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December 1962

Report No. 0162-01TN-62-20

STRUCTURAL VERIFICATION TESTS
OF THE AEROJET
UTILITY VAN

AFBSD TECHNICAL NOTE BSD-TDR-62-330

CONTRACT NO. AF 33(600)-36610

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AEROJET-GENERAL CORPORATION

SOLID ROCKET PLANT • SACRAMENTO, CALIFORNIA
A SUBSIDIARY OF THE GENERAL TIRE & RUBBER COMPANY

COPY NO.

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UTILITY VAN

Prepared by
W. D. Hulse
Mechanical Environment Group

AFBSD TECHNICAL NOTE BSD-TDR-62-330
CONTRACT NO. AF 33(600)-36610

Prepared for
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AIR FORCE SYSTEMS COMMAND, USAF
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Los Angeles 45, California

Attn: Tech Data Center

Approved by:


C. C. Conway, Manager
Minuteman Program



SOLID ROCKET PLANT SACRAMENTO, CALIFORNIA

A SUBSIDIARY OF THE GENERAL TIRE & RUBBER COMPANY

PREFACE

Acknowledgment is made to the following persons for the preparation of this report: W. D. Hulse, Mechanical Environment Group; H. E. Johnson, Environmental Test Operations; Max Halebsky, Minuteman Environmental Program; and D. P. Campbell, Technical Editor.



ABSTRACT

Structural tests to verify the acceptability of the Aerojet-General Utility van as a transport vehicle for second-stage Minuteman operational motors have been successfully completed. During the tests, the van and tie-downs were subjected to limit loads to determine stress levels at critical load points and to measure vehicle deflection and recovery from the downward and side loads imposed.



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I. INTRODUCTION

To verify the acceptability of the Aerojet-General Utility van as a transport vehicle for Minuteman second-stage operational motors, the van and motor-harness tie-downs were subjected to structural tests. These tests were conducted in conjunction with climatic environmental tests as described in AFBSD-TDR-62-331, "High- and Low-Temperature Tests of the Aerojet Utility Van."

II. SUMMARY

The Aerojet Utility van and tie-downs successfully met structural criteria. The van and tie-downs were subjected to limit loads to determine stress levels at critical load points and to measure vehicle deflection and recovery from the downward and sideward loads imposed.

III. TECHNICAL DISCUSSION

A. TEST UNITS

1. Test Facility

The tests were performed at the structural test facility of the Aerojet, Sacramento, Solid Rocket Plant. Hydraulic load actuators were used in the tests and a load factor of 1.0 was equal to 13,000 lb.

2. Aerojet Utility Van and Tie-downs

Aerojet Utility van, model VR-01152A, serial number 372911 (AF 348874), was the test vehicle. The van had been modified in accordance



III, A, Test Units (cont.)

with Aerojet drawing T-492674A. Figure 1 shows the van installed in the test stand and Figure 2 shows the harness tie-down attached to the Boeing operational harness.

3. Test Motor and Harness

Minuteman motor 44TR-1, serial number 519578, cast with propellant simulant, was the test motor. The motor was supported in the van by a Boeing operational harness, PN 25-18032.

B. INSTRUMENTATION AND DATA RECORDING

1. Eleven biaxial strain gages were located at critical van load points to determine stress levels (Figures 3 through 5). The strain gages were Baldwin-Lima-Hamilton type AX-5 gages designed to register strain to 20,000 microin/in.

2. One 50K and two 20K Baldwin-Lima-Hamilton load cells were used to record applied load.

3. A standard Aerojet balance and calibration unit with Kintel III BF amplifiers was used to check out the load cells.

4. The recording oscillograph was a Consolidated Electronics Corp. (CEC) model 5-119P4-36 with CEC-318 galvanometers.

5. Two horizontal reference datum lines of piano wire were installed approximately 4 in. below the walls of the van and parallel to the bottom



III, B, Instrumentation and Data Recording (cont.)

of the van for measuring deflection. Preload, at-load, and postload measurements were taken at 12 locations (Figure 6) in Phase 2 of the test and at 14 locations in Phase 3.

6. Two dial gages with 3-in. stroke indicators were located under the center of the van to measure deflection at data points 9 and 10 (Figure 6). Two dial gages with 1/2-in. stroke indicators were located under the rear axle to measure rear axle deflection.

7. Measurements taken at each of the data points were as follows:

- a. Prior to load application.
- b. Two minutes after the load had been applied.
- c. After removal of the applied load.

C. TEST CONDITIONS

1. General

The Aerojet Utility Van was instrumented and placed in the test stand as shown in Figures 1 and 7 for the forward and aft load tests, Phase 1, which were performed on 20 August 1962. Phase 3, the side-loading test, was performed 21 August. The motor was then removed from the van and the van was prepared for the downward-loading test, Phase 2, which was performed on 28 August.

2. Test Phases

The structural tests were conducted in three phases as follows:

- a. Phase 1



III, C, Test Conditions (cont.)

With the motor and harness secured in the van to provide a downward vertical load factor of 1.0, additional forward and aft loads of 2.0 were applied and maintained for 5 min. Figure 8 shows the method of applying forward and aft loads. Strain-gage measurements were recorded during this test phase.

b. Phase 2

With the van emptied of the motor and harness, a downward load of 3.0 was applied at the areas of harness wheel contact with the van rails. The load was applied evenly and simultaneously to the four points of contact by the hydraulic actuators acting against two beams extending through the side access doors of the van. The load was maintained for 5 min. Both strain-gage and deflection measurements were recorded during this test phase. Figures 9 and 10 show the downward-load test setup.

c. Phase 3

With the motor and harness secured in the van to provide a downward vertical load factor of 1.0, a side load factor of 1.0 was applied to act through the center of gravity of the motor. The load was maintained for 5 min. As in Phase 2, deflection and recovery measurements were recorded in addition to the strain-gage measurements. Figures 11 through 13 show the side-load test setup.

D. TEST RESULTS

Tables 1 through 4 list the recorded maximum strain for each phase of the test. Tables 5 and 6 show deflection and recovery data for Phases 2 and 3,



III, Test Results (cont.)

respectively. Load-vs-time plots for the forward- and aft-load tests of Phase 1 are shown in Figures 14 and 15, respectively. Figures 16 and 17 are load-vs-time plots for Phases 2 and 3, respectively. Appendix A is the Integrated Testing and Inspection documentation as contained in the Minuteman Engineering and Inspection Summary (MEIS). Appendix B is the Operations Log for the tests.

First postdeflection measurements taken at the close of Phase 2 differed from the predeflection measurements by approximately 1/2 in. This difference was caused by the normal loss of air in the air-bag suspension system during load application. Minimal air loss results in activation of the system's rotary air-control valve by the mechanical sensing linkage. To obtain correct postdeflection measurements, the system was bled and repressurized to the starting pressure.

Appendix C, Structural Analyses Summary Sheet, presents calculations of stress analyses of the transport tie-down fittings within the van, the aircraft tie-down fittings outside the van, and the stress analyses of the Aerojet-designed transport cradles.

IV. CONCLUSIONS

All test objections were achieved. The Aerojet Utility van and motor tie-downs successfully withstood the load forces applied in the three test phases. There was no evidence of structural failure or permanent deformation. The van with tie-downs, therefore, qualifies structurally as an acceptable transport vehicle for Minuteman second-stage operational motors.

TABLE 1

Maximum Strains Imposed During Forward-Load Test,
Utility Van Test Phase 1

Functions	Maximum Strain (Micro in./in.) (+) (-)		Stress $\frac{lb}{in^2}$
S1-X	12.87	0	386.1
S1-Z	33.12	0	993.6
S2-X	185.60	7.25	5568.0
S2-YX	9.80	749.70	2249.8(-)
S3-7	464.72	0	464.7
S3-Z	168.98	2.84	1689.8
S4-Y	2.94	183.75	1837.5(-)
S4-Z	45.57	0	455.7
S5-X	4.29	22.88	686.4(-)
S5-Y	2.96	42.92	1287.6(-)
S6-X	60.06	0	1801.8
S6-Y	0	153.70	4611.0(-)
R-2 Record			
S7-Y	0	113.16	1131.6(-)
S7-Z	2.80	36.40	364.0(-)
S8-X	21.76	0	652.8
S8-Y	30.36	4.14	910.8
S9-X	93.84	0	2815.2
S9-Y	79.65	10.80	2389.5
S10-Y	0	8.40	84.0(-)
S10-Z	21.92	0	219.2
S11-X	48.30	1.38	1449.0
S11-Y	5.48	10.96	328.8(-)

NOTE: (+) Indicates upward deflection on the record, (-) Indicates
Downward deflection.

Table 1



TABLE 2

Maximum Strains Imposed During Aft-Load Test,
Utility Van Test Phase 1

Functions	Maximum Strain (Micro in./in.)		Stress(psi)
	(+)	(-)	
S1-X	0.	8.58	257.4(-)
S1-Z	0.	37.26	1117.8(-)
S2-XY	0.	337.85	10135.5(-)
S2-YX	784.00	0	23520.0
S3-Y	325.60	0	3256.0
S3-Z	0	107.25	1072.5(-)
S4-Y	91.14	0	911.4
S4-Z	0	48.51	485.1(-)
S5-X	60.06	0	1801.8
S5-Y	19.24	37.00	1110.0(-)
S6-X	0	57.20	1716.0(-)
S6-Y	75.40	0	2262.0
R-2 Record			
S7-Y	0	20.70	207.0(-)
S7-Z	33.60	1.40	336.0
S8-X	1.36	17.68	530.4(-)
S8-Y	0	17.94	538.2(-)
S9-X	100.74	0	3022.2
S9-Y	22.95	12.15	688.5
S10-Y	0	61.61	616.1(-)
S10-Z	1.37	16.44	164.4(-)
S11-X	0	67.62	2028.6(-)
S11-Y	23.29	13.70	698.7

NOTE: (+) Indicates trace deflection upwards on record. (-) Indicates
Downward deflection.

Table 2



TABLE 3

**Maximum Strains Imposed During Downward-Load Test,
Utility Van Test Phase 2**

Functions	Maximum Strain (Micro in./in.)		Stress (psi)
	(+)	(-)	
S1-X	0	46.08	1382.4(-)
S1-Z	18.85	31.90	957.0(-)
S2-XY	0	307.34	9220.2(-)
S2-YX	50.40	0	1512.0
S3-Y	14.60	33.58	335.8(-)
S3-Z	No. Calibration Available		- - - -
S4-Y	224.51	14.30	2245.1
S4-Z	18.24	41.04	410.4(-)
S5-X	0	74.97	2249.1(-)
S5-Y	58.80	19.11	1764.0
S6-X	0	260.19	7805.7(-)
S6-Y	79.38	155.82	4674.6(-)
R-2 Record			
S7-Y	No Trace on Record		- - - -
S7-Z	12.69	19.74	197.4(-)
S8-X	0	26.22	786.6(-)
S8-Y	14.70	2.94	441.0
S9-X	72.61	0	2178.3
S9-Y	119.85	11.28	3595.5
S10-Y	6.90	19.32	193.2(-)
S10-Z	0	45.87	458.7(-)
S11-X	20.85	0	625.5
S11-Y	0	27.93	837.9

NOTE: (+) Indicates upward deflection on the record, (-) Indicates
Downward deflection.

Table 3



TABLE 4

Maximum Strains Imposed During Side-Load Test,
Utility Van Test Phase 3

Function	Maximum Strain (Micro in./in.)		Stress (psi)
	(+)	(-)	
S1-X	5.76	14.40	432.0(-)
S1-Z	0	24.31	729.3(-)
S2-XY	0	21.75	652.5(-)
S2-YX	102.48	29.28	3074.4
S3-Y	88.80	7.40	888.0
S3-Z	50.05	54.34	543.4(-)
S4-Y	172.50	12.00	1725.0
S4-Z	49.50	49.50	495.0
S5-X	0	14.70	441.0(-)
S5-Y	36.00	4.50	1080.0(-)
S6-X	60.90	62.35	1870.5(-)
S6-Y	40.88	48.78	1445.4(-)
R-2 Record			
S7-Y	99.36	107.64	1076.4(-)
S7-Z	14.00	77.0	770.0(-)
S8-X	29.92	35.36	1060.8(-)
S8-Y	39.20	30.80	1176.0
S9-X	142.80	0	4284.0
S9-Y	0	29.70	891.0
S10-Y	0	63.00	630.0(-)
S10-Z	0	75.90	759.0(-)
S11-X	13.60	29.92	897.6(-)
S11-Y	13.70	52.06	1561.8(-)

NOTE: (+) Indicates trace deflection upward on record. (-) Indicates downward deflection.

Table 4



TABLE 5

Deflection and Recovery Measurements, Phase 2,
Utility Van Test*

<u>LOCATION</u>	<u>PRE LOAD</u>	<u>AT LOAD</u>	<u>POST LOAD</u>
1	4.062	4.0	4.0
2	4.562	3.75	4.312
3	4.312	3.625	4.562
4	4.312	3.375	4.562
5	4.437	3.562	4.75
6	4.187	3.50	4.50
7	4.00	3.50	4.062
8	3.75	3.625	4.68
9	.000	.637	.25
10	.000	.879	.25
11	.000	.355	.039
12	.000	.467	.0625
Kt Bag Press	25#	90#	30#
Lt Bag Press	20#	70#	17#

* Measurements, in inches, show variations between van sub-frame and
reference datum lines

Table 5



TABLE 6

Deflection and Recovery Measurements, Phase 3,
Utility Van Test.*

<u>LOCATION</u>	<u>PRE LOAD</u>	<u>AT LOAD</u>	<u>POST LOAD</u>
1	4.42	7.625	4.50
2	4.73	7.75	4.81
3	5.06	7.93	5.12
4	5.50	8.125	5.43
5	4.72	3.109	5.68
6	5.12	2.84	5.12
7	5.75	2.75	4.68
8	4.25	2.67	4.25
9	0.0955	0.25	0.810
10	0.094	0.07	0.356
11	9.0	7.75	8.93
12	9.0	7.875	8.68
13	0.074	0.310	0.124
14	0.073	0.201	0.082
Rt Bag Press	75#	0#	60#
Lt Bag Press	75#	20#	65#

* Measurements, in inches, show variations between van sub-frame and reference datum lines

Table 6

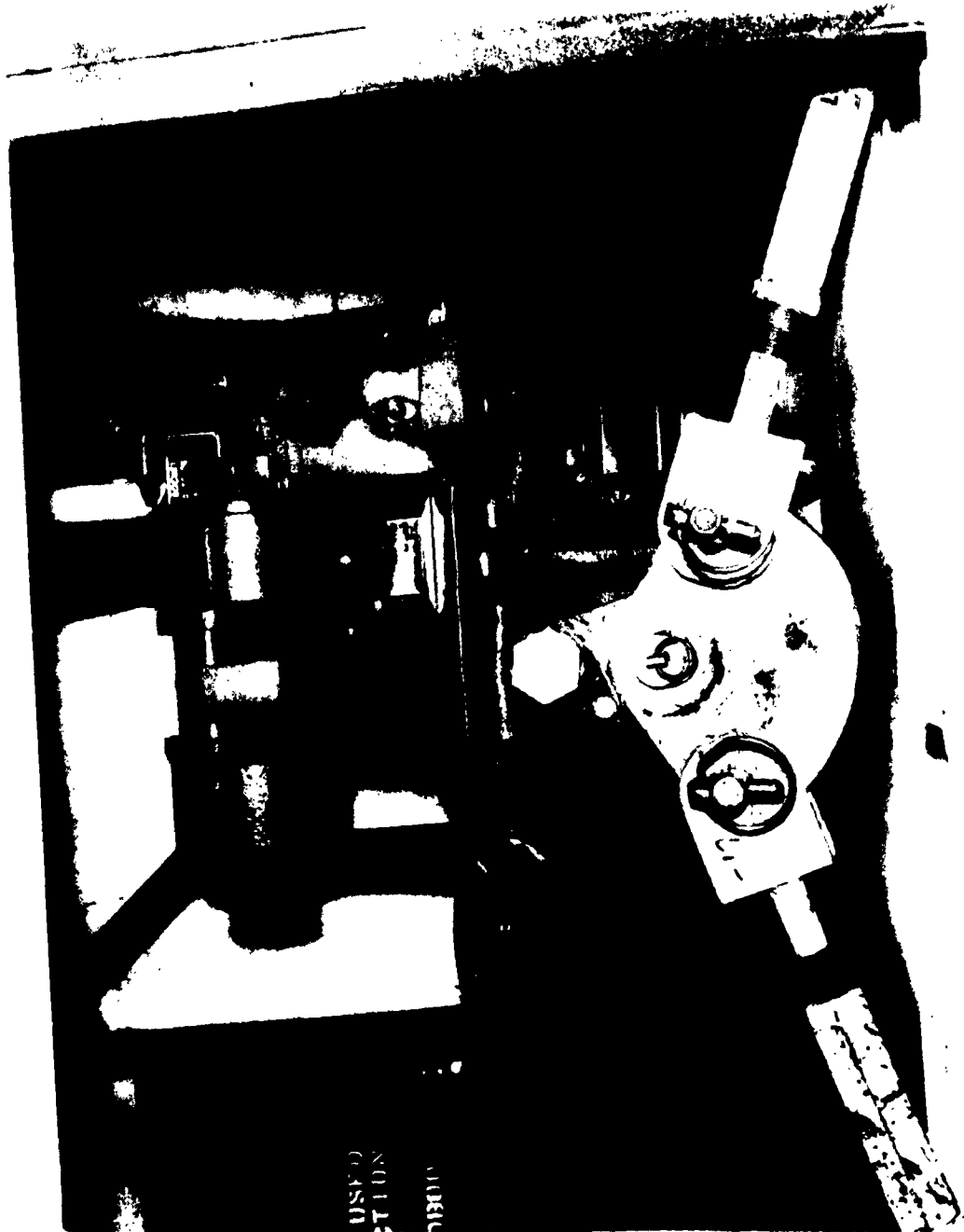




Aerojet Utility Van in Test Stand

Figure 1





Motor-Harness Tie-Down Attached to Boeing Harness

Figure 2



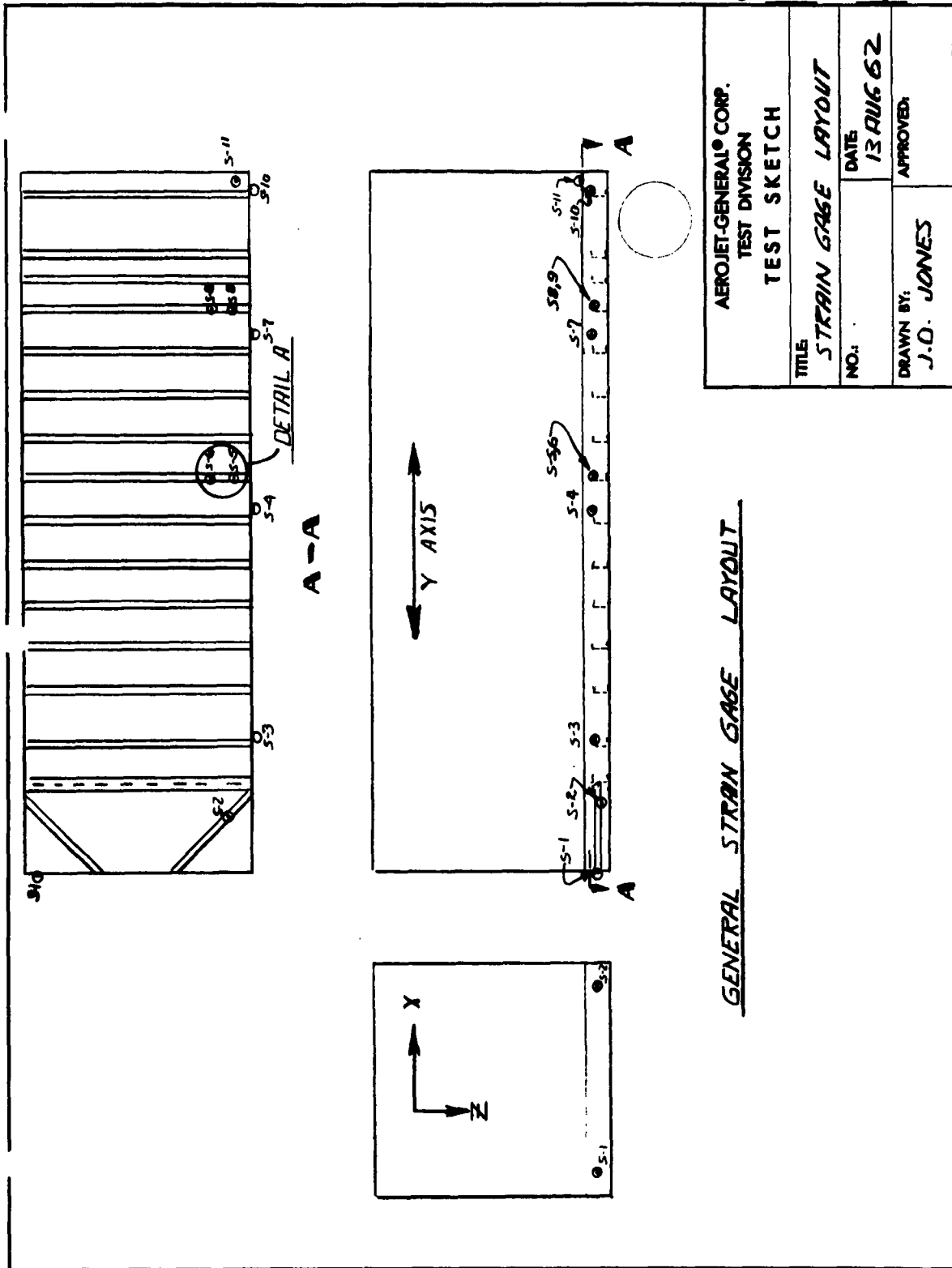
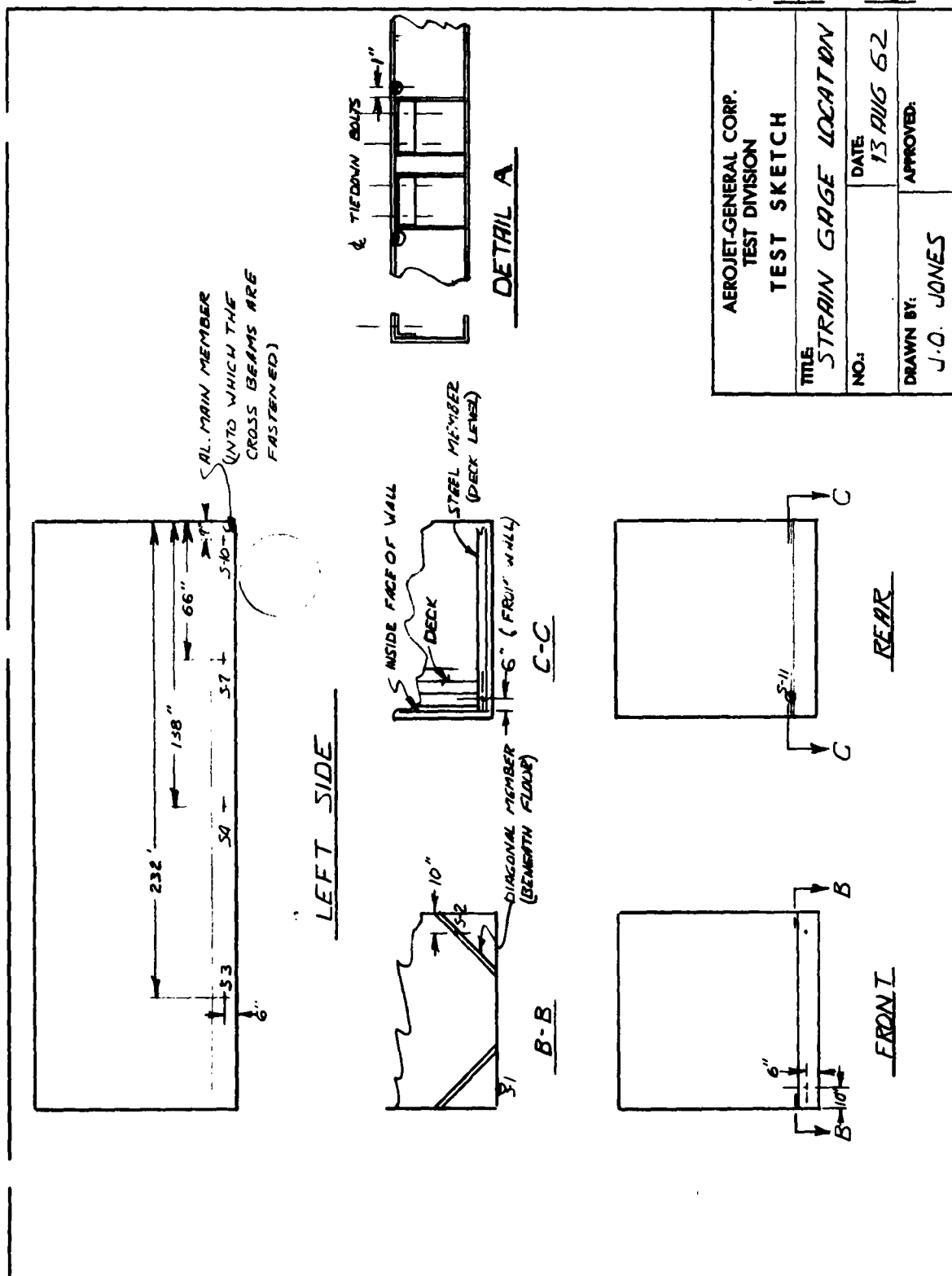


