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Addendum 1
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Earth Observing System (EOS)/ Advanced Microwave Sounding Unit-A (AMSU-A) Stress Analysis Report, A1 Module

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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 "3σ" 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
	Aerojet Reports
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:

$Q = 1/[2(c/c_c)]$ c/c_c = 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 "3σ" 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 "3σ" 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 "3σ" 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 "3σ" 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	1356626-1	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	100000000		0.00001
X-STRESS @ 2 SIGMA		6876	7161	100000000		0.00007
X-STRESS @ 1 SIGMA		3438	17707.2	100000000		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	100000000		0.00015
Z-STRESS @ 3 SIGMA		9174	1528.2	100000000		0.00002
Z-STRESS @ 2 SIGMA		6116	9339	100000000		0.00009
Z-STRESS @ 1 SIGMA		3058	23092.8	100000000		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	Fty	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

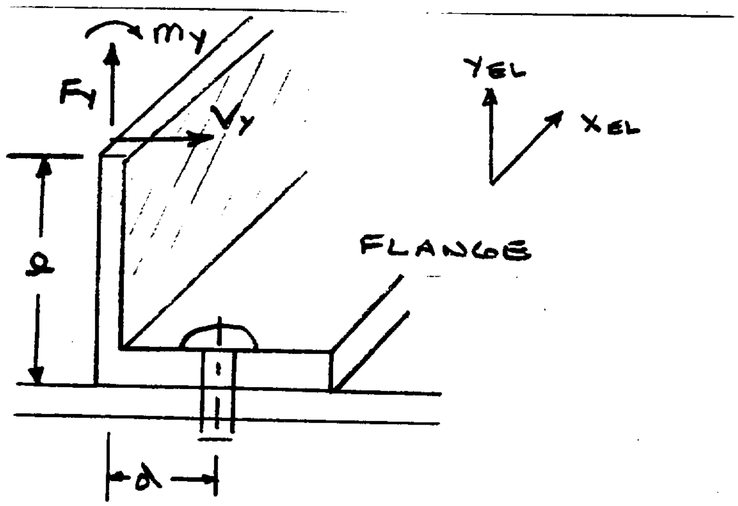
COMPONENT	PART NO.	TYPE	MAT'RL	FLANGE	Ftu PSI	LENGTH IN	NO. BOLTS	FORCE LB/IN	STRESS PSI	FS	MS
UPPER RIGHT FRONT SUPPORT	1331390	NAS1352N06	ALLOY STEEL	LOWER	160000	6.5	3	86.4	20605	1.4	4.55
		NAS1352N06	ALLOY STEEL	AFT	160000	6.2	3	70.65	16072	1.4	6.11
LOWER AFT PANEL	1331652	NAS1352N06	ALLOY STEEL	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/ Q = 7.1 "IT" LOADS

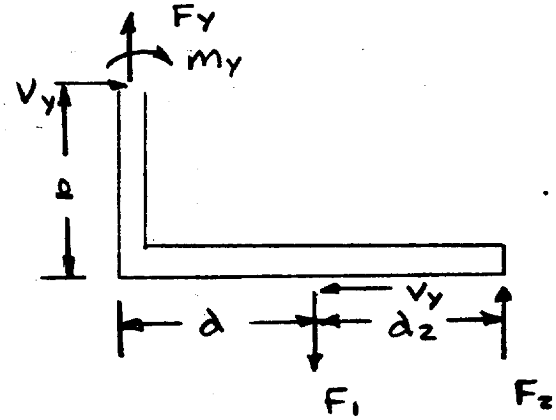
EL →	2589	2590	2591	2592	$\boxed{2593}$	
Fx	4.621	3.734	3.959	3.112	2.596	LB/IN
→ Fy	1.098	4.039	1.110	2.190	13.932	"
Fxy	4.641	4.917	5.086	4.390	4.710	"
Mx	.02107	.04215	.03439	.0886	.03597	IN-LB/IN
→ My	.03663	.1092	.1479	.2007	.1321	"
Mxy	.00616	.01483	.01294	.00854	.01441	"
Vx	.03292	.01364	.00332	.01937	.01848	LB/IN
→ Vy	.05388	.10674	.1473	.1981	.2623	"

Fy = 13.932 LB/IN
My = .1321 IN-LB/IN @ EL 2593 CENTROID
Vy = .2623 LB/IN



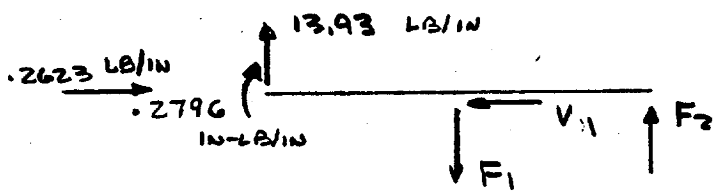
$d = .313$
$\ell = 1.125/2$ TO EL 2593 CENTROID

FLANGE STRESSES



F_y = 13.93 LB/IN
M_y = .1321 IN-LB/IN
V_y = .2623 LB/IN

t = .075 ± .010 FLANGE
l = 1.125/2
d = .313
d_2 = .312

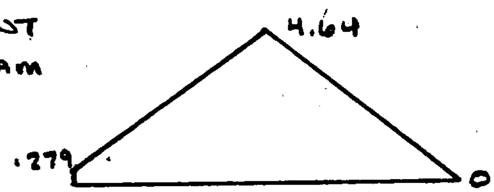


$\Sigma M_2 = 0$ $\quad F_1(.312) = .2796 + 13.93(.625)$

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

F_2 = 14.87 LB/IN

MOMENT
DIAGRAM



FLANGE TENSION (MEMBRANE + BENDING)
@ t_{min} = .065

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

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

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

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

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

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

CHECK RANDOM X w/ Q=7.1 1σ 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 1σ 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 "3σ LOADS"

BOLT STRESSES

AT BOLT LINE

$F = F_1 = 28.80$ LB/IN
$V = V_1 = .26$ LB/IN

3 NAS1352N06-6 SCREWS IN 6.500 IN

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

TOTAL LOAD/BOLT

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

"1T LOADS"

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

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

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

$D = .138$
$n = 32$

FS = 1.4

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

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

$$f_s = \sim 0$$

$$R_t \sim 1.0$$

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

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

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

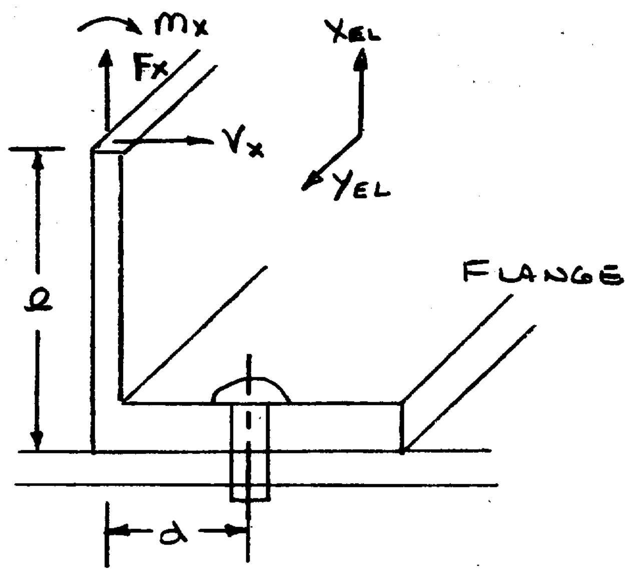
∴ BOLTS OK ON LOWER FLANGE
USING "3T LOADS"

UPPER RIGHT FRONT SUPPORT PANEL AFT FLANGE

RANDOM Y w/ Q = 7.1 "1σ LOADS"

EL →	2589	2594	2599	$\boxed{2604}$	2609	
➔ Fx	4.621	.862	.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	"

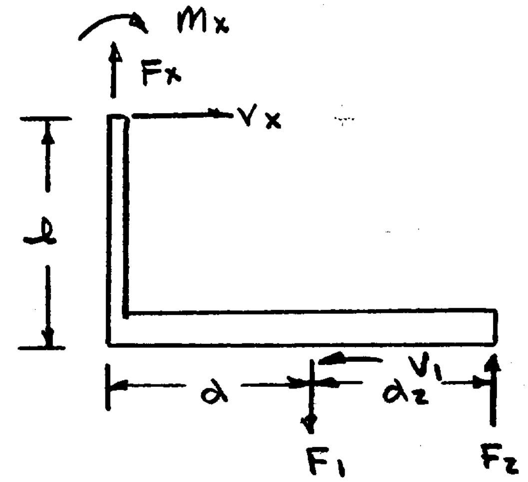
Fx = 6.816 LB/IN
Mx = .0680 IN-LB/IN   @ EL 2604 CENTROID
Vx = .0681 LB/IN



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

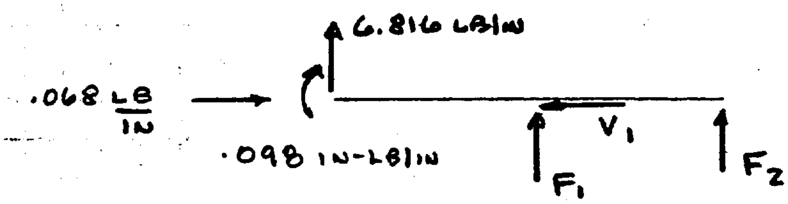
FLANGE STRESSES



$F_x = 6.816$ LB/IN
$M_x = .0680$ IN-LB/IN
$V_x = .0681$ LB/IN

$t = .065$ MIN FLANGE

$l = .870/2$
$d = .312$
$d_2 = .313$



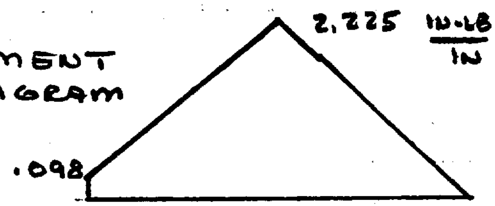
$\Sigma M_2 = 0 \qquad F_1(.313) = .098 + 6.816(.625)$

$F_1 = 13.92$ LB/IN

$F_2 = 7.11$ LB/IN

$V_1 = .07$ LB/IN

MOMENT DIAGRAM



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

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

$$= 3\left[1 + 3160\right]$$

$$= 9482 \text{ psi}$$

$$MS = \frac{F_{ty}}{1.25 \times S_t} - 1 \qquad F_{ty} = 35000 \text{ psi}$$

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

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

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

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

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

$\therefore$ <u>t=.065 FLANGE OK</u>

<u>USING "3T LOADS"</u>

CHECK RANDOM X w/ Q=7.1 1T LOADS

EL	2589	2594	2599	2604	$\boxed{2609}$	
Fx	2.509	.741	.914	1.212	11.718	LB/IN
Mx	.0187	.0527	.0706	.0684	.0326	IN-LB/IN
Vx	.0227	.0501	.0658	.0597	.0333	LB/IN

CHECK RANDOM Z w/ Q=7.1 1T LOADS

EL	2589	2594	2599	2604	2609	
Fx	1.425	.235	.833	3.688	4.290	LB/IN
Mx	.0166	.0495	.0730	.0626	.0272	IN-LB/IN
Vx	.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 LB/IN
M_x = .0326 IN-LB/IN
V_x = .0333 LB/IN

$$F_1 = [.0326 + (.870/2)(.0333) + 11.718(.625)]/.313$$
$$= 23.55 \text{ LB/IN}$$

F_2 = 11.83 LB/IN

V_1 = .033 LB/IN

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

$$S_t = 3\left[\frac{.033}{.065} + \frac{3{,}703\ (.065/2)}{(.065)^3/12}\right]$$

3T STRESS

$$= 3\left[1 + 5259\right]$$

$$= 15777 \text{ psi}$$

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

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

$$MS = \frac{42000}{1.4 \times 15177} - 1 = +.98$$

3T STRESS

$\therefore$ t=.065 AFT FLANGE OK

USING "3T LOADS"

BOLT STRESSES

AT BOLT LINE

$F = F_1 = 23.55$ LB/IN
$V = V_1 = .033$ LB/IN

3 SCREWS IN 6.200 IN LENGTH

TOTAL LOAD/SCREW

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

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

"1T LOADS"

$$S_t = (3)\frac{F_B}{A_s} = (3)\frac{48.67}{.009085}$$

"3T STRESS"

$$= 16072 \text{ psi}$$

$FS = 1.4$

$f_t = 1.4 \times S_t = 22500$ psi

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

$R_t \sim 1.0$

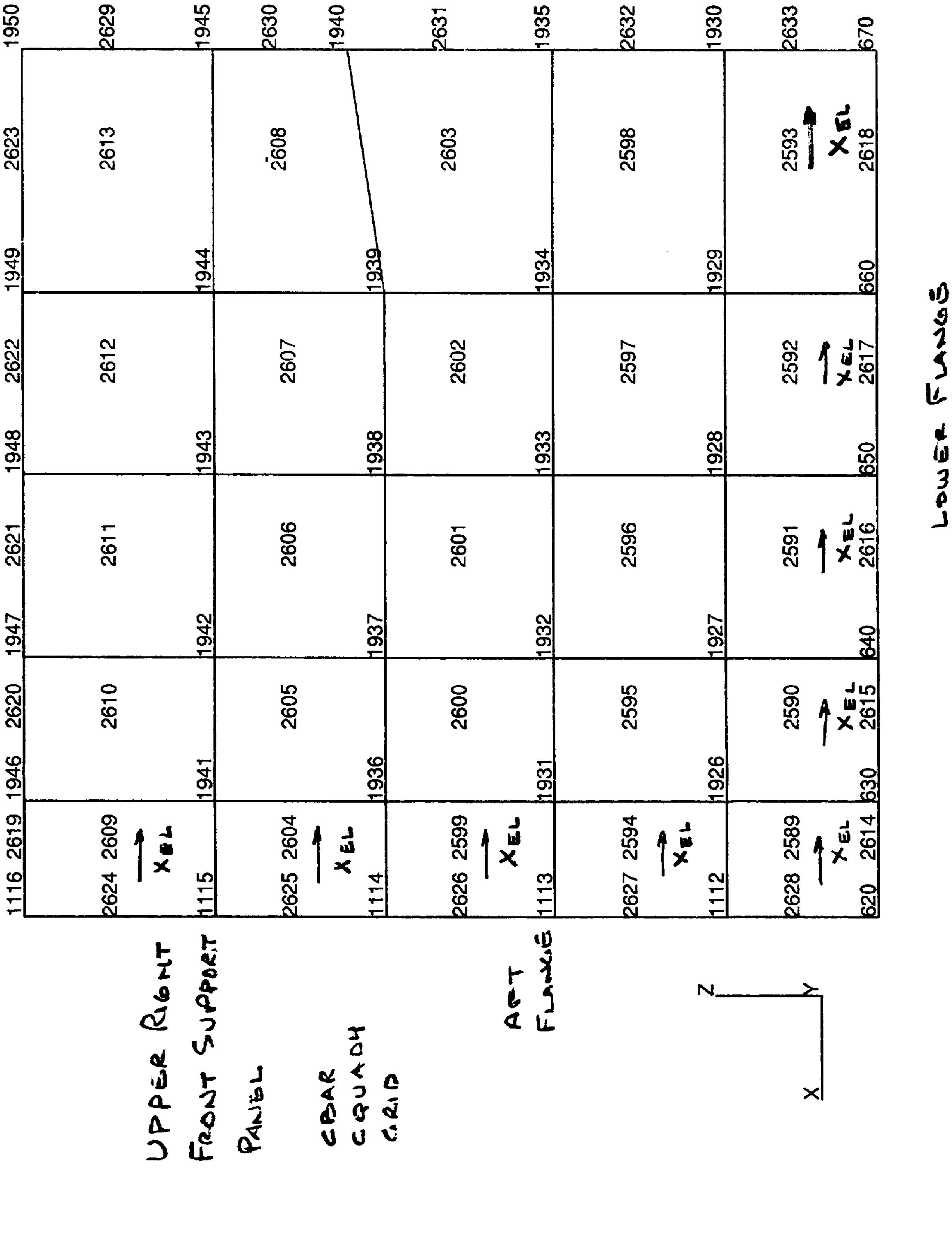
$$r_t = \frac{22500}{160000} = .141$$

$$u = \frac{r_t}{R_t} = .141$$

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

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

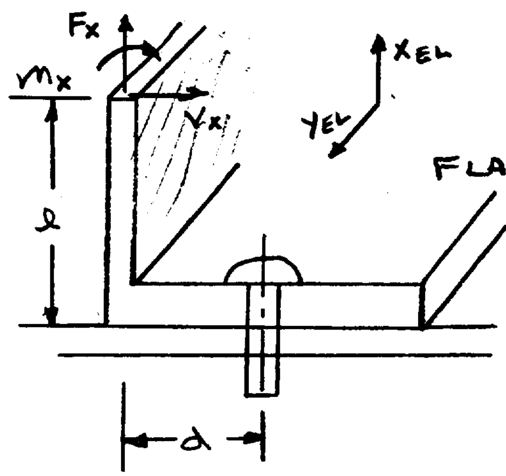
∴ BOLTS OK ON AFT FLANGE
USING 3T LOADS


UPPER RIGHT
FRONT SUPPORT
PANEL
CBAR
CQUAD4
GRID
AFT
FLANGE
LOWER FLANGE
X EL
Z
Y
X

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

EL	$\boxed{575}$	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	"

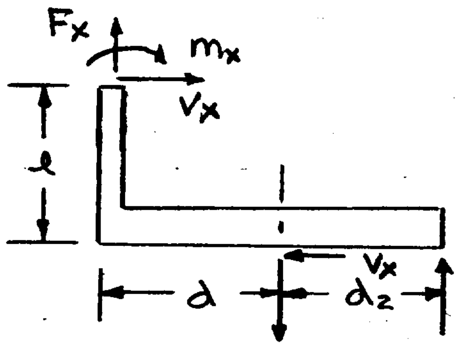
Fx = 118.6 LB/IN
Mx = .2462 IN-LB/IN   @ EL 575 CENTROID
Vx = .6860 LB/IN



d = .312
l = 1.131/2 TO
EL 575 CENTROID

FLANGE LENGTH   11.188 - .625 = 10.563 IN
BOLTS   8   NAS 1352 N 06-6
.138-32 UNCR-3A
HEAT-RESISTANT STEEL
W/ Ftu = 160000 PSI

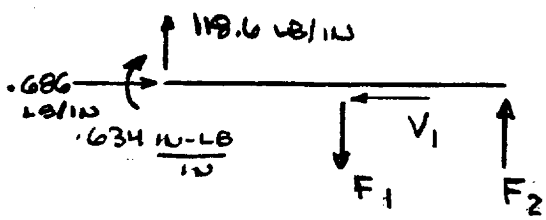
FLANGE STRESSES



$F_x = 118.6$ LB/IN
$m_x = .2462$ IN-LB/IN
$V_x = .686$ LB/IN

$t = .050$ FLANGE MIN t

$l = 1.131/2$
$d = .312$
$d_2 = .313$

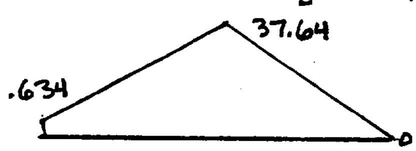


$\Sigma M_2 = 0$ $\qquad F_1\,(.313) = .634 + 118.6(.625)$

$F_1 = 238.8$ LB/IN $\qquad V_1 = .686$ LB/IN

$F_2 = F_1 - 118.6 = 120.2$ LB/IN

MOMENT DIAGRAM



$M_1 = 37.64$ IN-LB/IN

FLANGE TENSION (MEMBRANE + BENDING)

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

$$= 3\left[14 + 90330\right]$$

$$= 271028 \text{ PSI}$$

$$MS = \frac{F_{ty}}{1.25 \times S_t} - 1 \qquad F_{ty} = 35000 \text{ PSI} \quad \text{ALUM 6061 T651}$$

$$= \frac{35000}{(1.25)(271028)} - 1 = -.90 \quad \text{"3T LOADS"}$$

$$ms = \frac{F_{TU}}{1.4 \times S_t} - 1 \qquad F_{tu} = 42000 \text{ psi} \qquad \text{ALUM 6061-T651}$$

$$= \frac{42000}{1.4(27102\text{8})} - 1 = -.89$$

CONSIDERABLY OVERSTRESSED

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

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

$$= 3\left[4 + 8822\right] \qquad \text{3T LOADS}$$

$$= 26476 \text{ psi}$$

$$ms = \frac{35000}{1.25(26476)} - 1 = +.06 \qquad t = .160$$

$$ms = \frac{42000}{1.4(26476)} - 1 = +.13 \qquad t = .160$$

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

TRY 2024-T851 MAT'RL

F_{TY} = 58000 psi
F_{TU} = 66000 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

$$= 3\left[5 + 14453\right]$$

$$= 43374 \text{ psi}$$

$$MS = \frac{58000}{1.25(43374)} - 1 = +.07 \qquad t = .125$$

$$MS = \frac{66000}{1.4(43374)} - 1 = +.09 \qquad t = .125$$

∴ RAISE LOWER FLANGE t TO .125
USING "3T LOADS" & 2024-T851

BOLT STRESSES

AT BOLT LINE

$F = F_1 = 238.8$ LB/IN

$V = V_1 = .686$ LB/IN

8 BOLTS IN 10.563 IN

TOTAL LOAD/BOLT

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

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

"1T LOADS"

AT 3T LOADS

$$S_t = 3\frac{F_B}{A_S} = \frac{(3)(315.3)}{(.009085)} = 104\,119 \text{ psi}$$

$$S_S = 3\frac{V_B}{A_S} = 300 \text{ psi}$$

WITH FS=1.4

$f_t = 1.4 \times S_t = 145767$ psi

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

$f_S \rightarrow 0$

$R_t \sim 1.0$

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

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

WORST LOADED SCREW
LOWER AFT PANEL
LOWER FLANGE
3T LOADS

$\therefore$ BOLTS OK ON LOWER FLANGE
USING 3T LOADS

CHECK RANDOM X W/Q=7.1 1 T LOADS

EL	575	485	565	
Fx	52.82	38.07	27.41	LB/IN
Mx	.1612	.1444	.2315	IN-LB/IN
Vx	.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	
Fx	52.01	18.81	20.57	LB/IN
Mx	.1332	.0796	.2137	IN-LB/IN
Vx	.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 σ 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	.0369	.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 σ LOADS

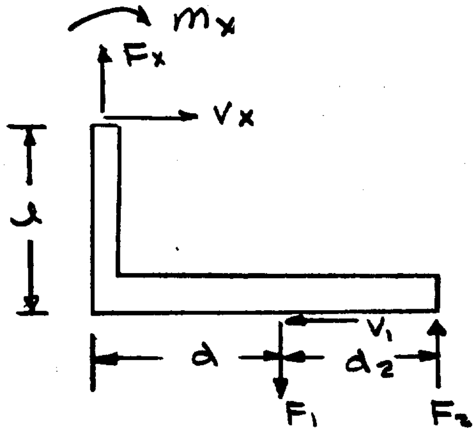
EL	584	574	$\boxed{494}$	504	
Fx	29.08	15.16	35.24	12.09	LB/IN
Fy	7.19	3.98	8.71	2.45	"
Fxy	7.96	7.53	4.00	6.80	"
Mx	.1832	.2635	.1548	.2691	IN-LB/IN
My	.0381	.0773	.0288	.1058	"
Mxy	.0470	.0583	.0426	.0779	"
Vx	.7046	.4163	.2452	.2856	LB/IN
Vy	.1224	.1897	.0763	.0891	"

RANDOM Z W/ Q=7.1 1 σ 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	3.84	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

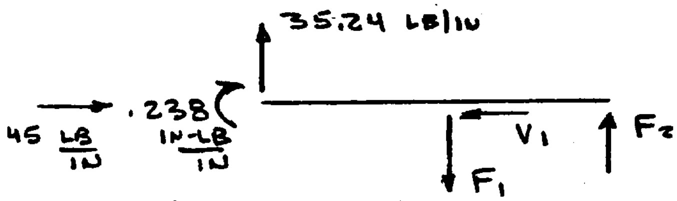


$F_x = 35.24$ LB/IN
$M_x = .1548$ IN-LB/IN
$V_x = .2452$ LB/IN

$t = .050$ FLANGE MIN t

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

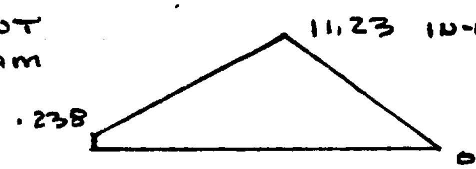
6 SCREWS IN 8.498 INCHES



$\Sigma M_2 = 0 \qquad F_1(.313) = .238 + 35.24(.625)$

$F_1 = 71.13$ LB/IN
$F_2 = 35.89$ LB/IN
$V_1 = .245$ LB/IN

MOMENT
DIAGRAM



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

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

$$= 3\left[5 + 26952\right]$$

$$= 80871 \text{ psi}$$

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

6061-T651
ALUM

$$MS = \frac{F_{su}}{1.4 \times S_t} - 1 = \frac{42000}{1.4\,(80871)} - 1 = -.63$$

6061-T651
ALUM

$\therefore$ UPPER FLANGE BAD @ $t = .055$

RAISE FLANGE MIN t TO .085 IN

$$S_t = 3\left[\frac{.245}{.085} + \frac{6\,(11.23)}{(.085)^2}\right]$$

$$= 3\left[3 + 9326\right]$$

3 ⊈ LOADS

$$= 27987 \text{ PSI}$$

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

$t = .085$

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

$t = .085$

$\therefore$ RAISE UPPER FLANGE t TO .085 MIN
USING 3 ⊈ LOADS

TRY 2024-T851

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

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

$$= 3\left[4 + 13751\right] \qquad \text{3T LOADS}$$

$$= 41264 \text{ psi}$$

$$MS = \frac{58000}{1.25(41264)} - 1 = +.12 \qquad t = .070$$

$$MS = \frac{66000}{1.4(41264)} - 1 = +.14 \qquad t = .070$$

$\therefore$ RAISE UPPER FLANGE t TO .070
USING 3T LOADS & 2024-T851

BOLT STRESSES

AT BOLT LINE

$F = F_1 = 71.13$ LB/IN
$V = V_1 = .245$ 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

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

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

$$f_s \Rightarrow 0$$

$$R_t \sim 1.0$$

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

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

WORST LOADED SCREW
LOWER AFT PANEL
UPPER FLANGE
3 T LOADS

∴ BOLTS OK ON UPPER FLANGE
USING 3 T LOADS

LOWER AFT PANEL - RIGHT FLANGE

RANDOM Y w/ Q=7.1 1 σ LOADS

EL	$\boxed{575}$	576	584	583	
Fy	34.32	3.051	4.12	1.25	LB/IN
My	.0587	.1880	.0369	.0624	IN-LB/IN
Vy	.4446	.4108	.0768	.1904	LB/IN

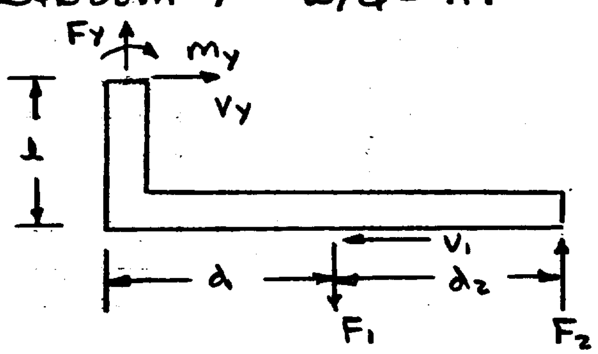
RANDOM X w/ Q=7.1 1 σ LOADS

EL	575	576	584	583	
Fy	13.26	.930	7.19	2.31	LB/IN
My	.0258	.1484	.0381	.1056	IN-LB/IN
Vy	.0302	.3042	.1224	.3321	LB/IN

RANDOM Z w/ Q=7.1 1 σ LOADS

EL	575	576	584	583	
Fy	20.48	1.54	3.86	.863	LB/IN
My	.0515	.0978	.0168	.0836	IN-LB/IN
Vy	.2260	.2551	.2010	.1588	LB/IN

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

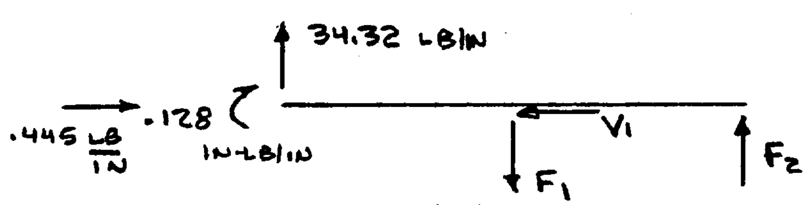


$F_y = 34.32$ LB/IN
$M_y = .0587$ IN-LB/IN
$V_y = .4446$ LB/IN

t = .050 FLANGE MINIMUM

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

7 SCREWS IN 8.77 IN

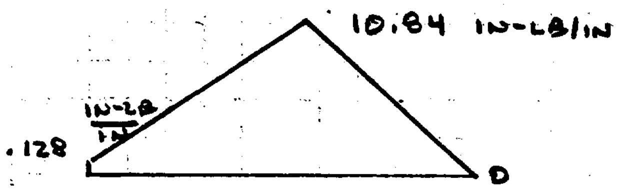


$\Sigma M_z = 0 \qquad F_1(.313) = .128 + 34.32(.625)$

$F_1 = 68.94$ LB/IN

$F_2 = 34.62$ LB/IN

$V_1 = .445$ LB/IN



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

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

$$= 3\left[9 + 26016\right] \qquad 3\,\text{T LOADS}$$

$$= 78075 \text{ PSI}$$

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

$$= \frac{35000}{1.25(78075)} - 1 = -.64 \qquad \text{6061-T651 ALUM}$$

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

$$= \frac{42000}{1.4(78075)} - 1 = -.62 \qquad \text{6061-T651 ALUM}$$

∴ <u>RIGHT FLANGE BAD @ t=.050</u>

RAISE FLANGE MIN t TO .085 IN

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

$$= 27022 \text{ psi}$$

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

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

∴ <u>RAISE RIGHT FLANGE t TO .085 MIN</u>
<u>USING 3T LOADS</u>

<u>2024-T851</u>

USE t MIN OF .070 IN

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

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

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

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

BOLT STRESSES

AT BOLT LINE

$F = F_1 = 68.94$ LB/IN
$V = V_1 = .445$ 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 3T LOADS

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

$$S_S = \frac{3V_B}{A_S} = 184 \text{ psi}$$

WITH FS = 1.4

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

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

$$f_s \approx 0$$

$$R_t \sim 1.0$$

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

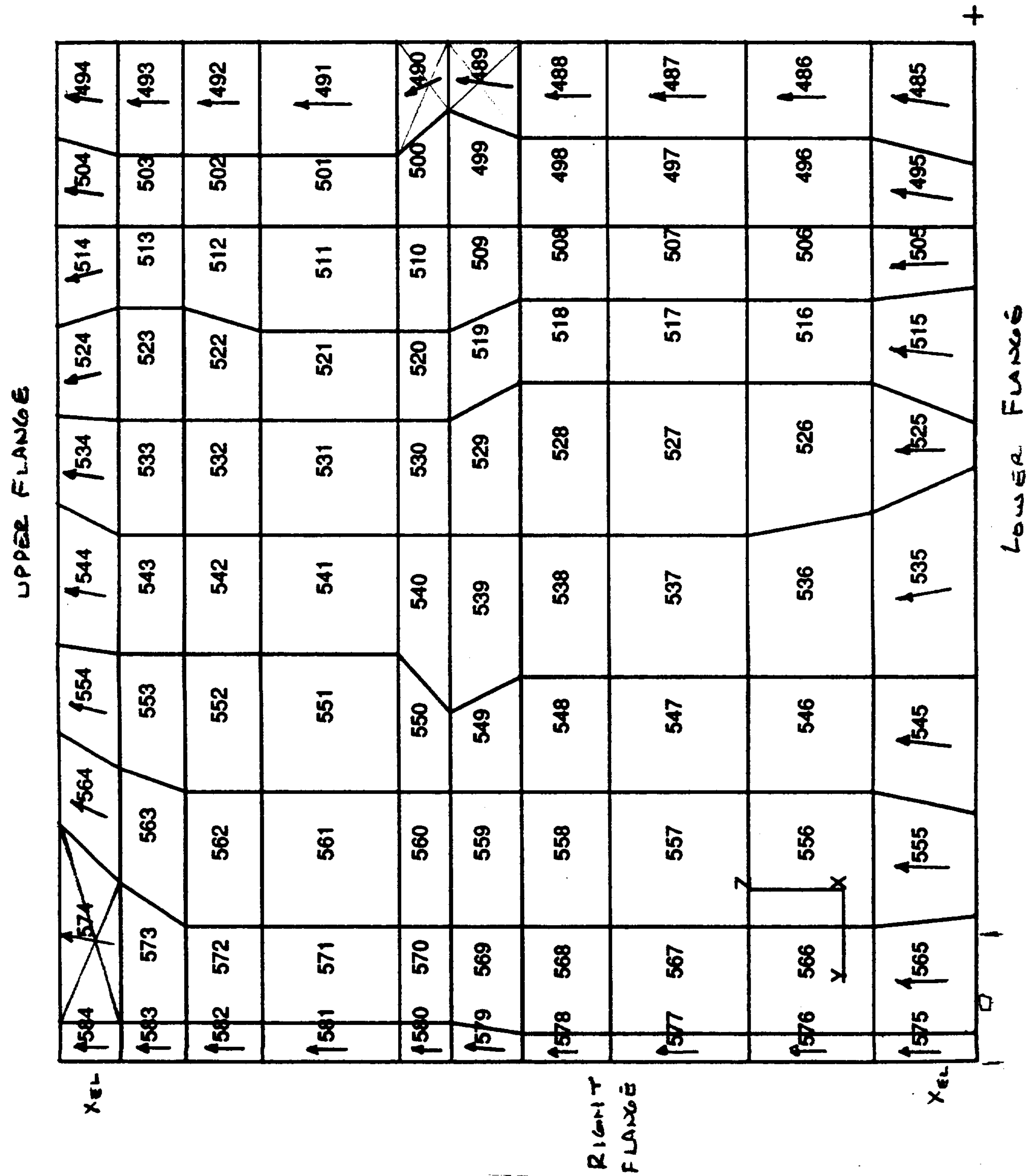
$$MS = \frac{1}{u} - 1 = +3.0$$

WORST LOADED SCREW
LOWER AFT PANEL
RIGHT FLANGE
3T LOADS

∴ BOLTS OK ON RIGHT FLANGE USING 3T LOADS

LOWER AFT PANEL

QUAD, TRI



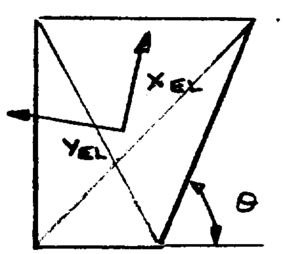
LOWER RIGHT PANEL – LOWER FLANGE

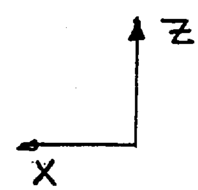
RANDOM Y W/ Q = 7.1 1T LOADS

EL	630	760	
F_x	46.95	38.80	LB/IN
F_y	15.03	3.41	"
F_{xy}	3.13	4.40	"
M_x	.0463	.0615	IN-LB/IN
M_y	.0346	.0675	"
M_{xy}	.0241	.0133	"
V_x	.215	.274	LB/IN
V_y	.457	.115	"

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

EL 630





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

$$\theta = 68.8^\circ$$

X_{EL} SKEWED +10.6°

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

$$= \frac{46.95+15.03}{2} + \frac{46.95-15.03}{2}\cos[2(10.6)] + 3.13\sin[2(10.6)]$$

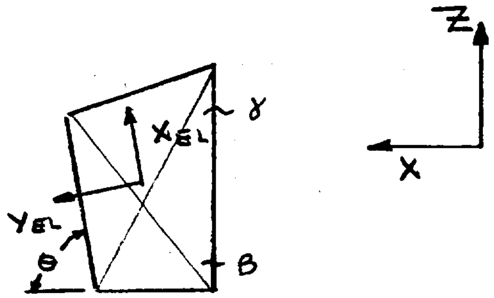
$$= 47.00 \text{ LB/IN}$$

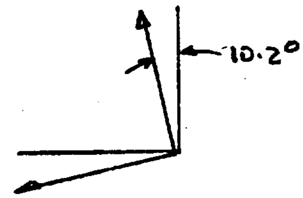
LIKEWISE $M_x' = .055$ IN-LB/IN

EL 760

$\measuredangle\ \gamma = 12.0°$
$\measuredangle\ \beta = 32.4°$

X_{EL} @ $32.4° - \left(\frac{12.0+32.4}{2}\right) = 10.2°$





FOR $\theta = -10.2°$

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

$= 36.16$ LB/IN

$m_x' = .065$ IN-LB/IN

RANDOM Y w/ Q = 7.1 1 σ 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 σ 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

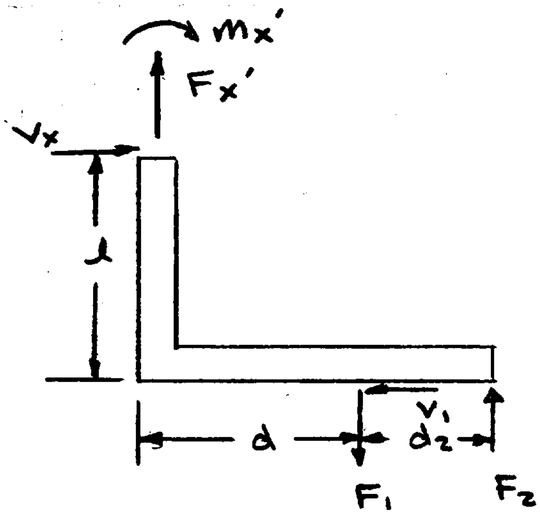
RANDOM Z w/ Q = 7.1

EL	630	760	1 σ LOADS
F_x'	26.47	21.98	LB/IN
m_x'	.0142	.0206	IN-LB/IN
V_x	.137	.0521	LB/IN

WORST CASE RANDOM Y @ EL 630

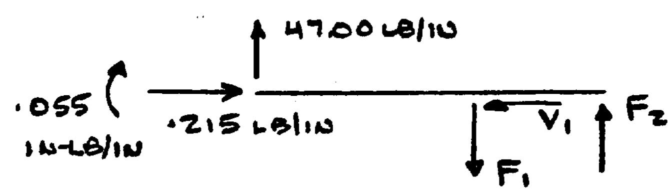
$F_x' = 47.00$ LB/IN
$m_x' = .055$ IN-LB/IN
$V_x = .215$ LB/IN

FLANGE STRESSES



$l = 1.331/2$
$d = .312$
$d_2 = .250$

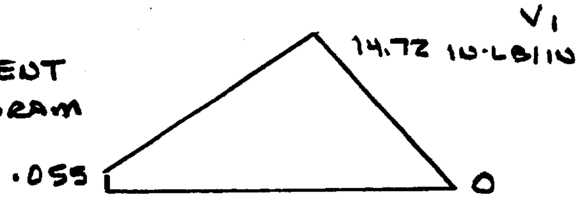
$t = .040$ FLANGE MIN t



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

$F_1 = 105.88$ LB/IN
$F_2 = 58.88$ LB/IN
$V_1 = .215$ LB/IN

MOMENT DIAGRAM



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

$$S_t = 3\left[\frac{V_1}{t} + \frac{6 m_1}{t^2}\right] = 3\left[\frac{.215}{.040} + \frac{6(14.72)}{(.040)^2}\right]$$

$$= 3\left[5 + 55200\right]$$

$$= 165616 \text{ psi}$$

3 σ LOADS

MAT'RL 6061-T651 $F_{TY} = 35000$ psi
$F_{TU} = 42000$ psi

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

$$= \frac{35000}{1.25(165616)} - 1 = -.83$$

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

$$= \frac{42000}{1.4(165616)} - 1 = -.82$$

OVERSTRESSED

RAISE FLANGE TO $t = .100$

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

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

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

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

$\therefore$ RAISE LOWER FLANGE TO $t = .100$ MIN

USING 3σ LOADS

BOLT STRESSES

AT BOLT

$F = F_1 = 105.88$ LB/IN

$V = V_1 = .215$ LB/IN

15 BOLTS IN 19.29 INCHES

TOTAL LOAD / BOLT

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

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

1σ LOADS

BOLTS ARE NAS1352N06-6 , $F_{TU} = 160000$ PSI

$$S_t = 3\frac{F_B}{A_S} = 3\,\frac{136.2}{.009085} = 44963 \text{ PSI}$$

3σ LOADS

$$S_S = 3\frac{V_B}{A_S} = 3\,\frac{.28}{.009085} = 96 \text{ PSI}$$

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

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

$$S_S = 1.4 \times 96 = 134 \text{ PSI}$$

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

$$R_t \sim 1.0$$

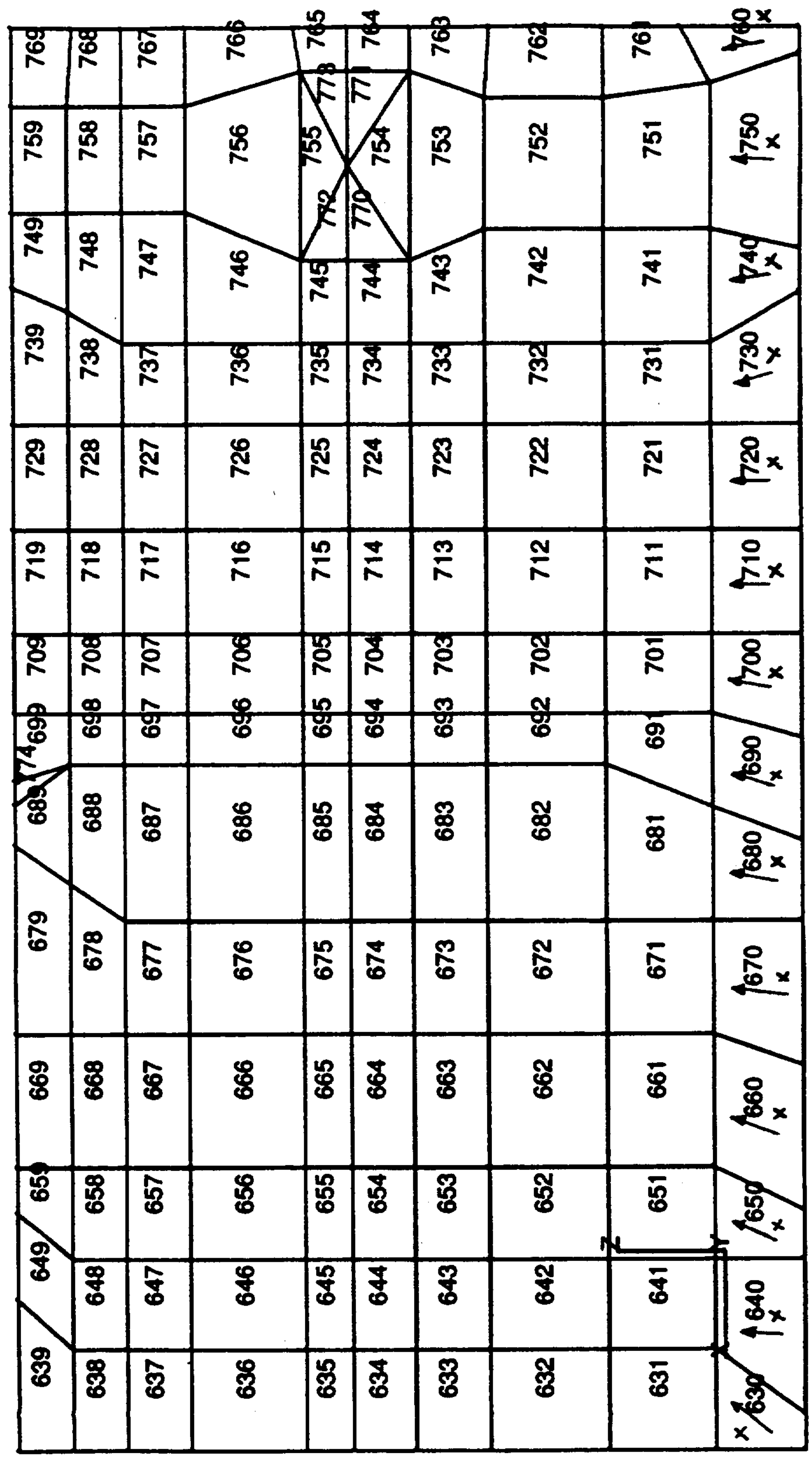
$$U = \frac{r_t}{R_t} = .393$$

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

WORST LOADED BOLT
LOWER RIGHT PANEL
LOWER FLANGE
3σ LOADS

∴ **BOLTS OK ON LOWER FLANGE**
USING 3σ LOADS

LOWER RIGHT PANEL - QUAD, TRI



UPPER FRONT PANEL - LOWER FLANGE

RANDOM Y w/ Q = 7.1 1 σ LOADS

EL	$\boxed{1652}$	$\boxed{1688}$	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	4.032	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 σ LOADS

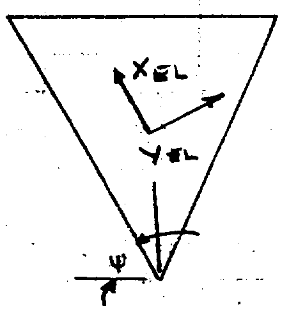
EL	1652	1688	1772	
Fx	8.903	4.143	3.228	LB/IN
Fy	2.235	4.422	.633	"
Fxy	6.105	2.256	4.193	"
Mx	.0179	.0405	.0256	IN-LB/IN
My	.0177	.0497	.0330	"
Mxy	.0189	.0223	.0165	"
Vx	.0367	.0688	.0243	LB/IN
Vy	.2350	.1797	.0733	"

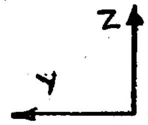
RANDOM Z w/ Q = 7.1 1 σ LOADS

EL	1652	1688	1772	
Fx	5.525	4.268	4.607	LB/IN
Fy	1.698	5.029	1.600	"
Fxy	7.991	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 @ EL1652 WORST LOCATION. EL1688 HAS SKEWED "ELEMENT X & Y" DIRECTIONS. ROTATING COMPONENTS TO HAVE "ELEM X" NORMAL TO LOWER FLANGE IS LESS SEVERE THAN EL1652

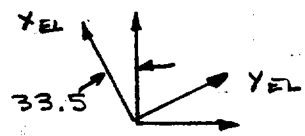
EL1688





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

$$\psi = 56.5^\circ$$
$$90-\psi = 33.5^\circ$$



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

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

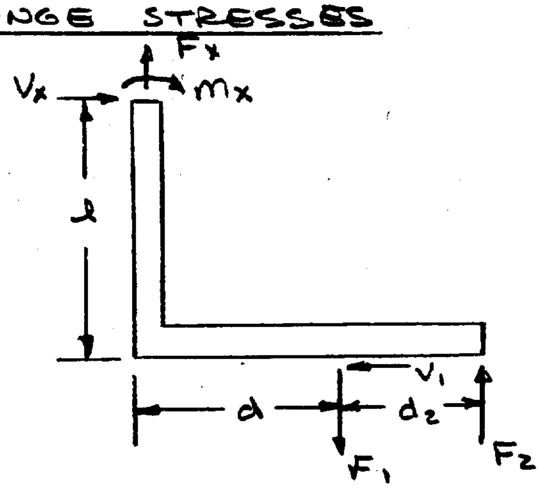
$$= 13.887 + (-1.326)(.3907) + (4.032)(-.9205) = 9.657 \text{ LB/IN}$$

∴ EL 1652 WORST CASE

EL 1652

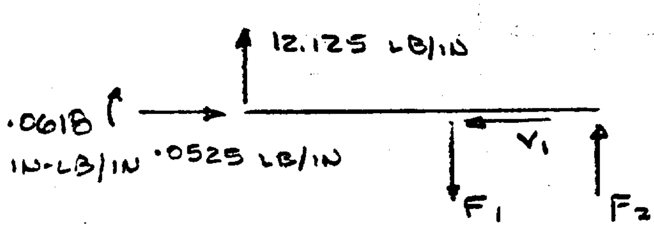
$F_x = 12.125$ LB/IN
$M_x = .0323$ IN-LB/IN
$V_x = .0525$ LB/IN

FLANGE STRESSES



$l = 1.125/2$
$d = .312$
$d_2 = .313$

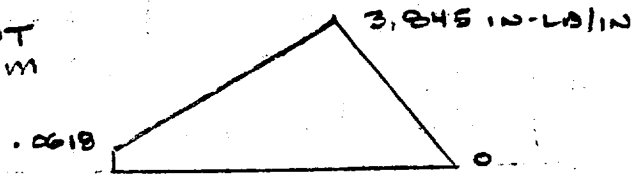
$t = .040$ FLANGE MINIMUM



$\Sigma M_2 = 0$

$F_1(.313) = 12.125(.625) + .0618$
$= 24.409$ LB/IN
$F_2 = 12.284$ LB/IN

MOMENT DIAGRAM



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

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

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

$$= 3\left[1 + 14419\right]$$

$$= 43260 \text{ PSI}$$

MAT'RL 7075-T651 $\qquad F_{TY} = 66000$ PSI
$\qquad\qquad\qquad\qquad\qquad\qquad F_{TU} = 75000$ 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 $\quad F = F_1 = 24.409$ LB/IN

$\qquad V = V_1 = .0525$ LB/IN

7 BOLTS IN $11.200 - .625 = 10.575$ 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 NAS1352N06-6, $F_{TU} = 160000$ PSI

@ 3σ LOADS

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

3σ LOADS

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

w/ FS = 1.4

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

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

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

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

$\therefore R_t \sim 1.0$

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

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

WORST LOADED BOLT
UPPER FRONT PANEL
LOWER FLANGE

∴ <u>BOLTS OK ON LOWER FLANGE</u>
<u>USING 3σ LOADS</u>

UPPER FRONT PANEL - UPPER FLANGE

RANDOM Y w/ Q=7.1 ... 1σ LOADS

EL	1663	1783	
Fx	1.483	1.172	LB/IN
Mx	.0348	.0072	IN-LB/IN
Vx	.0102	.0061	LB/IN

RANDOM X w/ Q=7.1 1σ 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 1σ 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 3σ LOADS

∴ UPPER FLANGE BOLTS OK

MS > 8.3 ULT

PER 3σ LOADS

UPPER FRONT PANEL - RIGHT FLANGE

RANDOM Y w/ Q=7.1 1 σ LOADS

EL	1652	$\boxed{1653}$	
Fy	5.468	6.116	LB/IN
My	.0213	.0277	IN-LB/IN
Vy	.3029	.6723	LB/IN

RANDOM X w/ Q=7.1 1 σ LOADS

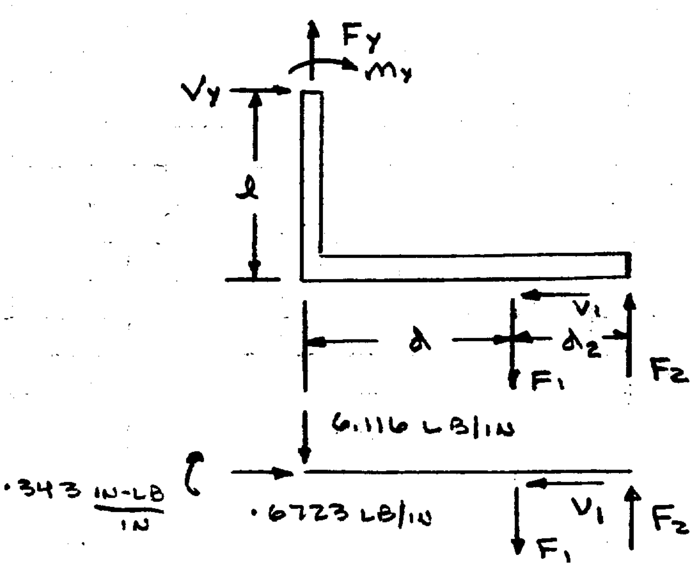
EL	1652	1653	1655	1656	
Fy	2.235	2.374	3.592	3.589	LB/IN
My	.0177	.0371	.1664	.2256	IN-LB/IN
Vy	.2350	.5163	1.081	1.711	LB/IN

RANDOM Z w/ Q=7.1 1 σ LOADS

EL	1652	1653	
Fy	1.698	2.492	LB/IN
My	.0094	.0207	IN-LB/IN
Vy	.1175	.2337	LB/IN

WORST CASE IS EL1653 RANDOM Y

F_y = 6.116 LB/IN
M_y = .0277 IN-LB/IN
V_y = .6723 LB/IN



ℓ = .937/2
d = .312
d_2 = .313

FLANGE t = .040 IN MIN

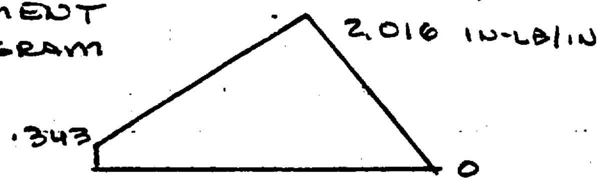
$\Sigma M_2 = 0 \qquad F_1(.313) = 6.116(.625) + .343$

$F_1 = 12.555$ LB/IN

$F_2 = 6.439$ LB/IN

$V_1 = .672$ LB/IN

MOMENT DIAGRAM



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

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

3σ LOADS

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

$= 3\left[17 + 7560\right] = 22730 \text{ psi}$

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

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

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

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

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

BOLT STRESSES

AT BOLT

$F = F_1 = 12.555$ LB/IN

$V = V_1 = .672$ LB/IN

8 BOLTS IN 12.500 − 1.000 = 11.500 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 , $F_{tu} = 160000$ PSI

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

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

3 T LOADS

$$f_t = 1.4 \times 5960 = 8345 \text{ PSI}$$

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

$$f_s = 1.4 \times 317 = 443 \text{ PSI}$$

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

$$R_t \sim 1.0$$

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

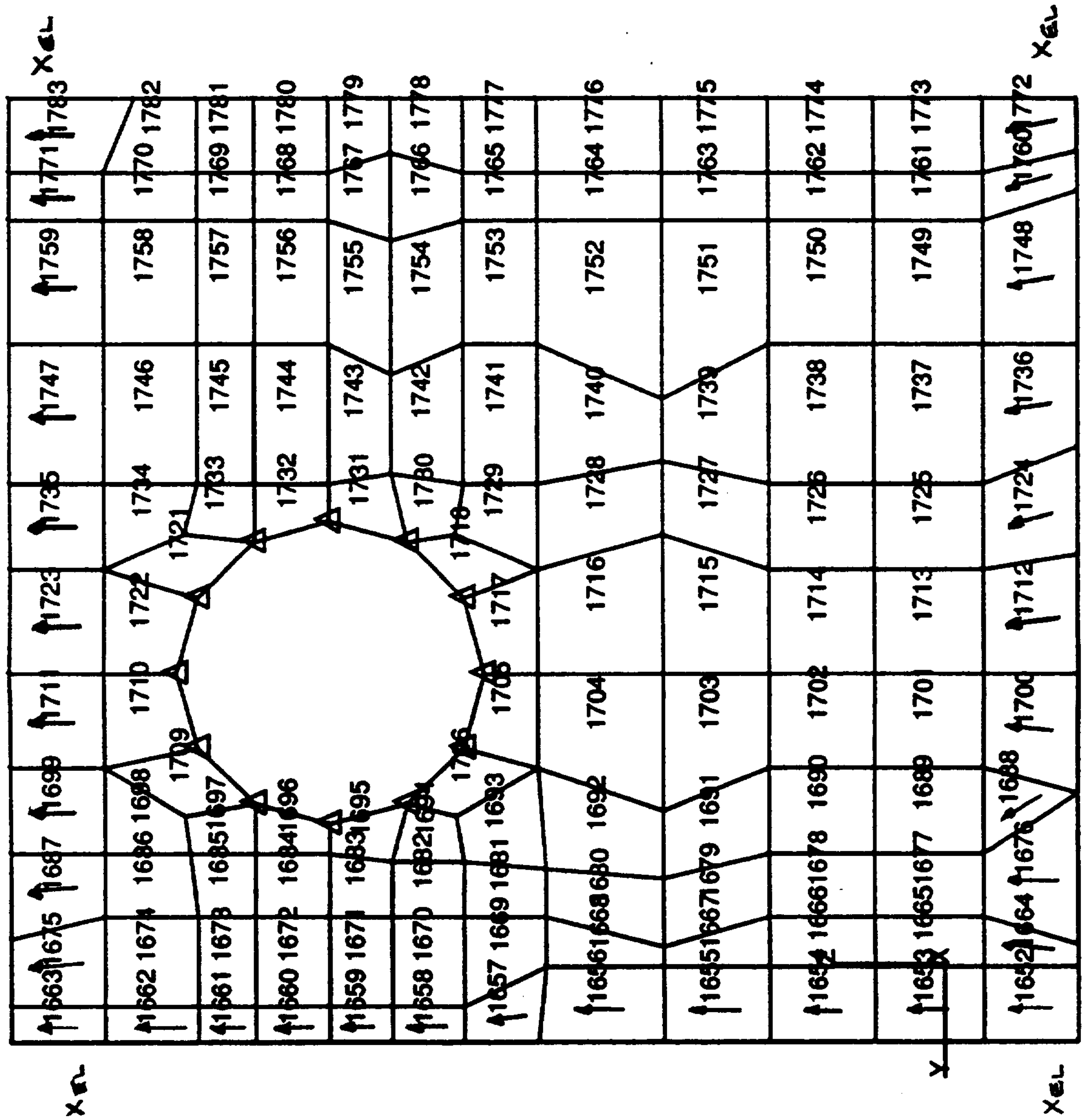
$$MS = \frac{1}{u} - 1 = +18$$

WORST LOADED BOLT
UPPER FRONT PANEL
RIGHT FLANGE
3T LOADS

∴ <u>BOLTS OK ON RIGHT FLANGE
WITH 3T LOADS</u>

UPPER FRONT PANEL

QUAD, TRI



LOWER MOTOR MOUNT PANEL - LOWER FLANGE

RANDOM Y w/ Q=7.1 1 σ LOADS

EL	2810	$\boxed{2812}$*	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

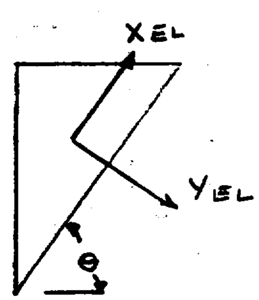
RANDOM X w/ Q=7.1 1 σ LOADS

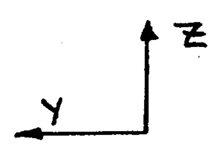
EL	2810	2811	2812*	2813	2817	
Fy	2.608	5.970	15.47	7.311	7.513	LB/IN
My	.0220	.0116	.090	.0735	.0463	IN-LB/IN
Vy	.0536	.1363	.1235	.1165	.1143	LB/IN

RANDOM Z w/ Q=7.1 1 σ 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 HAVE "ELEM X" NORMAL TO FLANGE

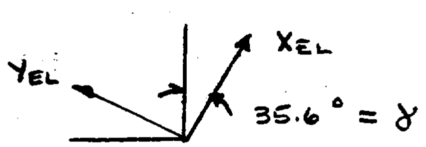




$$\tan\theta = \frac{\Delta Z}{\Delta Y} = \frac{1.131}{.811}$$

$$\theta = 54.4^\circ$$

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



RANDOM Y - EL 2812

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

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

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

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

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

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

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

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

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

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

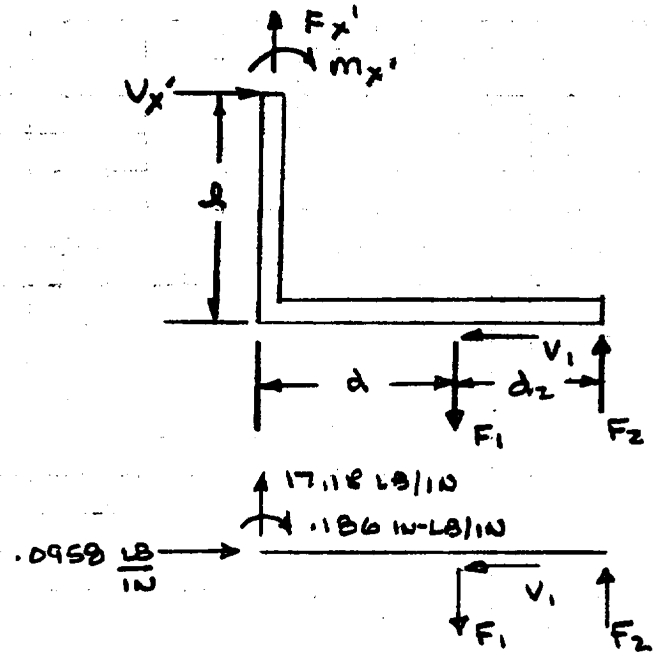
$$= .178 \text{ IN-LB/IN}$$

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

WORST CASE IS RANDOM Y @ EL 2812

$F_x' = 17.18$ LB/IN
$m_x' = .114$ IN-LB/IN
$V_x' = .0958$ LB/IN

FLANGE STRESSES



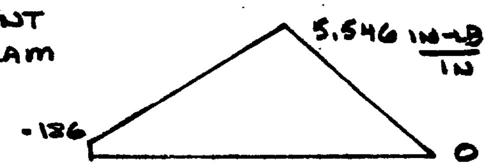
$\ell = 2/3(1.131) = .754$
$d = .312$
$d_2 = .438$

$t = .050$ FLANGE MINIMUM

$\Sigma M_2 = 0 \qquad F_1(.438) = 17.18(.750) + .186$

$F_1 = 29.84$ LB/IN
$F_2 = 12.66$ LB/IN
$V_1 = .096$ LB/IN

MOMENT DIAGRAM



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

$$S_t = 3\left[\frac{V_1}{t} + \frac{6 m_1}{t^2}\right] = 3\left[\frac{.096}{.050} + \frac{6(5.546)}{(.050)^2}\right]$$

$$= 3\left[2 + 13310\right]$$

$$= 39937 \text{ PSI}$$

3 ⊤ LOADS

MAT'RL 7075-T651

$F_{Ty} = 66000$ PSI

$F_{Tu} = 75000$ PSI

W/ FS = 1.25 LIMIT, 1.4 ULTIMATE

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

$$= \frac{60000}{1.25(39937)} - 1 = +.32$$

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

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

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

BOLT STRESSES

AT BOLT $F = F_1 = 29.84$ LB/IN

$V = V_1 = .096$ 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, FTU = 160000 PSI
@ 3T LOADS

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

3T LOADS

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

W/FS = 1.4

$f_t = 1.4 \times 17346 = 24284$ psi

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

$f_s = 1.4 \times 56 = 79$ psi

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

$R_t \sim 1.0$

$u = \dfrac{r_t}{R_t} = .152$

$MS = \dfrac{1}{u} - 1 = +5.6$

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

∴ 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 1 σ LOADS

EL	2878	2882	2884	2886	
Fx	1.624				LB/IN
Fy	1.999	.446	1.243	1.094	"
Fxy	1.281				"
Mx	.0124				IN-LB/IN
My	.0072	.0091	.0225	.0300	"
Mxy	.0067				"
Vx	.0339				LB/IN
Vy	.0332	.0241	.0715	.0698	"

RANDOM X w/ Q = 7.1 1 σ LOADS

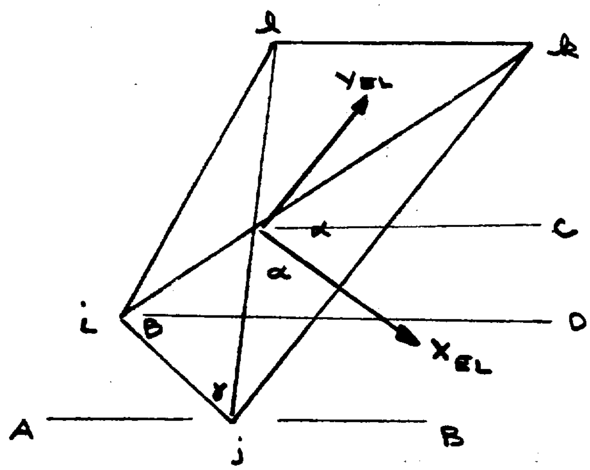
EL	$\boxed{2878}$	2882	2884	2886	
Fx	7.493				LB/IN
Fy	3.193	2.626	1.236	5.100	"
Fxy	2.547				"
Mx	.0493				IN-LB/IN
My	.0160	.0295	.1300	.1771	"
Mxy	.0325				"
Vx	.2168				LB/IN
Vy	.1489	.1224	.3743	.5323	"

RANDOM Z w/ Q = 7.1 1 σ LOADS

EL	2878	2882	2884	2886	
Fx	1.141				LB/IN
Fy	1.101	.496	.552	.968	"
Fxy	1.295				"
Mx	.0123				IN-LB/IN
My	.0057	.0100	.0241	.0327	"
Mxy	.0052				"
Vx	.0462	.0076	.0250	.0058	LB/IN
Vy	.0270				"

WORST CONDITION IS RANDOM X @ EL 2878 RIGHT SIDE

AT EL 2878 THE "X ELEM" DIRECTION IS SLIGHTLY SKEWED FROM THE $i\ell$ SIDE NORMAL



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

$\angle A j i \quad \tan^{-1} \dfrac{.240}{.270} = 41.63^\circ$

$\angle B j \ell \quad \tan^{-1} \dfrac{1.148}{.105} = 84.77^\circ$

$\angle B j k \quad \tan^{-1} \dfrac{1.148}{.955} = 50.24^\circ$

$\angle D_{ik} \quad \tan^{-1} \dfrac{.908}{1.225} = 36.55^\circ$

$\angle D i \ell \quad \tan^{-1} \dfrac{.908}{.375} = 67.56^\circ$

$\perp$ TO $i\ell$ $\quad \angle = 67.56 - 90 = -22.44^\circ$

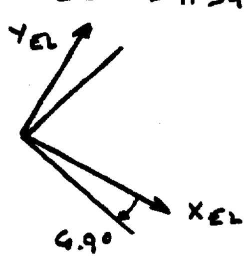
$\gamma = 180 - 84.77 - 41.63 = 53.60^\circ$

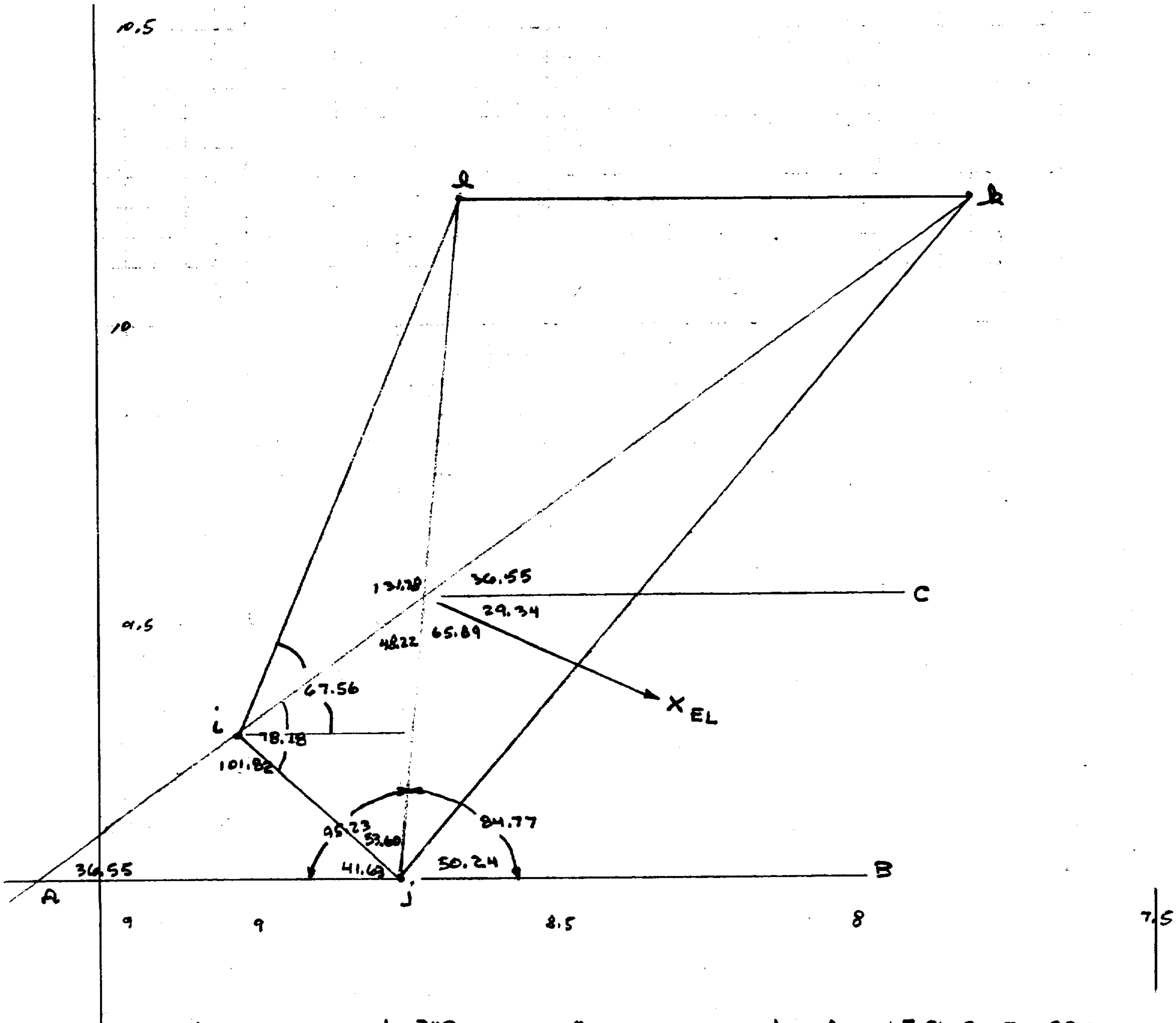
$B = 41.63 + 36.55 = 78.18^\circ$

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

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

ROTATE X_{EL} $\quad 29.34 - 22.44 = 6.9$ CW





$\angle$ Aji $\quad \tan^{-1} \dfrac{.240}{.270} = 41.63^\circ$

$\angle$ Bjl $\quad \tan^{-1} \dfrac{1.148}{.105} = 84.77^\circ$

$\angle$ Bjk $\quad \tan^{-1} \dfrac{1.148}{.955} = 50.24$

$\angle$ BAik $\quad \tan^{-1} \dfrac{.908}{1.225} = 36.55$

$\angle$ il $\quad \tan^{-1} \dfrac{.908}{.375} = 67.56$

$\perp$ il $\quad 67.56 - 90 = -22.44$

$X_{EL} \quad -29.34$

ROTATE 6.9° CW

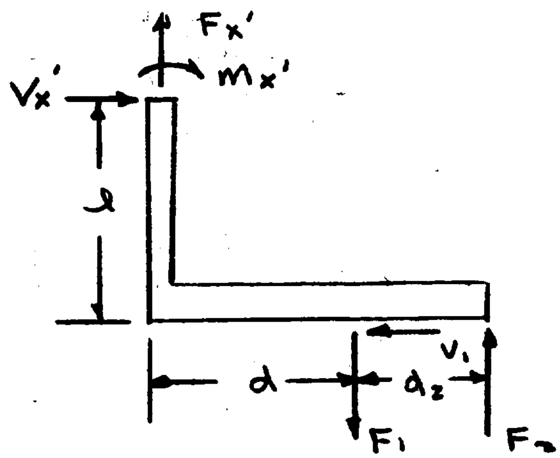
$$F_x' = \frac{7.493 + 3.193}{2} + \frac{7.493 - 3.193}{2}\cos(-13.8^\circ) + 2.547\sin(-13.8^\circ)$$

