SOAC
STATE-OF-THE-ART CAR DEVELOPMENT PROGRAM
FINAL TEST REPORT
VOLUME 1: COMPONENT TESTING

Boeing Vertol Company
(A division of The Boeing Company)
Surface Transportation Systems Branch
Philadelphia, Pa. 19142

AUGUST 1974
FINAL REPORT

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Office of Research and Development
Washington, D.C. 20590
NOTICE

This document is disseminated under the sponsorship of the Department of Transportation in the interest of information exchange. The United States Government assumes no liability for its contents or use thereof.
This document, Volume I of SOAC Final Test Report D174-10024, presents the test results for the component testing of the State-of-the-Art Car. The SOAC has been developed under UMTA's Urban Rapid Rail Vehicle and Systems program which has the objective of enhancing the attractiveness of rapid rail transportation to the urban traveler by providing him with transit vehicles that are as comfortable, reliable, safe and economical as possible. The SOAC is one phase of this program.

The purpose of these tests was to show compliance with the SOAC Detail Specification IT-06-0026-73-2. All component tests were conducted by the supplier of the applicable subsystem. All components tested met the requirements of the Detail Specification except as noted in Section 2.5.

This document, Volume I plus the following additional volumes comprise Boeing Vertol Report D174-10024, State-of-the-Art Car Final Test Report as specified in Section 17.1.4.2 of the SOAC Detail Specification.

Volume II - Subsystem Functional Testing  
Volume III - Acceptance Testing  
Volume IV - Simulated Demonstration Test  
Volume V - Post Repair Testing

The SOAC detail specification is available from the National Technical Information Services (NTIS).

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Rapid Transit Car  
UMTA URRV Program

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VOLUME I - COMPONENT TESTING

FOR LIMITATIONS IMPOSED ON THE USE OF THE INFORMATION CONTAINED IN THIS DOCUMENT AND ON THE DISTRIBUTION OF THIS DOCUMENT, SEE LIMITATIONS SHEET.

MODEL: SOAC
CONTRACT: DOT-UT-10007

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**ACTIVE SHEET RECORD**

**FORM 46283 (12/69)**
1. INTRODUCTION
2. TEST PROCEDURES AND RESULTS
3. CONCLUSIONS

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I. INTRODUCTION

The U.S. Department of Transportation, Urban Mass Transportation Administration (UMTA), under Contract DOT-UT-10007, has engaged the Boeing Vertol Company to act as Systems Manager of the Urban Rapid Rail Vehicle and Systems Program. This program is an integrated development program directed toward improving high speed, frequent-stop urban rail systems. The overall objective is to enhance the attractiveness of rail transportation to the urban traveler by providing service that is as comfortable, reliable, safe and economical as possible.

The objective of the State-of-the-Art Car (SOAC) is to demonstrate the best state-of-the-art in rapid rail car design, with two new improved cars using existing proven technology. Primary goals for the cars are passenger convenience and operating efficiency.

The SOAC Test Program Plan and Procedures are described in Boeing Vertol Report D174-10007-1 and is available from the National Technical Information Services (NTIS). The component testing was conducted in accordance with these procedures by system subcontractors to the car manufacturer, St. Louis Car Division, General Steel Industries, Inc. Major subcontractors conducting component testing are The AiResearch Manufacturing Company, a division of the Garrett Corporation - propulsion system; General Steel Industries, Inc., Castings Division - trucks and suspension systems; American Seating Company - seats; and Swedlow, Inc. - windshield.

This document, Volume I - Component Testing, plus the following additional volumes comprise Boeing Vertol Report D174-10024, State-of-the-Art Car Final Test Report as specified in Section 17.1.4.2 of the SOAC Detail Specification.

Volume II - Subsystem Functional Testing
Volume III - Acceptance Testing
Volume IV - Simulated Demonstration Test
Volume V - Post Repair Testing
2. TEST PROCEDURES AND RESULTS

2.1 Propulsion, Dynamic Braking and Auxiliary Power Equipment

The components comprising the propulsion, dynamic braking and auxiliary power systems were tested by AiResearch Manufacturing Company at Torrance, California. The AiResearch test report No. 73-9363 is included as Appendix I.

2.2 Truck Frame and Bolster

Truck frames and bolsters were statically tested by General Steel Industries at the GSI Test Lab. GSI Reports T34701-l and T34702-l are included as Appendix II.

2.3 Windshield

Qualification testing of the SOAC windshield was not conducted since the basic design is similar to the windshield used on the BART Car. The BART test results were reviewed and results extrapolated to the SOAC geometry. (Reference Swedlow Engineering Department Reports No. 724, April 7, 1971 and No. 755, February 2, 1972.)

The windshields are designed to the following criteria:

a. Shall be capable of resisting, without penetration, and the windshield retention, without separation, loads imposed by the equivalent of:

   (1) 175 mph at S/L Pressure (78 lbs. per square foot)
   
   (2) Impact of 1.0 lb. Stone at 80 mph or 5 lbs. at 50 mph.

b. Light transmission to be at least 85 percent (BART transmission 70% with solar coating).

The BART windshield was tested by Swedlow and Wyle Laboratories in July/August 1970. Swedlow Test Report No. ETR-010, December 17, 1970 is included as Appendix III.
2.4 **Seat Strength**

The seats for the SOAC were manufactured by the American Seating Company and are similar in design to the seats manufactured for the BART Car; therefore, no additional testing was performed for the SOAC. The American Seating Company strength and test data report on seats representative of the SOAC configuration is included as Appendix IV.

2.5 **Materials - Fire Resistance**

All major interior materials were tested for fire resistance in accordance with Section 2.4.9 of the Detail Specification. The seat upholstery met the requirements of Federal Highway Administration Standard No. 302 "Flammability of Vehicle Interior Materials" as tested by the American Seating Company. Test results are presented in Appendix V. The remaining items were tested by the Boeing Vertol Quality Assurance Laboratory to a more stringent specification, Federal Standard No. 191. The results of these tests are also presented in Appendix V.

The three items that failed to meet F.S. 191 were not considered to be a fire-potential problem because of their limited usage (Mylar side signs and window glazing rubber) or method of installation, i.e. leaded vinyl sheathing (combustible) sandwiched between the floor panels and the carpeting neither of which supported combustion.
3. CONCLUSIONS

A. SOAC Component Tests were conducted by the subsystem suppliers. All items met the requirements of the Detail Specification except as noted in C. below.

B. The windshield and seats were qualified by similarity to BART designs. BART test results were reviewed and accepted for these items.

C. Interior materials were tested for fire resistance to a more stringent specification than required by the Detail Specification. Three items which failed to meet this specification were accepted because of their limited usage or protective method of installation.
AIRESEARCH MANUFACTURING COMPANY
Torrance, California

COMPONENT AND SYSTEM DEVELOPMENT TESTS
FOR
PROPULSION, DYNAMIC BRAKING AND AUXILIARY POWER EQUIPMENT

73-9363 (SOAC)

Number of pages 148
Prepared by W. Curran
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Edited by

Approved by

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Component and System Development Tests

The test data, graphs and other information included in this document have been extracted from test records and engineering notes. This data was collected during the course of component study and system testing which was carried out in the development phase of the Propulsion and Auxiliary Power subsystem for SOAC. The system testing was done on a laboratory assembly of the vehicle components with motors driving equivalent inertial loads but excluded the gearboxes. The gearbox tests were run in a separate test stand.

The assembly of the test data follows the same general format as the A-2 section of Boeing Vertol document D174-10007-1 SOAC TEST PROGRAM (Rev. 6/12/72).

Paragraphs extracted from D174-10007-1 precede each group of data presented. The groups do not necessarily follow the exact order of the above test program and vary somewhat in content from the original plan.
2. PROPULSION AND DYNAMIC BRAKING, AND AUXILIARY POWER SYSTEMS

a. TRACTION MOTORS (P/N 200732-1)

Production Testing

Each traction motor is subjected to the following production acceptance tests:

1. Resistance of windings and polarity checks
2. Seating of brush faces
3. No load tests
4. Overspeed
5. Dielectric
6. Commutation tests (selected)
7. Black band tests (1st 2 units only)
8. Inspect all critical dimensions

Development Testing

Two traction motors will be utilized to perform the following development testing:

(1) No Load Saturation

Purpose

The purpose of this test is to confirm the capability of the motor magnetic circuit.

Configuration

Two motors are connected together with a flexible coupling. Each of the motors are provided with a constant cooling air flow of 900 cfm and are run in turn with the opposite motor acting as an open circuit generator. The no load saturation of the generating element is then determined as follows:

Procedure

Apply 312 volts motor input voltage. Adjust field current as required throughout the test to provide motor speed of 1560 RPM (base speed).

Change field current of the motor acting as a generator 0-60-0 amperes in 5 amp steps. Record output voltage, field current and speed of the motor acting as a generator.

(2) Efficiency

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a. TRACTION MOTORS (Contd.)

Purpose

Determine the overall motor efficiency

Configuration

Two motors are connected with a flexible coupling and are each provided with a constant cooling air flow of 900 cfm. The motors are electrically connected in parallel and the field currents are adjusted such that one is acting as a driving element and the other is acting as a generating (loading) element. The efficiency of the traction motor is then determined as follows:

Procedure

Apply an input voltage equal to \(312 - 600 (R_{\text{armature}} + R_{\text{stator}}) - 2\). (The armature and stator resistances are determined in the production acceptance tests). Load the motor and generator system at a rated speed of 1560 RPM such that the sum of the motor and generator armature currents equals 1200 amperes.

Calculate the efficiency of the motor in the following manner:

\[
\eta_m = \frac{2(E_{\text{input} \ I_{\text{arm}}} - E_{\text{input} \ I_{\text{line}}})}{2 E_{\text{input} \ I_{\text{arm}}}} \times 100
\]

Repeat the above procedure except at 4300 RPM and 1800 amperes. Regulate input voltage to \(600 + 900 (R_{\text{arm}} + R_{\text{stator}}) + 2\).

Calculate the efficiency of the motor as a braking generator in the following manner:

\[
\eta_g = \frac{2(E_{\text{input} \ I_{\text{arm}}})}{2 E_{\text{input} \ I_{\text{arm}}} + E_{\text{input} \ I_{\text{line}}}} \times 100
\]

As design goals, the efficiency of the motor, acting as a motor is 90.3% and the efficiency of the motor acting as a braking generator is 91.0%, with 110°C winding temperatures.

(3) Commutation Tests

Purpose

Verify that the commutating characteristics of the machine are acceptable by observation of arcing, tracing or flaring for the following configurations:
a. TRACTION MOTORS (Contd.)

Configuration

As a motor observe commutation at the following test conditions:

a. 175 Volt, 785 Amps, 780 RPM
b. 312 Volt, 750 Amps, 1560 RPM
c. 312 Volt, 750 Amps, 2400 RPM
d. 312 Volt, 750 Amps, 4300 RPM
e. 470 Volt, 565 Amps, 2400 RPM

As a generator, observe commutation at the following test conditions:

a. 125 Volt, 925 Amps, 780 RPM
b. 175 Volt, 925 Amps, 1560 RPM
c. 400 Volt, 925 Amps, 2160 RPM
d. 540 Volt, 710 Amps, 2900 RPM
e. 600 Volt, 740 Amps, 4300 RPM

4. Heat Run

Purpose

Verify that the motor thermal design is adequate for the purpose intended.

Configuration

Connect two motors in the same manner as in the efficiency tests (Item 2)

Procedure

Determine the mean armature temperature rise at each of the listed test conditions in the following manner.

Record the temperature of the thermocouples located in the stator every five minutes while at the test conditions. Stop the test when the temperature rise is not more than 20°F between readings on any of the thermocouples. Stop the cooling air flow when the test is stopped. Measure the rotor temperatures on the armature iron, end turns, risers and commutator surface as rapidly as possible. Measure the armature resistance. Calculate the final armature mean temperature using the following formula:

\[ t_f = \frac{R_f - R_i}{R_i} (234.5 + t_1) + t_i \]
a. TRACTION MOTORS (Contd.)

\[
\begin{align*}
    t_f &= \text{final temperature} \\
    t_i &= \text{initial temperature} \\
    R_f &= \text{final armature resistance} \\
    R_i &= \text{initial armature resistance}
\end{align*}
\]

Test Conditions

a. Continuous Rating at Base Speed 175 HP, 312 volts 460 amperes, 1560 RPM

b. One hour rating at Base Speed 230 HP, 312 volts 600 amperes, 1560 RPM
   (Same procedure as above except stop test at end of one hour)

c. Overload Test 156 volts, 900 amperes, 1560 RPM
   (Start test with armature temperature, computed as above, at 100 \pm 10^\circ C. Stop test when armature reaches 180 \pm 10^\circ C)

In the above tests the armature temperature shall not exceed 200^\circ C, and the field winding 180^\circ C.

5. **Overspeed**

**Purpose**

Prove the mechanical integrity of the rotor and commutator.

**Configuration**

Connect two motors in the same manner as in the efficiency tests (Item 2)

**Procedure**

With an armature temperature of 180 \pm 10^\circ C, run the motor at 5160 RPM (120\% of top rated speed) for 120 seconds.

No permanent deformation of the rotor and commutator shall have resulted.

6. **Dielectric**

**Purpose**

Prove the dielectric capability of the insulation system.
a. TRACTION MOTORS (Contd.)

Configuration

Test the motor in a static condition.

Procedure

Test the motor windings immediately after the overspeed test above with a dielectric voltage of 2700 V 60 Hz between each coil and the motor frame. Apply the voltage gradually, hold at the test voltage for 60 seconds, and reduce the voltage gradually. Each winding not being tested will be connected to the motor frame.

7. Commutation Limit Test

Purpose

Establish the momentary overload limit of the motor to determine the safety margin above the rated load.

Configuration

Connect two motors together through a flexible coupling such that one is being electrically driven as a motor element and the other is electrically connected through an electrical contactor to a resistive load and acting as a generator element.

Procedure

With the generator element unloaded (electrical load contactor open) adjust the resistive load in descending values starting at 1.0 ohm. At each resistive load, with the breaker open, run the motor at 1560 RPM and adjust the generator field current to provide a terminal voltage of 312 volts. Increase the motor speed to 4730 RPM (110% rated speed). The generator voltage shall be approximately 950 volts. Disconnect the motor from the input voltage and allow the system to coast down in speed to 4300 RPM, and close the generator load contactor. Repeat this procedure at gradually descending load resistances until the generator flashes over.

8. Vibration

Purpose

Prove the mechanical integrity of the motor and gearbox to vibratory input loading.
a. TRACTION MOTORS (Contd.)