FIGURE 1

Figure 3

Location of Strain Gages on Utility Van, X, Y, and Z Axis





AC-1.206A PRINTED ON DISPO NO. 105-13 CLEARPRINT FASE-OUT

Detail of Strain-Gage Locations

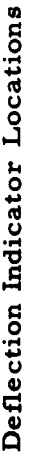
Figure 4

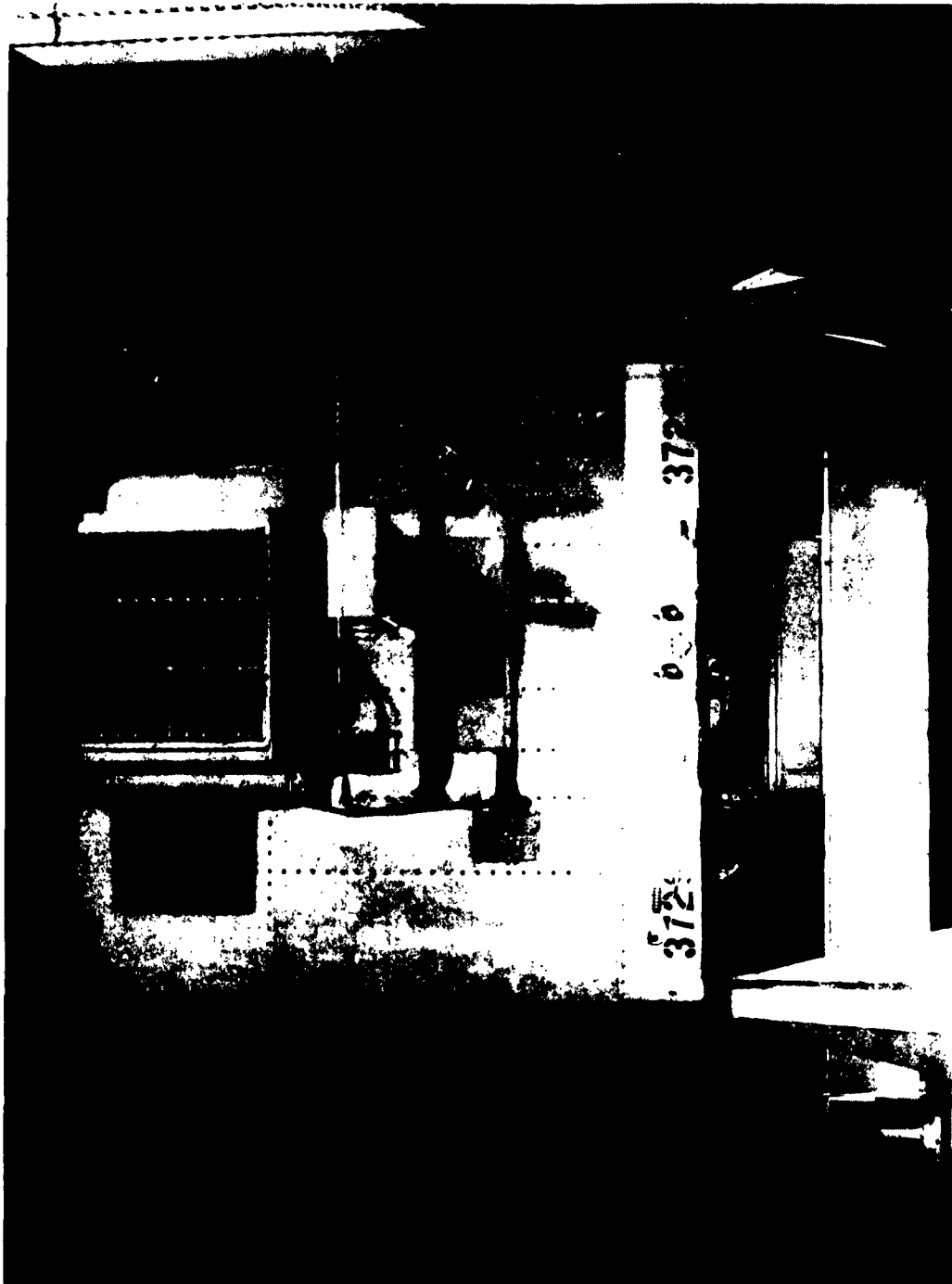




Wiring Detail of Six Strain-Gage Locations

Figure 5





Forward View of Utility Van in Test Stand

Figure 7





Method of Applying Forward and Aft Loads

Figure 8





Cross Beams Extending Through Van Access Doors,
Downward-Load Test

Figure 9





Side View of Test Setup, Downward-Load Test

Figure 10

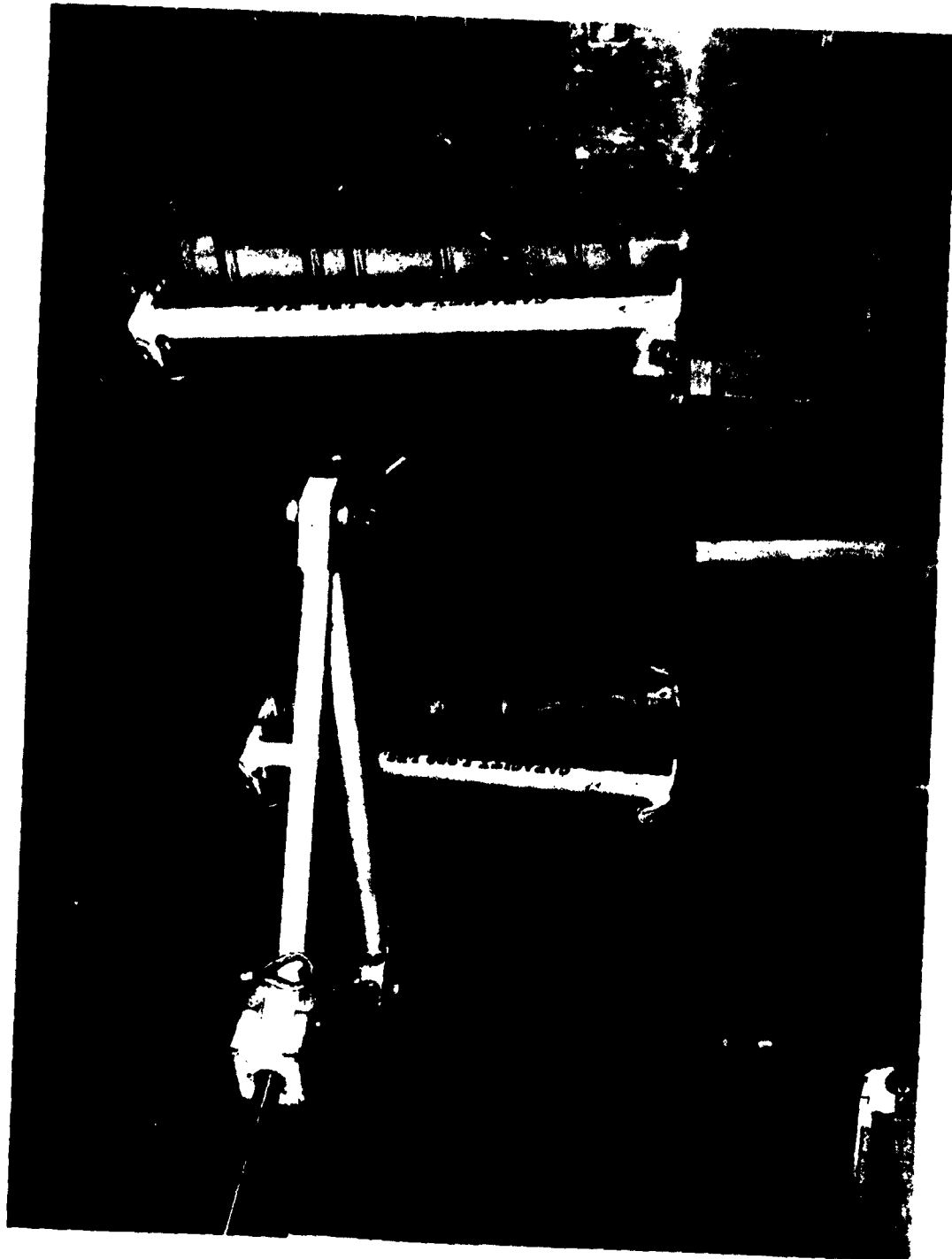




Hydraulic Load Actuator With Load-Measuring Device,
Side-Load Test

Figure 11





Arm Extension of Hydraulic Load Actuator, Side-Load Test

Figure 12



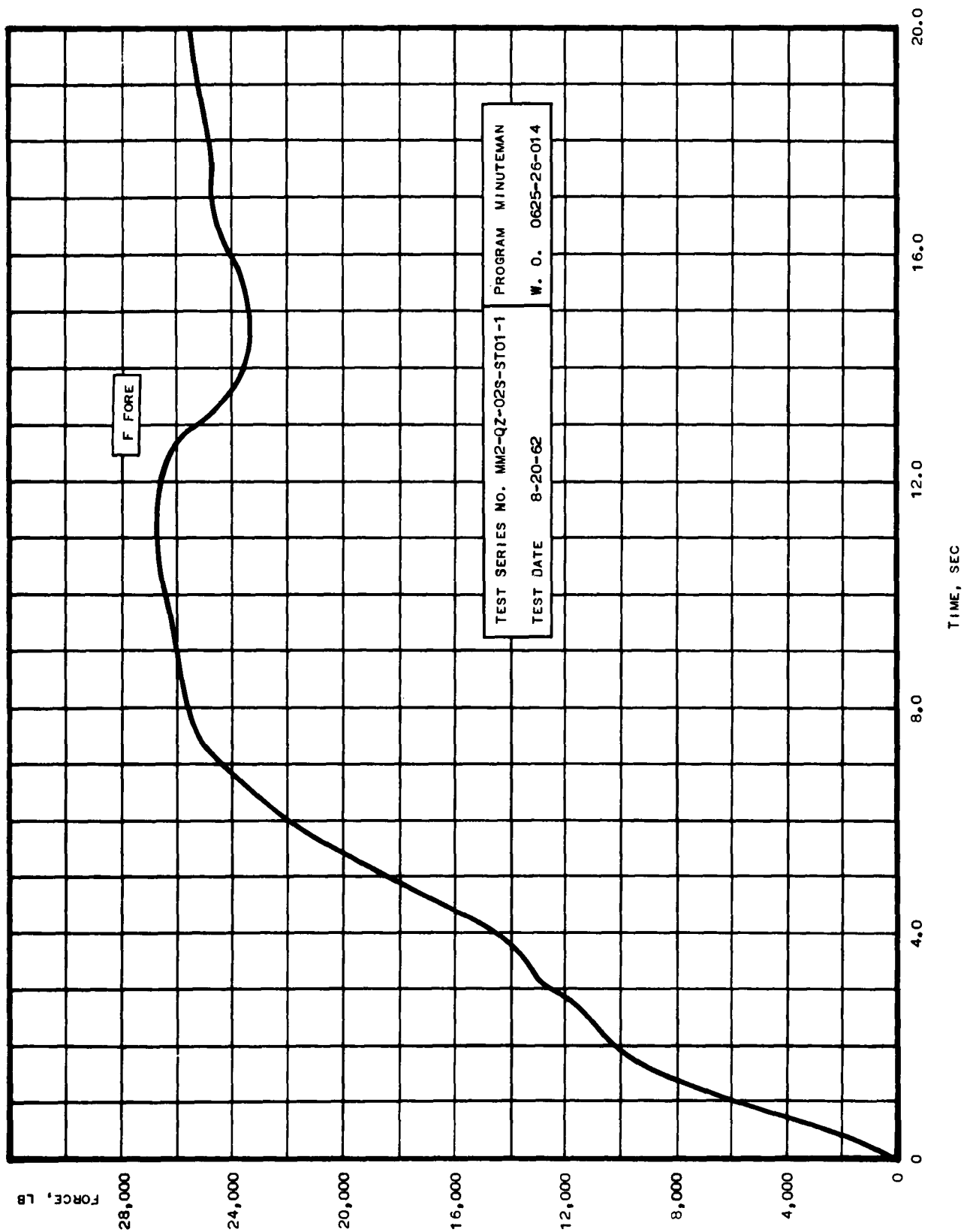


Motor-Belt Attachment to Load Actuator, Side-Load Test

Figure 13



RUN 1, PHASE 1



Load vs Time, Forward-Load Test

Figure 14



RUN 2, PHASE 1

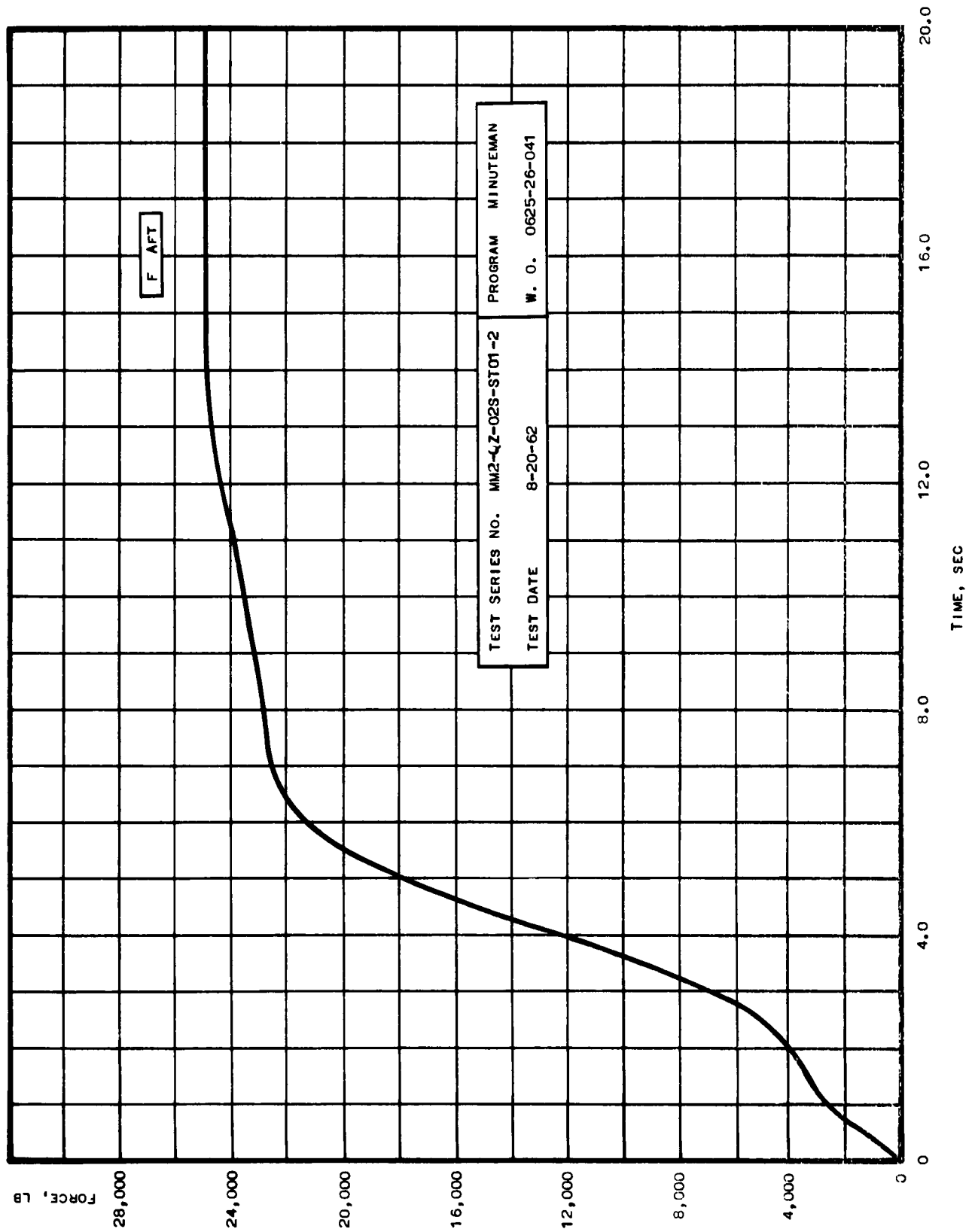
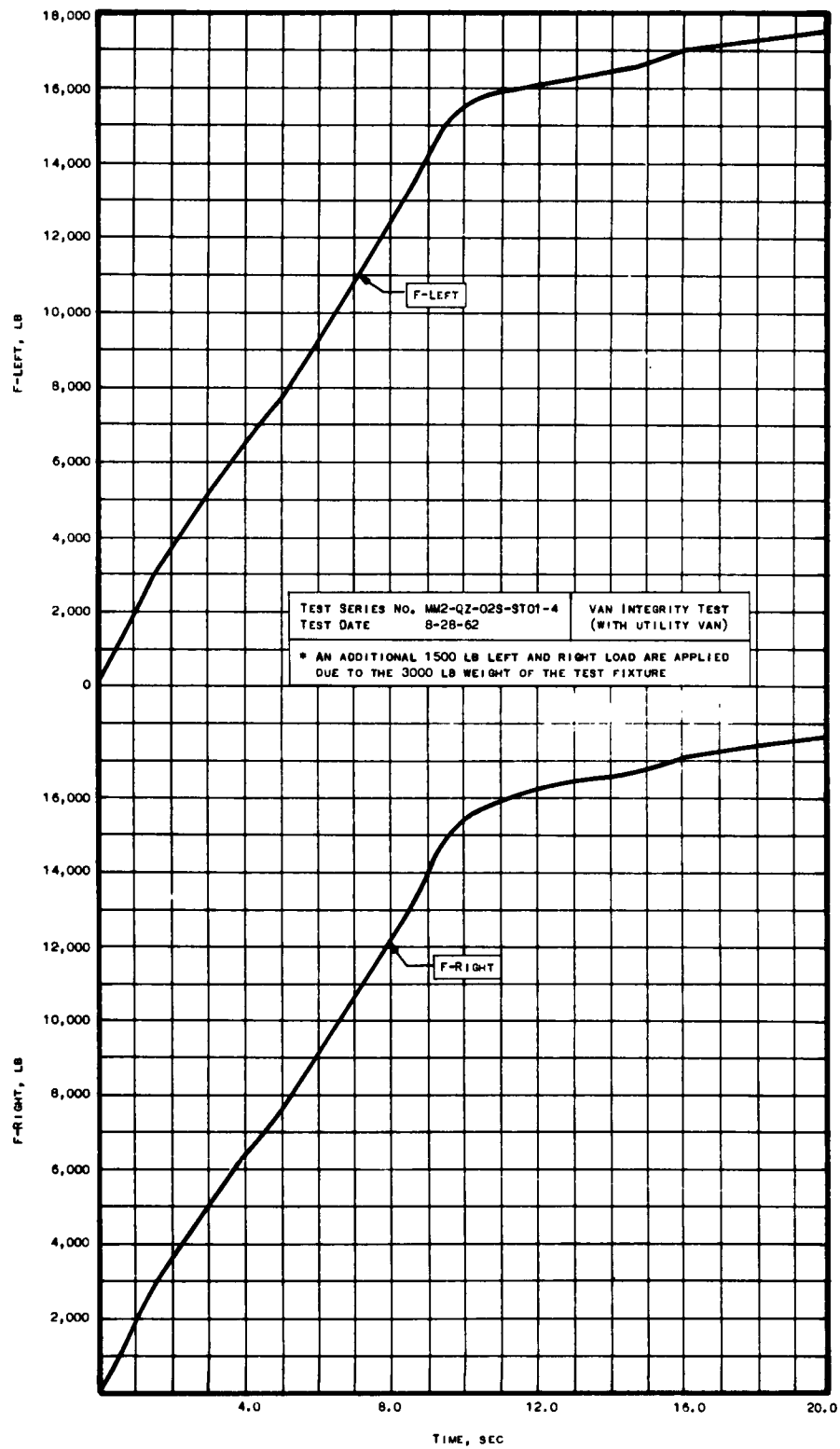