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

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

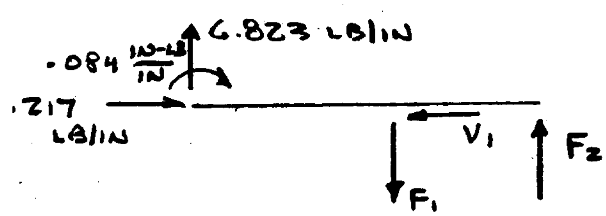
$$V_x' = V_x = .2168 \text{ LB/IN}$$

FLANGE STRESSES



$\ell = .2$
$d = .312$
$d_2 = .438$

$t = .050$ FLANGE MINIMUM



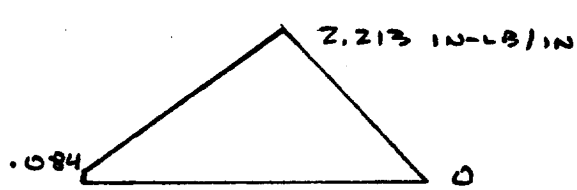
$$\Sigma M_2 = 0 \qquad F_1(.438) = 6.823(.750) + .084$$

$F_1 = 11.876$ LB/IN

$F_2 = 5.053$ LB/IN

$V_1 = .217$ LB/IN

MOMENT DIAGRAM



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

$$S_t = 3\left[\frac{V_1}{t} + \frac{6M_1}{t^2}\right] \qquad @\ 3T \text{ LOADS}$$

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

$$= 3\left[4 + .5311\right]$$ @ 3σ LOADS

$$= 15946 \text{ psi}$$

W/ FS = 1.25 LIMIT, 1.4 ULT

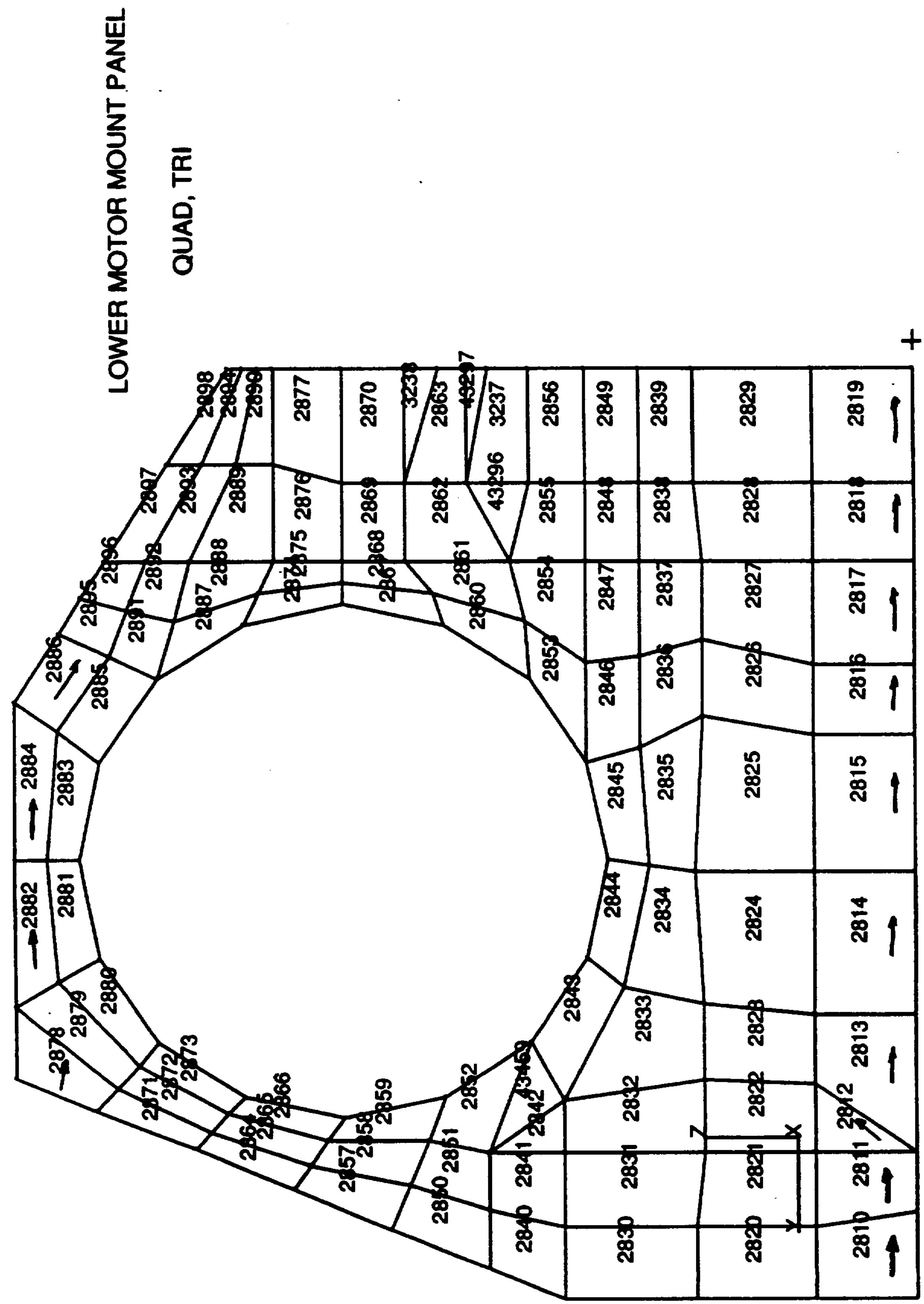
$$MS = \frac{F_{ty}}{1.25 \times S_t} - 1$$

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

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

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

∴ TOP FLANGE OK @ t=.050 USING 3σ LOADS


LOWER MOTOR MOUNT PANEL
QUAD, TRI

UPPER MOTOR MOUNT PANEL - LOWER FLANGE

RANDOM Y w/Q=7.1 1T LOADS

EL	2634	$\boxed{2635}$	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 1T LOADS

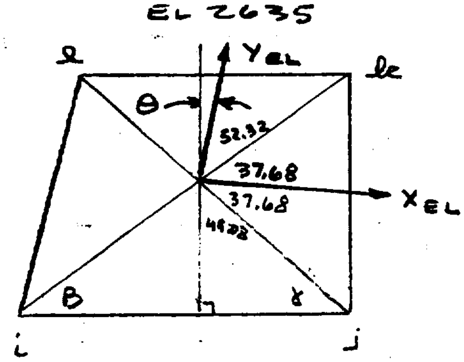
EL	2634	2635	$\boxed{2642}$	
F_y	4.000	8.365	14.176	LB/IN
M_y	.0211	.0263	.0166	IN-LB/IN
V_y	.0979	.0572	.0645	LB/IN

RANDOM Z w/Q=7.1 1T 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

EL 2635



$$B = \tan^{-1}\frac{1.125}{1.640} = 34.45°$$

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

$$90 - \gamma = 49.08$$

$$\alpha = \frac{\gamma + B}{2} = 37.68°$$

$$\theta = 180 - 52.32 - 2(37.68) - 49.08)$$
$$= 3.2° \text{ CCW}$$

ROTATE EL 2635 $\theta = 3.2°$

$$F_y' = \frac{13.795 + 2.476}{2} + \frac{13.795 - 2.476}{2} \cos(2 \times 3.2°)$$

$$+ 8.414 \sin(2 \times 3.2°)$$

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

$$m_y' = \frac{.0217 + .0278}{2} + \frac{.0217 - .0278}{2} \cos(2 \times 3.2°)$$

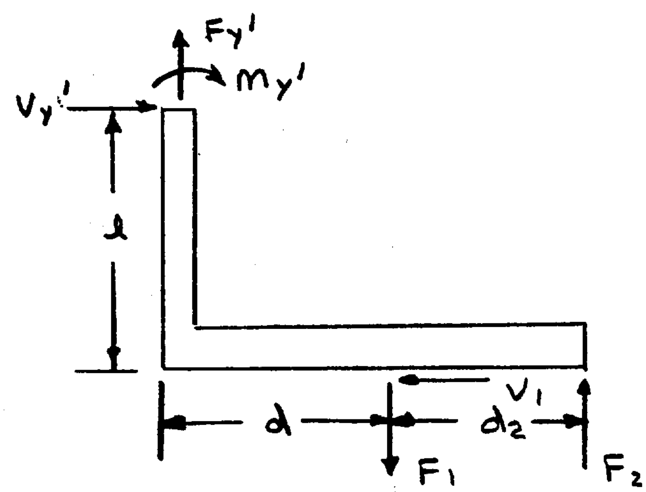
$$+ .0219 \sin(2 \times 3.2°)$$

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

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

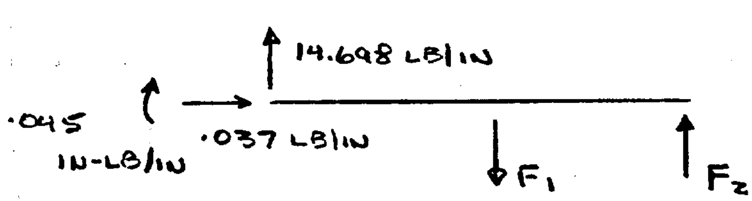
$F_y' =$ 14.698 LB/IN
$m_y' =$ .0242 IN-LB/IN
$V_y' =$ .0367 LB/IN

FLANGE STRESSES



$d = .312$
$d_2 = .438$
$l = 1.125/2$

FLANGE $t = .050$
MINIMUM



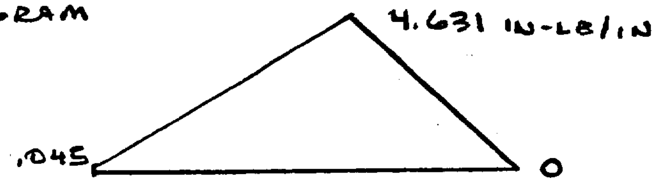
$\Sigma M_2 = 0 \qquad F_1(.438) = 14.698(.750) + .045$

$F_1 = 25.271$ LB/IN

$F_2 = 10.573$ LB/IN

$V_1 = .037$ LB/IN

MOMENT DIAGRAM



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

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

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

$$= 3\left[1 + 11114\right]$$

$$= 33345 \text{ PSI}$$

MAT'RL 7075-T651 $\qquad F_{TY} = 66000$ PSI
$\qquad F_{TU} = 75000$ PSI

W/FS 1.25 LIMIT, 1.4 ULT

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

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

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

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

$\therefore$ LOWER FLANGE OK @ t = .050

USING 3T LOADS

BOLT STRESSES

AT BOLT

$F = F_1 = 25.571$ LB/IN
$V = V_1 = .037$ 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 NAS1352N06, FTU = 160000 psi
@ 3T LOADS

$$S_t = 3\frac{F_B}{A_S} = 3\,\frac{45.02}{.009085} = 14866 \text{ psi}$$

3T LOADS

$$S_s = 3\frac{V_B}{A_S} = 3\,\frac{.065}{.009085} = 21 \text{ psi}$$

FS = 1.4

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

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

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

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

$$R_t \sim 1.0$$

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

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

WORST LOADED BOLT
UPPER MOTOR MT 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	$\boxed{2643}$	2652	
Fx	10.565	19.290	3.786	LB/IN
Mx	.0322	.0596	.0346	IN-LB/IN
Vx	.0842	.0788	.0349	LB/IN

RANDOM X w/Q=7.1 1σ LOADS

EL	2634	2643	2652	
Fx	6.362	10.206	5.221	LB/IN
Mx	.0237	.0492	.0261	IN-LB/IN
Vx	.1305	.1088	.3170	LB/IN

RANDOM Z w/Q=7.1 1σ LOADS

EL	2634	2643	2652	
Fx	4.810	8.451	1.537	LB/IN
Mx	.0164	.0346	.0259	IN-LB/IN
Vx	.0773	.0589	.3079	LB/IN

WORST CASE IS RANDOM Y @ EL 2643

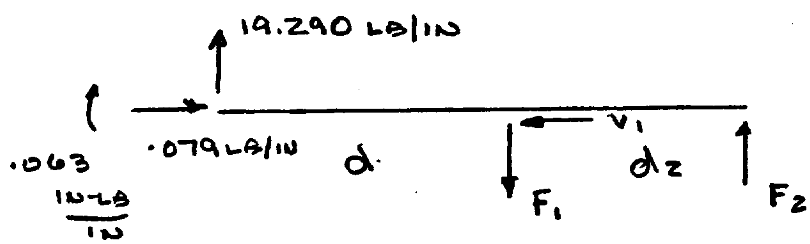
Fx = 19.290 LB/IN
Mx = .0596 IN-LB/IN
Vx = .0788 LB/IN

FLANGE STRESSES

SIMILAR TO LOWER FLANGE

$d_1 = .312$
$d_2 = .438$
$\ell = .595/2$

FLANGE t=.050 MINIMUM



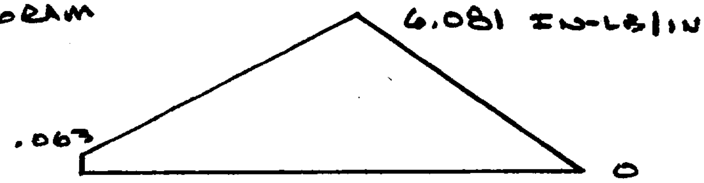
$\Sigma M_2 = 0 \qquad F_1(.438) = 19.290(.750) + .063$

$F_1 = 33.175$ LB/IN

$F_2 = 13.885$ LB/IN

$V_1 = .079$ LB/IN

MOMENT DIAGRAM



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

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

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

$$= \left[2 + 14594\right]$$

$$= 43788 \text{ PSI}$$

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

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

$\therefore$ RIGHT FLANGE OK @ t=.050
USING 3σ LOADS

BOLT STRESSES

AT BOLT

$F = F_1 = 33.175$ LB/IN

$V = V_1 = .08$ LB/IN

3 BOLTS IN 6.245 IN

TOTAL LOAD / BOLT

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

$$V_B = \frac{6.245}{3}(.08) = .17 \text{ LB}$$

BOLTS ARE NAS1352N06 , $F_{TU} = 160000$ psi

$$S_t = 3\frac{F_B}{A_S} = 3\frac{69.06}{.009085} = 22804 \text{ psi}$$

@ 3T LOADS

$$S_S = 3\frac{V_B}{A_S} = 3\frac{.17}{.009085} = 56 \text{ psi}$$

FS = 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

$\therefore$ BOLTS OK ON RIGHT FLANGE

USING 3T LOADS

UPPER 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 1 σ LOADS

EL	2700	2706	2708	2720	2722	2724	2727	
Fx	2.668	1.992	1.908	1.450	18.583	5.441	9.386	LB/IN
Fy	10.402	11.187	5.600	1.746	2.768	1.802	2.723	"
Fxy	14.836	3.392	1.508	1.531	4.418	6.550	4.165	"
Mx	.7180	.152	.109	.0028	.0018	.0175	.0323	IN-LB/IN
My	.2098	.0848	.0374	.0120	.0647	.0887	.0541	"
Mxy	.2478	.1788	.156	.0109	.0152	.0191	.0101	"
Vx	7.843	1.168	.461	.0180	.0274	.0833	.2003	LB/IN
Vy	2.017	.1869	.0524	.0312	.2143	.3327	.0937	"

RANDOM X w/Q=7.1 1 σ LOADS

EL	2700	2706	2708	2720	2722	2724	$\boxed{2727}$	
Fx	3.158	2.287	2.126	2.073	21.826	4.077	13.081	LB/IN
Fy	13.105	14.451	7.696	2.562	3.137	2.007	4.085	"
Fxy	18.454	4.006	1.654	1.376	6.375	8.781	5.128	"
Mx	.711	.1832	.1264	.0032	.0033	.0221	.0456	IN-LB/IN
My	.194	.1049	.0658	.0159	.0744	.1043	.0659	"
Mxy	.292	.2168	.1890	.0133	.0184	.0191	.0128	"
Vx	9.222	1.566	.703	.0279	.0404	.1072	.2467	LB/IN
Vy	2.480	.2698	.0650	.0546	.2441	.4011	.1086	"

RANDOM Z w/Q=7.1 1σ LOADS

EL	2700	2706	2708	2720	2722	2724	2727	
Fx	.930	1.615	.850	1.965	5.069	2.978	5.081	LB/IN
Fy	4.819	3.840	2.478	.647	.823	.575	1.156	"
Fxy	4.160	1.210	1.165	.0977	1.598	2.078	1.219	"
Mx	.184	.0633	.0462	.0013	.0009	.0056	.0128	IN-LB/IN
My	.0642	.0349	.0389	.0049	.0187	.0255	.0156	"
Mxy	.156	.0498	.0471	.0034	.0040	.0058	.0040	"
Vx	1.999	.360	.212	.0067	.0157	.0246	.0566	LB/IN
Vy	.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 @ EL 2727

F_Y = 4.085 LB/IN
M_Y = .0659 IN-LB/IN　　　1 ∇ LOADS
V_Y = .1086 LB/IN

THESE LOADS << LOWER FLANGE (F_Y' = 14.648 LB/IN)
AND RIGHT FLANGE (F_X = 19.290 LB/IN) THEREFORE
BY COMPARISON

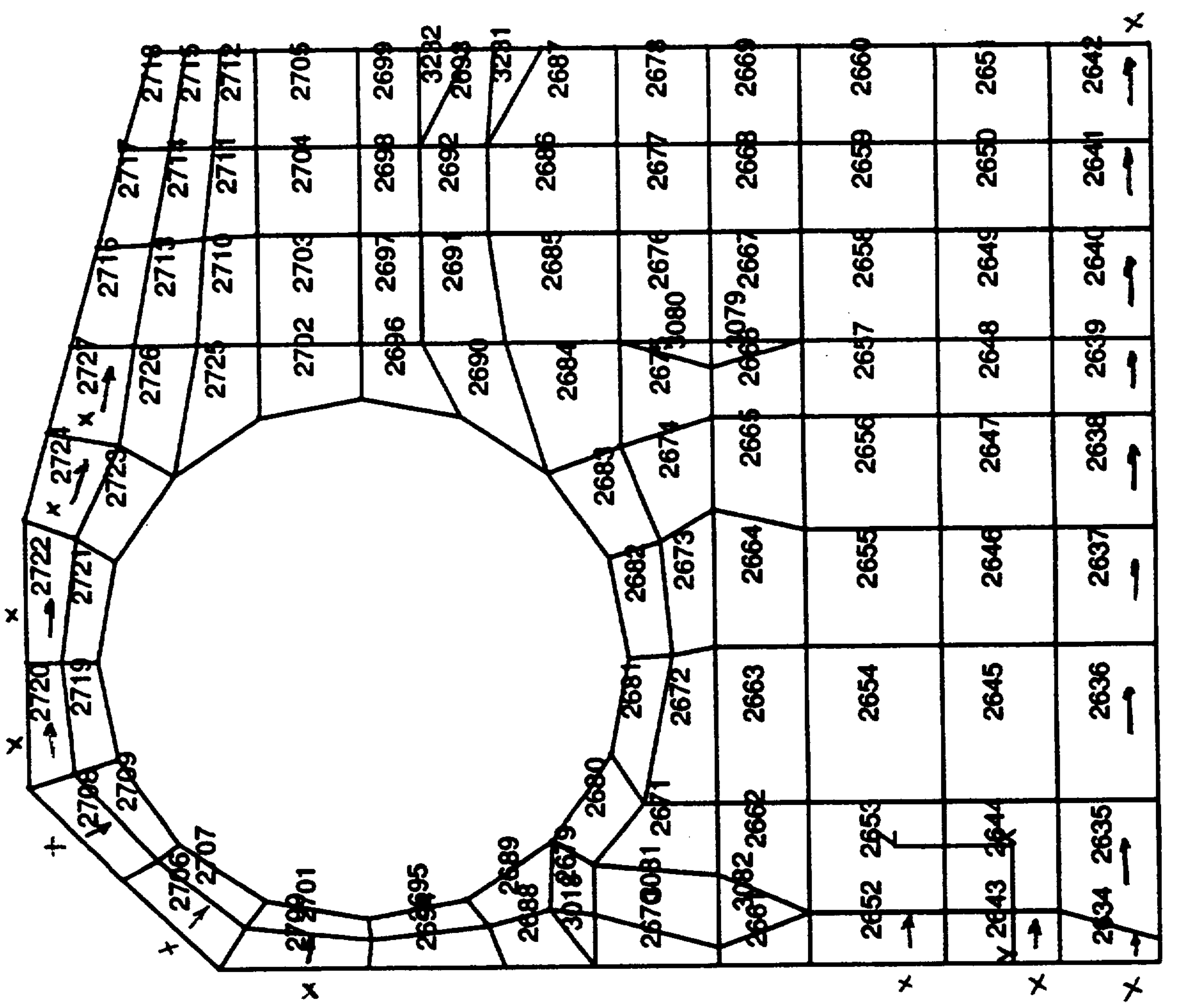
FLANGE STRESSES

MS > + .21　　LIMIT
　　　　　　　　　　　　3 ∇ LOADS
MS > + .22　　ULTIMATE

$\therefore$ TOP FLANGE OK @ t = .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	$\boxed{1547}$	
	Fx	18.694	11.462	13.066	14.183	4.526	LB/IN
⇒	Fy	8.847	15.037	13.761	22.265	28.357	"
	Fxy	17.828	11.104	12.167	2.028	51.044	"
	Mx	.0845	.1070	.0513	.0491	.0949	IN-LB/IN
	My	.0704	.0540	.0395	.0220	.0121	"
	Mxy	.0393	.0220	.0237	.0410	.0125	"
	Vx	.4041	.3688	.0823	.0701	.5882	LB/IN
	Vy	.1927	.2629	.0774	.0887	.5548	"

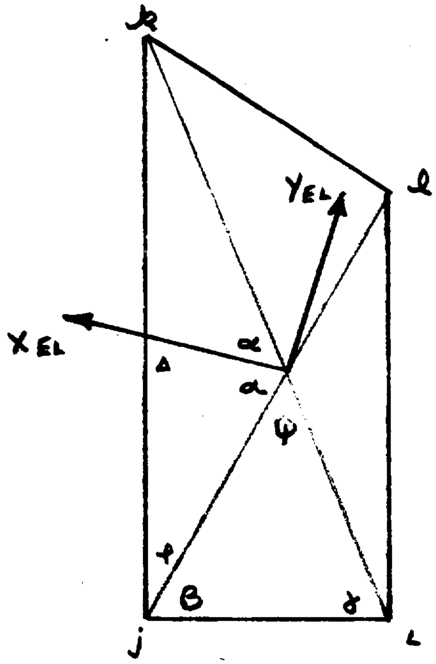
RANDOM X - W/Q=7.1 1 T LOADS

	EL	1435	1445	1475	1503	1547	
	Fx	8.380	4.856	3.713	5.100	1.181	LB/IN
⇒	Fy	9.004	7.217	3.547	5.689	11.649	"
	Fxy	7.575	3.470	4.028	1.905	8.993	"
	Mx	.2550	.3024	.0780	.0880	.0256	IN-LB/IN
	My	.2191	.0763	.0429	.0698	.0077	"
	Mxy	.1223	.0282	.0219	.0385	.0096	"
	Vx	1.170	.9037	.2663	.1545	.2745	LB/IN
	Vy	.5665	.8035	.1890	.1903	.2289	"

RANDOM Z - W/Q=7.1 1 T LOADS

	EL	1435	1445	1475	1503	1547	
	Fx	8.598	5.068	7.457	3.715	1.321	LB/IN
⇒	Fy	4.634	12.670	3.716	5.298	12.974	"
	Fxy	7.599	3.849	5.260	1.366	24.039	"
	Mx	.0425	.0565	.1794	.0855	.0578	IN-LB/IN
	My	.0432	.0984	.1173	.0476	.0056	"
	Mxy	.0177	.0127	.0782	.0703	.0087	"
	Vx	.1572	.1446	.1552	.1231	.3921	LB/IN
	Vy	.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

$\gamma = \measuredangle\, jLk \quad \tan^{-1} \dfrac{1.531}{.624} = 67.83^\circ$

$B = \measuredangle\, Ljl \quad \tan^{-1} \dfrac{1.131}{.624} = 61.11$

$\psi = 180 - \gamma - B = 51.06^\circ$

$\dfrac{\gamma + B}{2} = \alpha = 64.47^\circ$

$\phi = 90 - B = 28.89^\circ$

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

X_{EL} IS $90 - 86.64 = 3.36^\circ$ CW OF NORMAL
Y_{EL} " " " " " "

ROTATE Y_{EL} $+3.36^\circ$ (CCW)

EL 1547

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

$$+ 51.044 \sin(2 \times 3.36^\circ)$$

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

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

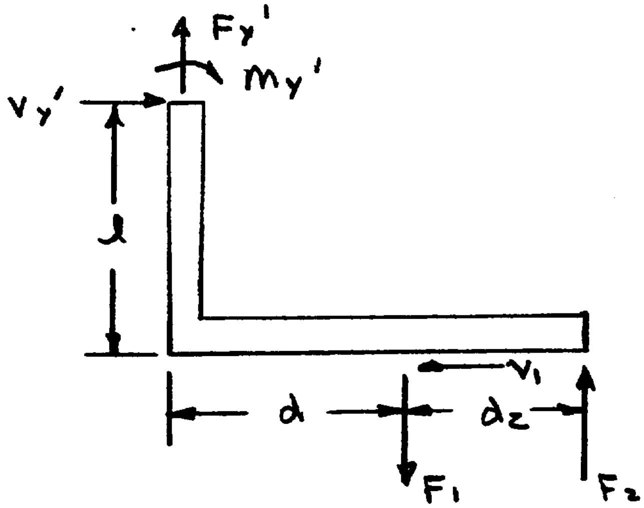
$$+ .0125 \sin(2 \times 3.36)^\circ$$

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

$V_y' = V_y = .5548$ LB/IN

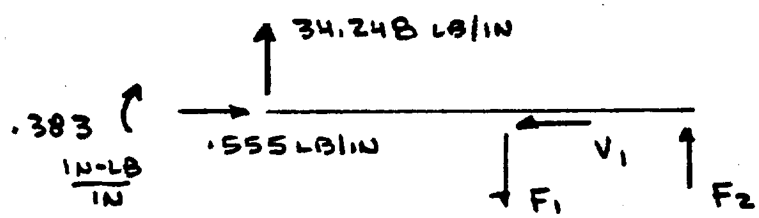
$F_y' = 34.248$ LB/IN
$M_y' = .014$ IN-LB/IN
$V_y' = .555$ LB/IN

FLANGE STRESSES



$d = .313$
$d_2 = .312$
$l = 1.331/2$

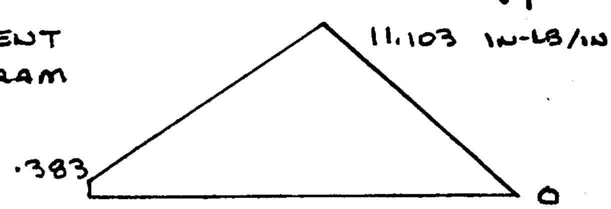
FLANGE $t = .040$ MINIMUM



$\Sigma M_2 = 0 \qquad F_1(.312) = 34.248(.625) + .383$

$F_1 = 69.83$ LB/IN
$F_2 = 35.59$ LB/IN
$V_1 = .555$ LB/IN

MOMENT DIAGRAM



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

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

$$= 3\left[14 + 41636\right]$$

@ 3T LOADS

$= 124950$ psi

MAT'RL 6061-T651 $F_{TY} = 35000$ PSI
$F_{TU} = 42000$ PSI

W/FS 1.25 LIMIT, 1.4 ULTIMATE

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

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

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

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

$\therefore$ FLANGE BAD @ $t = .040$ (LOWER FLANGE)

SEE RECOMMENDATION

BOLT STRESSES

AT BOLT

$F = F_1 = 69.83$ LB/IN
$V = V_1 = .555$ LB/IN

8 NAS1352N06 BOLTS ($F_{TU} = 160000$ PSI) IN

$11.188 - .625 = 10.563$ IN

TOTAL LOADS

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

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

@ 3T LOADS

$$S_t = 3\frac{F_B}{A_s} = 3\frac{92.2}{.009085} = 30445 \text{ PSI}$$

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

FS = 1.4

$f_t = 1.4 \times 30445 = 42623$ psi

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

$f_s = 1.4 \times 241 = 337$ psi

$r_s = \dfrac{337}{(.6)(160000)} = .003 \Rightarrow 0$

$R_t \sim 1.0$

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

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

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

$\therefore$ 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

FLANGE STRESSES

$$S_t = 3\left[\frac{.555}{.090} + \frac{6(11.103)}{(.090)^2}\right]$$
$$= 3\left[6 + 8224\right]$$
$$= 24692 \text{ psi}$$

$MS = \dfrac{35000}{1.25(24692)} - 1 = +.13$ t = .090

$MS = \dfrac{42000}{1.4(24692)} - 1 = +.21$ t = .090

$\therefore$ w/ t = .090 LOWER FLANGE OK
USING 3T LOADS

LOWER FRONT PANEL – UPPER FLANGE

RANDOM Y W/Q=7.1 1 T LOADS

EL	1454	1516	1526	1556	
Fx	8.270	5.185	1.767	2.517	LB/IN
⇒ Fy	9.043	7.708	8.068	7.965	"
Fxy	13.420	18.987	13.420	11.165	"
Mx	.0082	.0203	.0459	.0314	IN-LB/IN
My	.0147	.0954	.0920	.0100	"
Mxy	.0088	.0075	.0110	.0058	"
Vx	.0149	.0270	.0361	.0282	LB/IN
Vy	.0206	.1585	.1362	.0160	"

RANDOM X W/Q=7.1 1 T LOADS

EL	1546	
Fx	1.492	LB/IN
Fy	4.259	"
Fxy	4.086	"
Mx	.0137	IN-LB/IN
My	.0405	"
Mxy	.0180	"
Vx	.0128	LB/IN
Vy	.0781	"

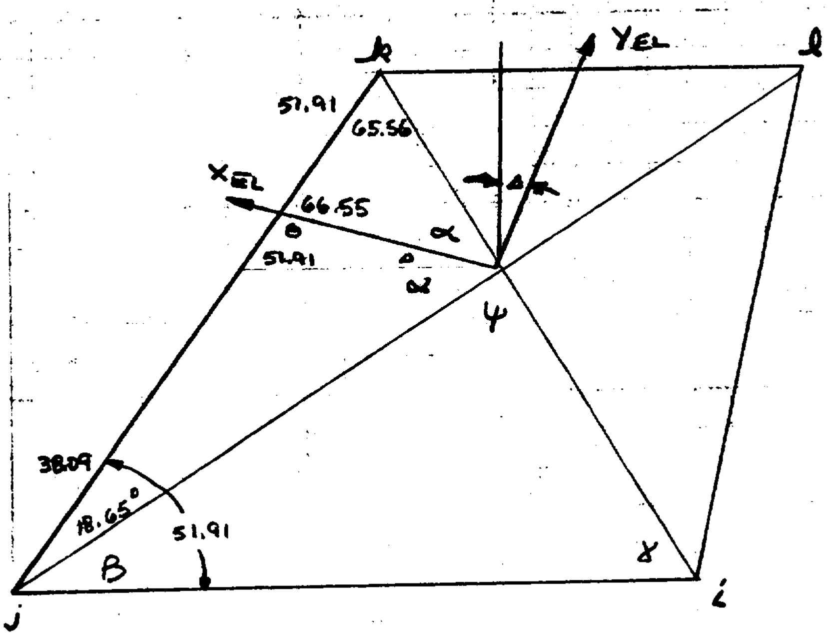
RANDOM Z W/Q=7.1 1 T LOADS

EL	1546	
Fx	.414	LB/IN
Fy	3.628	"
Fxy	2.445	"
Mx	.0088	IN-LB/IN
My	.0239	"
Mxy	.0094	"
Vx	.0108	LB/IN
Vy	.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



$\angle jik \quad \tan^{-1} \dfrac{.675}{.351} = 62.53° = \gamma$

$\angle ijl \quad \tan^{-1} \dfrac{.675}{1.029} = 33.26° = B$

$\angle \psi = 180 - \gamma - B = 84.21°$

$\alpha = \dfrac{\gamma + B}{2} = 47.89°$

$\angle ijk \quad \tan^{-1} \dfrac{.675}{.529} = 51.91°$

$\theta = 180 - 18.65 - \alpha = 113.45°$

$\Delta = 14.64°$

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

ROTATE F_y 14.64° CCW

$$F_y' = \frac{9.043 + 8.270}{2} + \frac{9.043 - 8.270}{2} \cos(2 \times 14.64°)$$

$$+ 13.420 \sin(2 \times 14.64°)$$

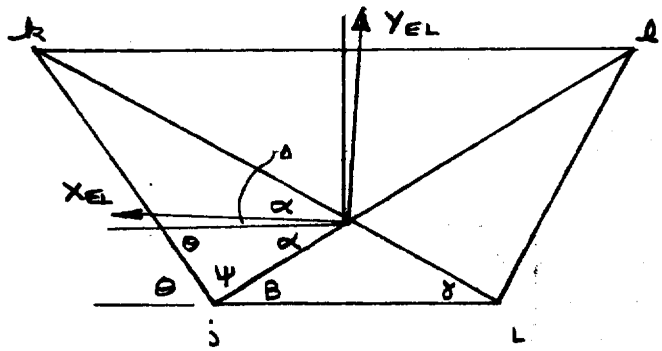
$= 15.557$ LB/IN

$M_y' = .0186$ IN-LB/IN

$V_y' = V_y = .0206$ LB/IN

EL 1516

	Y	Z
L	7.6	9.421
J	8.326	9.421
k	8.8	10.096
l	7.246	10.096



$\measuredangle jik \quad \tan^{-1} \dfrac{.675}{1.2} = 29.36° = \gamma$

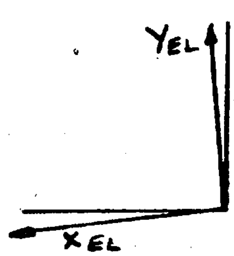
$\measuredangle ijl \quad \tan^{-1} \dfrac{.675}{1.08} = 32.01° = B$

$\alpha = \dfrac{\gamma + B}{2} = 30.68°$

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

$\psi = 180 - B - \theta = 93.07°$

$180 = \theta + \psi + (\alpha - \Delta) \qquad \Delta = -1.33°$



ROTATE Y_{EL} 1.33° CW TO ACHIEVE NORMAL

$F_y' = \dfrac{7.708 + 5.185}{2} + \dfrac{7.708 - 5.185}{2} \cos(2 \times -1.33°) + 18.987 \sin(-2.66°)$

$= 6.825$ LB/IN

LESS SEVERE THAN EL 1454

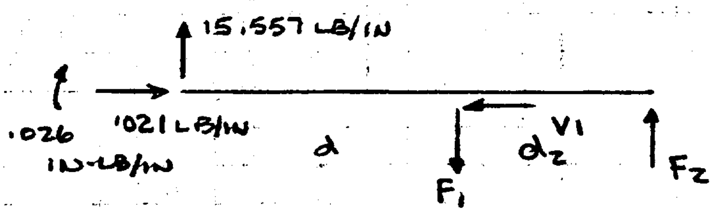
$F_y' = 15.557$ LB/IN
$M_y' = .0186$ IN-LB/IN
$V_y' = .0206$ LB/IN

@ EL 1454 RANDOMY

FLANGE STRESSES

SIMILAR TO LOWER FLANGE

$\ell = .675/2$
$d = .313$
$d_2 = .312$

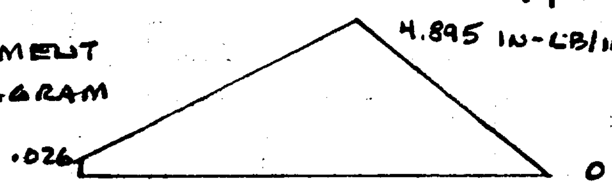


FLANGE t = .040
MINIMUM

$\Sigma M_2 = 0 \qquad F_1(.312) = 15.557(.625) + .026$

$F_1 = 31.247$ LB/IN
$F_2 = 15.690$ LB/IN 1σ LOADS
$V_1 = .021$ LB/IN

MOMENT DIAGRAM



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

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

@ 3σ 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 3σ LOADS

REQUIRE t=.060 MINIMUM, @ 3T LOADS

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

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

3T LOADS

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

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

BOLT STRESSES

AT BOLT

$F = F_1 = 31.247$ LB/IN
$V = V_1 = .021$ LB/IN

7 BOLTS IN 11.188 − .9 = 10.288 IN
NAS1352N06 W/ FTU = 160000 PSI

TOTAL LOAD/BOLT

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

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

1σ LOADS

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

@ 3σ LOADS

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

$S_t = 1.4 \times 15165 = 21230$ PSI

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

$R_t = 1.0$

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

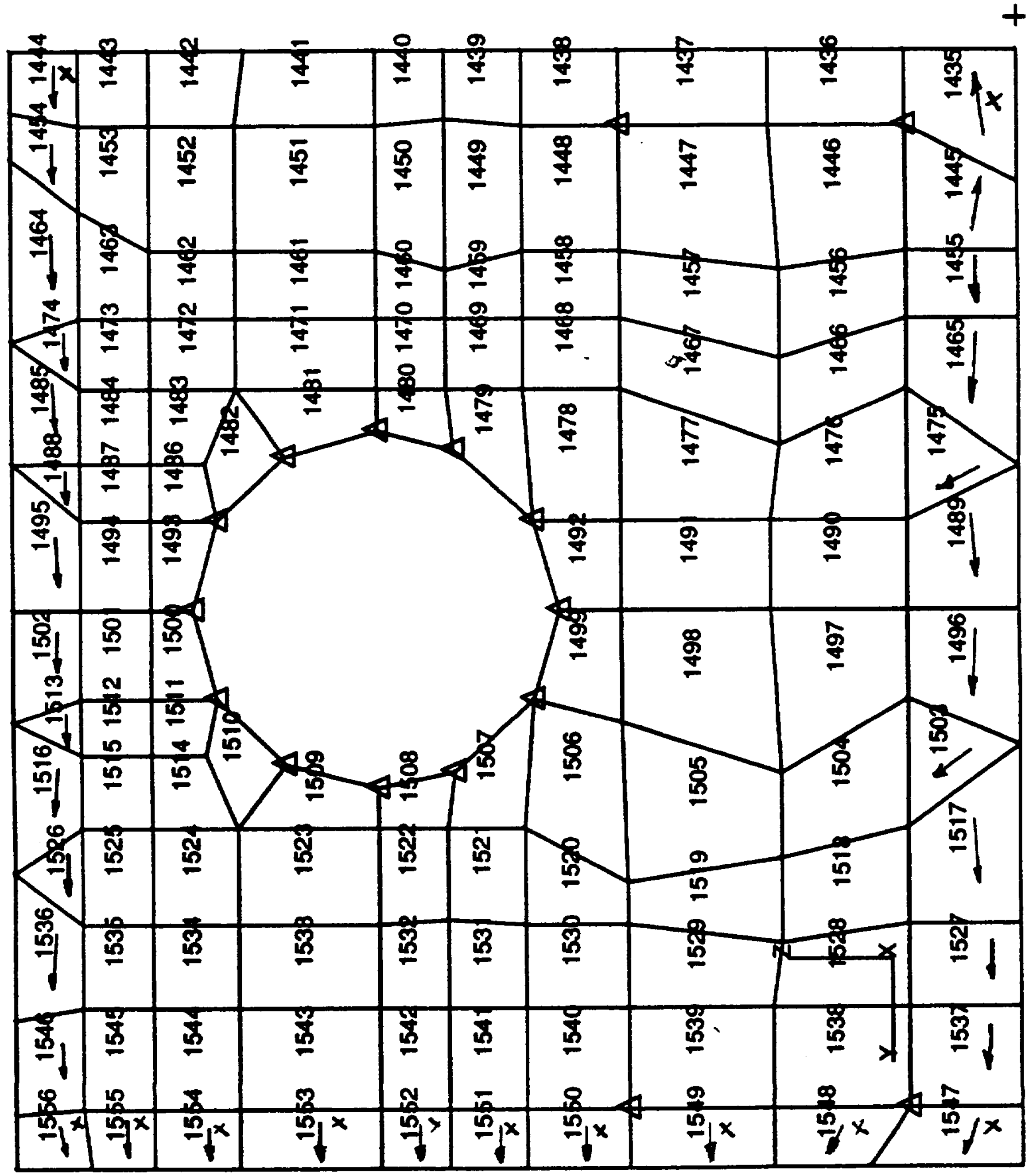
$MS = \frac{1}{u} - 1 = +6.5$

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

∴ BOLTS OK ON UPPER FLANGE
USING 3σ LOADS

LOWER FRONT PANEL

QUAD, TRI



UPPER AFT PANEL - LOWER FLANGE

RANDOM Y W/ Q=7.1 1 σ LOADS

EL	44328	44326	44339	
Fx			11.542	LB/IN
Fy	14.738	10.261		"
Fxy				"
Mx			1.426	IN-LB/IN
My	1.395	1.125		"
Mxy				"
Vx			2.512	LB/IN
Vy	.964	.517		"

RANDOM X W/ Q=7.1 1 σ LOADS

EL	44323	$\boxed{44329}$	44336	
Fx				LB/IN
Fy	16.378	17.394	17.282	"
Fxy				"
Mx				IN-LB/IN
My	1.228	10.041	10.496	"
Mxy				"
Vx				LB/IN
Vy	2.710	5.700	5.892	"

RANDOM Z W/ Q=7.1 1 σ LOADS

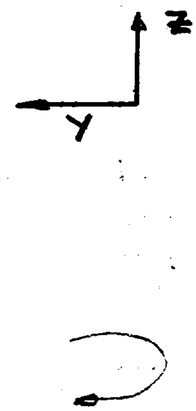
EL	44328	
Fx		LB/IN
Fy	10.544	"
Fxy		"
Mx		IN-LB/IN
My	1.519	"
Mxy		"
Vx		LB/IN
Vy	3.874	"

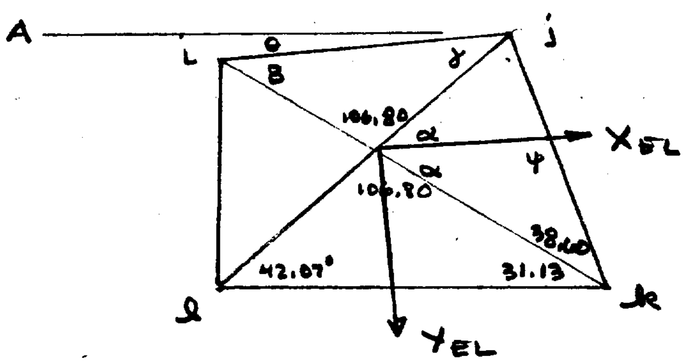
WORST CASE IS RANDOM X @ EL 44329

Fy = 17.394 LB/IN
My = 10.041 IN-LB/IN
Vy = 5.700 LB/IN

ELEMENT 44329 IS SLIGHTLY SKEWED

	Y	Z
L	8.15	10.7
j	17.40	10.773
k	7.15	10.096
l	8.15	10.096





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

$$\measuredangle\ A j l = \tan^{-1} \frac{.677}{.75} = 42.07^\circ$$

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

$$\angle\ l k i = \tan^{-1} \frac{.604}{1} = 31.13^\circ$$

$$B = 180 - 106.80 - 36.51 = 36.69$$

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

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

$$\psi = 180 - \alpha - 38.60 = 104.80$$

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

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

$F_y' = 16.732$ LB/IN

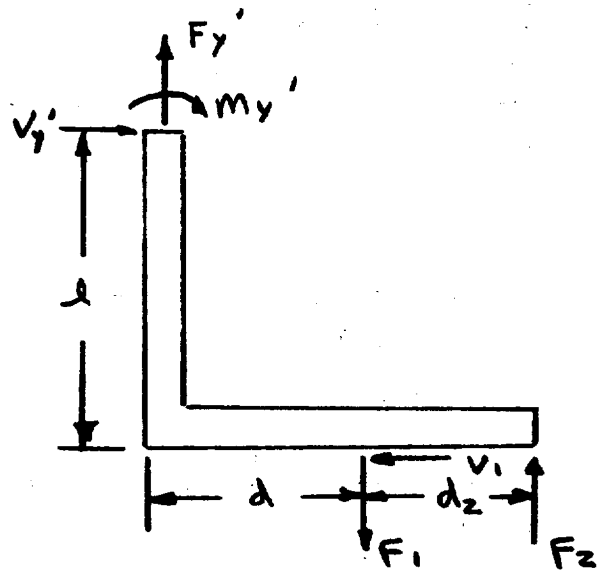
$$M_y' = \frac{10.041 + 3.332}{2} + \frac{10.041 - 3.332}{2} \cos(2x - 5.47^\circ)$$

$$+ 1.695 \sin(2x - 5.47)^\circ$$

$$= 9.658 \text{ IN-LB/IN}$$

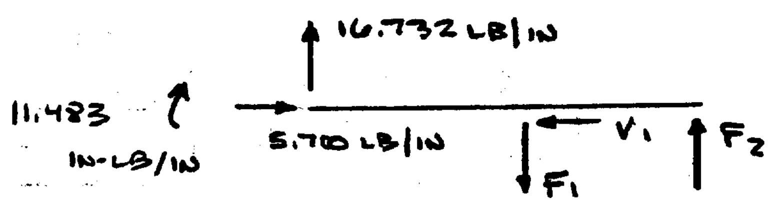
$V_y' = V_y = 5.700$ LB/IN

$F_y' = 16.732$ LB/IN
$M_y' = 9.658$ IN-LB/IN
$V_y' = 5.700$ LB/IN



$d = .562$
$d_2 = .188$
$l = .6405/2$

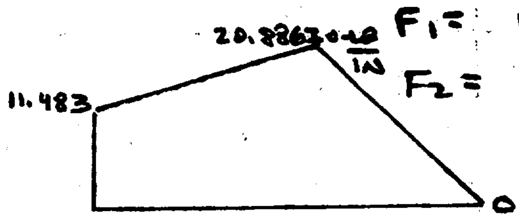
FLANGE $t = .060$ MINIMUM



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

$F_1 = 127.83$ LB/IN
$F_2 = 111.10$ LB/IN

MOMENT DIAGRAM



FLANGE STRESSES

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

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

$$= 3\left[\frac{5.700}{.060} + \frac{6(20.886)}{(.060)^2}\right]$$

$$= 3\left[95 + 34810\right]$$

$$= 104715 \text{ psi}$$

MAT'RL 6061-T651 $F_{ty} = 35000$ psi

$F_{tu} = 42000$ psi

W/ FS 1.25 LIMIT, 1.4 ULTIMATE

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

$$= \frac{35000}{1.25(104715)} - 1 = -.73$$

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

$$= \frac{42000}{1.4(104715)} - 1 = -.71$$

∴ LOWER FLANGE OVERSTRESSED @ $t = .060$

RAISE t TO $t = .120$

$$S_t = 3\left(\frac{5.700}{.120} + \frac{6(20.886)}{(.120)^2}\right.$$

$$= 3\left[48 + 8703\right] = 26250 \text{ psi}$$

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

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

$\therefore$ LOWER FLANGE OK @ t=.120 IN
USING 3σ LOADS

CONSIDER HIGHER STRENGTHENED 2024-T851 ALUM

F_{TY} = 58000 psi
F_{TU} = 66000 psi

RAISE t TO .095 IN MINIMUM WITH 2024-T851

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

3σ LOADS

= 41836 psi

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

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

$\therefore$ LOWER FLANGE OK @ t=.095 IN
USING 3σ LOADS ON 2024-T851 MAT'RL

BOLT STRESSES

AT BOLT LINE

$F = F_1 = 127.83$ LB/IN
$V = V_1 = 5.70$ LB/IN

9 NAS1352N06 BOLTS (F_{TU}=160000 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

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

FS = 1.4

$$f_t = 1.4 \times 54870 = 76818 \text{ psi}$$

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

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

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

$$R_t \sim 1.0$$

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

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

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	$\boxed{44206}$	44207
Fx	5,700	2,214
Fy	6,148	2,347
Fxy	4,136	6,712
Mx	.0947	.1050
My	.0511	.0325
Mxy	.0370	.0300
Vx	.1176	.1515
Vy	.0945	.0153

RANDOM X w/ Q=7.1 1σ LOADS

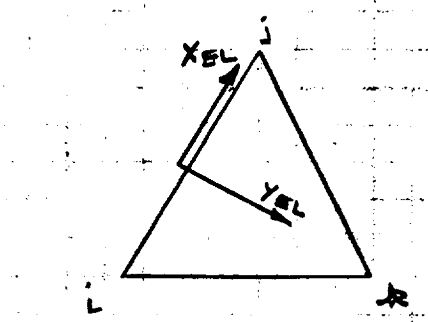
EL	44200	44211
Fx	4,224	3,963
Fy	4,162	3,433
Fxy	1,086	.7783
Mx	.2401	.2593
My	.2735	.2349
Mxy	.2060	.2051
Vx	.0832	.0961
Vy	.1819	.0955

RANDOM Z w/ Q=7.1 1σ LOADS

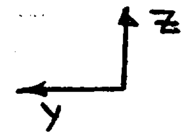
EL	44206
Fx	2,729
Fy	2,226
Fxy	1,955
Mx	.2549
My	.1680
Mxy	.0780
Vx	.3493
Vy	.1865

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



$$\measuredangle kLj = \tan^{-1} \frac{.971}{.496} = 62.94^\circ$$

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

$$F_x' = \frac{5.700+6.148}{2} + \frac{5.700-6.148}{2} \cos(2\times 27.06)^\circ$$

$$+ 4.136 \sin(2\times 27.06)^\circ$$

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

$$M_x' = \frac{.0947+.0511}{2} + \frac{.0947-.0511}{2} \cos(2\times 27.06)^\circ$$

$$+ .0370 \sin(2\times 27.06)^\circ$$

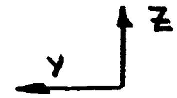
$$= .128 \text{ IN-LB/IN}$$

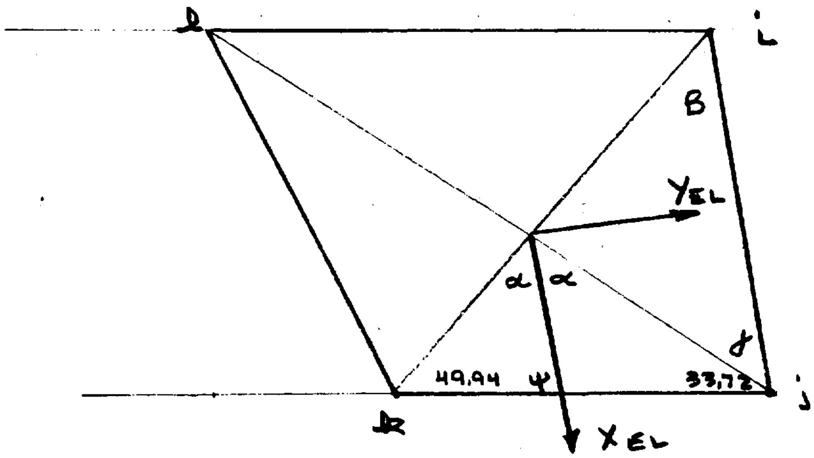
$$V_x' = V_x = .1176 \text{ LB/IN}$$

$F_x' = 9.013$ LB/IN
$M_x' = .128$ IN-LB/IN
$V_x' = .1176$ LB/IN

EL 44207

	Y	Z
i	4.396	22.752
j	4.236	21.775
k	5.216	21.777
l	5.7	22.752





$$\angle ikj = \tan^{-1}\frac{.975}{.820} = 49.94^\circ$$

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

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

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

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

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

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

X_{EL} IS 90. − 81.89 = 8.11° CCW OF NORMAL

ROTATE X_{EL} CW 8.11° TO ACHIVE NORMAL

$$F_x' = \frac{2.214 + 2.347}{2} + \frac{2.214 - 2.347}{2}\cos(2x - 8.11)^\circ + 6.712\sin(2x - 8.11)\Big|^\circ$$

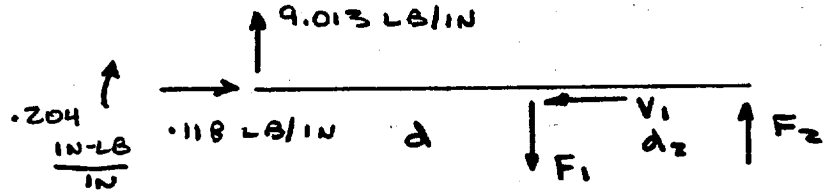
= .278 LB/IN   MUCH LESS SEVERE THAN EL 44206

FLANGE STRESSES

SIMILAR TO LOWER FLANGE, WITH

$F_x' = 9.013$ LB/IN
$M_x' = .128$ IN-LB/IN
$V_x' = .1176$ LB/IN

$l = 2/3(.972)$
$d = .562$
$d_2 = .188$

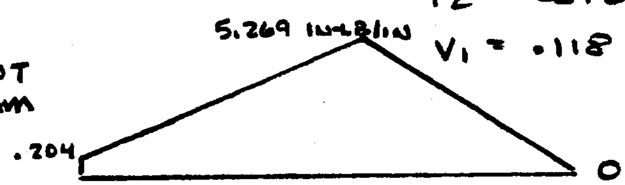


MINIMUM FLANGE $t = .050$

$$\Sigma M_2 = 0 \qquad F_1(.188) = 9.013(.750) + .204$$

$F_1 = 37.04$ LB/IN
$F_2 = 28.03$ LB/IN
$V_1 = .118$ LB/IN

MOMENT DIAGRAM



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

$$S_t = 3\left[\frac{V_1}{t} + \frac{6M_1}{t^2}\right] \qquad \text{@ 3T LOADS}$$

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

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

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

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

$\therefore$ UPPER FLANGE BAD @ $t = .05$
USING 3T LOADS

RAISE t TO .060 MIN, @ 3σ LOADS

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

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

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

∴ FLANGE OK @ t=.060
USING 3σ LOADS

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

$$S_t = 37944 \text{ PSI} \qquad @\ 3\sigma \text{ LOADS}$$

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

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

∴ FLANG OK @ t=.050
USING 3σ LOADS, USING 2024-T851

BOLT STRESSES

AT BOLT

$F = F_1 = 37.04$ LB/IN
$V = V_1 = .118$ LB/IN

7 BOLTS (NAS1352N06, FTU=160000 PSI)
IN $11.700 - 2(.950) = 9.800$ IN

TOTAL LOAD/BOLT

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

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

$$S_t = 3\frac{F_B}{A_S} = 3\frac{51.856}{.009085} = 17123 \text{ PSI}$$

@ 3T LOADS

$$S_S = 3\frac{V_B}{A_S} = 3\frac{.165}{.009085} = 54 \text{ PSI}$$

FS = 1.4

$$f_t = 1.4 \times 17123 = 23972 \text{ PSI}$$

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

$$f_s = 1.4 \times 54 = 76 \text{ PSI}$$

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

$$R_t \sim 1.0$$

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

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

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

∴ BOLTS OK ON UPPER FLANGE
USING 3T LOADS

UPPER AFT PANEL - SIDE FLANGES

RANDOM Y W/ Q = 7.1 1σ 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 1σ LOADS

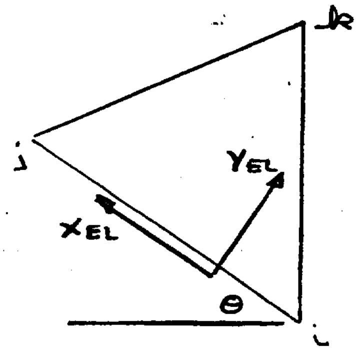
EL	44339	44303	44314	
Fx	14.481	3.925	5.501	LB/IN
Fy	5.088	14.671	8.150	"
Fxy	6.341	5.586	4.540	"
Mx	1.187	.3694	.3466	IN-LB/IN
My	.3179	.3466	.3986	"
Mxy	1.867	.3050	.2940	"
Vx	1.989	.3366	.1216	LB/IN
Vy	.766	.3135	.3499	"

RANDOM Z W/ Q=7.1 1σ LOADS

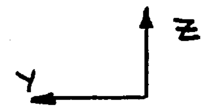
EL	44303	44314	
Fx	2.231	4.291	LB/IN
Fy	10.125	5.053	"
Fxy	1.188	4.474	"
Mx	.0854	.0356	IN-LB/IN
My	.0367	.0378	"
Mxy	.0259	.0265	"
Vx	.1224	.0866	LB/IN
Vy	.0785	.1075	"

WORST CASE IS RANDOM Y @ EL 44344, A SKEWED ELEMENT.

EL 44344



	Y	Z
i	.346	18.249
j	1.363	18.710
k	.346	18.971



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

ROTATE X_{EL} CCW 24.38° TO ACHIEVE NORMAL

RANDOM Y

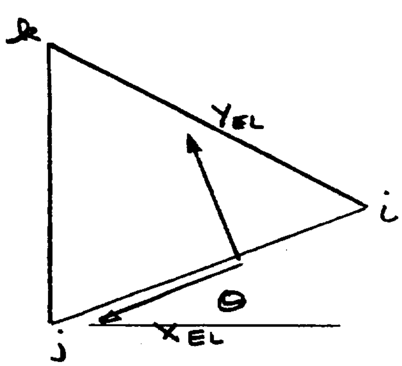
$$F_x' = \frac{5.191+6.417}{2} + \frac{5.191-6.417}{2} \cos(2\times 24.38^\circ) + 6.876 \sin(2\times 24.38^\circ)$$

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

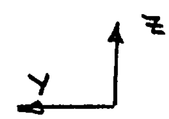
$$m_x' = .111 \text{ IN-LB/IN}$$

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

EL 44303



	Y	Z
i	.346	12.95
j	1.497	12.45
k	1.497	13.45



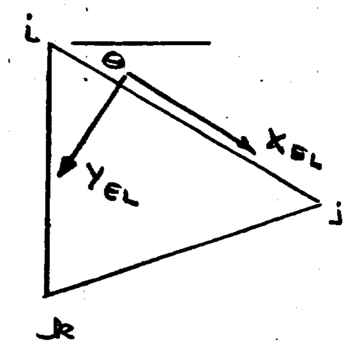
$$\angle ij = \theta = \tan^{-1} \frac{.50}{1.151} = 23.48^\circ$$

ROTATE X_{EL} CW 23.48° TO ACHIEVE NORMAL

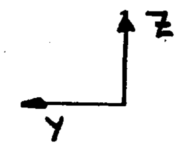
CW ROTATION IS A −23.48° ANGLE

∴ EL44303 LESS SEVERE THAN EL44344 RANDOM Y

EL 44345



	Y	Z
i	11.846	18.971
j	10.925	18.665
k	11.846	18.249



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

ROTATE XEL CCW 18.38° TO ACHIEVE NORMAL

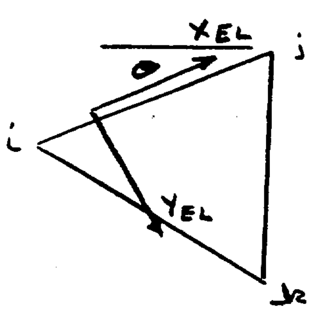
RANDOM Y

$$F_x{}' = \frac{.9843+14.568}{2} + \frac{.9843-14.568}{2}\cos(2\times18.38)^\circ$$

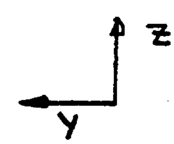
$$+ 2.508 \sin(2\times18.38)^\circ = 3.905 \text{ LB/IN}$$

∴ EL 44345 LESS SEVERE THAN EL 44344 RANDOM Y

EL 44314



	Y	Z
i	11.846	12.95
j	10.864	13.45
k	10.864	12.45



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

ROTATE XEL CW 26.98° TO ACHIEVE NORMAL

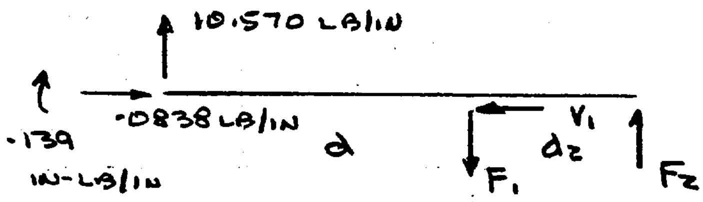
CW ROTATION IS A −26.98° ANGLE

∴ EL 44314 LESS SEVERE THAN EL 44344 RANDOM Y

$F_x' = 10.570$ LB/IN
$M_x' = .111$ IN-LB/IN
$V_x' = .0838$ LB/IN

FLANGE STRESSES

SIMILAR TO LOWER FLANG

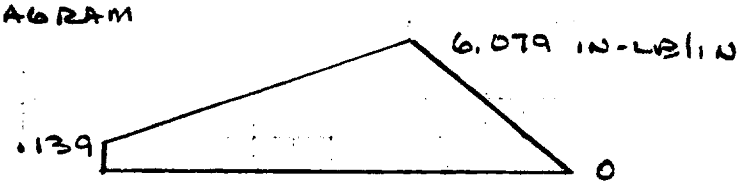


$\ell = 1/3(1.017)$
$d = .562$
$d_2 = .188$
FLANGE $t = .050$ MINIMUM

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

$F_1 = 42.907$ LB/IN
$F_2 = 32.337$ LB/IN   1T LOADS
$V_1 = .0838$ LB/IN

MOMENT DIAGRAM



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

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

$$= 3\left[2 + 14590\right] = 43774 \text{ psi}$$

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

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

$\therefore$ SIDE FLANGES BAD @ $t = .050$

USING 3T LOADS

RAISE t TO .065 MIN, @ 3T LOADS

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

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

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

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

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

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

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

$$MS = \frac{66000}{1.4(43774)} - 1 = +.08 \qquad t = .050$$

$\therefore$ FLANGE OK @ t = .050
USING 3T LOADS & 2024-T851 ALUM

BOLT STRESSES

AT BOLT

$F = F_1 = 42.907$ LB/IN
$V = V_1 = .0838$ LB/IN

8 BOLTS (NAS1352N06, $F_{TU} = 160000$ PSI)
IN 12.500 − .900 = 11.600 IN

TOTAL LOAD/BOLT

$$F_B = \frac{11.600}{8.00} \, 42.907 = 62.215 \text{ LB}$$

$$V_B = \frac{11.600}{8} \, .0838 = .12 \text{ LB}$$

$$S_t = 3\frac{F_B}{A_S} = 3\frac{62.215}{.009085} = 20543 \text{ PSI}$$

$$S_S = 3\frac{F_B}{A_S} = 3\frac{.12}{.009085} = 40 \text{ PSI}$$

@ 3σ LOADS

FS = 1.4

$$f_t = 1.4 \times 20543 = 28762 \text{ PSI}$$

$$r_t = \frac{28762}{160000} = .180$$

$$f_S = 1.4 \times 40 = 55 \text{ PSI}$$

$$r_S = \frac{55}{(.06)(160000)} = .0006 \Rightarrow 0$$

$$R_t \sim 1.0$$

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

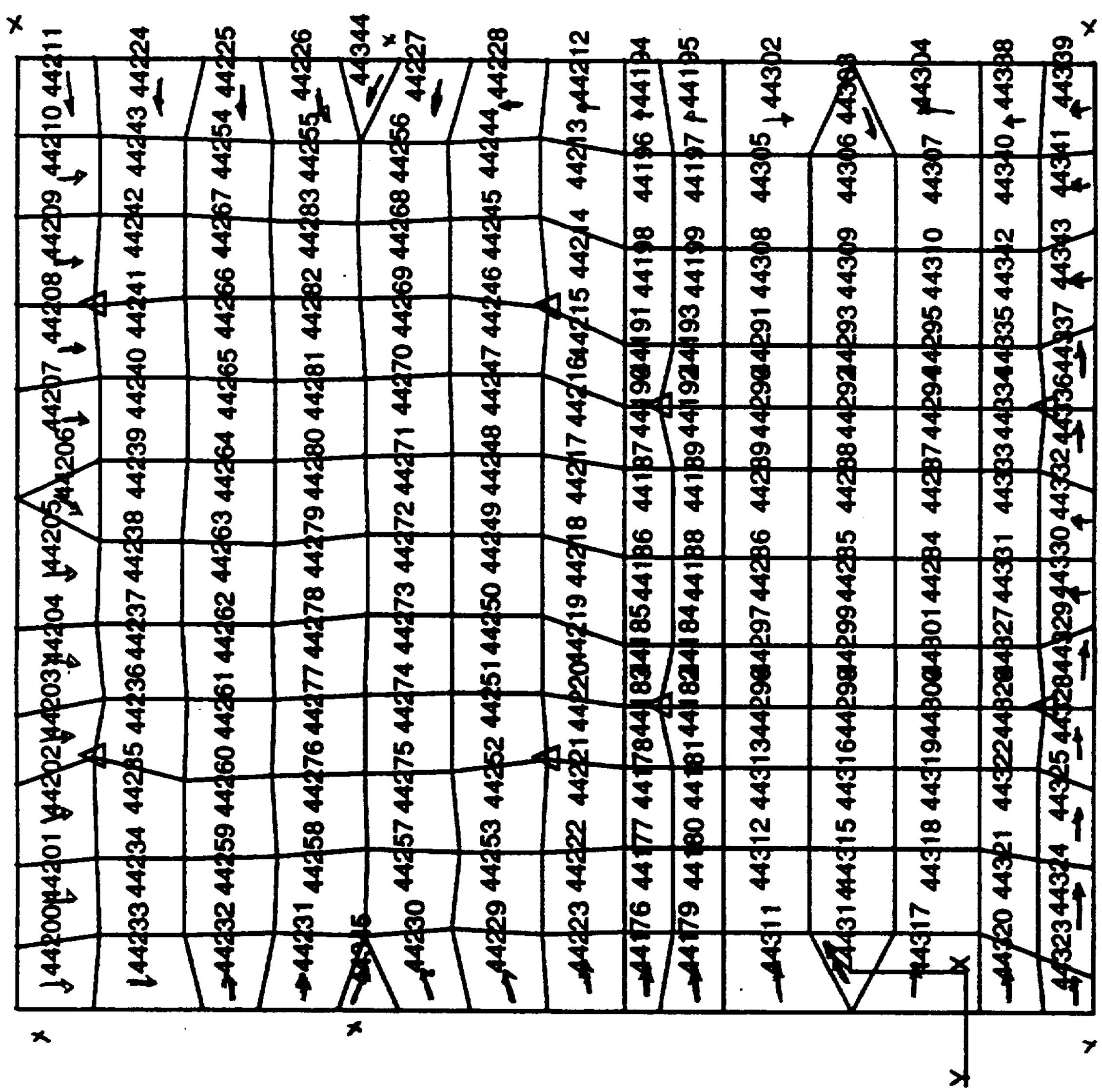
$$MS = \frac{1}{u} - 1 = +4.6$$

WORST LOADED SCREW
UPPER AFT PANEL
SIDE FLANGES
USING 3σ LOADS

∴ BOLTS OK ON SIDE FLANGES
USING 3σ LOADS

UPPER AFT PANEL

QUAD, TRI



UPPER RIGHT PANEL - LOWER FLANGE

RANDOM Y w/ Q=7.1 1σ LOADS

EL	1801	1813	$\boxed{1825}$	
Fx	16.715	15.460	15.294	LB/IN
Fy	2.502	1.895	1.479	"
Fxy	7.034	3.940	3.706	"
Mx	.0575	.1563	.2430	IN-LB/IN
My	.0511	.0363	.0641	"
Mxy	.0239	.0272	.0094	"
Vx	.0437	.2148	.2859	LB/IN
Vy	.4898	.0378	.0094	"

RANDOM X w/ Q=7.1 1σ LOADS

EL	1861	1873	
Fx	12.662	16.519	LB/IN
Fy	1.775	9.735	"
Fxy	12.724	3.842	"
Mx	.0544	.0293	IN-LB/IN
My	.0238	.0169	"
Mxy	.0191	.0137	"
Vx	.1285	.2530	LB/IN
Vy	.6565	.2800	"