**Configuration**

A vibration fixture which independently simulates the axle input to the gearbox and the motor-truck frame mounting will be utilized for this test.

**Procedure**

With the motor truck frame mounting fixture in a static rigid condition, drive the axle input fixture and scan for resonances in the 20 to 35 Hz region. Resonances in the 80 to 150 Hz region have been given special attention in the design and will not require evaluation.

A fatigue test will be run at any resonance determined or at 35 Hz if no resonance is determined. The desirable test life of the system is as follows: ±5 gs lateral, 10^6 cycles.

Due to the length of the testing at the low frequencies associated with this type of equipment, an accelerated simulated life at a higher g input and a reduced cycle length may be utilized.

9. **Noise**

**Purpose**

Determine the audible noise characteristics of the motor-gearbox combination.

**Configuration**

Connect a motor and gearbox in a manner simulating the installation on the car truck.

**Procedure**

Record audible noise levels on a broad noise level meter "C" scale. Recordings will be taken at a distance of 15 feet in each of the four longitudinal and lateral directions, and at various gearbox loadings and motor speeds.

As a design goal, a noise level of 85 db maximum (reference 0.02 microbar) will be recorded.
10. Black Band

Purpose

Determine the proper adjustments for the interpole turns and air gap.

Configuration

Two motors are connected together with a flexible coupling. The motors are electrically connected in parallel and the field currents are adjusted such that one is acting as a driving element and the other is acting as a generating (loading) element.

Procedure

NOTE: A buck-boost circuit will be required for this test.

Apply 312 volts motor input voltage. Adjust field current as required throughout the test to provide motor speed of 1560 RPM (base speed).

Increase the generator field to load the motor.

Increase the motor current to 150 amperes (1/4 load). Energize buck-boost power source and increase boost voltage until visible sparking occurs. Record: output voltage, field current, speed and direction of motor rotation.

Decrease buck voltage until visible sparking occurs and record as before. Change direction of rotation and repeat.

Repeat at 300, 450, 600, 750 and 900 amperes.

Repeat the tests at a speed of 4300 RPM.

Interchange motor and motor that acted as generator and repeat black band tests.

The data obtained from these tests will be utilized to establish an interpole air gap adjustment, and a turns adjustment if necessary, to provide the best compromise over the load and speed range of the motor.
a. Development Testing, Traction Motors

(1) No load saturation data taken on 530AC motor SN3 is shown on Fig. a.1-1.

(2) Motor efficiency data is taken in a test setup with one motor as a driving element coupled shaft to shaft to another motor used as a generator dumping power into a load bank. The data supplied here is for motor SN3 (motor SN7 was used as the generator for the efficiency data, see Fig. a.2-1)

\[ \eta_m = \sqrt{\frac{\text{Generator Watts out}}{\text{Motor Watts in}}} \]

The data has a spread of ±4% with a mean value of approximately 92%

(3) Data on commutation testing as done on each unit as shown for motor SN-3 in Figures a.3-1 and a.3-2. The ratings for visible commutation shown in the right hand columns of the above figures is defined as follows:

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<td>Few intermittent fine sparks</td>
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<tr>
<td>Continuous fine sparking over half the brush width</td>
<td>1-1/4</td>
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<tr>
<td>Continuous fine sparking over most of the brush width</td>
<td>1-1/2</td>
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<tr>
<td>Continuous fine sparking plus heavy sparking over half of the brush</td>
<td>2</td>
</tr>
<tr>
<td>Continuous heavy sparking</td>
<td>3</td>
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<tr>
<td>Continuous heavy sparking plus blue arcing or streamers</td>
<td>3-1/2</td>
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<tr>
<td>Continuous heavy sparking plus glowing at brush width</td>
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</tbody>
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Motor Test Data
P.N. 200732-1

Serial # B

1 - Resistance Measurements
F1 to F2 1.25 OHMS
Rotor at 90° 0.012 OHMS

2 - Insulation Resistance
A1 to Frame \( \frac{20 \times 10^3}{\text{Megohms}} \)
F1 to Frame \( \frac{2.00 \times 10^3}{\text{Megohms}} \)
Arm to Frame \( \frac{50 \times 10^3}{\text{Megohms}} \)
A1 to F1 \( \frac{20 \times 10^3}{\text{Megohms}} \)

3 - Arm Concentricity .0003 Inches

4 - Motor Rotation C.W.
\( \checkmark \) Passed
F1(+) F2(-), A2(+) A1(-) \( \Box \) Failed

5 - No Load Saturation
C.W. Rotation at 1560 R.P.M.

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</tr>
<tr>
<td>2420</td>
<td>470</td>
<td>740</td>
<td>30</td>
<td>1/4</td>
<td>325</td>
<td>960</td>
<td>58</td>
<td>1.6</td>
<td>1.2</td>
</tr>
<tr>
<td>2420</td>
<td>340</td>
<td>760</td>
<td>11</td>
<td>1/4</td>
<td>325</td>
<td>960</td>
<td>58</td>
<td>1.6</td>
<td>1.2</td>
</tr>
<tr>
<td>2420</td>
<td>470</td>
<td>740</td>
<td>30</td>
<td>1/4</td>
<td>470</td>
<td>740</td>
<td>22</td>
<td>1.4</td>
<td>3/2</td>
</tr>
<tr>
<td>2420</td>
<td>600</td>
<td>700</td>
<td>18</td>
<td>2/4</td>
<td>540</td>
<td>800</td>
<td>13</td>
<td>2/4</td>
<td>3/2</td>
</tr>
</tbody>
</table>

OVERSPEED AT 5160 RPM
S.N. 3
PASSED

HYPOT AT 2700 Y.A.C. S.N. 3
ARM
PASSED
FIELD
PASSED
**Motor Data Sheet**

### Serial # 3 as Motor

<table>
<thead>
<tr>
<th>Stated Actual</th>
<th>Speed</th>
<th>Arm. Volts</th>
<th>Arm. Amps</th>
<th>Field Amps</th>
<th>Rotation</th>
<th>Scale Volts (rpm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>S</td>
<td>780</td>
<td>75</td>
<td>785</td>
<td>54</td>
<td>CCW</td>
<td>1</td>
</tr>
<tr>
<td>A</td>
<td>860</td>
<td>20</td>
<td>760</td>
<td>32</td>
<td>CCW</td>
<td></td>
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<tr>
<td>S</td>
<td>1560</td>
<td>312</td>
<td>750</td>
<td>35</td>
<td>CCW</td>
<td>1</td>
</tr>
<tr>
<td>A</td>
<td>1500</td>
<td>310</td>
<td>780</td>
<td>38</td>
<td>CCW</td>
<td></td>
</tr>
<tr>
<td>S</td>
<td>2400</td>
<td>312</td>
<td>750</td>
<td>18</td>
<td>CCW</td>
<td>1½</td>
</tr>
<tr>
<td>A</td>
<td>2400</td>
<td>325</td>
<td>760</td>
<td>17</td>
<td>CCW</td>
<td></td>
</tr>
<tr>
<td>S</td>
<td>4300</td>
<td>312</td>
<td>750</td>
<td>9</td>
<td>CCW</td>
<td>3</td>
</tr>
<tr>
<td>A</td>
<td>4200</td>
<td>340</td>
<td>760</td>
<td>11</td>
<td>CCW</td>
<td>1½</td>
</tr>
<tr>
<td>S</td>
<td>2400</td>
<td>470</td>
<td>565</td>
<td>34</td>
<td>CCW</td>
<td></td>
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<tr>
<td>A</td>
<td>2400</td>
<td>435</td>
<td>580</td>
<td>30.5</td>
<td>CCW</td>
<td></td>
</tr>
</tbody>
</table>

### Serial # ___ as a Generator

<table>
<thead>
<tr>
<th>Stated Actual</th>
<th>Speed</th>
<th>Arm. Volts</th>
<th>Arm. Amps</th>
<th>Field Amps</th>
<th>Rotation</th>
<th>Scale Volts (rpm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>S</td>
<td>780</td>
<td>175</td>
<td>785</td>
<td>54</td>
<td>CCW</td>
<td>1</td>
</tr>
<tr>
<td>A</td>
<td>800</td>
<td>148</td>
<td>800</td>
<td>50</td>
<td>CCW</td>
<td></td>
</tr>
<tr>
<td>S</td>
<td>1500</td>
<td>312</td>
<td>750</td>
<td>35</td>
<td>CCW</td>
<td>1½</td>
</tr>
<tr>
<td>A</td>
<td>1400</td>
<td>375</td>
<td>925</td>
<td>18</td>
<td>CCW</td>
<td></td>
</tr>
<tr>
<td>S</td>
<td>2400</td>
<td>312</td>
<td>750</td>
<td>18</td>
<td>CCW</td>
<td>1½</td>
</tr>
<tr>
<td>A</td>
<td>2400</td>
<td>325</td>
<td>760</td>
<td>17</td>
<td>CCW</td>
<td></td>
</tr>
<tr>
<td>S</td>
<td>4300</td>
<td>312</td>
<td>750</td>
<td>9</td>
<td>CCW</td>
<td>2½</td>
</tr>
<tr>
<td>A</td>
<td>3980</td>
<td>500</td>
<td>700</td>
<td>18</td>
<td>CCW</td>
<td></td>
</tr>
<tr>
<td>S</td>
<td>2400</td>
<td>470</td>
<td>560</td>
<td>34</td>
<td>CCW</td>
<td>1½</td>
</tr>
<tr>
<td>A</td>
<td>3300</td>
<td>420</td>
<td>790</td>
<td>30</td>
<td>CCW</td>
<td></td>
</tr>
</tbody>
</table>

**Overspeed at 5160 RPM:**

- [ ] Passed
- [ ] Failed

**Hypot at 2700 V A.C. S.N.:**

- [ ] Passed
- [ ] Failed

---

*Fig 43-1*
### Motor Data Sheet

**Serial #3 as Motor**

<table>
<thead>
<tr>
<th>Stated Actual</th>
<th>Speed R.P.M.</th>
<th>Arm Volts</th>
<th>Arm Amps</th>
<th>Field Amps</th>
<th>Rotation</th>
<th>Scale Volts (RPM)</th>
</tr>
</thead>
<tbody>
<tr>
<td>S</td>
<td>780</td>
<td>175</td>
<td>785</td>
<td>54</td>
<td>CW</td>
<td>1</td>
</tr>
<tr>
<td>A</td>
<td>900</td>
<td>170</td>
<td>765</td>
<td>265</td>
<td>CW</td>
<td></td>
</tr>
<tr>
<td>S</td>
<td>1560</td>
<td>312</td>
<td>750</td>
<td>35</td>
<td>CW</td>
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<td>1380</td>
<td>312</td>
<td>730</td>
<td>38.5</td>
<td>CW</td>
<td>1</td>
</tr>
<tr>
<td>S</td>
<td>2400</td>
<td>312</td>
<td>750</td>
<td>18</td>
<td>CW</td>
<td>1</td>
</tr>
<tr>
<td>A</td>
<td>2390</td>
<td>312</td>
<td>780</td>
<td>17.5</td>
<td>CW</td>
<td>1</td>
</tr>
<tr>
<td>S</td>
<td>4300</td>
<td>312</td>
<td>750</td>
<td>9</td>
<td>CW</td>
<td>1</td>
</tr>
<tr>
<td>A</td>
<td>4250</td>
<td>340</td>
<td>780</td>
<td>19.5</td>
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<td>1</td>
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<tr>
<td>S</td>
<td>5600</td>
<td>470</td>
<td>565</td>
<td>34</td>
<td>CW</td>
<td>1</td>
</tr>
<tr>
<td>A</td>
<td>2350</td>
<td>130</td>
<td>590</td>
<td>34</td>
<td>CW</td>
<td>1</td>
</tr>
</tbody>
</table>

**Serial #-- as a Generator**

<table>
<thead>
<tr>
<th>Stated Actual</th>
<th>Speed R.P.M.</th>
<th>Arm Volts</th>
<th>Arm Amps</th>
<th>Field Amps</th>
<th>Rotation</th>
<th>Scale Volts (RPM)</th>
</tr>
</thead>
<tbody>
<tr>
<td>S</td>
<td>180</td>
<td>175</td>
<td>785</td>
<td>54</td>
<td>CW</td>
<td>1</td>
</tr>
<tr>
<td>A</td>
<td>720</td>
<td>126</td>
<td>620</td>
<td>20</td>
<td>CW</td>
<td>1</td>
</tr>
<tr>
<td>S</td>
<td>1560</td>
<td>312</td>
<td>750</td>
<td>35</td>
<td>CW</td>
<td>1</td>
</tr>
<tr>
<td>A</td>
<td>1500</td>
<td>186</td>
<td>925</td>
<td>20</td>
<td>CW</td>
<td>1</td>
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<td>2400</td>
<td>312</td>
<td>750</td>
<td>18</td>
<td>CW</td>
<td>1</td>
</tr>
<tr>
<td>A</td>
<td>1920</td>
<td>320</td>
<td>700</td>
<td>60</td>
<td>CW</td>
<td>1</td>
</tr>
<tr>
<td>S</td>
<td>4300</td>
<td>312</td>
<td>750</td>
<td>9</td>
<td>CW</td>
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<td>2500</td>
<td>550</td>
<td>720</td>
<td>39</td>
<td>CW</td>
<td>1</td>
</tr>
</tbody>
</table>

Overspeed at 5160 RPM: ☑ Passed

HyPOT. at 2700 V.A.C. S.N.: A.M. Field: ☑ Passed

---

*Fig 93-1*
4. **Heat Run**

The data included here is for the one hour rating test at 230 HP continuous. Fig A4-1 identifies the temperature sensor locations. Figure A4-2 is a series of 8 pages which are a copy of the strip chart record for a heat run test on Traction Motors SN No. 9 and 11, with No. 9 running as the motor.

The setup for this test is shown in Figure A4-3. The conditions noted on this figure are steady state operating conditions as taken from figure A4-2(7), just before the test was stopped and cooling air was turned off. The lines traced in on these charts are for thermocouple locations 10, 12, 21 and 22. Locations 21 and 22 are air outlet temperatures. Numbers 10 and 12 are winding temperatures near the air outlet which reached the highest values after shut down, see figure A4-2(8).

The airflow rates (approximately 900 CFM per motor) are about 20% lower than that of the forced air cooling system used in the vehicle.

Data from the Overload Heat Run are shown in Fig. A4-4.

Two views of the test set up are shown in the photographs Fig. A4-5 and A4-6.

5. **Overspeed**

Overspeed tests are run to 5160 RPM (20% above nominal maximum operating speed) on each unit as indicated in figure a2-1.