Figure 15

Load vs Time, Aft-Load Test



Load vs Time, Downward-Load Test

Figure 16

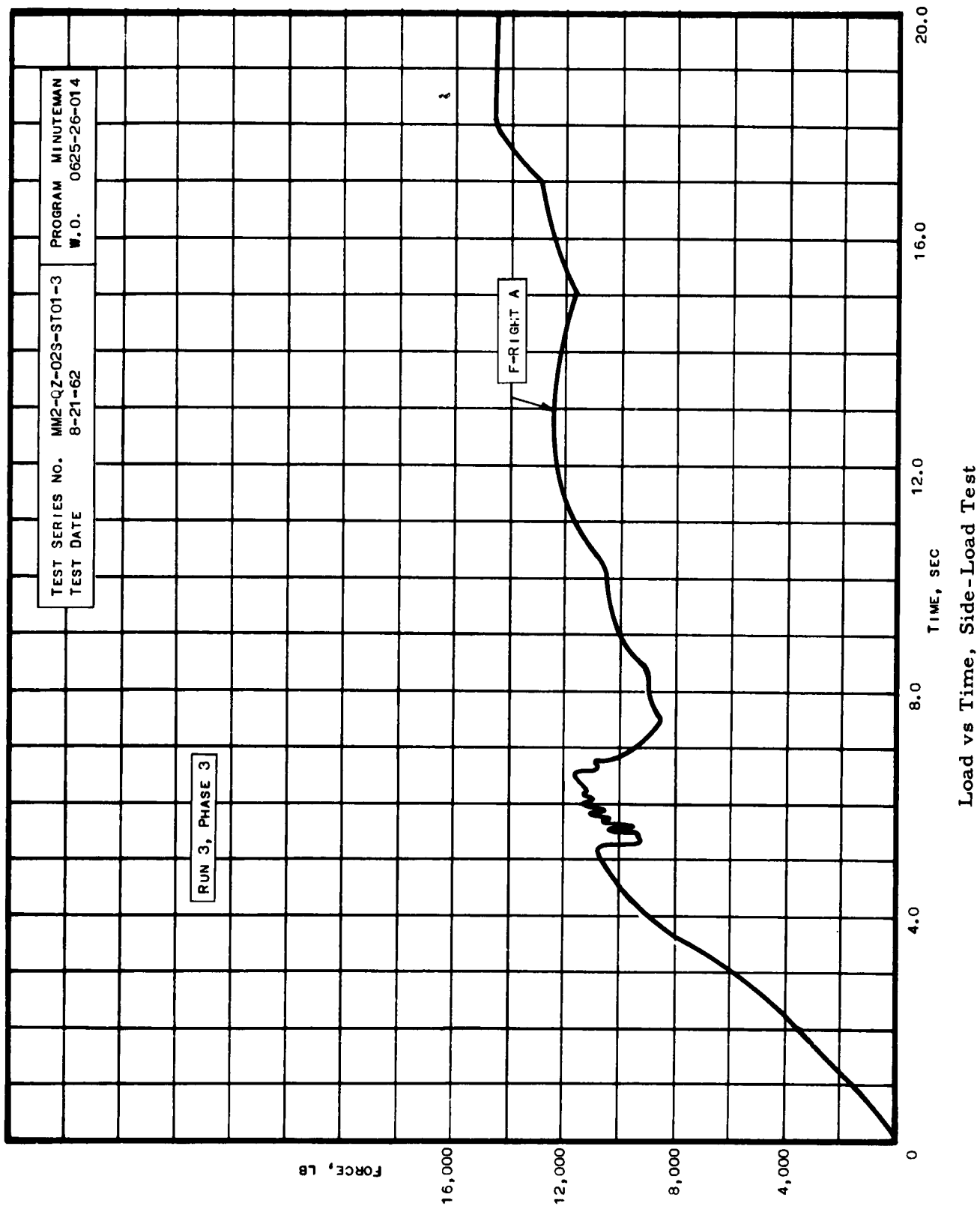


Figure 17

APPENDIX A

DOCUMENTATION OF TESTING

AND INSPECTION



AERJET-GENERAL CORPORATION
SOLID ROCKET PLANT
SACRAMENTO, CALIF.

MINUTEMAN INTEGRATED PLANNING RECORD

TITLE Structural Verification of AGC Utility Van

ENGINE NO. 44-TR1 SERIAL NO. 519578

Utility Van, VR-1152A, S/N ~~37895~~ 37291

ENGINEERING INSTRUCTION CHANGES

No Engineering Changes

APPROVED:

PROJECT

* LINE 1

* SAFETY

* WHEN REQUIRED

Jack W. Lake

APPROVED: INSPECTION
PLANNING

Ernest A. L. Leland

CODE 101	MES NO. HT-64	DATE 20 Aug 62	PAGE OF 1/1	MFR NO. 1
PREV. MES	NEXT MES		N.A.	
APPLICABLE DWGS.: T-492674A (Utility Van) T-430460 T-430467 APPLICABLE SPECS.: Test Plan 751A				
OP. INIT.	INSPECTION SUMMARY CHANGES		INSP. STAMP	DATE AND REMARKS
NA	No Inspection Changes 5.4.11 } ADDED, SEE 5.4.12 } PP. 10, 12 5.4.13 } 5.4.14 } ADDED, SEE 5.4.16 } PP. 12.			

AEROJET GENERAL CORP. SOLID ROCKET PLANT SACRAMENTO CALIF.		MEIS NO. HT- 64	ISSUE DATE 17 August 1962	PAGE 1 OF 18
MINUTEMAN		TITLE Utility Van Environmental Verification (STRUCTURAL)		
ENGINEERING AND INSPECTION SUMMARY		ENGINE NO. 44TR-1 Utility Van SERIAL NO. 519578 S/N 372981		
ENGINEERING INSTRUCTIONS		OF. INIT.	INSPECTION SUMMARY	REMARKS AND DATE
1. After completion of each step disclosed in the Engineering Instructions of the MEIS, the assigned Test Engineer or Technicians shall apply his initials in the column provided. 2. During actual operation, revisions to Testing Requirements contained in the MEIS will be made on the MIPR. Changes will be initiated by the cognizant test engineer. All entries on the MIPR should be made in a legible fashion with black ink. In no case shall the MEIS be altered except for recording the required data as requested. 3. When the MEIS is complete the assigned test engineer shall apply his signature in the space provided. The completed MEIS will then be forwarded to the Aerojet-General Quality Control Department. 4. Notify Inspection before proceeding with paragraphs marked with a double asterisk (**). Inspection disposition of previous or current operations required.		INSPECTOR: When a characteristic of this summary is not complied with, initiate an I.R. and record its number in the remarks column. Record on the I.R. the information that is necessary to give a complete description of the discrepancy. This information should include the methods and/or the materials used such as pressures, cure times, temperatures, weights, bonding agents and substitute materials. <u>INDICATION OF INSPECTION ACCEPTANCE</u> 1. Date and Stamp off related operations on AGC 3-109-439-2 and/or AGC 3-109-432-2 traveler tag. 2. Stamp off each characteristic of this summary as it is complied with. 3. Forward completed integrated planning to Line One (1) Inspection Office. NOTE: THIS INTEGRATED PLANNING IS NOT VALID AND SHALL NOT BE USED BY INSPECTION UNLESS COVER PAGE (MIPR) AGC 3-053-032, IS APPROVED BY INSPECTION PLANNING. EACH PAGE OF THE MEIS SHALL HAVE THE APPROVAL OF INSPECTION PLANNING AND QUALITY CONTROL ENGINEERING.		



MINUTEMAN ENGINEERING AND INSPECTION SUMMARY		CODE 101	MEIS NO. HT-64	ISSUE DATE 17 August 1962	PAGE 2 OF
ENGINEERING INSTRUCTIONS		OP. INIT.	INSPECTION SUMMARY		REMARKS AND DATE
1.0 Scope					
1.1 This Minuteman Engineering and Inspection Summary covers the Engineering and Inspection requirements necessary to verify the structural integrity of the utility van and tie-down equipment under limit loads, prior to qualification of the 2nd Stage Minuteman Transporter (Utility Van) for operational use.					
2.0 References Required					
2.1 Test Plan 751A, AGC Minuteman Division.					
2.2 Drawing T-492674A, Trailer, Transport, 44" motor.					
2.3 Contract change notification #182 to L. C. SALL to AF 33(600)-36610.					
2.4 Applicable drawings, sketches, specifications and procedures in accordance with Page 1 of attached MIPR.					
3.0 Items to be Tested					
3.1 AGC 2nd Stage Minuteman Transporter, T-492674. S/N to be specified on the attached MIPR. Installed in the transporter is an inert 2nd Stage Minuteman Motor, 44TR-1, S/N 519578.					
3.2 Boeing Operational Harness, P/N 25-18032.					
			2.0 All references used corresponds with number, Change letter or Revision listed on MIPR. Method: Visual		

MINUTEMAN ENGINEERING AND INSPECTION SUMMARY		CODE 101	MRIS NO. HT-64	ISSUE DATE 17 August 1962	PAGE 3 OF	REMARKS AND DATE
ENGINEERING INSTRUCTIONS		OP. INIT.	INSPECTION SUMMARY		INSP. STAMP	
4.0	Test Equipment Required	MEH				
4.1	T-430460 (Basic loading fixture)	MEH				
4.2	T-430467 (Side loading adapters)	MEH				
4.3	2 ea. 20K load cell	MEH				
4.4	1 ea. 50K load cell	MEH				
4.5	1 ea. 50K Servo-controlled Hydraulic Actuator	MEH				
4.6	2 ea. 20K Servo-controlled Hydraulic Actuator	MEH				
4.7	1 ea. 50K B-L-H Mono-Axial Assy.	MEH				
4.8	2 ea. 4-jaw Vene-Axial Assy.	MEH				
4.9	Thrust adapters as required.	MEH				
4.10	Hydraulic supply system.	MEH				
4.11	2 ea. dial indicators (3" stroke)	MEH				
4.12	Mechanics rule.	MEH				
4.13	Eleven (11) B-L-H Type A5X strain gages.	MEH				
4.14	Oscillographs as required.	MEH				
4.15	Miscellaneous hand tools as required.	MEH				
5.0	Engineering Requirements	MEH				
5.1	Pre-Test Preparations.	MEH				
5.1.1	Initial inspection of components.	MEH				
5.1.1.1	List S/N of the following.	MEH				
5.1.1.1.1	Utility Van 342874	MEH				
5.1.1.1.1.1	Verify transporter P/N of transporter agrees with S/N listed on MIPR.	MEH				
5.1.1.1.1.1.1	Method Visual: Record S/N 37291	MEH				

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5.1.1.1.2 BAC Harness <u>0000016</u>		<i>MDH</i>	5.1.1.2.2 Verify Boeing operational harness P/N is 25-18032. Method: Visual: Record S/N <u>666666</u>		<i>(A)</i>	
5.1.1.1.3 Inert 1/4" Motor <u>TR-1</u>		<i>MDH</i>	5.1.1.1.3.3 Verify inert motor is <u>WTR-1 S/N 519578</u> . Method: Visual: ... <u>TA(1)</u>			
5.1.1.1.2 Inspection of general condition of van, motor, and harness. (List any discrepancies.)		<i>MDH</i>	5.1.1.1.2 Motor, Van, and Harness, free of any apparent physical damage or deformation. Method: Visual		<i>(A)</i>	
5.1.1.1.3 Verify tie-down and motor/harness installation per acceptable MEIS (line 1) and inspection buy off on same accomplished.		<i>MDH</i>	5.1.1.1.4 Verify all components are security installed. Method: Visual			
5.1.1.1.4 Verify security at all tie-down points.		<i>MDH</i>	5.1.1.1.4 Strain gages installed per Test Plan 751A. Method: Visual		<i>(A)</i>	
5.1.2 Instrumentation.		<i>MDH</i>				
5.1.2.1 Install (11) Type A5X (or equiv.) strain gages at locations as called out in Test Plan 751A.		<i>MDH</i>			<i>(A)</i>	
5.1.2.1.1 Method of installation per standard Test Area practices.		<i>MDH</i>				
5.1.2.1.2 Verify satisfactory calibration and operation of each gage.		<i>MDH</i>			<i>(A)</i>	
5.1.2.1.3 List strain-gage number by actual designation and van location. (Attach sketch if required.)		<i>MDH</i>				

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5.1.2.1.4 List S/N and range of load cells used. Forward S/N <u>22166</u>, <u>50K</u> # Side S/N <u>18481</u>, <u>20K</u> # Down S/N <u>15681</u>, <u>20K</u> # <u>18481</u> #, <u>20K</u> #		<i>mtt</i>	5.1.2.1.4 Verify load cells have acceptable calibration and record S/N, P/N, and due date. Forward S/N <u>22166</u>, P/N <u>50K</u> Due date <u>11-2-62</u> Side S/N <u>18481</u>, P/N <u>20K</u> Due date <u>11-2-62</u> Down S/N <u>15681</u>, P/N <u>20K</u> Due date <u>11-2-62</u> (Order) S/N <u>18481</u>, P/N <u>20K</u> Due date <u>11-2-62</u>		8-20-62
5.1.3 Facility preparation. 5.1.3.1 Install basic test fixture, T-430460-202, -204, and -205. 5.1.3.2 Position van within center-line of basic fixture. 5.1.3.3 Holding fore end of van in air with overhead crane, install fifth wheel support fixture. 5.1.3.4 Lower van to fifth wheel support. Verify secure connection made.		<i>mtt</i> <i>mtt</i> <i>mtt</i> <i>mtt</i> <i>mtt</i>	Method: Visual		



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5.1.3.5 Verify wheels of van (inside) are against transverse restraint blocks.	<i>met</i>				
5.1.3.6 Install wheel tie-down cables. Tighten until no slack is apparent.	<i>met</i>				
5.2 Forward Loading Test.	<i>met</i>				
5.2.1 Tripod, T-430460-401, installed on aft end of inert motor. Verify (24) 1/4-24 bolts torqued.	<i>met</i>				
5.2.2 50K mono-axial assy. installed on tripod.	<i>met</i>				
5.2.3 50K load cell assembled to mono-axial assy.	<i>met</i>				
5.2.4 50K servo-controlled hydraulic actuator installed on cross beam, T-430460-205.	<i>met</i>				
5.2.5 Load cell to actuator connection made. Verify correct alignment. ($\pm 1/16"$ from level per 12".)	<i>met</i>				
5.2.6 Hydraulic lines connected to actuator.	<i>met</i>				
5.2.7 Verify satisfactory operation of system with 1000# loading. (15 sec. duration)	<i>met</i>				
5.2.8 Review and approve oscillograph record of functional checkout. (Re-range if necessary.)	<i>met</i>	5.2.8 Verify all Recording equipment has acceptable calibration. Method: Visual			8-20-62

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5.2.9	Take still photos of the test setup, showing motor, test hardware, and instrumentation.	<i>mtk</i>	5.2.9 Verify still photos taken prior to test of the following: Test setup Motor Test hardware Instrumentation Method: Verify per photograph setup. Method: Verify per photographer		<i>mtk</i>	8-20-62
5.2.10	Verify motion picture setup ready.	<i>mtk</i>				
5.2.11	Verify all interested people are present, or have been notified.	<i>mtk</i>				
	Test Coord. <u>5809</u> (Neesham)					
	Project <u>3856</u> (Halebsky)					
	STL <u>3856</u>					
	Structures <u>3939</u> (Heip)					
	Inspection <u>2565</u>					
5.2.12	Verify instrumentation ready.	<i>mtk</i>				
5.2.13	Apply forward load (+Fy) of 26,000 lbf (2200#), through CG of motor. This load to be applied within five (5) seconds.	<i>mtk</i>				
	<u>2100</u> F.S. (time) <u>26,000#</u> (time)					
5.2.14	Hold the 26,000 lbf load for five (5) minutes.	<i>mtk</i>				
	<u>2100</u> Start Time <u>2105</u> Finish					
5.2.15	Inspect motor, harness, tie-downs and van for any evidence of structural failure or deformation. List below any discrepancies.	<i>mtk</i>	5.2.15 Motor, Van, and Harness free of any apparent physical damage. Method: Visual		<i>mtk</i>	8-20-62

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5.2.16 Review data and approve before continuing next test. 5.3 Aft Loading Test (Py) 5.3.1 Verify items 5.2.1 through 5.2.11 completed and re-checked. 5.3.2 Apply aft load of 26,000 lbf (±200#) through CG of motor. Load to be applied within 5 seconds. 2200 P.S. (time) 26,000# (time) 5.3.3 Hold the 26,000 lbf load for five (5) minutes. 2200 Start Time 2205 Finish 5.3.4 Inspect motor, harness, tie-downs, and van for any evidence of structural failure or deformation. List below any discrepancies. NOTE: Condition of king-pin must be inspected carefully as all loads are re-acted here.	MMH MMH MMH MMH MMH MMH MMH	5.3.4 Motor, Van, and Harness free of any apparent physical damage. Method: Visual			8-20-62

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5.3.5	Inspection of all equipment completed and approval given to proceed to next test.	<i>MPH</i>				
5.3.6	All fore and aft loading equipment dismantled.	<i>MPH</i>				
5.4	Side Loading Test (F_s)	<i>MPH</i>				
5.4.1	Pre-test preparations.	<i>MPH</i>				
5.4.2	20K servo-controlled hydraulic actuator installed on T-703343 Rucker test stand.	<i>MPH</i>				
5.4.3	20K load cell assembled to 20K actuator arm.	<i>MPH</i>				
5.4.4	20K B-L-H mono-axial assy. connected to load cell.	<i>MPH</i>				
5.4.5	Loading yolk and belt assy., T-430467 installed on motor and connected to mono-axial assy.	<i>MPH</i>				
5.4.5.1	Verify alignment and security of force transfer members.	<i>MPH</i>				
5.4.6	Re-check motor/harness/tie-down security.	<i>MPH</i>				
5.4.7	Take still photos of the test setup.	<i>MPH</i>				
5.4.8	Verify readiness of the motion picture setup.	<i>MPH</i>				
5.4.9	Verify instrumentation is ready.	<i>MPH</i>				
			5.4.7 - Verify still photos taken of test set-up. Method: Verify per photographer			8-20-62
			5.4.8 Verify motion pictures cameras setup. Method: Verify per photographer			9-20-62

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ENGINEERING INSTRUCTIONS		OP. INIT.	INSPECTION SUMMARY	REMARKS AND DATE																																																																			
5.h.10 Service a'r-bag suspension system to 80-100 ps'. List actual pressure below. 90 PSI 5.h.11 Pre-test reflection measurements taken. NOTE: List all measurements here. (Distance from reference plane) <table border="1"> <thead> <tr> <th>Location</th> <th>Pre-Test</th> <th>At-Load</th> <th>Post-Test</th> </tr> </thead> <tbody> <tr><td>1</td><td>4.42</td><td>7.625</td><td>4.50</td></tr> <tr><td>2</td><td>4.73</td><td>7.75</td><td>4.81</td></tr> <tr><td>3</td><td>5.06</td><td>7.93</td><td>5.12</td></tr> <tr><td>4</td><td>5.50</td><td>8.125</td><td>5.43</td></tr> <tr><td>5</td><td>4.72</td><td>3.109</td><td>5.68</td></tr> <tr><td>6</td><td>5.12</td><td>2.84</td><td>5.12</td></tr> <tr><td>7</td><td>5.75</td><td>3.75</td><td>4.68</td></tr> <tr><td>8</td><td>4.25</td><td>3.67</td><td>4.25</td></tr> <tr><td>9</td><td>0.0955</td><td>0.25</td><td>.816</td></tr> <tr><td>10</td><td>0.094</td><td>0.07</td><td>.356</td></tr> <tr><td>13 Axle</td><td>0.074</td><td>.10</td><td>.124</td></tr> <tr><td>14 Axle</td><td>0.073</td><td>.001</td><td>.082</td></tr> <tr><td>Air Bag (R)</td><td>7.5</td><td>0</td><td>.80</td></tr> <tr><td>Pres. (L)</td><td>7.5</td><td>20</td><td>.65</td></tr> <tr><td>11</td><td>9.0</td><td>7.75</td><td>8.93</td></tr> <tr><td>12</td><td>9.0</td><td>7.875</td><td>8.68</td></tr> </tbody> </table>		Location	Pre-Test	At-Load	Post-Test	1	4.42	7.625	4.50	2	4.73	7.75	4.81	3	5.06	7.93	5.12	4	5.50	8.125	5.43	5	4.72	3.109	5.68	6	5.12	2.84	5.12	7	5.75	3.75	4.68	8	4.25	3.67	4.25	9	0.0955	0.25	.816	10	0.094	0.07	.356	13 Axle	0.074	.10	.124	14 Axle	0.073	.001	.082	Air Bag (R)	7.5	0	.80	Pres. (L)	7.5	20	.65	11	9.0	7.75	8.93	12	9.0	7.875	8.68	5.h.11 VERIFIED OK DEFLECTION MEASUREMENTS Method: Visual	8-21-2
Location	Pre-Test	At-Load	Post-Test																																																																				
1	4.42	7.625	4.50																																																																				
2	4.73	7.75	4.81																																																																				
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5.4.19 If results of 5.4.17 and 5.4.18 are satisfactory, dismantle test setup and ship van to Bldg. 48 Line 1. Test Comp. <u>1900</u> Time <u>8-21-62</u> Date	<i>hct</i>				
5.5 Downward (Ex) Loading Test. 5.5.1 Pre-test preparations. 5.5.1.1 Initial inspection.	<i>mtf</i>				
5.5.1.1.1 Van arrives back in SRPTA @ <u>0900</u> hrs. <u>6-22-62</u> date.	<i>mtf</i>	5.5.1.1.1 Verify still photos taken of test setup. Method: Verify per photographer	(A) 103	8-28	
5.5.1.1.2 King pin, rails, air suspension, and van general condition checked and found to be O.K. (or list discrepancies below.	<i>hct</i>	5.5.1.1.2 Verify motion picture cameras setup. Method: Verify per photographer	(A) 103	8-28	
5.5.1.2 Van positioned in test fixture	<i>mtf</i>				
5.5.1.3 Fifth wheel hook-up made and verified secure.	<i>mtf</i>				
5.5.1.4 Wheel tie-downs installed.	<i>hct</i>				