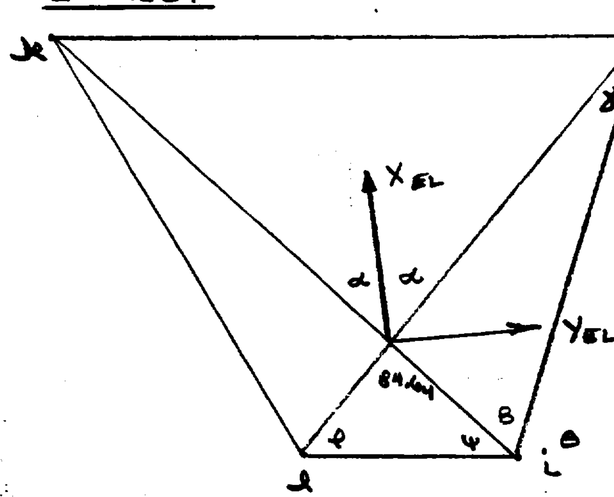
RANDOM Z w/ Q=7.1 1σ LOADS

EL	1873	
Fx	9.791	LB/IN
Fy	4.921	"
Fxy	2.159	"
Mx	.0067	IN-LB/IN
My	.0194	"
Mxy	.0047	"
Vx	.1000	LB/IN
Vy	.0763	"

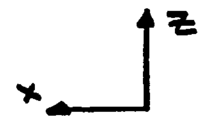
EL 1825 RANDOM Y IS WORST CASE, USING Fx, Mx, Vx

Fx = 15.294 LB/IN
Mx = .2430 IN-LB/IN
Vx = .2859 LB/IN

EL 1801



	x	z
i	17.472	10.096
j	17.157	11.221
k	18.682	11.221
l	18.022	10.096



$$\measuredangle ij = \theta = \tan^{-1} \frac{1.125}{.315} = 74.36^\circ$$

$$\measuredangle ik = \psi = \tan^{-1} \frac{1.125}{1.210} = 42.92$$

$$\measuredangle ilj = \tan^{-1} \frac{1.125}{.865} = 52.44 = \varphi$$

$$\alpha = (180 - \varphi - \psi)/2 = 42.32$$

ROTATE X_{EL} CW $(90 - 42.92) - 42.32 = 4.76^\circ$

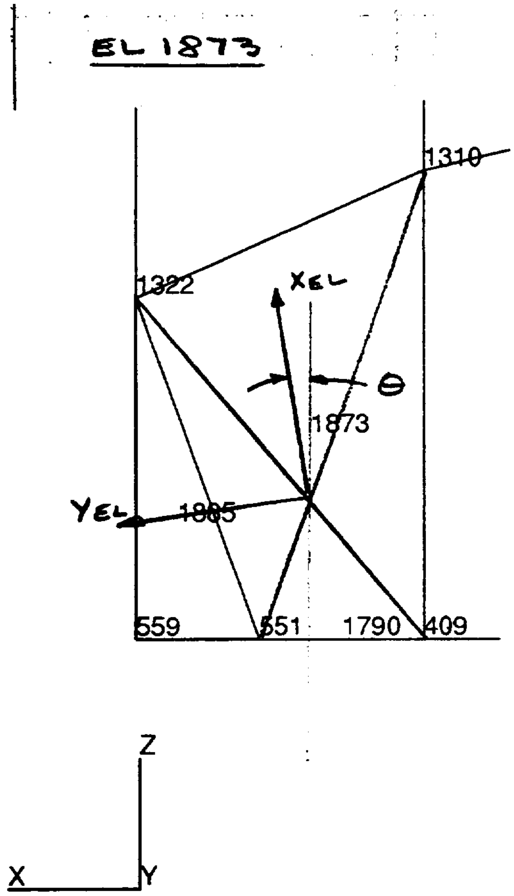
RANDOM Y

$$F_x' = \frac{(16.715 + 2.502)}{2} + \frac{(16.715 - 2.502)}{2} \cos(2x - 4.76)^\circ + 7.034 \sin(2x - 4.76^\circ)$$

$= 15.454$ LB/IN

$M_x' = .0567$ IN-LB/IN

$V_x' = V_x = .0437$ LB/IN



RANDOM X

ROTATE X_{EL} CW 10°, THUS $\theta = -10^\circ$, TO ACHIEVE NORMAL

$$F_x' = \frac{16.519 + 9.735}{2} + \frac{16.519 - 9.735}{2} \cos(-20^\circ)$$

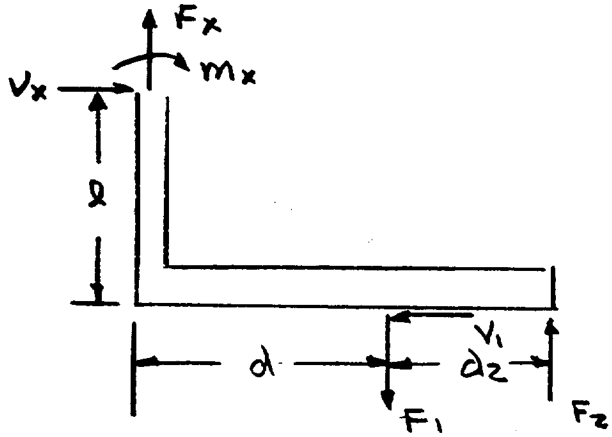
$$+ \; 3.842 \sin(-20^\circ)$$

$$= \; 15.000 \text{ LB/IN}$$

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

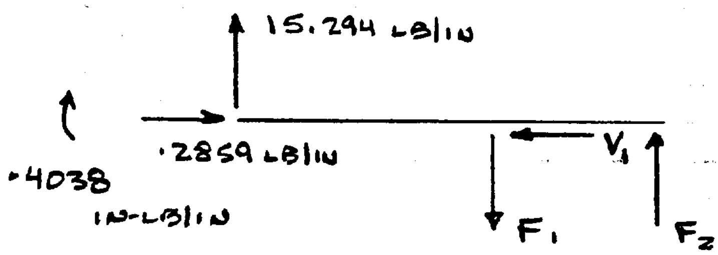
$$V_x' = V_x = .2530 \text{ LB/IN}$$

FLANGE STRESSES



l = 1.125/2
d = .312
d2 = .188

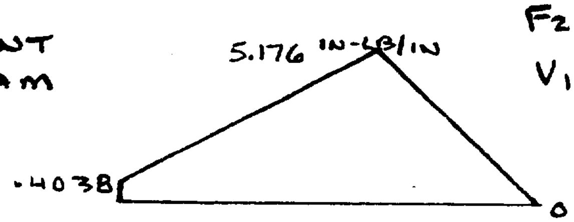
t = .040 FLANGE MINIMUM



$\Sigma M_2 = 0 \qquad F_1(.188) = 15.294(.5) + .4038$

$F_1 = 42.824$ LB/IN
$F_2 = 27.530$ LB/IN
$V_1 = .2859$ LB/IN

MOMENT DIAGRAM



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

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

@ 3T LOADS

$$= 3\left[\frac{.2859}{.040} + \frac{6(5.176)}{(.040)^2}\right]$$

$$= 3\left[7 + 19410\right]$$

$$= 58251 \text{ PSI}$$

MAT'RL 6061-T4 $\qquad F_{TY} = 16000$ PSI
$F_{TU} = 30000$ PSI

W/FS 1.25 YIELD, 1.4 ULTIMATE

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

$$= \frac{16000}{1.25(58251)} - 1 = -.78$$

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

$$= \frac{30000}{1.4(58251)} - 1 = -.63$$

$\therefore$ 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

$$MS = \frac{35000}{1.25(25894)} - 1 = +.08 \qquad t=.060$$

$$MS = \frac{42000}{1.4(25894)} - 1 = +.16 \qquad t=.060$$

$\therefore$ LOWER FLANGE OK @ t=.060 6061-T6

USING 3T LOADS

w/ t = .090 6061-T4

$$S_t = 3\left[\frac{.2859}{.090} + \frac{6(5.176)}{(.090)^2}\right]$$ @ 3∇ LOADS

$$= 3\left[3 + 3834\right]$$

$$= 11512 \text{ psi}$$

$$ms = \frac{16000}{1.25(11512)} - 1 = +.11$$

$$ms = \frac{30000}{1.4(11512)} - 1 = +.86$$

∴ LOWER FLANGE OK @ t = .090 6061-T4

USING 3∇ LOADS

BOLT STRESSES

$$F_B = \frac{8.783}{7}(42.824) = 53.73 \text{ LB}$$

7 NAS1352N06 BOLTS, F_{tu} = 160000 PSI IN 8.783 IN.

$$S_t = 3\frac{F_B}{A_s} = 3\frac{53.73}{.009085} = 17742 \text{ psi}$$ @ 3∇ LOADS

$f_t = 1.4 \times S_t = 24839$ psi

$r_t = \frac{24839}{160000} = .155$

$f_s \to 0$

$R_t = 1.0$

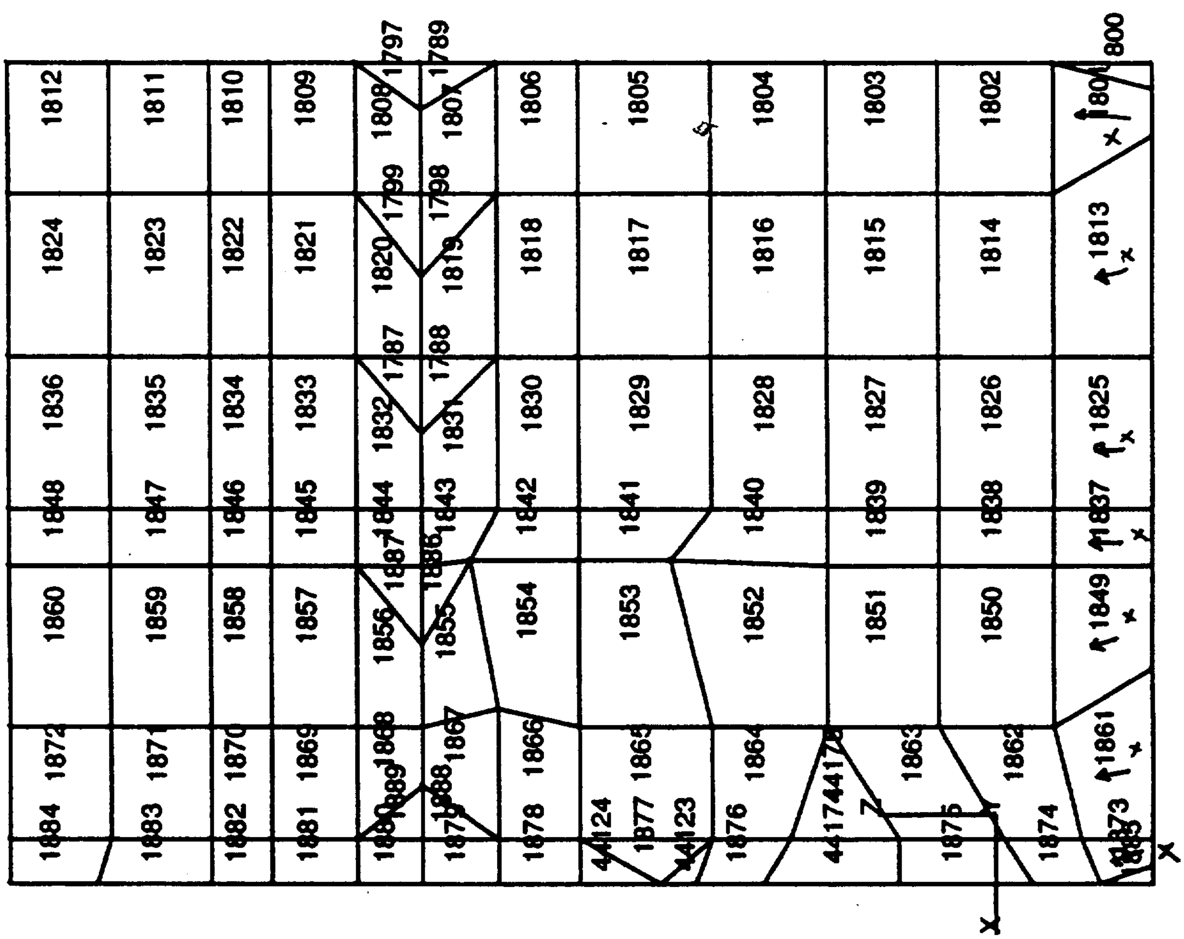
$u = r_t / R_t = .155$

$ms = \frac{1}{u} - 1 = +5.4$

WORST LOADED BOLT
UPPER RIGHT PANEL
LOWER FLANGE @ 3∇ LOADS

∴ BOLTS OK ON LOWER FLANGE @ 3∇ LOADS

UPPER RIGHT PANEL - QUAD, TRI



LOWER RIGHT SUPPORT PANEL- LOWER FLANGE, AFT FLANGE

RANDOM Y w/Q=7.1 1σ LOADS

EL	2565	
Fx		
Fy	8.277	LB/IN
Fxy		
Mx		
My	.0475	IN-LB/IN
Mxy		
Vx		
Vy	.0903	LB/IN

RANDOM X w/Q=7.1 1σ LOADS

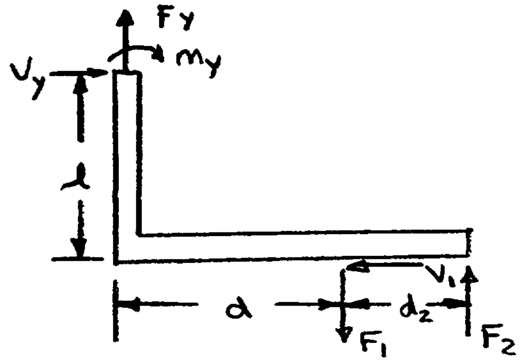
EL	2566	
Fy	3.334	LB/IN
My	.0044	IN-LB/IN
Vy	.0095	LB/IN

RANDOM Z w/Q=7.1 1σ LOADS

EL	2565	
Fy	5.195	LB/IN
My	.0126	IN-LB/IN
Vy	.0144	LB/IN

WORST CASE IS RANDOM Y @ EL 2565

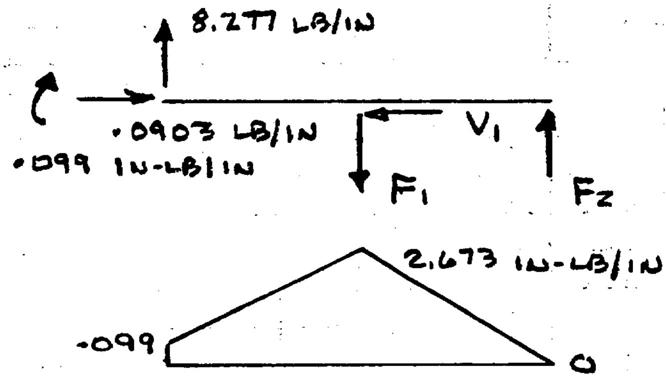
F_y = 8.277 LB/IN
M_y = .0475 IN-LB/IN
V_y = .0903 LB/IN



l = 1.131/2
d = .312
d_2 = .313

FLANGE t = .040
MINIMUM

FLANGE STRESSES



$\Sigma M_2 = 0$

$F_1(.313) = 8.277(.625) + .099$

$F_1 = 16.844$ LB/IN

$F_2 = 8.567$ LB/IN

$V_1 = .0903$ LB/IN

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

@ 3T LOADS

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

$$= 3\left[\frac{.0903}{.040} + \frac{6(2.673)}{(.040)^2}\right]$$

$$= 3\left[2 + 10024\right]$$

$$= 30078 \text{ psi}$$

MAT'RL 6061-T651

$F_{ty} = 35000$ psi

$F_{tu} = 42000$ psi

FS = 1.25, 1.4

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

$$= \frac{35000}{(1.25)(30078)} - 1 = -.07$$

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

$$= \frac{42000}{(1.4)(30078)} - 1 = -.003$$

$\therefore$ FLANGES BAD @ $t = .040$

USING 3T LOADS

RECOMMEND TIGHTENING TOLERANCE TO

$t = .050 \pm .005$

THEN @ $t_{MIN} = .045$, @ 3T LOADS

$$S_t = 3\left[\frac{.0903}{.045} + \frac{6(2.673)}{(.045)^2}\right] = 23766 \text{ PSI}$$

$$MS = \frac{35000}{1.25(23766)} - 1 = +.18 \qquad t = .045$$

$$MS = \frac{42000}{1.4(23766)} - 1 = +.26 \qquad t = .045$$

$\therefore$ FLANGES OK @ $t = .045$

USING 3T LOADS

BOLT STRESSES

3 NAS1352N06 SCREWS, $F_{TU} = 160000$ PSI IN 6.500 IN

$$F_B = \frac{6.500}{3} 16.844 = 36.50 \text{ LB}$$

$$S_t = 3\frac{F_B}{A_s} = 3\frac{36.50}{.009085} = 12052 \text{ PSI}$$ @ 3T LOADS

$$f_t = 1.4 \times 12052 = 16874 \text{ PSI}$$

$$r_t = \frac{16874}{160000} = .105$$

$$f_s \sim 0$$

$$R_t \sim 1.0$$

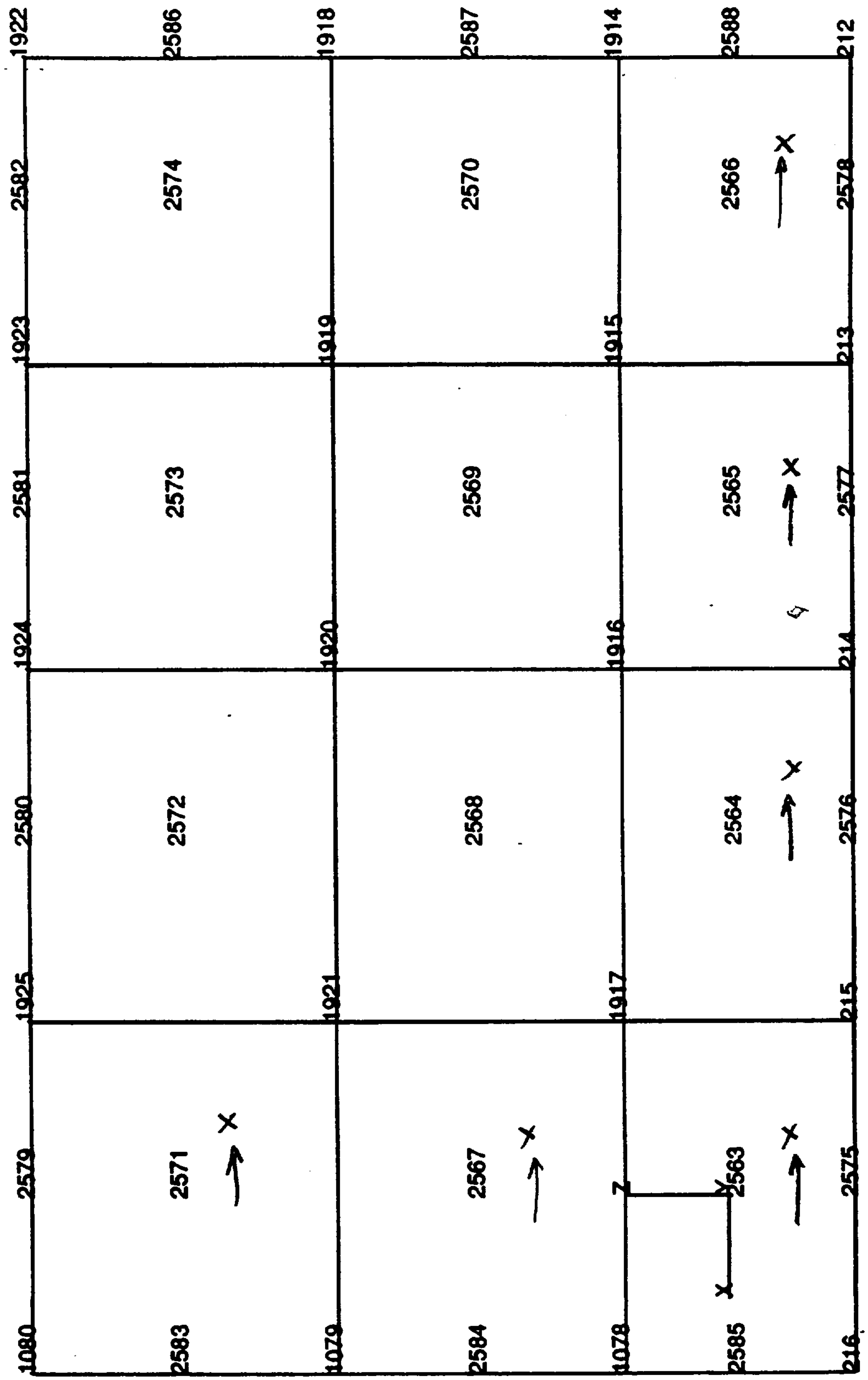
$$u = \frac{r_t}{R_t} = .105$$

$$ms = \frac{1}{u} - 1 = +8.5$$

WORST LOADED SCREW
LOWER RIGHT SUPPORT
LOWER FLANGE
USING 3T LOADS

$\therefore$ 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/Ftu (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 (IN2)	BEARING STRESS (PSI)	FS	ALLOW Ftu (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 Fsu (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 Fsu 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, 85, 105, 169, 189, 254, 257, 261, 263, 266, 269, 271, 275) REACT TENSION/COMPRESSION (NASTRAN T3 SPC FORCE) 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.

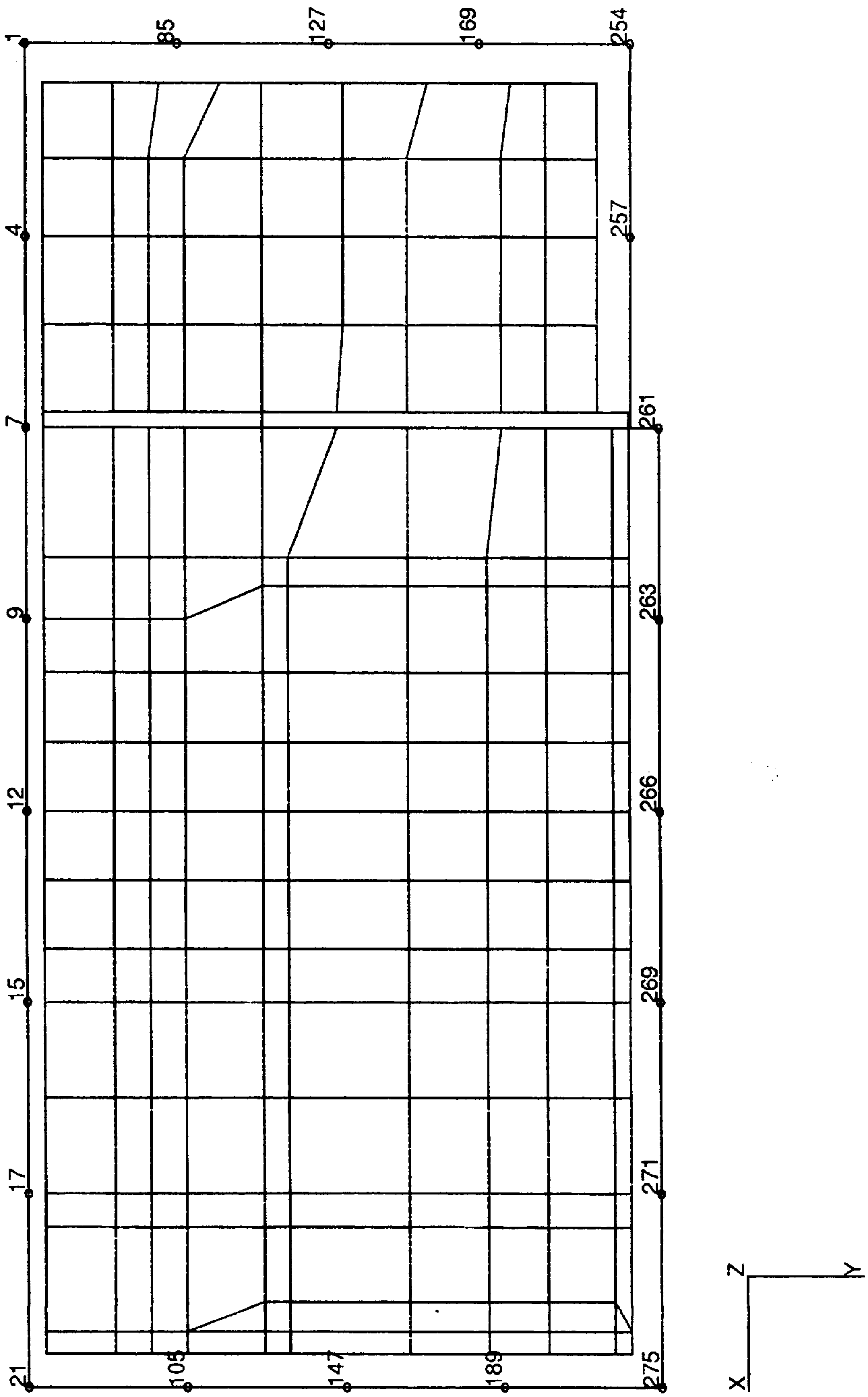
6) ALLOWABLES ARE PER MS16997 (UNC-3A)

TENSILE LOAD	2800	# 10-32 SCREWS
SHEAR LOAD	1273 LB	

TENSILE LOAD ALLOWABLE BASED ON F_{TU} (140000 PSI) AND TENSILE AREA ($A_s = .01999 \text{ IN}^2$)
SHEAR LOAD ALLOWABLE BASED OF $F_{SU} = .6 \times F_{TU}$ AREA PER MINOR ϕ ($\pi/4\,(.1389^2)$).

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 15g 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+01
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+02	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

$F_t = T_3 = 298.4$ LB APPLIED TENSION

$F_S = \sqrt{T_1^2 + T_2^2} = \sqrt{(13.9)^2 + (283.9)^2} = 284.2$ LB APPLIED SHEAR

PRELOAD TORQUE, $T = .2 F_L d$

F_L = PRELOAD
d = NOMINAL ϕ, .190 IN #10 SCREW

T	F_L
50 IN-LB	1315 LB

ASSUMING $F_i = 1315$ LB PRELOAD

TOTAL BOLT TENSILE LOAD, F_b, IS A FUNCTION OF PRELOAD, APPLIED TENSION, & JOINT STIFFNESS.

$$F_b = F_i + \frac{k_b F_t}{k_b + k_m}$$

$F_i = 421$ LB
$F_t = 298.4$ LB
k_b = BOLT STIFFNESS
k_m = MEMBER STIFFNESS

$$k_b = \frac{E_b A}{l}$$

$$= .9126 \times 10^6 \text{ LB/IN}$$

$E_b = 28 \times 10^6$ PSI
$A = \pi/4\,(.190)^2 = .02835\ \text{IN}^2$
l = GRIP OF THERMAL SPACERS + BP LEDGE
.25 + .25 + .31 + .06

$$k_m = \frac{\pi E_m d}{2 \ln\left[\frac{5(l + d/2)}{l + 2.5d}\right]}$$

$$= 58409 \text{ LB/IN}$$

FOR G-10 SPACER ONLY W/ FIBERS ⊥ THICKNESS USE EPOXY ONLY PROP

$E_m = 250000$ PSI
$l = .87$ IN
$d = .190$ IN

WITH $k_m << k_b$ USE $k_b/(k_b + k_m) = 1.0$ & 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

$R_t = .944$

$R_s = .477$

$$u = \frac{r_t}{R_t} = \frac{r_s}{R_s} = .656$$

$$MS = \frac{1}{u} - 1 = +.52$$

COMBINED TENSION
PLUS SHEAR ULTIMATE
GRID 261 SCREW
$G_Y = 15g$

CASE $G_Y = 15g$ GRID 21 BOLT

$F_t = T_3 = 308.3$ LB APPLIED TENSION

$F_s = \sqrt{T_1^2 + T_2^2} = \sqrt{86.3^2 + 164.1^2} = 185.4$ LB APPLIED SHEAR

$F_L = 1315$ LB PRELOAD

$f_t = 1315 + 1.4(308.3) = 1747$ LB

$f_s = 1.4(185.4) = 259.6$ LB

$$r_t = \frac{1747}{2800} = .624$$

$$r_s = \frac{259.6}{1273} = .204$$

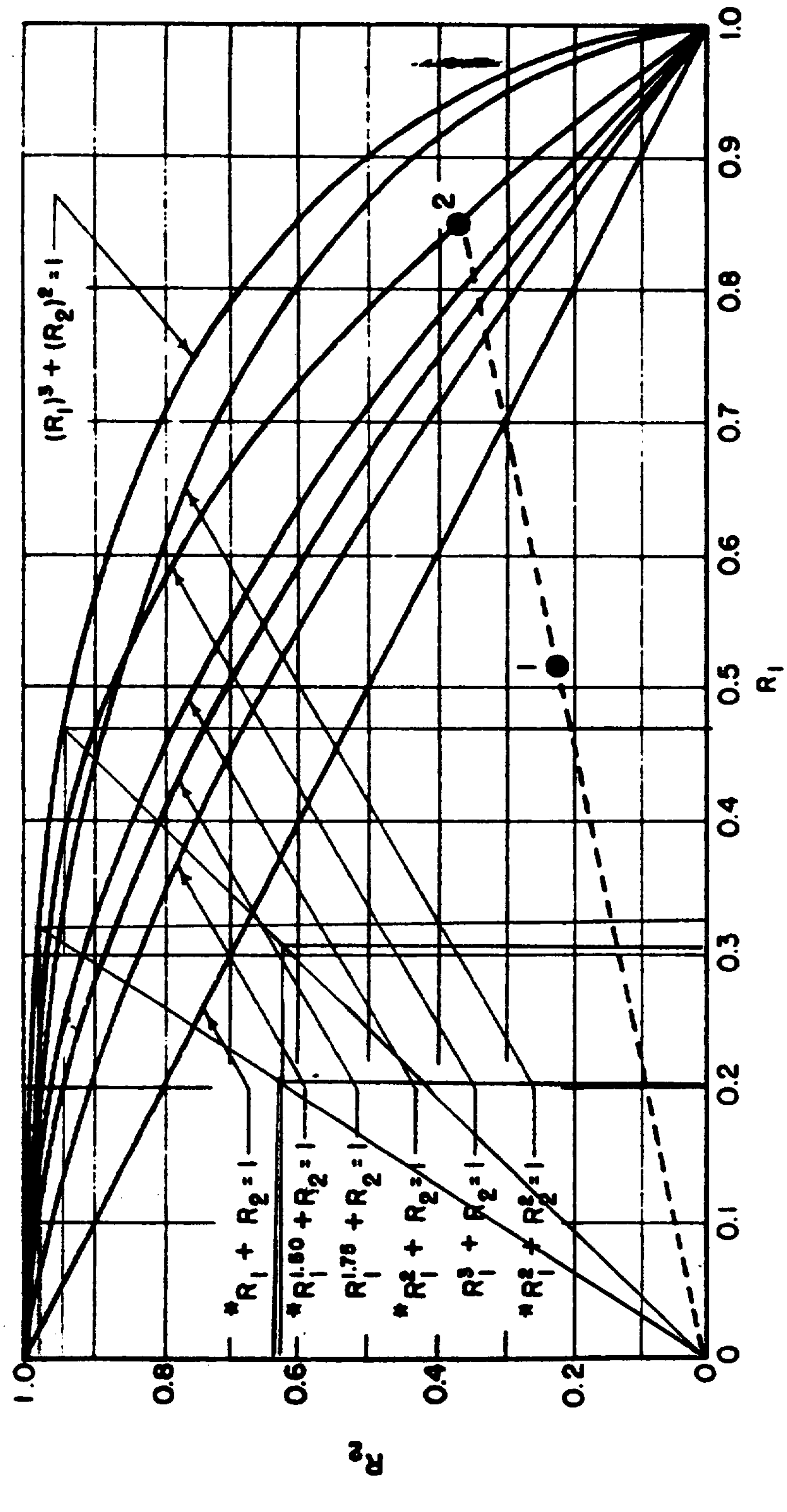
$R_t = .983$

$R_s = .320$

$$u = \frac{r_t}{R_t} = \frac{r_s}{R_s} = .635$$

$$MS = \frac{1}{u} - 1 = +.57$$

COMBINED TENSION
PLUS SHEAR ULTIMATE
GRID 21 SCREW
$G_Y = 15g$

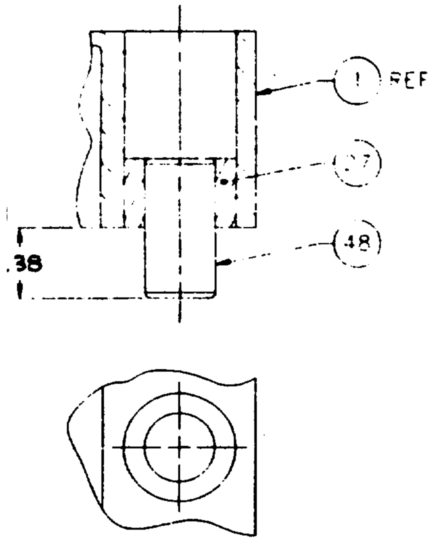


*Typical interaction curves for combined loading conditions. *Refer to Section 1.5.3.5 for analytical margin of safety.*

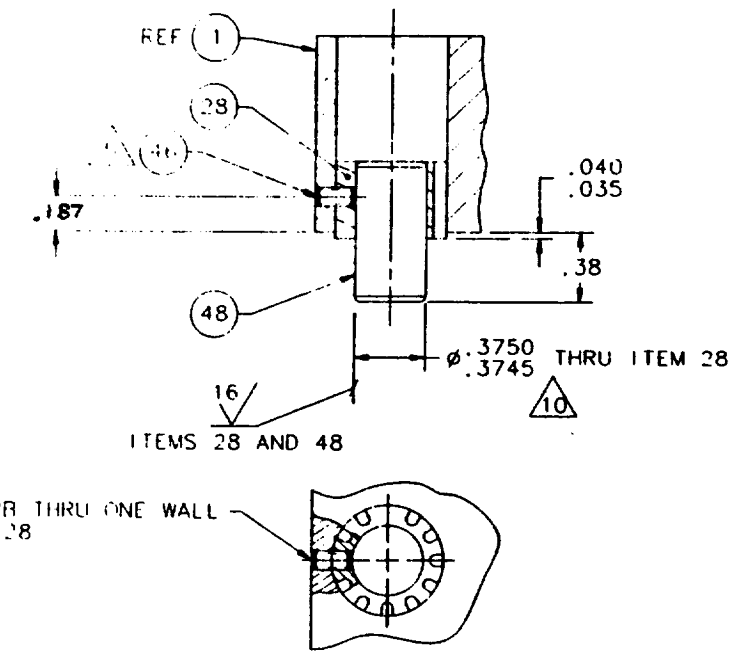
THE 2 SHEAR PIN HOLES ARE PER 1356405

.5964
.5960 Ø HOLES W/ ASSUMED TITANIUM BUSHINGS
& ALLOY STEEL PINS

ASSUME 1333395-2 & -3 TITANIUM BUSHINGS W/ .375 Ø ALLOY STEEL PINS. PER 1356404 THE PIN JOINTS ARE VIEW P & VIEW N

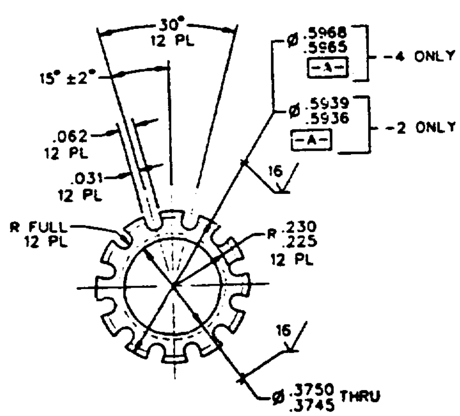


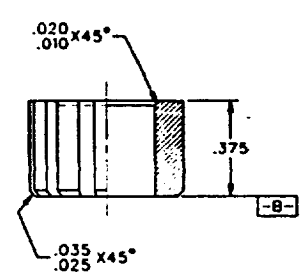
VIEW P 4 4 C
SCALE: 2/1



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.





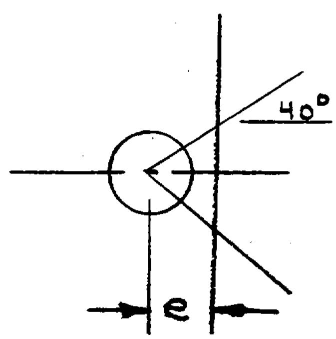
SHEAR-TEAROUT OF ALUMINUM BASEPLATE

THE SHEAR LOAD ORIGINATES FROM THE UNIT 15g STATIC SOLUTIONS WITH ALL SHEAR LOAD REACTED ONLY AT THE 2 PINS (NO SPC 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 BRUHN, "ANALYSIS AND DESIGN OF AIRPLANE STRUCTURES", 1973, P D1.4 - D1.5



$e = .404$ $\qquad \frac{e}{d} = 0.68$

$d = .5960$

$t = .375$

$$AS = (e - \tfrac{d}{2}\cos 40)(t)(2)$$

$$= .132 \text{ IN}^2$$

PER ULTIMATE SF 1.4

$$\tau = \frac{1.4 \times 985}{.132} = 10464 \text{ psi}$$

SHEAR ALLOWABLE FOR LOWER BASEPLATE (1356405) 6061-T6

$$F_{su} = 27000 \text{ psi}$$

$$MS = \frac{27000}{10464} - 1 = +1.6 \qquad \text{BASEPLATE}$$

BEARING OF 1333395-2 BUSHING ONTO ALUMINUM 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

$$\pi d = \pi(.5936) = 1.865$$

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 $F_{bry} = F_{cy}$

6061-T6 ALUMINUM

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

$$MS = \frac{35000}{10476} - 1 = +2.3$$ 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 $F_{bru} = F_{tu} = 42000 \text{ psi}$

$$MS = \frac{42000}{11733} - 1 = +2.6$$ 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

F O R C E S   O F   S I N G L E - P O I

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

F O R C E S   O F   S I N G L E - P O I

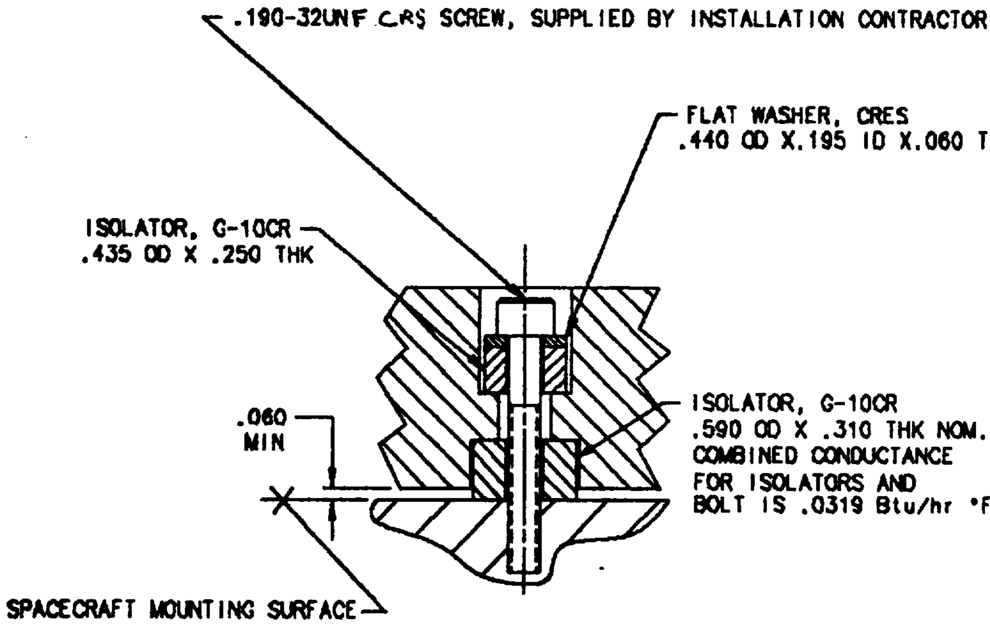
POINT ID.	TYPE	T1	T2	T3
1	G	0.0	0.0	-7.765912E+01
4	G	0.0	0.0	-3.411418E+01
7	G	0.0	0.0	-2.643308E+02
9	G	0.0	0.0	-8.226789E+01
12	G	0.0	0.0	-7.924261E+01
15	G	0.0	0.0	-8.992119E+01
17	G	0.0	0.0	-2.211956E+02
21	G	0.0	0.0	-2.993695E+02
85	G	0.0	0.0	-1.207610E+01
105	G	0.0	0.0	-1.094637E+02
127	G	8.818773E+00	-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-POI

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

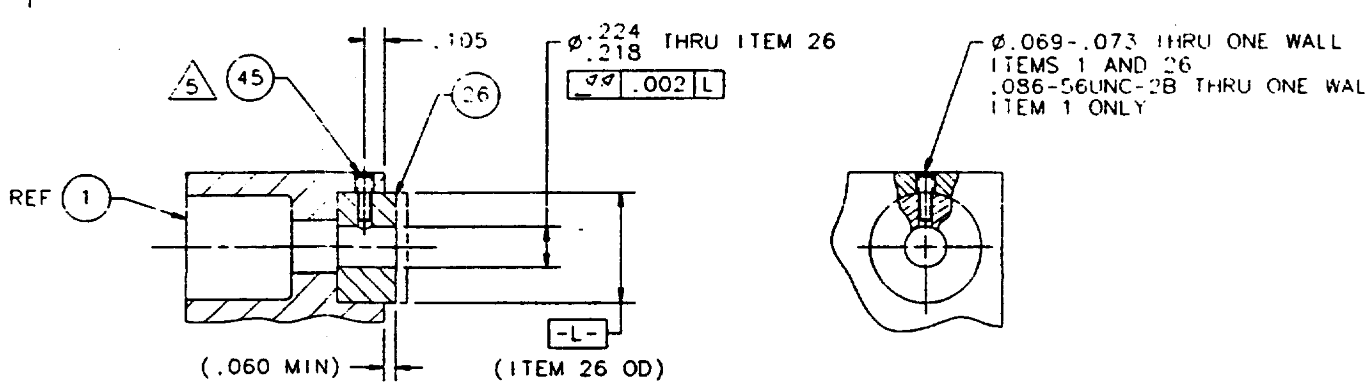
FROM 1356863 THERMAL INTERFACE CONTROL DWG, THE BOLT JOINT IS AS FOLLOWS



VIEW B
SCALE: 2/1

WHERE THE .435 Ø X.250 THK ISOLATOR IS A G-10CR SPACER, AND THE .590 OD X .310 THK ISOLATOR IS A 1333395-6 SPACER, ALSO G-10CR

THE BASEPLATE HOLE DIMENSIONS ARE PER 1356405 W/SKETCH PER 1356404 VIEW R



VIEW R
20 PL
SCALE: 2/1

COMPRESSION OF G-10CR ISOLATORS UNDER BOLT PRELOAD

MAXIMUM LOAD AS DETERMINED ABOVE FOR 50 IN-LB PRELOAD TORQUE (F_i = 1315 LB)

$F = 1315$ LB

APPLY A FS = 1.4 (ULTIMATE) (1.25 LIMIT FOR 6061-T6)

MINIMUM BOLT JOINT BEARING AREA'S WITH

BOLT	ASSUMED A-286 STEEL	F_{tu} = 140000 PSI
WASHER	ASSUMED ALLOY STEEL	F_{tu} = 160000 PSI
G-10CR ISOLATORS (LAMINATES ⊥ TO CENTERLINE)		F_{tu} = 60000 PSI
BASEPLATE	6061-T6 ALUM	F_{tu} = 42000 PSI F_{ty} = 35000 PSI

BOLT HEAD TO WASHER

ASSUME MS16775 .190-32UNC SCREW
ASSUME NAS1149E0363P WASHER

HEAD OD .3125 − 2(.005) = .3025 MIN
WASHER ID .203 + .010 = .213 MAX

$$A = \pi/4\,(.3025^2 - .213^2) = .0362\ \text{IN}^2\ \text{MIN}$$

$$F/A = \frac{1315}{.0362} = 36290\ \text{PSI}$$

$$MS = \frac{140000}{1.4 \times 36290} - 1 = +1.8 \quad \text{BOLT/WASHER}$$

WASHER TO .435 OD × .250 THK ISOLATOR

ASSUME NAS1149E0363P WASHER

WASHER OD .438 − .005 = .433 MIN ID .213 MAX
ISOLATOR OD .435 − .002 = .433 MIN (ASSUMED)

$$A = \pi/4\,(.433^2 - .213^2) = .112\ \text{IN}^2\ \text{MIN}$$

$$F/A = \frac{1315}{.112} = 11781\ \text{PSI}$$

$$MS = \frac{60000}{1.4 \times 11781} - 1 = +2.6 \qquad \text{ISOLATOR}$$

<u>.435 OD ISOLATOR TO BASEPLATE LEDGE</u>

ISOLATOR OD .433 MIN (ASSUMED)
BASEPLATE ID .287 MAX

$$A = \pi/4\,(.433^2 - .287^2) = .083 \text{ IN}^2$$

$$F/A = \frac{1315}{.083} = 15928 \text{ PSI}$$

$$MS = \frac{42000}{1.4 \times 15928} - 1 = +0.88 \qquad \text{BASEPLATE}$$

$$MS = \frac{35000}{1.25 \times 15928} - 1 = +0.76 \qquad \text{BASEPLATE}$$

<u>BASEPLATE LEDGE TO 1333395-6 .590 OD ISOLATOR</u>

ISOLATOR OD .590 − 2(.030) = .530 MIN
BASEPLATE ID .287 MAX

$$A = \pi/4\,(.530^2 - .287^2) = .156 \text{ IN}^2$$

$$F/A = \frac{1315}{.156} = 8433 \text{ PSI}$$

$$MS = \frac{42000}{1.4 \times 8433} - 1 = +2.6 \qquad \text{BASEPLATE}$$

$$MS = \frac{35000}{1.25 \times 8433} - 1 = +2.3 \qquad \text{BASEPLATE}$$

.590 OD ISOLATOR TO SPACECRAFT

ISOLATOR OD .590 MIN
ISOLATOR ID .224 MAX (ASSUMED)

$$A = \pi/4\,(.590^2 - .224^2) = .234 \text{ IN}^2$$

$$F/A = \frac{1315}{.234} = 5620 \text{ psi}$$

$$MS = \frac{60000}{1.4 \times 5620} - 1 = +6.6 \qquad \text{ISOLATOR}$$

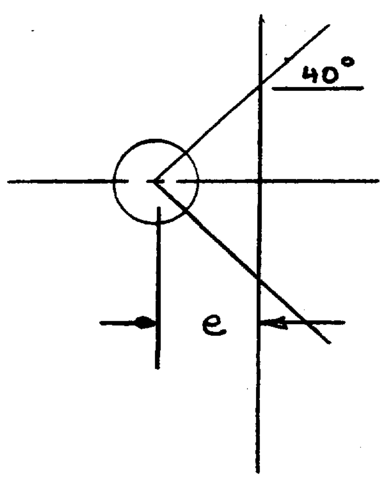
SHEAR-TEAROUT OF ALUMINUM BASEPLATE

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 GY=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



$e = .404$
$d = .5920$
$\frac{e}{d} = 0.68$
$t = .250$

$$AS = (e - \tfrac{d}{2}\cos 40)(t)(2)$$
$$= .089 \text{ IN}^2$$

$$\tau = \frac{1.4 \times 284}{.089} = 4486 \text{ psi}$$

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

$$\sigma = \frac{1.25 \times 284}{.148} = 2407 \text{ PSI} \quad \text{LIMIT LOAD w/ 1.25 FS}$$

WITH $e/D = .68 << 1.5$ USE $F_{bry} = F_{cy}$

$$F_{cy} = 35000 \text{ PSI} \quad \text{6061-T6 ALUM}$$

$$MS = \frac{35000}{2407} - 1 = +13 \quad \text{BASEPLATE}$$

WITH $e/D = .68 << 1.5$ USE $F_{bru} = F_{tu}$

$$F_{tu} = 42000 \text{ PSI} \quad \text{6061-T6 ALUM}$$

$$\sigma = \frac{1.4 \times 284}{.148} = 2696 \text{ PSI}$$

$$MS = \frac{42000}{2696} - 1 = +14 \quad \text{BASEPLATE}$$

FOR ISOLATOR USE $F_{bru} = F_{cu}$ EDGE $= 35000$ PSI

$$MS = \frac{35000}{2696} - 1 = +11 \quad \text{.590 OD ISOLATOR}$$

THREAD SHEAR OF .190-32UNF SCREW INTO SPACECRAFT MOUNTING SURFACE

ASSUMPTIONS

1) SCREW MAT'RL HAS F_{TU} = 140000 PSI
2) -3A SCREW THREAD
2) SCAPECRAFT HAS INSERT ALSO WITH F_{TU} = 140000 PSI
3) LENGTH OF ENGAGEMENT ≥ 1 DIA (≥ .190 IN)

SHEAR LOAD 1747 LB (REF COR1021 Gy=15g CASE)

SHEAR AREA

$$A_S = \frac{\pi E \, L_e}{2} \qquad E = .1697 \quad L_e = .190$$

$$= .05065 \text{ IN}$$

WITH FS=1.4

$$\tau = \frac{1747}{.05065} = 34484 \text{ PSI}$$

$$F_{SU} = .6 F_{TU} = .6(140000) = 84000 \text{ PSI}$$

$$MS = \frac{84000}{34484} - 1 = +1.4$$

∴ 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	INTERNAL	399	158	1.4	0.602	532	0.0355	14990	27000	0.80
Y	.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 "ELFORCE" DATA AS LOAD. PER LOWER FLANGE BENDING STRESS/ BOLT TENSILE STRESS EVALUATION, THE FORCE @ THE NAS 1352NØ6-6 SCREW IS:

$F_1 = 3 \times 105.88$ LB/IN $= 317.64$ LB/IN "3σ"

W/ 15 SCREWS IN 19.29 INCHES

LOAD PER SCREW, P

$$P = \frac{19.29}{15}(317.64) = 408 \text{ LB}$$

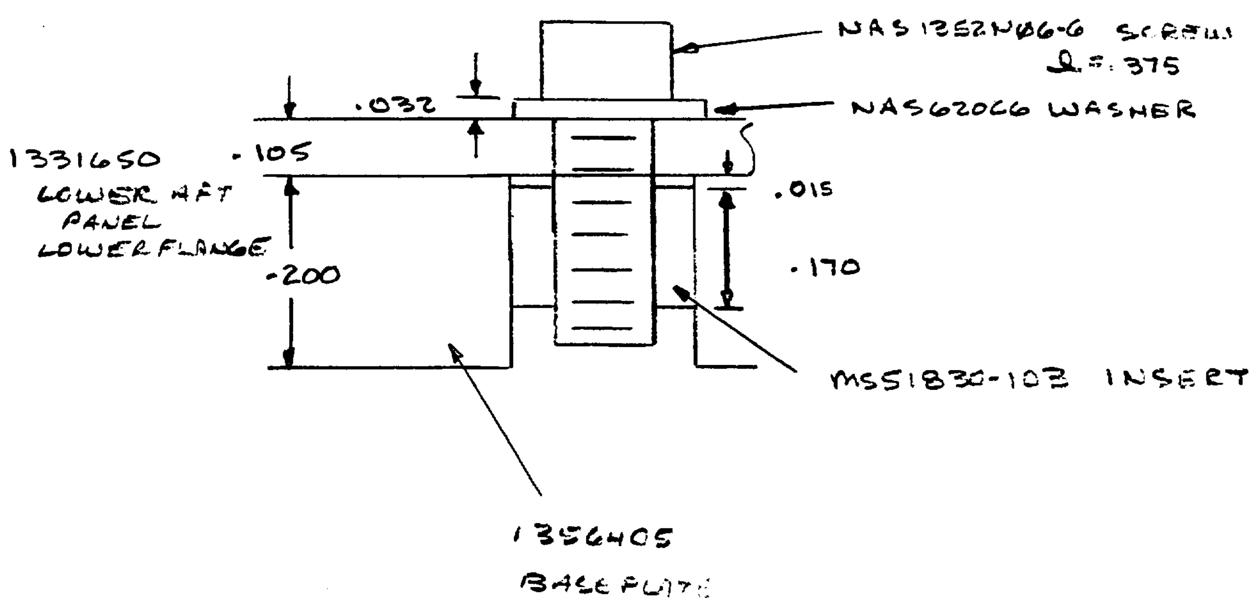
FACTOR OF SAFETY ON P

$FS = 1.4$

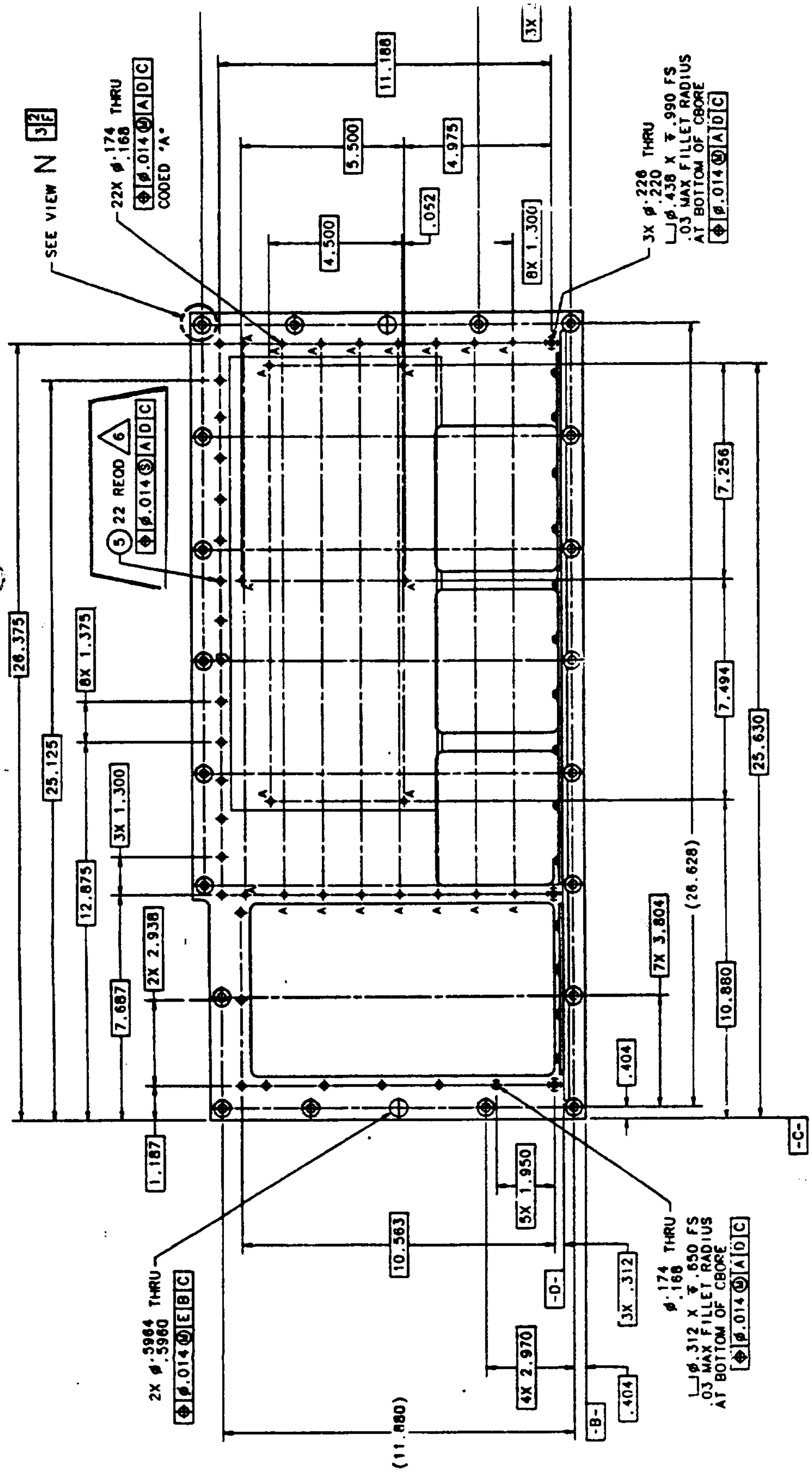
PRELOAD (9-11 IN-LB TORQUE)

$T = .2 F_i d$ $\qquad d = .138$

$F_i = 11/(.2)(.138) = 399$ LB



1356405 LOWER BASEPLATE
MS51830-103 INSERTS - ITEM 5



VIEW M–M

MS51830-103
15 TO 1331650 LOWER RIGHT PANEL
4 1331414 LOWER MOTOR MOUNT PANEL
3 1331447 LOWER RIGHT FRONT SUPPORT PANEL

FOR NAS1352N06 SCREW TO EXTEND BEYOND INSERT REQUIRES A -6 SCREW OF $\ell = .375$ 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

$$\ell_e = .125 - .010 - 1/n \qquad n = 28$$

$$= .079 \text{ IN}$$

MAT'RL

CRES 303 $F_{su} = .6(80000) = 48000$ PSI INSERT
6061-T6 $F_{su} = 27000$ PSI BASEPLATE

THREAD SHEAR AREA (H-28 APP A5)

INT THD

$$AS_n = \pi n \ell_e D_{s\,min} \left[\frac{1}{2n} + .57735 (D_{s\,min} - E_{n\,max}) \right]$$

$n = 28$
$\ell_e = .079$
$D_{s\,min} = .2085$ MIN MAJOR EXT
$E_{n\,max} = .1970$ MAX PITCH INT

$$AS_n = .0355 \text{ IN}^2$$

EXT THD

$$AS_s = \pi n \ell_e K_{n\,max} \left[\frac{1}{2n} + .57735 (E_{s\,min} - K_{n\,max}) \right]$$

$K_{n\,max} = .186$ MAX MINOR INT
$E_{s\,min} = .1886$ MIN PITCH EXT

$$AS_s = .0250 \text{ IN}^2$$

JOINT STIFFNESS

PER SHIGLEY, MECHANICAL ENGINEERING DESIGN,
4TH EDITION, 1983, P371-376, WITH ASSUMPTIONS
USE d = INSERT NOMINAL ϕ, .216 IN

$$F_b = \frac{k_b P}{k_b + k_m} + F_i$$

b = BOLT
m = MEMBER

$$k_b = \frac{EA}{l}$$

$E = 29 \times 10^6$ psi
$A = \pi/4\,(.216)^2 = .0366$ IN²
$l = .032 + .105 + .015 = .152$ IN
GRIP LENGTH

$$= 6.991 \times 10^6 \text{ LB/IN}$$

$$k_m = \frac{\pi E d}{2 \ln\left[5 \dfrac{l + d/2}{l + 2.5d}\right]}$$

$E = 10 \times 10^6$ psi
$d = .216$ IN
$l = .152$ IN

$$= 5.381 \times 10^6 \text{ LB/IN}$$

w/ $E = 10 \times 10^6$ psi
WHOLE GRIP LENGTH

TOTAL SCREW TENSILE LOAD

$P = 1.4\,F = 1.4(408) = 571$ LB

$F_i = 399$ LB

$F_b = (.565)(571) + 399 = 722$ LB

SHEAR STRESS

BASEPLATE 6061-T6 INT THD

$$\tau = \frac{F_b}{As_n} = \frac{722}{.0355} = 20335 \text{ psi}$$

$$MS = \frac{27000}{20335} - 1 = +.33 \quad \text{BASEPLATE}$$

∴ THREAD SHEAR OK IN BASEPLATE ID THDS

MS51830-103 INSERT CRES EXT THD

$$\tau = \frac{F_b}{AS_s} = \frac{722}{.0250} = 28880 \text{ PSI}$$

$$MS = \frac{48000}{28880} - 1 = +.66 \quad \text{INSERT}$$

∴ THREAD SHEAR OK IN INSERT OD THDS

MS51830-103 INT THD TO MS1352NØ6-6 SCREW EXT THD

- .138-32UNRC-3A EXT THD MS1352NØ6
- .138-32UNJC-3B INT THD MS51830-103

ENGAGEMENT LENGTH

$$l_e = .170 - .015 - 1/n \qquad n = 32$$

$$= .124 \text{ IN}$$

MAT'RL

ALLOY STEEL $F_{su} = .6(160000) = 96000$ PSI SCREW

CRES 303 $F_{su} = .6(80000) = 48000$ PSI INSERT

THREAD SHEAR AREA (H-28 APPA5)

INT THD

$$AS_n = \pi E \frac{3 l_e}{4} \qquad l_e = .124$$

E = BASIC PITCH Ø .1177 IN

$$= .0344 \text{ IN}^2$$

$$AS_s = \pi E \frac{5 l_e}{8}$$

$$= .0287 \text{ IN}^2$$

JOINT STIFFNESS

$$F_b = \frac{k_b}{k_b + k_m} P + F_i$$

b = BOLT
m = MEMBER

$$k_b = \frac{EA}{l_{GRIP}}$$

$E = 29 \times 10^6$ PSI
$A = \pi/4\,(.138)^2 = .0150\ \text{IN}^2$
$l = .032 + .105 + .015 = .152$ IN
GRIP LENGTH

$$= 2.854 \times 10^6\ \text{LB/IN}$$

$$k_m = \frac{\pi E d}{2 \ln\left[5\,\dfrac{l + d/2}{l + 2.5d}\right]}$$

$E = 10 \times 10^6$ PSI
$d = .138$ IN
$l = .152$ IN

W/ $E = 10 \times 10^6$ PSI ASSUMED
ENTIRE GRIP LENGTH

$$= 2.713 \times 10^6\ \text{LB/IN}$$

TOTAL SCREW TENSILE LOAD

$P = 1.4F = 1.4(408) = 571$ LB

$F_i = 399$ LB

$F_b = (.513)(571) + 399 = 692$ LB

SHEAR STRESS

MS51830-103 INSERT CRES INT THD

$$\tau = \frac{F_b}{AS_n} = \frac{692}{.03441} = 20108\ \text{PSI}$$

$$MS = \frac{48000}{20108} - 1 = +1.4 \qquad \text{INSERT}$$

∴ THREAD SHEAR OK IN INSERT ID THDS

MS1352N06 SCREW STEEL EXT THD (HEAT RESIST)

$$\tau = \frac{F_b}{AS_s} = \frac{692}{.0287} = 24111\ \text{PSI}$$

$$MS = \frac{96000}{24111} - 1 = +3.0 \qquad \text{SCREW}$$

∴ THREAD SHEAR OK IN SCREW OD THDS

12-7-95

1331414 LOWER MOTOR MT PANEL TO
1356405 LOWER BASEPLATE

FORCE @ NAS1352N06-6 SCREW IS

$F_1 = 3 \times 29.84$ LB/IN $= 89.52$ LB/IN "3σ RANDOM"

W/ 6 SCREWS IN 10.562 IN

LOAD PER SCREW, P

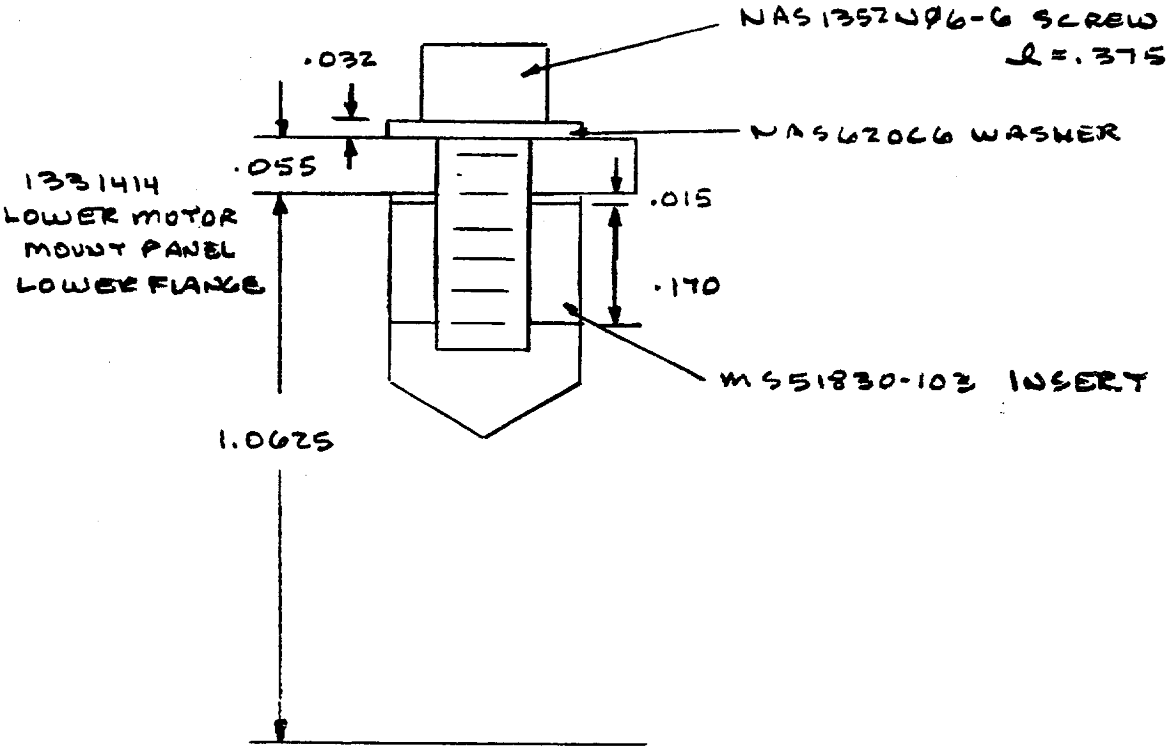
$$P = \frac{10.562}{6}(89.52) = 157.6 \text{ LB}$$

FACTOR OF SAFETY ON P

FS = 1.4

PRELOAD (9-11 IN-LB TORQUE)

$F_i = 11/(.2)(.138) = 399$ LB



THE NAS1352N06-6 SCREW (l=.375 IN) WILL EXTEND BEYOND INSERT THREADS. FULL le OF INSERT ID LENGTH IS MADE.

SIMILAR TO PREVIOUS JOINT

BASEPLATE INT THD TO INSERT EXT THD

.216-28UNF-2A INSERT MS51830-103
.216-28UNF-2B BASEPLATE

$$l_e = .125 - .010 - 1/n = .079 \text{ IN} \qquad n = 28$$

$F_{su} = 48000$ psi INSERT
$F_{su} = 27000$ psi BASEPLATE

$AS_n = .0355 \text{ IN}^2$
$AS_s = .0250 \text{ IN}^2$

JOINT STIFFNESS

$$F_b = \frac{k_b}{k_b + k_m} P + F_i$$

$$k_b = \frac{EA}{l_{GRIP}}$$

$E = 29 \times 10^6$ psi
$A = \pi/4\,(.216)^2 = .0366 \text{ IN}^2$
$l = .032 + .055 + .015$
$= .102$ IN
GRIP LENGTH

$$= 10.418 \times 10^6 \text{ LB/IN}$$

$$k_m = \frac{\pi E d}{2 \ln\left[5\,\frac{l + d/2}{l + 2.5d}\right]}$$

$E = 10 \times 10^6$ psi
$d = .216$ IN
$l = .102$ IN

$$= 6.897 \times 10^6 \text{ LB/IN}$$

TOTAL SCREW TENSILE LOAD

$$F_b = (.602)(1.4)(157.6) + 399 = 532 \text{ LB}$$

SHEAR STRESS

BASEPLATE 6061-T6 INT THD

$$\tau = \frac{F_b}{AS_n} = \frac{532}{.0355} = 14980 \text{ psi}$$

$$MS = \frac{27000}{14980} - 1 = +.80 \quad \text{BASEPLATE}$$

∴ THREAD SHEAR OK IN BASEPLATE

MS51830-103 INSERT CRES EXT THD

$$\tau = \frac{F_b}{AS_s} = \frac{532}{.0250} = 21280 \text{ psi}$$

$$MS = \frac{48000}{21280} - 1 = +1.3 \quad \text{INSERT}$$

∴ THREAD SHEAR OK IN INSERT EXT THDS

MS51830-103 INT THD TO MS1352NØ6-6 SCREW EXT THD

.138-32UNRC-3A EXT THD MS1352NØ6
.138-32UNJC-3B INT THD MS51830-103

$l_e = .170 - .015 - 1/n$ $\quad n = 32$
$= .124$ IN

$F_{su} = 96000$ psi SCREW
$F_{su} = 48000$ psi INSERT

$AS_n = .0344 \text{ IN}^2$
$AS_s = .0287 \text{ IN}^2$

$k_b = EA/l$ $\quad l = .102$ IN
$\quad A = .0150 \text{ IN}^2$
$= 4.253 \times 10^6$ LB/IN $\quad E = 29 \times 10^6$ psi

$k_m = 3.342 \times 10^6$ LB/IN

$F_b = (.560)(1.4)(157.6) + 399 = 523$ LB

SHEAR STRESS

MS51830-103 INSERT CRES INT THD

$$\tau = \frac{F_b}{AS_n} = \frac{523}{.0344} = 15191 \text{ psi}$$

$$MS = \frac{48000}{15191} - 1 = +2.2 \quad \text{INSERT}$$

∴ THREAD SHEAR OK IN INSERT ID THDS

<u>MS1352N∅6 SCREW</u> STEEL EXT THD (HEAT RESISTANT)

$$\tau = \frac{F_b}{A_{Ss}} = \frac{523}{.0287} = 18223 \text{ PSI}$$

$$MS = \frac{96000}{18223} - 1 = +4.3 \quad \text{SCREW}$$

$\therefore$ <u>THREAD SHEAR OK IN SCREW EXT THDS</u>

<u>1331447 LOWER RIGHT FRONT SUPPORT PANEL TO 1356405 LOWER BASEPLATE</u>

FORCE IN NAS1352N∅6-6 SCREW IS

$$F_1 = 3 \times 16.844 = 50.53 \text{ LB/IN} \qquad \text{"}3\sigma \text{ RANDOM"}$$

W/3 SCREWS IN 6.500 IN, LOAD PER SCREW

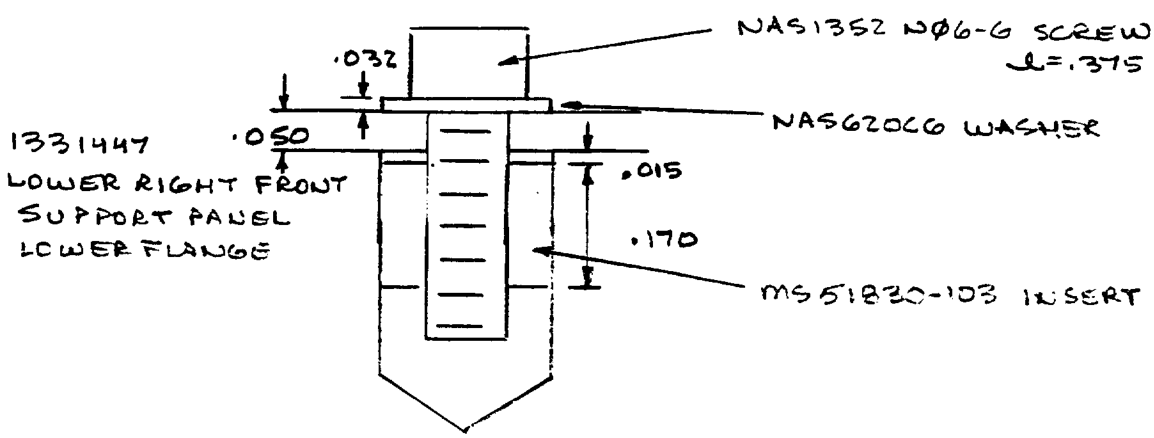
$$P = \frac{6.500}{3}(50.53) = 109.5 \text{ LB}$$

FACTOR OF SAFETY ON P, 1.4

PRELOAD @ 11 IN-LB TORQUE

$$F_L = 11/(.2)(.138) = 399 \text{ LB}$$

THE NAS1352N∅6-6 SCREW LENGTH, .375, IS ADEQUATE TO ENGAGE ENTIRE INSERT THREADS.