6. **Dielectric**

The results of the dielectric test are also shown in figure a2-1, part of the individual motor test data.

7. **Commutation Limit Test**

This test has not been run.
# Thermocouple Locations

<table>
<thead>
<tr>
<th>No.</th>
<th>Location</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Interpole Commutating Coil Air Inlet Side</td>
</tr>
<tr>
<td>2</td>
<td>A1</td>
</tr>
<tr>
<td>3</td>
<td>B1</td>
</tr>
<tr>
<td>4</td>
<td>B2</td>
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<td>5</td>
<td>C1</td>
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<tr>
<td>6</td>
<td>C2</td>
</tr>
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<td>7</td>
<td>D1</td>
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<td>8</td>
<td>E1</td>
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<td>H1</td>
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<td>12</td>
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<td>K1</td>
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<td>M1</td>
</tr>
<tr>
<td>16</td>
<td>N1</td>
</tr>
<tr>
<td>17</td>
<td>Shunt Drive End</td>
</tr>
<tr>
<td>18</td>
<td>Comp. Winding</td>
</tr>
<tr>
<td>19</td>
<td>Interpole (S/N 11 Unit)</td>
</tr>
<tr>
<td>20</td>
<td>T2 Duct 18.375&quot; OIA</td>
</tr>
<tr>
<td>21</td>
<td>G Feet Away From The Set Cil Ambient Thermsco</td>
</tr>
<tr>
<td>22</td>
<td>External Temp Sns: Brush Keller</td>
</tr>
<tr>
<td></td>
<td>F1</td>
</tr>
<tr>
<td></td>
<td>G1</td>
</tr>
<tr>
<td></td>
<td>#11 Motor (Air Out From Motor)</td>
</tr>
<tr>
<td></td>
<td>#9 Motor (&quot;&quot;&quot;&quot;)</td>
</tr>
</tbody>
</table>

Fig 4-1

Sheet 31
Forced air supply
133 lb/min
(1850 CFM)
100°F
Motor
Motor as Generator
Load bank
exit air
145°F
125°F
312 V
600A (230 HP)

FIG 44-3  30AC Traction Motor Heat Run Test
HEAT-RUN - OVERLOAD (900 AMPS)
SOAC TRACTION MOTOR s/n 9
TEST DURATION 12 MINUTES
WITH 900 CFM COOLING AIR

1 = Commutating coil air inlet side
2 = Commutating coil opp. air inlet
3 = Pole-face windings, inlet side
4 = " " opp. inlet
5 = Same as 1 drive end
6 = Same as 2 drive end
7 = Same as 5 " "
8 = Air inlet

H. Manuel 7-21-72

1 2 3 4
MINUTES AFTER SHUTDOWN
8. **Vibration**
   
   This test was not run.

9. **Noise**
   
   This test was not run. The motor is cooled by an external blower and is a relatively quiet unit by itself.

10. **Black Band**

    The data run on this test is shown in reduced form in the graphs on figure A10-1. The lines plotted represent the black band boundary for the conditions stipulated on the graph.
MOTOR: S/N - 1
Rotation: CCW

Base Speed ≈ 2250 RPM

Base Speed ≈ 2000 RPM

% Arm Current
100% = 600 Amps

FIC a10-1

Black Bond Test
b. INPUT REACTOR (P/N 524054-1)

Production Testing

1. Inductance test
2. Q shall be verified
3. Hi Pot
4. Resistance

Development Testing

Purpose

To insure reactor meets all design specifications.

Configuration

Power source and instrumentation to monitor tests.

Procedure

a. Inductance using incremental inductance bridge
   \( L = 0.30 + 0.03 - 0.0 \) mhy

b. Resistance using wheatstone bridge
   \( R_{dc} = 1.4 \times 10^{-3} \) ohm ± 10%

c. Hi Pot: Apply 3000 VAC 60 Hz between inductor terminals and support angles.

d. Thermal tests: Insert four thermocouples on specified surfaces. Connect inductor to a low voltage - high current direct current source. Increase voltage to obtain 1350 amperes through the inductor. Allow temperatures to stabilize. The hot spot temperature rise shall not exceed 100°C.
b. INPUT REACTOR (P/N 524054-1)

Production Testing

Each unit was tested to check compliance with the requirements of specification 422-0500.

Development Testing

No development testing of the component, as such, was made. A heat run was not considered necessary, since its heat load was less than the smoothing reactor.
c. SMOOTHING REACTOR (P/N 524056-1)

Production Testing

1. Inductance tests
2. Q shall be verified
3. Hi.Pot
4. Resistance

Development Testing

Purpose

To insure reactor meets all design specifications.

Configuration

Power source and instrumentation to monitor tests.

Procedure

a. Inductance using incremental inductance bridge
   \( L = 1.0 + .01 - 0.0 \text{ mhy} \)

b. Resistance using wheatstone bridge
   \( R_{dc} = 2.7 \times 10^{-3} \text{ ohm} \pm 10\% \)

c. Hi Pot: Apply 3000 VAC, 60 Hz between Inductor terminals and support angles.

d. Thermal tests: Insert four thermocouples on specified surfaces. Connect inductor to a low voltage - high current direct current source. Increase voltage to obtain 1350 amperes through the inductor. Allow temperatures to stabilize. The hot spot temperature rise shall not exceed 100°C.
c. SMOOTHING REACTOR (P/N 524056-1)

Production Testing

Each unit was tested to check compliance with the requirements of specification 422-0501.

Development Testing

The electrical and mechanical characteristics were verified and a heat run was made to determine the temperature rise of the unit. Details of the heat run follow:

**Smoothing Inductor Heat Run**

The smoothing inductor was tested for temperature rise by applying D.C. current and monitoring the temperature at selected points. The motion of the train was simulated by blowing air across the inductor.

The air flow across the inductor was not evenly distributed (see chart) but was approximately 2000 ft per minute or 23 miles per hour.

The thermocouples were placed in the air ducts but wedged under the last turn, so that they were not exposed to the air but were essentially covered on both sides by the conductor.

A load bank was utilized to permit the phase delayed rectifier to operate at an advanced firing angle. The voltage was adjusted to deliver 1200 Amp D.C. through the inductor.

A recorder was used to continuously monitor the thermocouple temperatures. Pertinent points are shown plotted on the chart.
Referring to Figure CI-1 it can be seen that the maximum temperature reached was 314°F, but the temperature was still increasing slightly. It did not appear that the final temperature would exceed 320°F. The length of the run was three hours. The ambient temperature was 104°F. The temperature rise was therefore 216°F.

Since the air flow was considered minimal as compared to the actual application, the results of this test were considered acceptable to verify the design of the inductor.

The input reactor had a thermal load of approximately 0.7 watts per sq. inch of surface whereas the smoothing inductor had a heat load of approximately 1.1 watts per sq. inch. It was therefore concluded that a test of the input inductor would not be necessary, since its lower heat load would result in a lower temperature rise.
d. DC-DC CHOPPER (P/N 524058-1)

Production Testing

1. Thyristors and rectifiers
   a. Blocking life
   b. Dynamic tests

2. Thyristor voltage sharing and snubber operation
3. Logic tests
4. Sensor tests
5. Hi Pot
6. 400 Hz operation to check snubber operation
7. Drive brake transition

Development Testing

Purpose
To insure that components will perform to the required specifications.

Configuration
Power source - loads - high and low temperature ovens - thermocouples - necessary test equipment for monitoring results.

Procedure

a. Thyristor acceptance
   1) Blocking life (72 hrs - 125°C - 960V)
   2) Gate sensitivity (25°C - 3.0V - 150 ma)
   3) Forward voltage drop (25°C - 300A - 1.6-1.9V)
   4) Anode blocking (125°C - 1200V)
   5) Gate sensitivity (125°C - 0.15V)
   6) Turn off time (125°C - 30 μsec max)

b. Rectifier acceptance
   1) Blocking life (72 hrs - 150°C - 1500V)
   2) Anode blocking (200°C - 2000V)
   3) Forward voltage drop (150°C - 300A)

c. Commutating capacitor
   1) Inductance (10.0 + 0.5 - 0.0 mH)
   2) Hi Pot (2500V - 60 Hz - 1 min)

SHEET 52
d. DC-DC CHOPPER (Contd.)

d. Commutating capacitor

1) Capacitance (4 uF ± 10%)
2) Hi Pot (1000V - 400 Hz - 1 Hr)

Full Load Operational Tests

Purpose

To determine that the DC-DC Chopper functions within all parameters of its design.

Configuration

Equipment required to perform operational tests.

a. Main power source
b. Logic power supply
c. Load bank
d. Capacitor bank
e. Smoothing inductor (or simulated)
f. Motor load (or simulated)
g. Oscilloscopes, ammeters, voltmeters, wattmeters, thermocouples, etc.
h. Cooling fans and ducts

Procedure

a. Chopper test

1) Apply logic power and observe gate drive on all thyristors. Ascertain that main thyristors and commutation thyristors are receiving proper signals.

2) Apply voltage to the capacitor voltage sensor. Increase voltage and observe that main thyristor gate signals are clamped to zero when the voltage exceeds 55 volts and recovers when voltage decreases below 45 volts.

3) Check that frequency is variable from 40 to 400 Hz.

b. Semiconductor tests

With the system connected in the drive mode and the drivers clamped off, apply 100 volts to the main input. Perform start-stop operation and observe DC current. It shall remain nearly zero.

Observe voltage waveform across all semiconductors and that the following exists:
d. DC-DC CHOPPER (Contd.)

1) Series pairs of the semiconductors share voltages
2) No excessive voltage spikes
3) Main thyristor turn-off time.

Increase the voltage in 100 volt steps to 750 volts and phase the control to full on and return to the chopping mode at each step. Observe the following:

1) Semiconductor voltage sharing
2) Commutator current
3) Current sharing of main thyristors, commutating thyristors and free wheeling rectifiers.

c. Brake mode operation

With the system connected in the braking mode operation, increase the voltage to 1200 volts in 100 volt steps and observe the voltage waveforms across semiconductors, the commutating current and the load current.

d. Heat run at 400 Hz

With the system connected in drive mode and with 2000 CFM cooling air, apply 750 VDC input voltage. Increase the demand signal to obtain 400 Hz at the minimum on time, allow temperature as measured by the thermocouples to stabilize. Record.

Repeat the above procedure at 25%, 50%, 75%, and Full On. Record.
d. DC-DC CHOPPER (P/N 524058-1)

Production Testing

A laboratory test was run on each power semiconductor to insure its suitability in the system. A sample data sheet is shown in Figure d1-1. The operation of the chopper was checked in accordance with an Acceptance Test Procedure. A sample test procedure and data sheet shown in Figure d1-2 and Figure d1-3. The drive brake transition was not included in the component test procedure since it was a system function and not a component function.

Each commutating inductor was checked for compliance with specification 422-0503-9001.

Each commutating capacitor was checked for compliance with specification 195-0500-9001.

Development Testing

The various phases of development testing included:

1. Commutating capability
2. Thyristor temperature rise
3. Heat sink optimization
4. Thyristor gate drive suitability
5. Temperature rise of commutating inductor and capacitor
6. Snubber optimization
7. Air flow distribution
8. Thyristor current and voltage sharing
9. Operation at maximum voltage in drive and brake modes

SHEET 55
ACCEPTANCE TEST DATA

D.C. CHOPPER
Part No. 524058-1

S/N 33-D7
Date: 5-14-73
Tested by: JOE CHUN

D. JACKSON

FIG d1-2 (1)
## ACCEPTANCE TEST DATA SHEET

<table>
<thead>
<tr>
<th>1.</th>
<th>PRELIMINARY</th>
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<th>REJECT</th>
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<td>Connections</td>
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<td>1.2</td>
<td>Wiring</td>
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<th>LOGIC</th>
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<th>REJECT</th>
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<tbody>
<tr>
<td>2.4</td>
<td>Gate voltage</td>
<td>Drawer A-1</td>
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<td></td>
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<td></td>
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<td>A-3</td>
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<tr>
<td>2.4.1</td>
<td>Minimum gate frequency</td>
<td>40 ±2 Hz</td>
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<td>2.5</td>
<td>Gate drive sequence</td>
<td></td>
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<tr>
<td></td>
<td>Displacement $T_d = 90 ±20 \mu s$</td>
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<tr>
<td>2.6.1</td>
<td>Common mode adjustment</td>
<td></td>
<td></td>
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<td>2.6.2</td>
<td>Capacitor ready voltage</td>
<td>$E_1 = 60 ±10\text{V}$</td>
<td></td>
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<td></td>
<td></td>
<td>$E_2 = 48 ±10\text{V}$</td>
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<td>2.6.3</td>
<td>Gate drive clamp</td>
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<td>2.7</td>
<td>Commutator contactor coil</td>
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<td>2.7.1</td>
<td>Auxiliary contacts</td>
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<tr>
<th>3.</th>
<th>POWER</th>
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<th>REJECT</th>
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</thead>
<tbody>
<tr>
<td>3.2.1</td>
<td>Commutator current</td>
<td>$E = 0.17 ±0.02\text{V}$</td>
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<tr>
<td></td>
<td>$R_{on} = 0.0009\Omega$</td>
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<td></td>
<td>$C = 4.63\mu\text{F}$</td>
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<td></td>
<td>$T = 130 ±15\mu s$</td>
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<tr>
<td>3.2.4</td>
<td>Snubber resistor voltage</td>
<td>R1</td>
<td></td>
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<td></td>
<td></td>
<td>R2</td>
<td></td>
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<td></td>
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<td>R3</td>
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<td></td>
<td></td>
<td>R4</td>
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</table>

*FIG. A1-2(2)*

SHEET 58
3.4 Semiconductor voltages

Total main thyristor \( E_{pk} = \pm 640, \pm 610 \)  
Total conduction thyristor \( E_{pk} = 720 \)  
Total free wheel diode \( E_{pk} = \pm 1150 \)  
Single main thyristor \( E_{pk} = \pm 360, \pm 300 \)  
Single conduction thyristor \( E_{pk} = 360 \)  
Single free wheel diode \( E_{pk} = 560 \)

3.5.2 Main thyristor current sharing

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<tr>
<th>HS</th>
<th>Voltage</th>
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<tbody>
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<td>1.30</td>
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<td>2</td>
<td>1.30</td>
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<tr>
<td>3</td>
<td>1.26</td>
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<tr>
<td>4</td>
<td>1.38</td>
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<tr>
<td>5</td>
<td>1.30</td>
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<tr>
<td>6</td>
<td>1.35</td>
</tr>
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</table>

Maximum deviation shall be \( \pm 10\% \)

3.6 Chopper recovery

3.7.1 Chopper operation at maximum current

**FIG. d1-2(3)**
ACCEPTANCE TEST PROCEDURE

D.C. CHOPPER

Part No. 524058-1
S/N 33-D7

FIG. 41-3(1)
1. **PRELIMINARY CHECK**

1.1 All accessible bolted and screw type connections shall be examined and tested for tightness.

1.2 Point-to-point wiring check shall be made using an ohmmeter where a visual check is not sufficient.

1.3 **NOTE:** A reject at any point must be cleared before proceeding.

