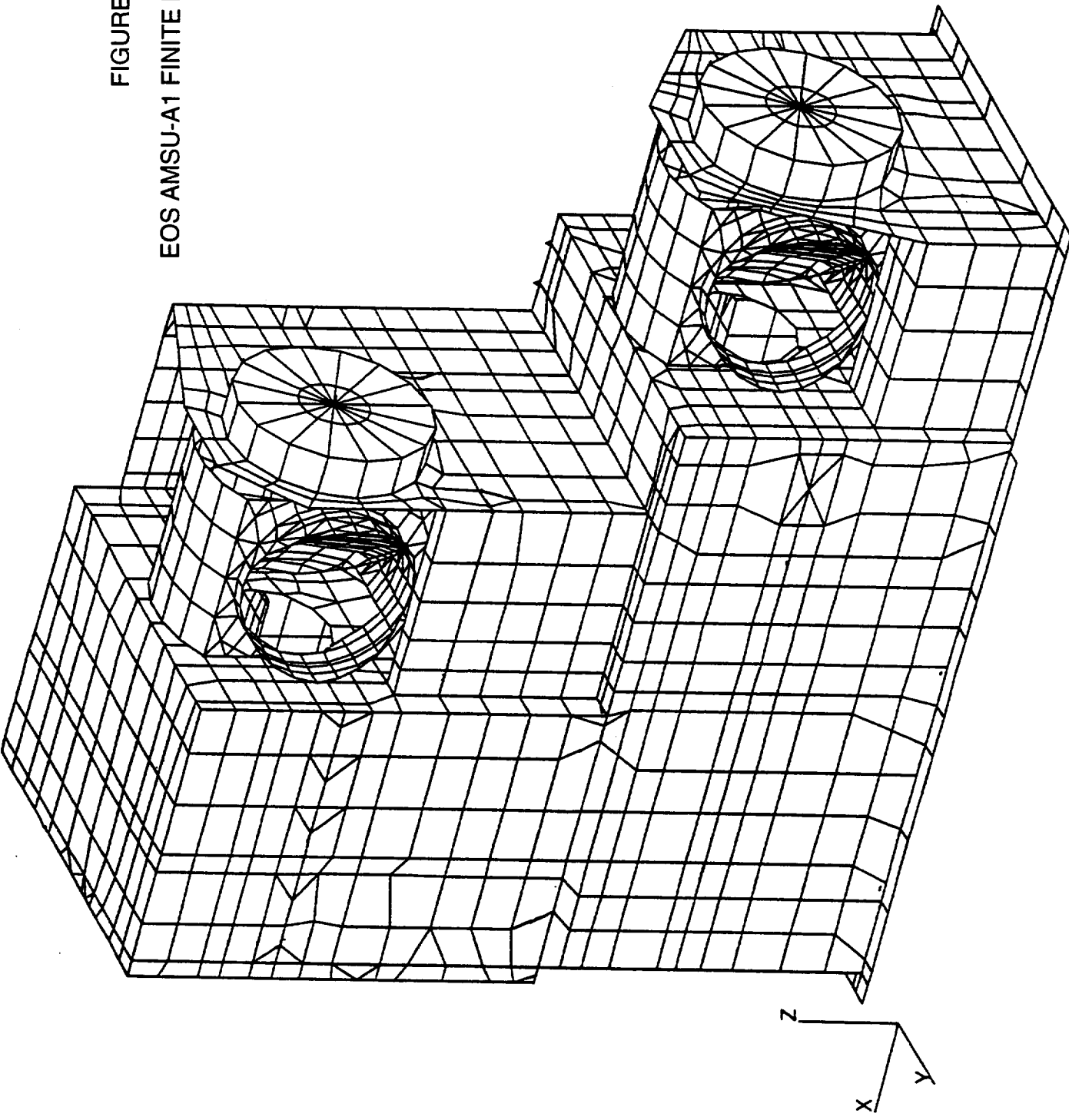