SIMILAR TO PREVIOUS JOINT

BASEPLATE INT THD TO INSERT EXT THD

$l_e = .125 - .010 - 1/n = .079$ IN $n = 28$

$AS_n = .0355$ IN^2
$AS_s = .0250$ IN^2

JOINT STIFFNESS

$$F_b = \frac{k_b}{k_b + k_m} P + F_i$$

$$k_b = \frac{EA}{l}$$

$E = 29 \times 10^6$ PSI
$A = \pi/4\,(.216)^2 = .0366$ IN^2
$l = .032 + .050\ .015 = .097$ IN

$$= 10.955 \times 10^6 \text{ LB/IN}$$

$$k_m = \frac{\pi E d}{2 \ln\left[5\, \frac{l + d/2}{l + 2.5d}\right]}$$

$E = 10 \times 10^6$ PSI
$d = 216$ IN
$l = .097$ IN

$$= 7.133 \times 10^6 \text{ LB/IN}$$

TOTAL SCREW TENSILE LOAD

$$F_b = (.606)(1.4)(109.5) + 399 = 492 \text{ LB}$$

SHEAR STRESS

BASEPLATE 6061-T6 INT THD

$$\tau = \frac{F_b}{AS_n} = \frac{492}{.0355} = 13855 \text{ PSI}$$

$$MS = \frac{27000}{13855} - 1 = +.95 \quad \text{BASEPLATE}$$

∴ THREAD SHEAR OK IN BASEPLATE

MS51830-103 INSERT CRES EXT THD

$$\tau = \frac{F_b}{AS_s} = \frac{492}{.0250} = 19680 \text{ PSI}$$

$$MS = \frac{48000}{19680} - 1 = +1.4 \quad \text{INSERT}$$

$\therefore$ THREAD SHEAR OK IN INSERT EXT THDS

MS51830 INT THD TO MS1352N06-6 SCREW EXT THD

$l_e = .170 - .015 - 1/n = .124$ IN $\qquad n = 22$

$AS_n = .0344$ IN^2
$AS_s = .0287$ IN^2

$k_b = 4.471 \times 10^6$ LB/IN

$k_m = 3.440 \times 10^6$ LB/IN

$F_b = (6.565)(1.4)(109.5) + 399 = 486$ LB

SHEAR STRESS

MS51830 INSERT CRES INT THD

$$\tau = \frac{F_b}{AS_n} = \frac{486}{.0344} = 14117 \text{ psi}$$

$$MS = \frac{48000}{14117} - 1 = +2.4 \qquad \text{INSERT}$$

$\therefore$ THREAD SHEAR OK IN INSERT INT THDS

MS1352N06 SCREW HEAT RESISTANT STEEL EXT THD

$$\tau = \frac{F_b}{AS_s} = \frac{486}{.0287} - 1 = 16934 \text{ psi}$$

$$MS = \frac{96000}{16934} - 1 = +4.7 \qquad \text{SCREW}$$

$\therefore$ 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 "ELFORCE" DATA AS LOAD. PER LOWER AFT PANEL LOWER FLANGE BENDING STRESS/ BOLT TENSILE STRESS EVALUATION, THE FORCE @ THE NAS 1352 N Ø6-8 SCREW IS:

$F_1 = 3 \times 238.8 = 716.4$ LB/IN "3σ"

WITH 8 SCREWS IN 10.563 IN, THE LOAD PER SCREW, P, IS

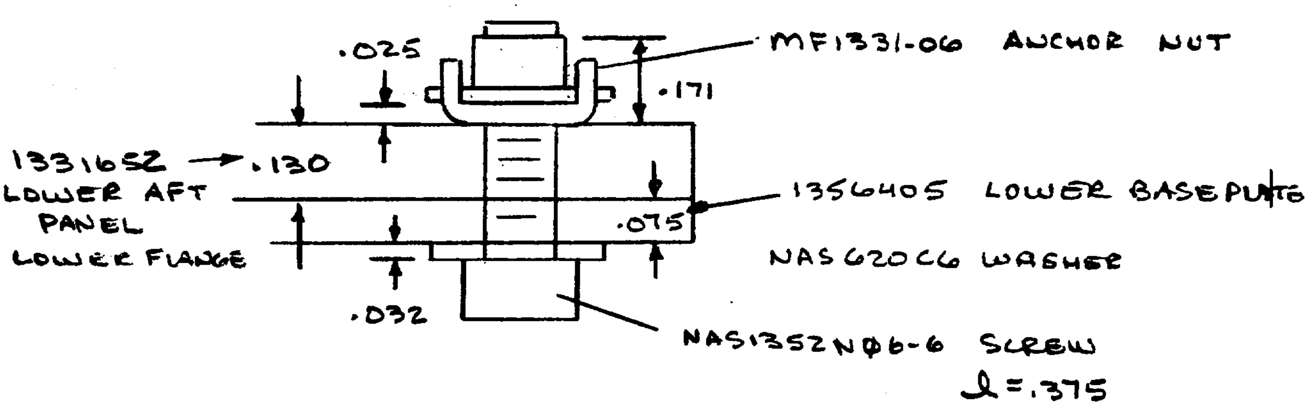
$P = \frac{10.563}{8}(716.4) = 946$ LB

FACTOR OF SAFETY ON EXTERNAL LOAD, P, IS 1.4

PRELOAD (11 IN-LB MAX TORQUE)

$F_L = T/.2d$ $d = .138$

$F_L = 11/(.2)(.138) = 399$ LB



FOR THE NAS1352NØ6 SCREW TO EXTEND BEYOND THE NUT PLATE, UTILIZING THE FULL COMPLIMENT OF NUTPLATE THREADS, ITS LENGTH MUST EXCEED

$l = .032 + .075 + .130 + .171 = .408$ IN

THUS A -8 l = .500 IN SCREW IS REQ'D.

MF1331-06 NUTPLATE INT THREADS TO NAS1352N06-8 SCREW

.1380-32 UNJC-3B MF1331-06 INT THD
.1380-32 UNRC-3A NAS1352N06-8 EXT THD

ENGAGEMENT LENGTH

$$l_e = .171 - .025 - 1/n = .115 \text{ IN} \qquad n = 32$$

MAT'RL

A286 STEEL	$F_{su} = .6(140000) = 84000$ PSI	ASSUMED NUTPLATE	
HEAT TREATED	(REF MSS1830 A-286 $F_{tu} = 140000$ PSI)	F_{tu}	
ALLOY STEEL	$F_{su} = .6(160000) = 96000$ PSI	SCREW	

THREAD SHEAR AREA (H-28

INT THD

$$AS_n = \pi n l_e D_{s\,min} \left[1/2n + .57735 (D_{s\,min} - E_{n\,max}) \right]$$

$n = 32$
$l_e = .115$
$D_{s\,min} = .1320$
$E_{n\,max} = .1204$

$$AS_n = .0341 \text{ IN}^2$$

$$AS_s = \pi n l_e K_{n\,max} \left[1/2n + .57735 (E_{s\,min} - K_{n\,max}) \right]$$

$K_{n\,max} = .1157$ IN
$E_{s\,min} = .1156$ IN

$$AS_s = .0208 \text{ IN}^2$$

JOINT STIFFNESS

PER SHIGLEY, MECHANICAL ENGINEERING DESIGN, 4TH ED, 1983, P371-376, WITH ASSUMPTIONS,

$$F_b = \frac{k_b P}{k_b + k_m} + F_i \qquad \begin{array}{l} b = \text{BOLT} \\ m = \text{MEMBER} \end{array}$$

$$k_b = \frac{EA}{l}$$

$E = 29\times10^6$ PSI
$A = \pi/4\,(.138)^2 = .0150$ IN
l = GRIP LENGTH
$= .032 + .075 + .130 + .025 = .262$ IN

$$= 1.656\times10^6 \text{ LB/IN}$$

$$k_m = \frac{\pi E d}{2\ln\left[5\,\dfrac{l+d/2}{l+2.5d}\right]}$$

$E = 10\times10^6$ PSI
$d = .138$ IN
$l = .262$ IN

$$= 2.161\times10^6 \text{ LB/IN}$$

TOTAL SCREW TENSILE LOAD

$$F_b = (FS)(P_b) + (F_i)$$

$$P_b = \frac{k_b}{k_b + k_m}\,P = (.434)(946) = 410 \text{ LB}$$

$$F_b = (1.4)(410) + 399 = 974 \text{ LB}$$

SHEAR STRESS

NUT PLATE A-286 INT THD

$$\tau = \frac{F_b}{AS_n} = \frac{974}{.0341} = 28600 \text{ psi}$$

$$MS = \frac{84000}{28600} - 1 = +1.9 \qquad \text{NUTPLATE}$$

SCREW HEAT RESIST STEEL EXT THD

$$\tau = \frac{F_b}{AS_s} = \frac{974}{.0208} = 46775 \text{ PSI}$$

$$MS = \frac{96000}{46775} - 1 = +1.1 \qquad \text{SCREW}$$

$\therefore$ BOTH NUT PLATE & SCREW ARE OK FOR THREAD SHEAR

1331642 UPPER AFT PANEL TO
1331356 UPPER BASEPLATE VIA MF1331-06 ANCHOR NUTS

FORCE @ MF1331-06 NUT PLATE/NAS1352N06-10 SCREW

$F_1 = 3 \times 127.83 = 383.49$ LB/IN "3T LOADS"

W/ 9 SCREWS IN 11.7 IN

LOAD PER SCREW, P

$P = \left(\frac{11.7}{9}\right)(383.49) = 498.5$ LB

FS ⇒ 1.4 ON P

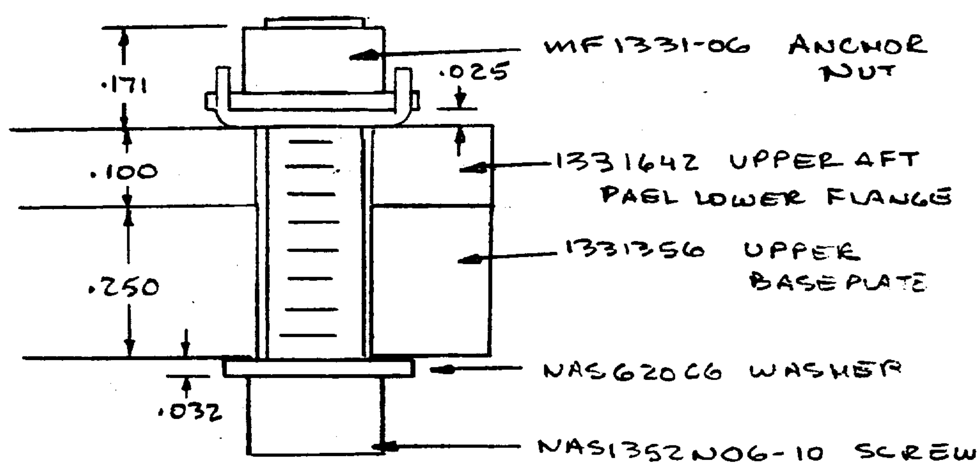
PRELOAD @ 11 IN-LB TORQUE

$F_i = 11/(.2)(.138) = 399$ LB

FOR THE NAS1352N06 SCREW TO EXTEND BEYOND NUT PLATE, UTILIZING FULL COMPLIMENT OF NUTPLATE THREADS, ITS LENGTH MUST EXCEED

$\ell = .032 + .250 + .100 + .171 = .553$

THUS A -10 ($\ell = .625$) IS REQ'D



PREVIOUS 1331642 FLANGE WAS .065 (NOW .100)
@ .065, THE REQ'D SCREW LENGTH WOULD BE

$\ell = .032 + .250 + .065 + .171 = .518$

THUS PREVIOUS -8 ($\ell = .500$) WOULD HAVE BEEN TOO SHORT

MF1331-06 NUT PLATE INT THD TO NAS1352N06-10 SCREW

.1380-32UNJC-3B MF1331-06 NUT PLATE
.1380-32UNRC-3A NAS1352N06-6 SCREW

ENGAGEMENT LENGTH $\ell_e = .171 - .025 - 1/n$ $n = 32$

$= .115$ IN

$F_{su} = 84000$ psi NUTPLATE
$F_{su} = 96000$ psi SCREW

$AS_n = .0341$ IN^2
$AS_s = .0208$ IN^2

JOINT STIFFNESS

$$F_b = \frac{k_b}{k_b + k_m} P + F_i$$

$$k_b = \frac{EA}{\ell_{GRIP}}$$

$E = 29 \times 10^6$ psi
$A = \pi/4\,(.138)^2 = .0150$ IN^2
$\ell = .032 + .250 + .100 + .025 = .407$ IN

$= 1.066 \times 10^6$ LB/IN

$$k_m = \frac{\pi E d}{2 \ln\left[5\,\dfrac{\ell + d/2}{\ell + 2.5d}\right]}$$

$E = 10 \times 10^6$ psi
$d = .138$ IN
$\ell = .407$ IN

$= 1.881 \times 10^6$ LB/IN

TOTAL SCREW LOAD

$$F_b = (FS)(P_b) + F_i$$

$$P_b = \frac{k_b}{k_b + k_m} P = (.362)(498.5) = 180.3 \text{ LB}$$

$$F_b = (1.4)(180.3) + 399 = 651.4$$

SHEAR STRESS

NUT PLATE A-286 INT THD

$$\tau = \frac{F_b}{AS_n} = \frac{651.4}{.0341} = 19102 \text{ psi}$$

$$MS = \frac{84000}{19102} - 1 = +3.4$$ NUTPLATE

SCREW HEAT RESISTANT STEEL EXT THD

$$\tau = \frac{F_b}{AS_s} = \frac{651.4}{.0208} = 31317 \text{ PSI}$$

$$MS = \frac{96000}{31317} - 1 = +2.1$$ SCREW

∴ BOTH NUTPLATE & SCREW ARE OK FOR THREAD SHEAR

ADDITIONAL PANAL ATTACHMENTS

1331051 UPPER RIGHT PANEL TO
1331356 UPPER BASEPLATE

MF1331-06 NUTPLATES

$F_1 = 3 \times 42.82 = 128.46$ LB/IN

"3T"

w/ 7 SCREWS NAS1352N06-10 IN 8.783 IN

$P = \frac{8.783}{7}\, 128.46 = 161.18$ LB

FS = 1.4 ON P

FL = 399 LB (PRELOAD)

USES NAS1352N06-10 SCREWS ($\ell = .625$ IN)

$\ell_{GRIP} =$	.250	t	UPPER BASEPLATE
	.065	t	UPPER RIGHT PANEL FLANGE
	.171	t	NUTPLATE MF1331-06
	.032	t	NAS620C6 WASHER
	.518		

$\ell_e = .171 - .025 - 1/n = .115$ IN

$AS_n = .0341$ IN^2
$AS_s = .0208$ IN^2

$$k_b = \frac{(29 \times 10^6)(.0150)}{(.518)} = 840 \times 10^3 \text{ LB/IN}$$

$$k_m = \frac{\pi (10 \times 10^6)(.138)}{2 \ln \left[5 \frac{.518 + .138/2}{.518 + 2.5(.138)} \right]} = 1771 \times 10^3 \text{ LB/IN}$$

$$F_b = (1.4)(.322)(161.18) + 399 = 472 \text{ LB}$$

$$\tau = \frac{472}{.0341} = 13829 \text{ PSI}$$

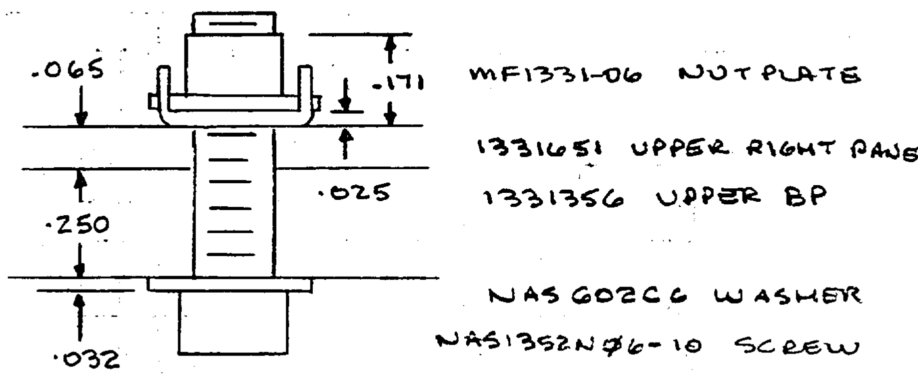
$$MS = \frac{84000}{13829} - 1 = +5.1 \quad \text{NUTPLATE}$$

$$\tau = \frac{472}{.0208} = 22692 \text{ PSI}$$

$$MS = \frac{96000}{22692} - 1 = +3.2 \quad \text{SCREW}$$

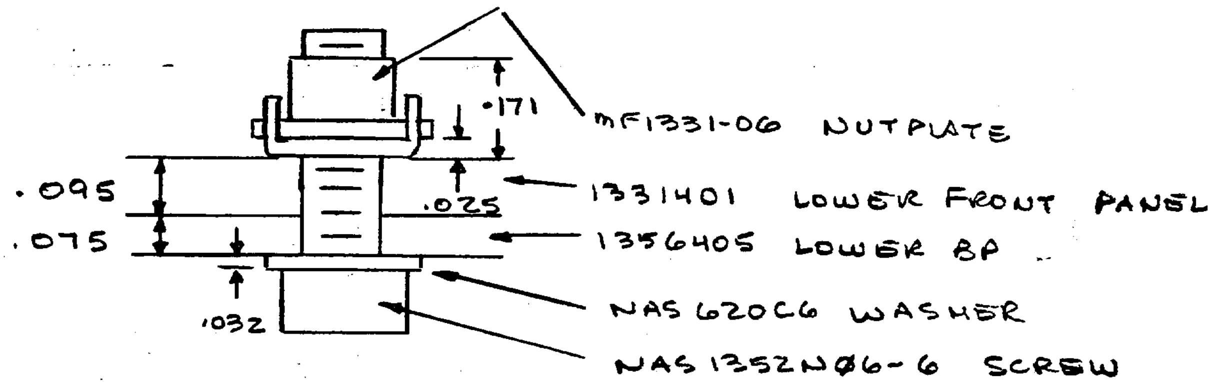
∴ BOTH NUTPLATE & SCREW ARE OK FOR THD SHEAR

1331651 UPPER RIGHT PANEL - 1331356 UPPER BASEPLATE

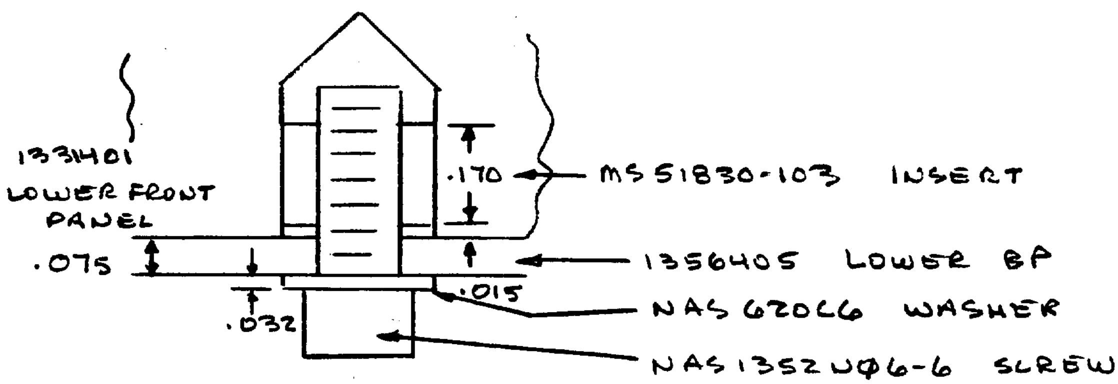


1331401 LOWER FRONT PANEL TO
1356405 LOWER BASEPLATE VIA 5 MF1331-06 NUTPLATES
3 MS51830-103 INSERTS

JOINT W/ NUTPLATES



JOINT W/ INSERT



$F_1 = 3 \times 69.83 = 209.49$ LB/IN "3T"

W/ 8 SCREWS IN 10.563 IN

$P = \frac{10.563}{8}(209.49) = 277$ LB

FS = 1.4 ON P

$F_L = 399$ LB (PRELOAD)

$l_{GRIP} = .032 + .075 + .095 + .025 = .227$ IN W/ NUTPLATE

$l_{GRIP} = .032 + .075 + .015 = .122$ IN W/ INSERT

REQ'D NAS1352N06-6 SCREW ($\ell = .375$ IN)

SCREW ℓ > .032 + .075 + .095 + .171 = .373 IN W/NUTPLATE

SCREW ℓ = .032 + .075 + .015 + .170 = .292 IN W/INSERT

$\therefore$ -6 SCREW $\ell = .375 >$ .373 IN
.292 IN

$\ell e = .171 - .025 - 1/n = .115$ IN W/NUTPLATE

$\ell e = .125 - .010 - 1/n = .079$ IN PANEL-INSERT $n = 28$

$= .170 - .015 - 1/n = .124$ IN INSERT/SCREW $n = 32$

$A_{Sn} = .0341$ IN^2
$A_{Ss} = .0208$ IN^2 W/NUTPLATE

$A_{Sn} = .0355$ IN^2
$A_{Ss} = .0250$ IN^2 PANEL-INSERT .216-28UNF

$A_{Sn} = .0344$ IN^2
$A_{Ss} = .0287$ IN^2 INSERT-SCREW .138-32UNRC

W/NUTPLATE

$k_b = 1.916 \times 10^6$ LB/IN

$$k_m = \frac{\pi(10 \times 10^6)(.138)}{2 \ln\left[5 \dfrac{.227 + .138/2}{.227 + 2.5(.138)}\right]} = 2.280 \times 10^6 \ \frac{LB}{IN}$$

$F_b = (1.4)(.457)(277) + 399 = 576$ LB

$$\tau = \frac{576}{.0341} = 16894 \text{ PSI}$$

$$MS = \frac{84000}{16894} - 1 = +4.0 \quad \text{NUTPLATE}$$

$$\tau = \frac{576}{.0208} = 27692 \text{ PSI}$$

$$MS = \frac{96000}{27692} - 1 = +2.5 \quad \text{SCREW}$$

$\therefore$ BOTH NUTPLATE & SCREW OK FOR THD SHEAR

W/ INSERT

PANEL/ INSERT OD

PANEL 6061-T6 $F_{su} = 27000$ psi

$$k_b = \frac{(29\times10^6)(.0366)}{(.122)} = 8.700\times10^6 \text{ LB/IN}$$

$$k_m = \frac{\pi(10\times10^6)(.216)}{2\ln\left[5\ \dfrac{.122+.216/2}{.122+2.5(.216)}\right]} = 6.144\times10^6 \text{ LB/IN}$$

$$F_b = (1.4)(.586)(277) + 399 = 626 \text{ LB}$$

$$\tau = \frac{626}{.0355} = 17642 \text{ psi}$$

$$MS = \frac{27000}{17642} - 1 = +.53$$ LOWER FRONT PANEL

$$\tau = \frac{626}{.0250} = 25040 \text{ psi}$$

$$MS = \frac{48000}{25040} - 1 = +.92$$ INSERT OD THD

$\therefore$ THREAD SHEAR OK IN PANEL/INSERT JOINT

INSERT ID/ SCREW

$$k_b = \frac{(29\times10^6)(.0150)}{.122} = 3.566\times10^6 \text{ LB/IN}$$

$$k_m = \frac{\pi(10\times10^6)(.138)}{2\ln\left[5\ \dfrac{.122+.138/2}{.122+2.5(.138)}\right]} = 3.030\times10^6 \text{ LB/IN}$$

$F_b = (1.4)(.541)(277) + 399 = 609$ LB

$\tau = \dfrac{609}{.0344} = 17693$ psi

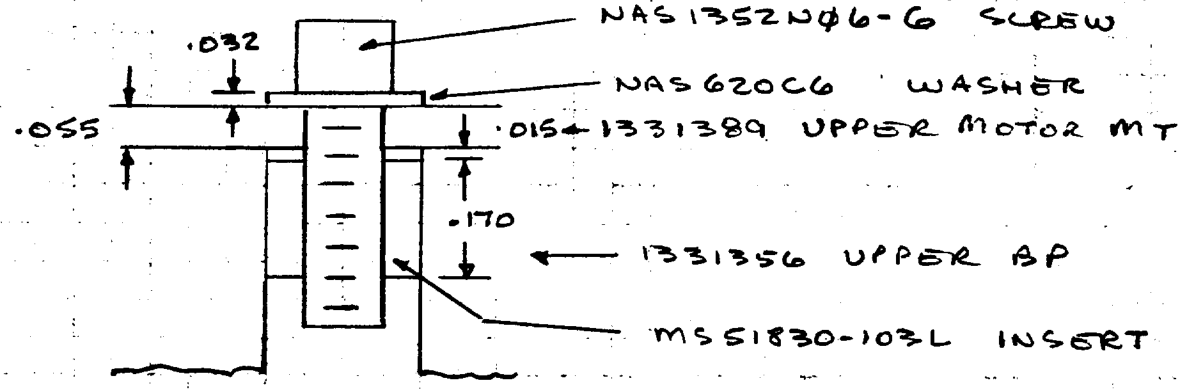
$MS = \dfrac{48000}{17693} - 1 = +1.7$ INSERT ID THDS

$\tau = \dfrac{609}{.0287} = 21220$ psi

$MS = \dfrac{96000}{21220} - 1 = +3.5$ SCREW

$\therefore$ THREAD SHEAR OK IN INSERT/SCREW THDS

1331389 UPPER MOTOR MT PANEL TO
1331356 UPPER BASEPLATE VIA MS51830-103L INSERTS



$F_1 = 3 \times 25.271 = 75.813$ LB/IN "3σ"

w/6 SCREWS IN 10.563 IN

$$P = \frac{10.563}{6}(75.813) = 133.5 \text{ LB}$$

FS = 1.4 ON P

$F_i = 399$ LB PRELOAD

$l_{GRIP} = .032 + .055 + .015 = .102$ IN

REQ'D. NAS1352N06 LENGTH .375 -6 OK

SCREW $l >$ $.032 + .055 + .015 + .170 = .272$ IN

$l_e = .125 - .010 - 1/n = .079$ IN BP-INSERT
.216-28UNF
n=28

$l_e = .170 - .015 - 1/n = .124$ IN INSERT-SCREW
.138-32UNRC
n=32

$AS_n = .0355 \text{ IN}^2$ UPPER BP-INSERT
$AS_s = .0250 \text{ IN}^2$

$AS_n = .0344 \text{ IN}^2$ INSERT-SCREW
$AS_s = .0287 \text{ IN}^2$

BP - INSERT OD

UPPER BASEPLATE 6061-T6 $F_{su} = 27000$ PSI

$$k_b = \frac{(29\times10^6)(.0366)}{.102} = 10.406\times10^6 \text{ LB/IN}$$

$$k_m = \frac{\pi(10\times10^6)(.216)}{2\ln\left[5\,\frac{.102+.216/2}{.102+2.5(.216)}\right]} = 6.897\times10^6 \text{ LB/IN}$$

$$F_b = (1.4)(.601)(133.5) + 399 = 511 \text{ LB}$$

$$\tau = \frac{511}{.0355} = 14406 \text{ PSI}$$

$$MS = \frac{27000}{14406} - 1 = +.87 \qquad \text{UPPER BP}$$

$$\tau = \frac{511}{.0250} = 20456 \text{ PSI}$$

$$MS = \frac{48000}{20456} - 1 = +1.3 \qquad \text{INSERT OD THD}$$

∴ THREAD SHEAR OK IN UPPER BP/INSERT JOINT

INSERT ID - SCREW

$$k_b = \frac{(29\times10^6)(.0150)}{.102} = 4.265\times10^6 \text{ LB/IN}$$

$$k_m = \frac{\pi(10\times10^6)(.138)}{2\ln\left[5\,\frac{.102+.138/2}{.102+2.5(.138)}\right]} = 3.342\times10^6 \text{ LB/IN}$$

$$F_b = (1.4)(.561)(133.5) + 399 = 504 \text{ LB}$$

$$\tau = \frac{504}{.0344} = 14645 \text{ PSI}$$

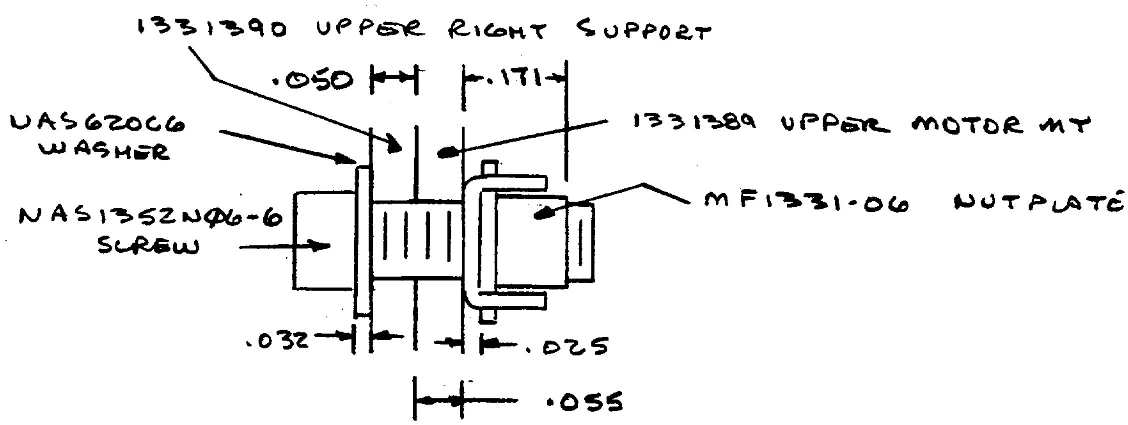
$$MS = \frac{48000}{14645} - 1 = +2.3$$ INSERT ID THDS

$$\tau = \frac{504}{.0287} = 17561 \text{ psi}$$

$$MS = \frac{96000}{17561} - 1 = +4.5$$ SCREW

∴ THREAD SHEAR OK IN INSERT/SCREW THDS

1331389 UPPER MOTOR MT PANEL TO
1331390 UPPER RIGHT FRONT SUPPORT PANEL
VIA MF1331-06 NUTPLATE



$F_1 = 3 \times 33.175 = 99.525$ LB/IN "3T"

w/3 SCREWS IN 6.245 IN

$$P = \frac{6.245}{3}(99.525) = 207 \text{ LB}$$

FS=1.4 ON P

$F_i = 399$ LB (PRELOAD)

REQ'D NAS1352 $\ell = .032 + .050 + .055 + .171 = .308$ IN

∴ −6 $\ell = .375$ IS OK

$\ell_{GRIP} = .032 + .050 + .055 + .025 = .162$ IN

$l_e = .171 - .025 - 1/n = .115$

$AS_n = .0341 \text{ IN}^2$
$AS_s = .0208 \text{ IN}^2$

$$k_b = \frac{(29\times10^6)(.0150)}{.162} = 2.685\times10^6 \text{ LB/IN}$$

$$k_m = \frac{\pi(10\times10^6)(.138)}{2\ln\left[5\;\frac{.162+.138/2}{.162+2.5(.138)}\right]} = 2.633\times10^6 \text{ LB/IN}$$

$F_b = (1.4)(.505)(207) + 399 = 545 \text{ LB}$

$$\tau = \frac{545}{.0341} = 15992 \text{ PSI}$$

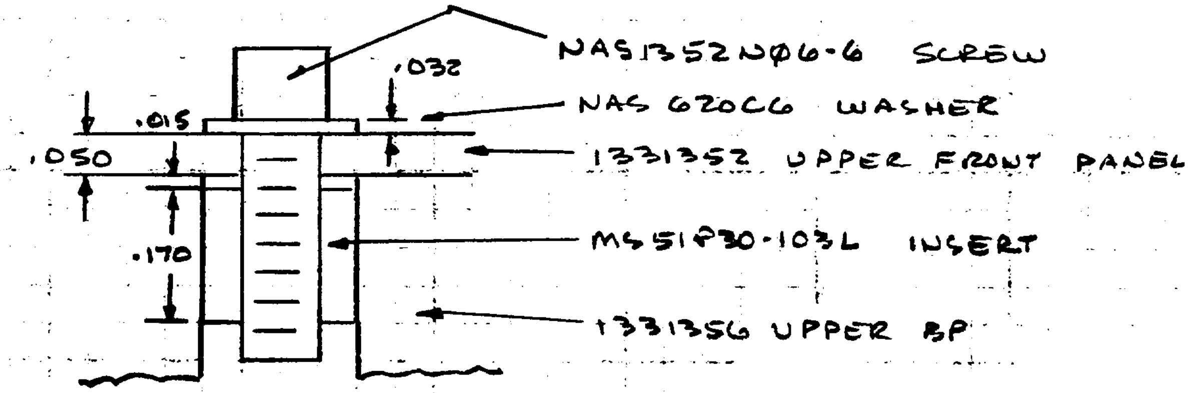
$$MS = \frac{84000}{15992} - 1 = +4.3 \qquad \text{NUTPLATE}$$

$$\tau = \frac{545}{.0208} = 26202 \text{ PSI}$$

$$MS = \frac{96000}{26202} - 1 = +2.7 \qquad \text{SCREW}$$

∴ <u>THREAD SHEAR OK IN JOINT</u>

1331352 UPPER FRONT PANEL TO
1331356 UPPER BASEPLATE VIA MS51830-103L INSERTS



$F_1 = 3 \times 24.409 = 73.227$ LB/IN

7 SCREWS IN 10.575 IN

$$P = \frac{10.575}{7}(73.227) = 111 \text{ LB}$$

FS = 1.4 ON P

F_L = 399 LB (PRELOAD)

$\ell_{GRIP} = .032 + .050 + .015 = .097$ IN

REQ'D NAS1352NØ6 LENGTH .375 -6 OK

SCREW $\ell >$ .032 + .050 + .015 + .170 = .267 IN

$\ell e = .125 - .010 - {}^1/n = .079$ IN   BP-INSERT
.216-28UNF
n = 28

$\ell e = .170 - .015 - {}^1/n = .124$ IN   INSERT-SCREW
.138-32UNRC
N = 32

$AS_n = .0355$ IN^2
$AS_s = .0250$ IN^2 BP-INSERT

$AS_n = .0344$ IN^2
$AS_s = .0287$ IN^2 INSERT-SCREW

BP - INSERT OD THD

$$k_b = \frac{(29\times10^6)(.0366)}{.097} = 10.942\times10^6 \text{ LB/IN}$$

$$k_m = \frac{\pi(10\times10^6)(.216)}{2\ln\left[5\ \frac{.097+.216/2}{.097+2.5(.216)}\right]} = 7.133\times10^6 \text{ LB/IN}$$

$$F_b = (1.4)(.605)(111) + 399 = 493 \text{ LB}$$

$$\tau = \frac{493}{.0355} = 13889 \text{ PSI}$$

$$MS = \frac{27000}{13889} - 1 = +.94 \qquad \text{UPPER BP}$$

$$\tau = \frac{493}{.0250} = 19720 \text{ PSI}$$

$$MS = \frac{48000}{19720} - 1 = +1.4 \qquad \text{INSERT OD THD}$$

∴ THREAD SHEAR OK IN UPPER BP/INSERT JOINT

INSERT ID - SCREW

$$k_b = \frac{(29\times10^6)(.0150)}{.097} = 4.485\times10^6 \text{ LB/IN}$$

$$k_m = \frac{\pi(10\times10^6)(.138)}{2\ln\left[5\ \frac{.097+.138/2}{.097+2.5(.138)}\right]} = 3.440\times10^6 \text{ LB/IN}$$

$$F_b = (1.4)(.566)(111) + 399 = 487 \text{ LB}$$

$$\tau = \frac{487}{.0344} = 14155 \text{ PSI}$$

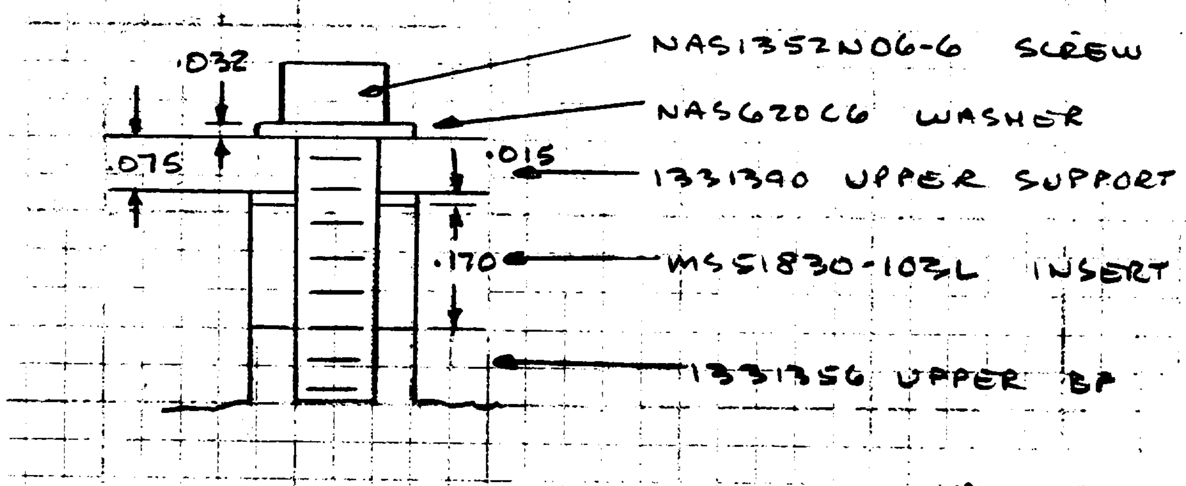
$$MS = \frac{48000}{14155} - 1 = +2.4$$ INSERT ID THD

$$\tau = \frac{487}{.0287} = 16969 \text{ psi}$$

$$MS = \frac{96000}{16969} - 1 = +4.7$$ SCREW

$\therefore$ THREAD SHEAR OK IN INSERT/SCREW THDS

133 1390 UPPER RIGHT FRONT SUPPORT PANEL TO
1331356 UPPER BASEPLATE VIA MS51830-103L INSERTS



$F_1 = 3 \times 28.80 = 86.40$ LB/IN "3T"

W/ 3 SCREWS IN 6.500 IN

$$P = \frac{6.500}{3}(86.40) = 187.2 \text{ LB}$$

FS = 1.4 ON P

$F_L = 399$ LB (PRELOAD)

$l_{GRIP} = .032 + .075 + .015 = .122$ IN

REQ'D NAS1352N06 LENGTH .375 -6 OK

SCREW $l > .032 + .075 + .015 + .170 = .292$ IN

$l_e = .125 - .010 - 1/n = .079$ IN BP-INSERT
.216-28UNF
n=28

$l_e = .170 - .015 - 1/n = .124$ IN INSERT-SCREW
.138-32UNRC
n=32

$A_{Sn} = .0355 \text{ IN}^2$
$A_{Ss} = .0250 \text{ IN}^2$ UPPER BP- INSERT

$A_{Sn} = .0344 \text{ IN}^2$
$A_{Ss} = .0287 \text{ IN}^2$ INSERT-SCREW

BP - INSERT OD THD

$$k_b = \frac{(29\times10^6)(.0366)}{.122} = 8.700\times10^6 \text{ LB/IN}$$

$$k_m = \frac{\pi(10\times10^6)(.216)}{2\ln\left[5\ \frac{.122+.216/2}{.122+2.5(.216)}\right]} = 6.144\times10^6 \text{ LB/IN}$$

$$F_b = (1.4)(.586)(187.2) + 399 = 553 \text{ LB}$$

$$\tau = \frac{553}{.0355} = 15566 \text{ psi}$$

$$ms = \frac{27000}{15566} - 1 = +.73 \qquad \text{UPPER BP}$$

$$\tau = \frac{553}{.0250} = 22120 \text{ psi}$$

$$ms = \frac{48000}{22120} - 1 = +1.2 \qquad \text{INSERT OD}$$

$\therefore$ THREAD SHEAR OK IN UPPER BP/INSERT OD THD

INSERT ID - SCREW

$$k_b = \frac{(29\times10^6)(.0150)}{.122} = 3.566\times10^6 \text{ LB/IN}$$

$$k_m = \frac{\pi(10\times10^6)(.138)}{2\ln\left[5\ \frac{.122+.138/2}{.122+2.5(.138)}\right]} = 3.030\times10^6 \text{ LB/IN}$$

$$F_b = (1.4)(.541)(187.2) + 399 = 541 \text{ LB}$$

$$\tau = \frac{541}{.0344} = 15718 \text{ psi}$$

$$MS = \frac{48000}{15718} - 1 = +2.1$$ INSERT ID THD

$$\tau = \frac{541}{.02871} = 18850 \text{ psi}$$

$$MS = \frac{96000}{18850} - 1 = +4.1$$ SCREW

$\therefore$ 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	1331555											
PLO ASSY 1	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	NAS1352NO4	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	1331490											
BRACKET	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

DC/DC CONVERTER ATTACHMENT 1-2-96

REF 1356010 DC/DC CONVERTER
1356008 EOS/AMSU A1 TOP ASSEMBLY
NAS1352 SCREW
NAS1149 WASHER
MS21043 NUT

LOADING CONDITION RANDOM VIBRATION (9.97 GRMS)

METHOD I - TENSILE LOAD DEVELOPED IN SCREW DUE TO:

1) MASS @ NASTRAN MODEL GRIDPOINTS
X ACCELATION 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	X-RESPONSE			Y-RESPONSE			Z-RESPONSE		
		DIRECTION	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	5769	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	14.5492	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 1σ GRMS LEVEL OF 17.98 G AT GR 1403.

STATISTICAL 3σ LOAD AT GR 1403

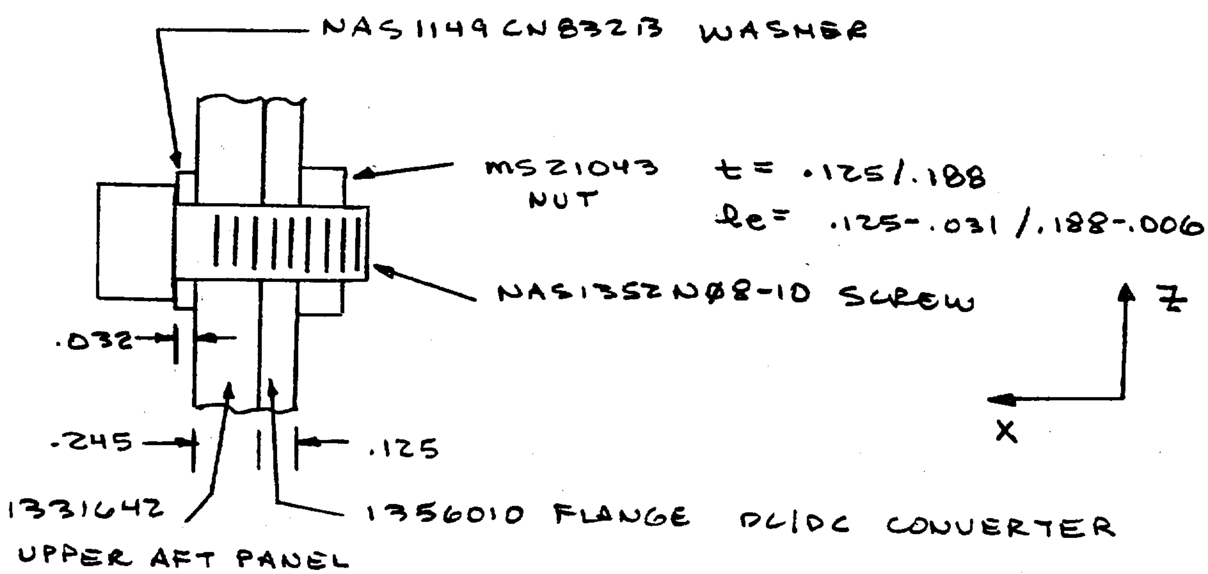
$$F_{t_1} = 3\,(17.98)(0.91) = 49.1\ \text{LB}$$

PRELOAD TORQUE, $T = .2\,F_i d$

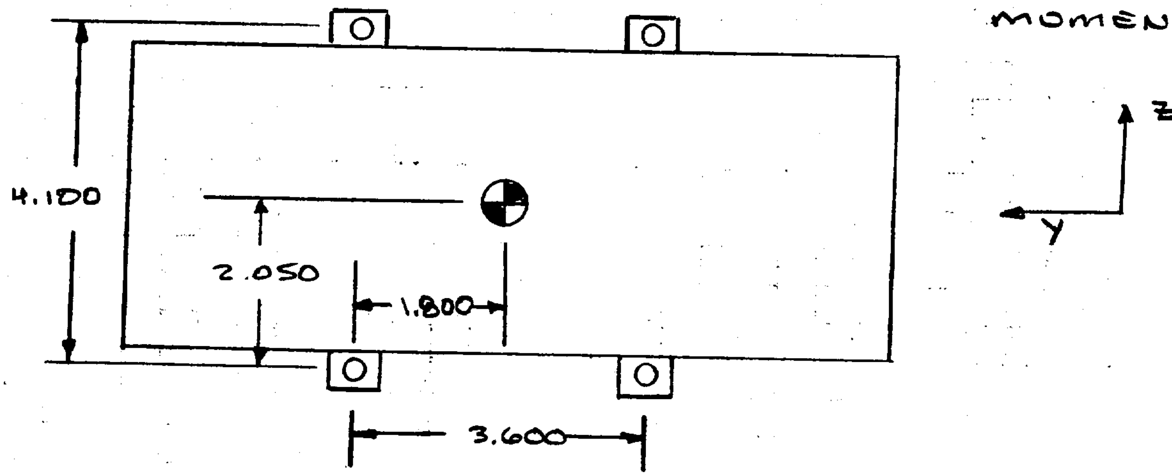
F_i = PRELOAD
d = NOMINAL SCREW Ø   NAS1352NØ8-10
.1640-32UNRC-3A
= .164
T = 26 IN-LB MAX

$$F_i = \frac{26}{(.2)(.164)} = 792.7\ \text{LB}$$

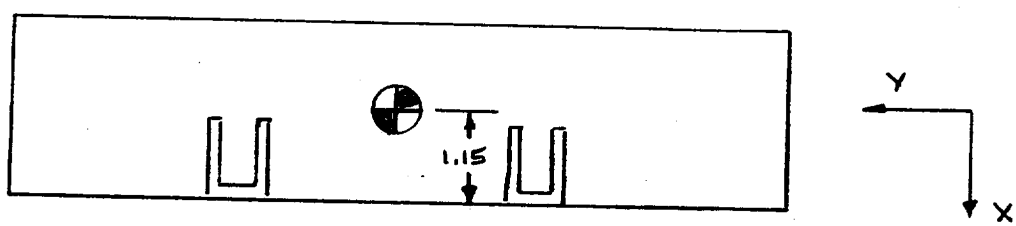
JOINT SKETCH



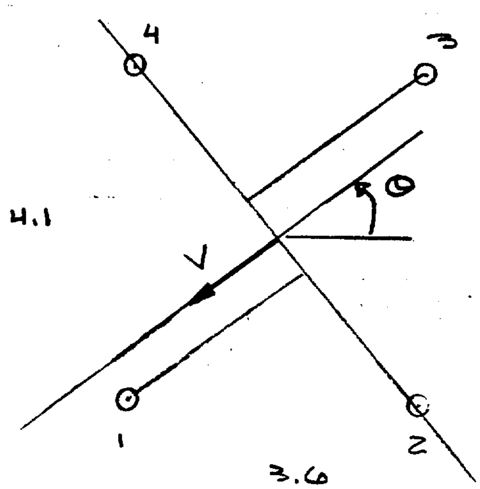
OVERTURNING MOMENT USING "3σ" LOADS. LARGEST RESPONSE (17.98 GRMS @ 1σ) IS USED IRRESPECTIVE OF DIRECTION TO CONSERVATIVELY FIND THE OVERTURNING MOMENT.



ASSUMED CG @ CENTER OF ATTACHMENT BOLT PATTERN. HEIGHT ASSUMED AT MID HEIGHT OF ENCLOSURE



ASSUMED ~~LOAD~~ DIRECTION THROUGH SCREW #4



$V = (4)(.91)(3)(17.98)$

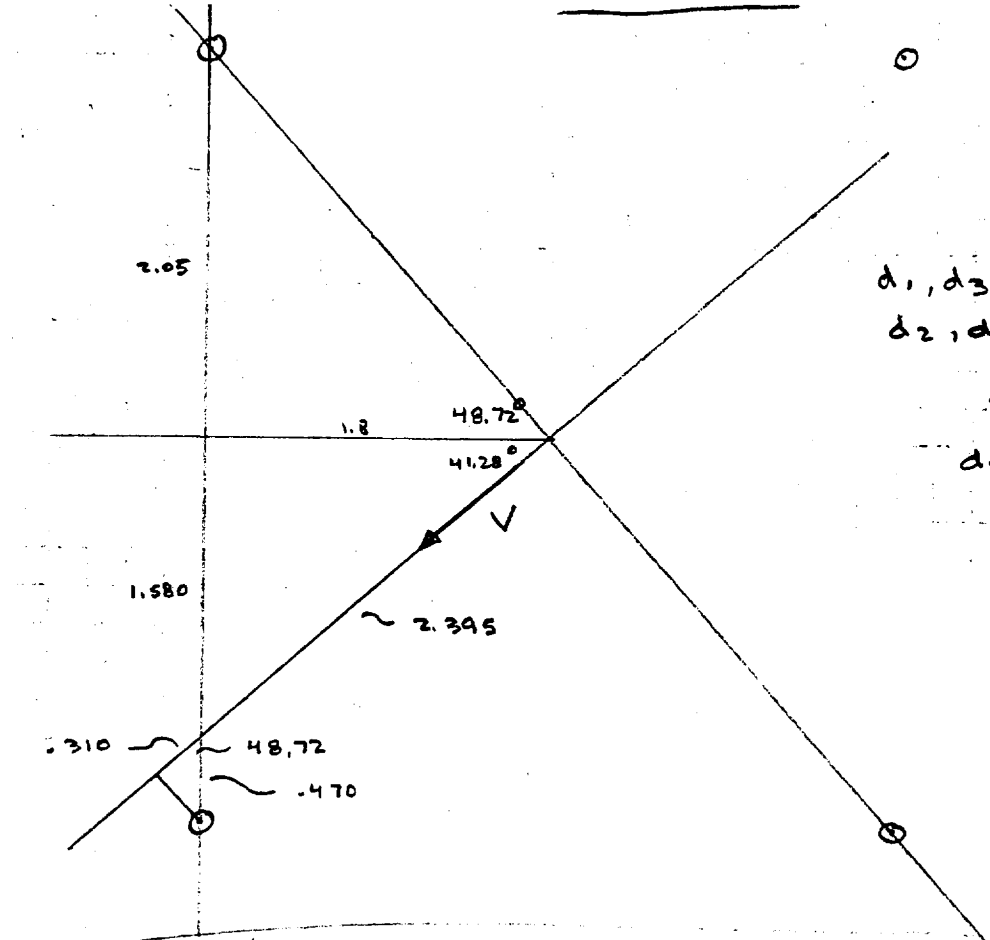
$= 196.3$ LB

$M_t = 1.15(V)$

$= 225.8$ IN-LB

$\theta = 48.72°$

WORSE CASE

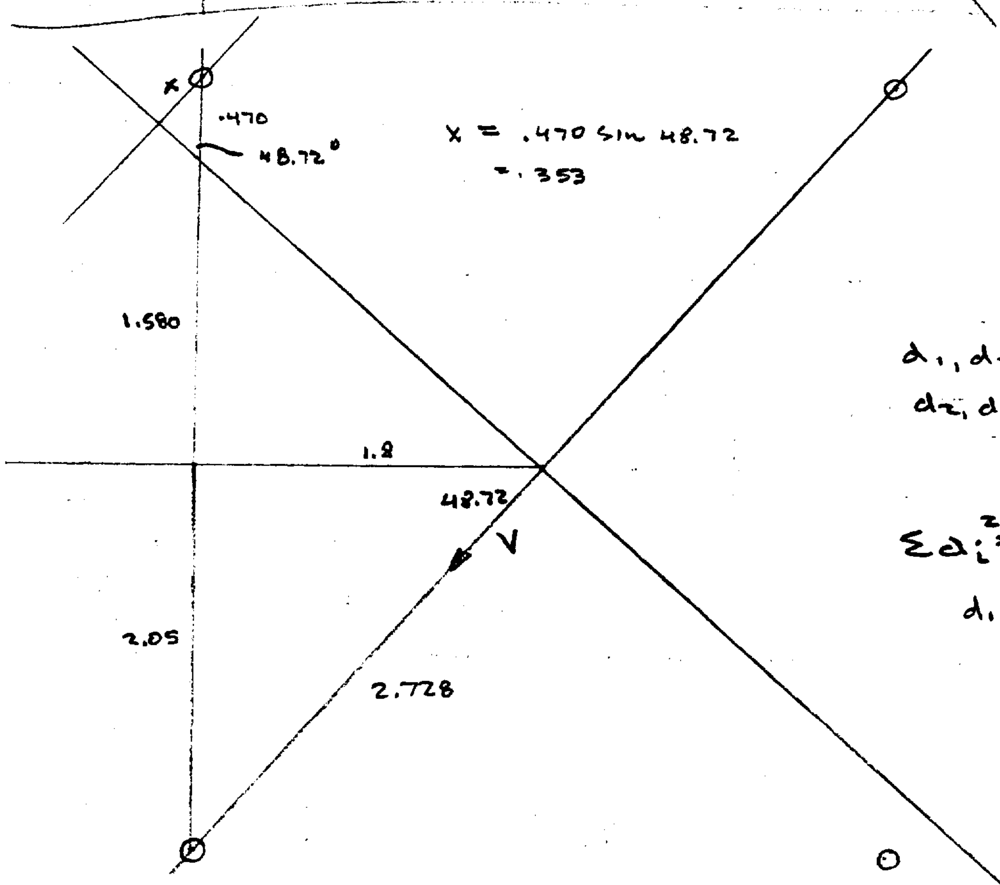


$d_1, d_3 = 2.705$

$d_2, d_4 = 0$

$\Sigma d_i^2 = 14.634$

$d_1 / \Sigma d_i^2 = \underline{\underline{.185}}$



$x = .470 \sin 48.72$

$= .353$

$d_1, d_3 = 2.728$

$d_2, d_4 = .353$

$\Sigma d_i^2 = 15.133$

$d_1 / \Sigma d_i^2 = \underline{\underline{.180}}$

TENSILE DISTANCES ALONG SKEWED AXES

$d_2 = 0$

$d_4 = 0$

$d_3 = 2.395 + .310 = 2.705$

$d_1 = 2.705$

$\Sigma d_i^2 = 2.705^2 + 2.705^2 + 0^2 + 0^2 = 14.634 \text{ IN}^2$

TENSILE FORCE AT SCREW #2

$$F_{t_2} = \frac{M_t d_2}{\Sigma d_i^2} = \frac{196.3 \quad 2.705}{14.634}$$

$= 36.3$ LB

TOTAL TENSILE LOAD, F_b

$F_i = 792.7$ LB PRELOAD

$F_t = F_{t_1} + F_{t_2} = 49.1 + 36.3 = 85.4$ LB

PER SHIGLEY "MECHANICAL ENGINEERING DESIGN", 4TH EDITION, P371, THE TOTAL TENSILE LOAD DEVELOPED IN THE SCREW IS A FUNCTION OF JOINT STIFFNESS

$$F_b = F_i + \left(\frac{k_b F_t}{k_b + k_m}\right) FS$$

FS = 1.4 ON APPLIED LOAD ONLY

$$k_b = \frac{EA}{l}$$

$E = 28 \times 10^6$ PSI

$A = \pi/4 (.164)^2 = .02112 \text{ IN}^2$

l = GRIP LENGTH

$= 1.471 \times 10^6$ LB/IN

$= .032 + .245 + .125 = .402$ IN

$$k_m = \frac{\pi E d}{2 \ln\left[\frac{5(l + d/2)}{(l + 2.5d)}\right]}$$

$E = 10 \times 10^6$ PSI
$d = .164$ IN
$l = .402$ IN

$$= 2.359 \times 10^6 \text{ LB/IN}$$

$$\frac{k_b}{k_b + k_m} = .384$$

$$F_D = 792.7 + .384(1.4)(85.4) = 839 \text{ LB}$$

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},

$$F_{TU} = 2240 \text{ LB}$$

$$MS = \frac{2240}{120} - 1 = +17$$ ∴ OK

DETECTOR PREAMP ATTACHMENT

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 RMS	X-RESPONSE GRMS	X-RESPONSE Q	Y-RESPONSE RMS	Y-RESPONSE GRMS	Y-RESPONSE Q	Z-RESPONSE RMS	Z-RESPONSE GRMS	Z-RESPONSE Q
	999	X	9362	$\boxed{24.25389}$	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 "1G" LOAD IS 24.25 G.

STATISTICAL 3T LOAD AT GR 999

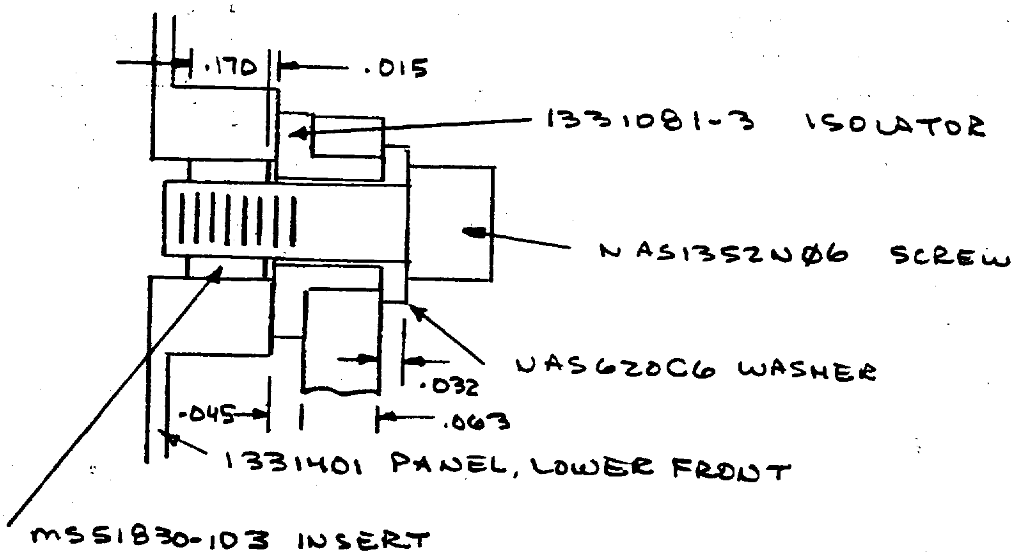
$F_{t_1} = 3(24.25)(0.7225) = 52.6$ LB

PRELOAD TORQUE , $T = .2 F_i d$

F_i = PRELOAD
d = .138 IN   NOM SCREW Ø   NAS1352NØ6-6
T = 14 IN-LB   MAX   .138-32UNRC-3A

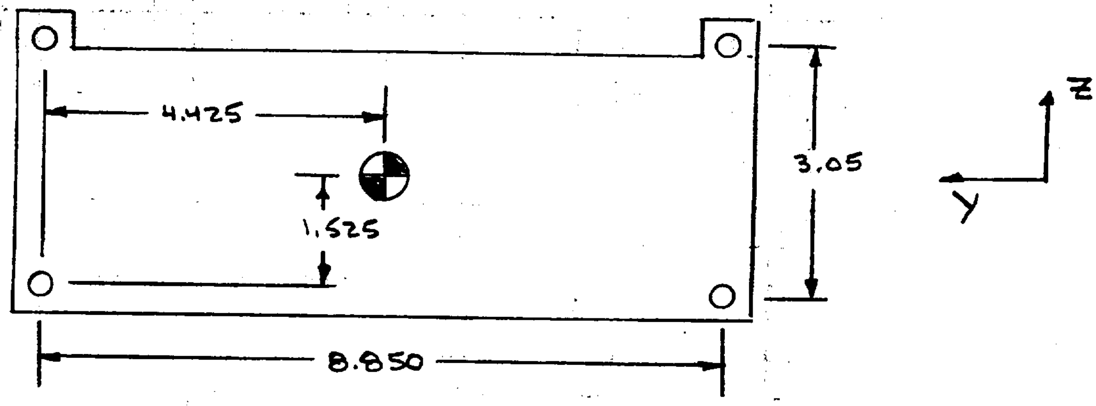
$$F_i = \frac{14}{(.2)(.138)} = 507.2 \text{ LB}$$

SKETCH OF JOINT

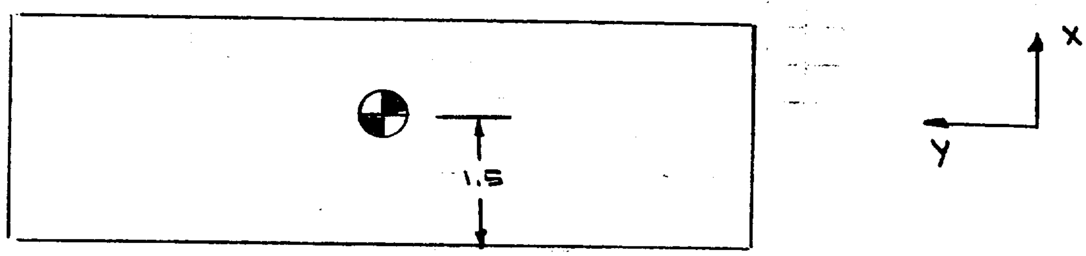


OVERTURNING MOMENT

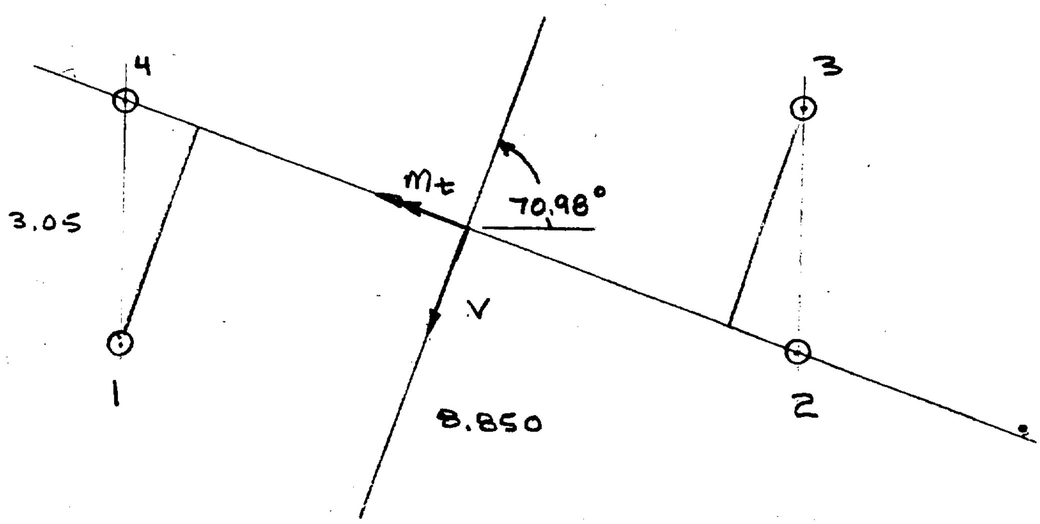
USING "3T" LOADS FROM RANDOM VIBRATION, THE LARGEST RESPONSE (24.25 GRMS @ 1T) IS APPLIED WITHOUT REGARD TO DIRECTION, AS A FORCE THROUGH THE ASSUMED PREAMP DETECTOR CG TO DEVELOP THE LARGEST POSSIBLE OVERTURNING MOMENT BOLT TENSILE LOAD.



ASSUMED CG @ CENTER OF ATTACHMENT BOLT PATTERN. HEIGHT OF CG ASSUMED AT 1.5 INCHES



ASSUMED LOAD DIRECTION IS ⇒ ⊥ TO SCREW #4



$V = 4(.7225)(3)/(24.25) = 218.9$ LB

$M_t = (1.5)(V) = 328.4$ IN-LB

TENSILE LOAD DISTANCES ALONG SKEWED AXIS

$d_2 = d_4 = 0$

$d_1 = d_3 = 3.050 \cos(19.02) = 2.884$ IN

$\Sigma d_i^2 = 16.629 \text{ IN}^2$

TENSILE FORCE AT SCREW # 2

$$F_{t2} = \frac{M_t d_2}{\Sigma d_i^2} = \frac{(328.4)(2.884)}{16.629} = 56.9 \text{ LB}$$

TOTAL TENSILE LOAD, F_b

$F_i = 507.2$ LB PRELOAD

$F_t = F_{t1} + F_{t2} = 52.6 + 56.9 = 109.5$ LB

WITH FS = 1.4 APPLIED TO F_t ONLY

$$F_b = F_i + (FS) \frac{k_b}{k_b + k_m} F_t$$

$$k_b = \frac{EA}{l}$$

$E = 28 \times 10^6$ psi

$A = \pi/4 \, (.138)^2 = .01496 \text{ IN}^2$

l = GRIP LENGTH

$= .032 + .063 + .045 + .015$

$= .155$

$= 2.702 \times 10^6$ LB/IN

WITH A LOW E FIBERGLAS ISOLATORS WASHER IN THE MEMBER STACK-UP, CONSERVATIVELY ASSUME

$$k_m \to 0$$

THEN

$$\frac{k_b}{k_b + k_m} = 1.0$$

$$F_t = F_i + (FS) F_t = 507.2 + (1.4)(109.5) = 661 \text{ LB}$$

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},

$$F_{TU} = 1458 \text{ LB}$$

$$MS = \frac{1458}{153.3} - 1 = +8.5 \qquad \therefore \text{ OK}$$

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

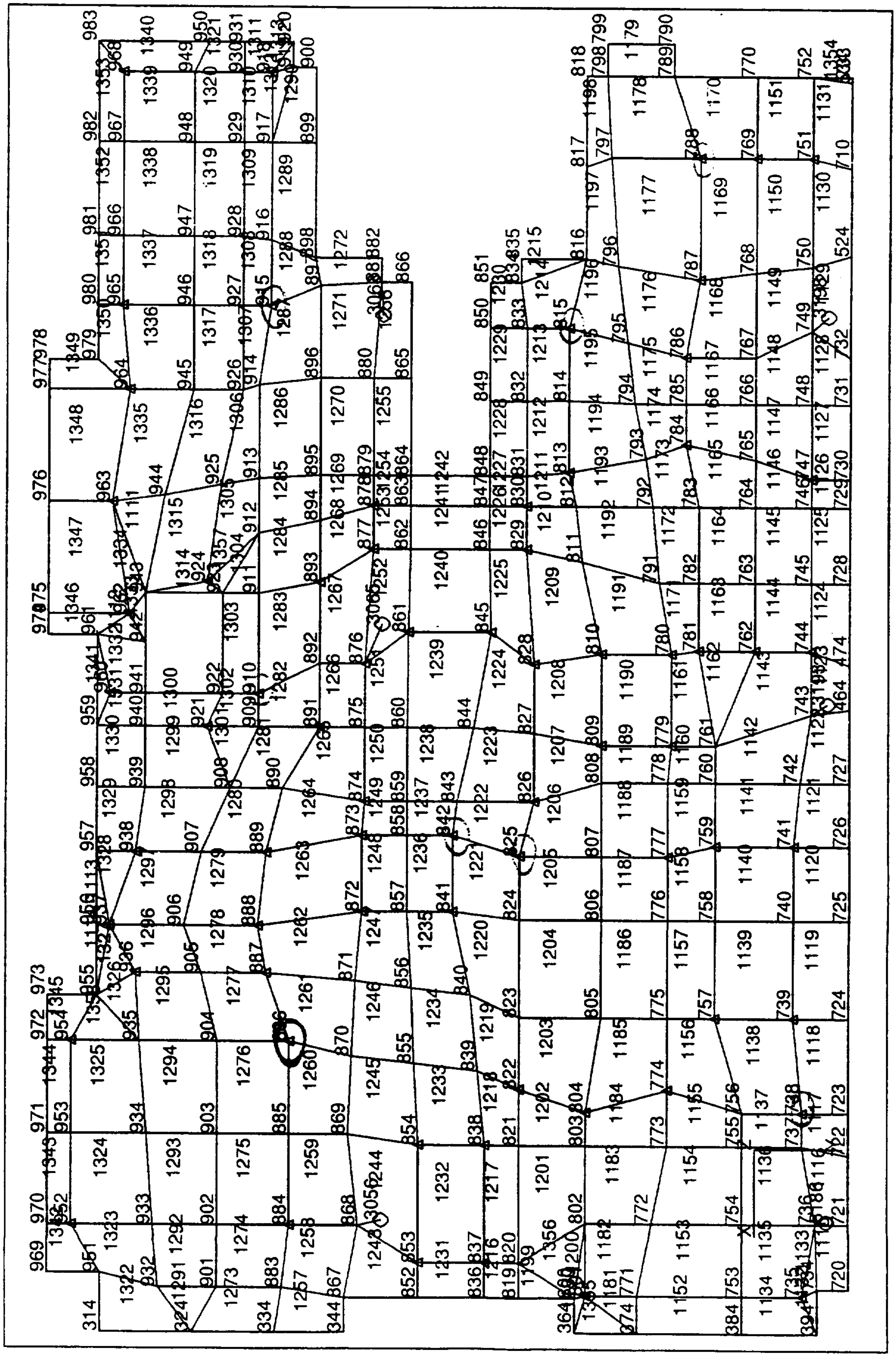
2) PRELOAD (REF 1356429)

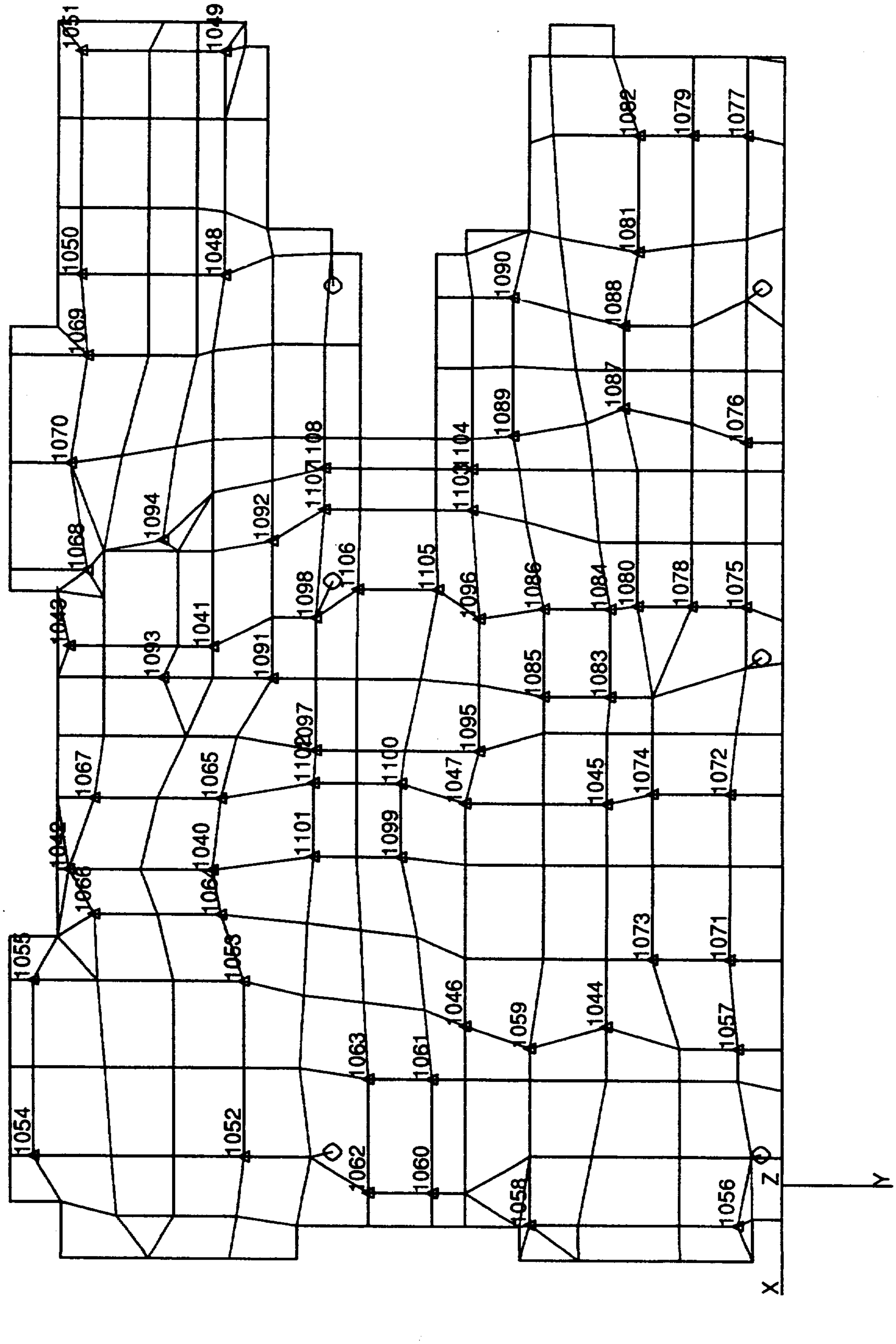
3) ADDITIONAL OVERTURNING MOMENT EFFECTS

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 (CONM2 1056-1059) TO REPRESENT THE PLO, EACH PT MASS IS 0.529 LB.