2. **LOGIC CHECK OUT**

2.1 Insert logic cards in their proper spaces.

2.2 Connect logic cable from chopper to propulsion control.

2.3 Apply logic power with command signal at minimum and gates clamped.

2.4 Release gate clamps and observe gate voltage waveforms at terminal boards, on drawers A, A2 and A3. Place scope probe on terminal I and reference on terminal 3. The waveform shall be:

![Waveform Diagram](image)

2.4.1 The frequency of the gate pulses shall be 40 ±2 Hz.

2.5 Place scope reference on logic common and the probe of channel 1 on Al Term 1. Place the probe of channel 2 on A3 Term 1. Observe waveform on chopped input.

![Waveform Diagram](image)

**FIG.d1-3(2)**
Note displacement of lower waveform (commutation drive) in time from
the upper waveform (main drive). Displacement shall be 90 ±20 µsec.

\[ T = 70 \mu \text{sec}. \]

2.6 Connect a laboratory power supply (0-150V, 1/2 amp) across resistors
R5+7. B+ is connected to the top terminal of the resistor and B- is
connected to common. Leave chopper output terminal open.

2.6.1 Place scope reference on logic common and probe on UI Term. 6.
Adjust potentiometer \( R_{\text{pot}} \) to obtain minimum ac component on scope.

2.6.2 Move scope probe to U2. Term. 6. The display, \( C_o \), will be 12 volts
dc. Increase the auxiliary supply voltage slowly until \( C_o \) falls to
zero. Note this voltage \( E_1 = 60 \pm 10 \text{V} \)
Decrease the auxiliary supply voltage until \( C_o \) rises to 12v.
Note this voltage \( E_2 = 40 \pm 10 \text{V} \)

2.6.3 Observe gate voltages at drawers A1 and A3. When \( C_o \) is 12 volts,
gate signals are present.

When \( C_o \) is 0 volts, gate signals are absent

2.7 Apply 28 volts to commutator contactor coil. It shall close. \( \text{NA} \)

2.7.1 Observe auxiliary contact. It shall operate to indicate condi-
tion of main contactor. \( \text{NA} \)

2.8 Remove auxiliary power supply. Turn off logic power.

3 POWER

3.1 Connect smoothing inductor and load bank to the output of the chopper.
Close commutator contactor. Connect main power supply to the input

\[ \text{FIG. d}1-3 (3) \]
of the chopper. B1 connects to the input terminal. B- connects to the commen terminal.

3.2 Apply logic power, but clamp gate drive signals and set $\theta_{\text{com}}$ signal to zero. Apply main power. Increase the main power voltage to approximately 200 volts. Release gate clamp. Adjust main voltage to 200 volts if necessary.

3.2.1 Observe commutation current waveform as developed across a 0.0005 ohm coaxial shunt. 

$$I_{pk} = \frac{1200 \text{V}}{4000} = 0.3 \text{A}$$

$$T = 130 \mu\text{sec}$$

3.2.2 Observe voltages across main thyristors, commutating thyristors, and the free wheeling diodes. Note peak voltages

$$e_{\text{main}} = -240 \text{V} + 205 \text{V}$$

$$e_{\text{com}} = +260 \text{V}$$

$$e_{\text{FW}} = +365 \text{V}$$

3.2.3 Observe voltages across each semiconductor. The voltages shall be one-half ±10% of the corresponding voltages of sect. 3.2.2.

3.2.4 Observe voltages across snubber resistors. $R_1$, $R_2$, $R_3$, and $R_4$. Voltage spikes indicate operation of snubber circuits.

3.3 Increase main supply voltage to 400 volts. Observe voltage waveforms. The peaks shall not be greater than twice the peaks of sect. 3.2.2. Do not record.
3.4 Increase main supply voltage to 650 volts. Observe voltage waveforms. The peaks shall not be greater than 3.3 times the peaks of sect. 3.2.2 and 3.2.3.

<table>
<thead>
<tr>
<th>Voltage</th>
<th>Value</th>
</tr>
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<tbody>
<tr>
<td>$E_{main}$</td>
<td>640V</td>
</tr>
<tr>
<td>$1/2 E_{main}$</td>
<td>360V</td>
</tr>
<tr>
<td>$E_{com}$</td>
<td>720V</td>
</tr>
<tr>
<td>$1/2 E_{com}$</td>
<td>360V</td>
</tr>
<tr>
<td>$E_{FW}$</td>
<td>1150V</td>
</tr>
<tr>
<td>$1/2 E_{FW}$</td>
<td>560V</td>
</tr>
</tbody>
</table>

3.5 Turn on air supply to cool thyristors. Reduce main supply voltage to 200V. Advance $\theta_{com}$ signal to obtain approximately 50% duty cycle. Measure voltage developed across the current sharing resistors. The voltage is not critical at this point, except as an indication of conduction.

<table>
<thead>
<tr>
<th>Heat Sink</th>
<th>Voltage</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>-70V</td>
</tr>
<tr>
<td>2</td>
<td>300V</td>
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<tr>
<td>3</td>
<td>235V</td>
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<td>4</td>
<td>130V</td>
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<td>5</td>
<td>280V</td>
</tr>
<tr>
<td>6</td>
<td>300V</td>
</tr>
</tbody>
</table>

3.5.1 Advance $\theta_{command}$ signal to maximum to obtain FULL ON condition. Note voltage across sharing resistors.
The maximum deviation shall be 30°.

3.5.2 Increase the main supply voltage to 392. Note voltages across the sharing resistors.

<table>
<thead>
<tr>
<th>HEAT SINK</th>
<th>VOLTAGE</th>
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</thead>
<tbody>
<tr>
<td>1</td>
<td>1.30</td>
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<td>2</td>
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<td>1.26</td>
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<td>1.30</td>
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<td>1.35</td>
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</table>

The maximum deviation shall be ±10%.

3.6 Retard \( \theta \) command signal. Chopper shall chop at maximum duty cycle, decrease in duty cycle and finally decrease in frequency as the \( \theta \) command signal is decreased to zero. Note the main supply voltage will have to be adjusted to maintain a constant 600v when the chopper is phased back.

Chopper recovery \( E_{oc} = 564, R = 368 \)

3.7 Clamp gate signals. Turn Main Power Supply down to zero and OFF. Short load resistor, leaving the smoothing inductor as the only load.

3.7.1 Turn on main power supply. Increase the voltage to 150v. With \( \theta \) command at zero, release the gate drive. Increase the voltage to 600v. Advance \( \theta \) command if necessary to obtain 1800 A load current.

Chopper shall operate satisfactorily.
The results of some of the various development tests follow:

**Full Load Operation Tests**

The full load operational tests were conducted as indicated with the exception of the brake mode operation which was done on the prototype and later during system test.
Commutation Temperature Rise

Test Conditions set up for the heat run of the commutation components are as follows:

The air flow distribution was adjusted so that 200 CFM was passed through the Inductor Capacitor compartment and 1200 CFM through the thyristor drawers. Thermocouples were placed in the commutation inductor, commutation capacitor and commutation thyristors. The main thyristors were also monitored. The chopper was operated at 600V, 400 Hz with the duty cycle just off minimum, approximately 5% on time. The reduced data from this part of the heat run is shown in Fig. dl-4.

The commutation inductor did not overheat but it was not stressed to the maximum. The worst case occurs when the system is in brake and all braking current is passing through the free wheel path. This is not a continuous condition, however, and a current rating equivalent to that of the smoothing reactor plus the commutating current is considered adequate. The rms current is

\[
\begin{align*}
    i_{rms} &= \sqrt{i_{SR}^2 + i_c^2} = 1450 \, A \\
    i_{SR} &= 1360 \, A_{rms} \\
    i_c &= 500 \, A_{rms}
\end{align*}
\]

A Litz type wire is presently used in order to reduce A.C. resistance. Further testing of the inductor will be accomplished in the prototype.

This test was extended to include various Duty Cycles. After the temperatures
stabilized, the duty cycle was increased and the temperature allowed to stabilize again. This was repeated for steps of 25%, 50%, 75% and Full On. The reduced data is shown in the graphs in fig. d1-5.

Note that the inlet air temperature showed an increase of 12°F over the ambient. It is likely that this increase is due to the heating of the sharing resistors which protrude into the duct area. By placing the sharing resistors on the outlet end of the heat sinks, the temperature of the inlet air could be reduced by approximately 10°F. The extra heat would then be transferred from the main thyristors to the commutators and the rectifiers.

Two views of the chopper test setup for the full load operational tests are shown in the photographs figures d2-1 and d2-2. In figure d2-2 the load banks are in the left and center foreground; the chopper is in the right rear background behind the blower, the calibrated airflow section and lead in ducting.
e. RESISTOR GRID (P/N 2000428-1)

**Production Testing**

1. Resistance check
2. Inductance check
3. Meg-ohm check
4. Visual inspection

**Development Testing**

**Purpose**

To insure resistor grid meets all design specifications.

**Configuration**

Power source and instrumentation required to monitor the test results.

**Procedure**

Subject the grid to a load simulating the maximum duty cycle expected during actual car operation. While at the hot temperature perform the following tests:

a. Resistance measurement using a Wheatstone Bridge
   
   \[1.520 \text{ Ohms} \pm 1.5\%\]

b. Inductance measurement using incremental inductance bridge
   
   \[100 \times 10^{-6} \text{ Henry's}\]

c. Hipot at 3400 V AC - 60 Hz from the resistor elements to the frame for one min.
f. BLOWER - COOLING (P/N 650932-1)

Production Testing

1. Direction of rotation
2. Rotational speed
3. Current
4. End play
5. Visual inspection for critical dimension

Development Testing

Purpose

To determine the aerodynamic performance.

Configuration

Power source and instrumentation to monitor and record test results.

Procedure

Supply 230 V AC - 60 Hz - 3 phase power. The rotation of the fan shall be CCW. The rotational speed shall be 3,450 RPM (min). The input current, per phase, shall be 18.7 AMPS (max). The aerodynamic performance shall be within the limits specified in curve PA 85799.
f. Development Tests, Blower

Test data for the Motor Driven Fan is shown in Figure f1-1. The plotted points are test data and the solid line is predicted performance data for this unit (605932-1). The designation of this curve is PA89900 as opposed to the PA85799 curve which was an earlier performance estimate.

Over the actual operating range of 2300 to 2500 CFM the actual fan performance (as modified with front and back spacers) is very close to the original estimate. Figure f1-1 also shows the predicted and actual values for power consumption and line current. The data sheets for these tests are included and shown in figures f2-1 and f2-2. The line current is approximately 5% above the originally predicted value of 18.7 amps per phase.
**LAB DATA SHEET**

**FMO:** 3520-171190-30-0401 **DATE:** 5-8-72  TEST PURPOSE: AERODYNAMIC CALIBRATION

**P/N:** 605932-1  **BARON 30.00" H.G.A.**

**S/N:**  **TEMP:** 65°F  **TEST PERS:** DEJE, FAY., ARTHUR KRAMER

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**REMARKS:**

- Run 1: 5-6.72 1670
- Run 2: 5-6.72 1670
- Run 3: 5-6.72 1670
- Run 4: 5-6.72 1670
- Run 5: 5-6.72 1670
- Run 6: 5-6.72 1670
- Run 7: 5-6.72 1670

**FIG. F2-1**

<table>
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<td>5-8-72</td>
<td>48 WH 7&quot; CLINCH</td>
</tr>
<tr>
<td>5-9-72</td>
<td>49 H. 10</td>
</tr>
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<td>5-10-72</td>
<td>50 PXX111111</td>
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**SHEET 77**
### LAB DATA SHEET

**TEST PURPOSE**: AERODYNAMIC CALIBRATION

**P/N**: 605-932-1  **BARON 30.00" H2O**

**S/N**: 605-932-1  **TEMP 65°F**  **TEST PERS.**: PETE HAY, ARTHUR KRAMER

<table>
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<th>APo *H2O</th>
<th>Po *H2O</th>
<th>To</th>
<th>W *min</th>
<th>C</th>
<th>Q</th>
<th>FAN AP</th>
<th>FAN AP/H2O</th>
<th>I Avg</th>
<th>I/F</th>
<th>KW</th>
<th>KW/1000</th>
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<td>0.754</td>
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<td>31.13</td>
<td>72</td>
<td>6.3</td>
<td>128.2</td>
<td>0.754</td>
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<td>15.25</td>
<td>2.15</td>
<td>15.46</td>
<td>15.67</td>
<td>17.3</td>
</tr>
</tbody>
</table>

**REMARKS**

---

**FIG. A2-2**
9. HOSTLING CONTROL (P/N 2000502-1)

Production Testing

1. Ohm meter check of circuits per schematic
2. Visual inspection

Development Testing

1. Drop test

**Purpose**

To insure the design and packaging of the control is adequate to withstand rough handling during normal use.

**Configuration**

No special equipment required.

**Procedure**

Unit to be subjected to numerous drops, from various angles, to the simulated car floor from a height of approximately 6 ft.

Cable integrity, switches and internal hardware will show no basic degradation.
h. TRUCK CONNECTOR (P/N 515216-1)

Production Testing

1. Hi Pot
2. Visual inspection

Development Testing

1. Hi Pot

Purpose

To insure insulation between the connectors and the enclosure is adequate.

Configuration

Hi Pot tester

Procedure

Apply 3500 V AC - 60 Hz - between the connectors and the enclosure for 1 min.
1. KNIFE SWITCH (P/N 2000504-1)

Production Testing

1. Visual inspection only

Development Testing

1. None required
j. SPEED INDICATOR (P/N 421-0501-9001)

Production Testing

1. Operational test

Development Testing

1. None required
k. JET PUMP (P/N 2002921-1)

Production Testing

1. Visual and dimensional inspection only

Development Testing *

1. Aerodynamic calibration test

Purpose

To determine the aerodynamic performance requirements, i.e. primary flow and scavange flow.

Configuration

Place the Jet Pump in a test fixture capable of monitoring fluid temperature, pressure and rates of primary, secondary and total flows.

Procedure

Apply inlet pressure of 10 in. H₂O to primary inlet at established flow rate and record secondary flows and total flows.