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5.5.1.5	Instrumentation hook-up initiated.	<i>init</i>			
5.5.1.6	T-430460-302, -306 simulated wheels and loading beams installed	<i>init</i>			
	Fore	<i>init</i>			
	Aft	<i>init</i>			
5.5.1.7	Longitudinal load transfer beams, T-430460-301, assembled to -302 beams.				
	Right	<i>init</i>			
	Left	<i>init</i>			
5.5.1.8	20K mono-axial assy., load cell, and hydraulic actuator installed on each side.				
	Right	<i>init</i>			
	Left	<i>init</i>			
5.5.1.8.1	Verify identical setup and pre-load on each side (to prevent un-equal loading)	<i>init</i>			
5.5.1.9	Install hydraulic lines to actuators.				
	Right	<i>init</i>			
	Left	<i>init</i>			

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5.4.12 Apply side load ($-F_s$) of 13,000 lbf ($\pm 100\#$), through motor CG. Apply within five (5) seconds. 11:45 P.S. (time) 1145 13,000# (time) 5.4.13 Hold the 13,000 lbf side load for five minutes. 1145 start time. 5.4.14 After two (2) minutes of static load, take van deflection measurements and record in 5.4.11. 5.4.15 Release the load after five (5) minutes. 1150 completion time. 5.4.16 Take recovery measurements and record in 5.4.11. 5.4.17 Inspect motor, harness, tie-downs, and van for any evidence of structural failure or deformation. List any discrepancies. 5.4.18 Review data and ascertain all test objectives accomplished.	MPH MPH MPH MPH MPH MPH MPH	5.4.12 13,000 lbf side load applied through motor CG. Apply within five (5) seconds. 5.4.13 13,000 lbf side load held for five minutes. 5.4.14 Van deflection measurements taken and recorded in 5.4.11. 5.4.15 Load released after five (5) minutes. 5.4.16 Recovery measurements taken and recorded in 5.4.11. 5.4.17 Motor, Van, and Harness free of any apparent physical damage. Method: Visual	(7A) (130) (7A) (130) (7A) (130) (7A) (130) (7A) (130) (7A) (130) (7A) (130)	8 21	

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5.5.1.1.10 Verify, by low-pressure functional check, equal loading rate at each side.		<i>hcn</i>				
5.5.1.1.11 Take still photos of the test setup.		<i>hcn</i>				
5.5.1.1.12 Verify movie setup ready.		<i>hcn</i>				
5.5.1.1.13 Verify instrumentation ready.		<i>hcn</i>				
5.5.1.1.14 Verify all interested parties present or notified.		<i>hcn</i>				
5.5.1.1.15 Service air-bags to 80-100 psi - record actual pres. below.		<i>hcn</i>				
5.5.1.1.16 Take pre-test deflection measurements. Record below (Distance from reference)		<i>hcn</i>				
Location	Pre-Test	At-Load	Post-Test			
1	4.062	4.00	4.6			
2	4.562	3.75	4.32			
3	4.312	3.625	4.562			
4	4.312	3.375	4.562			
5	4.437	3.562	4.75			
6	4.187	3.50	4.50			
7	4.00	3.50	4.062			
8	3.75	3.637	4.68			
9 Forward	.666	.879	.25			
10 Aft	.666	.879	.25			
AXLE A	.666	.879	.25			
AXLE B	.666	.879	.25			
At. Bag Pres. 2.5*						
Lt. Bag Pres. 2.0						

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5.5.2 Downward Loading Test 5.5.2.1 Apply downward (Fx) load of 39,000 lbf ($\pm 300\#$), within five (5) seconds, through the four simulated harness wheels. NOTE: This is 19,500 lbf at each actuator. <u>1345</u> F.S. (time) <u>39,000#</u> (time)		<i>MDH</i>			
Held load for five (5) minutes. 5.5.2.2 After two (2) minutes of static load, record any deflections in para. 5.5.1.15.		<i>MDH</i>			
5.5.2.3 Release load after five (5) minutes. <u>1350</u> Comp. time.		<i>MDH</i>			
5.5.2.4 Take recovery measurements and record in 5.5.1.15.		<i>MDH</i>			
5.5.2.5 Inspect condition of van rails, structural members, floor, etc. for evidence of structural failure or deformation. List discrepancies below.		<i>MDH</i>	5.5.2.5 Motor, Van, and Harness free of any apparent physical damage Method: Visual		8-28 

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5.5.2.6	Review data and ascertain all test objectives accomplished.	<i>MPH</i>			
5.5.2.7	If results of 5.5.2.5 and 5.5.2.6 are satisfactory, dismantle test setup.	<i>MPH</i>			
5.5.3	All oscillograph records and data sheets identified and forwarded to Data Reduction.	<i>MPH</i>			
5.6	The four (4) access holes in side of van repaired.	<i>MPH</i>			
5.7	All entries on this MEIS complied with and signed off.	<i>MPH</i>	5.7 All preceding characteristics have been complete by inspection. Method: Review MEIS and MIPR		8-28
5.8	All testing accomplished per Test Plan 751A and this MEIS and attached MIPR.	<i>MPH</i>			
<i>Mr. A. N. N. N.</i> Test Engineer Environmental Testing Dept.					

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Written By <i>J. B. Sohl</i> J. B. Sohl Minuteman Environmental Program Manager Environmental Testing Dept. Solid Rocket Plant Approved By <i>W. W. Lauderdale</i> W. W. Lauderdale Section Supervisor Environmental Testing Section Environmental Testing Dept. Solid Rocket Plant		<i>E. D. Kline</i> Quality Control Planning <i>M. Kline</i> Quality Engineer			



APPENDIX B

OPERATIONS LOG



W.O. NO. E-00488

AGC 3-128-631

TYPE OF TEST

TEST SPECIMEN Utility Van VR-1152A

[illegible]

APPENDIX C

STRUCTURAL ANALYSES

SUMMARY SHEET



SUBJECT

ANALYSIS OF ROUGH ROAD TEST TRAILER TIEDOWNS

DATE

Nov 27, 1961

WORK ORDER

0380-22-905

BY

WEG

CHK BY

T. CHAMINS

DATE

12/11/61

DESIGN PURPOSE: TRANSPORT VEHICLE FOR LIVE MOTOR ROAD TESTS.

ANALYSIS REQUEST: MAX HALEBSKY, DEPT 5210. { X 3876
X 5721

APPLICABLE DESIGN CRITERIA:

1) FROM STL (SEE P. 12 FOR ENVELOPE)

- 1) 3g's DOWN
- 2) 1/2 UP
- 3) 1/2 LATERAL
- 4) 2g FORE & AFT
- 5) 40 MPH MAX

THESE ARE LIMIT LOADS; USE 1.5 D.F. ON ULTIMATE UNIT STRESSES

2) AGC SRP CRITERIA (SECTION 5.4)

- 1) COVER EQUIPMENT FOR IN-PLANT USE ONLY, AND LIMITS ALL HAZARDOUS TRANSPORT TO 10 MPH MAXIMUM SPEED.

DOES NOT GOVERN

Loads:

LIVE ASSEMBLED MOTOR :	11,900 LB
HANDLING CONTAINER :	1810 LB
TRANSPORT CRADLES :	750 LB (PAIR)
	14,460 LB SAY 14,500 LB

TRW. ART TIEDOWNS & BAILS :	500 LB
	14,960 LB SAY 15,000 LB

SUBJECT

LOAD COMBINATIONS - STL CRITERIA

DATE

11/27/61

WORK ORDER

0380-22-905

BY

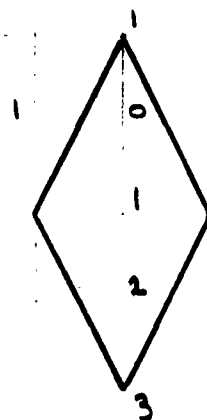
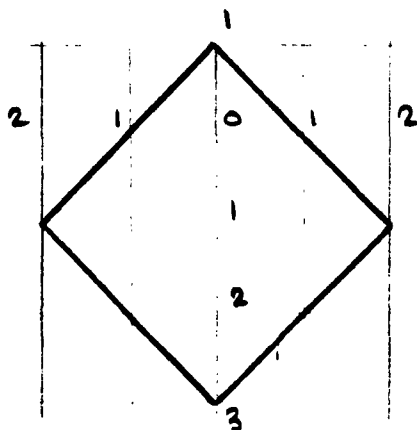
Wieg

CHK BY

T. Cunnings

DATE

12/1/61



THESE ARE LIMIT LOADS; DESIGN FACTOR REQ'D: 1.5 ON ULTIMATE ALLOWABLE LIMIT STRESSES.

SUBJECT

ANALYSIS OF ROUGH ROAD TEST TRAILER TIEDOWNS

DATE
11/29/61

WORK ORDER
0380-22-905

BY
Wies

CHK BY
T. CANNINS

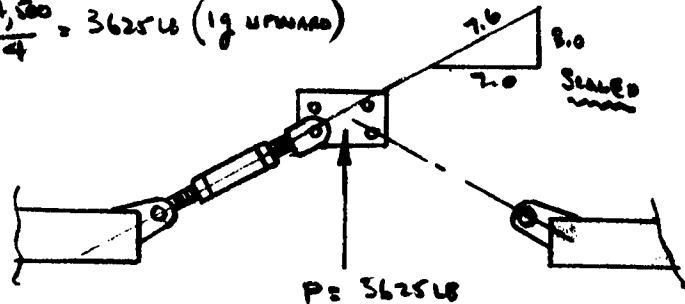
DATE
12-11-61

CHECK BAC CONTAINER TIEDOWN:

UPWARD LOAD:

$$P = \frac{14,500}{4} = 3625 \text{ LB (1g UPWARD)}$$

AXIAL COMPONENT OF
VERTICAL LOAD = $\frac{3625}{2} \left(\frac{7.6}{3.0} \right) = 4600 \text{ LB}$

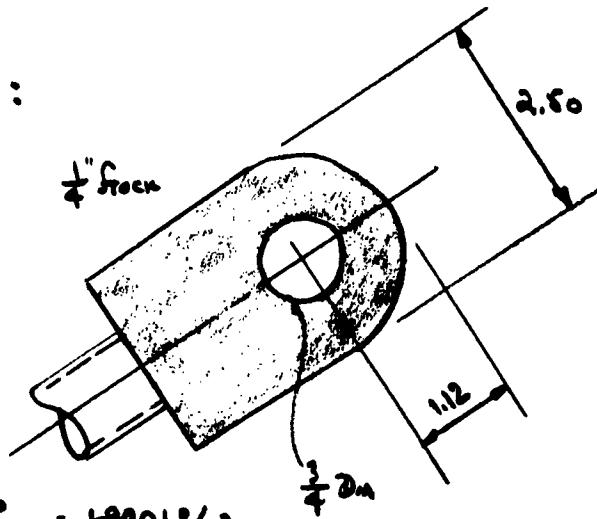


UNIT STRESS IN $\frac{3}{4}$ " Rod = $\frac{4600}{.302} = 15,250 \text{ LB/IN}^2$ (LESS THAN HALF YIELD VALUE)
↑ THRO. ROOT AREA

LUG AT CRADLE ADAPTER:

UNIT TENSILE STRESS @ HOLE

$$= \frac{4600}{.25(2.50 - .75)(2)} = 5250 \text{ LB/IN}^2 \text{ (LOW)}$$

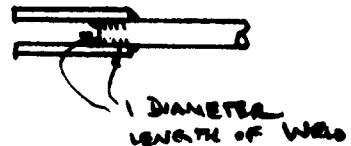


UNIT BENDING STRESS @ HOLE = $\frac{4600}{.25(.75)(2)} = 6900 \text{ LB/IN}^2 \text{ (LOW)}$

WELD ATTACHMENT BETWEEN $\frac{3}{4}$ " Rod AND LUGS:

LINEAL WELD UNIT LOAD = $\frac{4600}{1(.75)} = 1070 \text{ LB/LIN. INCH}$
NET BOUND. DIM'S.

FOR $\frac{1}{2}$ " WELD, $f_s = \frac{1070}{.707(.5)} = 5800 \text{ LB/IN}^2 \text{ (LOW)}$



ANALYSIS OF ROUGH ROAD TEST TRAILER TIEDOWNS

BY
WEG

CHK BY
T. CHAMBERS

DATE
11/28/61
WORK ORDER
0380-22-905
DATE
12-12-61

CHECK BAC CONTAINER TIEDOWN - CONT'D:

$$\begin{aligned} \text{END } \left\{ \begin{aligned} h &= \frac{2.5 - .75}{2} = \frac{1.75}{2} = .875 \\ S &= \frac{bh^2}{6} = \frac{.15(.875)^2}{6} = .0221 \text{ in}^3 \end{aligned} \right. \end{aligned}$$

UNWEIGHTED LOAD - CONT'D:

LUG AT CRADLE ADAPTER - CONT'D:

UNIT BENDING STRESS ON LUG:

(CONSIDER FIXED-END BEAM)

$$\text{AT END } f_b = \frac{M}{S} = \frac{wl^2}{12(S)(2)} = \frac{\frac{4600}{.75} (.75)^2}{12(.0221)(2)} = 445 \text{ psi}$$

AT MIDSPAN

$$\left\{ \begin{aligned} h &= .75 \\ S &= \frac{bh^2}{6} = \frac{.15(.75)^2}{6} = .0234 \text{ in}^3 \end{aligned} \right.$$

$$\text{AT MIDSPAN } f_b = \frac{M}{S} = \frac{wl^2}{24(S)} = \frac{\frac{4600}{.75} (.75)^2}{24(.0234)} = 6150 \text{ LB/in}^2$$

UNIT SHEAR STRESS AT LUG:

$$f = \frac{P}{A} = \frac{4600}{.15(.75)(2)} = 6100 \text{ LB/in}^2$$

COMBINING, MAX UNIT STRESS (f_{max}) $\sim f + .35 f_b = 6100 + 1600 = 7700 \text{ LB/in}^2$
(LOW)

SUBJECT

ANALYSIS OF ROUGH ROAD TEST TRAILER TIEDOWNS

DATE

11/29/61

WORK ORDER

0380-22-905

BY

WHEB

CHK BY

T. CAMPBELL

DATE

12.17.61

CHECK BAC CONTAINER TIEDOWN - CONT'D :

UPWARD LOAD - CONT'D :

LUG AT FLOOR YOKE :

WELD CONNECTION BETWEEN LUG & 2 1/2" O.D. SLEEVE :

$$\text{LINEAL WELD UNIT LOAD} = \frac{4600}{\pi (2.5) (2)} = 600 \text{ LB/LIN. EACH (LOW)}$$

CHECK FLOOR YOKE IN BENDING AND SHEAR :

NOTE : MAX STRESSES OCCUR DURING FULL & RT LOAD CONDITION
SEE P. 8.

NOTE : SINCE $\frac{E}{D} = 1.5$ FOR HOLE, ^{BENDING,} LUG A BENDING & SHEAR
WILL NOT BE A PROBLEM. (REF. P. 8 & 4)

SUBJECT

ANALYSIS OF ROUGH ROAD TEST TRAILER TIEDOWNS

DATE

11/29/61

WORK ORDER

0380-22-905

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WIEG

CHK BY

T. CHAMINI

DATE

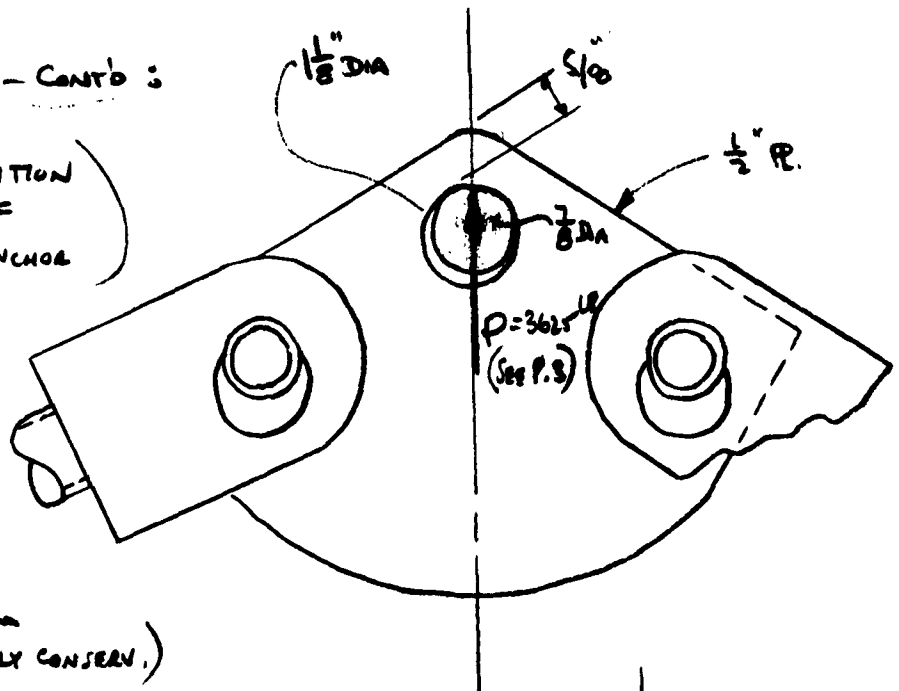
17-12-61

CHECK BAC CONTAINER TIEDOWN - CONT'D:

UPWARD LOAD - CONT'D:

LUG AT CRADLE ADAPTER - CONT'D:

(SHADED AREA DENOTES POSITION
& RELATIVE DIAMETER OF
BAC SPRING-LOADED ANCHOR
PIN.)



CONSIDER A FIXED-END BEAM
LOADED AT MIDSPAN (SLIGHTLY CONSERV.)

$$\text{MAX MOM} = \frac{PL}{8} = \frac{3625(1.12)}{8}$$

$$f_b = \frac{M}{I} = \frac{3625(1.12)}{8(.0326)} = 15,500 \text{ LB/IN}^2 \quad \left(\text{THIS STRESS MUST BE MODIFIED BY A CURVED-BEAM FACTOR} \right)$$

$$I = \frac{bh^3}{12} = \frac{.5(.625)^3}{12} = .0326 \text{ IN}^4$$

FROM CASE I, TABLE VII, P. 148 ROARK:

$$\frac{R}{c} = \frac{25/32}{7/32} = 3.57$$

$$R = \frac{21}{32}$$

$$c = \frac{7}{32}$$

$$k_i = 1.20 - .10(.57) = 1.24$$

$$f_s = \frac{3625}{2(.5)(.44)} = 8200 \text{ LB/IN}^2$$

COMBINING:

$$f_{\text{MAX}} = 19,200 + .35(8200) = 22,100 \text{ LB/IN}^2$$

$$\text{MODIFIED } f_b = 1.24(15,500) = 19,200 \text{ LB/IN}^2$$

SUBJECT

ANALYSIS OF ROUGH ROAD TEST TRAILER TIEDOWNS

DATE

12/8/61

WORK ORDER

0380-22-905

BY

WIEG

CHK BY

T. CHANNIN

DATE

12.12.61

CHECK BAC CONTAINER TIEDOWN - CONT'D:

FORE & AFT LOAD: (REFER TO P. 3)

$$\text{AXIAL COMPONENT OF FORE \& AFT LOAD} = \frac{L_2 \left(\frac{7.6}{7.0} \right)}{\frac{1}{2}} = \frac{7.6 \left(\frac{14.6}{2} \right)}{1} = 7900 \text{ LB}$$

No. OF TIEDOWNS IN TENSION

$$\text{UNIT STRESS IN } \frac{3}{4}'' \text{ ROD} = \frac{7900}{.302} = 26,200 \text{ LB/IN}^2$$

LOW FOR 4130

LUG AT CRADLE ADAPTER OK BY INSPECTION

UNIT BEARING STRESS AT LUG HOLE OK BY INSP.