LARGEST RESPONSE PER Z-LOAD, Z-RESPONSE IS A 1σ GRMS LEVEL OF 15.56 GRMS. AT GR 738




1051
1049
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1062
1060
1058
1056
Z
Y
X

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	$\boxed{15.5622}$	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 GR 738

$$F_{t_1} = 3(15.56)(0.529) = 24.7 \text{ LB}$$

PRELOAD TORQUE

$$T = .2\, F_i\, d$$

F_i = PRELOAD
d = NOMINAL SCREW ϕ = .112

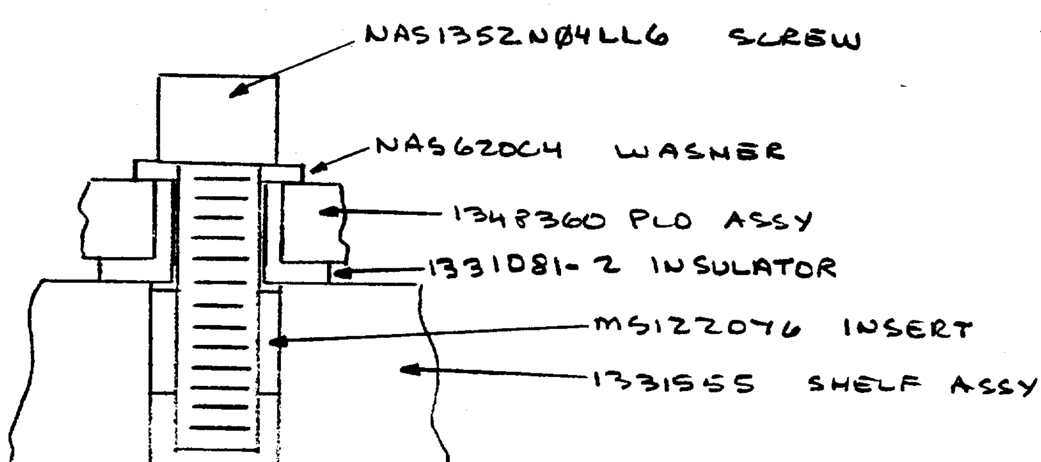
ATTACHMENT SCREWS ARE (4) NAS1352N04LL6

.112-40UNRC-3A #4 SCREWS

T = 4.5 TO 5.5 IN-LB (1356429 SH 1)

$$F_i = \frac{5.5}{.2(.112)} = 246 \text{ LB}$$

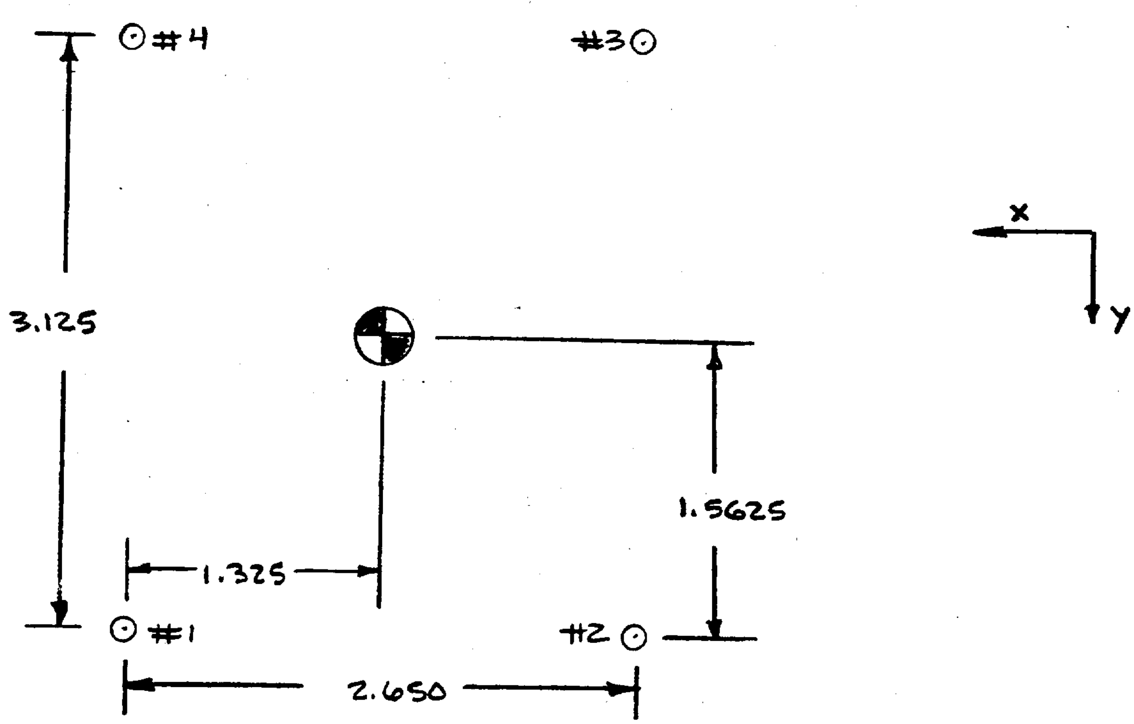
SKETCH OF JOINT

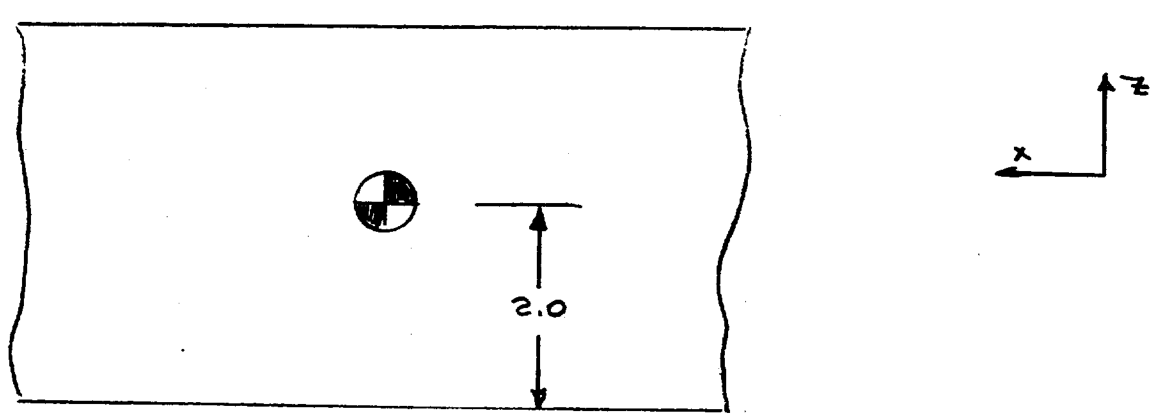


OVERTURNING MOMENT

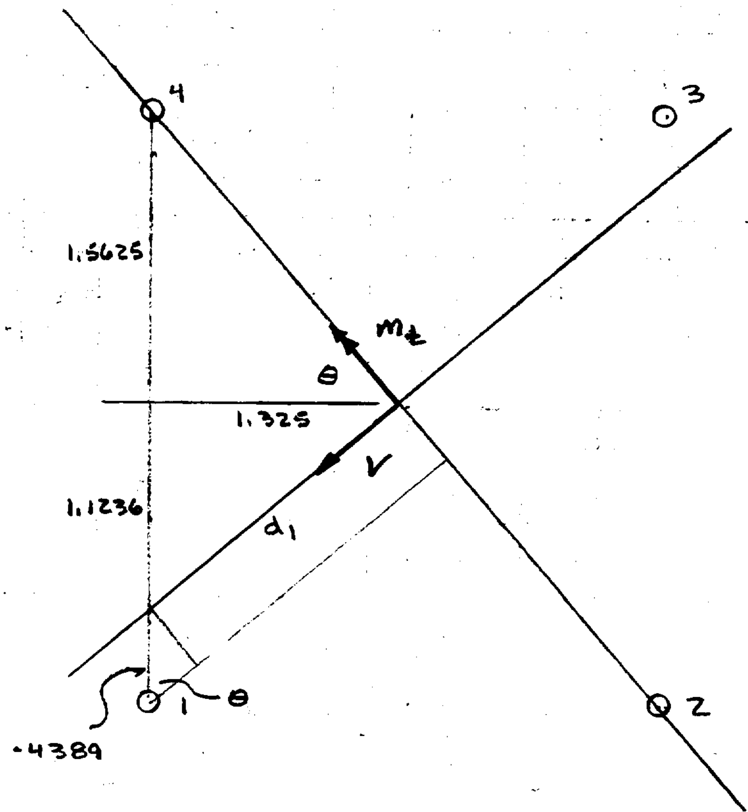
USING "3σ" LOADS FROM RANDOM VIBRATION WITH A Q=7.1, THE LARGEST RESPONSE (15.56 GRMS @ IT AT GR738) IS APPLIED WITHOUT REGARD TO DIRECTION, AS A FORCE THROUGH THE ASSUMED PLO ASSY CG TO DEVELOP THE LARGEST POSSIBLE OVERTURNING MOMENT BOLT TENSILE LOAD.

ASSUMED IN-PLANE CG IS @ CENTER OF ATTACHMENT BOLT PATTERN. HEIGHT OF CG ASSUMED AT 2.0 INCHES.





ASSUMED LOAD DIRECTION IS ⊥ TO SCREW #4 - #2



$\theta = \tan^{-1} \dfrac{1.5625}{1.325}$

$= 49.702°$

$90 - \theta = 40.298°$

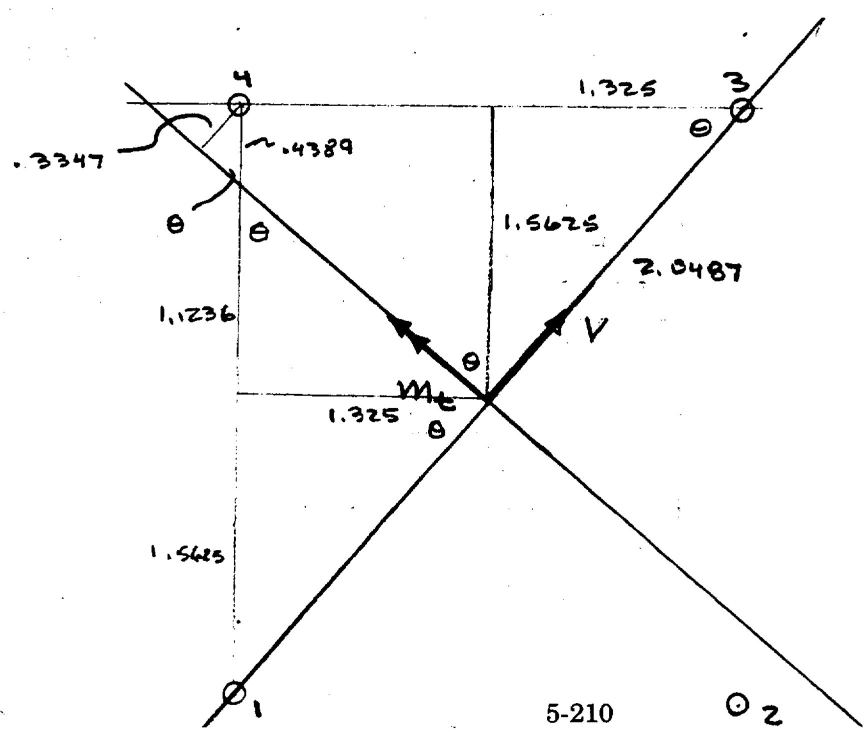
$d_3 = d_1 = 1.737$

$d_2 = d_4 = 0$

$\Sigma d_i^2 = 6.036$

$d_1 / \Sigma d_i^2 = \underline{\underline{.288}}$

ASSUMED LOAD DIRECTION IS ∥ TO SCREW #3 - #1



$\theta = \tan^{-1} \dfrac{1.5625}{1.325}$

$= 49.702°$

$90 - \theta = 40.298°$

$d_1 = d_3 = 2.0487$

$d_2 = d_4 = .3347$

$\Sigma d_i^2 = 8.618$

$d_1 / \Sigma d_i^2 = .238$

∴ LESS SEVERE CASE

$V = 4(.529)(3)(15.56) = 98.8$ LB

$M_t = (2.0)\,V = 197.5$ IN-LB

TENSILE FORCE AT SCREW #1

$$F_{t_2} = \frac{M_t d_1}{\Sigma d_i^2} = \frac{(197.5)(1.737)}{6.036} = 56.8 \text{ LB}$$

TOTAL TENSILE LOAD, F_b

$$F_b = F_i + FS \frac{k_b}{k_b + k_m} F_t$$

$$F_t = F_{t_1} + F_{t_2} = 24.7 + 56.8 = 81.5 \text{ LB}$$

WITH FS = 1.4 APPLIED TO F_t ONLY

$$F_b = F_i + (FS) \frac{k_b}{k_b + k_m} (F_t)$$

WORST CASE SCENARIO IS

$$k_b >> k_m$$

THEN

$$F_b = F_i + (FS)(F_t)$$

$$= 246 + 1.4(81.5) = 360 \text{ LB}$$

PER NAS1352 FOR N04 SCREW OF HEAT RESISTANT STEEL, MIN BREAKING STRENGTH

$$F_{tu} = 966 \text{ LB}$$

$$MS = \frac{966}{360} - 1 = +1.7$$

∴ 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 Z-LOAD, Z-RESPONSE IS A 1σ 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	X-RESPONSE			Y-RESPONSE			Z-RESPONSE		
		DIRECTION	RMS	GRMS	Q	RMS	GRMS	Q	RMS	GRMS	Q
LOWER SHELF	884	X	4185	10.84197	1.1	1003	2.598446	0.3	2102	5.4456	0.5
PLO +X+Y		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 3σ LOAD AT GR 886

$$F_{t_1} = 3(16.26)(.532) = 25.9 \text{ LB}$$

PRELOAD

$$F_i = 246 \text{ LB}$$

SKETCH OF JOINT

SEE OTHER PLO ON LOWER SHELF.

OVERTURNING MOMENT

SEE OTHER PLO ON LOWER SHELF

$$V = 4(.532)(3)(16.26) = 103.8 \text{ LB}$$

$$M_t = (2.0)V = 207.6 \text{ IN-LB}$$

TENSILE FORCE AT SCREW # 1

$$F_{t_2} = \frac{M_t d_1}{\Sigma d_i^2} = \frac{(207.6)(1.737)}{6.036} = 59.7 \text{ LB}$$

TOTAL TENSILE LOAD, F_b

$$F_b = F_i + FS \frac{k_b}{k_b + k_m} F_t$$

$$F_t = F_{t_1} + F_{t_2} = 25.9 + 59.7 = 85.6 \text{ LB}$$

WORST CASE SCENARIO

$$k_b >> k_m$$

THEN

$$F_b = F_i + (FS)(F_t)$$

$$= 246 + 1.4(85.6) = 366 \text{ LB}$$

PER NAS1352

$$F_{tu} = 966 \text{ LB}$$

$$MS = \frac{966}{366} - 1 = +1.6$$

∴ PLO MOUNTING SCREWS ARE OK IN TENSION FOR +X+Y PLO.

1336610 OSCILLATOR'S 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, 960) 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 1σ 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	X-RESPONSE			Y-RESPONSE			Z-RESPONSE		
		DIRECTION	RMS	GRMS	Q	RMS	GRMS	Q	RMS	GRMS	Q
ORO	960	X	4002	10.36788	-1.0	1568	4.062176	0.4	1963	5.08549	0.5
(BOTTOM MT)		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	$\boxed{19.3109}$	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

$$F_{t1} = 3(19.31)(0.393) = 22.8 \text{ LB}$$

PRELOAD TORQUE

ATTACHMENT SCREWS ARE NAS1352N04LL6 (SAME AS USED WITH PLO'S) #4 SCREWS

$$F_i = \frac{5.5}{(.2)(.112)} = 246 \text{ LB}$$

SKETCH OF JOINT

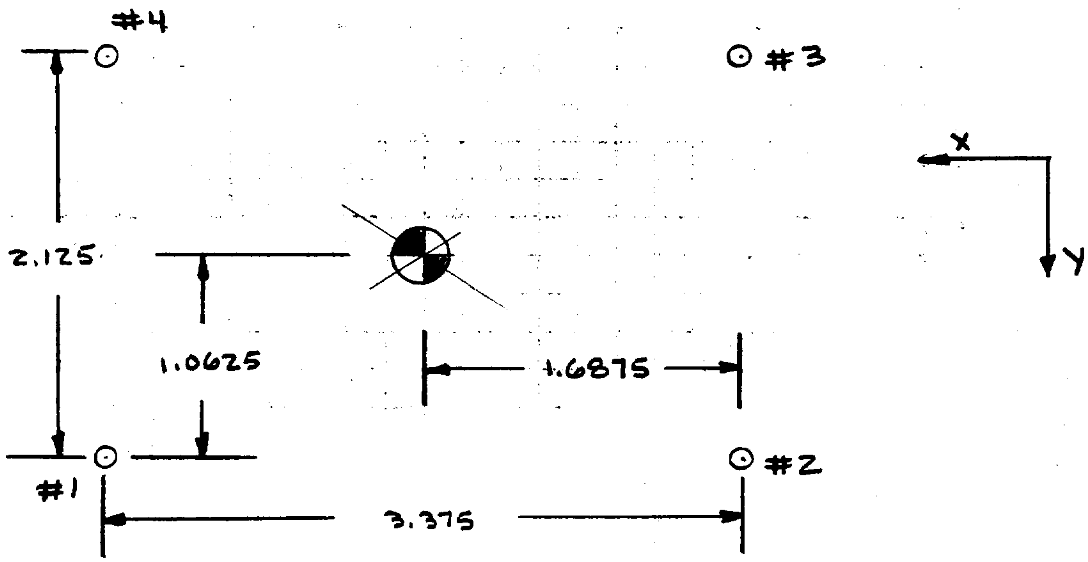
SEE PLO JOINT SKETCH, SUBSTITUTE 1336610 FOR 1348360.

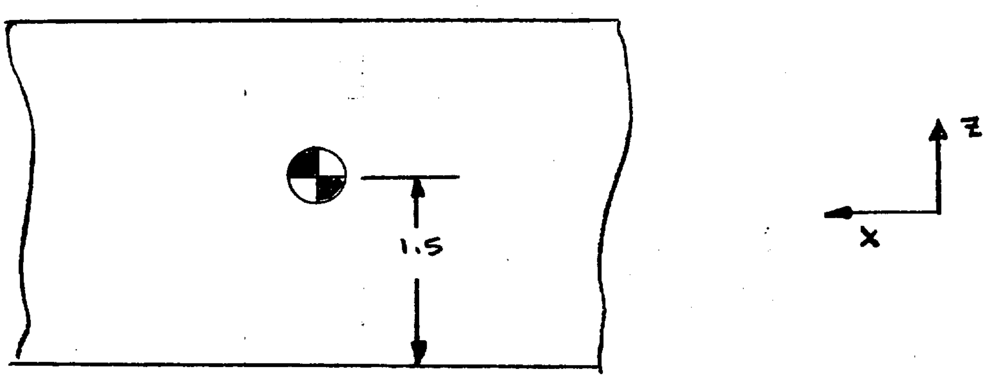
1-8-95

OVERTURNING MOMENT

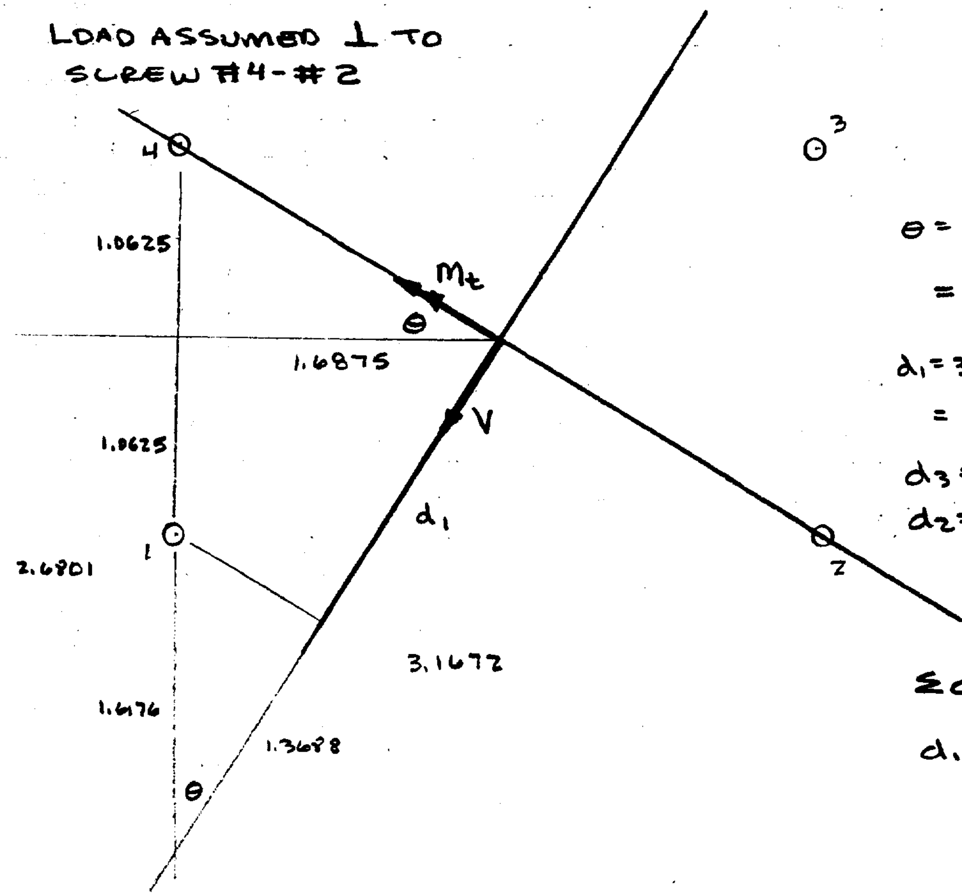
USING "3σ" LOADS FROM RANDOM VIBRATION Q=7.1 WITH LARGEST RESPONSE (19.31 GRMS @ 1σ AT GR 910) APPLIED WITHOUT REGARD TO DIRECTION, AS A FORCE THROUGH THE ASSUMED DRO ASSY CG, DEVELOPING THE LARGEST POSSIBLE OVERTURNING MOMENT BOLT TENSILE LOAD

ASSUMED IN-PLANE CG @ CENTER OF ATTACHMENT BOLT PATTERN. HEIGHT OF CG ASSUMED AT 1.5 INCHES.





LOAD ASSUMED ⊥ TO SCREW #4-#2



$$\theta = \tan^{-1} \frac{1.0625}{1.6875}$$
$$= 32.20^\circ$$

$$d_1 = 3.1672 - 1.3688$$
$$= 1.7983$$

$d_3 = d_1$

$d_2 = d_4 = 0$

$\Sigma d_i^2 = 6.468$

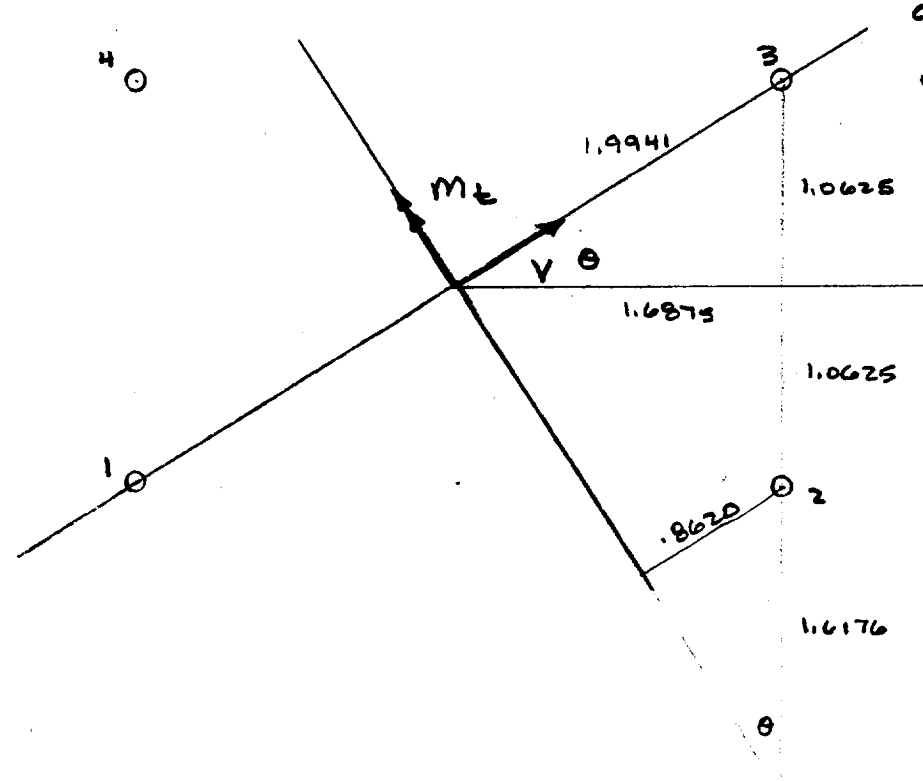
$d_1 / \Sigma d_i^2 = \underline{\underline{.2780}}$

LOAD ASSUMED ∥ TO SCREW #3-#1

$\theta = 32.20^\circ$

$d_1 = d_3 = 1.9941$

$d_2 = d_4 = .8620$



$\Sigma d_i^2 = 9.439$

$d_1 / \Sigma d_i^2 = .2113$

∴ LESS SEVERE THAN ABOVE CASE

$V = 4(.393)(3)(19.31) = 91.1$ LB

$M_t = 1.5\,V = 136.6$ IN-LB

TENSILE FORCE @ SCREW #3

$$F_{t_2} = \frac{M_t d_3}{\Sigma d_i^2} = \frac{(136.6)(1.7983)}{(6.468)} = 38.0 \text{ LB}$$

TOTAL TENSILE LOAD, F_b

$$F_b = F_i + FS \frac{k_{eb}}{k_{eb}+k_{em}} F_t$$

$$F_t = F_{t_1} + F_{t_2} = 22.8 + 38.0 = 60.8 \text{ LB}$$

ASSUME WORST CASE SCENARIO

$$k_{eb} >> k_{em}$$

$$k_{eb}/(k_{eb}+k_{em}) = 1.0$$

USE $FS = 1.4$, THEN

$$F_b = 246 + (1.4)(1.0)(60.8) = 331 \text{ LB}$$

PER NAS1352N04LL6 SCREW, #4, HEAT RESISTANT STEEL, MIN BREAKING STRENGTH

$$F_{tu} = 966 \text{ LB}$$

$$MS = \frac{966}{331} - 1 = +1.9$$

$\therefore$ 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 1σ GRMS LEVEL OF 14.52 GRMS AT GRID 915.

RANDOM VIBRATION RESULTS w/ Q=7.1

COMPONENT	GRID	LOAD DIRECTION	RESPONSE OF LARGE MASSES Q=7.1 X-RESPONSE RMS	GRMS	Q	Y-RESPONSE RMS	GRMS	Q	Z-RESPONSE 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	$\boxed{14.5155}$	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 @ GR915

$F_{t_1} = 3(14.52)(.390) = 17.0$ LB

PRELOAD

$F_i = 246$ LB

SKETCH OF JOINT

SEE PLD JOINT SKETCH, SUBSTITUTE 1336610 DRG FOR 1348360 PLD

OVERTURNING MOMENT

SEE OTHER DRG ABOVE FOR GEOMETRY

$V = (4)(.390)(3)(14.52) = 68.0$ LB

$M_t = (1.5)V = 101.9$ IN-LB

TENSILE FORCE AT SCREW #3

$$F_{t_2} = \frac{M_t d_3}{\Sigma d_i^2} = \frac{(101.9)(1.7983)}{(6.468)} = 28.3 \text{ LB}$$

TOTAL TENSILE LOAD, F_b,

w/ $k_b >> k_m$ $k_b / k_b + k_m = 1.0$

$F_t = F_{t_1} + F_{t_2} = 17.0 + 28.3 = 45.3$ LB

FS = 1.4 ON F_t ONLY,

$$F_D = 246 + (1.4)(1.0)(45.3) = 310 \text{ LB}$$

ALLOWABLE, NAS1352NØ4LL6

$$F_{tu} = 966 \text{ LB}$$

$$MS = \frac{966}{310} - 1 = +2.1$$

∴ 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 1σ 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 RMS	X-RESPONSE GRMS	X-RESPONSE Q	Y-RESPONSE RMS	Y-RESPONSE GRMS	Y-RESPONSE Q	Z-RESPONSE RMS	Z-RESPONSE GRMS	Z-RESPONSE Q
LOWER SHELF	825	X	4354	11.27979	1.1	1396	3.61658	0.4	2179	5.64508	0.6
		Y	1286	3.331606	0.3	4525	11.7228	1.2	1832	4.74611	0.5
		Z	1262	3.26943	0.3	1133	2.935233	0.3	8389	$\boxed{21.7332}$	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 3σ LOAD @ GRID 825

$$F_{t_1} = (3)(21.73)(.34) = 22.2 \text{ LB}$$

PRELOAD

$F_i = 246$ LB

JOINT SKETCH

SEE PLO JOINT SKETCH, REPLACE 1348360 PLO WITH 1336610 GDO.

OVERTURNING MOMENT

SEE SKETCHES AT 1ST DRO EVALUATED FOR GEOMETRY

$V = (4)(.34)(3)(21.73) = 88.7$ LB

$M_t = (1.5)V = 133.0$ IN-LB

TENSILE FORCE @ SCREW #3

$$F_{t2} = \frac{M_t d_3}{\Sigma d_i^2} = \frac{(133.0)(1.7983)}{(6.468)} = 37.0 \text{ LB}$$

TOTAL TENSILE LOAD, F_b

w/ $k_b >> k_m$ $\therefore$ $k_b / k_b + k_m = 1.0$

$F_t = F_{t1} + F_{t2} = 22.2 + 37.0 = 59.2$ LB

$FS = 1.4$

$$F_b = F_i + FS \frac{k_b}{k_b + k_m} F_t$$

$= 246 + (1.4)(1.0)(59.2)$

$= 329$ LB

PER NAS1352N04LL6 SCREW, $F_{tu} = 966$ LB

$$MS = \frac{966}{329} - 1 = +1.9$$

$\therefore$ 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 NASTRAN MODEL TO APPLY PT. MASSES (CONM2 1075-1082) TO REPRESENT THIS ASSY. EACH PT MASS IS .248 LB.

LARGEST RESPONSE PER Z-LOAD, Z-RESPONSE IS A 1σ GRMS LOAD OF 16.71 GRMS AT GRID 788.

RANDOM VIBRATION RESULTS WITH Q=7.1

RESPONSE OF LARGE MASSES Q=7.1

COMPONENT	GRID	LOAD DIRECTION	X-RESPONSE RMS	X-RESPONSE GRMS	X-RESPONSE Q	Y-RESPONSE RMS	Y-RESPONSE GRMS	Y-RESPONSE Q	Z-RESPONSE RMS	Z-RESPONSE GRMS	Z-RESPONSE 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	$\boxed{16.7073}$	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

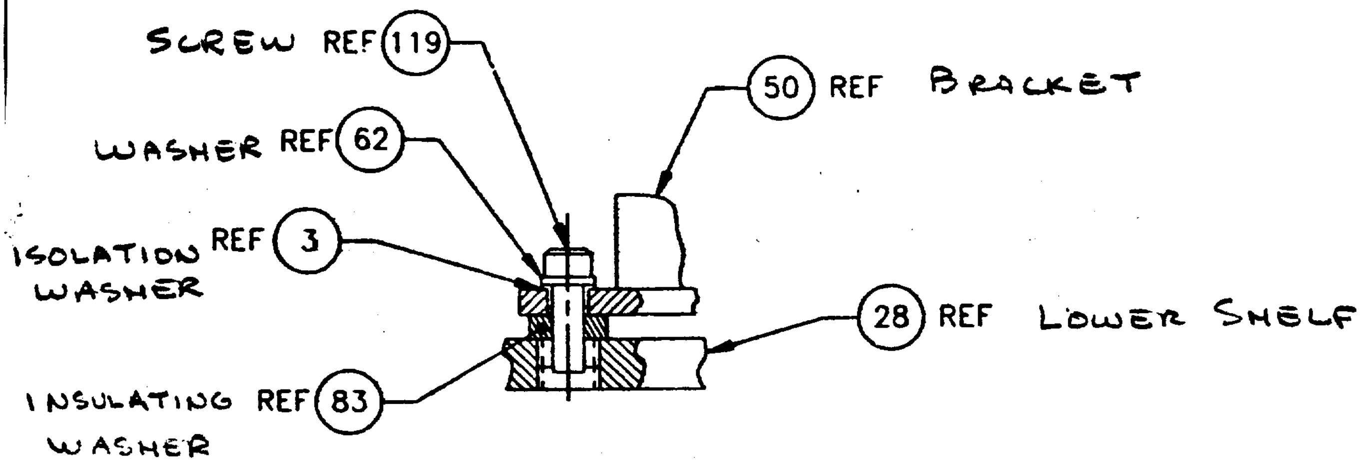
$$F_{t1} = 3(16.71)(.248) = 12.4 \text{ LB}$$

PRELOAD TORQUE

ATTACHMENT SCREWS ARE NAS1352N0477 (#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)



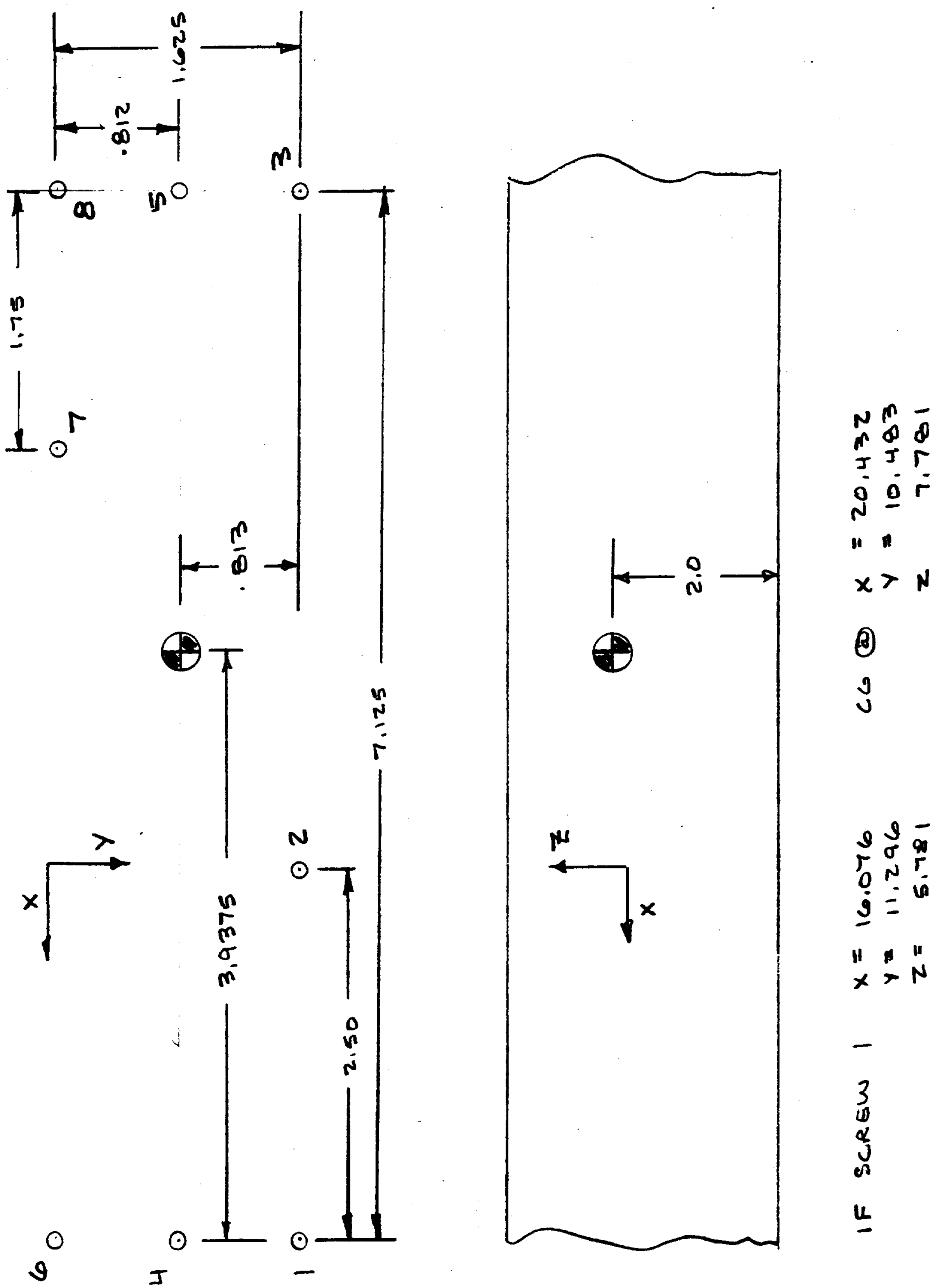
VIEW F 4 2 E

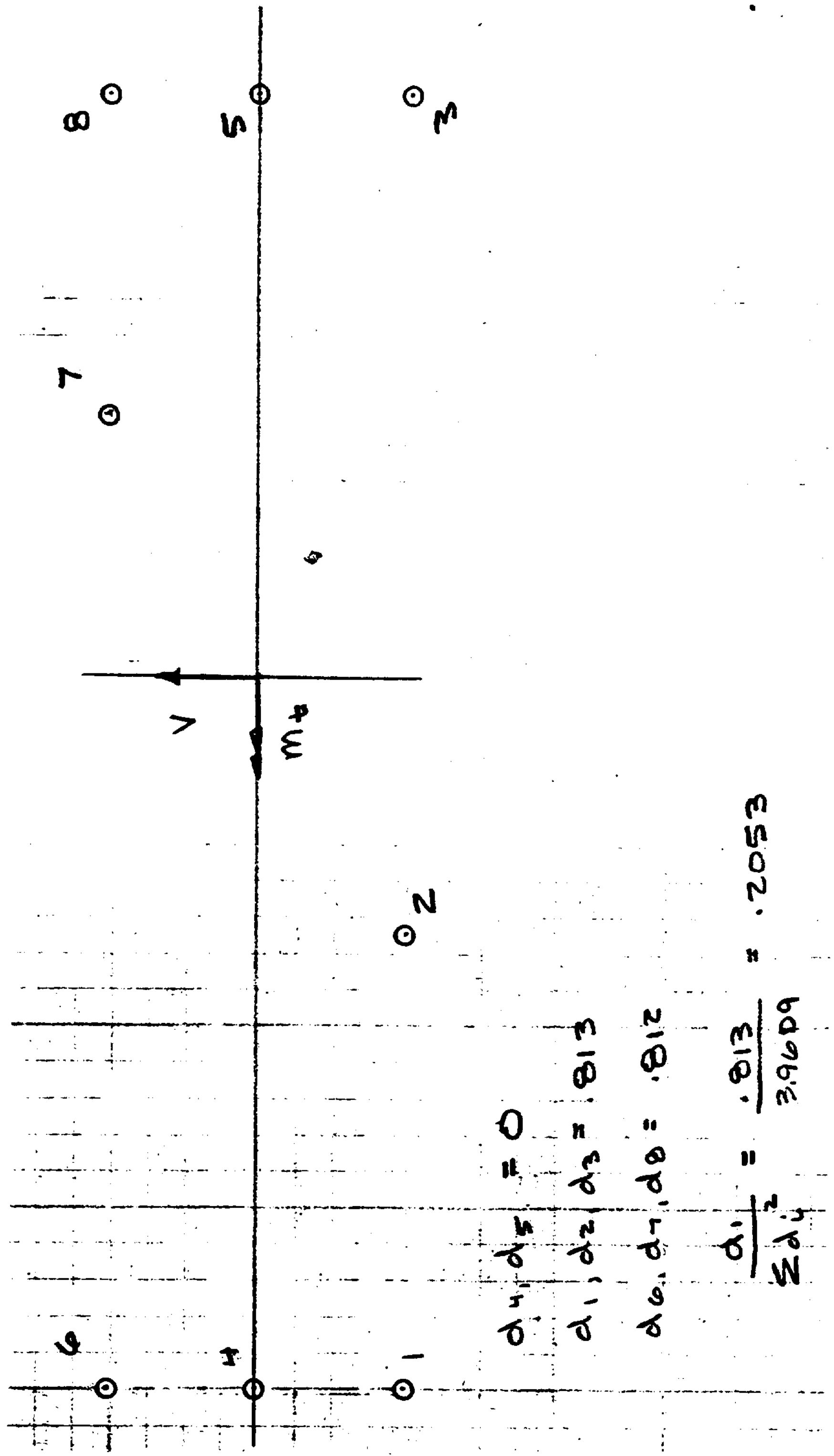
HARDWARE USAGE, 8 PL (REF)
SCALE: 2/1

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


1.625
.812
3
5
8
1.75
7
.813
2.0
X = 20.432
Y = 10.483
Z 7.781
CG
7.125
3.9375
Y
X
2
Z
X
2.50
X = 16.076
Y = 11.296
Z = 5.781
1F SCREW 1
6
4
1

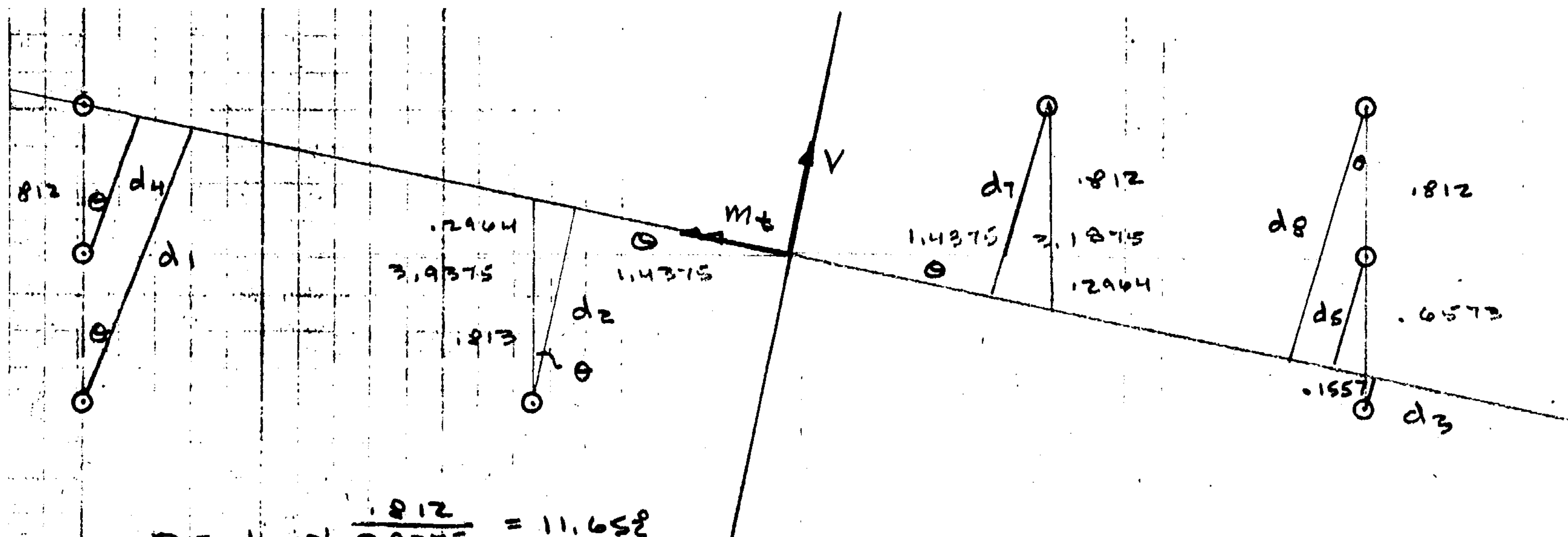


$d_4, d_5 = 0$

$d_1, d_2, d_3 = .813$

$d_6, d_7, d_8 = .812$

$$\frac{d_1}{\Sigma d_i^2} = \frac{.813}{3.9609} = .2053$$



$\theta = \tan^{-1} \dfrac{.812}{3.9375} = 11.65°$

$d_4 = .812 \cos \theta = .7953$

$d_1 = 1.625 \cos \theta = 1.5915$

$d_2 = 1.1094 \cos \theta = 1.0866$

$d_6 = 0$

$\dfrac{d_1}{\Sigma d_i^2} = \dfrac{1.5915}{8.037} = .1981$

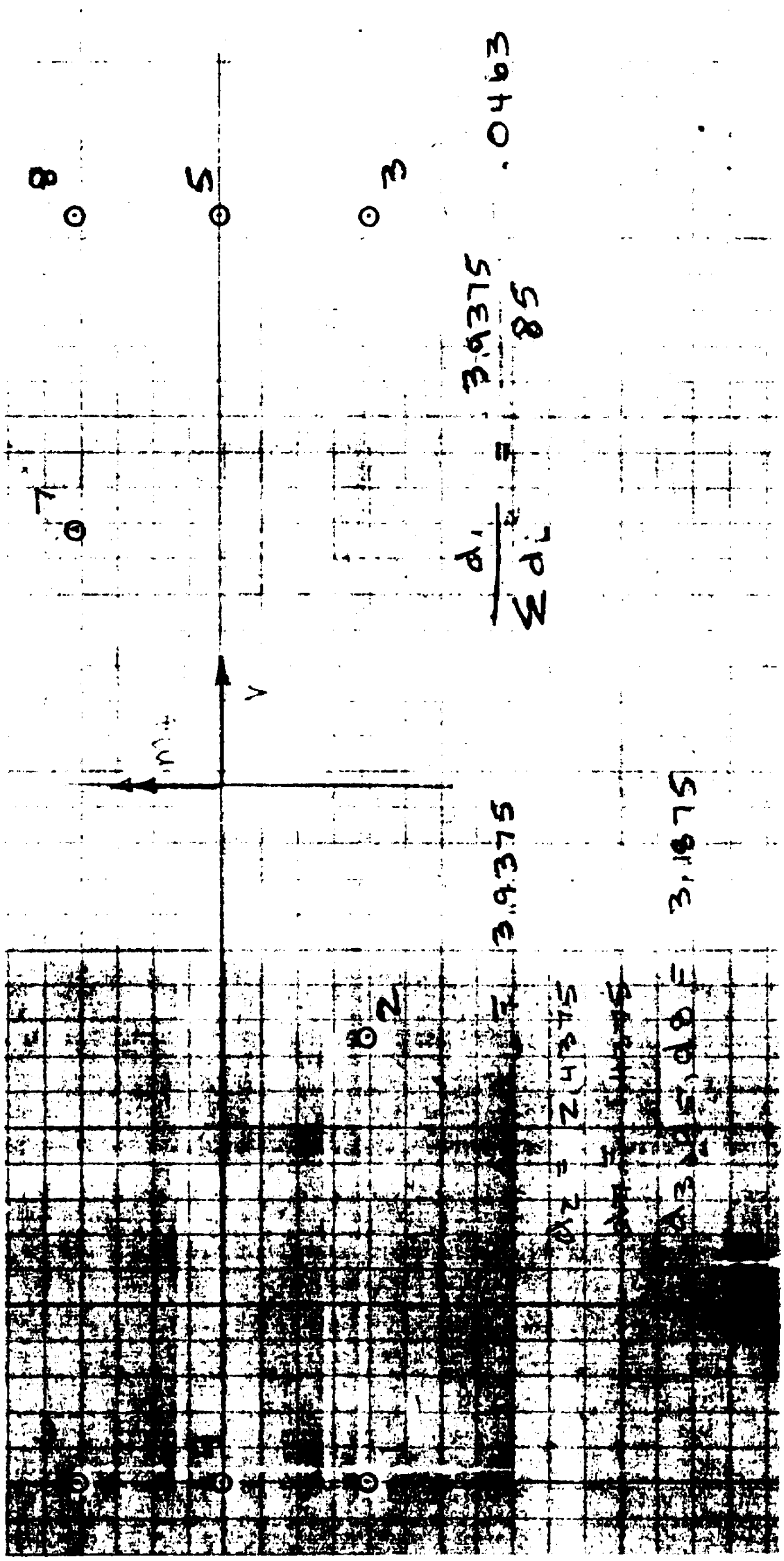
$d_5 = .6573 \cos \theta = .6438$

$d_3 = .1557 \cos \theta = .1525$

$d_8 = 1.4693 \cos \theta = 1.4390$

$d_7 = 1.1084 \cos \theta = 1.0856$

LESS SEVERE THAN -Y DIRECTION
APPLYING V IN


8
5
3
7
2
V
d1 / Σd² = 3.9375 / 85 = .0463
3.9375
3.1875

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

$$F_{t2} = \frac{M_t d_1}{\Sigma d_i^2} = \frac{(199.2)(.813)}{(3.9609)} = 40.9 \text{ LB}$$

TOTAL TENSILE LOAD, F_b

$$F_b = F_i + FS \frac{k_b}{k_b + k_m} F_t$$

$$F_t = F_{t1} + F_{t2} = 12.4 + 40.9 = 53.3 \text{ LB}$$

$$FS = 1.4$$

ASSUME $k_b >> k_m$

THEN $\frac{k_b}{k_b + k_m} = 1.0$

$$F_i = 246 \text{ LB}$$

$$F_b = 246 + (1.4)(1.0)(53.3) = 321 \text{ LB}$$

PER NAS1352N04LL7 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

1-9-96

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 Z-LOAD Z-RESPONSE IS A 1σ GRMS LOAD OF 21.15 GRMS AT GRID 815.

			RESPONSE OF LARGE MASSES_Q=7.1								
COMPONENT	GRID	LOAD	X-RESPONSE			Y-RESPONSE			Z-RESPONSE		
		DIRECTION	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	$\boxed{21.1503}$	2.1

STATISTICAL 3σ LOAD @ GR815

$$F_{t1} = 3(21.15)(.292) = 18.5 \text{ LB}$$

PRELOAD

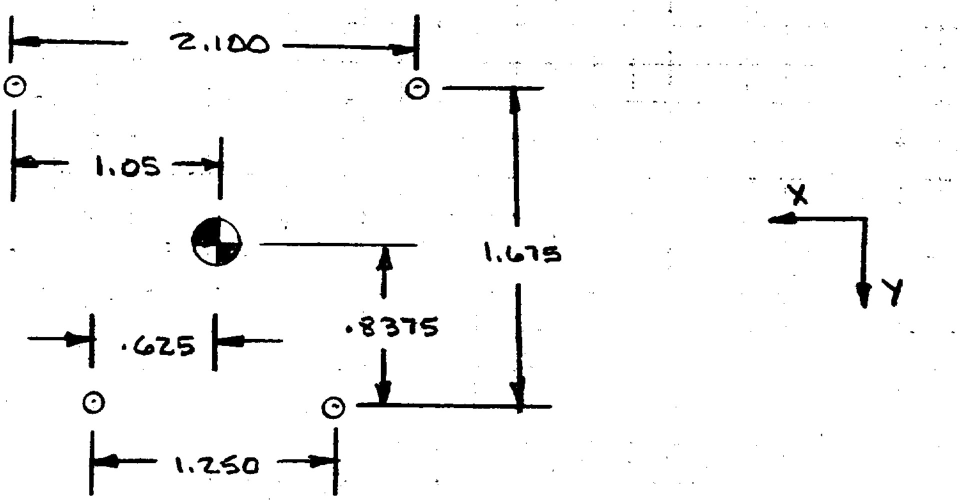
#4 ATTACHMENT SCREWS WITH T = 5.5 IN-LB MAX TORQUE PER 1356429

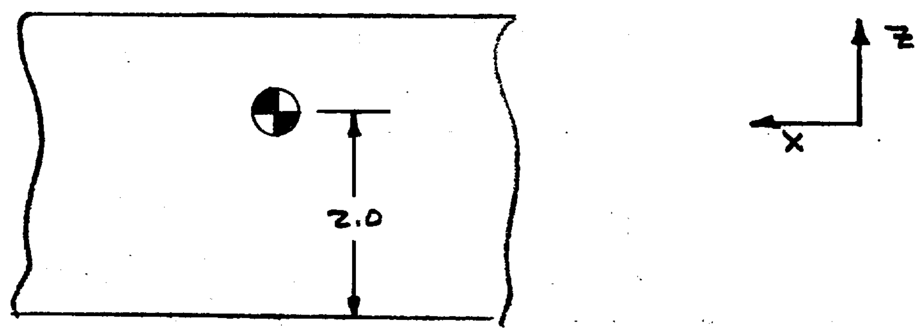
$$F_i = \frac{5.5}{(.2)(.112)} = 246 \text{ LB}$$

OVERTURNING MOMENT

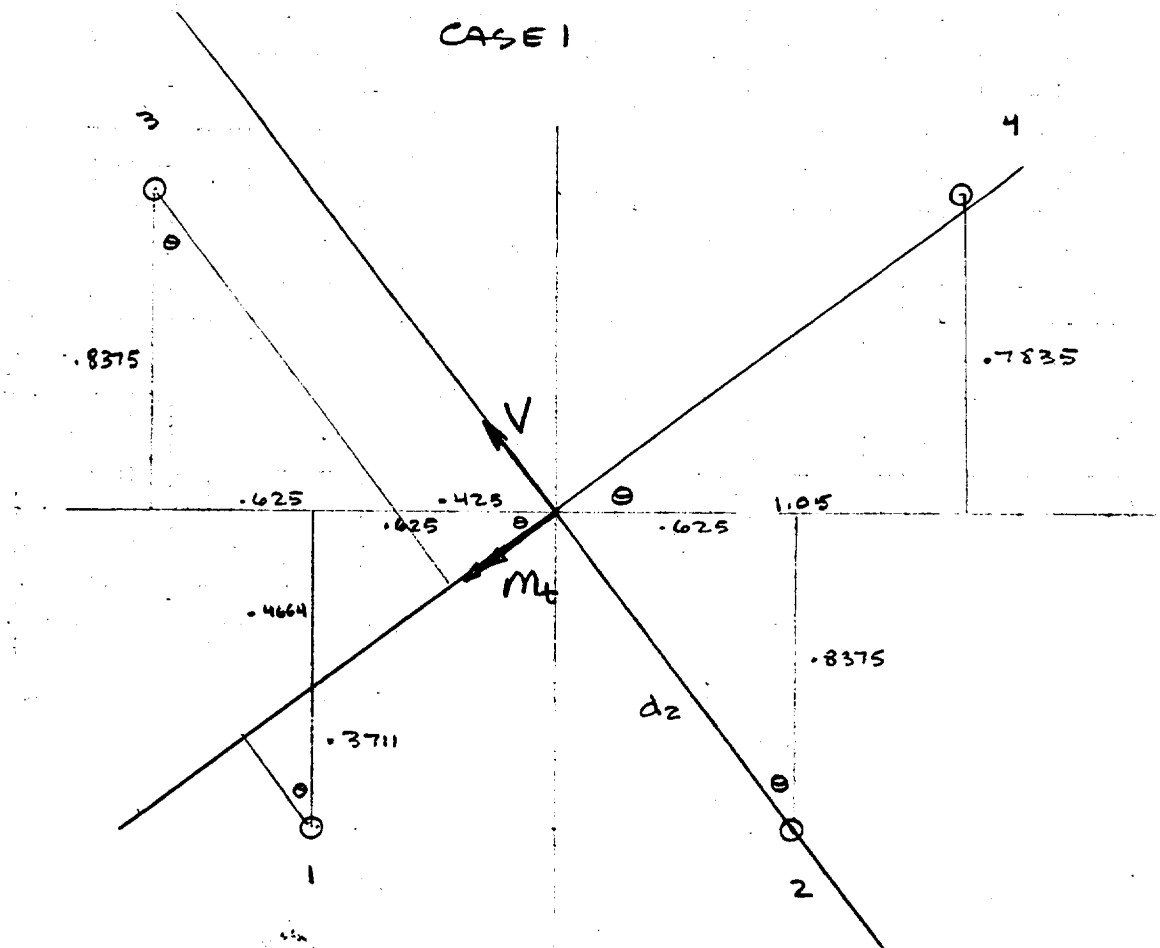
"3σ" LOADS FROM RANDOM VIBRATION, Q=7.1, WITH LARGEST RESPONSE (21.15 GRMS @ 1σ @ GR815) APPLIED WITHOUT REGARD TO DIRECTION OR LOCATION. LOAD IS APPLIED AS A FORCE THROUGH ATTACHMENT BOLT PATTERN CG TO FIND LARGEST POSSIBLE OVERTURNING MOMENT AND BOLT TENSILE LOAD.

ASSUMED IN-PLANE CG @ ATTACHMENT BOLT PATTERN CENTER. HEIGHT OF CG ASSUMED AT 2.0 INCHES.