* See data under system Airflow Test Pages 106-120
1. POWER CONTROL UNIT (P/N 524060-1)

Production Testing

1. Meg-ohm checks
2. Ohm meter check of wiring per schematic
3. Power checks for pull-in voltage
   a. Main contactor
   b. Chopper contactor
   c. Drive brake switch
4. Sensor calibration tests
5. Overload current sensor tests
6. Differential current sensor tests

Development Testing

1. Heat run - all sections operating

Purpose

To insure that proper thermal conditions exist within the power control unit.

Configuration

Set up the power control unit with dummy electrical loads and appropriate input source voltages and signals, so that all equipment within the unit is exhibiting maximum thermal output. Place thermocouples on all major heat sources within the unit.

Procedure

Run the unit in a steady state, maximum heat output condition and monitor temperatures within the enclosure. After thermal equilibrium is obtained, record temperatures of the major heat source elements by both the thermocouple and delta resistance method.

Temperatures recorded shall not exceed 60°F above the unit ambient temperature.
1. Development Testing, PCU

The tests on this unit consisted of point to point wiring checks and control logic operational checks without 600 VDC power. Further functional tests were conducted on this unit during system checkout.

No heat run was made on the box since, even at full power, the dissipation was much less than 0.1 watts per square inch of surface.

The subsequent modification of adding the two truck isolating diodes (in series with the armature circuits) raised this peak dissipation to something less than 0.2 watts per square inch. The local heating at the diodes could reach a peak of 2 kW but this assembly has integrally mounted forced air blower and there is radiation shielding separating other components in the area.
m. GEAR BOX AND COUPLING

Production Testing

1. Inspect for critical dimensions
2. Back lash measurement
3. No load torque

Development Testing

1. Proof Torque Test

Purpose

Prove the gearbox-coupling system will withstand (with adequate margin) the torque expected to be experienced in the intended usage of the unit.

Configuration

Place the gearbox-coupling in a test fixture, with the output (axle) held stationary. Using an auxiliary high gear ratio gearbox unit, apply torque to the subject gearbox input shaft.

Procedure

Apply a torque of 56,000 inch lbs to the gearbox input shaft. This input torque results in an output gearbox torque of approximately 267,000 inch lbs. Repeat the test in the reverse direction and examine the gearbox-coupling. The unit shall exhibit no permanent deformation.

2. Acceleration and Deceleration Torque Loads

Purpose

Prove the unit capable of operating at the torque levels experienced during acceleration and deceleration.

Configuration

Connect two motor-gearbox combinations through a common axle. Connect the motors electrically so that one acts as a driving element and the other acts as a loading element (generator). Provide an air flow source.
m. GEAR BOX AND COUPLING (Contd.)

Procedure

Vary the load on the gear box by loading the generator element electrically. Vary the field currents of the motor element and the generator element to simulate the load and speed of the system at various points in the acceleration and deceleration of the vehicle. Provide an airflow of a velocity equivalent to the speed of the vehicle at each test point. Run the following test points for a time period of one minute or until an oil temperature of 250°F has been reached:

<table>
<thead>
<tr>
<th>Motor Torque (Ft/Lbs)</th>
<th>RPM</th>
<th>Vehicle Velocity (MPH)</th>
<th>Air Velocity (Ft/Sec)</th>
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</thead>
<tbody>
<tr>
<td>1000</td>
<td>900</td>
<td>17</td>
<td>24.7</td>
</tr>
<tr>
<td>900</td>
<td>1560</td>
<td>28</td>
<td>40.6</td>
</tr>
<tr>
<td>560</td>
<td>2400</td>
<td>44</td>
<td>63.7</td>
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<tr>
<td>320</td>
<td>4300</td>
<td>80</td>
<td>116.0</td>
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<tr>
<td>-960</td>
<td>200</td>
<td>3</td>
<td>4.3</td>
</tr>
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</table>

The unit will be disassembled and inspected following these tests. No permanent deformation shall have resulted.

3. High Temperature Test

Purpose

Prove that the lubricant, and method of lubrication is adequate so as not to degrade the performance of the gearbox through the entire operating temperature range.

Configuration

Same as Acceleration and Deceleration Tests (Item 2).

Procedure

Run the gearbox at a speed and load equivalent to the one hour motor rating (230 HP, 1560 RPM). Measure oil sump temperature as in acceleration and deceleration test, except provide no air flow equivalent to the vehicle velocity. Stop testing after a period of one hour, or 250°F oil temperature is reached. If the 250°F oil temperature is reached before one hour, repeat the test with 10, 30 and 40 ft/sec air flow across the gearbox.

The unit shall be capable of one hour of operation at the given input with less than 40 ft/sec air flow and less than 250°F oil temperature.
4. Audible Noise Tests

Purpose

Determine the audible noise characteristics of the motor-gearbox combination.

Configuration

Connect a motor and gearbox in a manner simulating the installation on the car truck.

Procedure

Record audible noise levels on a broadband noise level meter "C" scale. Recordings will be taken at a distance of 15 feet in each of the four longitudinal and lateral directions, and at various gearbox loadings and motor speeds.

As a design goal, a noise level of 85 db maximum (reference 0.0002 microbar) will be recorded.

5. Oil Consumption and Leakage Test

Purpose

To insure that the case seals are adequate to prevent leakage and the labyrinth seals allow proper but not excessive lubrication.

Configuration and Procedure

Oil consumption and leakage tests will be monitored throughout the test program.

6. Spring Rate of Axle Couplings

Purpose

To confirm that the actual spring rate of the coupling is within the limits calculated for the intended use. (Actual testing to be accomplished by Lord Mfg Co.)

Configuration

Place the unit in a static test fixture capable of measuring displacement and load in various directions of force application.

Procedure

Obtain data of load vs deflection of the coupling. The coupling spring rates, as a design goal, shall be as follows:

Note: There is considerable tolerance that can be allowed in the actual spring rates.
m. GEAR BOX AND COUPLING (Contd.)

\[
\begin{align*}
K_{\theta Z} &= 50,000 \frac{\text{in-lb}}{\text{deg}} \\
K_{\theta Y} &= 50,000 \frac{\text{in-lb}}{\text{deg}} \\
K_{\theta X} &= 48,000 \frac{\text{in-lb}}{\text{deg}} \\
K_Z &= 67,500 \text{ lb/in} \\
K_Y &= 67,500 \text{ lb/in} \\
K_X &= 170,000 \text{ lb/in} \\
K_B &= \text{cocking spring rate} \\
K_Q &= \text{torsional spring rate} \\
X &= \text{axis through axle length} \\
Y &= \text{fore and aft axis through center of coupling} \\
Z &= \text{vertical axis through center of coupling}
\end{align*}
\]

7. Gearbox and Coupling Efficiency

**Purpose**

Prove that the gearbox-coupling efficiency meets the intended requirements.

**Configuration**

Same as acceleration and deceleration torque load tests (Item 2).

**Procedure**

Utilizing the motor efficiencies determined for the specific motor used in this test, determine the input and output power of the combined series gearboxes. The efficiency of each gearbox is defined as

\[
\eta_{GB} = \frac{\text{Power Out}}{\sqrt{\text{Power In}}} \times 100
\]

Determine the gearbox efficiency at each of the various tests accomplished during acceleration and deceleration tests (Item 2).

The gearbox efficiency, as a design goal, shall be a minimum of 96%.

SHEET 89
m. GEAR BOX AND COUPLING (Contd.)

8. Vibration

Purpose

Prove the mechanical integrity of the motor and gearbox to vibratory input loading.

Configuration

A vibration fixture which independently simulates the axle input to the gearbox and the motor-truck frame mounting will be utilized for this test.

Procedure

With the motor truck frame mounting fixture in a static rigid condition, drive the axle input fixture and scan for resonances in the 20 to 35 Hz region. Resonances in the 80 to 150 Hz region have been given special attention in the design and will not require evaluation.
m. Development Testing, Gear Box and Coupling

1. Proof Torque

This test was not run. The basis for this is the large margin of load vs design stress calculations. The normal maximum operating torque level is 1200 lb ft at the motor end of the gear train. The ultimate stress level in this application for the materials and processing used in the manufacturing of these gears is in excess of 5 times the normal maximum operating level. The infinite cycle fatigue stress level is slightly greater than 2.2 times the normal maximum operating level.

2. Acceleration Deceleration Torque Loads

This test was not run as a separate test. Some data relevant to this item was acquired during testing done in para 3. below.

3. High Temperature Test

This test was run at a RPM (2400 at motor) considered to be representative of a continuous severe operating condition. The reduced data is shown in curve form in Fig. m3-1. This test was run without forced air cooling.

4. Audible Noise Test

No data was recorded for this test because the actual noise level was judged to be an order of magnitude less than the test requirement as observed during item 3 above.

5. Oil Consumption Test

This test was not run.
6. Coupling Spring Rates

The SOAC coupling spring rates as obtained from Lord Mfg. Co.

<table>
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<tr>
<th>Spring Rates</th>
<th>Static*</th>
<th>Dynamic**</th>
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<tr>
<td>in. lb/deg.</td>
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<tr>
<td>( K_x ), Axial, lbs/in</td>
<td>170,000</td>
<td>320,000</td>
</tr>
<tr>
<td>( K_z ), Transverse</td>
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<td>56,000</td>
</tr>
<tr>
<td>lbs/in.</td>
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<td></td>
</tr>
<tr>
<td>( K_{ty} ), Cocking,</td>
<td>None</td>
<td>76,000</td>
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<tr>
<td>in. lbs/deg.</td>
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<td>(estimated from test)</td>
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</table>

* Test by Lord

** Estimated by Lord

The fatigue life of the coupling was estimated by Lord Mfg. Co. as five years based on a set of combined loads which Lord considered as conservative. In reviewing the fatigue analysis, the most damaging load to the coupling appears to be the transverse (vertical) load due to 8g vibration, which consumes about 40% of the life.
7. **Gear Box Efficiency**

Two data points were extracted from 8-24-72 laboratory test data shown in Fig. M7-1. The data reduction is illustrated in Fig. m7-2. The motor and generator efficiency data was supplied from other data not part of this test (*)..

These calculations show the Gear Box + Coupling combination to be approximately 97% efficient by the definition:

\[
\eta_{GB} = \frac{\sqrt{\frac{\text{Power Output (Electrical) \times \eta_G}}{\text{Power Input (Electrical) \times \eta_M}}}}{100}
\]

The test setup is shown in block diagram form in figure m7-2. The actual test fixture is illustrated in figures m7-3 and m7-4 with one of the two drive units mounted.

8. **Vibration**

This test was not run. A test to determine the assembly natural frequency was run for information purposes and the data and a plot of a point of maximum displacement of the Gear Box/Motor assembly is shown in Fig. m8-1.
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FIG. 117-1
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<td>(lb.ft.)</td>
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<td>Volts</td>
<td>Amps</td>
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<td>RPM</td>
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Test Set-Up

![Diagram of Test Set-Up]

**FIG. m7-2**  Gear Box - Coupling Efficiency Data
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<thead>
<tr>
<th>MOTOR DISP TOTAL</th>
<th>AXEL RPM</th>
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<td>PEAK TO PEAK</td>
<td>0</td>
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<td>0.25</td>
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<td>0.34</td>
<td>600</td>
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<td>0.40</td>
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<td>0.028</td>
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**FIG. 1**

---

**ORIGINAL (YELLOW) FILE**

**REMARKS**

**REMARKS ONLY**

**SHEET 99**
n. P SIGNAL GENERATOR

Production Testing
1. Continuity checks
2. Operational tests

Development Testing
None required
O. FILTERS AND DUCTS

Production Testing

1. Visual and dimensional inspection only.

Development Testing *

1. Test to establish AP in duct section between DC chopper and traction motor (cab end No. 1)

Purpose

To establish the duct size.

Configuration

Test setup simulating fan ducting, DC chopper, ducting (to be tested) and traction motor.

Procedure

Install duct in test setup monitoring inlet pressure, temperature differential pressure (across duct being tested) and outlet pressure and temperature.

* See data under system airflow test pages 106-120
p. MASTER CONTROLLER (P/N 2000503-1)

Production Testing

1. Ohm meter checkout of wiring per schematic
2. Operation of key and handles to check mechanical interlock
3. Visual inspection

Development Testing

1. Operation with P signal generator, and logic electronics

Purpose

That
To determine the controller functions properly within its design parameters.

Configuration

Install the controller in a test setup, with the necessary instrumentation to monitor all inputs and test results.

Procedure

Operate master controller through a sequence simulating normal car operation. Determine that the master controller provides the required inputs to P signal generator and logic electronics.
q. PROPULSION CONTROL (P/N 524062-1)

Production Testing

1. Hi Pot (rack, prior to logic card installation)
2. Continuity check of all circuits
3. Functional test all logic cards prior to installation
4. Functional test logic system.

Development Testing

1. Thermal tests

Purpose

To insure the proper thermal conditions exist within the propulsion control unit.

Configuration

Install the propulsion control unit in a test setup using simulated loads, signals and required input voltages. Install thermocouples on all major heat sources within the unit.

Procedure

Test the unit in a steady state, maximum heat output condition. After temperature within the unit has stabilized, measure and record the major heat source elements by both the thermocouple and delta resistance methods.

Temperature recorded shall not exceed 60°F above the unit ambient temperature.
Development Testing, PPCU

Testing included point to point wiring checks and extensive control logic tests using simulator developed for this purpose. Further functional tests were carried out on this unit during system test.

The card stacks are forced air cooled with internally mounted fans; however, the total dissipation is considerably less than 0.1 watts per square inch of box area and a heat run for this unit was deemed unnecessary.
r. AUX POWER CONTROL (P/N 2000434-1)

Production Testing

1. Continuity checks of all circuits and contactors
2. Hi Pot
3. Functional test all logic cards prior to Installation
4. Functional test all components (i.e. field power supply, voltage regulator, etc.) prior to Installation
5. Operation and checkout of motor alternator start circuits.

Development Testing

1. Motor alternator start sequence

Purpose

To insure the motor alternator start circuit is functioning properly.

Configuration

Install the aux power control in a test setup with the motor/alternator, associated circuit breakers, contactors, simulated loads and variable high voltage-high current DC source.

Procedure

Apply 600 VDC to M/A start circuit breaker. With no load applied, close circuit breaker, allowing start sequence to occur. After M/A has reached rated speed (1750 RPM) and rated voltage, (230 VAC 60 Hz 3Ø) apply loads.

Reduce voltage to 400 VDC. M/A will shut down shedding all loads.

Increase voltage to 550 VDC, M/A set will restart going through its normal start sequence.