WELD ATTACHMENT BETWEEN $\frac{3}{4}''$ ROD & LUG:

(SIMILAR TO P. 3)

$$f_{\text{weld}} = 5800 \left(\frac{7900}{4600} \right) = 10,000 \text{ LB/IN}^2 \text{ (LOW)}$$

LUG AT CRADLE ADAPTER:

(SIMILAR TO P. 4)

$$f_{\text{max}} = 7100 \left(\frac{7900}{4600} \right) = 13,200 \text{ LB/IN}^2 \text{ (LOW)}$$

SUBJECT

ANALYSIS OF ROUGH ROAD TEST TRAILER TIEDOWNS

DATE

12/11/61

WORK ORDER

0380-22-905

BY

WIEG

CHK BY

T. CUNNINGHAM

DATE

12-12-61

CHECK BAC CONTAINER TIEDOWNS - CONT'D :

FORD APT LOAD - CONT'D :

CHECK FLOOR YOKE IN BENDING & SHEAR :

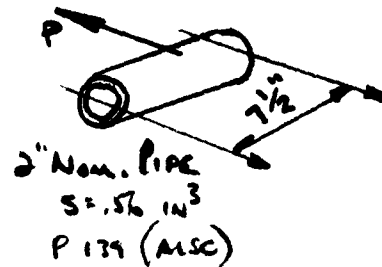
$$P = 7900 \text{ (SEE P. 7)}$$

$$f_b = \frac{M}{S} = \frac{P L}{4 S} = \frac{7900 (3.75)}{4 (1.56)} = 13,200 \text{ LB/IN}^2 \text{ (LOW)}$$

WELD ATTACHMENT @ ENDS OF PIPE

$$\text{IN SHEAR : } f_s = \frac{7900}{\pi (2.375)^2} = 1060 \text{ LB/LIN INCH}$$

OD. (LOW FOR 1/4" WELD)



FLOOR YOKE IS FASTENED TO RAILS BY 4-1/2" BOLTS AT EACH END :

$$\text{SHEAR/BOLT} = \frac{7900}{2 (4)} = 990 \text{ LB/BOLT}$$

$$f_s = \frac{990}{.126} = 7850 \text{ LB/IN}^2 \text{ (LOW)}$$

THREAD ROOT AREA

SUBJECT

ANALYSIS OF ROUGH ROAD TEST TRAILER TIEDOWNS

DATE

12/11/61

WORK ORDER

0380-22-905

BY

WIEG

CHK BY

T Cummins

DATE

12-12-61

CHECK BAC CONTAINER TIEDOWNS - CONT'D:

FORE & AFT LOADS - CONT'D:

CHECK $\frac{3}{4}$ " BOLT IN DOUBLE SHEAR: AT SPHERCO SWIVEL ATTACHMENT

FULL DIA AREA = .442 IN²

$$f_s = \frac{1900}{2(.442)} = 9000 \text{ LB/IN}^2 \text{ (LW)}$$

(THIS MAKES THE AP PINS ASSOCIATED WITH
THIS CONNECTION OK BY COMPARISON)

AT OPPOSITE END

SUBJECT

ANALYSIS OF ROUGH ROAD TEST TRAILER TIEDOWNS

DATE

12/12/61

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BY

WIEG

CHK BY

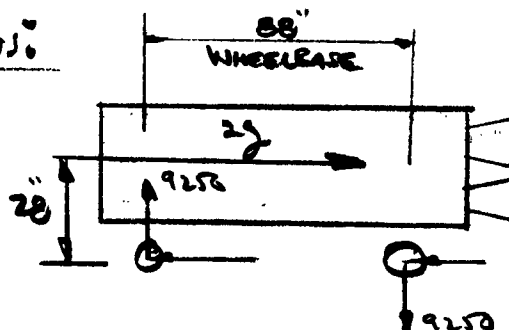
T. CAMMINS

DATE

12/12-61

BAC CONTAINER TIEDOWNS:

LOAD COMBINATIONS:



$$\text{Pitch Load} = \frac{2g(28)}{88} = 9250 \text{ AT EACH END}$$

$$\text{VERT Load} = \frac{14500}{4} = 4625 \text{ LB/WHEEL}$$

At 1g Down + 2g's Fwd or Aft:

$$\text{Pitch Load/WHEEL} = 4625 \text{ LB}$$

$$\text{VERT Load/WHEEL} = 3625 \text{ LB}$$

1000 LB NET UPLIFT

CONVERTING 1000 LB NET UPLIFT TO AXIAL COMPONENT:

$$1000 \left(\frac{7.6}{3} \right) = 2530 \text{ LB}$$

REF. P. 3

ADDITIONAL LOAD INCREASE BY ADDITION OF PITCH LOAD COMPONENT TO FWD & AFT COMPONENTS =

$$\frac{7900 + 2530}{7900} - 1 = 32\%$$

(REF. P. 7)

EXAMINATION OF THE UNIT STRESS LEVELS AS CALCULATED ON PAGES 7, 8, AND 9 INDICATE THAT THIS 32% INCREASE IS NOT OF SERIOUS SIGNIFICANCE.

**STRUCTURAL
ANALYSIS**

**SOLID ROCKET PLANT
SACRAMENTO, CALIFORNIA**

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OF 42

SUBJECT SADDLE - TRANSPORT - 49" DA ENGINE T-421167

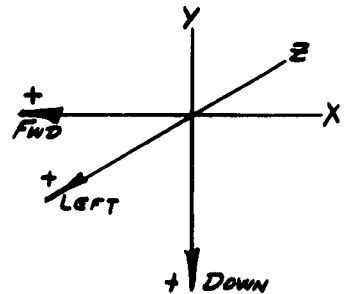
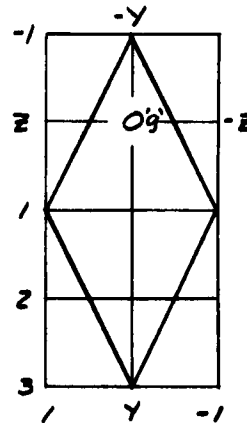
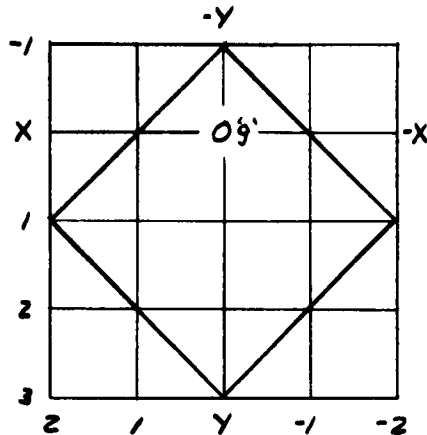
BY T. CUMMINS

DATE 11-30-61

CHK.
BY W. H. H.

DATE 12/12/61

LOADING DIAGRAMS:



ALLOWABLE MOTOR LOADING:

1. ALLOWABLE COMPRESSION LOADING ON SKIRT = 1000 #/IN
2. ALLOWABLE MOMENT IN CHAMBER = $3.66 \times 10^6 \text{ in}^2$
3. ALLOWABLE LOAD PER SKIRT BOLT = APPROX 8000 #/BOLT

**STRUCTURAL
ANALYSIS**

**SOLID ROCKET PLANT
SACRAMENTO, CALIFORNIA**

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SUBJECT SADDLE - TRANSPORT - 44" DIA ENGINE

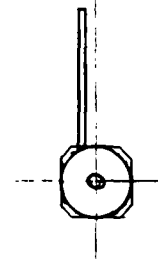
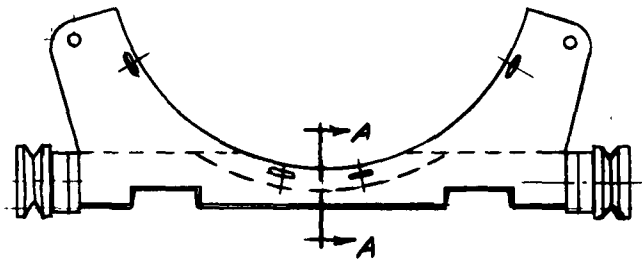
BY T. CUMMINS

DATE 11-30-61

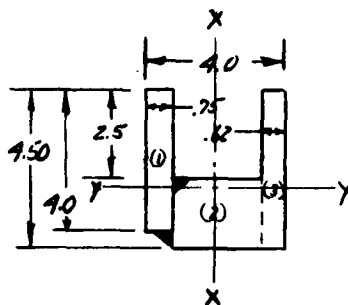
CHK. BY WIEG

DATE 12/12/61

T-421167 B



SECT A-A



E	A	X	AX	A	Ah ²	I _o
1	3.00	2.5	7.50	.78	1.82	9.00
2	5.26	1.0	5.26	.72	2.73	1.75
3	2.79	2.25	6.28	.43	.51	9.71
	<u>11.05</u>		<u>19.04</u>		<u>5.06</u>	<u>10.46</u>

$$\bar{X} = \frac{19.04}{11.05} = 1.72 \text{ in}$$

$$I_{yy} = 5.06 + 10.46 = 15.52 \text{ in}^4$$

E	A	Y	AY	A	Ah ²	I _o
1	3.00	3.62	10.86	1.61	7.78	.14
2	5.26	1.94	10.21	.05	.01	3.04
3	2.79	.32	.89	1.67	7.78	.09
	<u>11.05</u>		<u>21.96</u>		<u>15.57</u>	<u>3.27</u>

$$\bar{Y} = \frac{21.96}{11.05} = 1.99$$

$$I_{xx} = 15.57 + 3.27 = 18.84 \text{ in}^4$$

**STRUCTURAL
ANALYSIS**

Airjet-General CORPORATION

**SOLID ROCKET PLANT
SACRAMENTO, CALIFORNIA**

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SUBJECT SADDLE-TRANSPORT-44" DIA ENGINE

BY T. CUMMINS

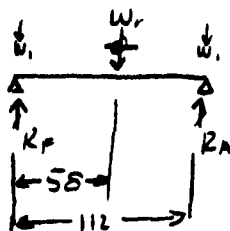
DATE 12/1/61

CHK.
BY W. G.

DATE 12/12/61

LOADING CONDITIONS:

1. 3' down



$$W_v = 3(11800 + 1930) = (13730)(3) = 41190^{\#}$$

$$W_1 = (400^{\#})(3) = 1200^{\#} \text{ (saddle nt)}$$

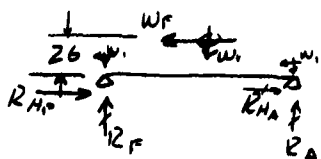
$$R_A = \frac{(41190)(58)}{112} + 1200 = 21350 + 1200$$

$$= 22550^{\#} = 11275^{\#}/\text{wheel}$$

$$R_F = 41190 + (2)(1200) - 22550 = 43590 - 22550$$

$$= 21040^{\#} = 10520^{\#}/\text{wheel}$$

2. 1' down, 2' fwd



$$W_F = (2)(13730) = 27460^{\#}$$

$$W_v = 13730$$

$$W_{1F} = (2)(400) = 800$$

$$W_{1V} = 400^{\#}$$

$$R_{HF} = 27460 + 800 = 28260^{\#} = 14130^{\#}/\text{wheel}$$

$$R_{HA} = 800^{\#} = 400^{\#}/\text{wheel}$$

$$R_F = \frac{(54)(13730)}{112} + 400 + \frac{(26)(27460)}{112}$$

$$= 6630 + 400 + 6380$$

$$= 13410^{\#}$$

$$= 6705^{\#}/\text{wheel}$$

$$R_A = \frac{(58)(13730)}{112} + 400 - \frac{(26)(27460)}{112}$$

$$= 7120 + 400 - 6380$$

$$= 1140^{\#}$$

$$= 570^{\#}/\text{wheel}$$

**STRUCTURAL
ANALYSIS**

**SOLID ROCKET PLANT
SACRAMENTO, CALIFORNIA**

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SUBJECT SADDLE - TRANSPORT - 44" DIA. ENGINE

BY T. CUMMINS

DATE 12/6/01

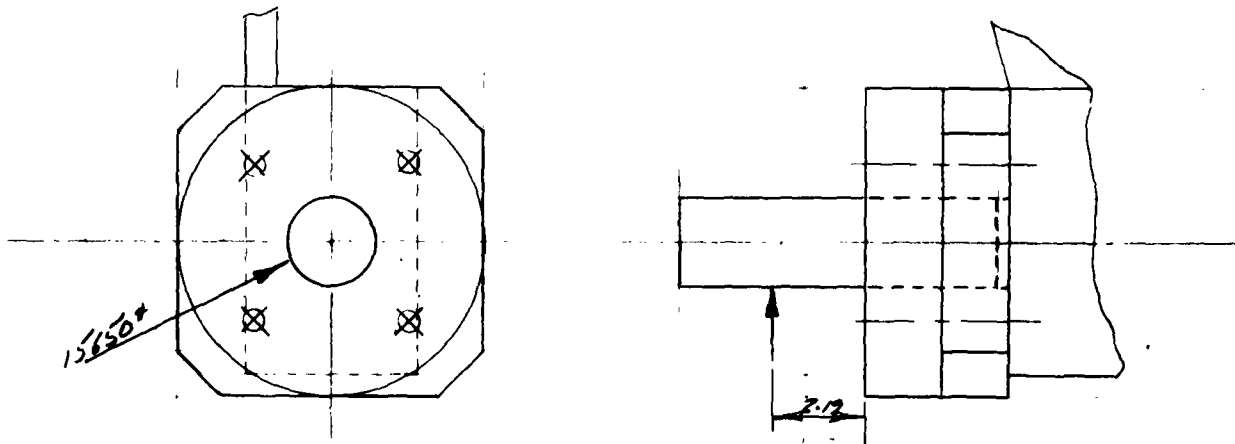
CHK. BY WEG

DATE 12/12/01

LOAD CONDITION #2 (cont)

AXLE LOADING

$$\text{MAX AXLE LOAD} = [(14130)^2 + (6705)^2]^{1/2} = [200 \times 10^6 + 45 \times 10^6]^{1/2} \\ = 15650 \#$$



BENDING IN AXLE -

$$M = (2.12 \times 15650) = 34300 \text{ in}\cdot\text{lb}$$

$$S = .785 R^3 = (.785)(1)^3 = .785 \text{ in}^3$$

$$f_b = M/S = 34300/.785 = 43700 \text{ psi}$$

$$f_s = \frac{3V}{8L} = \frac{(4)(15650)}{(8)(.785)(2)} = 6650 \text{ psi}$$

4340 STL HT 160,000 psi

M.S.

HIGH

ATTACH BOLTS -

$$\text{Max Bolt Tension} = \frac{(14130)(3.24)}{(2)(3.54)} + \frac{(6705)(3.24)}{(2)(3.54)} = 7860 + 3730 = 11,600 \#$$

$$F_T = 24000 \#$$

$$f_t = (1.5)(11,600) = 17400 \#$$

$$M.S. = \frac{24000}{17400} - 1 =$$

1.38

SADDLE - TRANSPORT - 44" DIA ENGINE

DATE
12-7-61
WORK ORDER
0380-22-905
DATE
12/12/61

BY
T. CUMMINS

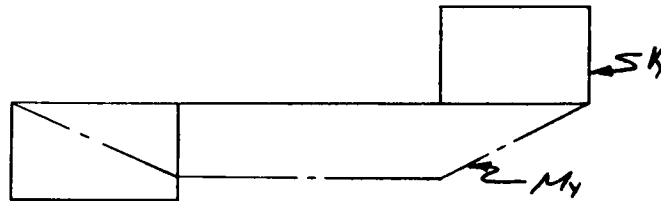
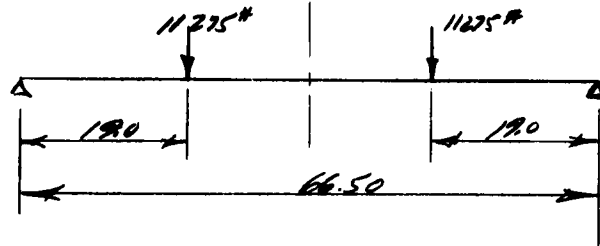
CHK. BY
WIEG

LOAD CONDITION #1 - 3'g' down

BEAM LOADING —

MAX SADDLE LOAD = 22550# ON OFF saddle

DUE TO DEFORMATION OF SADDLES, AT MAXIMUM LOAD FACTOR THE LOADING WILL BE AS SHOWN:



$$V_{max} = 11275\#$$

$$M_{max} = 214500\text{in}\#$$

BENDING IN BEAM: at sect A-A.

$$f = \frac{M_c}{I} = \frac{(214500)(2.78)}{15.52} = -38,400\text{psi}$$

$$*F_{tu} = 63000\text{psi}$$

$$F_y = 46000\text{psi}$$

M. S. (yield)

$$= \frac{46000}{38000} - 1$$

$$= 1.21$$

* AVERAGE MECHANICAL PROPERTIES OF HOT ROLLED, LOW CARBON STEEL - RYERSON DATA BOOK.

SADDLE - TRANSPORT - 44' DIA ENGINE

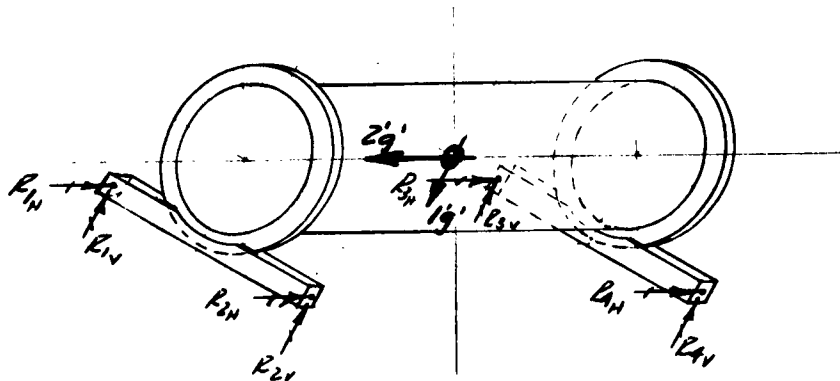
DATE
12-8-61
WORK ORDER
0380-22-905
DATE
12/12/61

BY
T. CUMMINS

CHK. BY
WIEG

LOAD COND #2

REVISED BEAM LOADING



MOTOR WT

$$(a) 2g' = (2)(13730) = 27460$$

$$(b) 1g' = (1)(13730) = 13730$$

SADDLE WT:

$$(a) 2g' = (2)(400) = 800 \text{ (each)}$$

$$(b) 1g' = (1)(400) = 400 \text{ (each)}$$

$$R_{1H} = R_{2H} = R_{3H} = R_{4H} = [27460 + (2)(800)](1/4) = 7265 \#$$

$$R_{1V} = R_{2V} = \left[\frac{(27460)(26)}{112} + \frac{(58)(13730)}{112} + 400 \right] 1/2 = [6380 + 7120 + 400] 1/2$$

$$= 6950 \#$$

$$R_{3V} = R_{4V} = \left[\frac{(58)(13730)}{112} - \frac{(27460)(26)}{112} + 400 \right] 1/2 = [6620 - 6380 + 400] 1/2$$

$$= 320 \#$$

SUBJECT

SADDLE - TRANSPORT - 44" DIA ENGINE

DATE

12-8-61

WORK ORDER

0380-22-905

T. CUMMINS

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WIEG

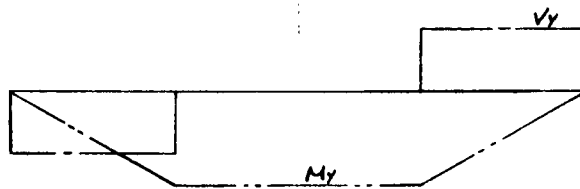
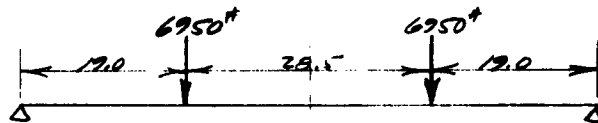
DATE

12/12/61

LOAD COND #2

REVISED BEAM LOADING

1. VERTICAL LOADING



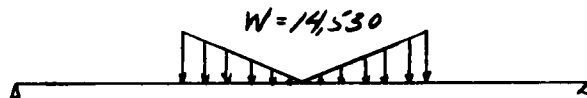
$$V_{MAX} = 6950\#$$

$$M_{MAX} = -132000 \text{ in-lb}$$

bending in beam: (sect A-A)

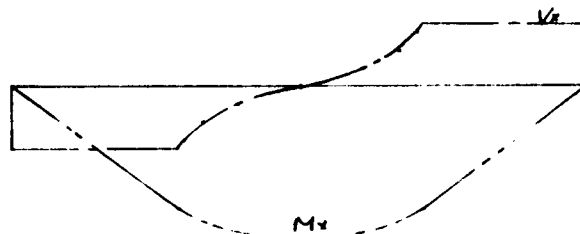
$$f_b = \frac{M_{MAX}}{I} = \frac{(132000)(278)}{1552} = -23650 \text{ psi}$$

2. HORIZONTAL LOADING



$$R_1 = 7265\#$$

$$R_2 = 7265\#$$



$$V_{MAX} = 7265\#$$

$$M_{MAX} = -176,400 \text{ in-lb}$$

SADDLE - TRANSPORT- 44" DIA ENGINE

DATE
12-11-61
WORK ORDER
0850-22-905
DATE
12/12/61

BY
T. CUMMINS

CHK. BY
WIEG

LOAD COND #2

REVISED BEAM LOADING

2. HORIZONTAL LOADING (CONT)

bending in beam (sect A-A)

$$f_{b_{x-x}} = \frac{M_c}{I} = \frac{(472,400)(12.00)}{18.84} = \pm 18300 \text{ psi}$$

3. COMBINED BENDING

$$f_{b_{x-x}} + f_{b_{y-y}} = f_{b_t}$$

$$f_{b_t} = -18300 - 23650 = -41,950 \text{ psi}$$

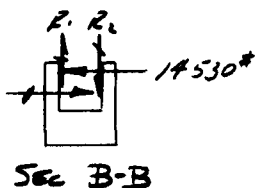
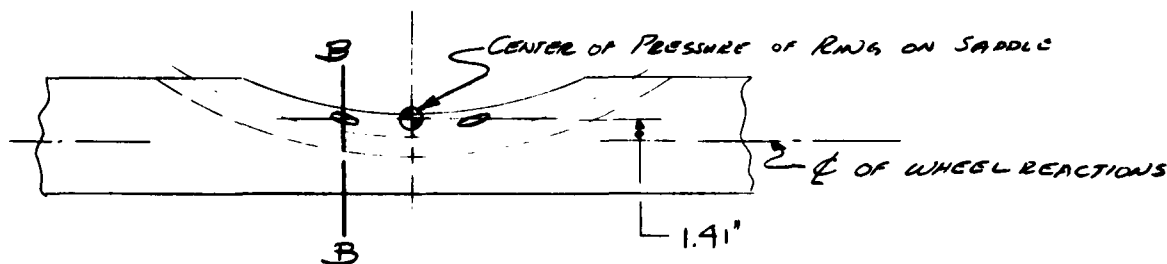
$$F_{b_{yeld}} = 46,000 \text{ (ref p915)}$$

M.S. (yield)

$$= \frac{46000}{42000} - 1 =$$

1.09

ATTACH RINGS TO SADDLE:



ROTATIONAL MOMENT IS REACTED
BY 2-1/2" BOLTS (1/2" HEX HEAD CAP SCREWS)

$$R_1 = R_2 = \left(\frac{1}{2}\right) \left[\frac{(1.41)(14530)}{2.50} \right] = 4$$

$$F_s = 18500 \#$$

M.S.