CASE 1



$$\theta = \tan^{-1} \frac{.625}{.8375} = 36.73°$$

$$d_2 = .8375/\cos\theta = 1.0450$$

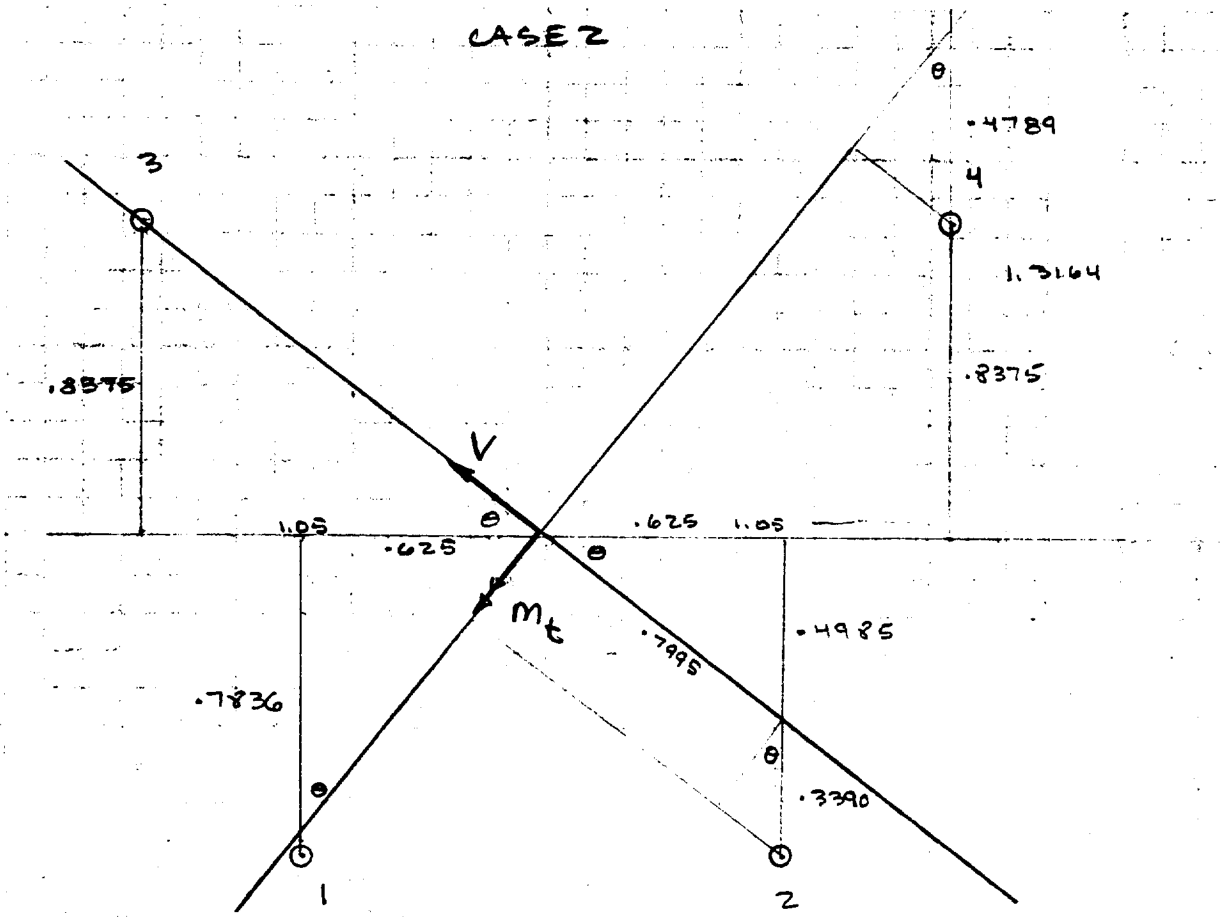
$$d_4 = (.8375 - .7835)\cos\theta = .0433$$

$$d_3 = .8375/\cos\theta + .425 \sin\theta = 1.2991$$

$$d_1 = .3711 \cos\theta = .2974$$

$$\frac{d_3}{\Sigma d_i^2} = \frac{1.2991}{2.8701} = .4526$$

CASE 2



$$\theta = \tan^{-1} \frac{.8375}{1.05} = 38.58°$$

$d_3 = .8375/\sin\theta = 1.3431$

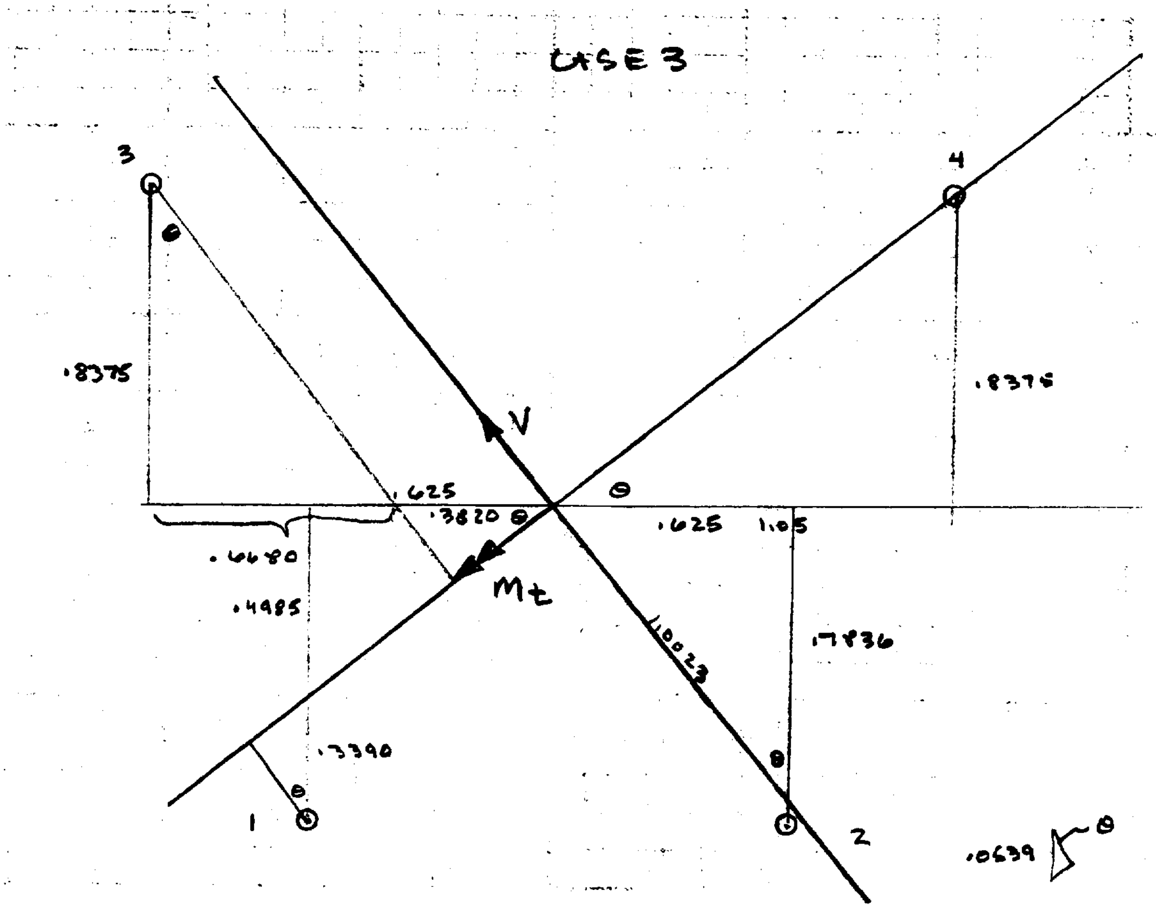
$d_1 = (.8375 - .7836) \sin\theta = .0336$

$d_2 = .7995 + .3390 \sin\theta = 1.0108$

$d_4 = .4789 \sin\theta = .2986$

$$\frac{d_3}{\Sigma d_i^2} = \frac{1.3431}{2.9160} = \underline{\underline{.4606}}$$

WORST CASE



$$\theta = \tan^{-1} \frac{.8375}{1.05} = 38.58°$$

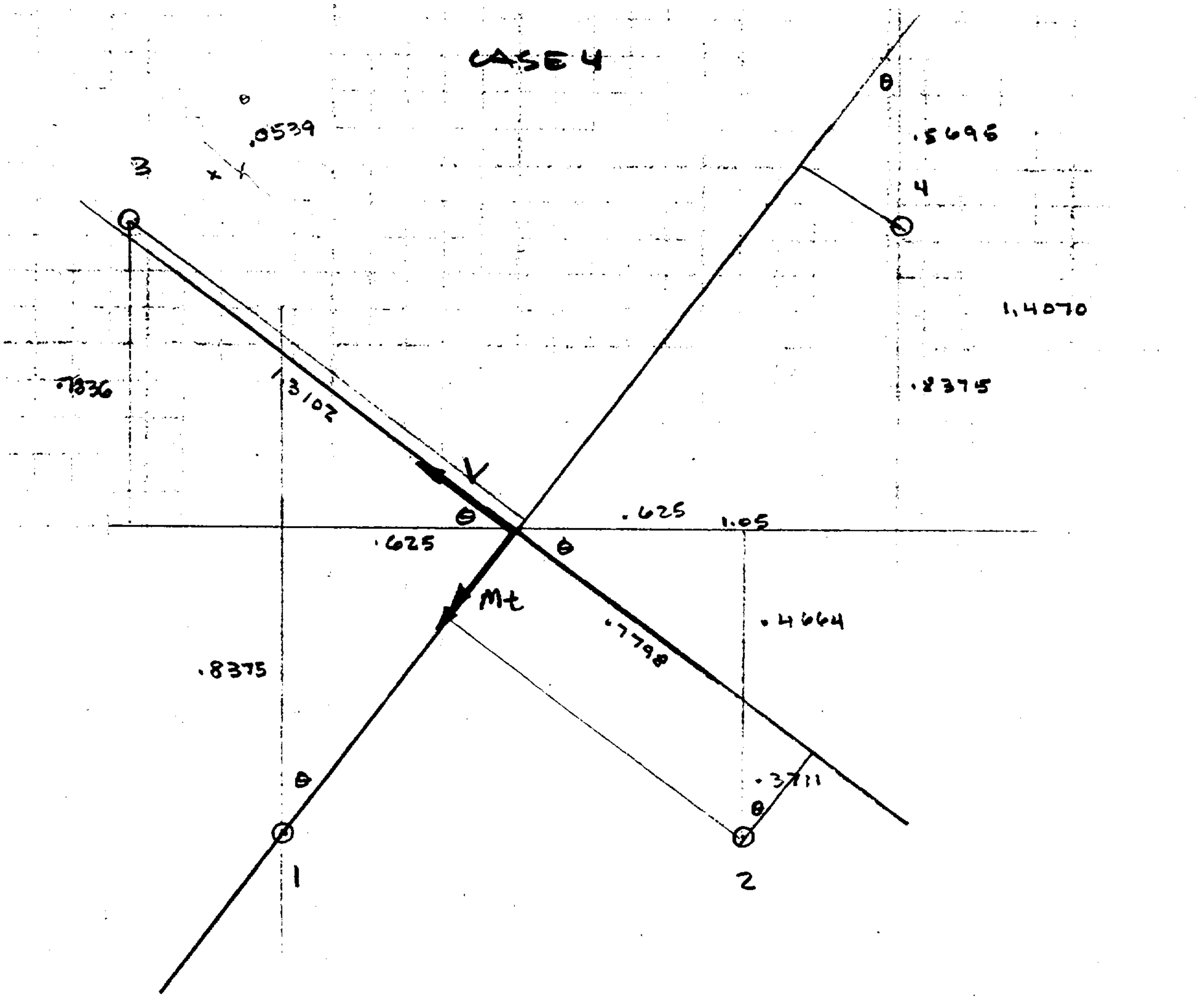
$$d_4 = 0$$

$$d_1 = .3390 \cos\theta = .2650$$

$$d_3 = .8375/\cos\theta + .3820 \sin\theta = 1.3095$$

$$d_2 = 1.0023 + .0539 \cos\theta = 1.0444$$

$$\frac{d_3}{\Sigma d_i^2} = \frac{1.3095}{2.8759} = .4553$$



$$\theta = \tan^{-1} \frac{.625}{.8375} = 36.73^\circ$$

$d_1 = 0$

$d_3 = 1.3102 + .0539 \sin\theta = 1.3424$

$d_2 = .7798 + .3711 \tan\theta = 1.0568$

$d_4 = .5695 \sin\theta = .3406$

$$\frac{d_3}{\Sigma d_i^2} = \frac{1.3424}{3.0348} = .4423$$

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

$$F_{t_2} = \frac{M_t d_3}{\Sigma d_i^2} = \frac{(148.2)(1.3431)}{(2.9160)} = 68.3 \text{ LB}$$

TOTAL TENSILE LOAD F_b

$$F_b = F_i + FS \frac{k_b}{k_b + k_m} F_t$$

$$F_t = F_{t_1} + F_{t_2} = 18.5 + 68.3 = 86.8 \text{ LB}$$

$$FS = 1.4$$

ASSUME $k_b \gg k_m$

$$\frac{k_b}{k_b + k_m} = 1.0$$

$$F_i = 246 \text{ LB}$$

$$F_b = 246 + 1.4(1.0)(86.8) = 367 \text{ LB}$$

NAS1352N04-16 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 NAS1352N04-15 #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 1σ 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	4307	11.15803	1.1	1336	3.46114	0.3	2399	6.21503	0.6
		Y	1249	3.235751	0.3	4450	11.5285	1.1	2103	5.44819	0.5
		Z	1360	3.523316	0.3	1057	2.738342	0.3	7942	20.5751	2.0
	842	X	4303	11.14767	1.1	1417	3.670984	0.4	2116	5.48187	0.5
		Y	1248	3.233161	0.3	4549	11.78497	1.2	2115	5.47927	0.5
		Z	1358	3.518135	0.3	1160	3.005181	0.3	8550	$\boxed{22.1503}$	2.2
	872	X	4234	10.96891	1.1	1337	3.463731	0.3	2445	6.3342	0.6
		Y	1208	3.129534	0.3	4450	11.5285	1.1	2529	6.55181	0.6
		Z	1493	3.867876	0.4	1056	2.735751	0.3	7504	19.4404	1.9
	873	X	4232	10.96373	1.1	1418	3.673575	0.4	2178	5.64249	0.6
		Y	1210	3.134715	0.3	4550	11.78756	1.2	2701	6.99741	0.7
		Z	1490	3.860104	0.4	1160	3.005181	0.3	8045	20.842	2.1

STATISTICAL 3σ LOAD @ GR 842

$$F_{t_1} = 3(22.15)(.194) = 12.9 \text{ LB}$$

PRELOAD

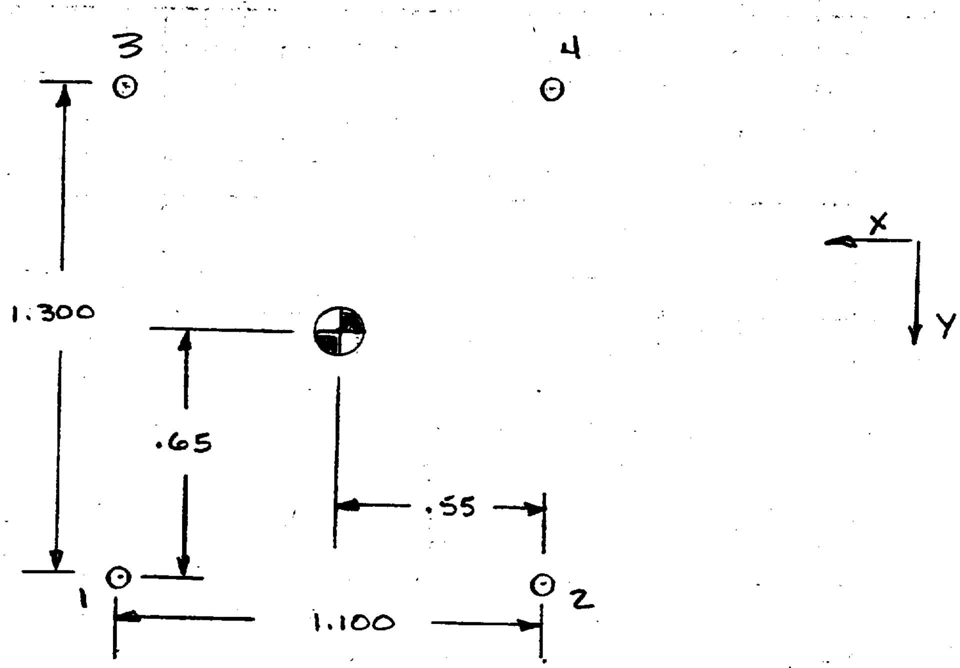
PER 1356429 FOR #4 SCREWS W/ 5.5 IN-LB T_{MAX}

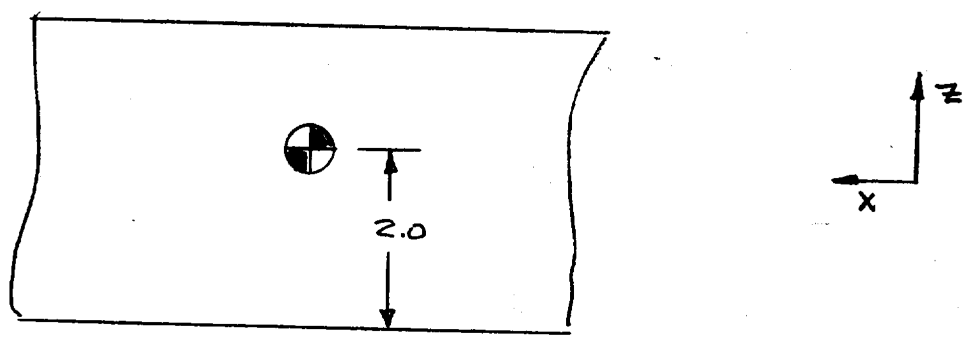
$$F_i = \frac{5.5}{(.2)(.112)} = 246 \text{ LB}$$

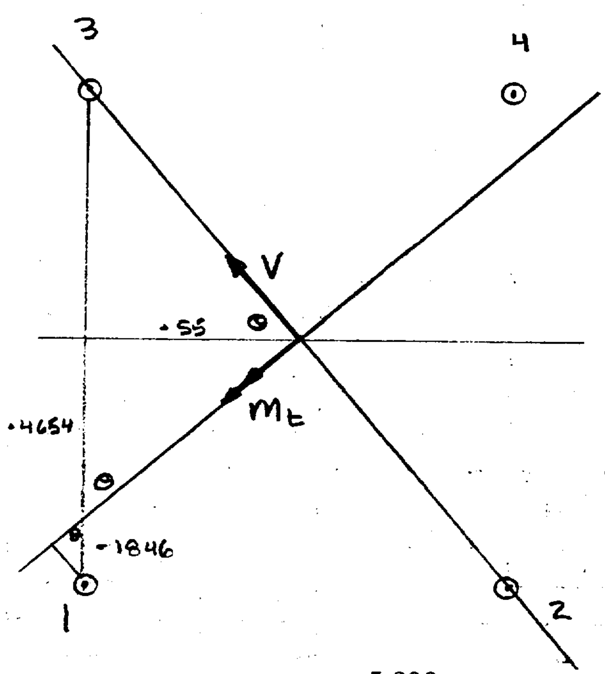
OVERTURNING MOMENT

"3σ" LOADS FROM RANDOM VIBRATION, Q=7.1 WITH LARGEST RESPONSE (22.15 GRMS @ 1σ @ 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







$\theta = \mathrm{TAN}^{-1} \dfrac{.65}{.55} = 49.76^\circ$

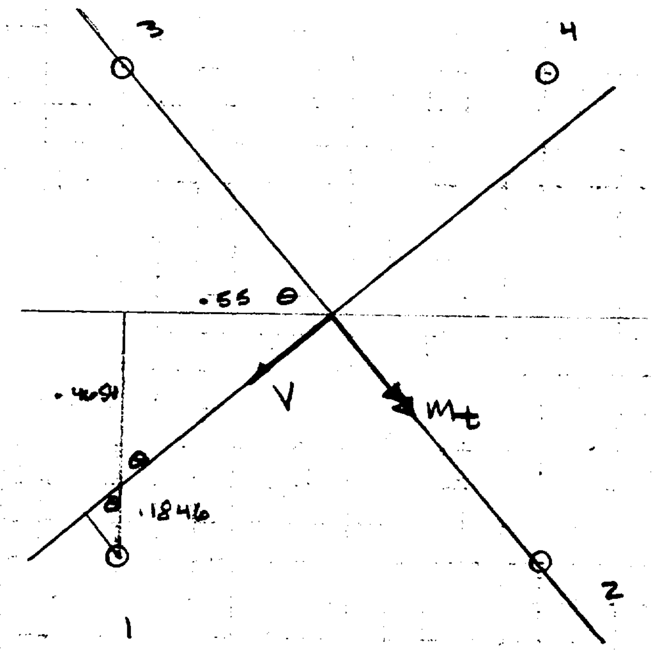
$d_2 = d_3 = \dfrac{.65}{\sin\theta} = .8515$

$d_1 = d_4 = .1846 \sin\theta$

$= .1409$

$\dfrac{d_2}{\Sigma d_i^2} = \dfrac{.8515}{1.4897} = .5716$

NOT WORST CASE



$\theta = \mathrm{TAN}\ \frac{.65}{.55} = 49.76°$

$d_2 = d_3 = 0$

$d_1 = d_4 = .4654/\cos\theta + .1846\cos\theta = .8397$

$\frac{d_1}{\Sigma d_i^2} = \frac{.8397}{1.4103} = .5954$

WORST CASE

$V = 4(.194)(3)(22.15) = 51.5$ LB

$M = (2.0)V = 103$ IN-LB

$F_{t2} = \frac{M_t d_4}{\Sigma d_i^2} = \frac{(103)(.8397)}{(1.4103)} = 61.3$ LB

$F_t = F_{t1} + F_{t2} = 12.9 + 61.3 = 74.2$ LB

$FS = 1.4$

$k_b \gg k_m$

$F_b = F_i + FS \frac{k_b}{k_b + k_m} F_t = 246 + (1.4)(1.0)(74.2) = 350$ LB

NAS1352NØ4-15 SCREW, $F_t = 966$ LB

$MS = \frac{966}{350} - 1 = +1.8$

∴ 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 & OUTHER 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 1σ GRMS LOAD OF 16.27 GRMS AT GR 1806

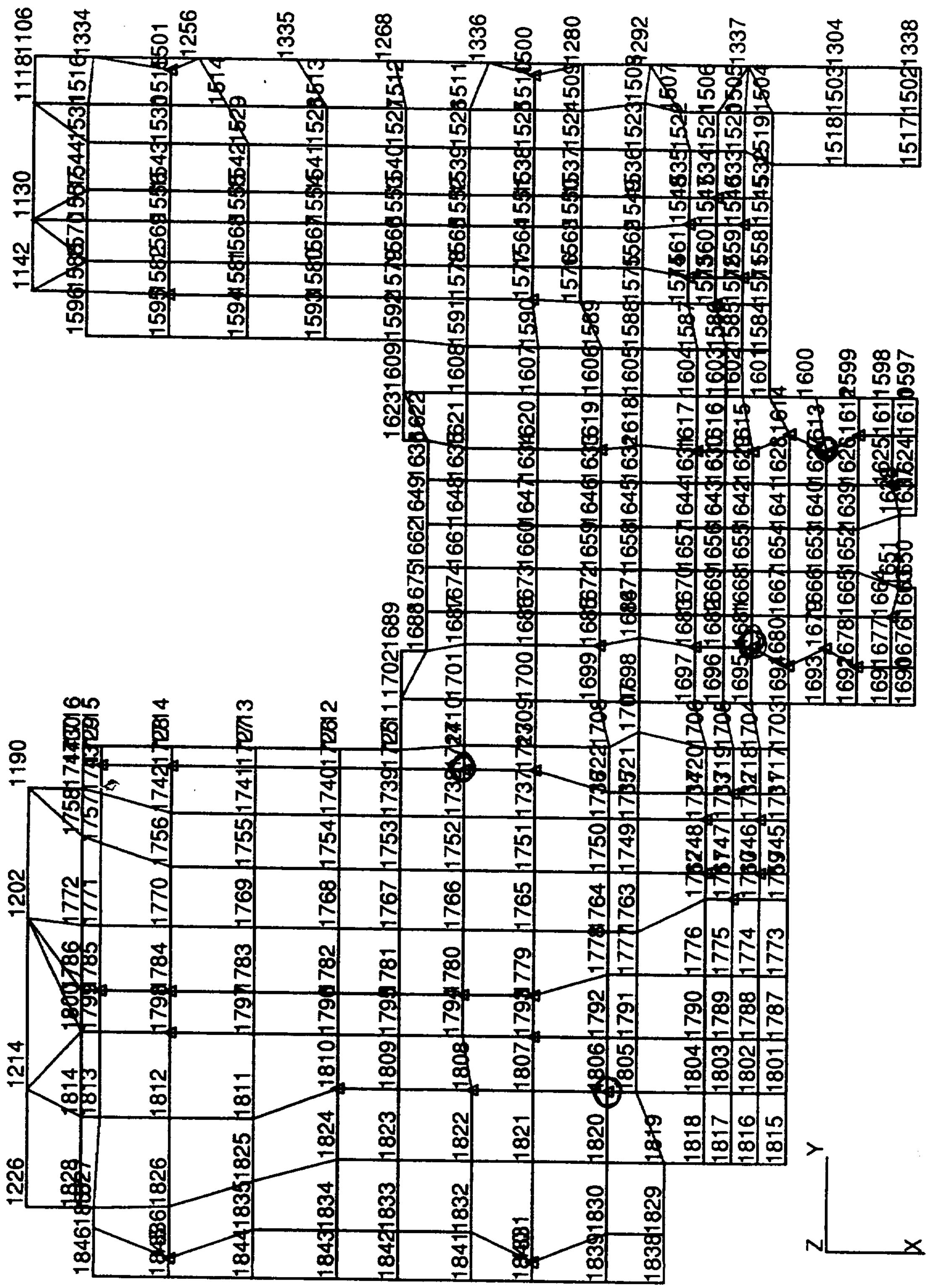
RANDOM VIBRATION RESULTS, Q=7.1

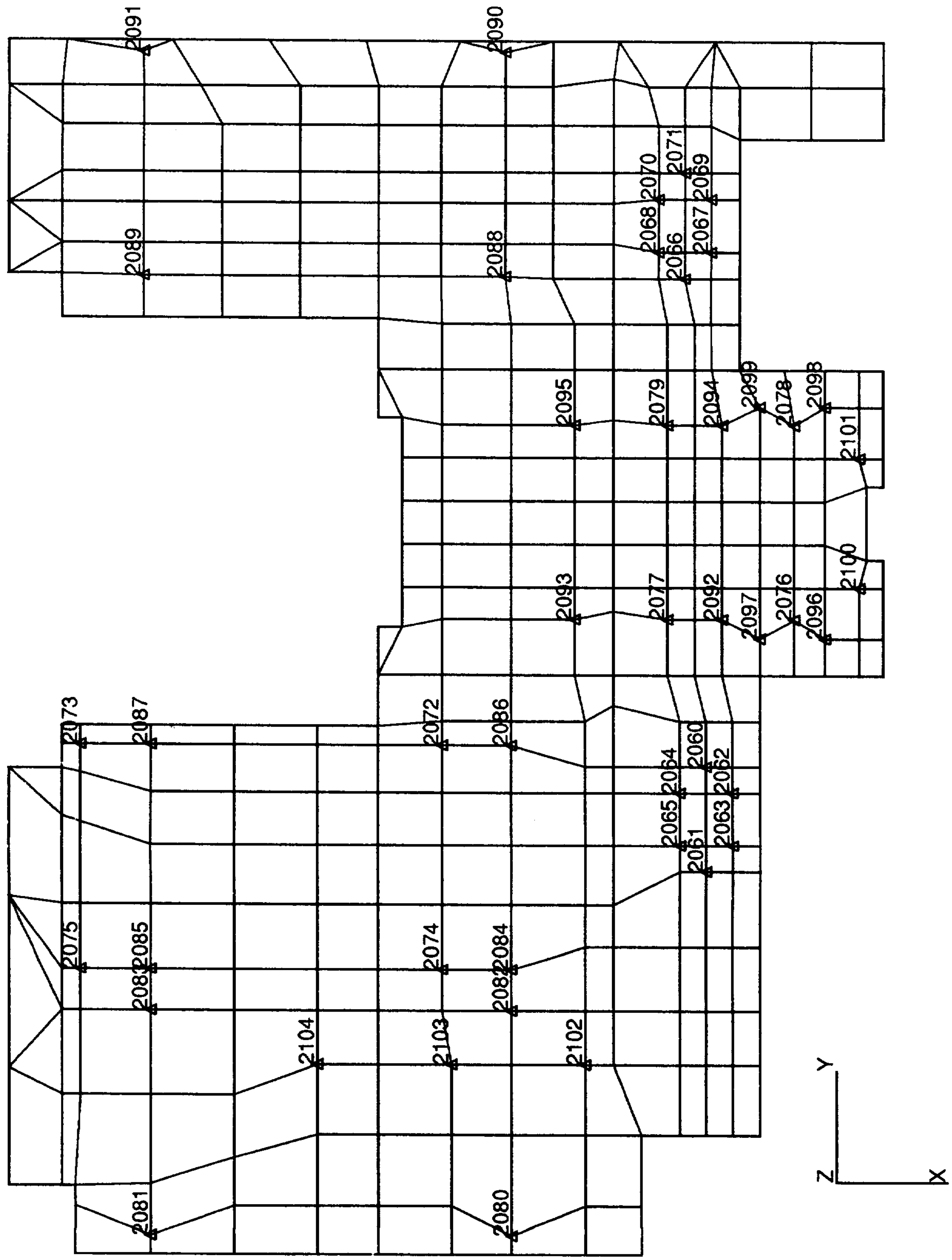
RESPONSE OF LARGE MASSES Q=7.1

COMPONENT	GRID	LOAD DIRECTION	X-RESPONSE RMS	X-RESPONSE GRMS	X-RESPONSE Q	Y-RESPONSE RMS	Y-RESPONSE GRMS	Y-RESPONSE Q	Z-RESPONSE RMS	Z-RESPONSE GRMS	Z-RESPONSE 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	2.958549	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	$\boxed{16.2746}$	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

$$F_{t_1} = 3(16.27)(.403) = 19.7 \text{ LB}$$


Y
Z
X


2091
2090
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2101
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2077
2092
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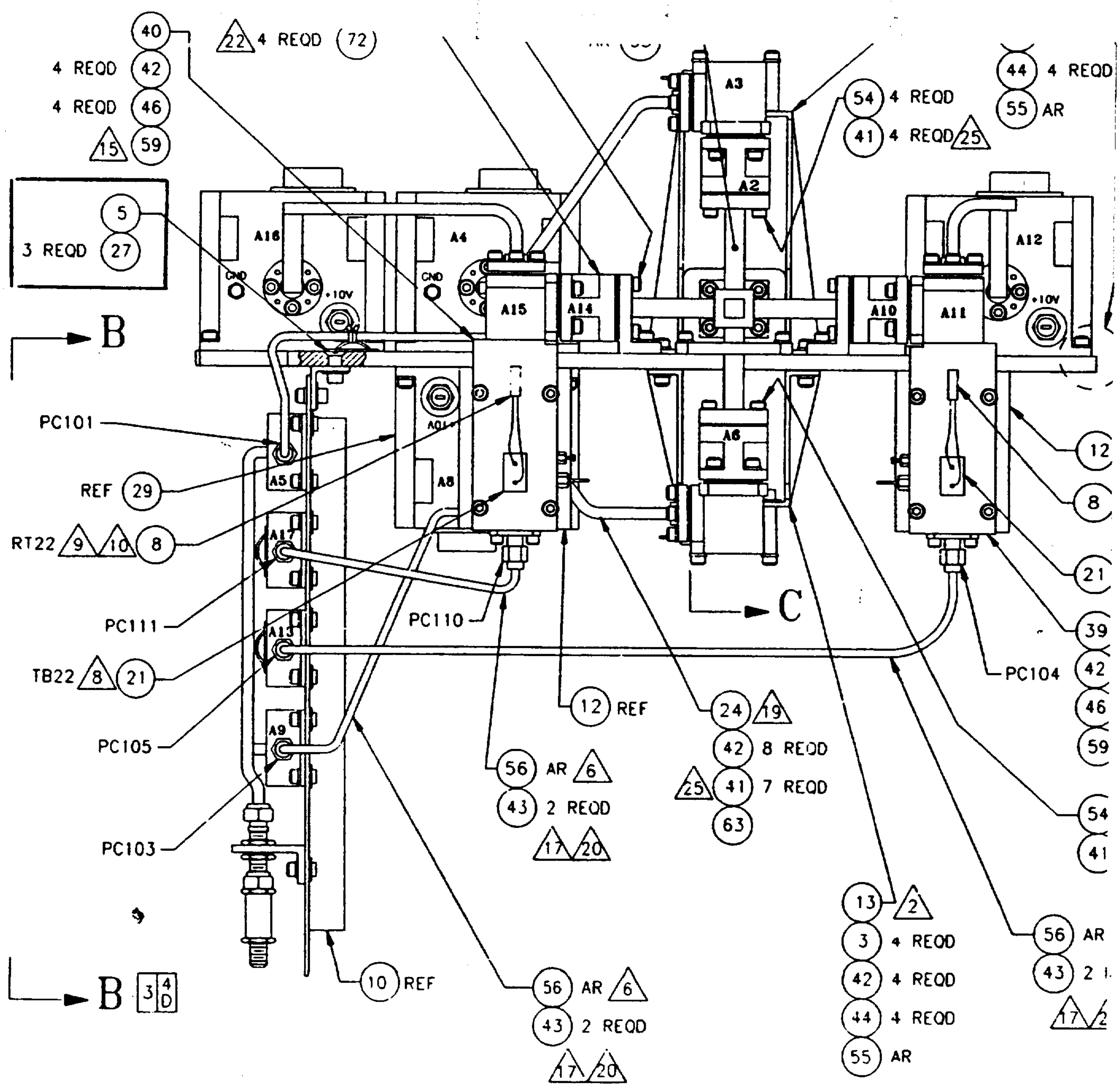
2073
2087
2072
2086
2060
2064
2062
2065
2063
2061
2075
2085
2074
2084
2104
2103
2102
2081
2080
Y
Z
X

PRELOAD TORQUE 1-10-96.

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

$$F_i = \frac{T}{(.2)(d)} = \frac{10}{(.2)(.138)} = 362 \text{ LB}$$

JOINT SKETCH

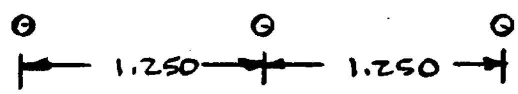


THE JOINT IN QUESTION IS A LINE OF 3 SCREWS. CONNECTING THE ITEM 5 1331165 BRACKET WITH THE ITEM 27 SCREWS TO THE ITEM 15 SHELF.

OVERTURNING MOMENT

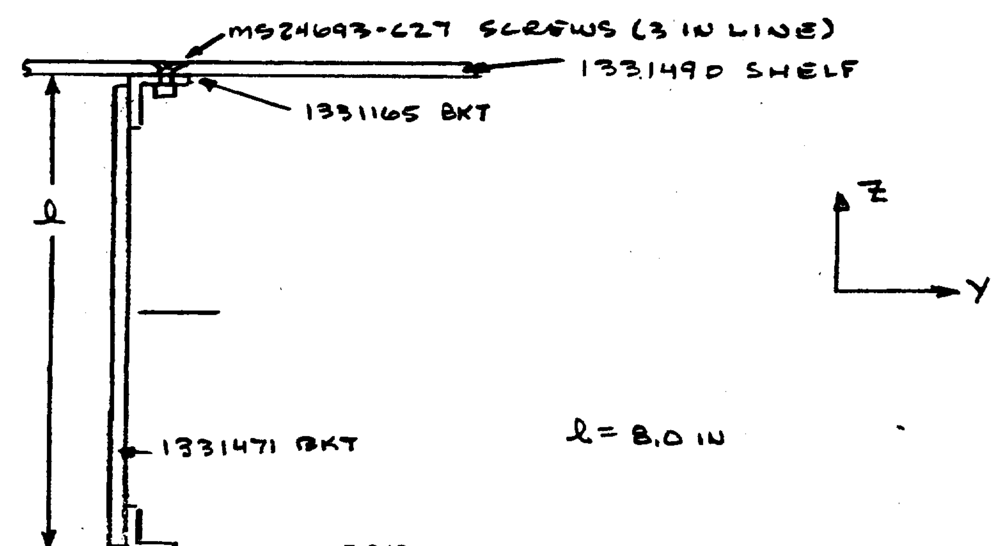
BECAUSE THE PRESENT BOLT PATTERN OF INTEREST IS ARRANGED IN A LINE AND NOT A PLANER PATTERN, THE PROCEDURE USED IN DETERMINING ADDITIONAL TENSILE LOADS IN THE ATTACHMENT SCREWS, AS UTILIZED ABOVE FOR OTHER COMPONENT MOUNTINGS, NEED BE MODIFIED.

THE PATTERN IS 3 SCREWS SPACED 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 MS 24693-C27 SCREWS (ITEM 29) 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 "3σ" LOAD

$$F_y = (3)(.4033)(3)(4.47) = 16.2 \text{ LB}$$

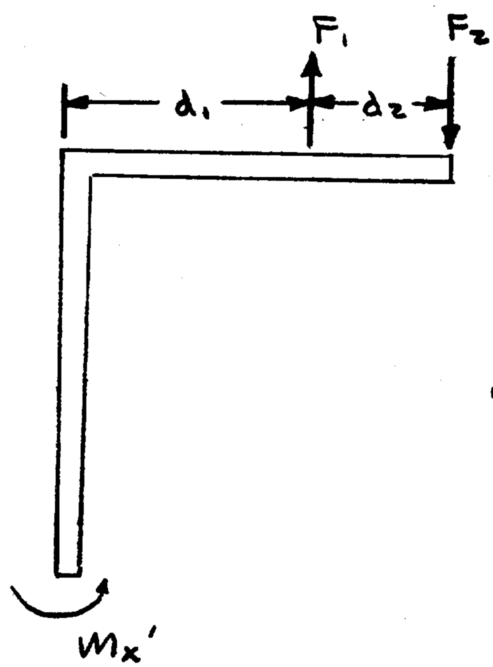
$$M_x = \frac{F_y(\ell)}{8} = (16.2)(1) = 16.2 \text{ IN-LB}$$

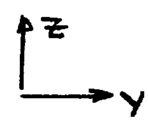
FIXED ENDS W/CENTER LOAD

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





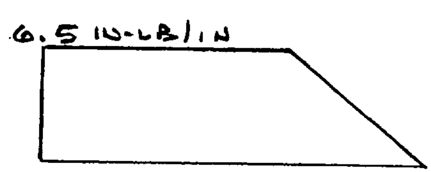
$d_1 = .312$
$d_2 = .188$

$$\Sigma M_z = 0 \qquad F_1(.188) = 6.5$$

$$F_1 = 34.5 \text{ LB/IN}$$

$$F_2 = 34.5 \text{ LB/IN}$$

MOMENT DIAGRAM



BOLT LOAD / BOLT   3 BOLTS SHARE LOAD

$$F_{t_2} = (34.5)(2.500)/3 = 28.7 \text{ LB}$$

TOTAL TENSILE LOAD, F_b, IN SCREW

$$F_b = F_i + FS \frac{k_b}{k_b + k_m} F_t$$

$$F_t = F_{t_1} + F_{t_2} = 19.7 + 28.7 = 48.4 \text{ LB}$$

WITH FS = 1.4 APPLIED TO F_t ONLY, AND $F_i = 362$ LB

USING WORST CASE SCENARIO $k_b >> k_m$

$$F_b = F_i + FS(1) F_t$$

$$= 362 + (1.4)(1.0)(48.4) = 430 \text{ LB}$$

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 $M = 6.5$ IN-LB/IN MOMENT. A BENDING STRESS IS SET UP IN THE 1331165-1 BKT

$$S = \frac{6M}{t^2} \qquad M = 6.5 \text{ IN-LB/IN}$$

$$t = .062 - .010 \text{ MIN}$$

$$= \frac{6(6.5)}{(.052)^2}$$

$$= 14423 \text{ PSI}$$

MAT'RL 6061-T6 ALUM (1331165-1 BKT)

$F_{ty} = 35000$ psi
$F_{tu} = 42000$ 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 NAS1352N04LL4 #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 1σ GRMS LOAD OF 26.728 GRMS AT GR 1613.

THE 1331482 BRACKET MOUNTS ABOVE THE 1331490 SHELF WITH 4 NAS1352N04LL6 #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 1σ GRMS LOAD OF 19.09 GRMS AT GR 1681.

RESPONSE OF LARGE MASSES Q=7.1

COMPONENT	GRID	LOAD DIRECTION	X-RESPONSE RMS	X-RESPONSE GRMS	X-RESPONSE Q	Y-RESPONSE RMS	Y-RESPONSE GRMS	Y-RESPONSE Q	Z-RESPONSE RMS	Z-RESPONSE GRMS	Z-RESPONSE 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	$\boxed{19.0933}$	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	$\boxed{26.728}$	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 1613

$F_{t1} = 3(26.728)(.222) = 17.8\ LB$

PRELOAD

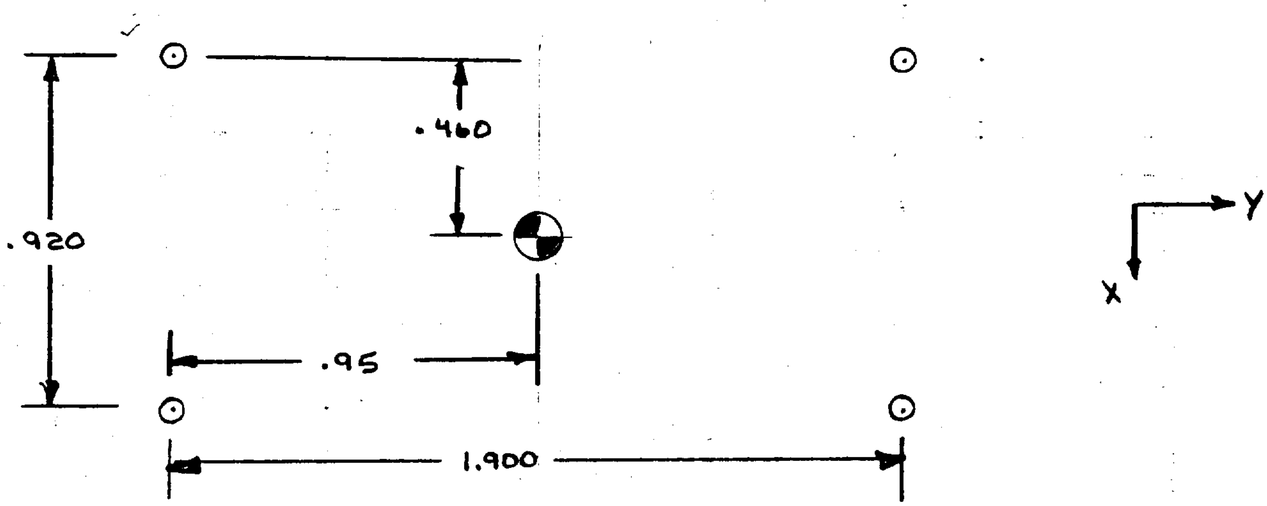
#4 SCREWS NAS1352N04L4, REF 1356409

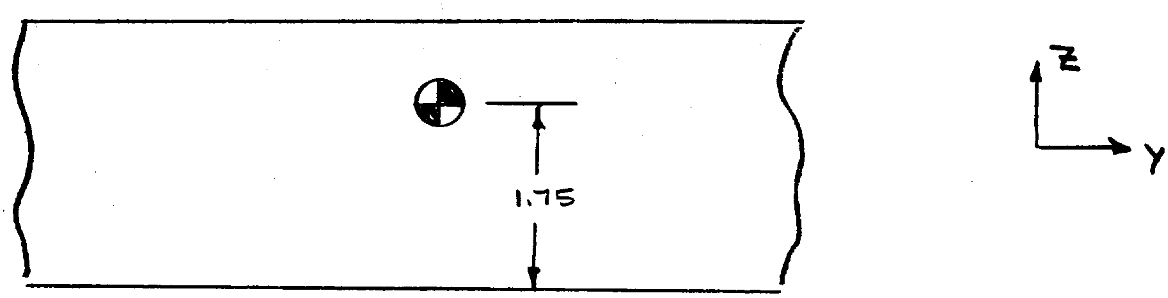
$F_L = \frac{5.5}{(.2)(.112)} = 246\ LB$

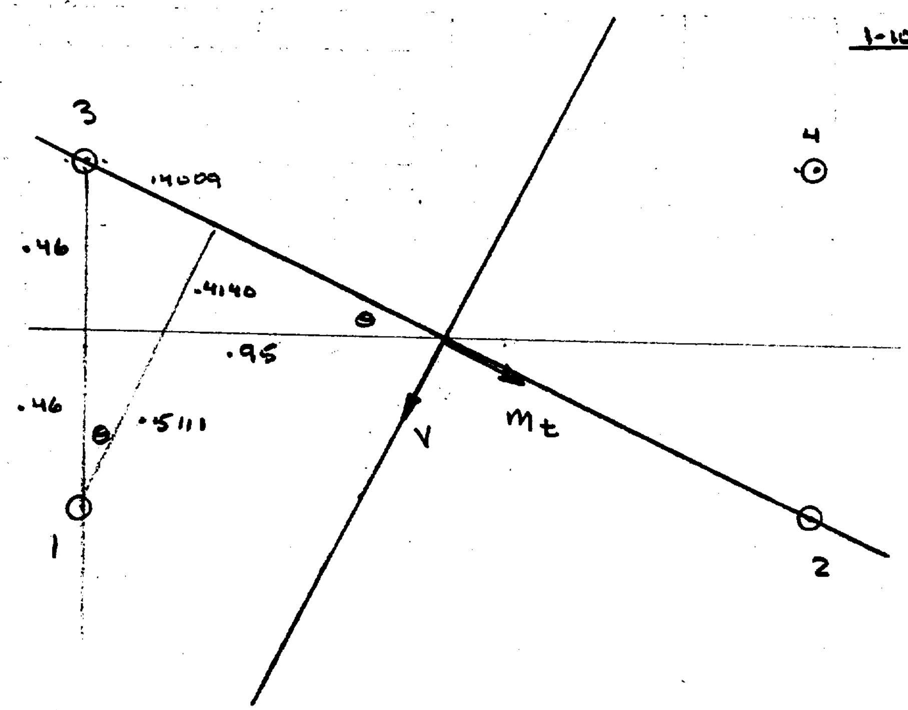
OVERTURNING MOMENT

RANDOM VIBRATION "3σ" LOADS (Q=7.1) LARGEST RESPONSE (26.728 GRMS @ 1σ @ GR 1613) 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.







$$\theta = \tan^{-1} \frac{.460}{.950} = 25.84°$$

$d_1 = .92 \cos\theta = .8280$

$d_2 = d_3 = 0$

$d_4 = d_1$

$$\frac{d_4}{\Sigma d_i^2} = .6038$$

$V = 4(.222)(3)(26.728) = 71.2$ LB

$M_t = (1.75)V = 124.6$ IN-LB

TENSILE FORCE @ SCREW #4

$$F_{t_2} = \frac{M_t d_4}{\Sigma d_i^2} = \frac{(124.6)(.8280)}{(1.3711)} = 75.2 \text{ LB}$$

TOTAL TENSILE FORCE, F_b

$$F_b = F_L + F_S \frac{k_b}{k_b + k_m} F_t$$

$F_t = F_{t_1} + F_{t_2} = 17.8 + 75.2 = 93.0$ LB

$FS = 1.4$

$k_b >> k_m$ ASSUMED

$F_b = 246 + (1.4)(1.0)(93.0) = 376$ LB

FOR NAS1352NØ4 SCREWS

$F_{tu} = 966$ LB

$$MS = \frac{966}{376} - 1 = +1.6$$

∴ MOUNTING SCREWS OK @ 1331481 LOWER BKT.

1331482 UPPER BKT MOUNTING BOLTS

$F_{t_1} = 3(19.09)(.237) = 13.6$ LB

$F_i = 246$ LB 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

$V = 4(.237)(3)(19.09) = 54.3$ LB

$M_t = (3.0)V = 162.9$ IN-LB

$$F_{t_2} = \frac{(162.9)(.8280)}{(1.3711)} = 98.3 \text{ LB}$$

$F_t = F_{t_1} + F_{t_2} = 13.6 + 98.3 = 111.9$ LB

$F_b = 246 + (1.4)(1.0)(111.9) = 403$ LB

$F_{tu} = 966$ LB

$MS = \dfrac{966}{403} - 1 = +1.4$

∴ MOUNTING SCREWS OK @ 1331482 UPPER BKT

1336610 DRO ATTACHMENTS

1-10-96

4 1336610 MOUNT TO THE 1331440 UPPER SHELF, 3 ABOVE THE SHELF AND 1 BELOW. ALL USE 4 NAS1352N04LL6 #4 SCREWS. 4 GRID PTS ARE USED PER DRO TO APPLY PT MASS.

DRO	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 1σ GRMS LOAD OF 22.10 GRMS AT GR 1724.

STATISTICAL 3σ LOAD @ GR1724

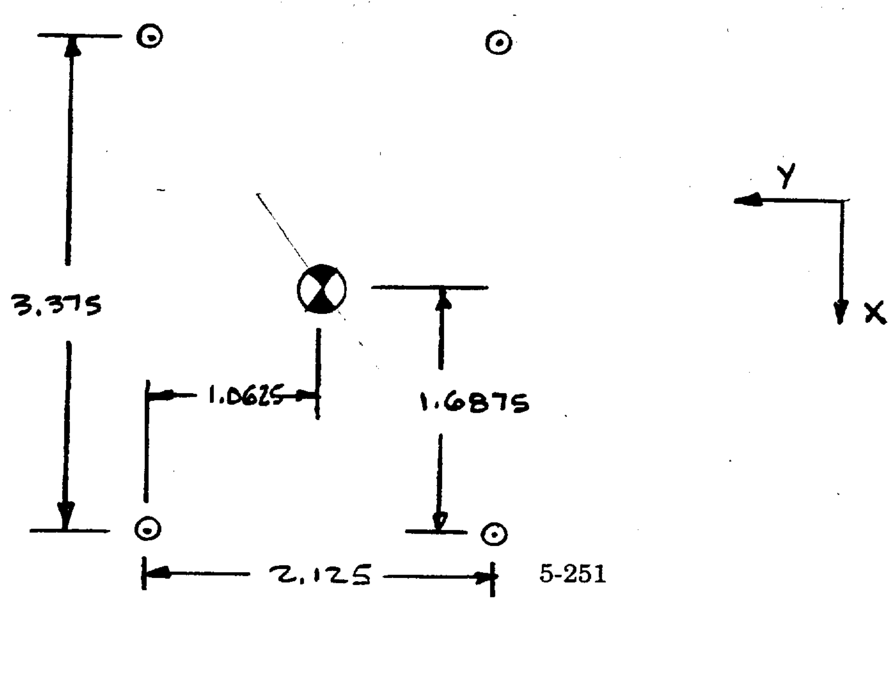
$$F_{t_1} = 3(22.10)(.3966) = 26.3 \text{ LB}$$

PRELOAD

$$F_i = 246 \text{ LB} \qquad \#4 \text{ SCREW}$$

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.



RESPONSE OF LARGE MASSES Q=7.1

COMPONENT	GRID	LOAD DIRECTION	X-RESPONSE RMS	X-RESPONSE GRMS	X-RESPONSE Q	Y-RESPONSE RMS	Y-RESPONSE GRMS	Y-RESPONSE Q	Z-RESPONSE RMS	Z-RESPONSE GRMS	Z-RESPONSE 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	X-RESPONSE RMS	X-RESPONSE GRMS	X-RESPONSE Q	Y-RESPONSE RMS	Y-RESPONSE GRMS	Y-RESPONSE Q	Z-RESPONSE RMS	Z-RESPONSE GRMS	Z-RESPONSE 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	3.559585	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	$\boxed{22.0984}$	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

$$\frac{d_1}{\Sigma d_i^2} = .2780$$

$$V = 4(.3966)(3)(22.10) = 105.2 \text{ LB}$$

$$M_t = (1.5)(V) = 157.8 \text{ IN-LB}$$

TENSILE FORCE @ SCREW

$$F_{t2} = \frac{M_t d_3}{\Sigma d_i^2} = (157.8)(.2780) = 43.9 \text{ LB}$$

$$F_t = F_{t1} + F_{t2} = 26.3 + 43.9 = 70.2 \text{ LB}$$

TOTAL TENSILE LOAD

$$F_b = F_i + FS \frac{k_b}{k_b + k_m} F_t$$

$$= 246 + (1.4)(1.0)(70.2) = 344 \text{ LB}$$

FOR NAS1352N04LL6 SCREW

$$F_{tu} = 966 \text{ LB}$$

$$MS = \frac{966}{344} - 1 = +1.8$$

∴ 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	Fty/Ftu PSI	FS	MARGIN OF SAFETY
STRESSES UNDER	RANDOM Z	EL 289	6061-T6	5755	35000	1.25	3.87
LOWER CARD CAGE				5755	42000	1.4	4.21
STRESS CATEGORY	LOAD CASE	LOCATION	MATERIAL	3s STRESS PSI	Fty/Ftu PSI	FS	MARGIN OF SAFETY
STRESSES UNDER PANEL	RANDOM Y	LOWER FRONT	6061-T6	18594	35000	1.25	0.51
ATTACHMENTS		PANEL		18594	42000	1.4	0.61
	RANDOM Y	LOWER AFT	6061-T6	25654	35000	1.25	0.09
		PANEL		25654	42000	1.4	0.17
	RANDOM Y	LOWER RIGHT	6061-T6	8737	35000	1.25	2.20
		PANEL		8737	42000	1.4	2.43
STRESS CATEGORY	LOAD CASE	LOCATION	MATERIAL	3s STRESS PSI	Fsu PSI	FS	MARGIN OF SAFETY
SHEAR STRESS IN LEFT	RANDOM Y	EL 3256	6061-T6	1023	27000	1.4	17.85
PANEL FLANGE GROOVE							

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 UNIDIRECTION 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/ TRIA3 ELEMENTS
259-271
277-289
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
3σ STRESS 5755 psi

MATERIAL 6061-T6 F_{ty} = 35000 psi
F_{tu} = 42000 psi

1-8-96

FACTORS OF SAFETY

1.25 YIELD
1.4 ULTIMATE

MARGINS OF SAFETY

YIELD

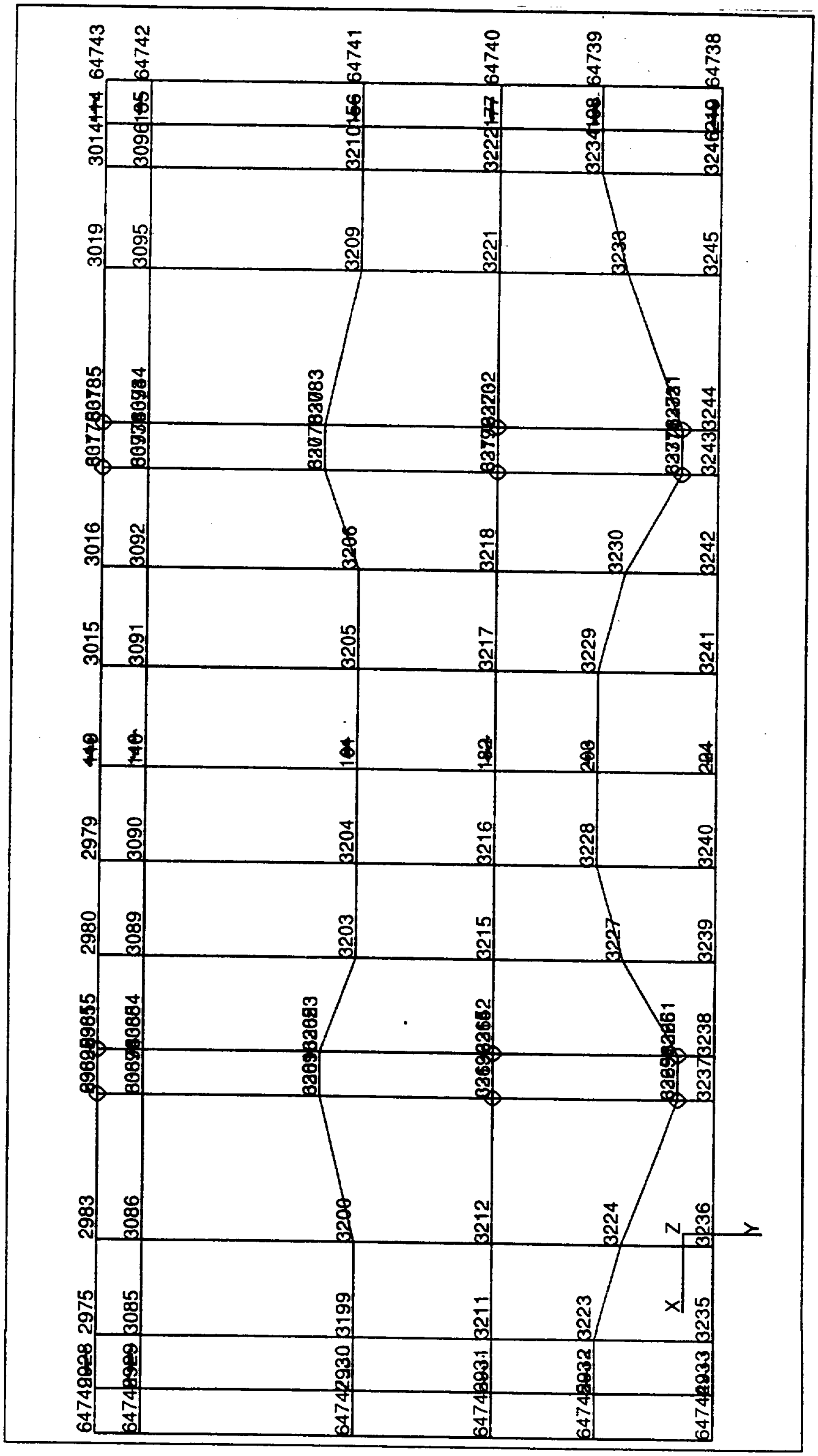
$$MS = \frac{35000}{1.25 \times 5755} - 1 = +3.8$$

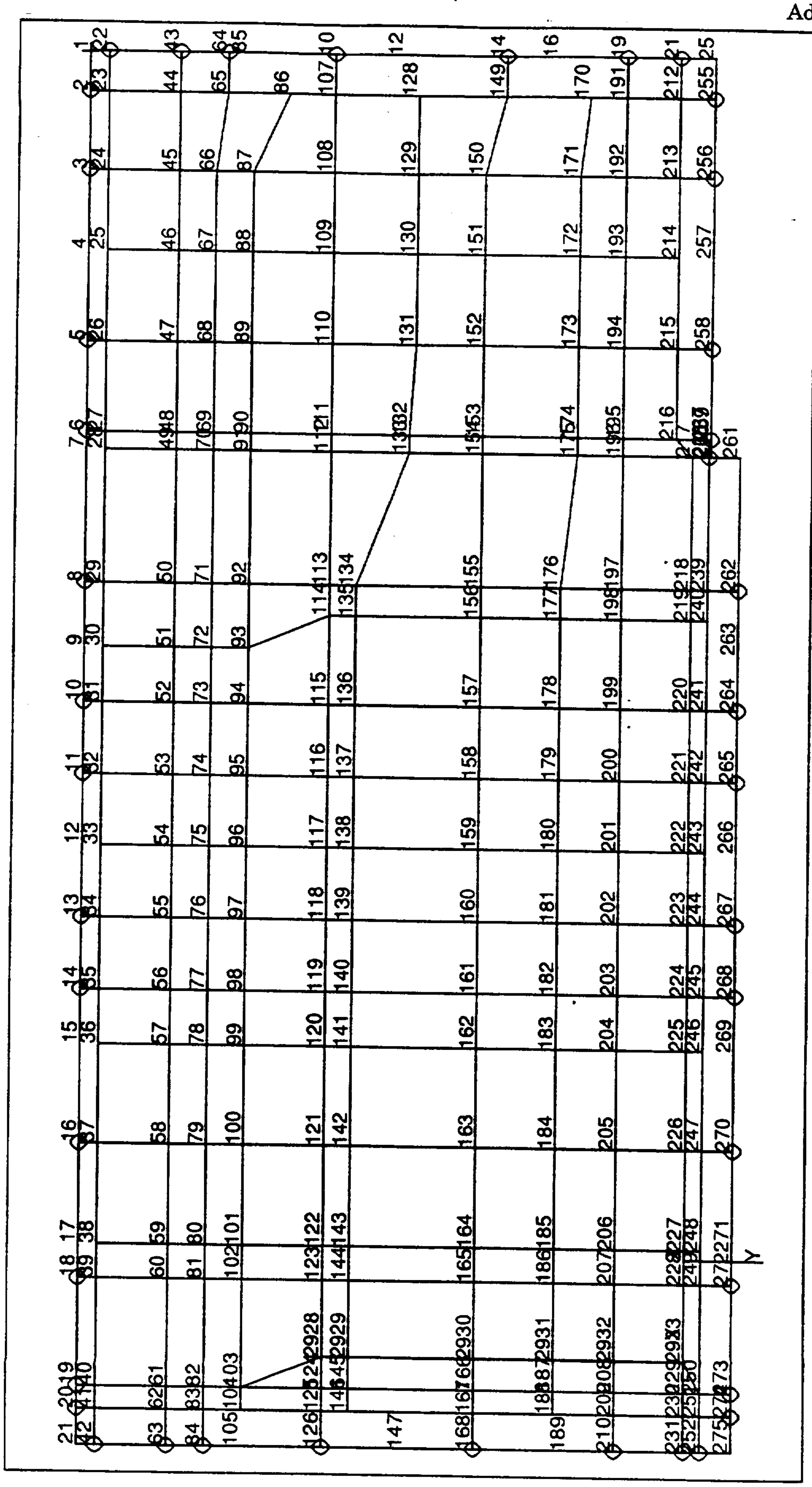
ULTIMATE

$$MS = \frac{42000}{1.4 \times 5755} - 1 = +4.2$$

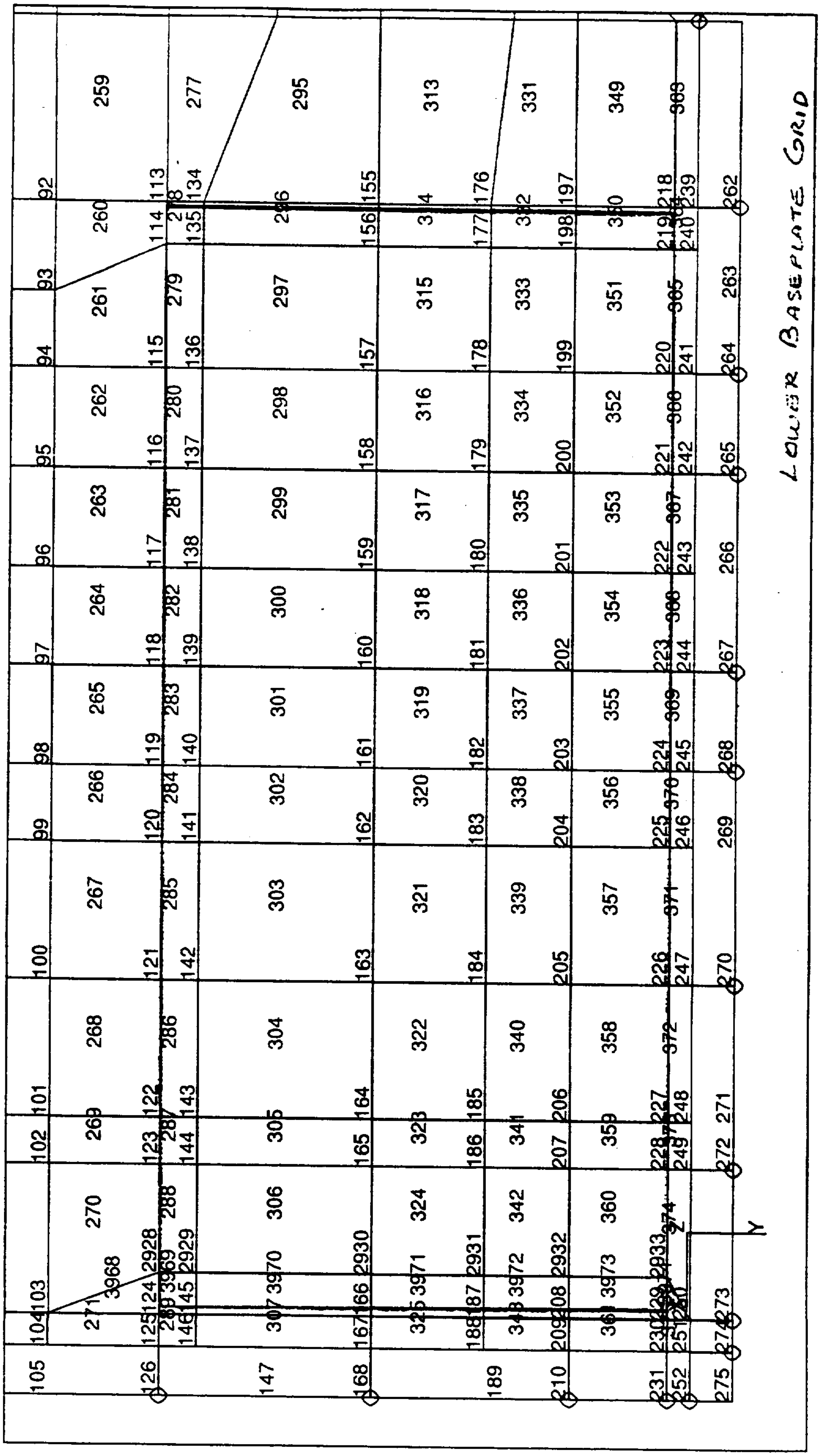
∴ MAGNITUDES OF STRESSES IN THIN SHELLS OF LOWER BASEPLATE UNDER THE CARD CAGE ARE ACCEPTABLE FOR RANDOM VIBRATION "3σ" STRESSES

BOTTOM PLATE OF LOWER CARD CAGE
GRIDS,
GRIDS ON LOWER BP





LOWER BP GRIDS @ LOWER CC



LOWER BASEPLATE GRID

LOWER CARD CAGE FOOTPRINT SILHOUETTE

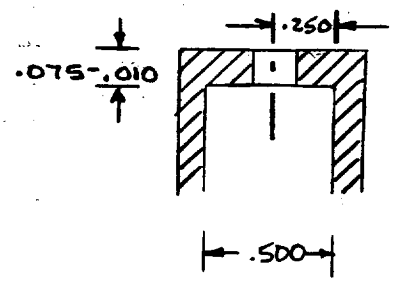
TEMPZ

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
		Page 4	

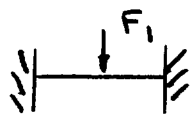
5.4.5.2
LOWER BASEPLATE - LOCALIZED STRESSES UNDER PANEL ATTACHMENTS

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

$F_1 = 69.83$ LB/IN "1σ" LOAD
$= 209.5$ LB/IN "3σ" LOAD

MAXIMUM BENDING MOMENT IS

$$M = \frac{F_1 l}{8}$$ @ ENDS OF BEAM & AT CENTER

$$= \frac{(209.5)(.500)}{8} = 13.09 \text{ IN-LB/IN}$$

BENDING STRESS IN BEAM

$$\sigma = \frac{6M}{t^2} = \frac{6(13.09)}{(.075-.010)} = 18594 \text{ psi}$$

APPLY FS = 1.25 YIELD, 1.4 ULTIMATE

ALLOWABLE, 6061-T6 ALUMINUM

$F_{TY} = 35000$ psi

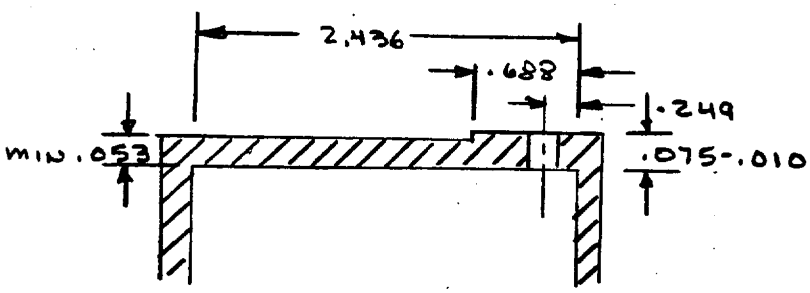
$F_{TU} = 42000$ psi

$$MS = \frac{35000}{1.25(18594)} - 1 = +.51$$

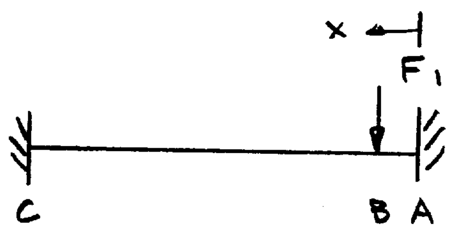
$$MS = \frac{42000}{1.4(18594)} - 1 = +.61$$

∴ 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

$F_1 = 238.8$ LB/IN "1σ" LOAD

$= 716.4$ LB/IN "3σ" LOAD

MAXIMUM BENDING MOMENT IS FOUND FROM

$$R_A = \frac{F_1 b^2}{l^3}(3a+b) = .97079\,F_1 = 695.5 \text{ LB/IN}$$

$$R_B = \frac{F_1 a^2}{l^3}(3b+a) = .02921\,F_1 = 20.9 \text{ LB/IN}$$

$a = .249$
$b = 2.187$
$l = 2.436$

$$M = -\frac{F_1 ab^2}{l^2} + R_A x \qquad A \text{ to } B$$

$$= -\frac{F_1 ab^2}{l^2} + R_A x - F_1(x-a) \qquad B \text{ to } C$$

MAXIMUM M @ END A $(x=0)$

$M = -143.78$ IN-LBS/IN

BENDING STRESS (@ $x=0$)

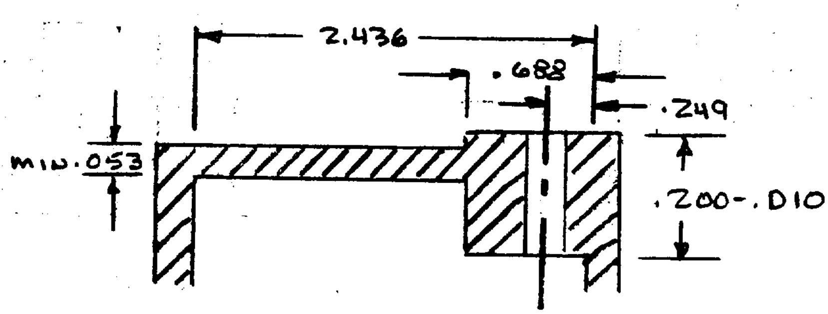
$$\sigma = \frac{6M}{t^2} = \frac{6(143.78)}{(.075-.010)^2} = 204184 \text{ PSI}$$

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 MAJOR STRESS	MAX VON MISES STRESS
3	28781 psi	25400 psi

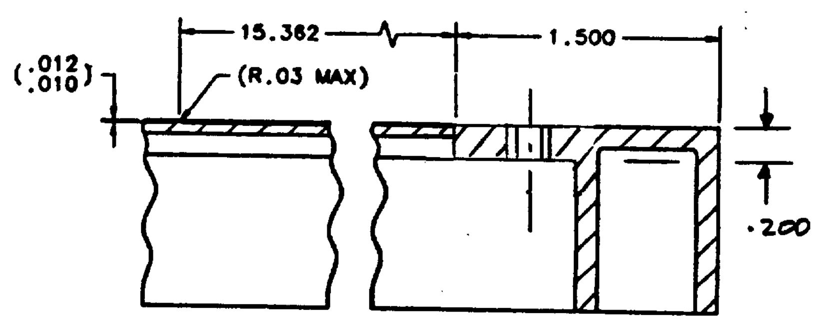
ADJUST MAX VON MISES STRESS BY 1% AND APPLY FACTORS OF SAFETY

$$\sigma = (1.01)(25400) = 25654 \text{ psi}$$

$$MS = \frac{35000}{1.25 \times 25654} - 1 = +.09$$

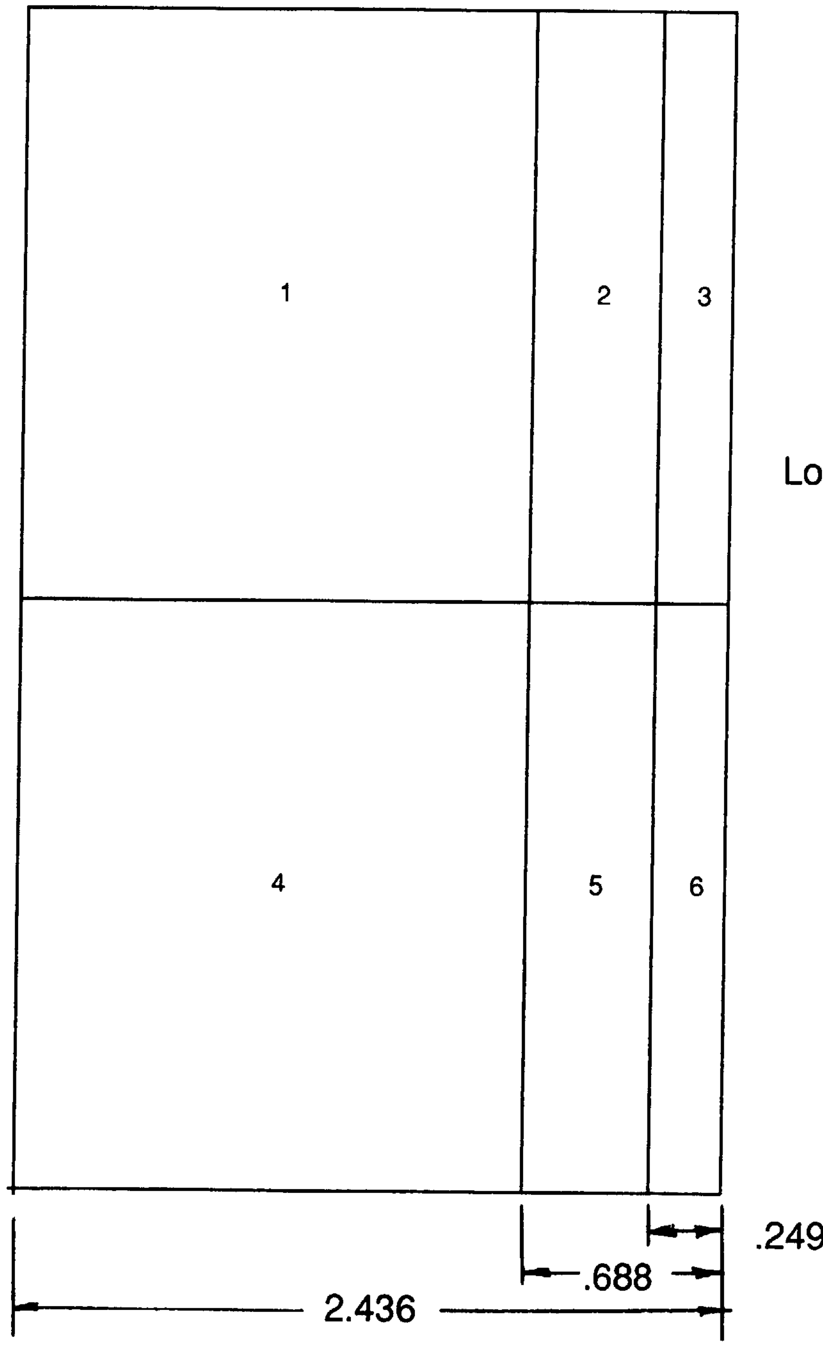
$$MS = \frac{42000}{1.4 \times 25654} - 1 = +.17$$

∴ INCREASING t TO .200-.010 BELOW LOWER AFT PANEL SOLVES STRESS PROBLEM.