2. Rail Break Operation (June 30)

Purpose

To prove that the start, control, regulation and protection circuits of the Motor Alternator are functioning properly.

Configuration

Install the aux power control in a test setup with the motor alternator, associated circuit breakers, contactors, simulated loads and variable high voltage-high current DC power source.
r. AUXILIARY POWER CONTROL (Contd.)

Procedure

Apply 600 VDC to the M/A circuit breaker. Close circuit breaker. Allow M/A to start and reach rated speed and rated voltage.

Apply 3-phase loads, air conditioners last.

Open contactor (simulating rail break) for 1 sec. and close. Check to insure that all circuits are functioning properly.

3. Heat Run. All sections operating

Purpose

To insure that proper thermal conditions exist within the aux power control unit.

Configuration

Set up the aux power control unit with simulated loads, signals and input voltage, so that all equipment within the unit is exhibiting maximum thermal output. Place thermocouples on major heat sources.

Procedure

Run the unit in a steady state, maximum heat output condition and monitor temperatures within the enclosure. After thermal equilibrium is obtained record temperature of the major heat source elements by both the thermocouple and delta resistance method.

Temperature recorded shall not exceed 60°F above the unit ambient temperature.
Development tests. Auxiliary Power Control Unit

Individual component functional tests were made on the Field Phase Delay Rectifiers (PDR's) on the transformer rectifier unit (TR) and the Battery Charger. The PDR's (NA set and two field PDR's) all have integrally mounted forced air blowers. The battery charger is in good thermal contact with the base of the APCU box. No single sub-unit requires to dissipate more than 500 watts peak and the unit as a whole will not exceed 0.2 watts per square inch of surface. No heat run was made on this unit. Observation during system test confirmed that heat dissipation was not a problem even though there was no external forced air flow in that set up.
s. SYSTEM TESTING

Purpose of Test

To functionally test and evaluate the propulsion dynamic braking and auxiliary power system as an integrated transit car system.

To check out each subsystem as it would be arranged in the integrated car system.

To evaluate each subsystem and compare results with predicted values.

To evaluate system protection by failing and/or exceeding prescribed limits.

Procedure

(1) Perform production test on each component to be used in system test or check to see that tests have already been made. Install thermocouples.

(2) Install component in system test facility in correct relative position as in actual car installation. Use system installation Dwg. 2000027-1 as a reference. The traction motors are the exception, and will be mounted outside the test cell wall.

(3) Connect the components per wiring diagrams and wire lists. Check out thermocouples.
s. SYSTEM TESTING (Contd.)

(4) Install circuit breakers in system which are part of cab controls.

(5) Check wiring for grounds.

(6) Test low voltage circuits, using battery voltage to see if contactors, circuit breakers, interlocks, etc., are working properly.

(a) Power Control Unit
Contactor operation, auxiliary contact circuits, overcurrent relay circuits, differential current relay circuit current sensor outputs.

(b) Propulsion Control Unit
Relays which operate drive-brake contactors.
Limit check (response to "P" signal).
Check shutdown circuits from various sensors and switches.

(7) Run cooling fans and measure air flow parameters of fan, chopper, and duct work.
S. SYSTEM TESTING (Contd.)

(8) Air flow to motors on system test will not be ducted as in car. Therefore, adjust air flow to get the desired cubic feet per minute. Measure pressure drop across motor only.

(9) Check start-up, controls, and operation of motor-alternator set.
   (a) normal operation
   (b) quick shut-down circuits
   (c) simulation of rail breaks; short, long, and repetitive gaps

(10) Connect cooling fans to M.A. set.
   (a) check starting current of fans when contactor is closed, and voltage transient
   (b) steady state load requirement and P.F. of fan motors.

(11) Add traction motor field power supplies to M.A. set output
   (a) response to control logic commands
   (b) accuracy of field current
   (c) steady state loads and Power Factors

(12) Battery charger and battery bus checkout
   (a) operation of charger when connected into system
   (b) operation of transition to battery and from battery to transformer rectifier as motor/alternator voltage fails
   (c) measured voltage variation due to transition and see if any transients present that affect logic power supplies.
(13) Check chopper operation at light loads below base speed. Motoring mode. Observe chopper operation, control logic, waveforms, capacitor bank voltages and currents, temperatures in equipment boxes, chopper turn off time.

(a) variable frequency operation at start
(b) variable angle operation; normal running
(c) stability of closed loops

(14) Check chopper operation at light loads during transition through base speed. Motoring mode.

(15) Check operation of field control and current balance in motors above base speeds.

(16) Check chopper in braking mode, beginning with operation of system above 2900 rpm and using field control. Observe transition into chopping mode.

(a) observe power in brake grids; voltage and/or current
(b) traction motor current balance
(c) voltages on chopper
(d) cushion off

(17) Check operation of speed indicator

(a) accuracy
(b) limit speed buttons
(c) transients; jerk rate

(18) Run full power acceleration performance tests. Strip chart recording of rpm, (or mph) motor current, 3rd rail current and voltage, capacitor bank current. Waveforms of chopper input and output voltage.
SYSTEM TESTING (Contd.)

(19) Add dynamic braking at full capability. Observations as in (18).

(20) Run simulated driving schedule, including 30 second station stops.
Record temperatures.
(a) repetitive response accuracy
(b) hot spots
(c) component
(d) power consumption and system efficiency

(21) Heat runs at balanced loads; temperature rise
(a) below base speed; various grades
(b) above base speed; various grades
(c) component wear
(d) component noise; electrical and acoustic
(e) power consumption and system efficiency

(22) Full power acceleration with rail breaks under various conditions
(a) M.A. set operation
(b) control logic
(c) air pressure switches

(23) Perform M.A. load shedding tests, with chopper running at various 3rd rail voltages.

(24) Run performance tests at various voltages

(25) System protection tests
(a) overload current relays
(b) differential current relay
s. SYSTEM TESTING (Contd.)

(c) loss of motor field current
(d) loss of air flow
(e) M.A. set malfunctions
   Overspeed
   Overvoltage
   Open-phase
   Too long to start
   Undervoltage

(f) filter capacitor fuses open
(g) chopper lock up
(h) dead man
(i) brake loss (activation of PKO switch)
(j) loss of logic power
(k) overtemperature sensors
(l) undervoltage 3rd rail
(m) overvoltage 3rd rail
(n) reset trainline
(o) fuse

(26) Slip-slide
5. **SOAC System Test**

The system test setup was configured to represent the vehicle undercar area. The main frame was of steel "I" beam construction with approximately six feet of ground clearance and all of the components of the Propulsion group excluding the traction motors were mounted in their proper relative positions suspended from the steel frame. With this arrangement it was intended that the local fields due to the large reactors and heavy current carrying conductors would bear some similarity to the vehicle environment. The 600 VDC supply originated from a large transformer/rectifier located remotely in the same building. The cable runs to the traction motors were several times longer than those in the vehicle.

A view looking into the test cell is shown in the photograph, figure s1-1. The suspended components shown at the entrance are the PCU (on the right) and the chopper (on the left). The two motors in the foreground were positioned here temporarily for part of the Air Flow test.

The traction motors used for the system load were located outside the test cell housing the Propulsion Control components for safety reasons. Photographs of this setup are shown in Figures s1-2 and s1-3.

Forced air cooling for the Traction Motors was supplied from an independent blower system. Each motor was directly coupled to an inertial load (flywheel) representing the vehicle. This setup was designed to represent the GTE vehicle and reflected a much higher weight in terms of SOAC wheel size and gear ratio (204,000 lbs) consequently acceleration and deceleration times could not reflect SOAC performance.
The SOAC brake grids were also situated external to the test cell and forced air cooling was applied because of the heating (1.8 megawatts peak). Repeated cycles of acceleration and dynamic braking causes these resistors to glow at visible red level. No attempt was made to build up a simulated Air Brake Subsystem.

Air Flow

The first section of this setup to be tested was the Traction Motor Cooling group which consisted of the axial flow fan and filter, the Jet Pump, the Chopper, simulated center sill and flexible ducting to the motors. This setup was fed with a calibrated orifice section used to measure input air flow. The calibrated test section and blower used to compensate for test section pressure drop are shown in figure s2-1. The input section to the filter (ahead of the fan) can be seen in figure s2-2, just behind the small manometer. The Chopper access door is the panel in the upper left of figure s2-2.

The following pages (106 through 120) are reduced data and analysis of the Air Flow Test.
Air Flow Test (June 28, 29, 1972)

This test was run to assess the performance of the air cooling system for the chopper and traction motors at the No. 1 end (front) of the SOAC car. The cooling system is shown in Figure A. Air is taken in at the filter due to suction at the fan. A small amount of air is bled off to the jet pump ahead of the fan (filter scavenge flow, Q_s) and again downstream of the fan (primary flow, Q_p). The bulk of the airflow goes through the chopper (Q_{CH}) and ducting to the two traction motors. A calibrated orifice was placed at the filter air intake for total flow measurements (Q_T).

The analysis examines the various flows to see if adequate cooling flow is attained for the chopper and the two traction motors. It also determines at what efficiency the "filter/jet pump" is operating. Finally, calculations are made to show what adjustments in flow should be made to attain acceptable overall performance with adequate cooling flow and high filter efficiency.

Examination of the test data (see attached laboratory test log) shows that motor rotational speed has little effect on cooling flow. This can be seen from the consistency of the readings in the calibrated orifice data (columns 10 and 11, Page 115) for different motor speeds. Therefore, a nominal speed was selected (3000 rpm, see point no. 7) and the analysis based on this set of data.
FIG. 58-3  Air Flow Test set up
(North end Cell 29)
Calculate mass flow at calibrated orifice from Lab data sheet point 7 - columns 10, 12, 13

Input (gage) pressure = 1.31'' Hg (31.23'' Hg abs)
Temperature = 88°F

\[ \Delta P = 19.15 \text{'' } H_2O \]

\[ \sigma = \frac{31.23}{29.92} \times \frac{519}{460 + 88} = 0.99 \]

\[ \Delta P = 0.99 \times 19.15 = 18.95 \text{'' } H_2O \]

From orifice curve data (p.120) the mass flow is determined to be 187 lb/min.

Step 2. Calculate fan volumetric flow rate from data (Page 115)
columns 4 and 5

Fan inlet pressure = -2.75 '' H_2O gage
Fan outlet pressure = +9.05 '' H_2O gage
\[ \Delta P = 11.5 \text{'' } H_2O \]

\[ \sigma_F = \frac{406.8 - 2.75}{406.8} \times \frac{519}{460 + 88} = .945 \]

\[ \sigma_F \cdot \Delta P = 11.2 \text{'' } H_2O \]
(Note: 406.8 '' H_2O = 29.92'' Hg)

Fan inlet air density = \( \sigma_F \times .0765 = .0723 \text{ lb/ft}^3 \)

Volumetric flow rate = \( \frac{187}{.0723} = Q_F = 2560 \text{ CFM (neglecting scavenge flow)} \)
Step 2 (continued)

Filter scavenge flow design point is 200 CFM

$\therefore$ Fan volumetric flow (1st approximation) is 2360 CFM ($Q_F$)

Step 3

Calculate fan total pressure rise and flow velocity, go to fan performance curve (Page B-1) and enter curve at 2360 CFM.

$$\frac{\Delta P_T}{\sigma_F} = 13.9 \text{ "H}_2\text{O}$$

$$\Delta P_T = 13.9 \times 0.945 = 13.1 \text{ "H}_2\text{O}$$

Fan cross section area = 1.0 sq ft

$\therefore$ Flow speed velocity = \text{Volumetric flow rate} \over \text{Area} = 2360 \times \frac{1}{1.0 \times 60} = 39.3 \text{ ft/sec}$

Step 4

Calculate fan static pressure rise and duct loss, go to velocity pressure conversion curve (Page 1/8).

$$\frac{P_V}{\sigma_F} = 0.35 \text{ for } 39.3 \text{ ft/sec}$$

$\therefore$ Static pressure rise across fan = 13.1 - 0.35 (0.945) = 12.8 "H$_2$O

Duct entrance loss = $\Delta P_{\text{calc.}} - \Delta P_{\text{meas.}}$
Step 5

Summarize pressure drops in system ("H2O")

Filter = P2 - P5 = - .05 - (-2.75) = 2.7

(Dart entrance loss = 1.0)

Fan pressure rise = 12.7

Duct expansion and turning = P4 - P9 = 9.05 - 9.05 ≤ 0.0

Chopper P9 - P6 = 9.05 - 8.15 = 0.9

Duct to Motor No. 1

Duct to Motor No. 1

P9 - P8 = 8.15 6.30 = 1.85

Duct to Motor No. 2

P6 - P7 = 8.15 - 5.70 = 2.45

Motor 1 inlet to Atm

P8 - P0 = 6.30 - 0 = 6.30

Motor 2 inlet to Atm

P7 - P0 = 5.70 - 0 = 5.70

Step 6

Determine jet pump operating conditions, go to Page B-3 showing jet pump performance curve (note switch in nomenclature)

Nozzle pressure P3 (column 3 in data) is 7.55 "H2O and

ΔP2 on curve (Page 119) = P3 - 0.0
Step 6 (continued)

Pressure rise in scavenge path is $\Delta P = P_2 - P_1 = 1.96 = \Delta P_1$

$$\sigma = \frac{460.8 + 1.96}{460.8} \times \frac{519}{460 + 88} = 0.95$$

$$\Delta P_1 \sigma = 1.86 \text{ "H}_2\text{O}$$

:. from curve, volumetric flow = 147 CFM (Scavenge, $Q_s$)

and the jet nozzle flow = 107 CFM ($Q_p$)

Step 7

Summarize flows. It will be noted that the approximation made in Step 2 was 200 CFM instead of 147 CMF but this results in less than 2% error in fan pressure rise

$$Q_T = 2650 \text{ CFM}$$

$$Q_{fan} = 2560 - 147 = 2413 \text{ CFM}$$

$$Q_{JP} = 254$$

$$Q_{CH} = 2413 - 107 = 2306 \text{ CFM}$$

Sheet 126
### SUMMARY OF OPERATING FLOW CONDITIONS

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<tr>
<th></th>
<th>Desired</th>
<th>Test</th>
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<td>Flow per motor</td>
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<td>1150 CFM</td>
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<td>Jet Pump</td>
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<td>107</td>
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<td>Scavenge</td>
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<tr>
<td>Fan</td>
<td>2145</td>
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**Conclusions**