High

SADDLE - TRANSPORT - 44" DIA ENGINE		DATE 12-11-61
		WORK ORDER 0380-22-905
BY T. CUMMINS	CHK. BY WIEG	DATE 12/12/61

LOAD COND # 2

TORSIONAL STRESS (sect A 12)

$$T = (1.41)(14530) = 20500 \text{ in}^{\#}$$

$$f_s = \frac{T(3a + 1.8b)}{8ab^2} = \frac{20500[(3)(2) + (1.8)(1)]}{(8)(4)(1)}$$

$$= \frac{(20500)(7.8)}{32}$$

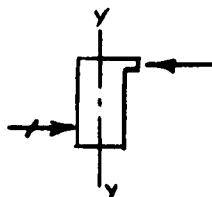
$$= 5000 \text{ psi}$$

$$FS = 35000 \text{ psi}$$

MS.

High

RING LOADING (T-421079 HANDLING HARNESS)



$$14580/24 = 610 \text{ #/IN}$$

$$I_{yy} = \frac{bh^3}{12} = \frac{(5.15)(2.5)^3}{12} = 6.6 \text{ in}^4$$

$$* f_b = \frac{Mrc}{I} = \frac{(610)(4)(24.5)(1.125)}{6.6} = 11,300 \text{ psi}$$

$$F_b = 63000 \text{ (pg 7)}$$

MS =

High

* CONSERVATIVE ASSUMPTION OF RING LOADED ON FULL CIRCUMFERENCE.

AGC UTILITY VAN PROPOSED AIRCRAFT TIEDOWN

DATE 5/21/62
WORK ORDER 0625-26-006
DATE SEPT 6, 1962

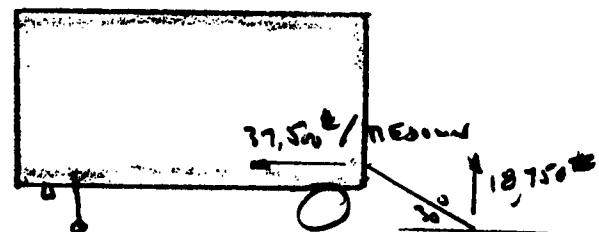
BY WREG
CHK. BY ALLEN

AGC UTILITY VAN

VERT.
1) 10,000 LB CAPACITY TIEDOWNS AT 6 POINTS ON EACH SIDE OF TRAILER (AT ENDS OF CROSS CHANNELS) - THESE CHANNELS WILL NEED AN END-CONNECTION INTO THE SIDE EXTRUSIONS CAPABLE OF TRANSMITTING 7000 LB SHEAR (LIMIT LOAD)

2)
$$\frac{37,500}{2} = \frac{3(25,000)}{2} = 37,500 \quad \frac{37,500}{.866} = 43,300 \text{ LB}$$

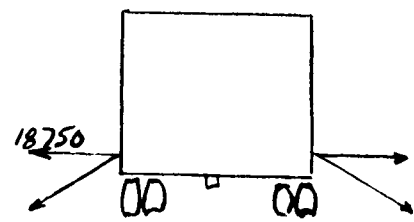
Force & Act



45,000 LB CAPACITY (LIMIT LOAD) TIEDOWNS AT 2 POINTS ON EACH END (LOCATION NOT DETERMINED YET)

ULT CAPACITY REQ'D = 1.5 (43,300) = 65,000 LB

3) LATERAL



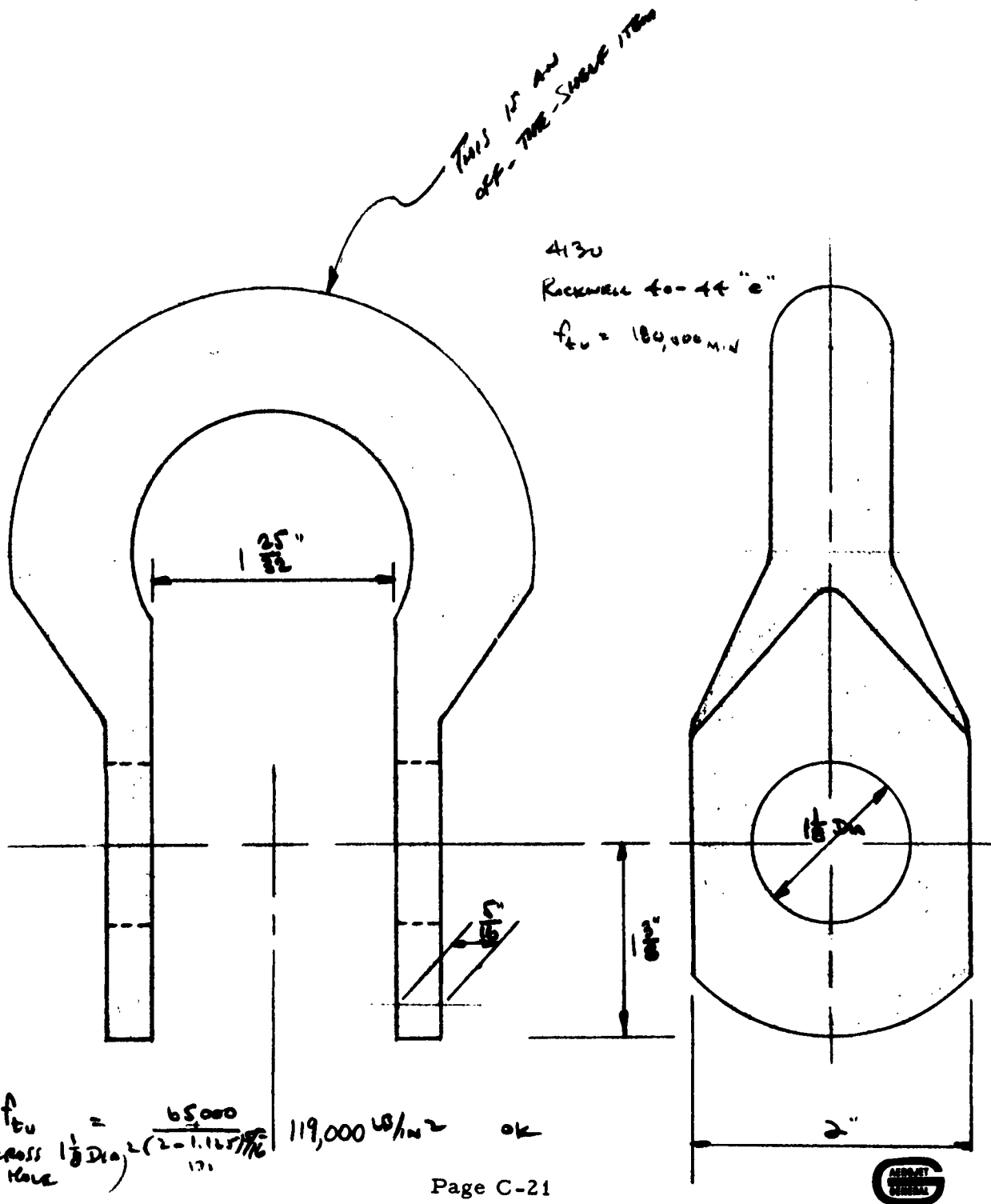
AGC UTILITY VAN PROPOSED AIRCRAFT TIEDOWN

DATE
6/7/62
WORK ORDER
0625-26-006
DATE
SEPT 6, 1962

BY
WIEG

CHK. BY
ALLEN

EASTERN ROTORCRAFT SHACKLE No. SP-2225, CAPACITY 99,000 LB ULT.



AGC UTILITY VAN PROPOSED AIRCRAFT TIEDOWN

DATE
6/7/62
WORK ORDER
0625-26-006
DATE
SEPT 6, 1962

BY
WIEG

CHK. BY
ALLEN

DEVELOP 65,000 LB CONNECTION BETWEEN SHACKLE & AGC VAN :
(SP-2225)

CHECK SHEAR VALUE OF $1\frac{1}{16}$ " DIA PIN :
DOUBLE SHEAR

$$f_s = \frac{65,000}{2(.8864)} = 36,700 \text{ LB/IN}^2$$

$$\text{REQ'D } f_{tv} = \frac{36,700}{.65} = 56,000 \text{ LB/IN}^2$$

HOT ROLLED MILD STEEL OK

CHECK BEARING LOAD ON SIDE MEMBERS :

$$P_b = \frac{65,000}{2(1.125)(.313)} = 92,000 \text{ LB/IN}^2$$

TOO HIGH FOR MILD STEEL

NEED 4130 OR SOME FORM
OF COLD-ROLLED STEEL

AGC UTILITY VAN PROPOSED AIRCRAFT TIEDOWNS

DATE
JUNE 14, 1962

WORK ORDER
0625-26-004

BY
WIEG

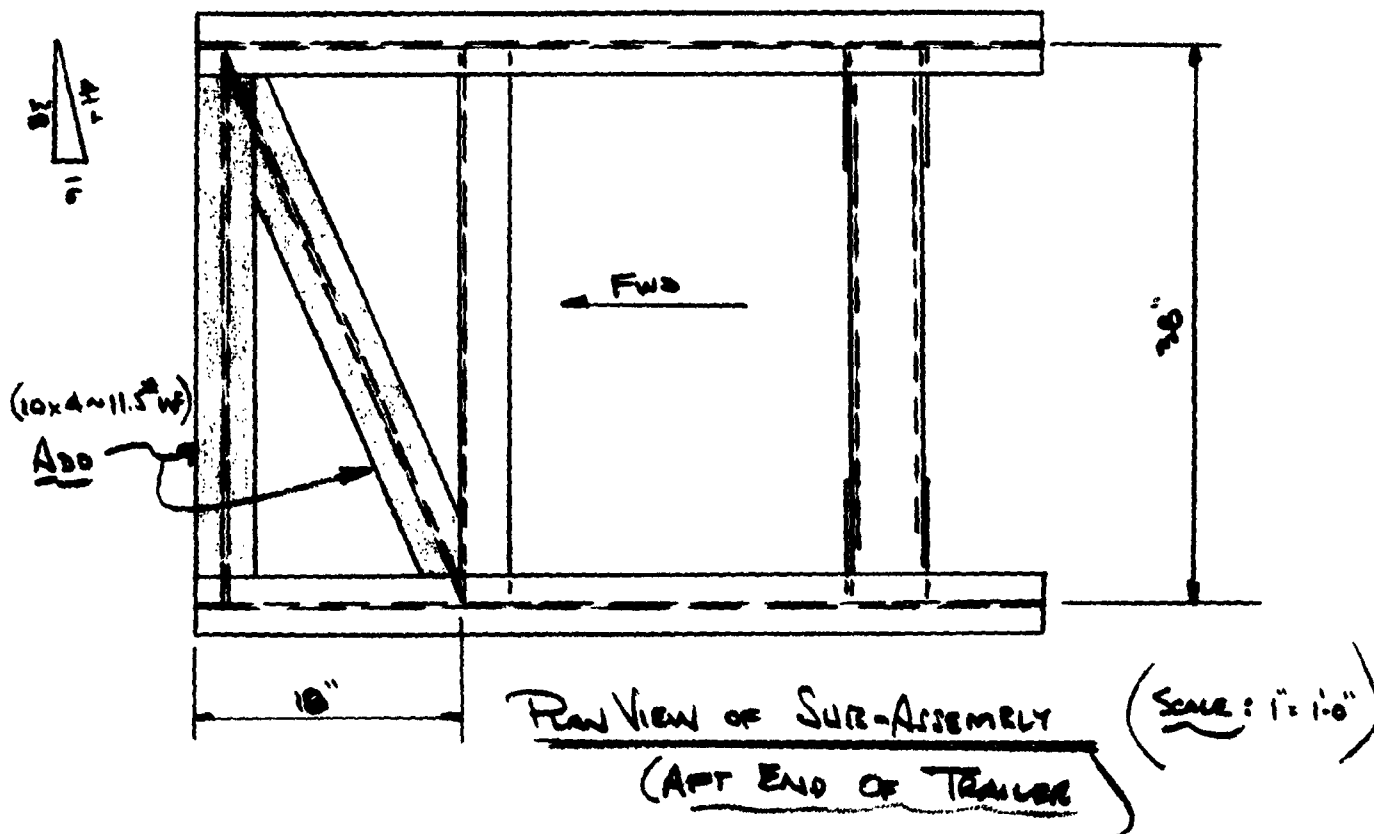
CHK. BY
ALLEN

DATE
SEPT 6, 1962

INVESTIGATE LOAD PATH OF LATERAL TIEDOWN FORCES:

(REF: UTILITY TRAILER MFG CO. DRAWING NO CB-1084)

MAYNARD LAGRASSE PROPOSES ATTACHING TIEDOWN FITTINGS TO THE FORWARD END OF 10"~11.5" BEAMS WHICH ARE THE MAJOR COMPONENTS OF THE AGC VAN AFT SUB-ASSEMBLY. THIS IS FINE IF THE SUB-ASSEMBLY IS STRENGTHENED WITH ADDITIONAL SHEAR-RESISTING COMPONENTS, SINCE THE 10"~11.5" BEAMS CAN NOT RESIST LATERAL TIEDOWN-LOAD BENDING MOMENTS ABOUT THE Y-Y AXIS.



AGC UTILITY VAN PROPOSED AIRCRAFT TIEDOWNS

DATE
JUNE 14, 1962
WORK ORDER
0625-26-006
DATE
SEPT 6, 1962

BY
WIEG

CHK. BY
ALLEN

INVESTIGATE 10"x4" WF FOR ADEQUACY AS A COLUMN:

$$\begin{aligned} \text{HORIZONTAL LOAD COMPONENT} &= \frac{1}{2} \text{ FORE } \frac{1}{2} \text{ AFT LOAD COMPONENT (SEE PAGE 10)} \\ &= \frac{1}{2} (37,500) = 18,750 \text{ LB} \end{aligned}$$

$$\text{AXIAL LOAD COMPONENT IN DIAGONAL COMPRESSION MEMBER} = 18,750 \left(\frac{41}{38} \right) = 20,200 \text{ LB}$$

$$\frac{l}{r} = \frac{41}{.77} = 52 ; \text{ AISC } F_c = 15,600 \text{ LB/IN}^2 \text{ (P. 20)}$$

$$\text{ALLOWABLE AXIAL LOAD} = 15,600 \left(\underset{\text{AREA}}{3.39} \right) = 52,800 \text{ LB}$$

$$\text{D.F.} = \frac{52,800}{20,200} > 2, \text{ OK}$$

TIEDOWN CONFIGURATION PROPOSAL

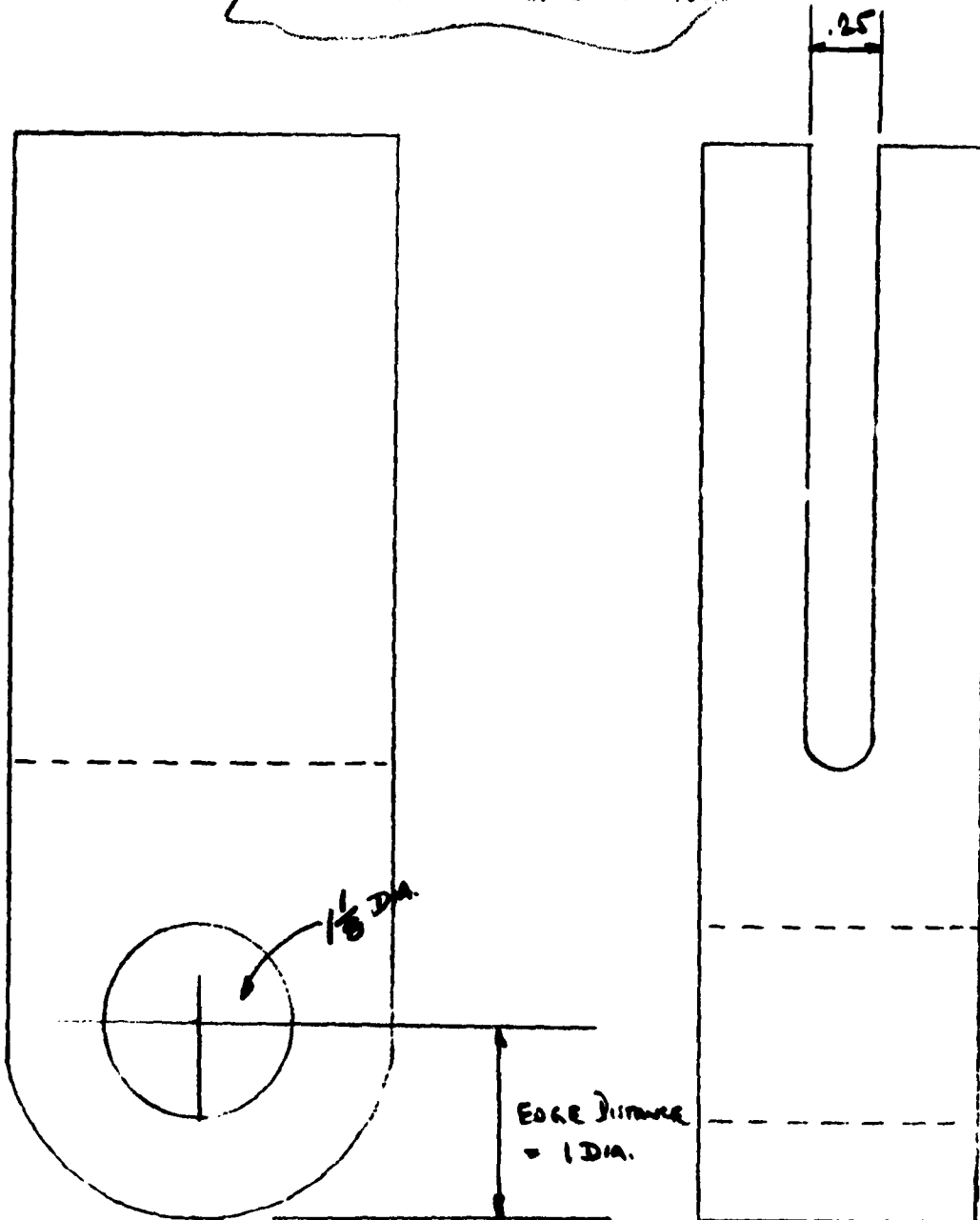
BY
LAGASSE

CHK BY
ALLEN

DATE
WORK ORDER
0625-24-006
DATE
SEPT 6, 196.

TIEDOWNS FOR FORE & AFT LOADS

10" x 11.5" W/ THICKNESS = .180



SUBJECT

AGC UTILITY VAN PROPOSED AIRCRAFT TIEDOWNS

DATE

JUL 5 1962

WORK ORDER

0625-26-006

BY

WIEG

CHK. BY

ALLEN

DATE

SEPT 6, 1962

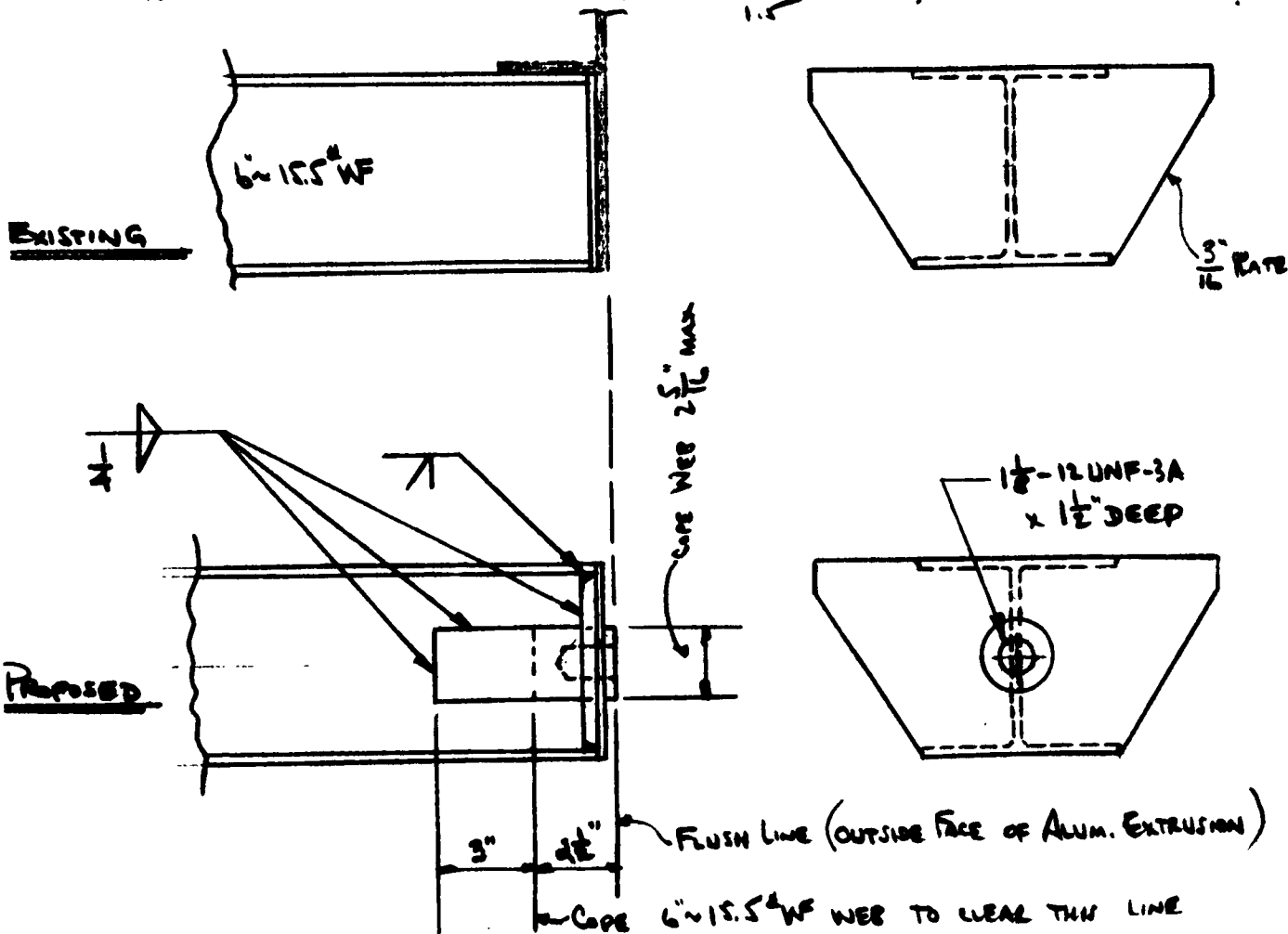
CLEARANCE REQUIREMENTS BENEATH THE VAN AND AT THE SIDES OF THE VAN NECESSITATE FLUSH SIDE CONNECTIONS FOR LATERAL TIEROWN AT THE FRONT OF THE VAN. (PER DISCUSSION w/ JACK CREW, DEPT 5731)

$$\text{LATERAL LOAD PER FITTING} = \frac{1.5 \times 3}{2} = .75(25,000) = 18,750 \text{ LB/FITTING}$$