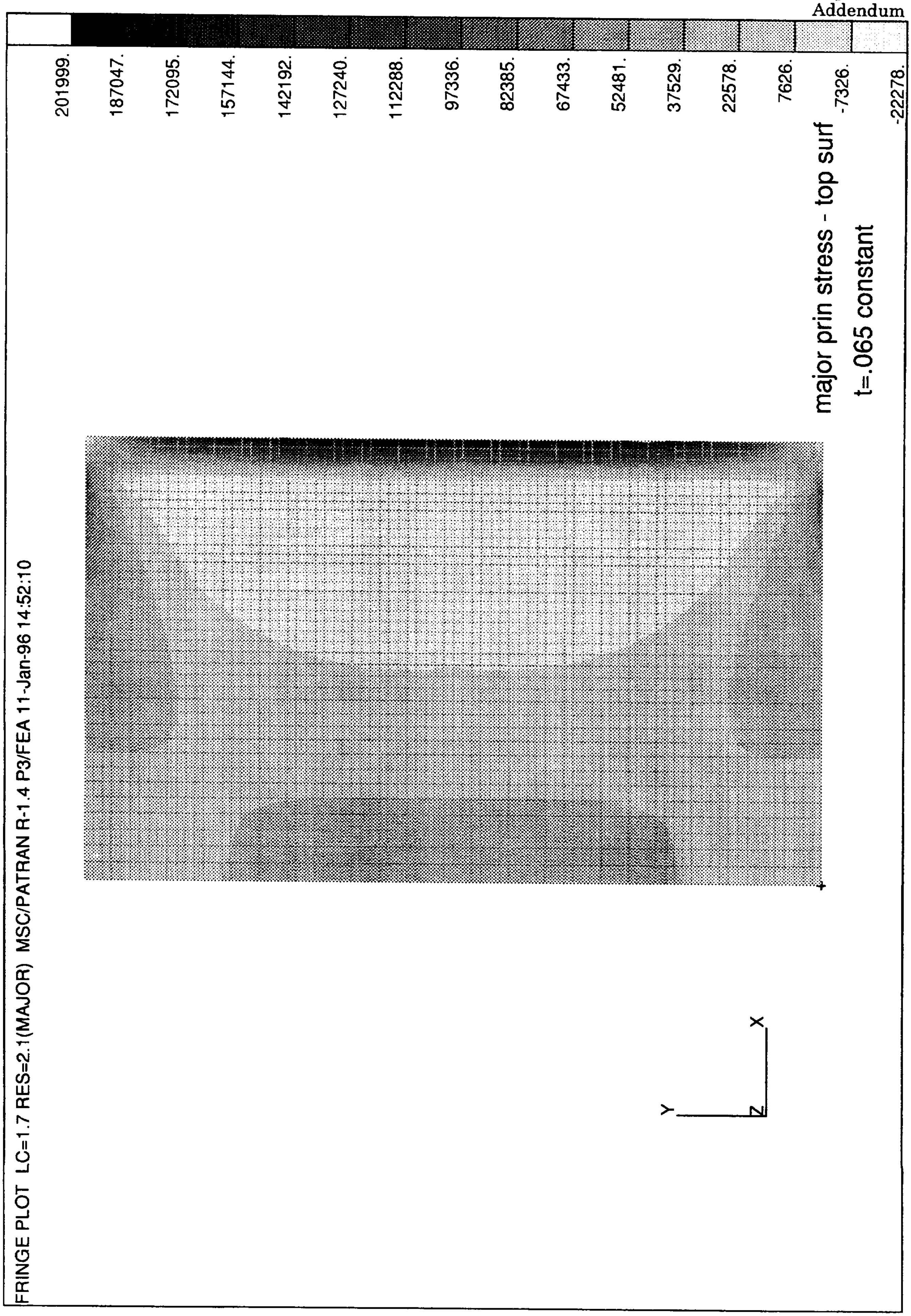
SECTION B-B 1|2/G
SCALE : 2/1

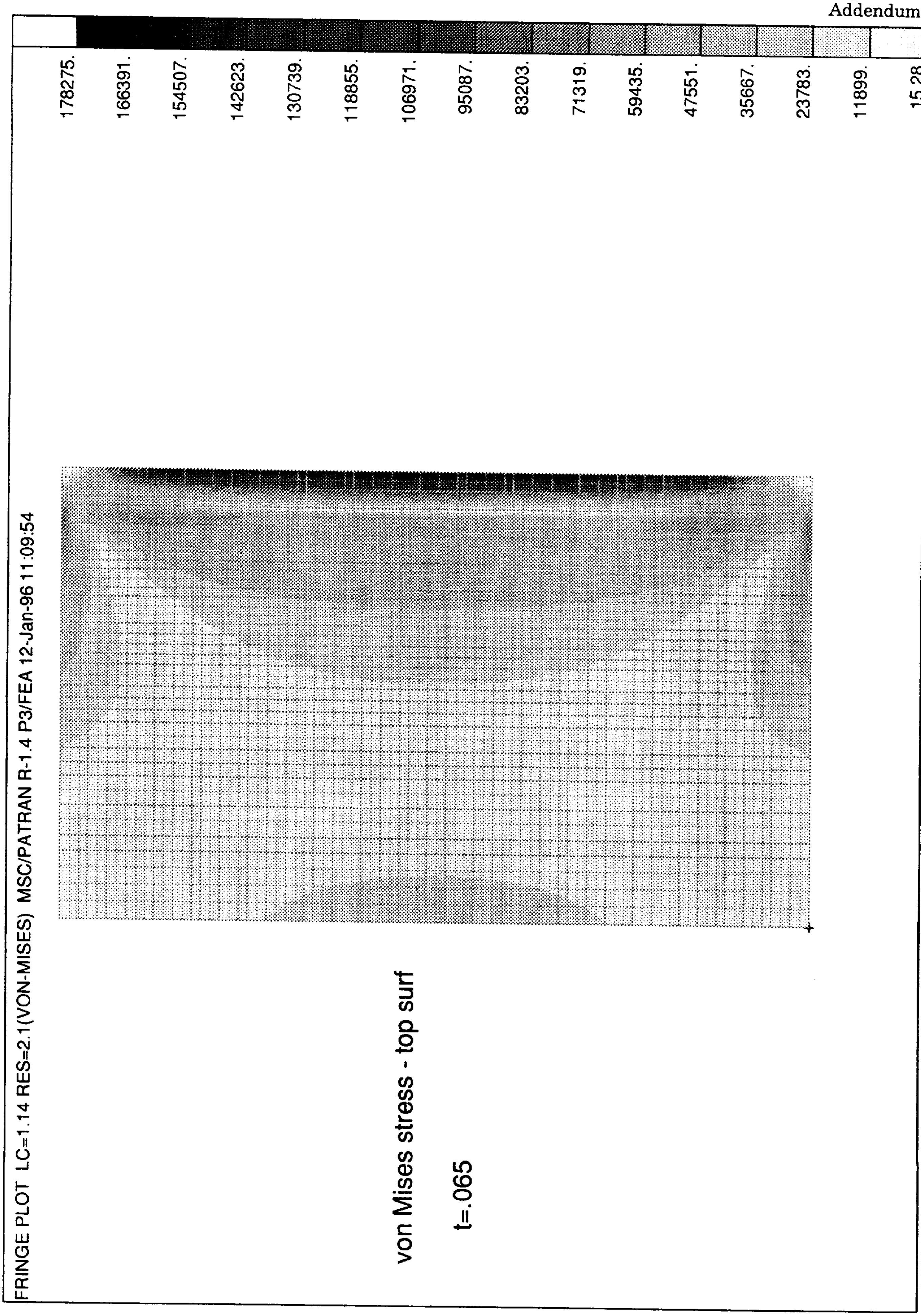
REVISED LOWER BASEPLATE

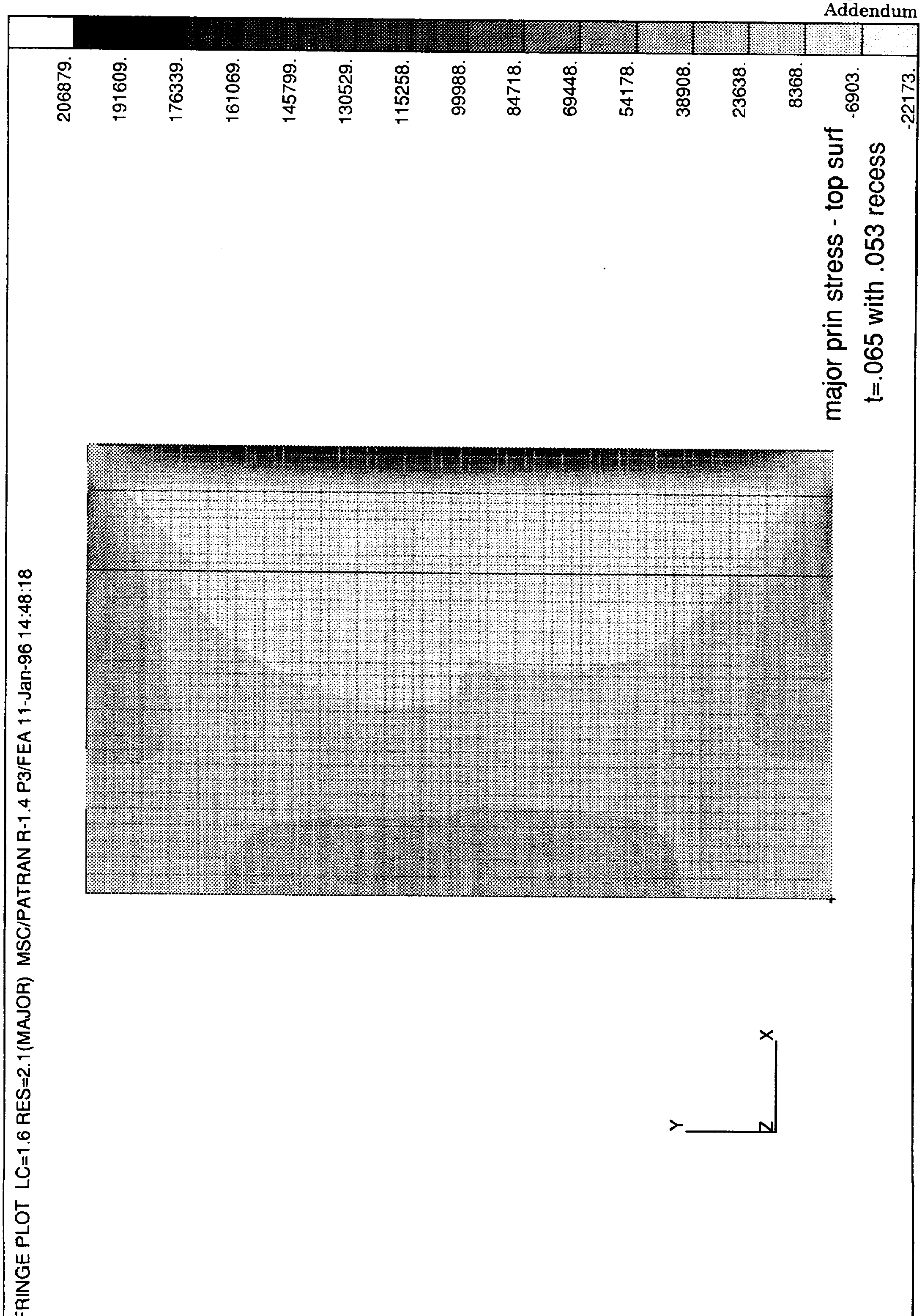


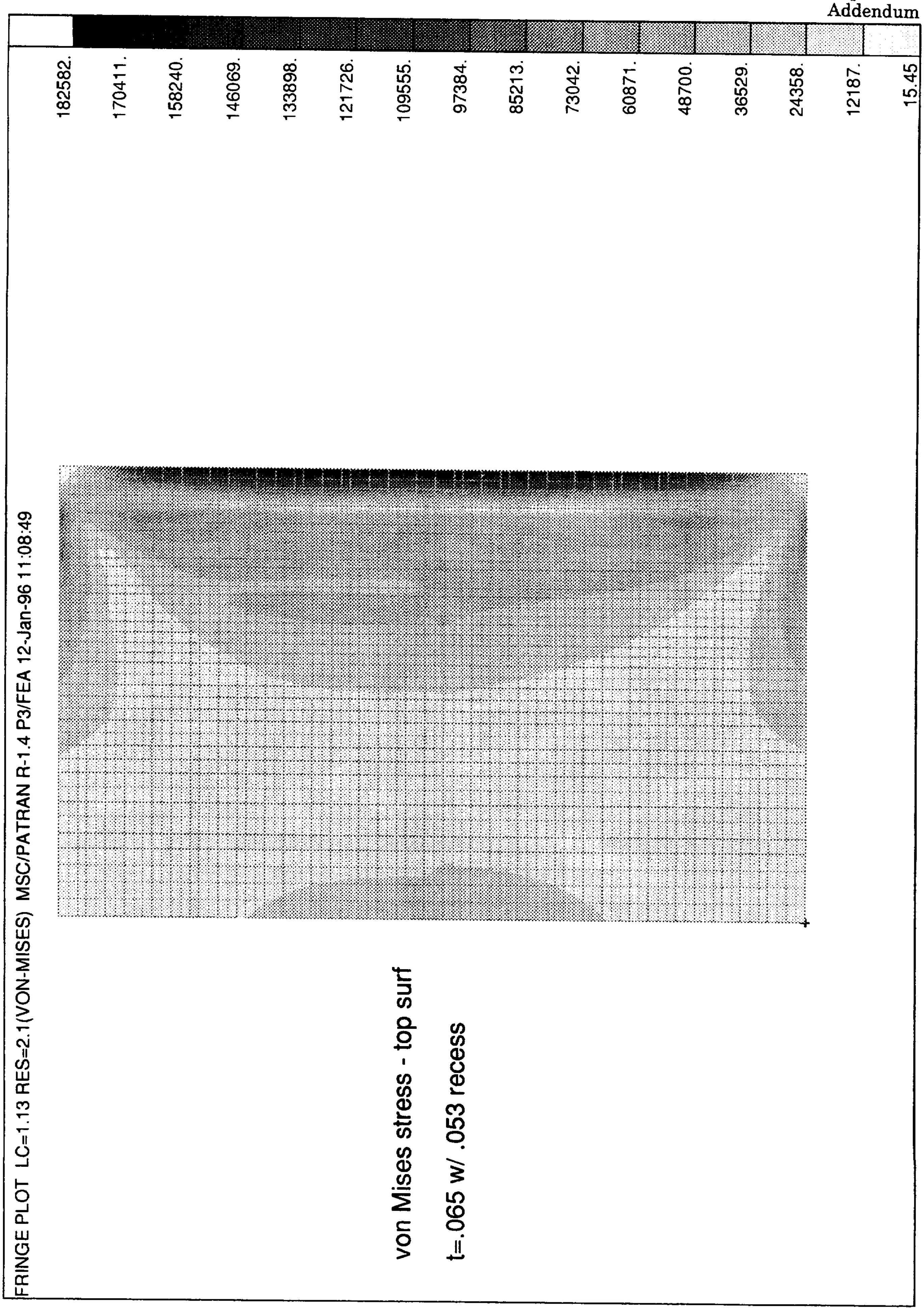
Lower Baseplate @ Lower Aft Panel

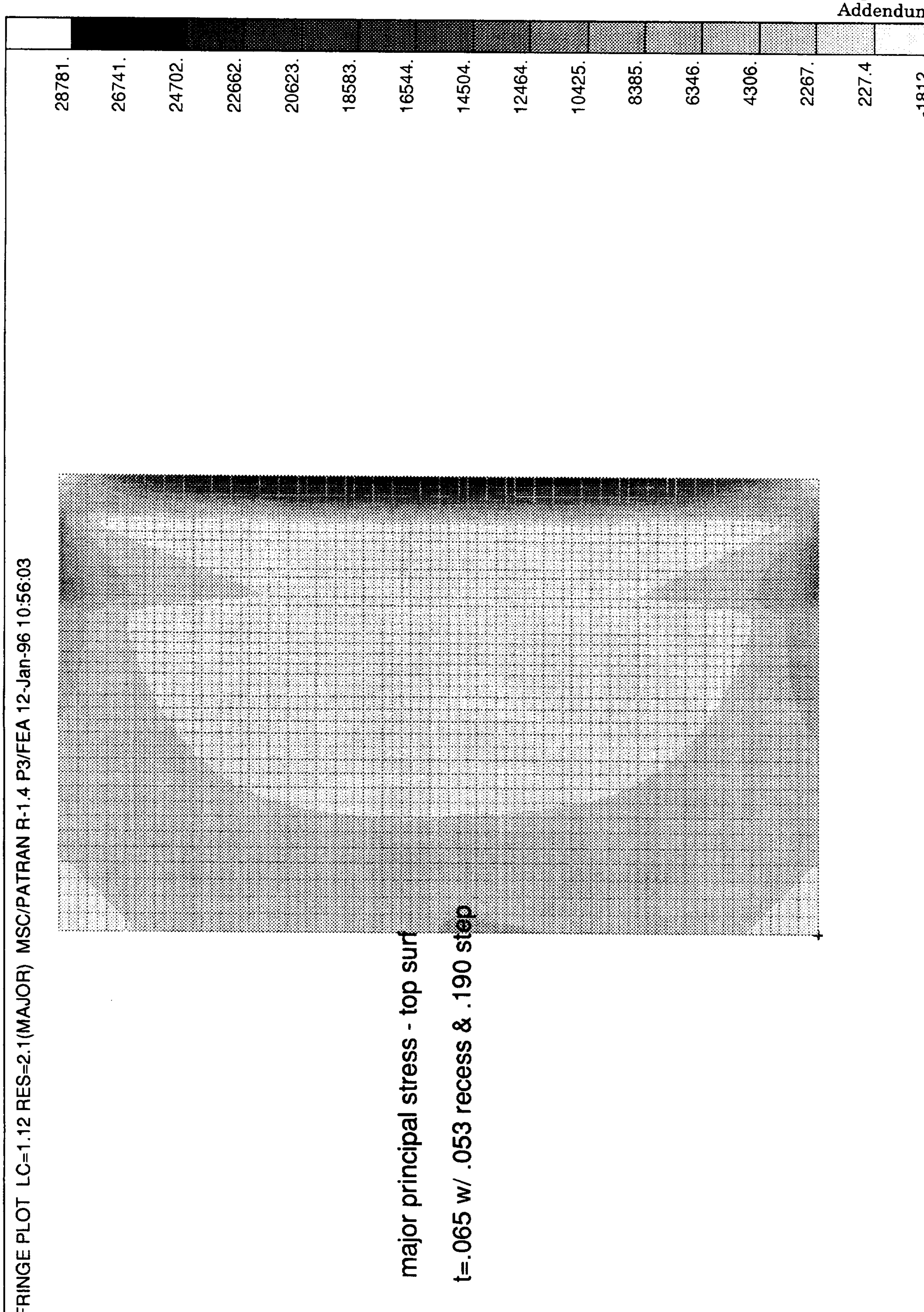
Thickness	Surface
.053	1
.065	4
.190	2, 3, 5, 6

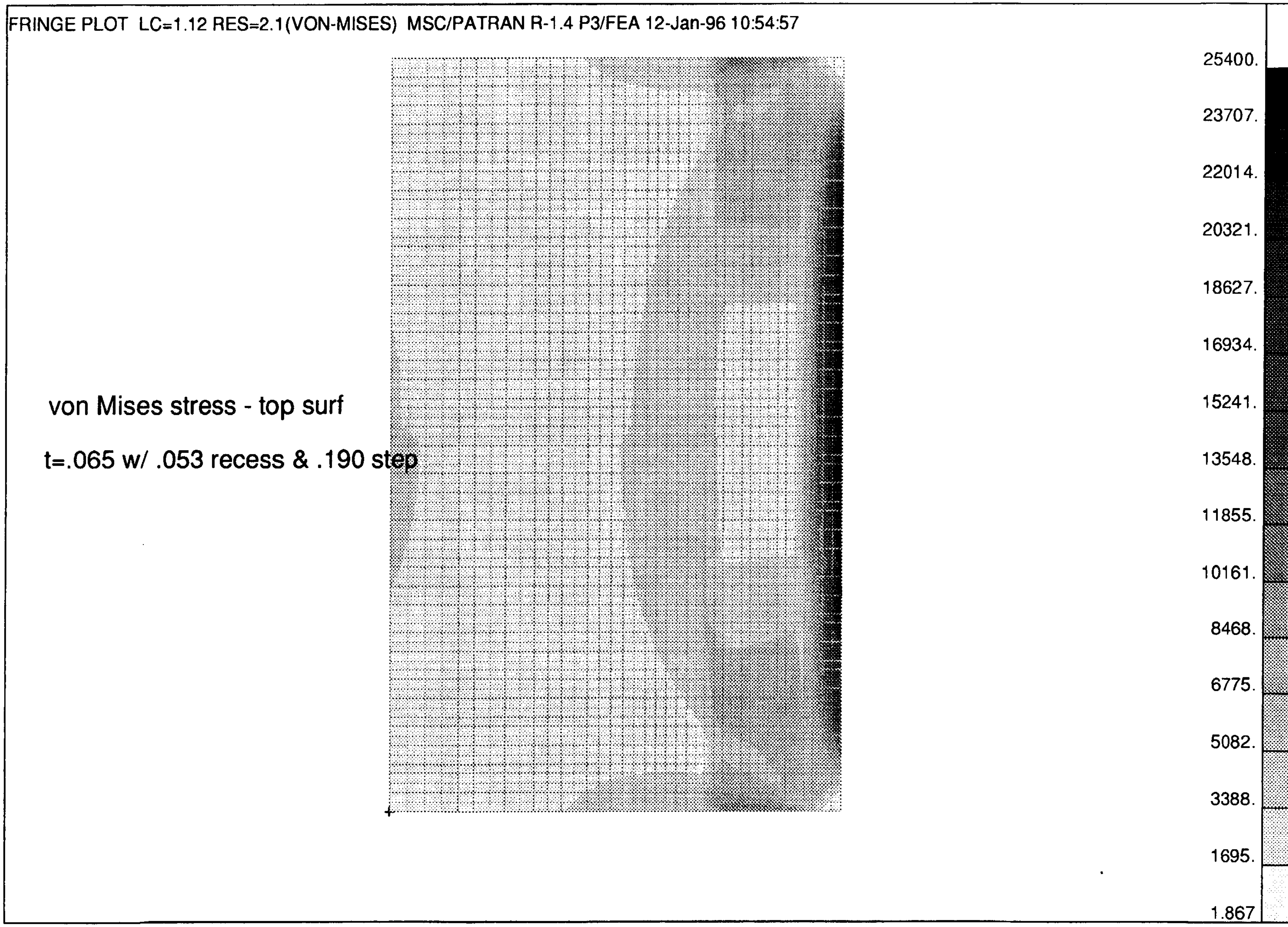

FRINGE PLOT LC=1.7 RES=2.1(MAJOR) MSC/PATRAN R-1.4 P3/FEA 11-Jan-96 14:52:10
201999.
187047.
172095.
157144.
142192.
127240.
112288.
97336.
82385.
67433.
52481.
37529.
22578.
7626.
-7326.
-22278.
major prin stress - top surf
t=.065 constant
Y
Z
X


FRINGE PLOT LC=1.14 RES=2.1(VON-MISES) MSC/PATRAN R-1.4 P3/FEA 12-Jan-96 11:09:54
178275.
166391.
154507.
142623.
130739.
118855.
106971.
95087.
83203.
71319.
59435.
47551.
35667.
23783.
11899.
15.28
von Mises stress - top surf
t=.065


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
X
Y
Z

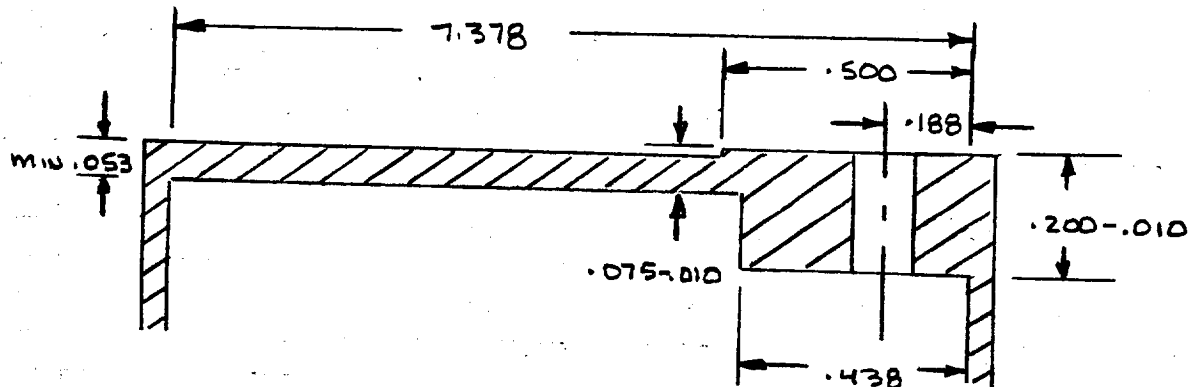

FRINGE PLOT LC=1.13 RES=2.1(VON-MISES) MSC/PATRAN R-1.4 P3/FEA 12-Jan-96 11:08:49
182582.
170411.
158240.
146069.
133898.
121726.
109555.
97384.
85213.
73042.
60871.
48700.
36529.
24358.
12187.
15.45
von Mises stress - top surf
t=.065 w/ .053 recess


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(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

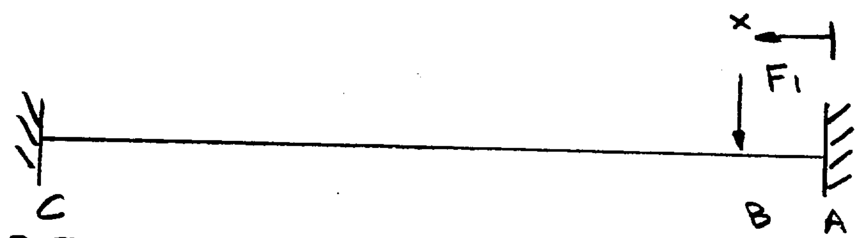

FRINGE PLOT LC=1.12 RES=2.1(VON-MISES) MSC/PATRAN R-1.4 P3/FEA 12-Jan-96 10:54:57
von Mises stress - top surf
t=.065 w/ .053 recess & .190 step
25400.
23707.
22014.
20321.
18627.
16934.
15241.
13548.
11855.
10161.
8468.
6775.
5082.
3388.
1695.
1.867

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 LB/IN "1σ" LOAD
= 317.6 LB/IN "3σ" LOAD

MAXIMUM M

$$R_A = \frac{F_1 b^2}{\ell^3}(3a+b) = .948\,F_1 = 317.0 \text{ LB/IN}$$

R_B = .6 LB/IN

$a = .188$
$b = 7.190$
$\ell = 7.378$

$$M = \frac{-F_1 a b^2}{\ell^2} + R_A X \qquad \text{A to B}$$

$$= \frac{-F_1 a b^2}{\ell^2} + R_A X - F_1 (X-a) \qquad \text{B to C}$$

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 ALL ENDS 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

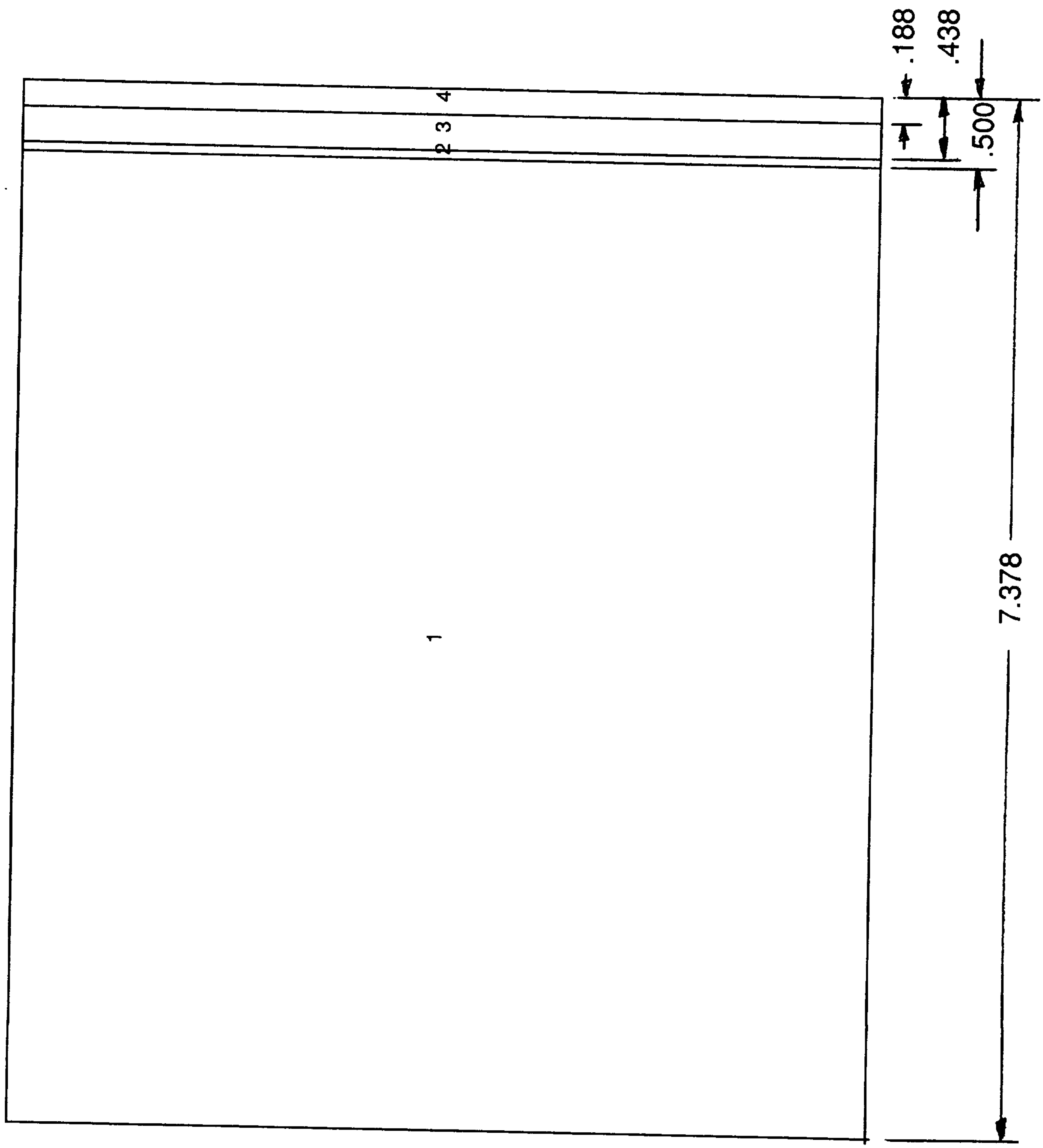
$$MS = \frac{35000}{1.25 \times 8737} - 1 = +2.2$$

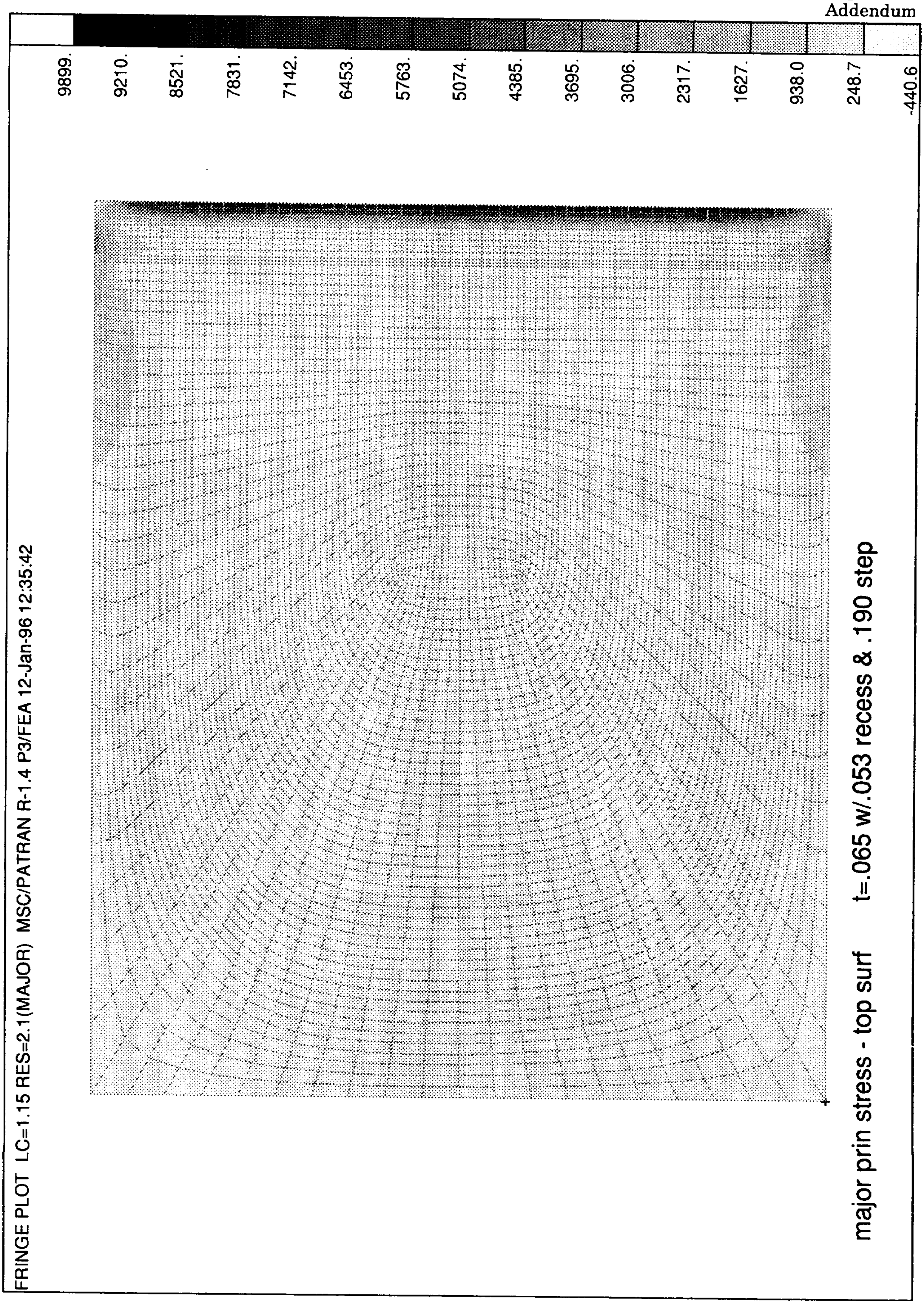
$$MS = \frac{42000}{1.4 \times 8737} - 1 = +2.4$$

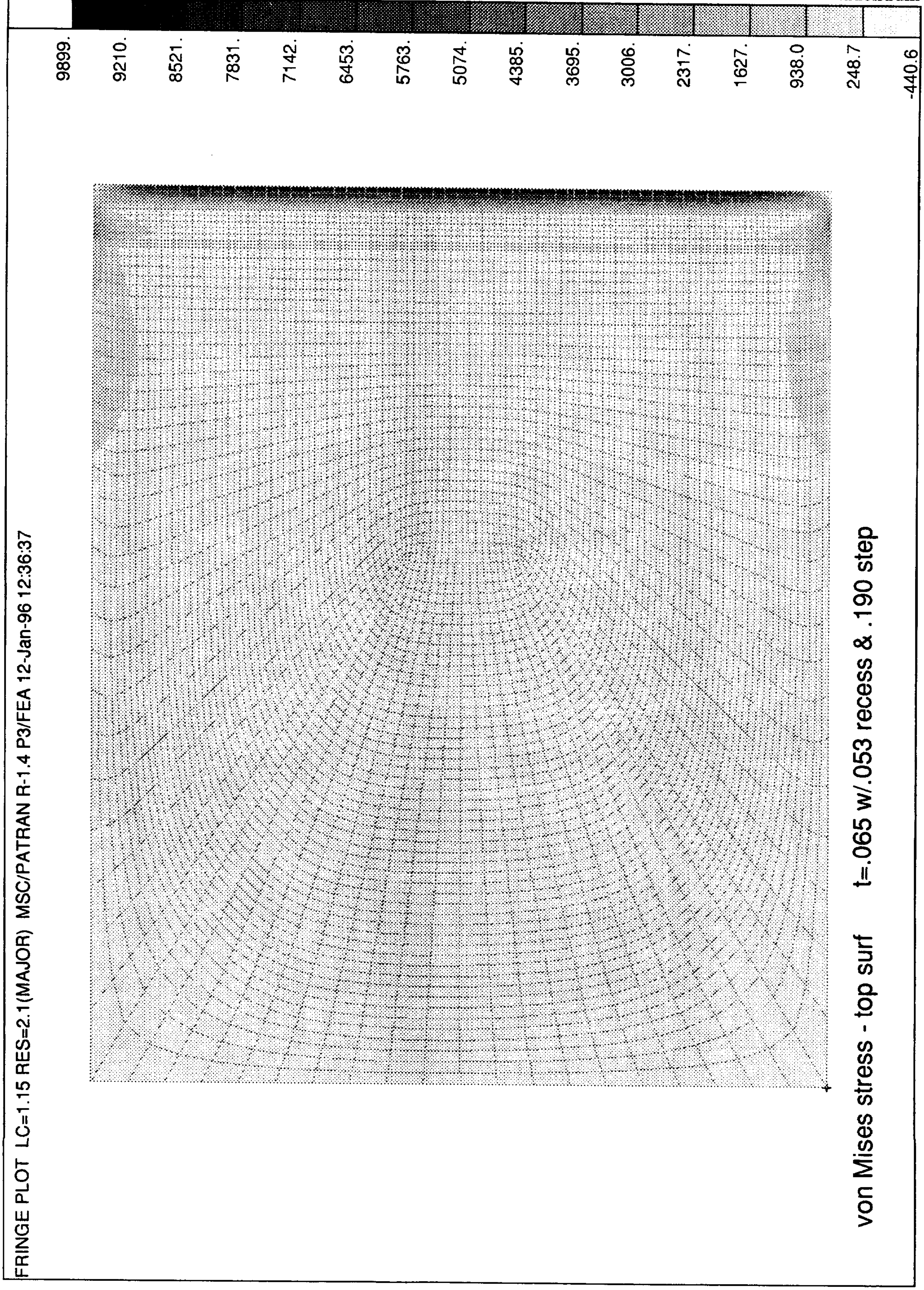
$\therefore$ LOWER BASEPLATE CROSS SECTION OK UNDER LOWER RIGHT PANEL.

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

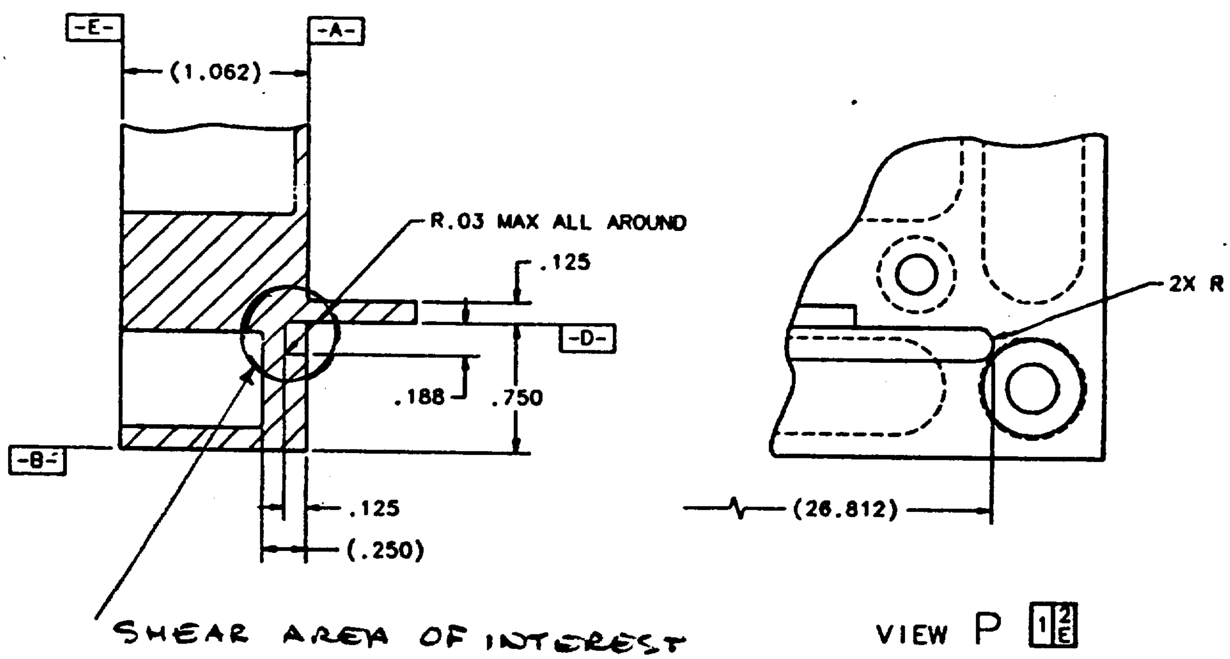
5.4.5.3

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

$$F = 127.9 \text{ LB/IN} \qquad \text{"}3\sigma\text{" LOAD}$$

THE GROOVED SECTION AT THE LEFT PANEL FLANGE ON THE LOWER BASEPLATE (1356405 VIEW P) IS SHOWN IN THE SKETCH BELOW



VIEW P 1/2 E
SCALE : 2/1

RANDOM VIBRATION DATA FOR THE "3σ" CONDITION IS USED IN THE EVALUATION ALONG WITH A FACTOR OF SAFETY, FS OF 1.4.

RANDOM VIBRATION RESULTS - LEFT PANEL

1σ LOADS, Q=7.1

RANDOM X

EL	3243	3256	
Fx	5.90	16.50	LB/IN
Fy	23.56	33.73	"
Fxy	8.61	6.25	"

RANDOM Y

EL	3243	3253	3254	3255	3256	
Fx	5.39	8.24	11.17	11.80	21.28	LB/IN
Fy	22.25	25.39	24.63	23.36	44.51	"
Fxy	4.54	4.23	6.21	7.35	5.39	"

RANDOM Z

EL	3243	3256	
Fx	4.58	10.54	LB/IN
Fy	16.00	18.55	"
Fz	3.51	3.92	"

CRITICAL LOAD CASE IS RANDOM Y, CRITICAL ELEMENT IS EL 3256, WHICH IS A SLIGHTY SKEWED ELEMENT, AT $\theta = -7.80°$. ROTATING $-7.80°$ GIVES A FORCE Fy' OF

$$F_y' = 42.63 \text{ LB/IN} \qquad 1\sigma \text{ LOAD}$$

$$= 127.9 \text{ LB/IN} \qquad 3\sigma \text{ LOAD}$$

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 "3σ" LOAD

$$\tau = \left(\frac{127.9}{.125}\right) \frac{\text{LB/IN}}{\text{IN}} = 1023 \text{ PSL}$$

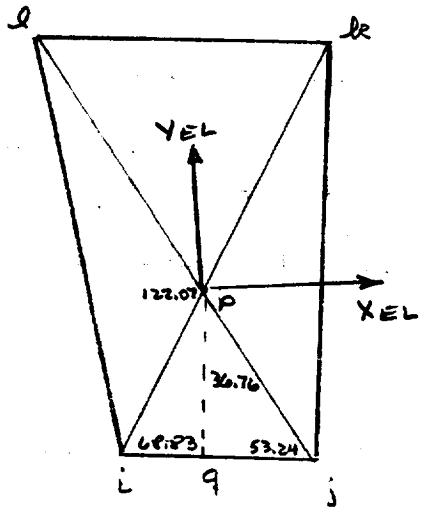
MATERIAL , 6061-T6 ALUMINUM,

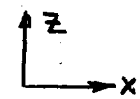
$F_{su} = 27000$ psi

$$MS = \frac{27000}{1.4(1023)} - 1 = +17$$

$\therefore$ SHEAR STRESS IN GROOVED SECTION AT LEFT PANEL FLANGE IS OK

EL 3256





	GRID	X	Z
i	40	25.532	0
j	41	25.970	0
k	300	25.970	1.131
l	2352	25.125	1.131

$\measuredangle kij = \tan^{-1} \dfrac{1.131}{.438} = 68.83°$

$\measuredangle lji = \tan^{-1} \dfrac{1.131}{.845} = 53.24°$

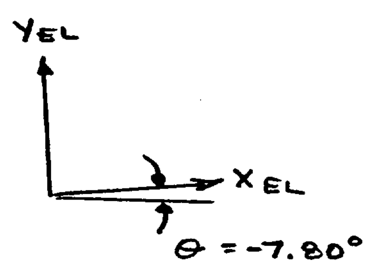
$\measuredangle ijk = \tan^{-1} \dfrac{1.131}{0} = 90°$

$\measuredangle ikj = 180 - 90 - 68.83 = 21.17°$

$\measuredangle ljk = 90 - 53.24 = 36.76°$

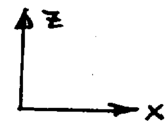
$\measuredangle kpj = 180 - 21.17 - 36.76 = 122.07°$

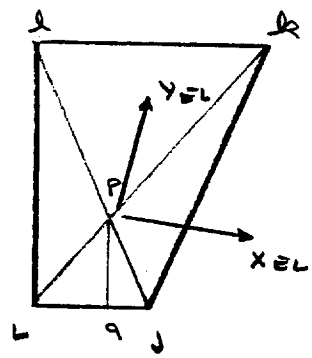
$\measuredangle qPj = 90 - 53.24 = 36.76°$



$$F_y' = \frac{F_x + F_y}{2} + \frac{F_x - F_y}{2} \cos(2(-7.80)) + F_{xy} \sin(2(-7.80))$$

EL3243





	GRID	X	Z
i	27	7.282	0
j	28	7.608	0
k	2369	8.100	1.131
l	990	7.282	1.131

$\measuredangle\, k\,i\,j \quad \tan^{-1} \dfrac{1.131}{.818} = 54.12°$

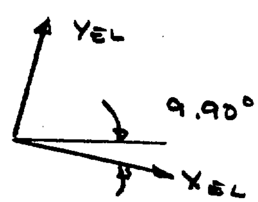
$\measuredangle\, l\,j\,i \quad \tan^{-1} \dfrac{1.131}{.326} = 73.92°$

$\angle\, i\,q\,P = 90 - 54.12 = 35.88°$

$\angle\, q\,P\,j = 90 - 73.92 = 16.08°$

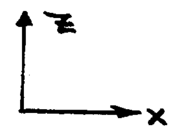
$\angle\, k\,P\,j = 180 - 35.88 - 16.08 = 128.04°$

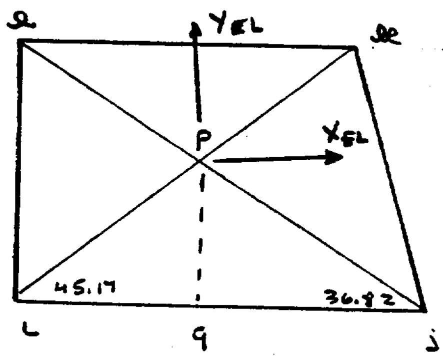
X_{EL} AXIS @ $16.08 + (54.12 + 73.92)/2 = 80.10°$



$$F_y' = \frac{F_x + F_y}{2} + \frac{F_x - F_y}{2}\cos(2(9.90°)) + F_{xy}\sin(2(9.90))$$

EL 3239





	GRID	X	Z
i	23	.782	0
j	24	2.293	0
k	2338	1.9065	1.131
l	2057	.782	1.131

$\angle ijl \quad TAN^{-1} \dfrac{1.131}{1.511} = 36.82^\circ$

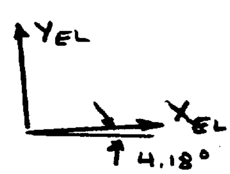
$\angle kij \quad TAN^{-1} \dfrac{1.131}{1.1245} = 45.17$

$\angle iqp = 90-45.17 = 44.83^\circ$

$\angle qpj = 90-36.82 = 53.18^\circ$

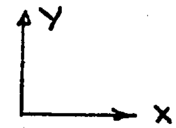
$\angle kpj = 180-44.83-53.18 = 81.98^\circ$

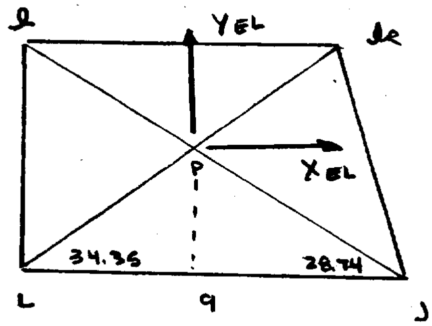
$X_{EL\,AXIS}$ @ $53.18 + (45.17+36.82)/2 = 94.18^\circ$



$$F_y' = \frac{F_x+F_y}{2} + \frac{F_x-F_y}{2}\cos(2(-4.18)) + F_{xy}\sin(2(-4.81))$$

EL 3255





	GRID	X	Z
i	39	23.470	0
j	40	25.532	0
k	2352	25.125	1.131
l	2351	23.470	1.131

$\angle kij \quad TAN^{-1} \dfrac{1.131}{1.655} = 34.35^\circ$

$\angle ljk \quad TAN^{-1} \dfrac{1.131}{.407} = 70.21^\circ$

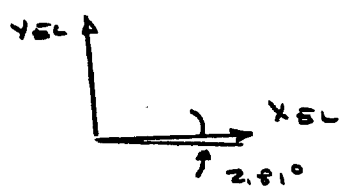
$\angle ijl \quad TAN^{-1} \dfrac{1.131}{2.062} = 28.74^\circ$

$\angle pqj = 180 - 90 - 28.74 = 61.26^\circ$

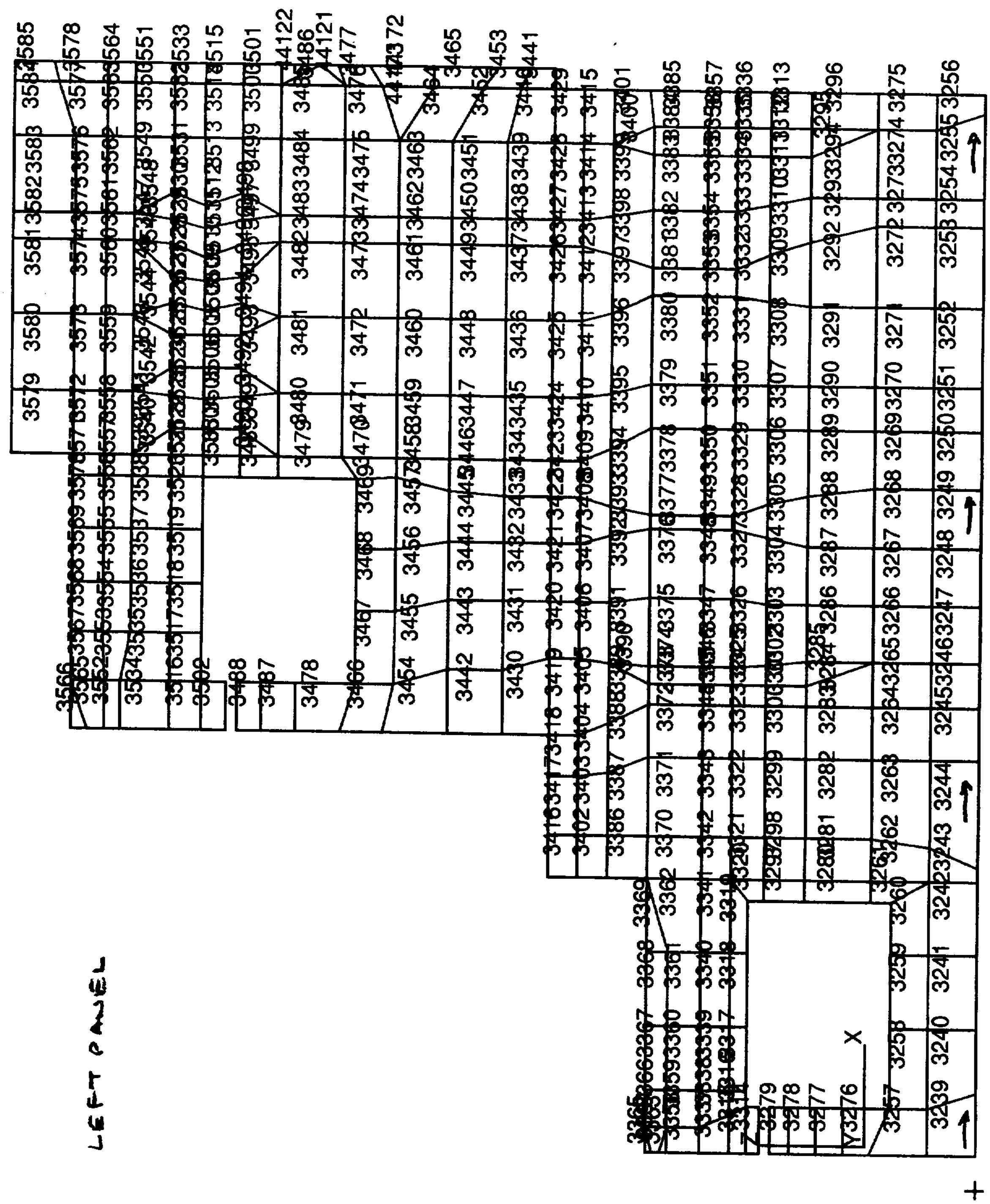
$\angle iqp = 180 - 90 - 34.35 = 55.65^\circ$

$\angle kpj = 180 - 61.26 - 55.65 = 63.09$

X_{EL} AXIS @ $61.26 + (34.35 + 28.74)/2 = 92.81^\circ$



$$Fy' = \frac{Fx+Fy}{2} + \frac{Fx-Fy}{2}\cos(2(-2.81)) + Fxy\sin(2(-2.81)) =$$


LEFT PANEL
XEL
YEL

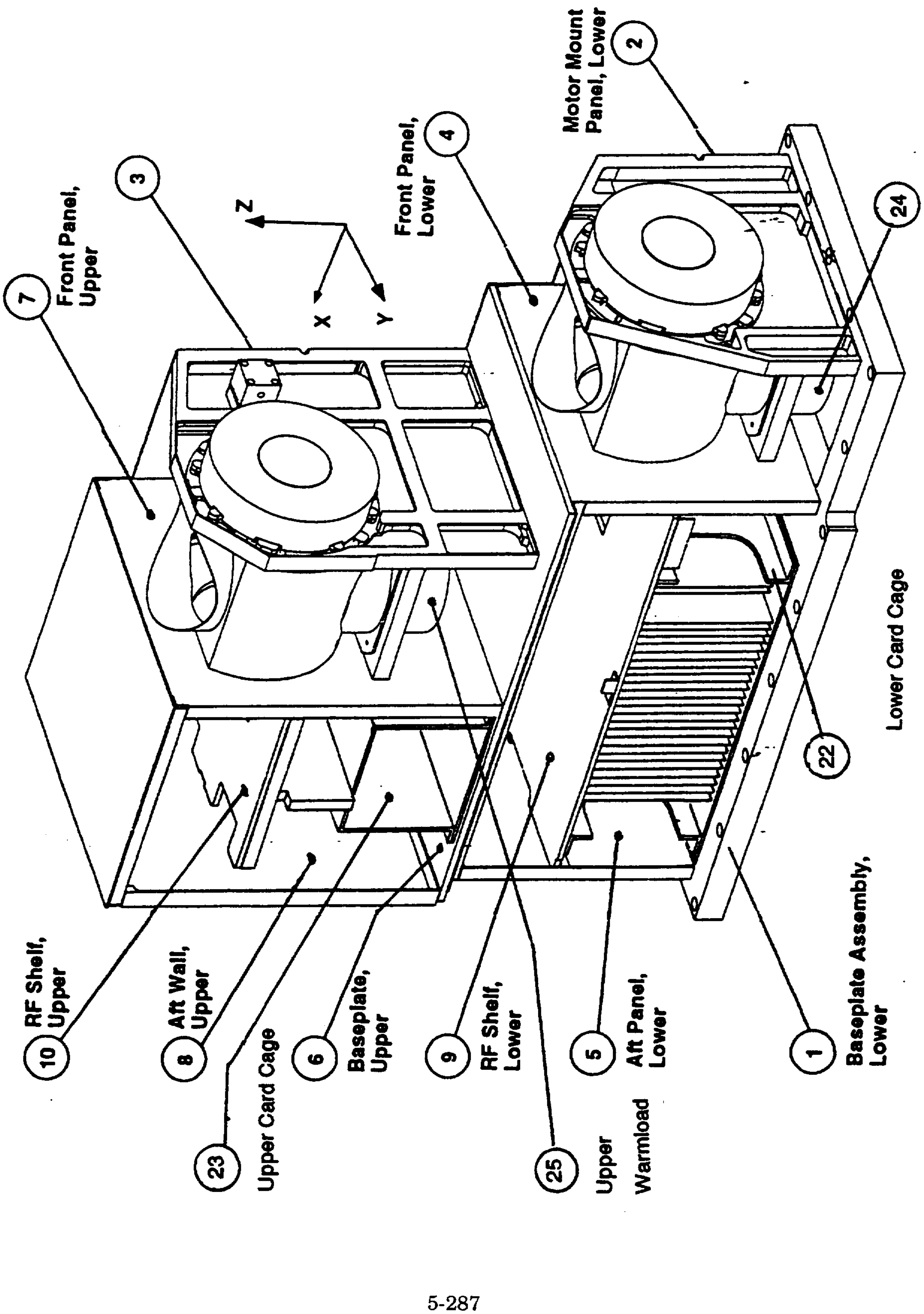


Figure 1 AMSU A1 Axes And Parts Identification

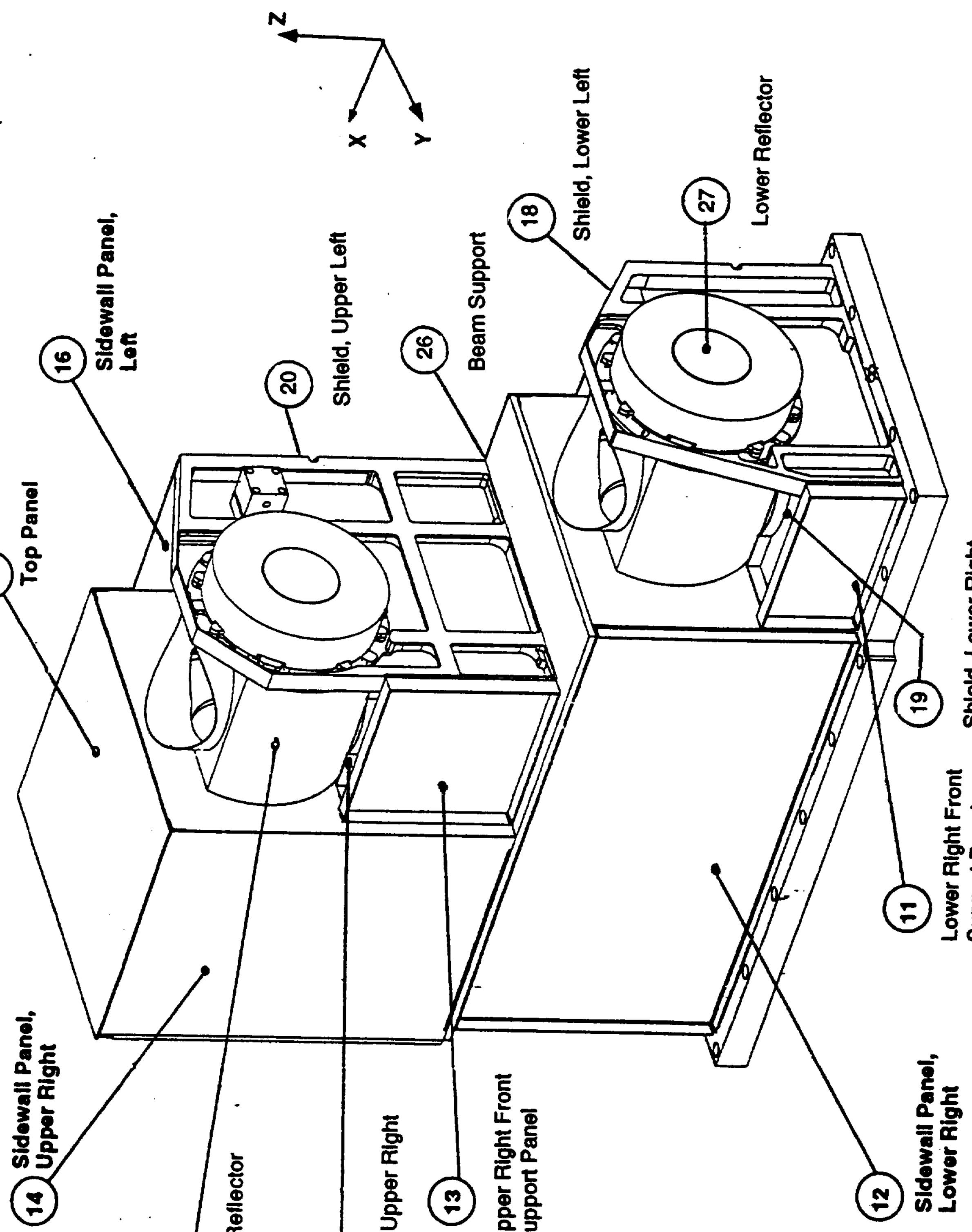
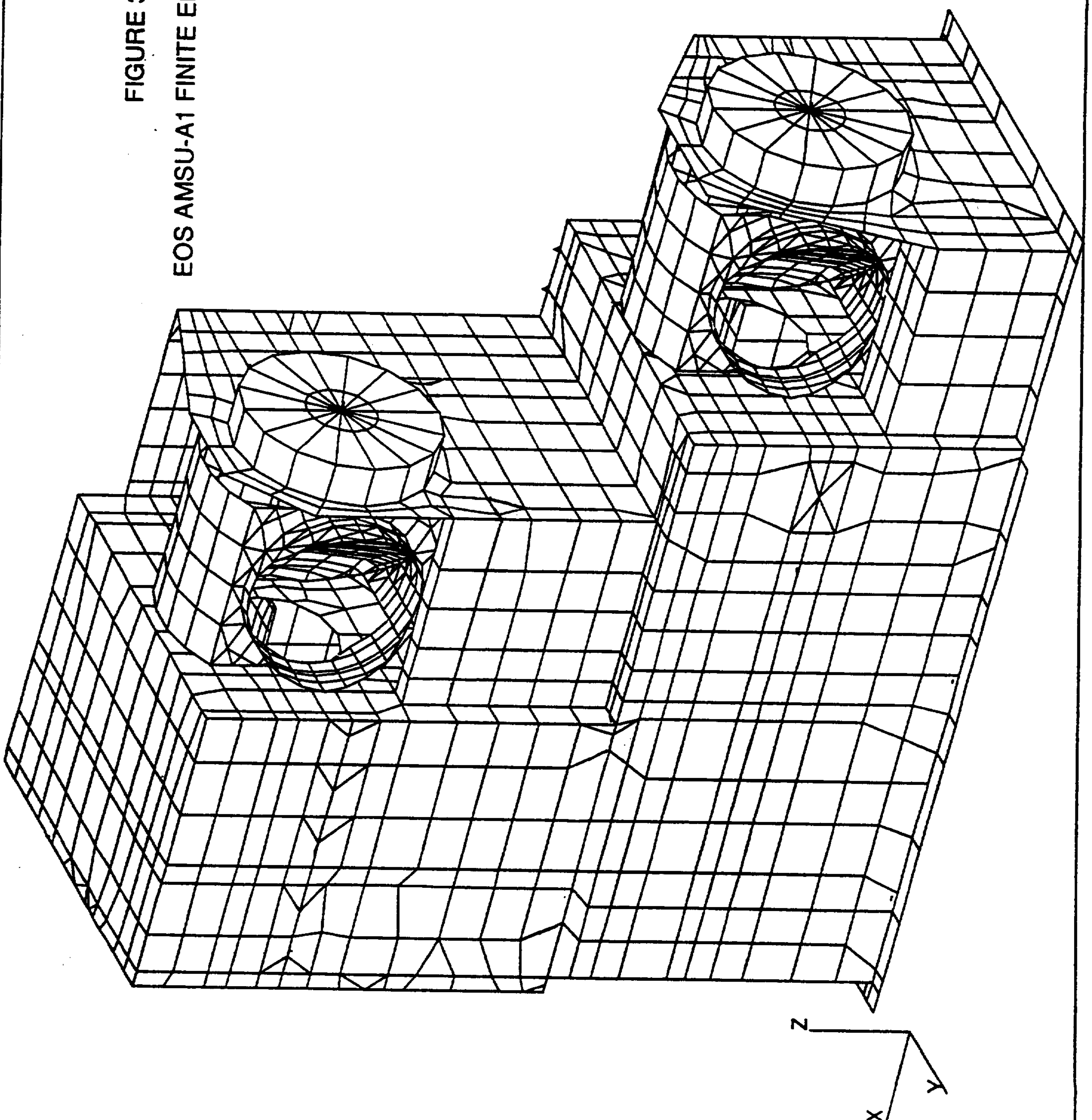
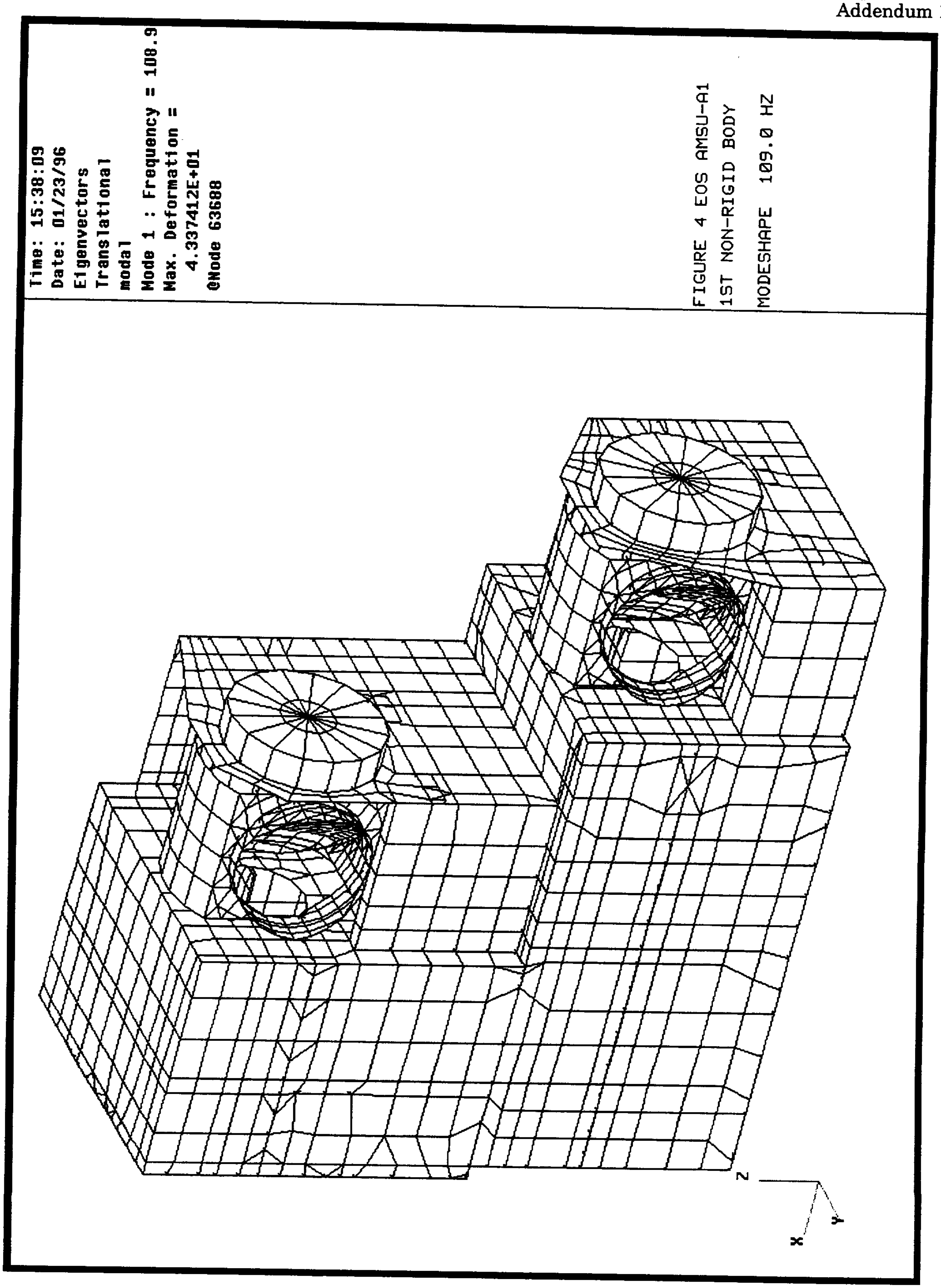


Figure 2 AMSU A1 External Parts Identification

FIGURE 3

EOS AMSU-A1 FINITE ELEMENT MODEL

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Eigenvectors
Translational
modal
Mode 1 : Frequency = 108.9
Max. Deformation =
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@Node 63688
FIGURE 4 EOS AMSU-A1
1ST NON-RIGID BODY
MODESHAPE 109.0 HZ
Z
Y
X