Operating characteristics of the system are quite close to the predicted levels. By orificing the motor outlets for higher pressure drop (and better flow balance) total flow can be brought to the desired level of 1000 CFM for each motor and this will also increase the fan pressure rise so that the jet pump will operate nearer its nominal values, resulting in improved filtration of the cooling air flow.
## LABORATORY TEST LOG

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<td>JET Pump Low (FILTER SUCTION)</td>
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<tr>
<td>P-2</td>
<td>FILTER INLET</td>
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<tr>
<td>P-3</td>
<td>JET Pump HIGH</td>
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<td>FAN OUTLET</td>
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<td>P-6</td>
<td>CHOPPER OUTLET</td>
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**PAGE TIME:**

**TOTAL TIME:**

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<th>14</th>
<th>15</th>
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<td>1.86</td>
<td>0</td>
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<td>7.6</td>
<td>30</td>
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<tr>
<td>2</td>
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<td>6.3</td>
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<td>4.75</td>
<td>7.45</td>
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<td>1.15</td>
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<tr>
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<td>0.3</td>
<td>6.3</td>
<td>7.4</td>
<td>2.95</td>
<td>6.75</td>
<td>5.1</td>
<td>4.75</td>
<td>7.5</td>
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</tr>
<tr>
<td>4</td>
<td>1.83</td>
<td>0.2</td>
<td>6.3</td>
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</tr>
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<td></td>
<td></td>
<td></td>
<td>1620 RPM</td>
</tr>
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<td></td>
<td></td>
<td></td>
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<td>820 RPM</td>
</tr>
</tbody>
</table>

Remarks:
- 25-10-72: 1105
- FIG. 52.5
| NO. | 1    | 2    | 3    | 4    | 5    | 6    | 7    | 8    | 9    | 10   | 11   | 12   | 13   | 14   | 15   | REMARKS |
|-----|------|------|------|------|------|------|------|------|------|------|------|------|------|------|-------|
| 1   |      |      |      |      |      |      |      |      |      |      |      |      |      |      |       |
| 2   |      |      |      |      |      |      |      |      |      |      |      |      |      |      |       |
| 3   |      |      |      |      |      |      |      |      |      |      |      |      |      |      |       |
| 4   |      |      |      |      |      |      |      |      |      |      |      |      |      |      |       |
| 5   |      |      |      |      |      |      |      |      |      |      |      |      |      |      |       |
| 6   |      |      |      |      |      |      |      |      |      |      |      |      |      |      |       |
| 7   |      |      |      |      |      |      |      |      |      |      |      |      |      |      |       |
| 8   |      |      |      |      |      |      |      |      |      |      |      |      |      |      |       |
| 9   |      |      |      |      |      |      |      |      |      |      |      |      |      |      |       |
| 10  |      |      |      |      |      |      |      |      |      |      |      |      |      |      |       |
| 11  |      |      |      |      |      |      |      |      |      |      |      |      |      |      |       |
| 12  |      |      |      |      |      |      |      |      |      |      |      |      |      |      |       |
| 13  |      |      |      |      |      |      |      |      |      |      |      |      |      |      |       |
| 14  |      |      |      |      |      |      |      |      |      |      |      |      |      |      |       |
| 15  |      |      |      |      |      |      |      |      |      |      |      |      |      |      |       |
| 16  |      |      |      |      |      |      |      |      |      |      |      |      |      |      |       |
| 17  |      |      |      |      |      |      |      |      |      |      |      |      |      |      |       |
| 18  |      |      |      |      |      |      |      |      |      |      |      |      |      |      |       |
| 19  |      |      |      |      |      |      |      |      |      |      |      |      |      |      |       |
| 20  |      |      |      |      |      |      |      |      |      |      |      |      |      |      |       |


**FIG. 52-6**
| NO. | 1   | 2   | 3   | 4   | 5   | 6   | 7   | 8   | 9   | 10  | 11  | 12  | 13  | 14  | 15  | Remarks |
|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|--------|
| 1   |     |     |     |     |     |     |     |     |     |     |     |     |     |     |        |
| 2   |     |     |     |     |     |     |     |     |     |     |     |     |     |     |        |
| 3   |     |     |     |     |     |     |     |     |     |     |     |     |     |     |        |
| 4   |     |     |     |     |     |     |     |     |     |     |     |     |     |     |        |
| 5   |     |     |     |     |     |     |     |     |     |     |     |     |     |     |        |
| 6   |     |     |     |     |     |     |     |     |     |     |     |     |     |     |        |
| 7   |     |     |     |     |     |     |     |     |     |     |     |     |     |     |        |
| 8   |     |     |     |     |     |     |     |     |     |     |     |     |     |     |        |
| 9   |     |     |     |     |     |     |     |     |     |     |     |     |     |     |        |
| 10  |     |     |     |     |     |     |     |     |     |     |     |     |     |     |        |
| 11  |     |     |     |     |     |     |     |     |     |     |     |     |     |     |        |
| 12  |     |     |     |     |     |     |     |     |     |     |     |     |     |     |        |
| 13  |     |     |     |     |     |     |     |     |     |     |     |     |     |     |        |
| 14  |     |     |     |     |     |     |     |     |     |     |     |     |     |     |        |
| 15  |     |     |     |     |     |     |     |     |     |     |     |     |     |     |        |
| 16  |     |     |     |     |     |     |     |     |     |     |     |     |     |     |        |
| 17  |     |     |     |     |     |     |     |     |     |     |     |     |     |     |        |
| 18  |     |     |     |     |     |     |     |     |     |     |     |     |     |     |        |
| 19  |     |     |     |     |     |     |     |     |     |     |     |     |     |     |        |
| 20  |     |     |     |     |     |     |     |     |     |     |     |     |     |     |        |
| 21  |     |     |     |     |     |     |     |     |     |     |     |     |     |     | FIG. 52-7 |

**Test Purpose:** J A A C Air Flow Test

**P/N:** NA  **Barom:** NA

**S/N:** NA  **Temp:** NA  **Test Pers.:** See Sheet 1 of 2
Fig. 52-9

Velocity Pressure as a Function of Velocity

Note: Based on std. conditions of 21 °F and 29.92 in Hg A air.
Fan Heat Run

The fan motor was run with its normal loading using the same equipment used in the air flow test (see Fig. 52-3A). After one hour's running, the fan was shut down and electrically disconnected so that one pair of terminals could be monitored for resistance change with respect to time after shutdown. The results of this test are shown in Fig. 52-12 in terms of resistance and equivalent temperature rise as compared to ambient conditions prior to the run startup.

Airflow Switch (PN 684-0504-9001)

Static tests with a water manometer were made on four units. The "switch on" under slowly rising pressure occurred over a range of 3.9 to 4.1 inches of water. Starting from 5.0" H₂O and going down slowly the turn off range was 3.0 to 2.5" H₂O. These units were later reworked to provide a smaller up/down hysteresis (approximately 0.5" H₂O in place of the original 1.5" H₂O spread).
Fan Run for 1 hour: 19 amps per phase. Tested 6-29-72

Temperature Rise:

\[ \frac{.515}{.61} = \frac{234.5 + 20.56 + \Delta T}{234.5 + 20.56} \]

\[ \Delta T = 47^\circ C \text{ rise} \]

Temp. = 67.56°C or 153°F. (Very conservative)

Local

Resistance of Fan motor (A-B terminals)

Time in minutes after shut-down

Fig. 52-12

Sheet 137
Traction Motor Cooling

Summarizing the data from the Air Flow Test and from the Traction Motor heat run in Section "a" it is evident that adequate cooling capacity is available.

Figure s2-J is a block diagram of the elements contained in the SOAC car related to the front truck of the vehicle. This diagram shows the sea level test data for air flow. Motor test data for steady state full power operation is represented in Figure s2-J'. It can be seen that the cooling system capacity for pumping air exceeds that used in the motor heat run test by a 30% margin and, consequently, the motors will run cooler in the system than in the test setup.

The hottest temperatures that were recorded were in the compensating pole face winding and the shunt coil at the air outlet side. In steady state 230 HP operation these regions stabilized at approximately 225°F and eventually rose, after shutdown, to 260°F.
**FIG. 52-13** Cooling System SOAC front end

**FIG. 52-14** SOAC Traction Motor Heat Run Test
Auxiliary Power

The second phase of the system test was putting the Auxiliary Power Subsystem into operation. This consisted of: (1) checking out the DC supply which includes the transformer/rectifier (T/R), the battery charger and battery B+ circuitry; (2) checking out the MA protective and control circuits without 600 VDC being present; (3) start and run the MA with no load using facility 600 VDC and battery only for logic and B+; (4) add T/R load and Battery Charger; (5) with fully operating Auxiliary Power supply check system reaction to added loads.

The above series of checks occurred over a three week period in July 1972. The strip chart record shown in figures s3-1, s3-2, and s3-3 were run in September, after modification and is representative of the subsystem performance in near final form.

Propulsion Control and Dynamic Braking

The main propulsion control components PCU, Chopper and PPCU were individually checked and then coupled together for a preliminary system checkout. At this time no 600 VDC power was applied but a simulator was connected which represented the drive system on the two trucks. The simulator modelled the traction motors in detail so that system responses to conditions of RPM and torque generated demands for corresponding field current and Chopper control of simulated armature current. All of the control logic and the large contactors were exercised in the simulator runs and these activities were critically examined to determine that safe and proper sequencing was occurring.
After a thorough checkout with the Traction Motor Simulator, the test stand motors were coupled to the system and motor field control tests were made prior to application of 600 VDC power. Then low RPM starts were made with 600V facility power applied. By mid-September 1972, the test stand was fully operative and testing continued through February 1973, concurrent with field testing at Pueblo, Colorado.

Some representative strip chart recordings of actual runs are shown in figures s4-1, s4-2, and s4-3. Figures s5-1 and s5-2 are the instrumentation data sheets which identify the traces and related scaling of data.

Figure s4-1 shows a typical low speed drive/brake transition. Figure s4-2 shows conditions during acceleration as motor passes through base speed (motor field current begins to decrease). Figure s4-3 shows a typical drive brake transition at 73 MPH (approximately 3900 RPM).

Other tests completed during the later part of 1973 included: speedometer calibration, speed limiting, Hostler control checkout, motor stability tests and maximum load cycling. System testing in the test cell was terminated in February 1973.
FIG. S4-2 Acceleration through Base Speed

- Vertical scale = 2. in.
- Time scale = 1.0 sec
- Base speed
FIG. 54-3  High Speed Drive/Brake Transition
<table>
<thead>
<tr>
<th>TRACE</th>
<th>TRACED TRACE PARAMETER</th>
<th>TRANSMITTER</th>
<th>EQUAL CONDITIONING</th>
<th>OSCILLOSCOPE</th>
<th>REMARKS</th>
</tr>
</thead>
<tbody>
<tr>
<td>ARM 1 SET 1</td>
<td>50 MV/500 VDC</td>
<td>1</td>
<td>400 AMP</td>
<td>2.364 3.0</td>
<td></td>
</tr>
<tr>
<td>FIELD 1 SET 1</td>
<td>2.0 VDC</td>
<td>3</td>
<td>30 AMP</td>
<td>7.364 4.5</td>
<td></td>
</tr>
<tr>
<td>FIELD 1 SET 2</td>
<td>2.0 VDC</td>
<td>4</td>
<td>30 AMP</td>
<td>8.364 9.5</td>
<td></td>
</tr>
<tr>
<td>ARM 1 SET 2</td>
<td>50 MV/1000 VDC</td>
<td>2</td>
<td>400 AMP</td>
<td>10.364 5.0</td>
<td></td>
</tr>
<tr>
<td>BATT 'T'</td>
<td>50 MV/500 VDC</td>
<td>10</td>
<td>50 AMP</td>
<td>19.364 7.0</td>
<td></td>
</tr>
<tr>
<td>BATT 'E'</td>
<td>50 VDC</td>
<td>11</td>
<td>2.0 AMP</td>
<td>20.319 7.0</td>
<td></td>
</tr>
<tr>
<td>TORQUE SET 1A</td>
<td>1500/1500 ft-lb</td>
<td>12</td>
<td>500 ft-lb</td>
<td>21.319 7.0</td>
<td></td>
</tr>
<tr>
<td>TORQUE SET 2A</td>
<td>1500/1500 ft-lb</td>
<td>14</td>
<td>500 ft-lb</td>
<td>22.319 7.0</td>
<td></td>
</tr>
<tr>
<td>FIELD 'E' SET 1</td>
<td>300 VDC</td>
<td>6</td>
<td>600 VDC</td>
<td>25.363 8.5</td>
<td></td>
</tr>
<tr>
<td>FIELD 'E' SET 2</td>
<td>300 VDC</td>
<td>7</td>
<td>600 VDC</td>
<td>27.363 10.0</td>
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<td>1500/1500 VDC</td>
<td>16</td>
<td>600 VDC</td>
<td>31.364 10.0</td>
<td></td>
</tr>
<tr>
<td>PWIRE</td>
<td>50 VDC</td>
<td>15</td>
<td></td>
<td>33.341 11.5</td>
<td></td>
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<tr>
<td>MOTOR SPEED # 1</td>
<td>4300 RPM</td>
<td>19</td>
<td>2000 RPM</td>
<td>35.341 11.5</td>
<td></td>
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<tr>
<td>MOTOR SPEED # 2</td>
<td>4300 RPM</td>
<td>20</td>
<td>2000 RPM</td>
<td>36.341 11.5</td>
<td></td>
</tr>
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</table>