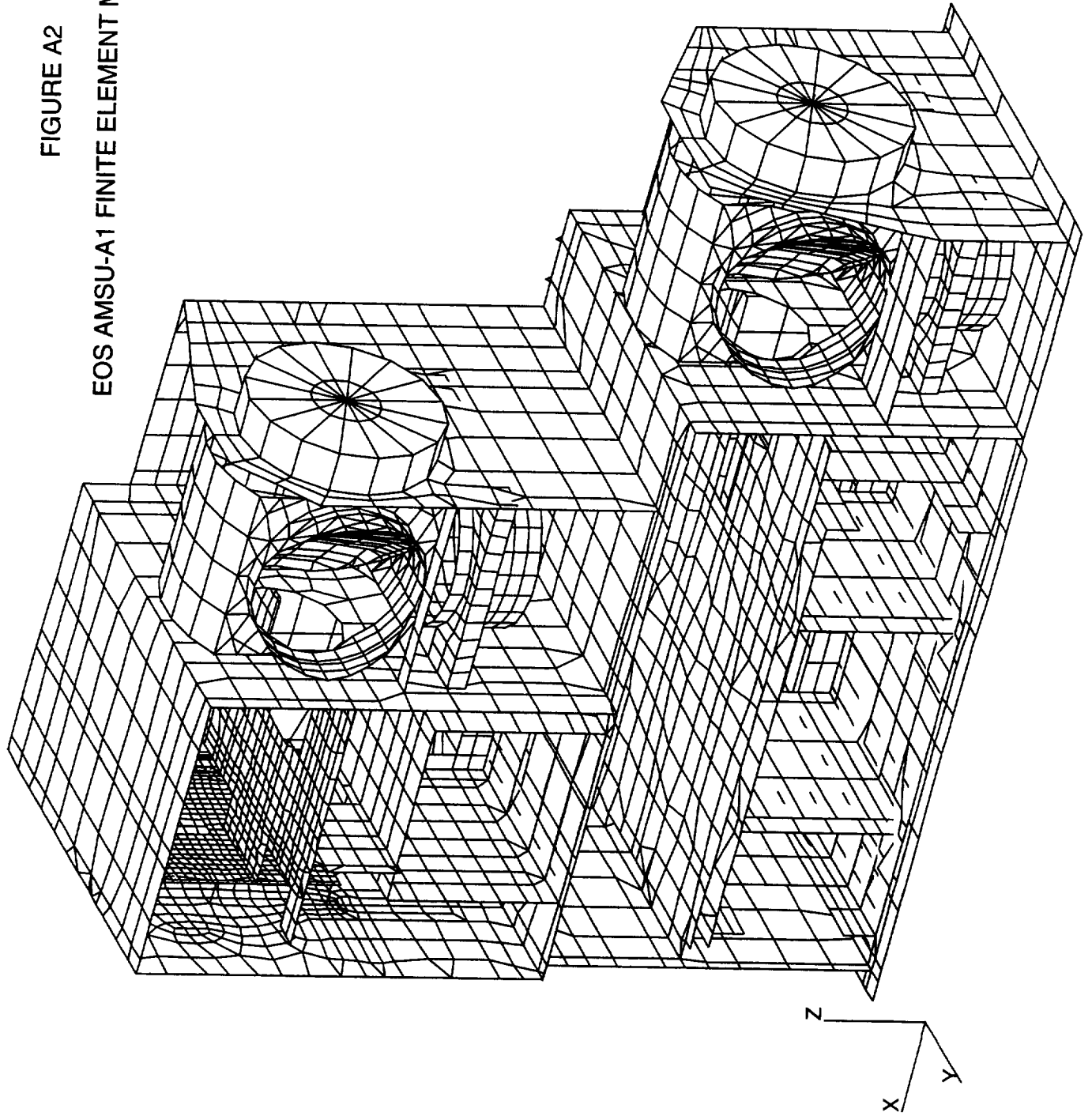