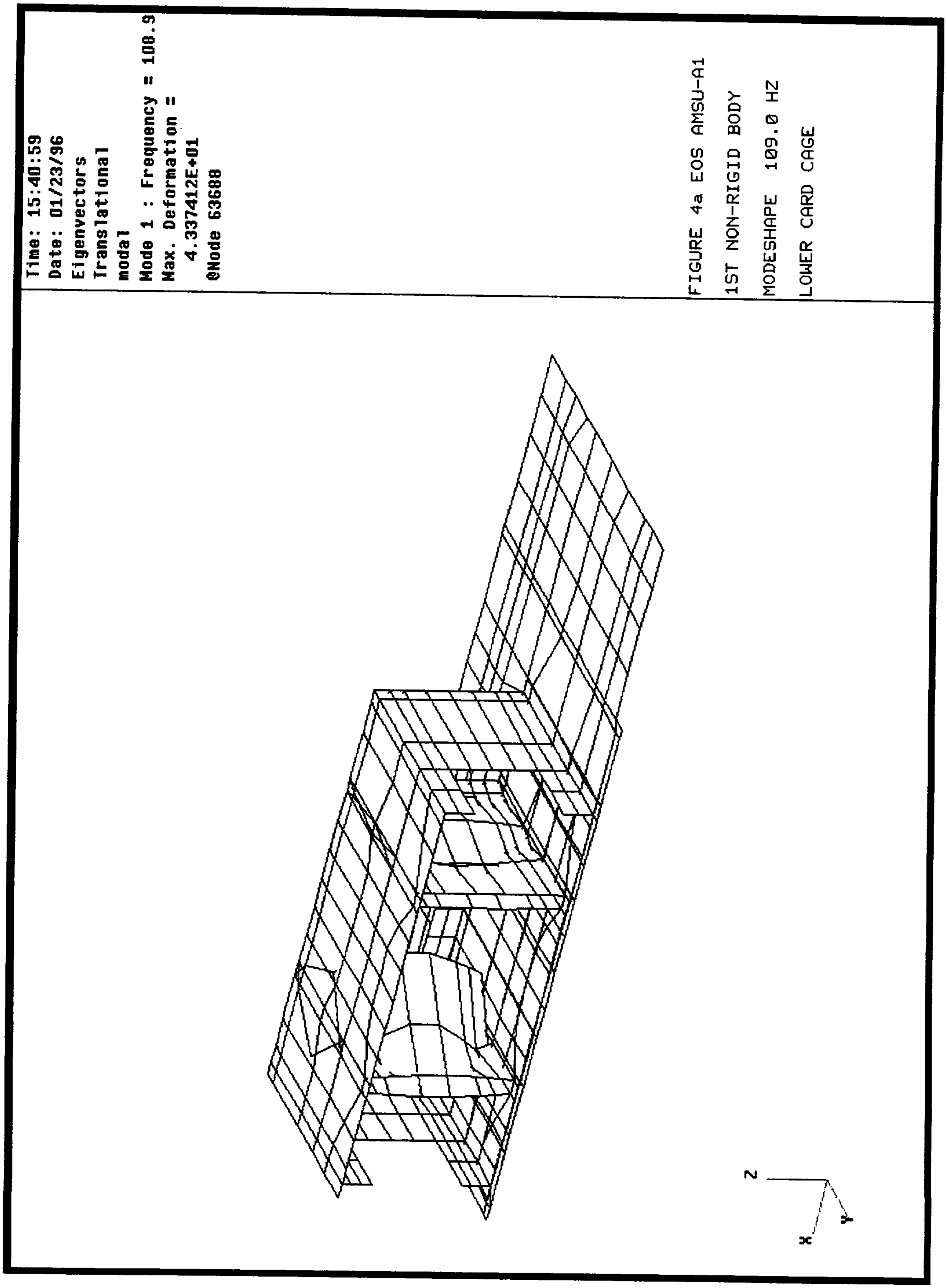


FIGURE 4a EOS AMSU-A1
1ST NON-RIGID BODY
MODESHAPE 109.0 HZ
LOWER CARD CAGE

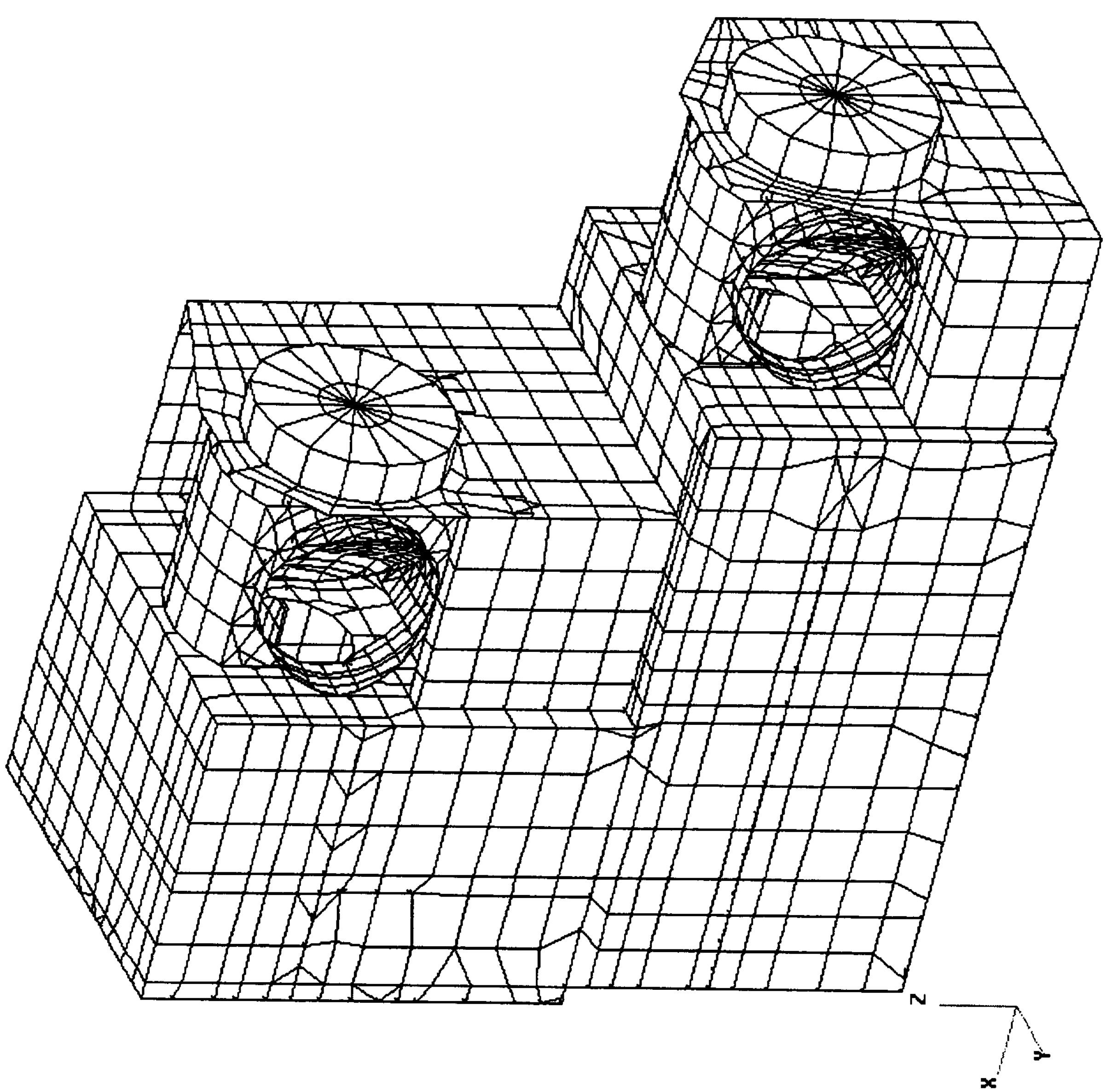


FIGURE 5 EOS AMSU-A1
2ND NON-RIGID BODY
MODESHAPE 109.0 HZ

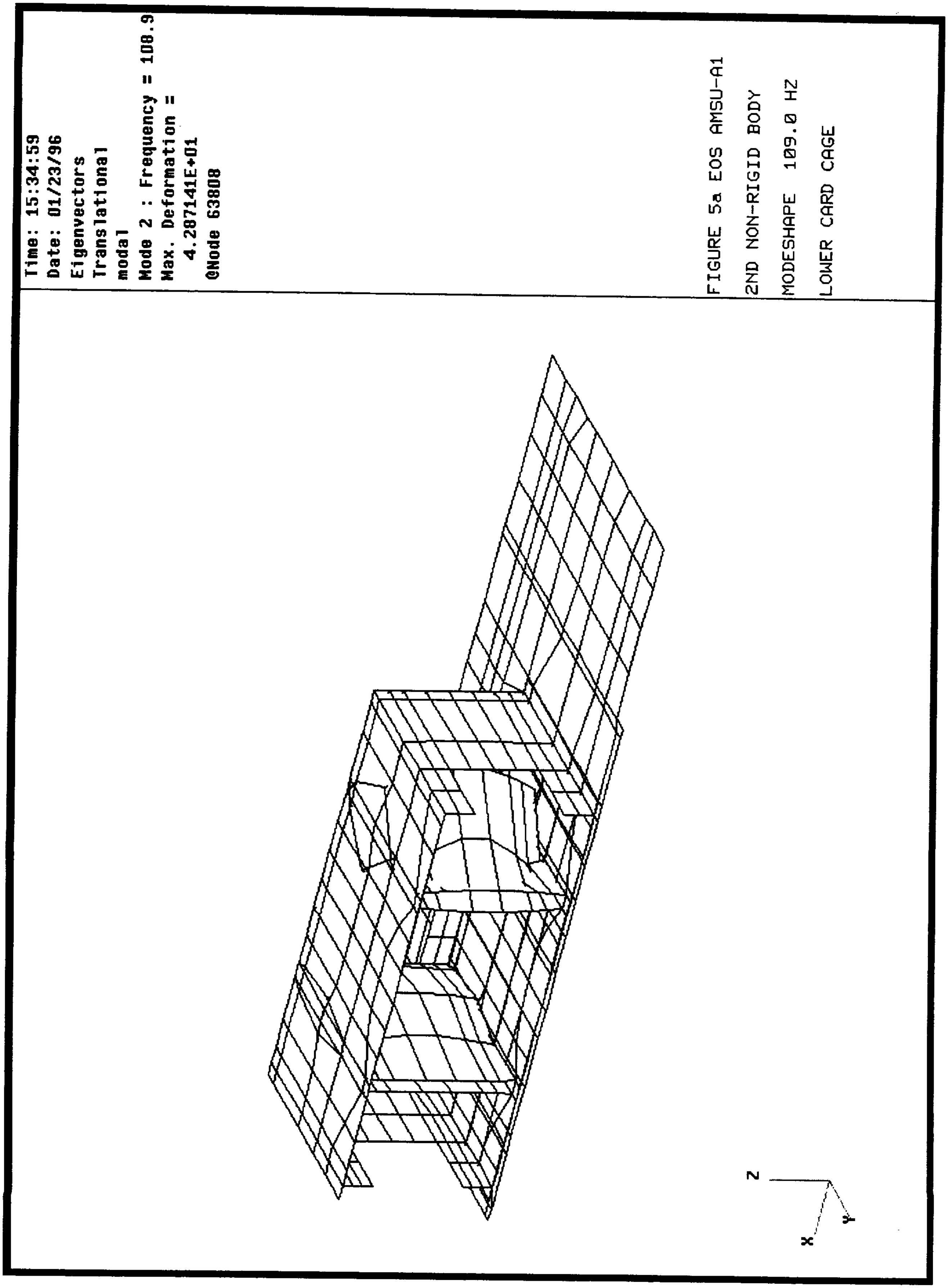


FIGURE 5a EOS AMSU-A1
2ND NON-RIGID BODY
MODESHAPE 109.0 HZ
LOWER CARD CAGE

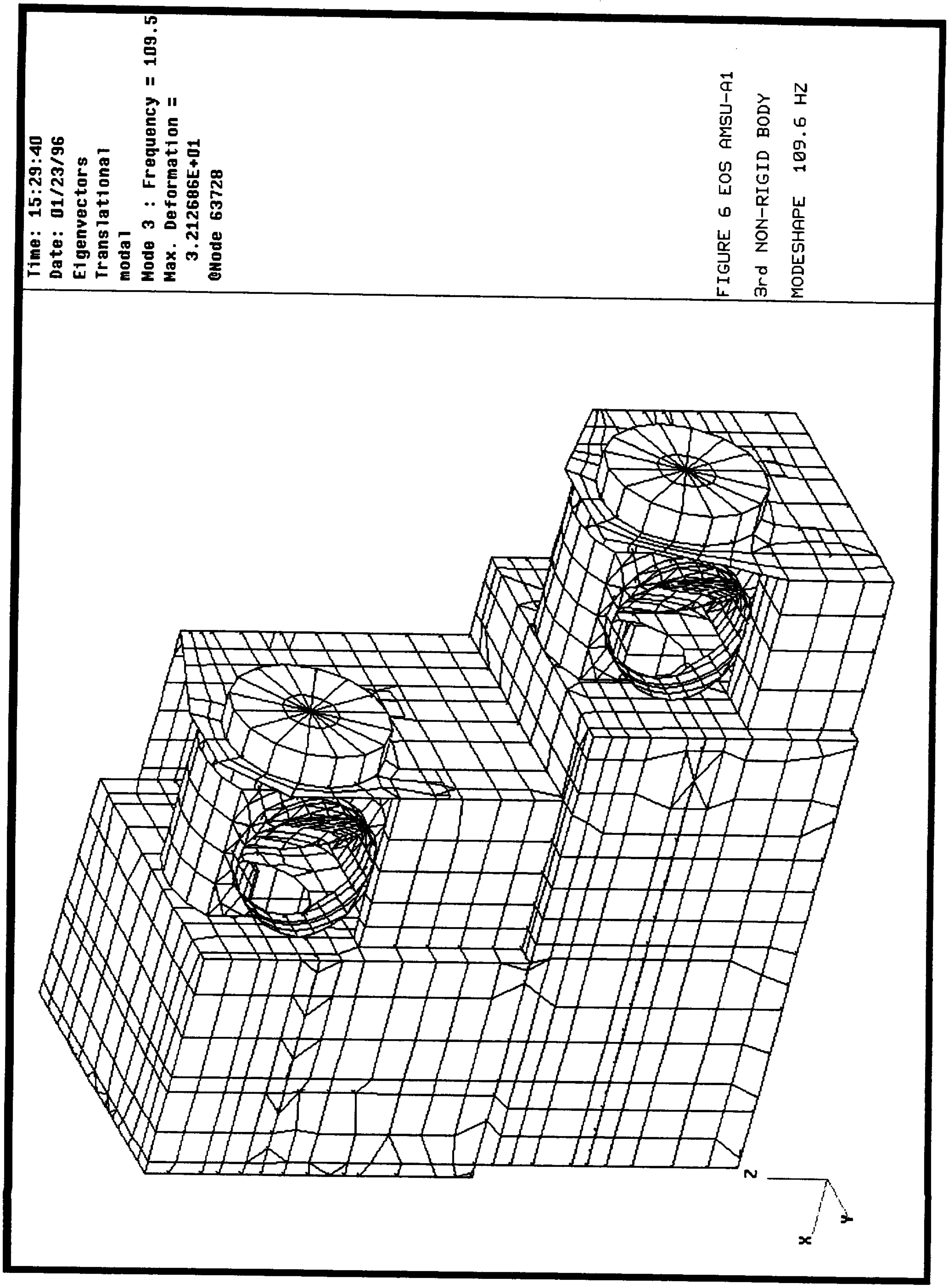


FIGURE 6 EOS AMSU-A1
3rd NON-RIGID BODY
MODESHAPE 109.6 HZ

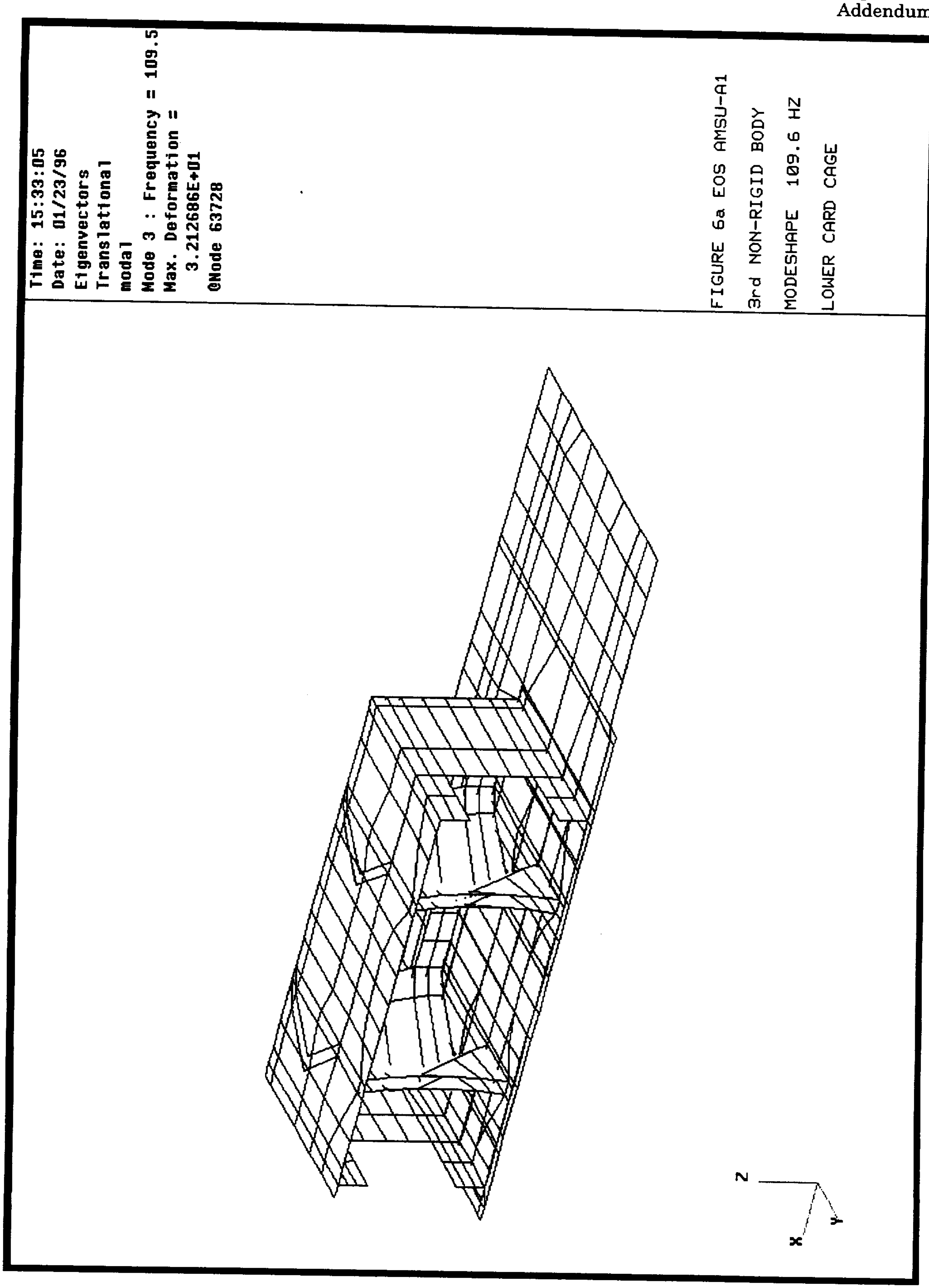


FIGURE 6a EOS AMSU-A1
3rd NON-RIGID BODY
MODESHAPE 109.6 HZ
LOWER CARD CAGE

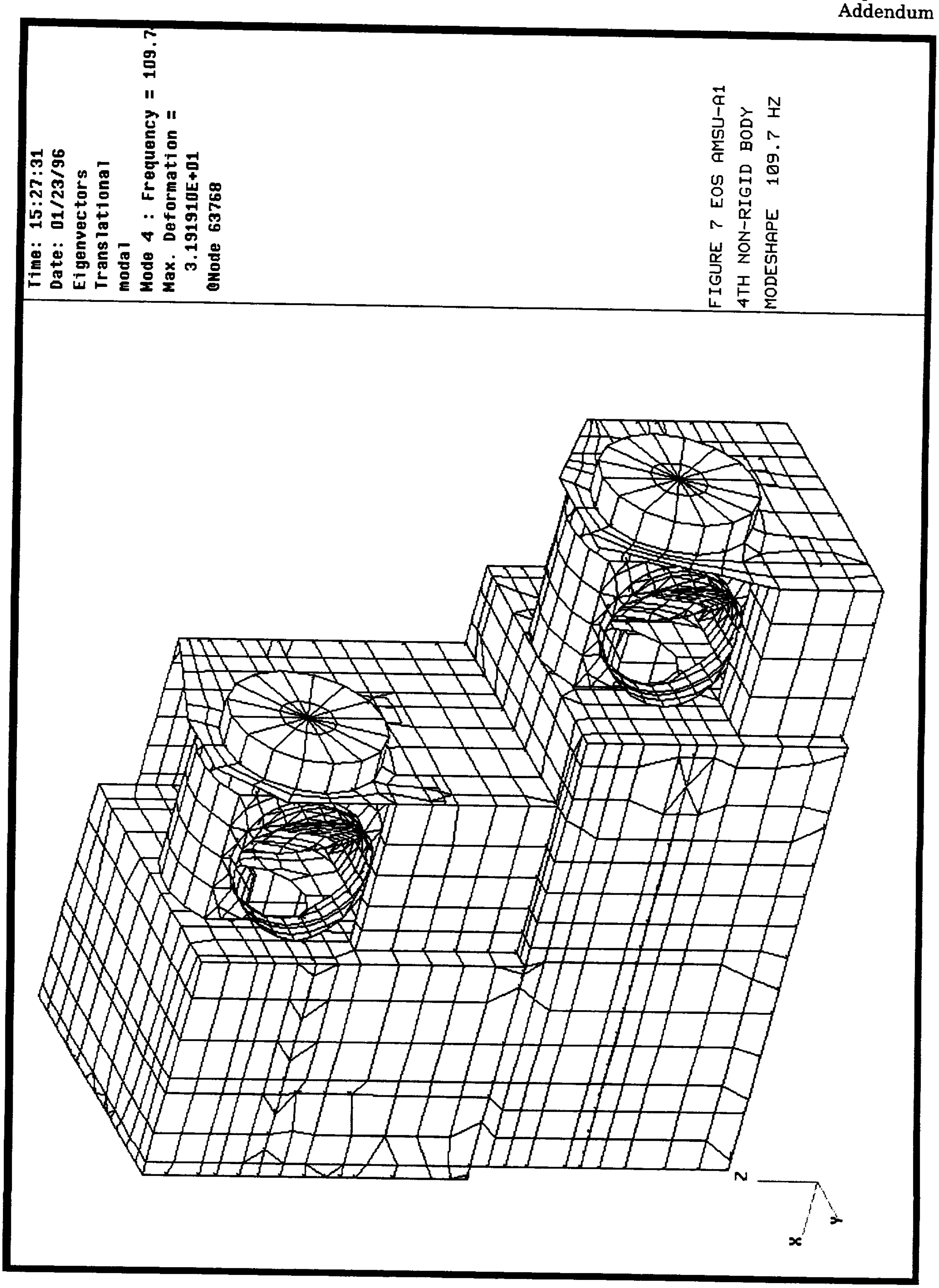
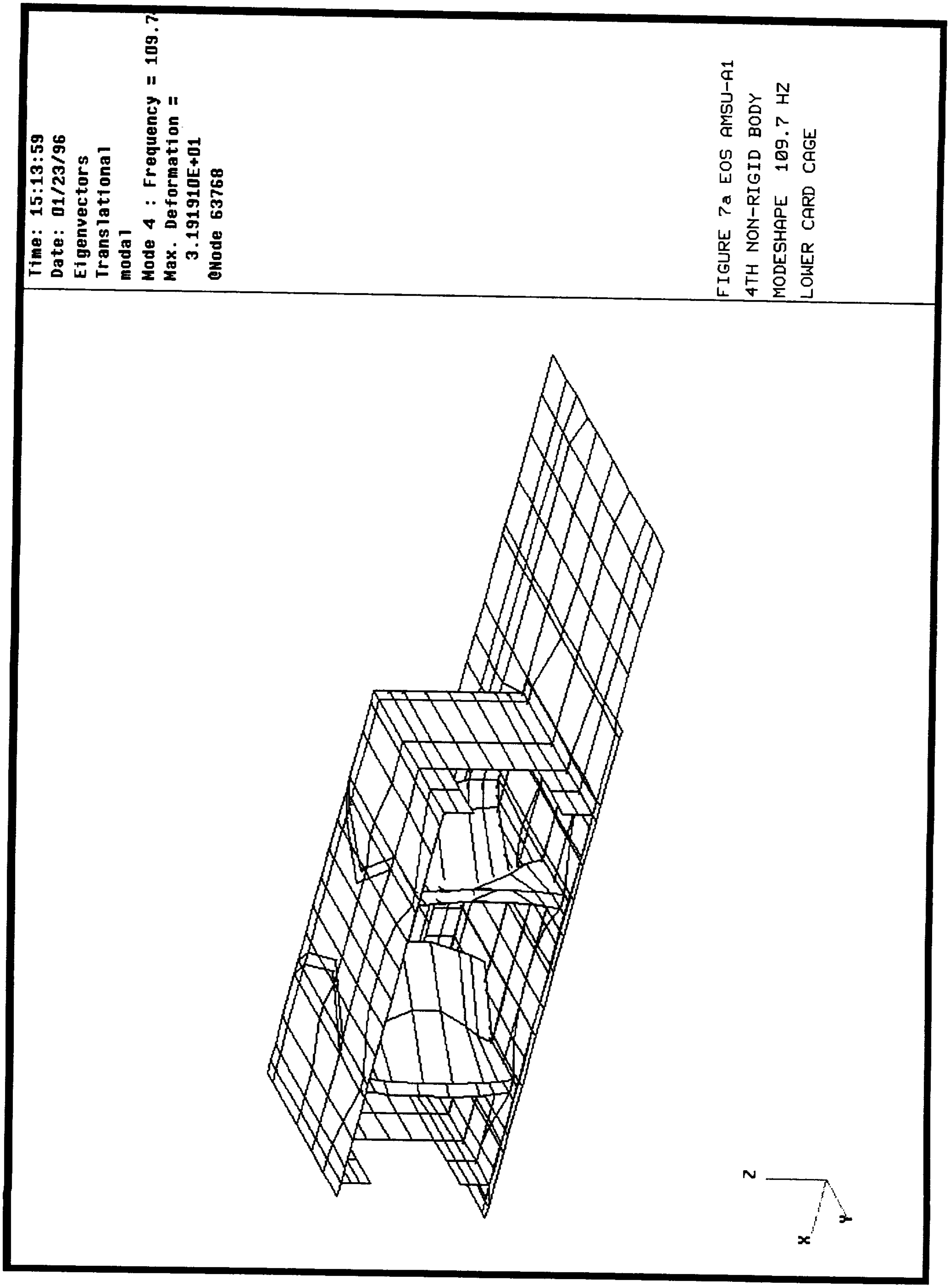


FIGURE 7 EOS AMSU-A1
4TH NON-RIGID BODY
MODESHAPE 109.7 HZ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Translational
modal
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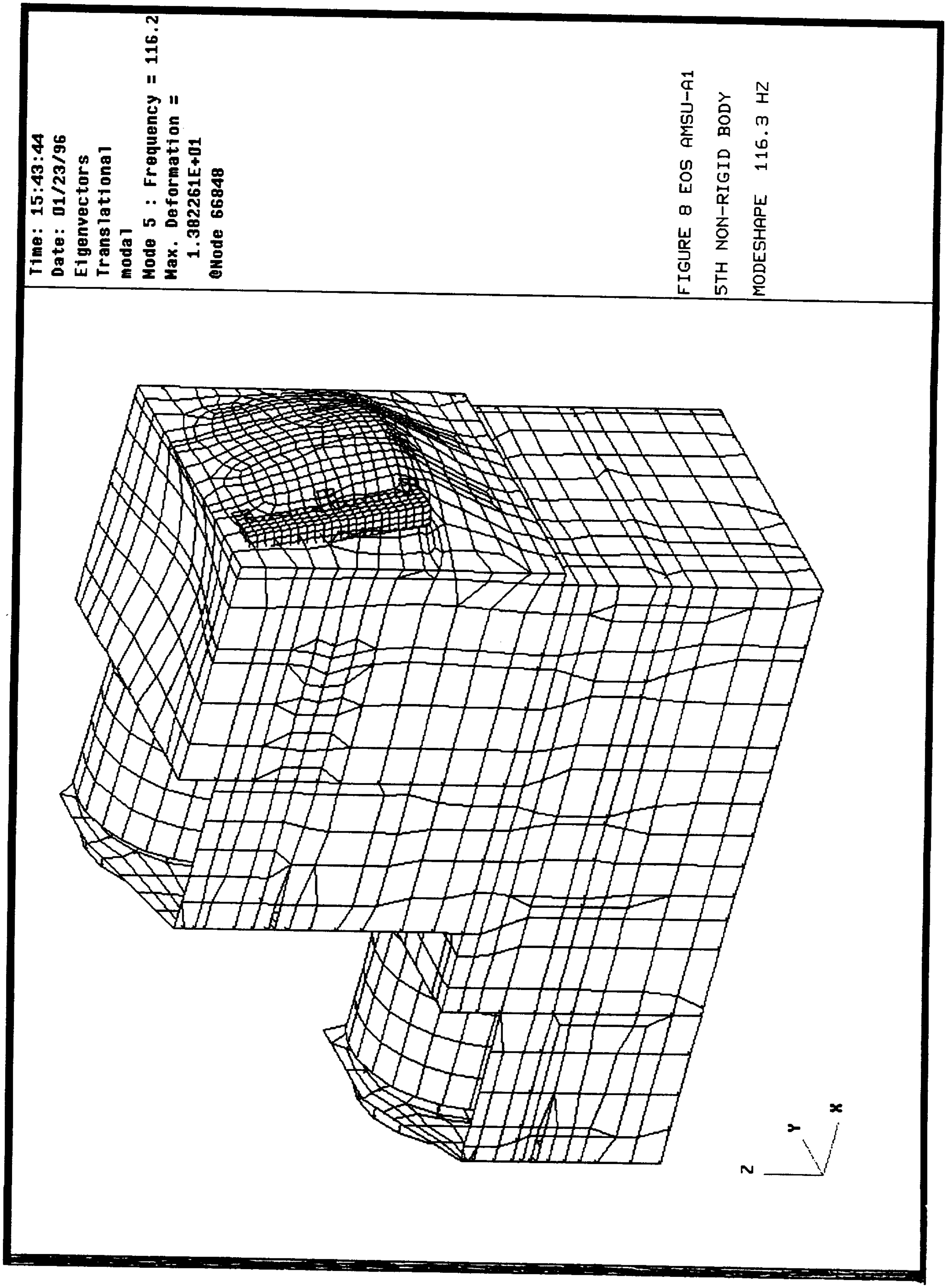
FIGURE 7a EOS AMSU-A1
4TH NON-RIGID BODY
MODESHAPE 109.7 HZ
LOWER CARD CAGE
Z
Y
X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Translational
modal
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FIGURE 8 EOS AMSU-A1
5TH NON-RIGID BODY
MODESHAPE 116.3 HZ
Z
Y
X

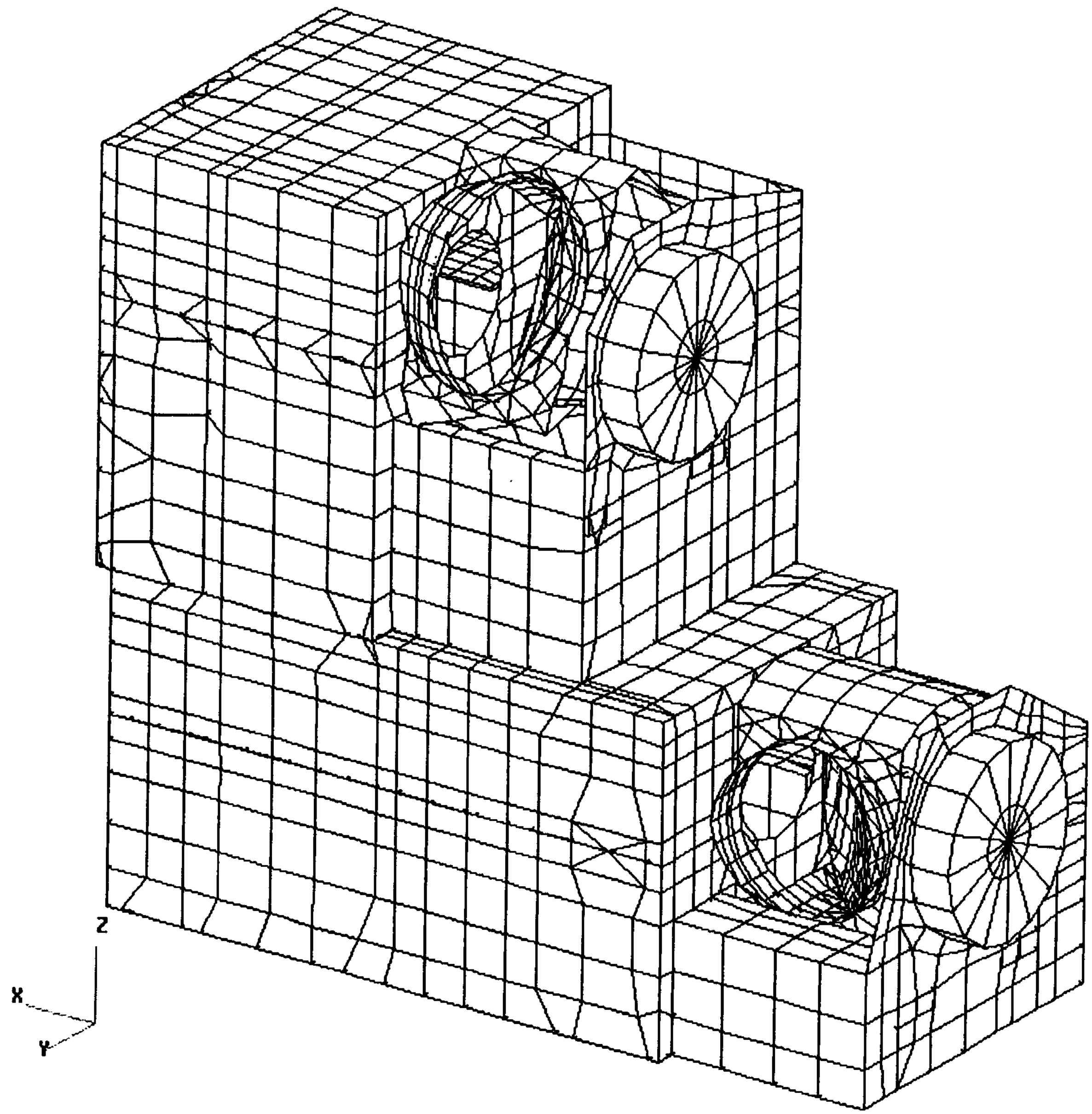


FIGURE 9 EOS AMSU-A1
6TH NON-RIGID BODY
MODESHAPE 121.4 HZ

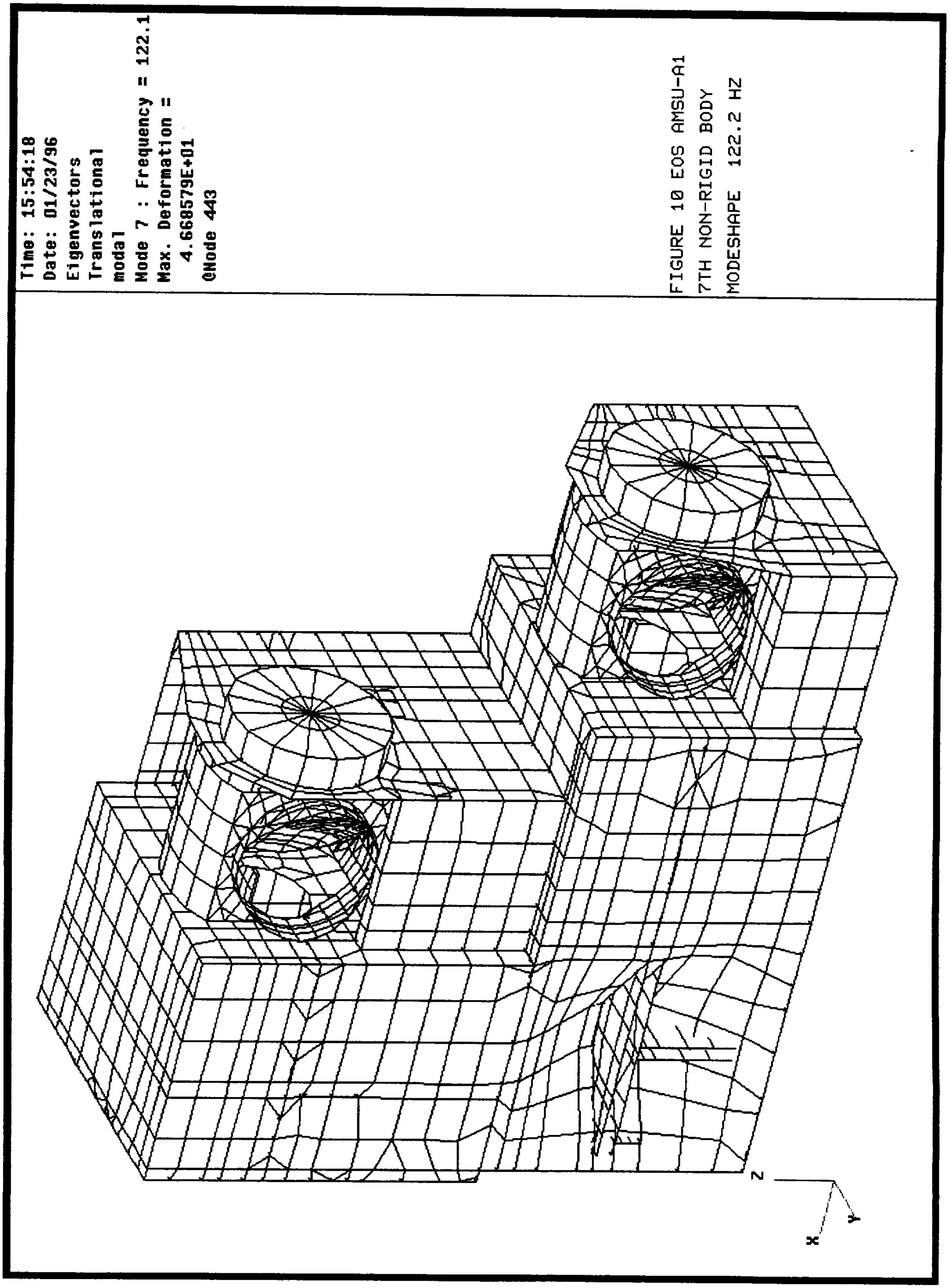


FIGURE 10 EOS AMSU-A1
7TH NON-RIGID BODY
MODESHAPE 122.2 HZ

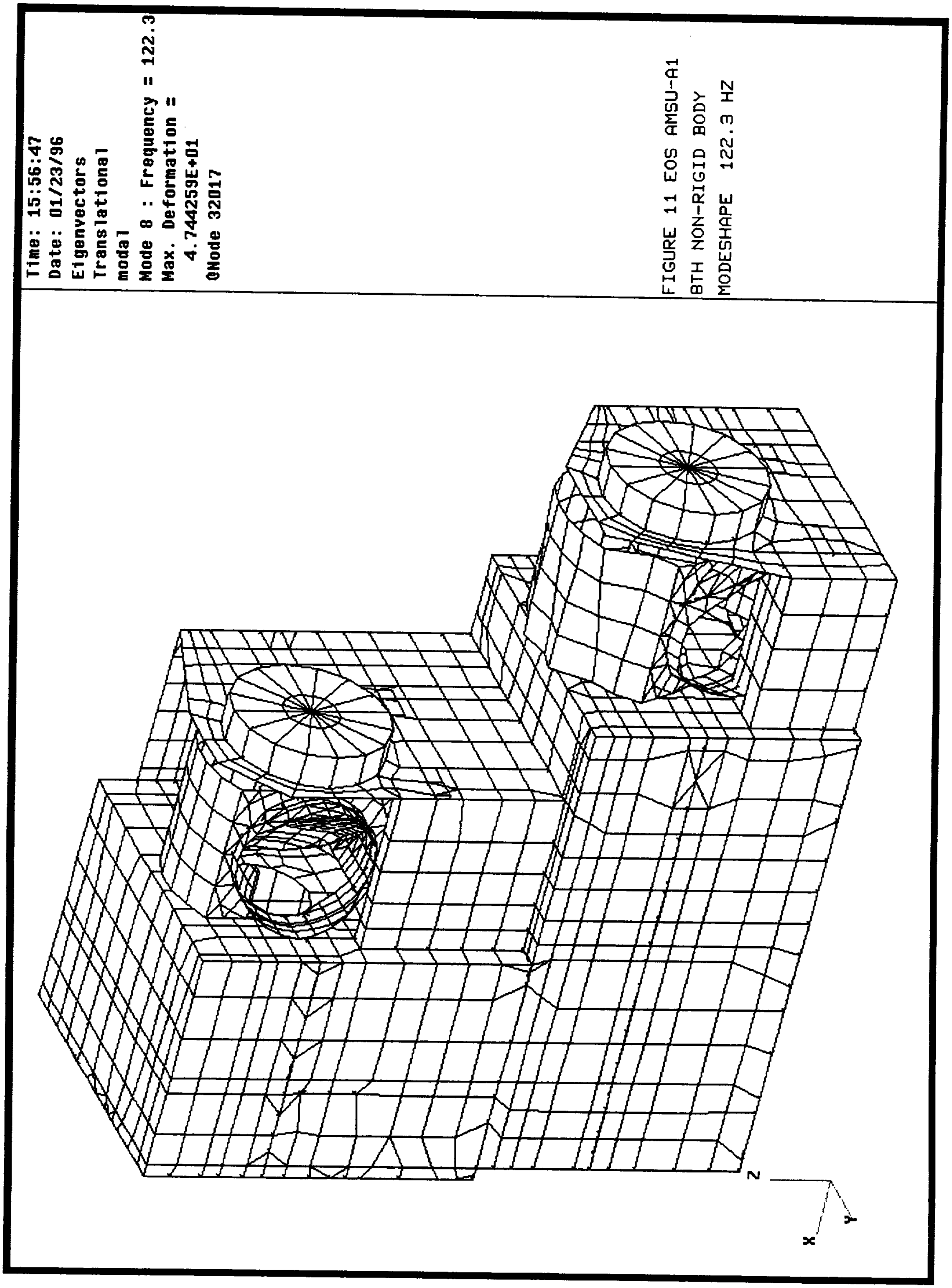


FIGURE 11 EOS AMSU-A1
8TH NON-RIGID BODY
MODESHAPE 122.3 HZ

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).

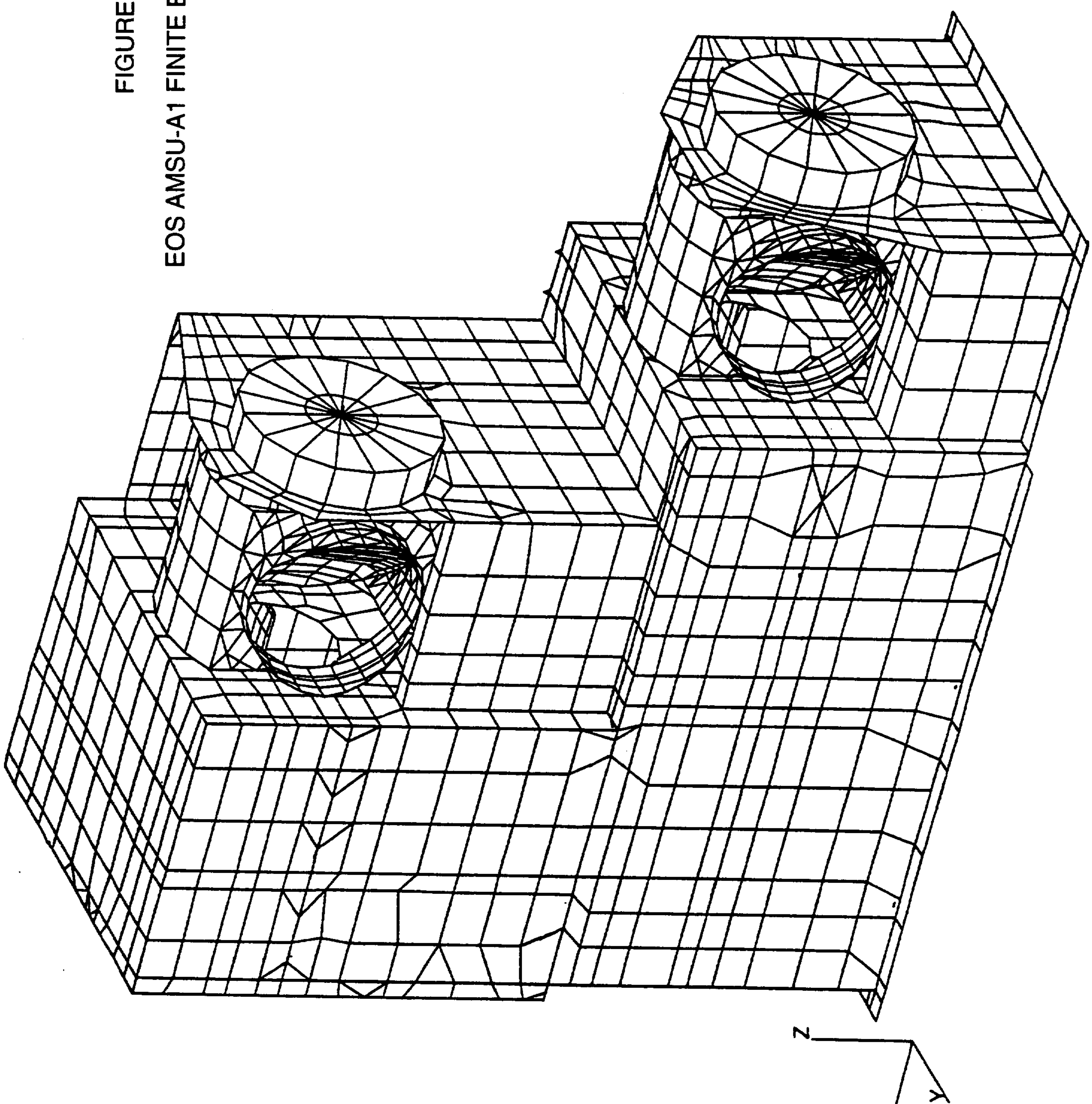
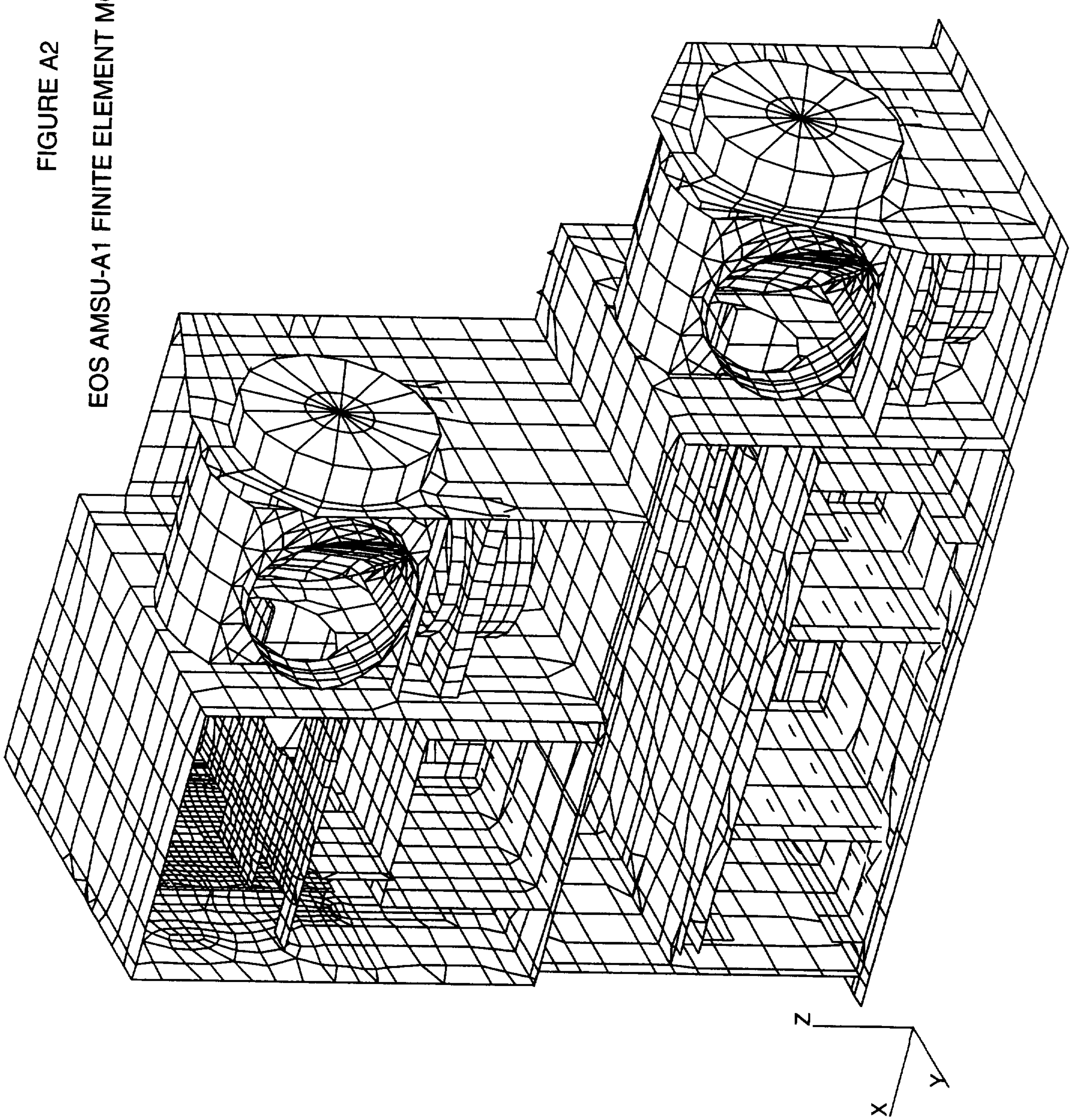


FIGURE A1
EOS AMSU-A1 FINITE ELEMENT MODEL

FIGURE A2

EOS AMSU-A1 FINITE ELEMENT MODEL - SECTION



Figures A3 through A22 not re-evaluated in *Addendum 1*.

FIGURE A23
UPPER AFT PANEL

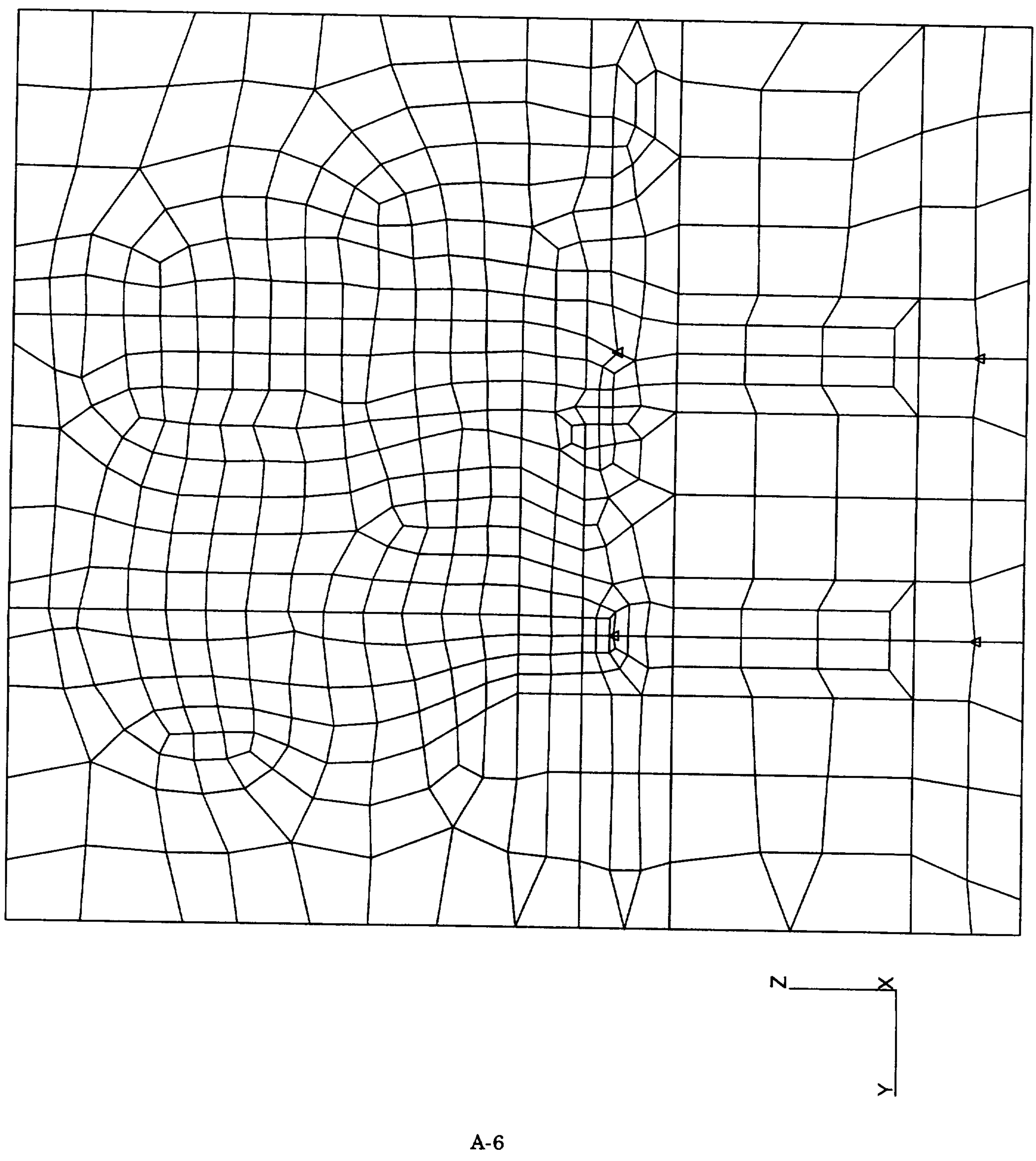


FIGURE A23A
UPPER AFT PANEL
QUAD, TRI

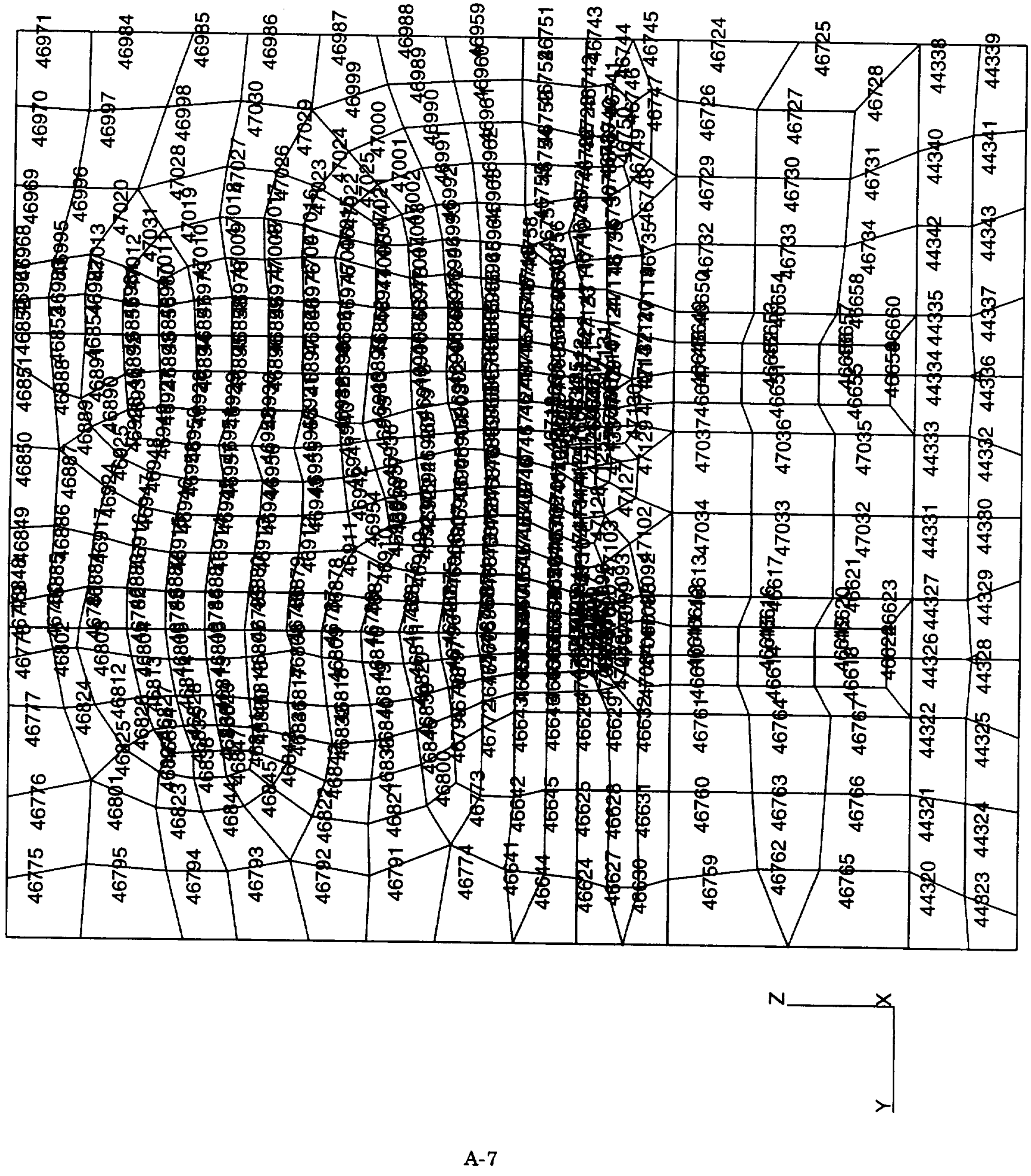
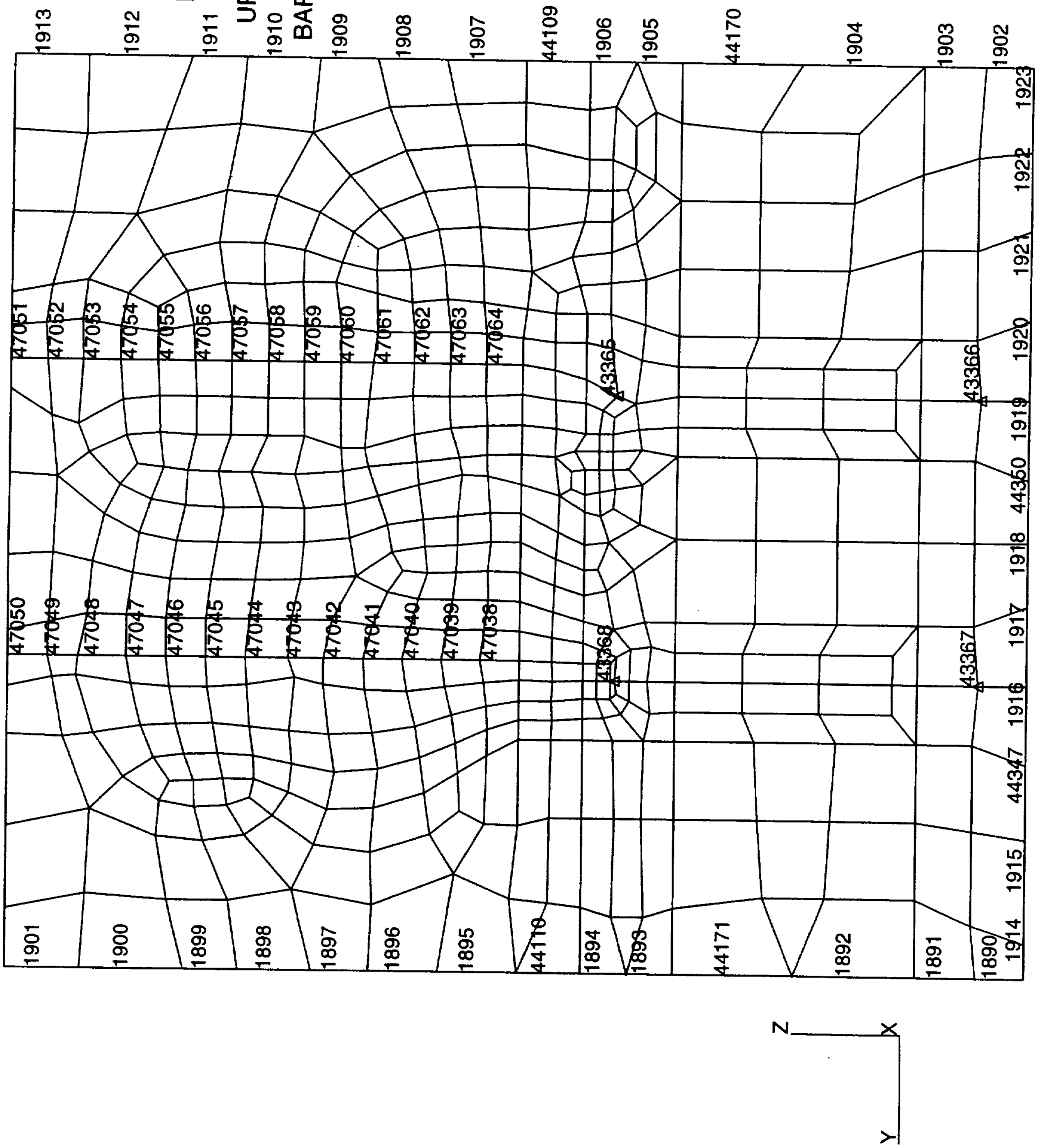


FIGURE A24
UPPER AFT PANEL
BARS, BEAMS, MASS



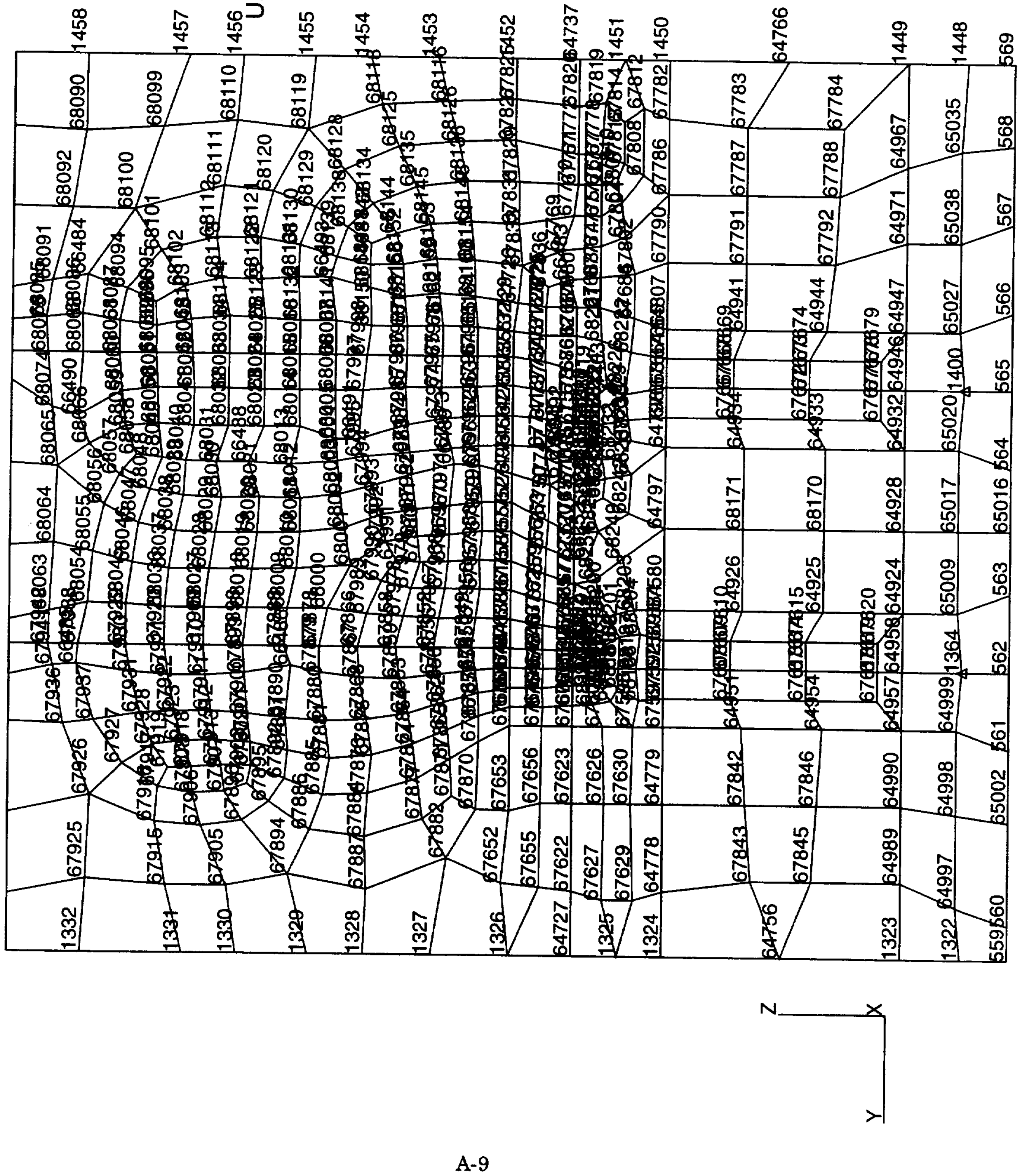
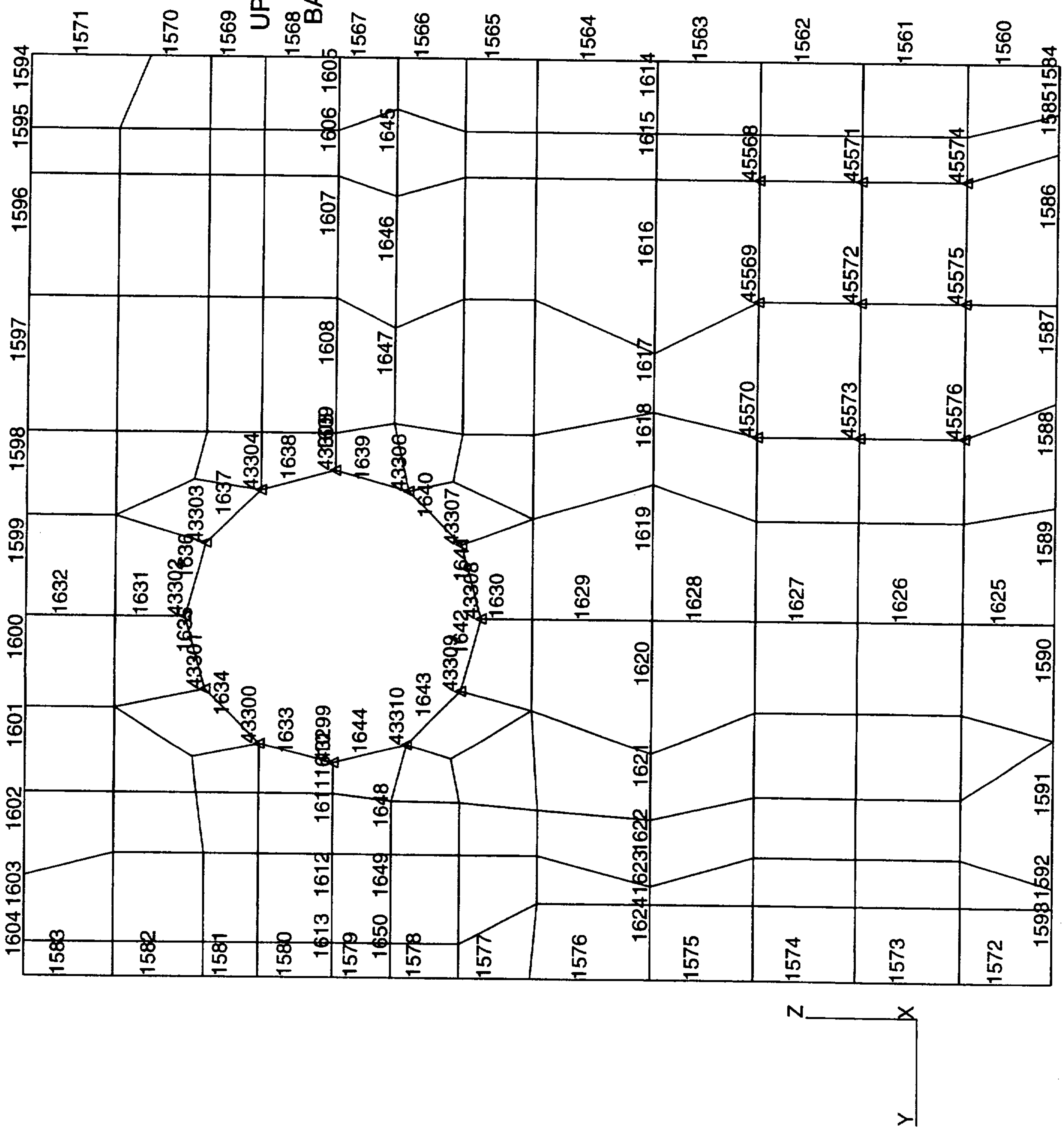


FIGURE A25
UPPER AFT PANEL
GRID

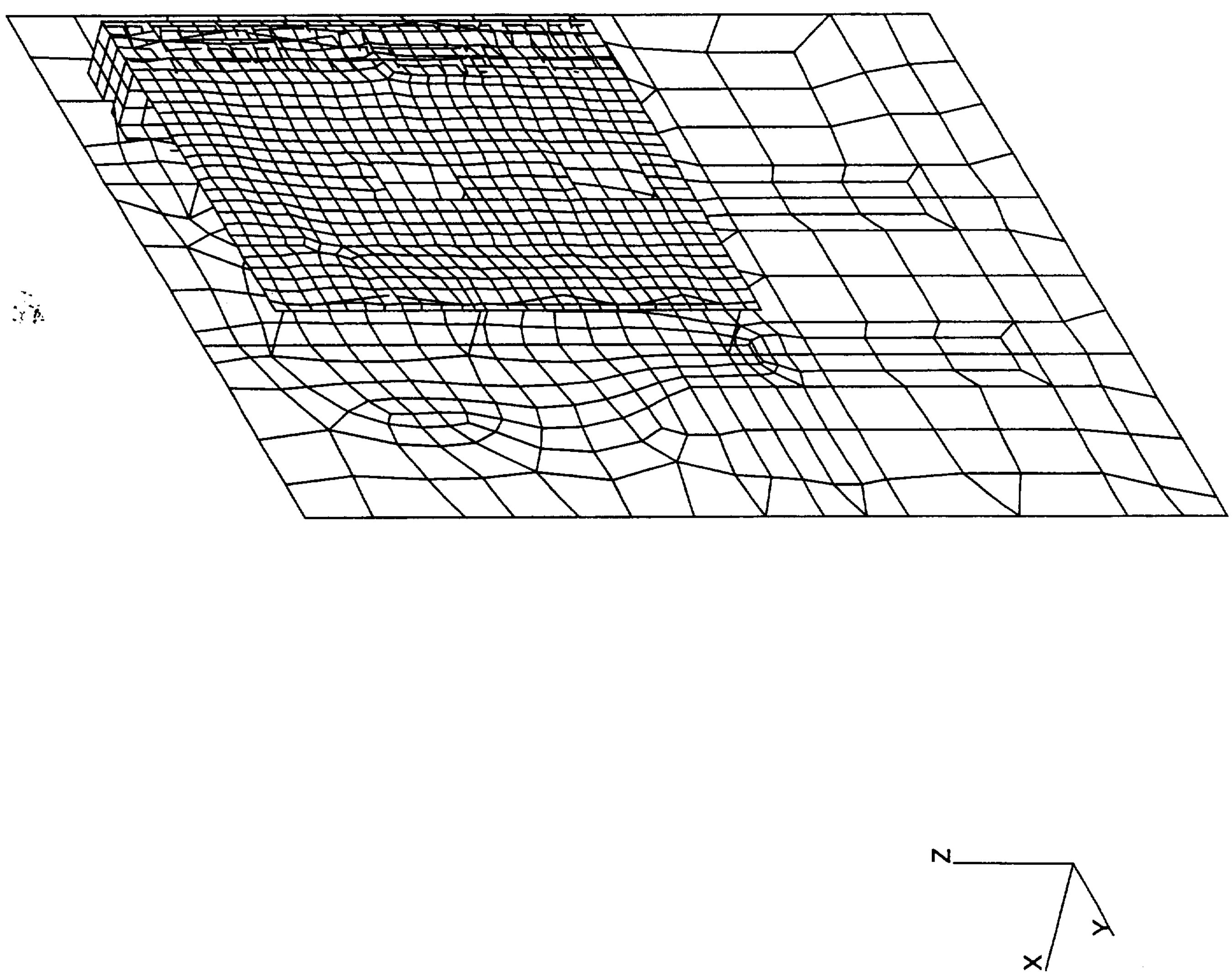
Figures A26 through A29 not re-evaluated in *Addendum 1*.

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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13. ABSTRACT *(Maximum 200 words)*

This addendum supplements Report 10381, dated June 1995, to include a new and more refined finite element model.

14. SUBJECT TERMS

EOS, Microwave System, AMSU-A

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