EASTERN ROTORCRAFT CATALOG PART NO. SP-3079 HAS AN ULTIMATE CAPACITY OF 35,250 LB

APPLYING DESIGN FACTOR OF 1.5,

$$\text{ALLOWABLE LOAD ON PART SP-3079} = \frac{35,250}{1.5} = 23,500 \text{ LB} > 18,750 \text{ LB OK.}$$



AGC UTILITY VAN-PROPOSED AIRCRAFT TIEDOWNS

DATE
JULY 6, 1962

WORK ORDER
0625-26-006

BY
WHEG

CHK. BY
ALLEN

DATE
SEPT 6, 1962

DETERMINE MINIMUM MILD STEEL ROUND WHICH WILL DEVELOP THE CAPACITY OF FITTING SP-3079 (35,000 LB)

FOR MILD STEEL, ALLOWABLE $F_{bu} = \frac{55,000}{5} = 11,000 \text{ LB/IN}^2$
DESIGN FACTOR

REQ'D CROSS-SECTIONAL AREA = $\frac{35,000}{11,000} = 3.18 \text{ IN}^2$

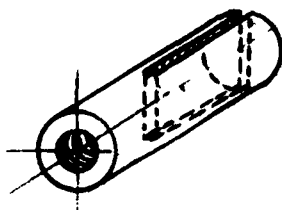
AREA OF $1\frac{1}{8}"$ ROD = $.99 \text{ IN}^2$

GROSS AREA REQ'D = 4.17 IN^2

$A_{2\frac{1}{2}} = 3.98 \text{ IN}^2$ $\frac{4.17}{3.98} = 1.047$

$A_{2\frac{1}{2}} = 4.91 \text{ IN}^2$

$2\frac{1}{2}"$ IS ADEQUATE



DETERMINE REQ'D LENGTH OF WELD FOR ATTACHMENT TO 6" WF WEB:

AT ALLOWABLE WELD LOAD OF 2400 LB/INCH ($\frac{1}{4}"$ FILLER)

WELD LENGTH REQ'D = $\frac{35,000}{2400} = 14.6 \text{ LIN. INCHES}$

USE 3" PROJECTION BEYOND CAPE LINE

SUBJECT

AGC UTILITY VAN - PROPOSED AIRCRAFT TIEDOWNS

DATE

SEPT 6, 1962

WORK ORDER

0625-26-006

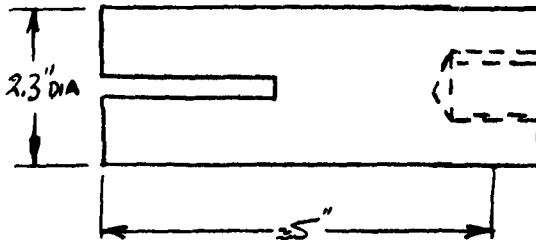
BY

ALLEN

CHK BY

Weg

DATE



$$\text{LENGTH OF WELD} = 2(5 + 5 + 2.3) = 24.6"$$

FROM PG. 27, ONLY 14.6" ARE NEEDED
SO THIS IS O.K..

TRANSPORT SADDLE - 44" FW ENGINE
(REF: AGC DWG T-421194)

DATE 8-16-62

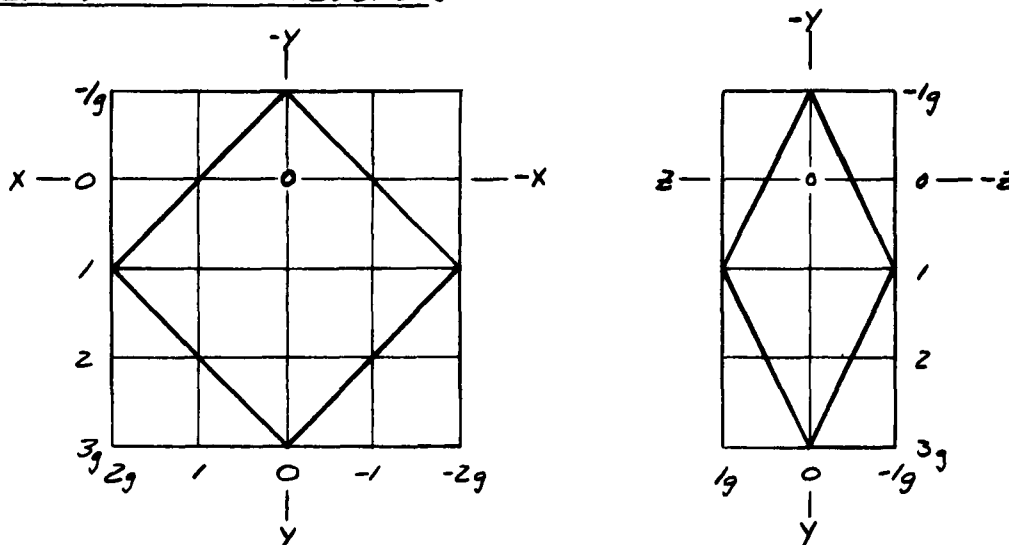
WORK ORDER
0625-26-006

BY T. CUMMINS

CHK. BY R.F. ALLEN

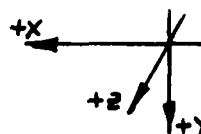
DATE 9-10-62

LIMIT LOAD ENVELOPE:



SIGN CONVENTION:

X = POS. FWD
Y = POS. DOWN
Z = POS. LEFT



WEIGHT SUMMARY

ENGINE = 11,800#
HANDLING CONTAINER = 1930#
FWD RING = 60 } 965# @ FWD END
AFT RING = 570 } 945# @ AFT END
RAILS = 750
TRANSPORT SADDLES = 250# EACH
 $\Sigma = 14,230\#$

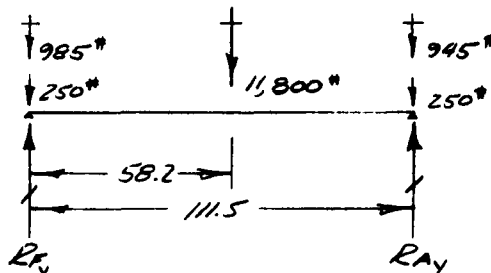
LOAD CONDITIONS - 3 CONDITIONS WILL BE INVESTIGATED.

COND 1 - 3'g' DOWN
COND 2 - 2'g' FWD & 1'g' DOWN
COND 3 - 1'g' SIDE & 1'g' DOWN

TRANSPORT SADDLE - 44" FW ENGINE		DATE 8-16-62
		WORK ORDER 0625-26-006
BY T. CUMMINS	CHK. BY R.T. ALLEN	DATE 9-10-62

LOAD CONDITIONS (LIMIT LOADS)

COND 1 - 39 DOWN



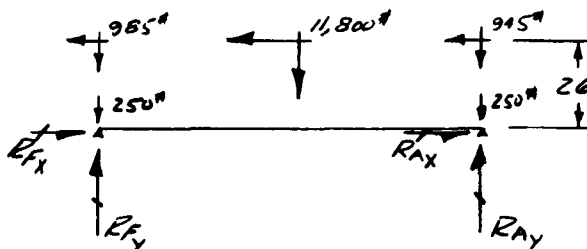
$$R_{FY} = \frac{(3 \times 11,800)(53.3)}{111.5} + (3 \times 985 + 250) = 16,920 + 3,705$$

$$= 20,625 \# = 10,315 \#/\text{WHEEL}$$

$$R_{AY} = (3 \times 11,800) - 16,920 + (3 \times 945 + 250) = 18,480 + 3,585$$

$$= 22,065 \# = 11,035 \#/\text{WHEEL}$$

COND 2 - 29 FWD & 19 DOWN



$$R_{FX} = \frac{(2)(11,800)}{2} + (2)(985) = 11,800 + 1,970$$

$$= 13,770 \# = 6,885 \#/\text{WHEEL}$$

$$R_{AX} = \frac{(2)(11,800)}{2} + (2)(945) = 11,800 + 1,890$$

$$= 13,690 \# = 6,845 \#/\text{WHEEL}$$

$$R_{FY} = 985 + 250 + \frac{(11,800)(53.3)}{111.5} + \frac{(2)(11,800 + 985 + 945)(26)}{111.5} = 6,405$$

$$= 13,280 \# = 6,640 \#/\text{WHEEL}$$

$$R_{AY} = 945 + 250 + \frac{(11,800)(58.2)}{111.5} - \frac{(2)(11,800 + 985 + 945)(26)}{111.5} = 7,355 - 6,405$$

$$= 950 \# = 475 \#/\text{WHEEL}$$

TRANSPORT SADDLE - 44" FW ENGINE

DATE
8-17-62

WORK ORDER
0625-26-006

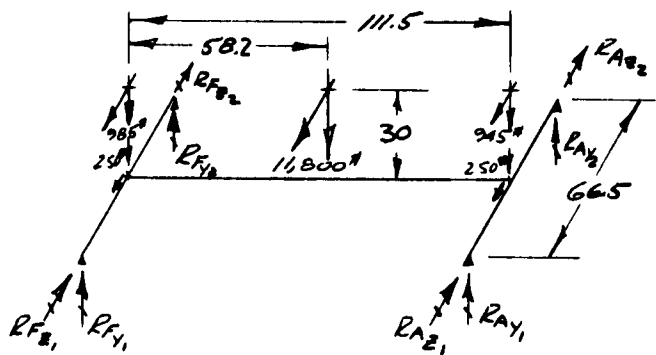
BY
T. CUMMINS

CHK. BY
R.F. ALLEN

DATE
9-10-62

LOAD CONDITIONS - (LIMIT LOADS), (CONT)

COND 3 - 1'g' SIDE & 1'g' DOWN



$$R_{F2} = R_{F2_2} = \left[\frac{(11800)(58.2)}{111.5} + 985 + 250 \right] \frac{1}{2} = \frac{1}{2} (5640 + 985 + 250) \\ = 3440 \#$$

$$R_{A2_1} = R_{A2_2} = \left[11800 - 5640 + 945 + 250 \right] \frac{1}{2} = \frac{1}{2} (6160 + 1195) \\ = 3680 \#$$

$$R_{Fy_1} = \left(\frac{1}{2} \right) (5640 + 985 + 250) + \frac{(30)(5640 + 985)}{66.5} = 3440 + 2990 \\ = 6430 \#$$

$$R_{Fy_2} = 3440 - 2990 \\ = 450 \#$$

$$R_{Ay_1} = \left(\frac{1}{2} \right) (6160 + 945 + 250) + \frac{(30)(6160 + 945)}{66.5} = 3680 + 3210 \\ = 6890 \#$$

$$R_{Ay_2} = 3680 - 3210 \\ = 470 \#$$

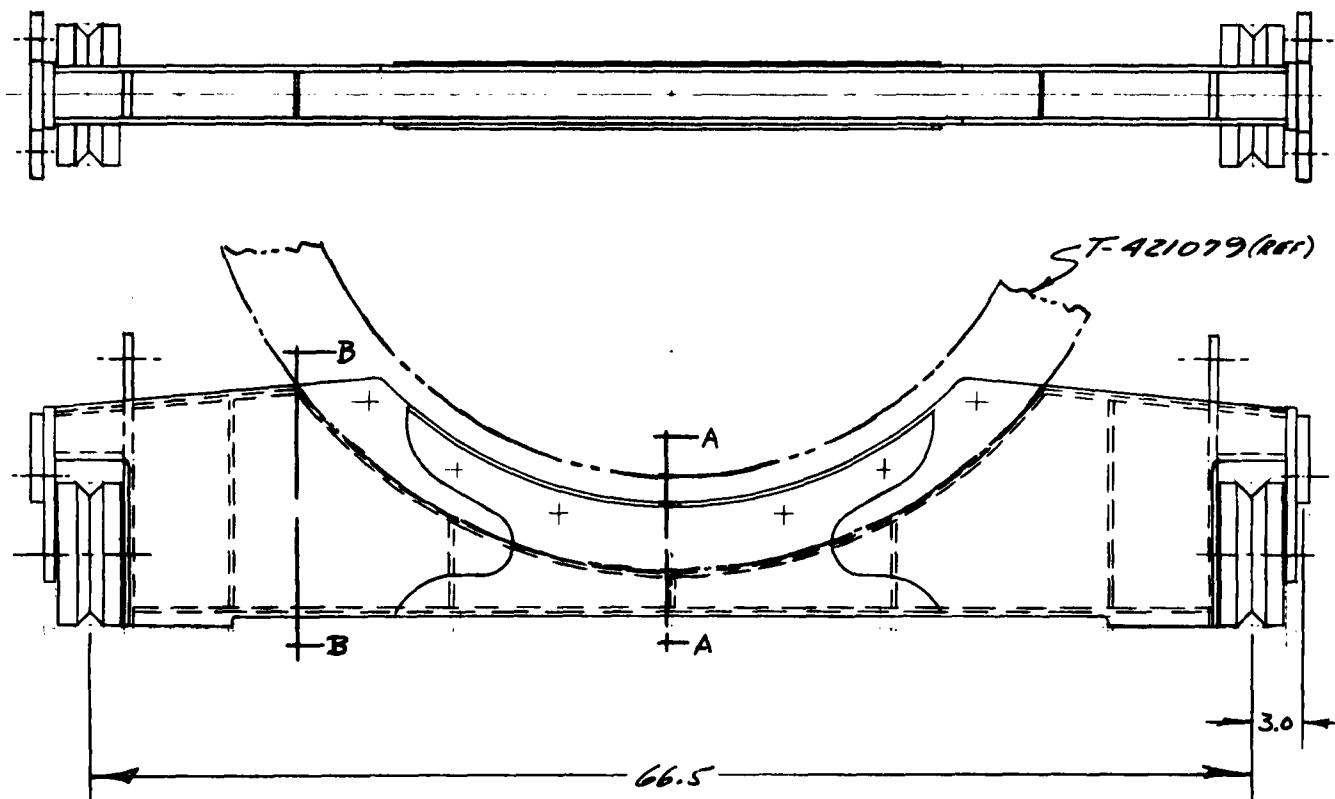
TRANSPORT SADDLE - 44" FW ENGINE

BY
T. CUMMINS

CHK. BY
R. F. ALLEN

DATE
8-17-62
WORK ORDER
0625-26-006
DATE
9-10-62

AGC DWG T-421914



TRANSPORT SADDLE- 44" FW ENGINE

DATE
8-22-62

WORK ORDER
0625-26-006

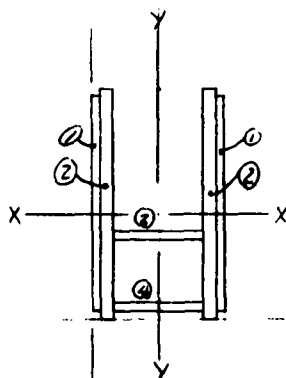
BY
T. CUMMINS

CHK BY
R.F. ALLEN

DATE
9-10-62

SECTION PROPERTIES (REF Pg 33)

SECT A-A



E	A	Y	AY	h_y	Ah_y^2	I_{oy}
1	3.00	3.30	9.90	.29	.25	9.00
2	4.88	3.25	15.87	.24	.28	17.16
3	.64	2.38	1.52	.63	.25	-
4	.64	.37	.24	2.64	4.46	-
	9.16 IN ²		27.53		5.24	26.16

$$\bar{Y} = \frac{27.53}{9.16} = 3.01 \text{ IN}$$

$$I_{xx} = 5.24 + 26.16 = 31.40 \text{ IN}^4$$

$$C_{TOP} = 6.50 - 3.01 = 3.49 \text{ IN}$$

$$C_{BOT} = 3.01 \text{ IN}$$

$$I_{y-y} = \sum A h_x^2 + \sum I_{oy}$$

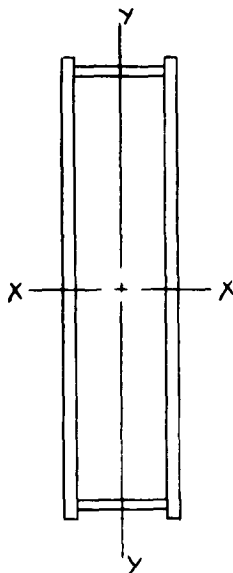
$$= (2)(1.50)(1.78)^2 + (2)(2.44)(1.47)^2 + \frac{(5)(2.56)^3}{12} + \frac{(2)(.62)^3(6)}{12}$$

$$= 10.03 + 10.54 + .70 + .24$$

$$= 21.51 \text{ IN}^4$$

$$C = 1.91 \text{ IN}$$

SECT B-B



$$AREA = (2)(.375)(13) + (2)(.25)(2.56) = 9.75 + 1.28 = 11.03 \text{ IN}^2$$

$$I_{x-x} = \sum A h^2 + \sum I_o$$

$$= (1.28)(6.12)^2 + (2)(.38)(12)^2/12$$

$$= 47.9 + 117.1$$

$$= 165 \text{ IN}^4 \quad C = 6.5$$

$$I_{y-y} = \sum A h^2 + \sum I_o$$

$$= (9.75)(1.47)^2 + (5)(2.56)^2/12 + (2)(13)(.38)^2/12$$

$$= 21.1 + .7 + .1$$

$$= 21.9 \text{ IN}^4 \quad C = 1.66$$

TRANSPORT SADDLE - 44" FW ENGINE

BY
T. CUMMINS

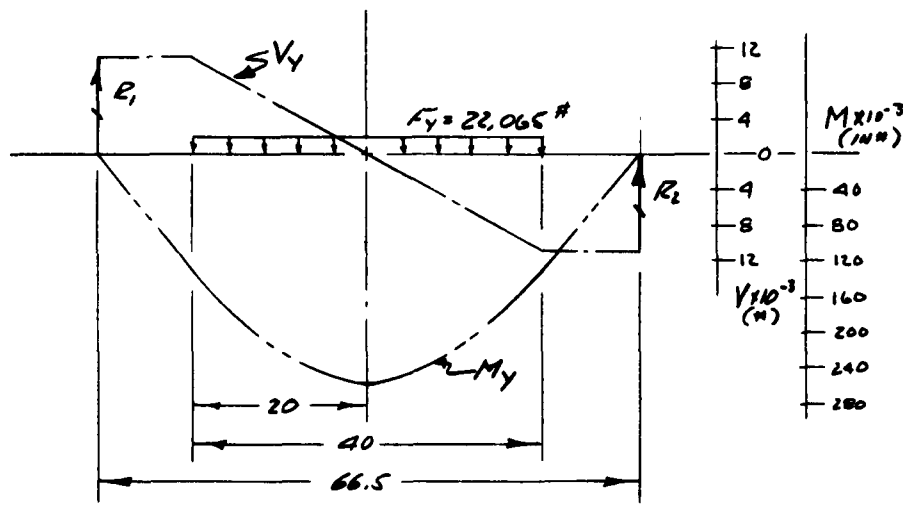
CHK. BY
R. F. ALLEN

DATE
8-22-62

WORK ORDER
0625-26-006

DATE
9-10-62

CONDITION 1 MAX VERTICAL LOAD



$$R_1 \cdot R_2 = \left(\frac{1}{2}\right)(22065) = 11,035 \text{ #}$$

$$M_{MAX} = \left(\frac{22065}{2}\right)\left(13.15 + \frac{40}{4}\right) = (11035)(23.75) = 257,500 \text{ in #}$$

BENDING IN SECT A-A (REF PG 32)

$$M = 257500$$

$$f_b = \frac{Mc}{I} = \frac{(257500)(3.49)}{31.4} = -28,600 \text{ psi}$$

$$F_{cy} = 36,000 \text{ psi}$$

$$M.S. (yield) = \frac{36000}{28600} - 1 = .26$$

TRANSPORT SADDLE - 44" FW ENGINE

DATE 8-24-62

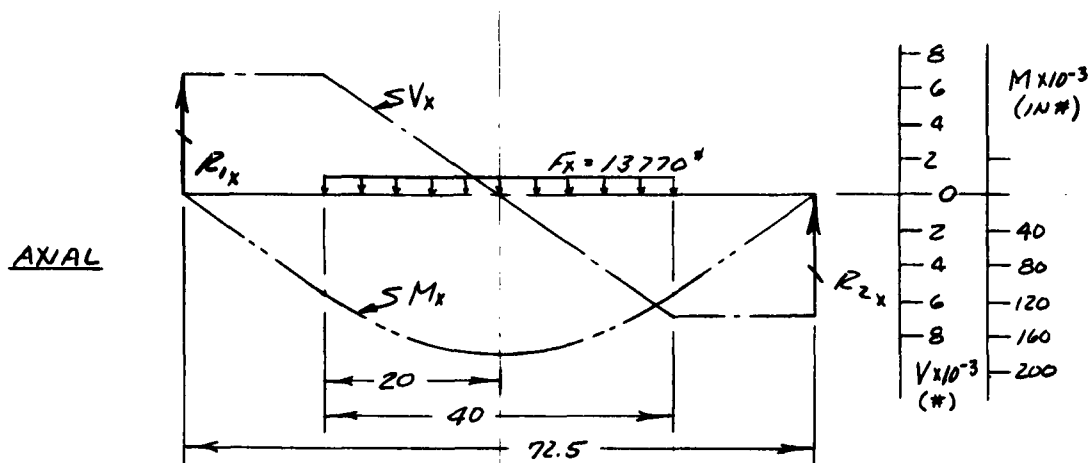
WORK ORDER 0625-26-006

BY T. CUMMINS

CHK. BY R. F. ALLEN

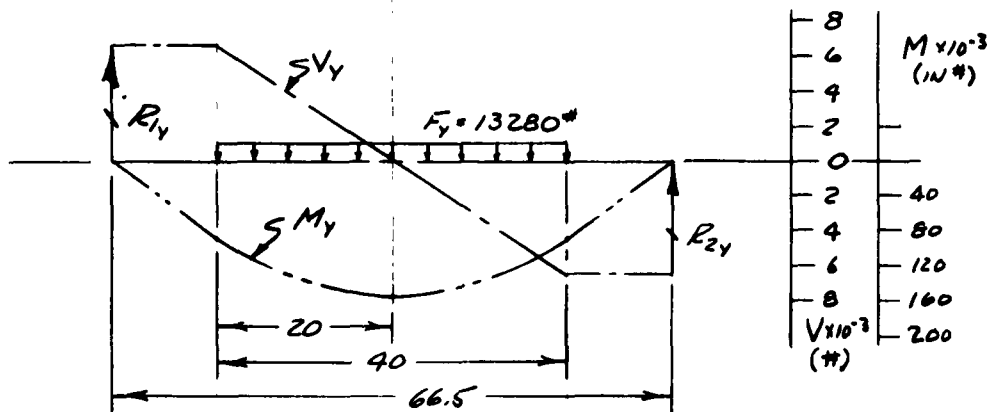
DATE 9-10-62

CONDITION 2 - MAX COMBINED LOADING



$$R_{1x} = R_{2x} = \left(\frac{1}{2}\right)(13770) = 6885 \#$$

$$M_{MAX} = \left(\frac{13770}{2}\right)\left(16.25 + \frac{40}{4}\right) = (6885)(26.25) = 181,000 \text{ in} \#$$



$$R_{1y} = R_{2y} = \left(\frac{1}{2}\right)(13280) = 6640 \#$$

$$M_{MAX} = \left(\frac{13280}{2}\right)\left(13.25 + \frac{40}{4}\right) = (6640)(23.25) = 154,000 \text{ in} \#$$