FIGURE A2
EOS AMSU-A1 FINITE ELEMENT MODEL - SECTION



Figures A3 through A22 not re-evaluated in *Addendum 1*.

FIGURE A23
UPPER AFT PANEL

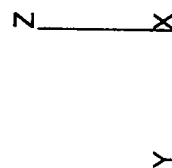
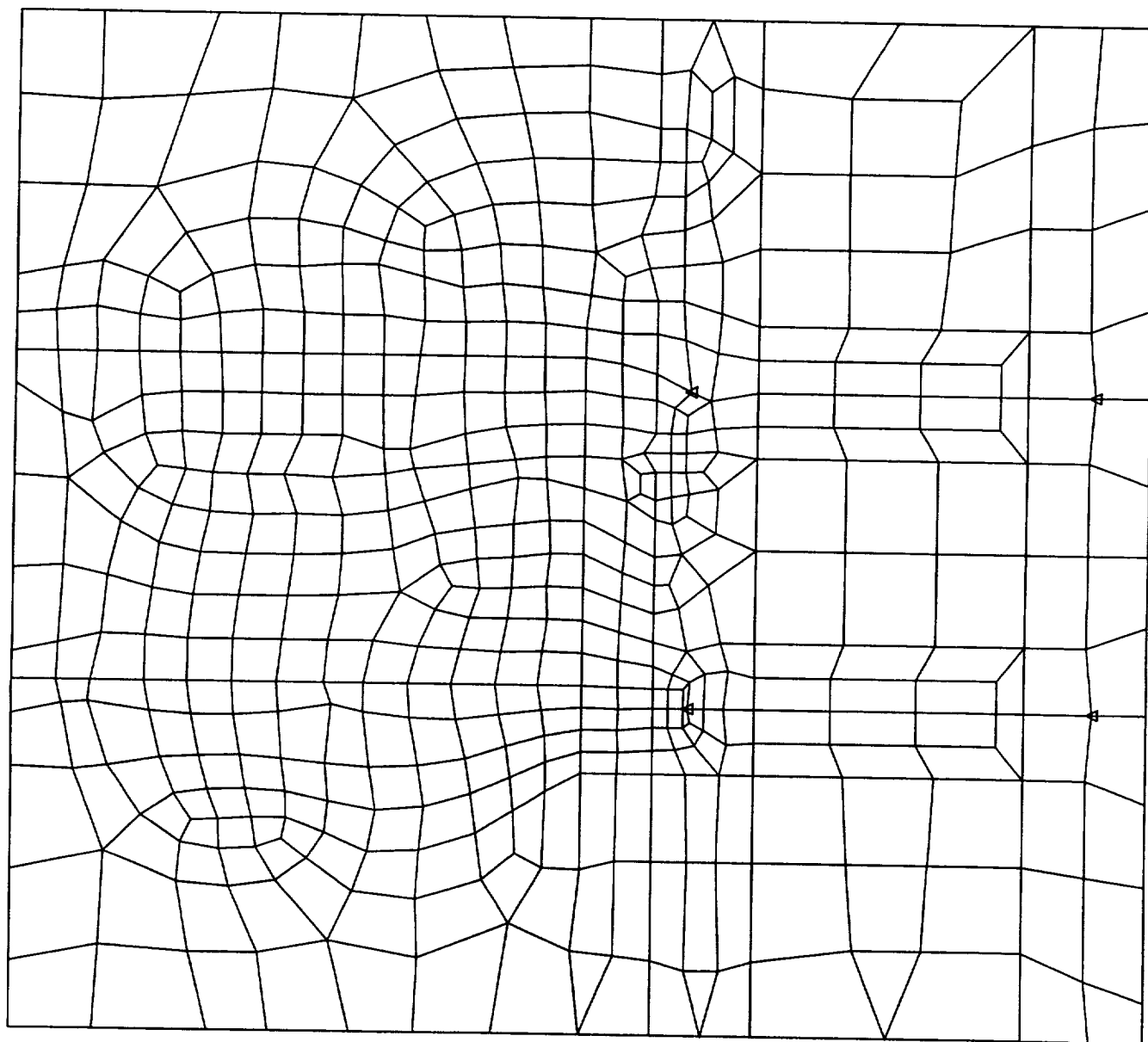
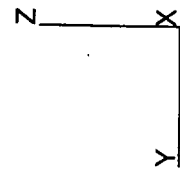
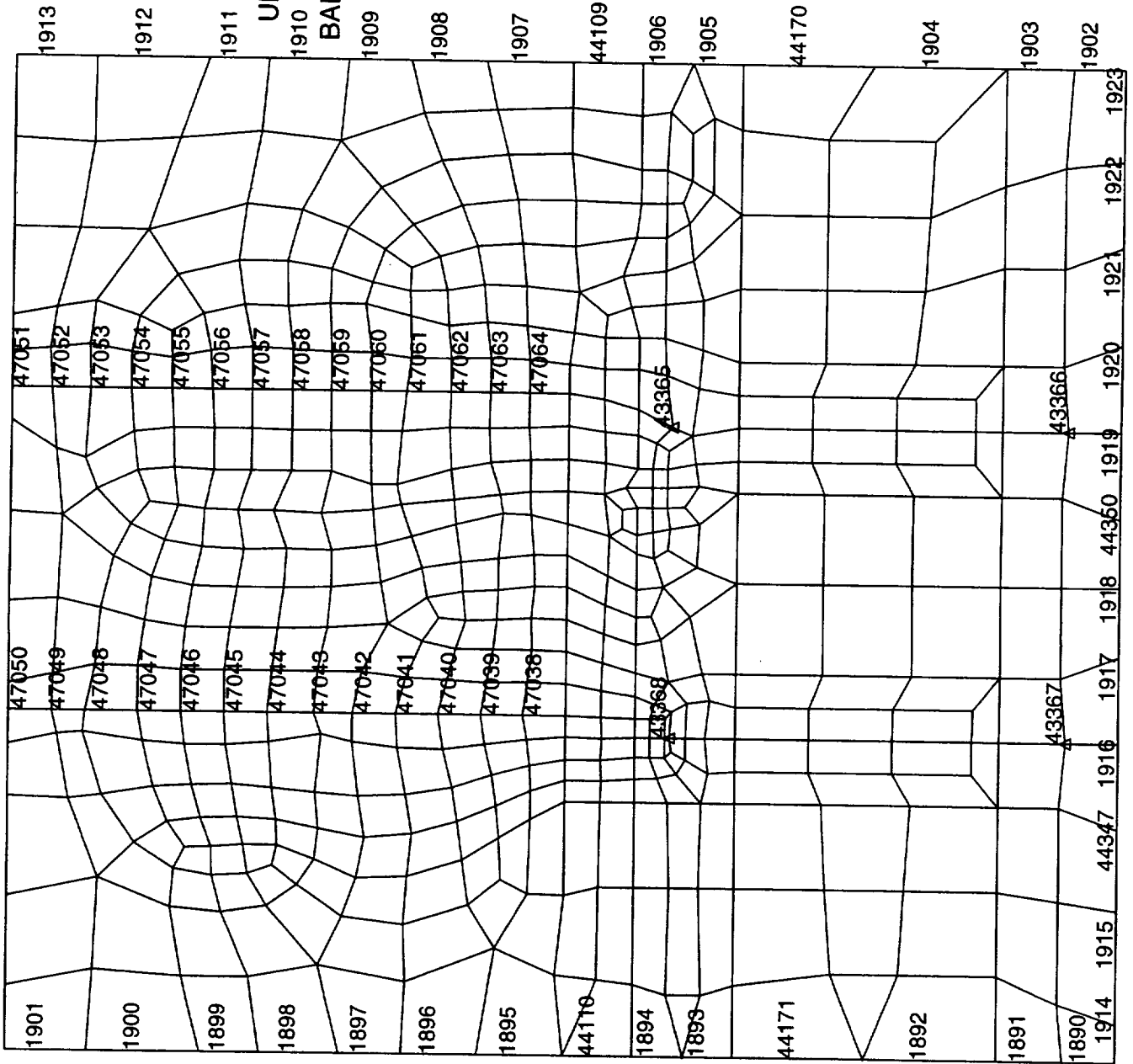
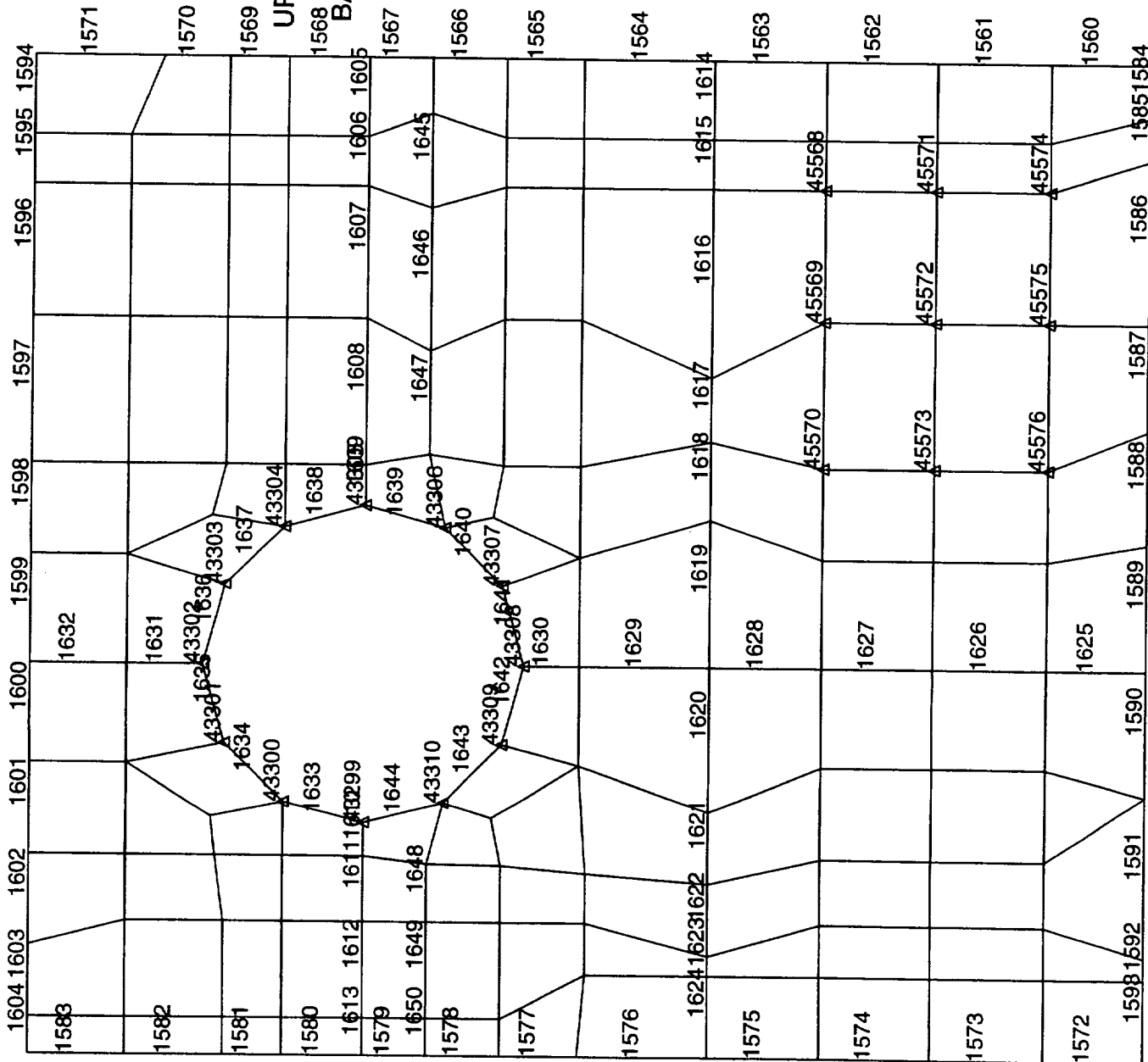