TRANSPORT SADDLE - 44" FW ENGINE

DATE
5-24-62
WORK ORDER
0625-26-006
DATE
9-10-62

BY T. CUMMINS CHK. BY R. F. ALLEN

CONDITION 2 - (CONT)

BENDING IN SECTION A-A (REF PG 32)

$$M_y = 154,000 \text{ in} \cdot \text{lb}$$

$$M_x = 181,000 \text{ in} \cdot \text{lb}$$

$$f_{bx} = \frac{M_{yx}}{I_y} = \frac{(181,000)(-1.91)}{21.51} = -16,100 \text{ psi}$$

$$f_{by} = \frac{M_{xy}}{I_x} = \frac{(154,000)(-3.49)}{31.40} = -17,100 \text{ psi}$$

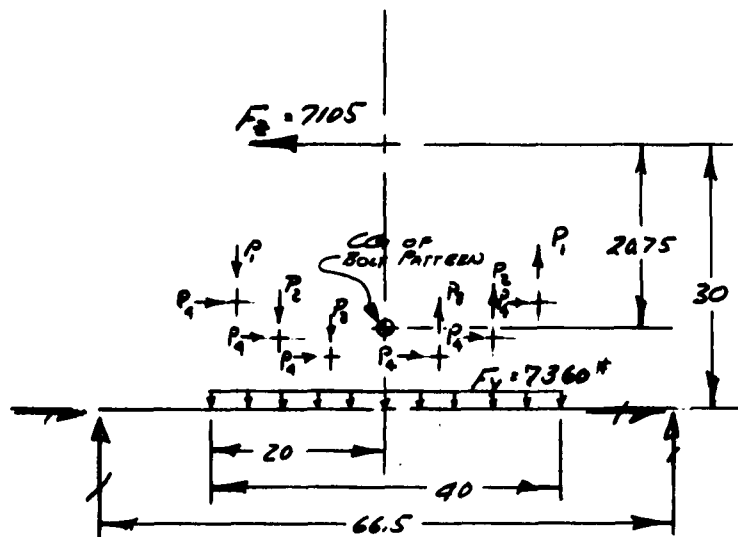
$$f_{b \text{ tot}} = -16,100 - 17,100 = -33,200 \text{ psi}$$

$$F_{cy} = 36,000 \text{ psi}$$

$$\text{M.S. (yield)} = \frac{36,000}{33,200} - 1 = 1.08$$

CONDITION 3 - MAX SIDE LOAD

ASSUME BOLTS HOLDING SADDLE TO RING TRANSFER SIDE LOAD & COUPLE.



SUBJECT

TRANSPORT SADDLE - 44" FW ENGINE

DATE
8-27-62

WORK ORDER
0625-26-006

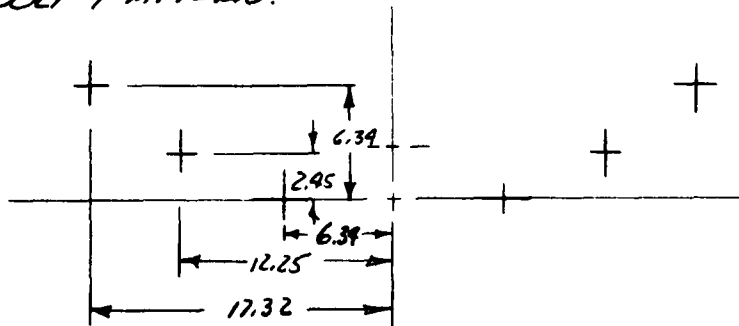
BY
T. CUNNINGHAM

CHK. BY
R. F. ALLEN

DATE
9-10-62

CONDITION 3 - (CONT)

BOLT PATTERN:



BOLT #	X	Y
1	-17.32	6.34
2	-12.25	2.45
3	-6.34	0
4	6.34	0
5	12.25	2.45
6	17.32	6.34
$\bar{x}$	0	17.58

$$\bar{y} = \frac{17.58}{6} = 2.93$$

$$\bar{x} = 0$$

$$I_{BP} = \sum x^2 = (2)(17.32)^2 + (2)(12.25)^2 + (2)(6.34)^2 \\ = 600 + 300 + 80 \\ = 980 \text{ in}^2$$

BOLT LOADS:

$$M = (7105)(20.75) = 147,700 \text{ in} \cdot \text{lb}$$

$$P_1 = \left(\frac{147,700}{980} \right) (17.32) = 2610 \text{ lb}$$

$$P_2 = \left(\frac{147,700}{980} \right) (12.25) = 1845 \text{ lb}$$

$$P_3 = \left(\frac{147,700}{980} \right) (6.34) = 955 \text{ lb}$$

$$P_4 = 7105/6 = 1185 \text{ lb}$$

$$\text{MAX BOLT LOAD} = [(1185)^2 + (2610)^2]^{1/2} = [8,215 \times 10^3]^{1/2} = 2870 \text{ lb}$$

$$\frac{1}{2} \text{ HEX HEAD SCREW } F_s = (35000)(.785)(.406)^2 = 4600 \text{ lb}$$

$$M.S. (\text{ULTIMATE}) = \frac{4600}{(1.5)(2870)} = 1.07$$

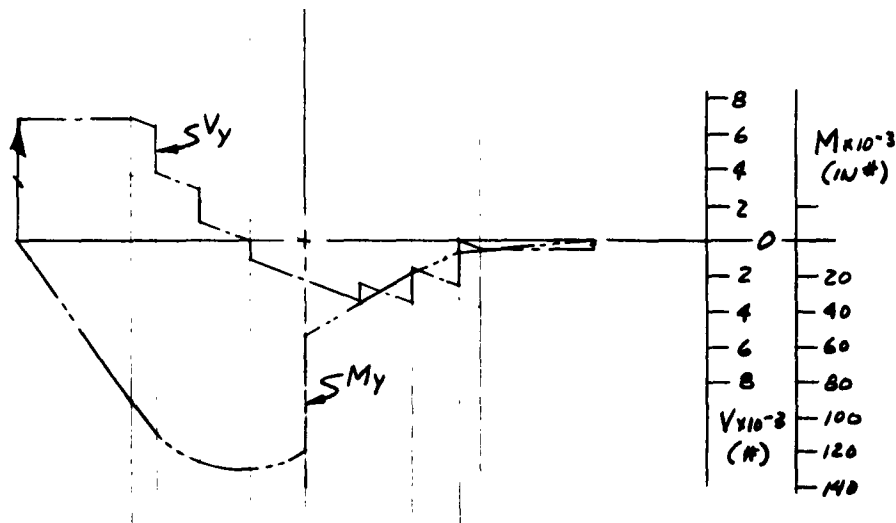
TRANSPORT SADDLE - 44" FW ENGINE

DATE
8-28-62
WORK ORDER
0625-26-006
DATE
9-10-62

BY
T. CUMMINS

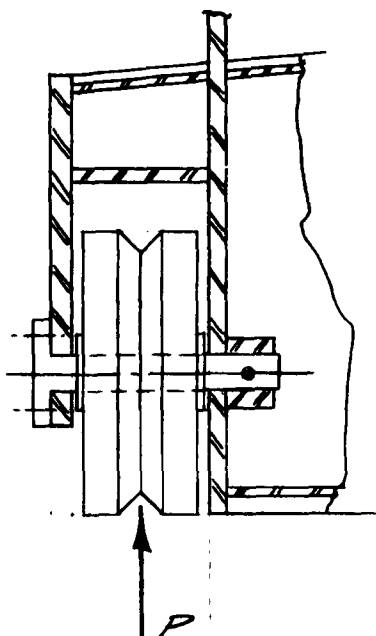
CHK. BY
R. F. ALLEN

CONDITION 3 - (CONT)



BENDING IN SADDLE NOT CRITICAL FOR THIS COND

MAX WHEEL LOAD



$$P_{MAX} (COND 1) = 11,035 \#$$

WHEEL IS "AEROL" V-GROOVE #3001
1'9" LOAD RATING = 8000 #

AXLE -

1" STEEL 120D

$$F_s = (35000 \times .785 \times 1) = 27000 \#$$

$$f_s = (\frac{1}{2} \times 11035) = 5520 \#$$

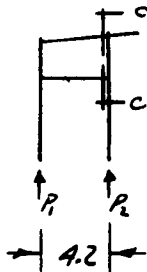
$$MS = \frac{27000}{5520} - 1 = \underline{HIGH}$$

TRANSPORT SADDLE - 44" FW ENGINES

BY T. CUMMINS
CHK. BY R. F. ALLEN

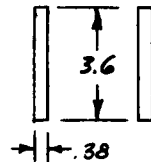
MAX WHEEL LOAD (CONT)

WHEEL SUPPORT -



$$P_1 = P_2 = 5520 \#$$

SECTION C-C
(USE ONLY SIDE PLATES TO CARRY LOAD)



$$S = \frac{(2)(.38)(3.6)^2}{6} = 1.62 \text{ in}^3$$

$$M = 4.2 P = (4.2)(5520) = 23,200 \text{ in} \#$$

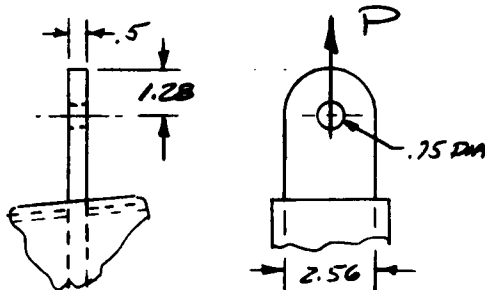
$$f_b = \frac{M}{S} = \frac{23,200}{1.62} = 14,300 \text{ psi}$$

$$f_s = \frac{1.5 V}{ab} = \frac{(1.5)(5520)}{(3.6)(.38)} = 6060 \text{ psi}$$

$$F_{cy} = 36,000 \text{ psi}$$

$$M.S. (\text{YIELD}) = \frac{36,000}{14,300} - 1 = \underline{+ \text{HIGH}}$$

LIFTING LUG



DESIGN FACTOR = 5 (ULTIMATE)

$$P_{DES} = \left(\frac{5}{3}\right)(11,035) = 18,400 \#$$

SHEAR OUT

$$F_s = (2)\left(\frac{1}{2}\right)(.95)(35,000) = 33,200 \#$$

TENSION

$$F_T = (.75)(2.56 - .75)\left(\frac{1}{2}\right)(55,000) = 49,500 \#$$

$$M.S. = \frac{33,200}{18,400} - 1 = \underline{+ .80}$$

Transport Saddle 44" F.W. Engine

BY Schultz

CHK. BY Wieg

DATE
5-8-62
WORK ORDER
0625-98-012
DATE
8-20-62

This change was required in order to strengthen saddle for tie down loads in the "Utility Van."

Max. H due to force of 2G

$$H = \frac{(1300)(2)}{4} = 6500 \#$$

$$T = \frac{6500}{\cos 46^\circ} = \frac{6500}{0.670} = 9700 \#$$

Torsion applied box section.

$$\text{Torque} = (9700)(1.3) = 12,600 \text{ in-}\#$$

$$S = \frac{T}{2t(a-t)(b-t)} = \frac{12,600}{(2)(.375)(2.25)} = 3950 \text{ psi}$$

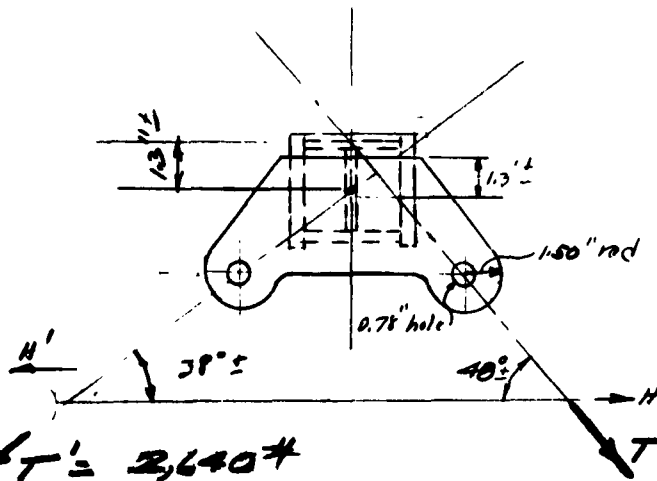
low in OH

Max Bending:

$$M = (9700)(5) = 48,500 \text{ in-}\#$$

$$I = \frac{(4)(5)^3}{12} = \frac{(2.25)(2.25)^3}{12} = 592 \text{ in}^4 \quad z = \frac{5.92}{1.5} = 3.95 \text{ in}$$

$$f_b = \frac{48,500}{3.95} = 12,300 \text{ psi low in OH}$$



$$T' = 2,640 \#$$

vert. load

$$T' = \frac{3250}{\sin 38^\circ} = \frac{3250}{(0.616)} = 2640 \#$$

Check Lugs:

$$M = K P r \quad K = 0.28 \quad P = T = 9,700 \quad r = 0.70 \text{ in}$$

$$M = (0.28)(9,700)(.70) = 1900 \text{ in-}\#$$

(curved beam factor)

$$Z = \frac{(0.75)(1.1)^2}{6} = 0.0466 \text{ in}^3$$

$$f_b = \frac{(1.5)(1900)}{(0.0466)} = 61,000 \text{ psi}$$

too high

Try an edge distance of 1.5"

$$r = 0.73$$

$$M = \frac{(1900)(.93)}{(.70)} = 2520 \text{ in-}\#$$

$$Z = \frac{(1.75)(1.1)^2}{6} = 0.159 \text{ in}^3$$

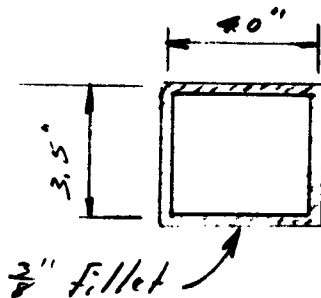
$$f_b = \frac{(61,000)(0.0466)}{0.159} = 18,500 \text{ psi}$$

Des. Factor = 3.25:1 OK

Use 1.5" Edge Dist.

Transport Saddle 99" F.W. Engine		DATE 5-8-62
		WORK ORDER 0625-98-012
BY Schultz	CHK. BY WHEG	DATE 8-28-62

Check Welds



Direct Shear = 9700 #
 $T = 12,600 \text{ in-lb}$

throat depth = $(.707) / (.375) = 0.265" = t = t_1$
 torsional shear ~
 $S = \frac{T}{2t(0-t)(6-t)} = \frac{9700}{(2)(0.265)(.125)(3.75)} = 2200 \text{ psi}$

direct shear ~

$\frac{P}{A} = \frac{9700}{(5)(.265)} = 2930 \text{ psi}$

Total Shear = 9630 psi

Des. Factor $\frac{35}{4.6} = 7.6:1 \text{ OK}$

Transport Saddle 44" F.W. Engine

BY Schulte

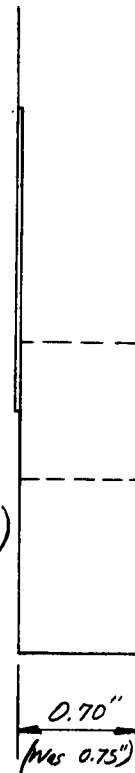
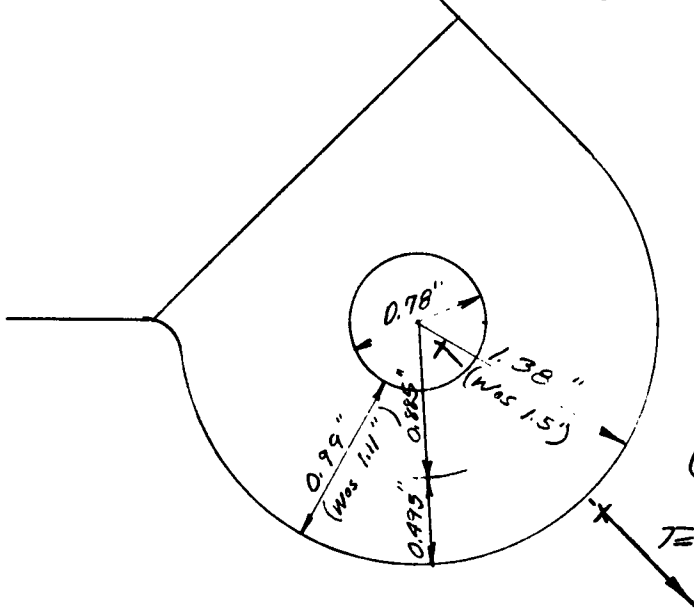
CHK. BY
WIEG

DATE
8-17-62

WORK ORDER

DATE
8-28-62

Revision to Lug ~



Section modulus
@ Sec X-Y

$$Z = \frac{(6.99)^2 (0.70)}{6} = 0.114 \text{ in}^3$$

$$A = (6.70)(0.94) = 0.70 \text{ in}^2$$

Ring Action ~

$$M = K P r = (0.28)(9700)(0.885) = 2400 \text{ in-lb}$$

$$\frac{R}{C} = \frac{0.885}{0.495} = 1.79 \quad \therefore K_r = 1.63 \quad (\text{Rorick Case 1 Pg. 198})$$

$$\text{Max. bending} = f_b = \frac{M K_r}{Z} = \frac{(2400)(1.63)}{0.114} = 34,200 \text{ psi}$$

$$\text{Des. Factor} = \frac{60,000}{34,200} = 1.75:1$$

Just bent, OK

Max. Shear Stress ~

$$\tau = \frac{3}{2} \frac{V}{A} \times (1.10) = (1.10) \left(\frac{3}{2} \right) \frac{9700}{2} \left(\frac{1}{0.70} \right) = 11,450 \text{ psi}$$

$$\text{Des. Factor} = \frac{35,000}{11,450} = 3.06:1$$

Aerojet-General Corporation Sacramento, California STRUCTURAL VERIFICATION TESTS OF THE AEROJET UTILITY VAN, by W. D. Hulse. November 1962 5 PP 22 illus. 3 Appendices. Technical Report AFBSD-TN-RSD-TDR-62-330 Unclassified Report The Aerojet-General Utility van successfully completed structural tests to verify the accepta- bility of the van as a transport vehicle for second- stage Minuteman operational motors. The van and tie-downs were subjected to limit loads to determine stress levels at critical load points and to measure vehicle deflection and recovery from the downward and side loads imposed.	UNCLASSIFIED I. Structural Verification Tests of the Aerojet Utility Van I. Aerojet-General Corp. II. Air Force Ballistic Systems Division, Air Force Systems Command, USAF III. Contract No. AF 33(600)-36610 UNCLASSIFIED	Aerojet-General Corporation Sacramento, California STRUCTURAL VERIFICATION TESTS OF THE AEROJET UTILITY VAN, by W. D. Hulse. November 1962 5 PP 22 illus. 3 Appendices. Technical Report AFBSD-TN-RSD-TDR-62-330 Unclassified Report The Aerojet-General Utility van successfully completed structural tests to verify the accepta- bility of the van as a transport vehicle for second- stage Minuteman operational motors. The van and tie-downs were subjected to limit loads to determine stress levels at critical load points and to measure vehicle deflection and recovery from the downward and side loads imposed.	UNCLASSIFIED I. Structural Verification Tests of the Aerojet Utility Van I. Aerojet-General Corp. II. Air Force Ballistic Systems Division, Air Force Systems Command, USAF III. Contract No. AF 33(600)-36610 UNCLASSIFIED	Aerojet-General Corporation Sacramento, California STRUCTURAL VERIFICATION TESTS OF THE AEROJET UTILITY VAN, by W. D. Hulse. November 1962 5 PP 22 illus. 3 Appendices. Technical Report AFBSD-TN-RSD-TDR-62-330 Unclassified Report The Aerojet-General Utility van successfully completed structural tests to verify the accepta- bility of the van as a transport vehicle for second- stage Minuteman operational motors. The van and tie-downs were subjected to limit loads to determine stress levels at critical load points and to measure vehicle deflection and recovery from the downward and side loads imposed.	UNCLASSIFIED I. Structural Verification Tests of the Aerojet Utility Van I. Aerojet-General Corp. II. Air Force Ballistic Systems Division, Air Force Systems Command, USAF III. Contract No. AF 33(600)-36610 UNCLASSIFIED
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