FIGURE A24
UPPER AFT PANEL
BARS, BEAMS, MASS



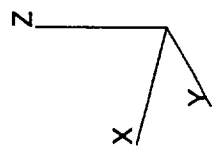
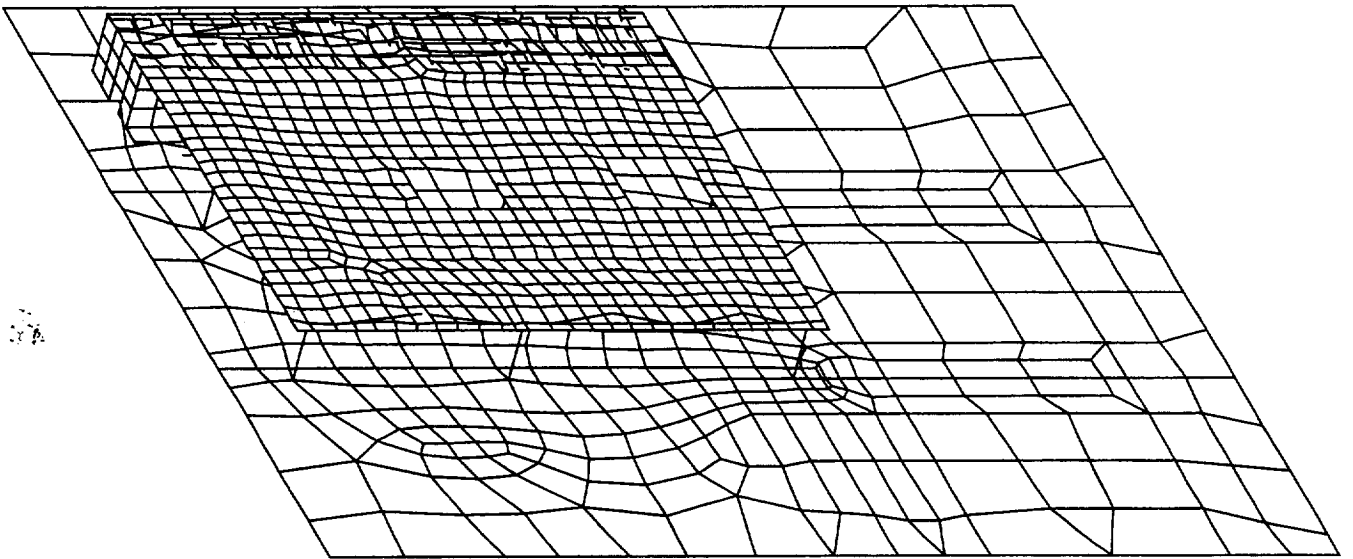
Figures A26 through A29 not re-evaluated in *Addendum 1*.

FIGURE A30
UPPER FRONT PANEL
BARS, BEAMS, MASS




Figures A31 through A57 not re-evaluated in *Addendum 1*.

FIGURE A58
UPPER AFT PANEL W/PCM



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4. TITLE AND SUBTITLE METSAT Advanced Microwave Sounding Unit-A2 (AMSU-A2), Stress Analysis Report, A1 Module			5. FUNDING NUMBERS NAS 5-32314	
6. AUTHOR(S) W. Ely				
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) Aerojet 1100 W. Hollyvale Azusa, CA 91702			8. PERFORMING ORGANIZATION REPORT NUMBER CDRL 113-A! 10381, Addendum 1 8 February 1996	
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			16. PRICE CODE ---	
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7. Author(s) W. Ely		8. Performing Organization Report No. 10381, Addendum 1	10. Work Unit No. ---
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G - Grant	TA - Task						
PE - Program Element	WU - Work Unit Accession No.						

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