8-21-72

FIG. 55-1
## Instrument Recording Data

<table>
<thead>
<tr>
<th>Recorded Trace Parameter</th>
<th>Transducer</th>
<th>Calibrated Level</th>
<th>Signal Conditioning</th>
<th>Oscilloscope</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Event Sig. #1</td>
<td></td>
<td>22</td>
<td>100 VDC</td>
<td>1.361 0.4</td>
<td>Chopfer on Amp.</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>26</td>
<td>100 VDC</td>
<td>2.361 0.6</td>
<td>Trace after Amp.</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>27</td>
<td>100 VDC</td>
<td>3.361 0.8</td>
<td>Pass Contin. Amp.</td>
</tr>
<tr>
<td></td>
<td>4</td>
<td>25</td>
<td>100 VDC</td>
<td>4.361 1.0</td>
<td>A Command N/A.</td>
</tr>
<tr>
<td>Spare Hi Volt #1</td>
<td>1500 VDC</td>
<td>21</td>
<td>600 VDC</td>
<td>5.361 3.0</td>
<td>Command Contin. Amp.</td>
</tr>
<tr>
<td>Spare Hi Volt #2</td>
<td>1500 VDC</td>
<td>23</td>
<td>600 VDC</td>
<td>6.361 3.0</td>
<td>Pass Contin. Amp.</td>
</tr>
<tr>
<td>Total Motor I</td>
<td>666 VDC</td>
<td>5</td>
<td>1000 AOC</td>
<td>7.364 3.0</td>
<td></td>
</tr>
<tr>
<td>Total Sys. I</td>
<td>566 VDC</td>
<td>24</td>
<td>1000 AOC</td>
<td>9.364 4.5</td>
<td></td>
</tr>
<tr>
<td>MA O.C. Input I</td>
<td>500 AOC</td>
<td>28</td>
<td>400 AOC</td>
<td>10.364 4.5</td>
<td></td>
</tr>
<tr>
<td>MA (Hi-v) Field I</td>
<td>100 VDC</td>
<td>29</td>
<td>10 AOC</td>
<td>14.364 5.0</td>
<td></td>
</tr>
<tr>
<td>CAP Bank E</td>
<td>750 VDC</td>
<td>31</td>
<td>400 VDC</td>
<td>1.364 5.0</td>
<td></td>
</tr>
<tr>
<td>Total Sys. Input E</td>
<td>750 VDC</td>
<td>32</td>
<td>400 VDC</td>
<td>16.364 5.0</td>
<td></td>
</tr>
<tr>
<td>MA Output Freq</td>
<td>500 AOC</td>
<td>39</td>
<td>10 Hz</td>
<td>26.364 6.0</td>
<td></td>
</tr>
<tr>
<td>MA Output I Q &amp; A</td>
<td>500 AOC</td>
<td>33</td>
<td>300 AOC</td>
<td>28.364 6.0</td>
<td></td>
</tr>
<tr>
<td>MA Output I Q &amp; G</td>
<td>500 AOC</td>
<td>34</td>
<td>300 AOC</td>
<td>31.364 6.8</td>
<td></td>
</tr>
<tr>
<td>MA Output I Q &amp; C</td>
<td>500 AOC</td>
<td>34</td>
<td>300 AOC</td>
<td>34.364 7.0</td>
<td></td>
</tr>
<tr>
<td>MA Output E Q &amp; B</td>
<td>250 VDC</td>
<td>36</td>
<td>300 AOC</td>
<td>39.364 8.5</td>
<td></td>
</tr>
<tr>
<td>MA Output E Q &amp; B &amp; C</td>
<td>250 VDC</td>
<td>37</td>
<td>100 VDC</td>
<td>42.364 9.7</td>
<td></td>
</tr>
<tr>
<td>MA Output E Q &amp; B &amp; C</td>
<td>250 VDC</td>
<td>38</td>
<td>200 VDC</td>
<td>45.364 11.1</td>
<td></td>
</tr>
</tbody>
</table>

**Remarks:**

- Command on Amp.
- Trace after Amp.
- Pass Contin. Amp.
- Command N/A.
t. MA-SET (P/N 2014606) (DC-Motor and AC-Generator with Exciter)

Production Testing

Each motor alternator set is subjected to the following production acceptance tests.

A. DC-Motor

1. Resistance of windings and polarity check
2. Seating of brush faces
3. No-load tests
4. Overspeed
5. Dielectric
6. Commutation check
7. Black-band tests (1st unit only)
8. Inspect all critical dimensions of set.

B. AC-Generator

1. Resistance of windings
2. -
3. No-load tests
4. Overspeed
5. Dielectric
6. -
7. Load test
8. -

Development Testing

One MA-set will be utilized to perform the following development tests.

A. DC-Motor

1. No-Load Saturation

Purpose

The purpose of this test is to confirm the capability of the motor magnetic circuit.

Configuration

The motor will be driven by the alternator connected to a 220 VAC, 3 phase power supply with a capacity of about 450 amperes. The start-up is made with either a variable power supply (Variac) or a starting transformer to limit the starting inertia current. The exciter field current shall be about 5 amperes at about 12 volts.

Procedure

A voltmeter is measuring the output voltage on the motor leads.
A variable DC power supply of 220V, 20 amperes provides the field power.

Change field current of the motor 0-15-0 amperes in 1.5 amperes steps. Field current shall be adjusted increase only up to 15 amperes and decrease only down to zero. Record output voltage and field current.
2. Efficiency of MA-Set

Purpose

Determine the overall motor-alternator efficiency

Configuration

The DC-motor will be connected to a variable DC-power supply of 650 volts and about 250 amperes, the AC-generator will be connected to a 3 phase load bank which can absorb about 125 kw at 220 volts. Remove overspeed switch and connect a speed pick-up wheel of the optical or magnetic type to the shaft. Field power for motor and exciter same as for no-load saturation test.

Procedure

Supply full field current to motor, start motor by increasing armature voltage up to 650 volt. Check speed and adjust field current to get 1800 RPM. Energize the exciter field and adjust AC voltage to 230 volts. Close the breaker to the load bank and increase the load gradually to 125000 = 314 amperes. Adjust motor 
\[
\sqrt{3} \times 230
\]
field at the same time to keep the speed of 1800 RPM constant.

Record: Motor: Armature current: $I_m$, Armature voltage: $E_m$
Field current: $I_f$, Field voltage: $E_f$
Alternator: Alternator current: $I_a$, Alternator voltage: $E_a$
Exciter current: $I_e$, Exciter voltage: $E_e$

Set: Speed: RPM

Efficiency: $\eta = \frac{\sqrt{3} \times I_a \times E_a \times 100}{I_m \times E_m} \%$ (excluding field power)

Overall Efficiency: $\eta = \frac{\sqrt{3} \times I_a \times E_a \times 100}{(I_m \times E_m) + (I_f \times E_f) + (I_e \times E_e)} \%$

As design goal the overall efficiency of the set is 75%.
3. Commutation Tests

**Purpose**

Verify the commutation characteristic of the DC-motor arc within the design limits.

Start and load the DC-motor as above but check commutation at the following load points.

<table>
<thead>
<tr>
<th>Volts</th>
<th>Amps</th>
<th>RPM</th>
<th>Load</th>
</tr>
</thead>
<tbody>
<tr>
<td>a.</td>
<td>650</td>
<td>230</td>
<td>1800</td>
</tr>
<tr>
<td>b.</td>
<td>750</td>
<td>200</td>
<td>1800</td>
</tr>
<tr>
<td>c.</td>
<td>750</td>
<td>200</td>
<td>1800</td>
</tr>
<tr>
<td>d.</td>
<td>550</td>
<td>270</td>
<td>1800</td>
</tr>
<tr>
<td>e.</td>
<td>400</td>
<td>270</td>
<td>1800</td>
</tr>
<tr>
<td>f.</td>
<td>650</td>
<td>290</td>
<td>1800</td>
</tr>
</tbody>
</table>

4. Heat Run

**Purpose**

Verify that the motor, alternator and exciter thermal design is adequate for the purpose intended.

**Configuration**

Same as in Tests 2 and 3. Install thermoindicators in the motor at the mainpole coil, interpole coil and compensating coil, in alternator at the stator coil, on exciter in the stator coil, at the air outlet end use ambient thermometer in oil cup.

**Test Conditions**

a. Alternate continuous rating of 125 kw, 230 VAC, 1800 RPM with motor voltage at 650 VDC.

b. Same alternator rating with motor voltage at 550 VDC.

**Procedure**

After set has been at room ambient temperature for at least 8 hours, measure the resistance of the three phases of the alternator, AC-motor resistance at the two diode plates, resistance of the exciter stator winding and resistance of the DC-motor armature between bars about 40 bars apart and marked with permanent markers and record, all resistances and ambient temperatures. Record all temperatures at beginning of test and every five minutes while at test conditions. Stop test when temperature rise between readings.
t. MA-SET (Contd.)

is not more than 2°C at any of the test points. Measure the DC-motor
temperature on the iron and end turns, risers and commutation surface.

Measure the resistances of all windings specified above and record.

Calculate the final winding temperatures using the following formula:

\[ t_f = \frac{R_f - R_i}{R_i} \left( 234.5 + t_i \right) + t_i \] °C

\( t_f \) = Final temperature in °C
\( t_i \) = Initial temperature
\( R_f \) = Final winding resistance in Ohms
\( R_i \) = Initial winding resistance in Ohms

In the above tests the temperature shall not exceed 180°C.

5. Overspeed

Purpose

To prove the mechanical integrity of the rotors and commutator and
the speed setting of the overspeed switch.

Configuration

Mount overspeed switch to the MA-set and connect the normally closed
switch to a lamp and a 120 VAC power supply. Disconnect the alternator
from the load bank to run at no load. Connect one phase to a digital
counter. Start up and run motor as before. Reduce motor field slowly
and observe when overspeed switch is interrupting the lamp circuit.
The circuit shall interrupt at 2,260 RPM (120% of 1890 RPM). The
motor shall run for 5 minutes at overspeed and commutation shall be
observed to see if sparking occurs from deformation of commutator
due to high speed.

6. Dielectric

Purpose

Prove the dielectric capability of the insulation system.

Configuration

Test the motor, alternator and exciter in static condition with
windings disconnected.
t. MA-SET (Contd.)

Procedure

Test the power circuit of the motor with a voltage of 2700 VAC, 60 Hz between windings and frame. The shunt field with a voltage of 2000 VAC, 60 Hz. The alternator stator winding with 1500 VAC, 60 Hz. The exciter circuit, after short circuiting the diodes with 600 VAC, 60 Hz. All voltages shall be applied gradually, hold the test voltage for 60 seconds and reduce the voltage gradually. Each winding not tested will be connected to the frame.

7. Vibration and Shock

Purpose

Prove the mechanical integrity of the MA-set vibratory and shock input loading.

Configuration

A vibration fixture which simulates the car body input will be utilized in this test.

Procedure

With the MA set on the mounting fixture in a static rigid condition, drive the input fixture and scan for resonances in the 20 Hz to 150 Hz region. Any resonances in the 80 to 150 Hz region will require special attention and evaluation.

The MA-set will be shock-tested in the axial direction at ±10 g's, 30 ms.

8. Noise

Purpose

Determine the audible noise characteristic of the MA-set.

Configuration

The MA set is running at no-load and at full-load at 1800 RPM.

Procedure

Record audible noise levels on a broadband noise level meter "C" scale. Recordings will be taken at a distance of 15 ft at lateral and longitudinal direction.

As a design goal, a noise level of 85 db maximum (reference 0.0002 microbar) will be recorded.

SHEET 154
9. Black Band Test (First unit only)

**Purpose**

To set the right interpole strength by adjusting the interpole air gap.

**Configuration**

The DC-motor will be loaded by the alternator.

**Procedure**

Note: A buck-boost circuit at the interpole circuit will be required for this test.

Supply 650 volts motor input voltage. Adjust field current as required throughout the test to provide a set-speed of 1800 RPM and load the motor with the alternator to rated load of 230 amperes.

Energize buck boost source and increase the boost voltage until visible sparking occurs. Record output voltage field current, boost current and speed of motor. Decrease buck voltage until visible sparking occurs and record as before.

Adjust interpole air gap to give signal buck and boost current until sparking occurs.
1. **Motor No load Saturation**

The data for this test is given for unit SN52-D3 in Figure t1-1(4).

2. **Efficiency of the MA Set**

The efficiency as defined by \( \frac{\text{Watts out (AC)}}{\text{Watts in (DC)}} \times 100 \)

is given by the expression \( 3E_\Phi I_\Phi \times 100 \left( \frac{E_{\text{arm}}}{I_{\text{arm}}} \right) \) to an accuracy of approximately +1% at full load since the exciter and the motor field power input is less than a kilowatt.

For SOAC the nominal maximum operating load is about 1/2 the rating of this unit and therefore excitation and field contribute about -2% to the efficiency

\[
\eta_{MA} = \left[ \frac{3 \times 135 \times 124 \times 100}{(650 \times 90)} \right] - 2 = 83.5\%
\]

as taken from the fourth line of data in figure t1-1(3).

3. **Commutation tests**

From the last row of data in figure t1-1(3) there is no sparking throughout the input power range from 6.5 KW to 270 KW.

4. **Heat Run**

The heat run test data for a nominal maximum power input of 125 KW is shown in figure t4-1. This unit has its own self contained air filter and blower for cooling.

5. **Overspeed**

The overspeed (+20%) test data is shown on figure t1-1(5).

6. **Dielectric**

The test data for Hi-Pot is also shown on figure t1-1(5).
A. PREPARATION

4. RESISTANCE MEASUREMENT

I. SHUNT COIL \( R_{sh} \) 7.52 \( \Omega \)

II. STATOR COIL \( R_{stator} \) 0.0437 \( \Omega \)

III. ARMATURE 90° \( R_{a} \) 0.063 \( \Omega \)

IV. ALTERNATOR \( T_1 \) to \( G_1 \) 0.005 \( \Omega \)

V. ALTERNATOR \( T_2 \) to \( G_1 \) 0.005 \( \Omega \)

VI. ALTERNATOR \( T_3 \) to \( G_1 \) 0.005 \( \Omega \)

VII. EXCITER FIELD \( C_1 \) to \( D \) 2.5 \( \Omega \)

5. INSULATION RESISTANCE

I. SHUNT COIL to GND. \( 16 \times 10^4 \) \( M\Omega \)

II. STATOR COILS to GND. \( 16 \times 10^3 \) \( M\Omega \)

III. ROTOR to GND. \( 20 \times 10^3 \) \( M\Omega \)

IV. STATOR COILS to SHUNT \( 14 \times 10^6 \) \( M\Omega \)
B. DC MOTOR TEST

1. No Load Test

1.1 Field Resistance Calculation

I. Field Current $I_f$ = 17.0 AMPS
II. Field Voltage $E_f$ = 134 VOLTS
III. Ambient Temperature = 78 °F

VI. $R_{sh} = \frac{E_f}{I_f} = 7.52$ OHMS

1.3 Full Speed Test

I. Armature current = 7.2 AMPS
II. Armature Voltage = 650 VOLTS
III. Field current = 71.5 AMPS
IV. Field Voltage = Not TAKEN or Required
V. SPEED = 1800 RPM
<table>
<thead>
<tr>
<th>Motor</th>
<th>Alternator</th>
<th>Load Bank</th>
<th>Commutator</th>
<th>Spark</th>
</tr>
</thead>
<tbody>
<tr>
<td>Armature</td>
<td>Armature</td>
<td>Field</td>
<td>Armature</td>
<td>Exiter</td>
</tr>
<tr>
<td>Volts DC</td>
<td>Amps DC</td>
<td>Amps DC</td>
<td>Volts AC</td>
<td>Amps DC</td>
</tr>
<tr>
<td>650</td>
<td>2.0</td>
<td>12.2</td>
<td>134</td>
<td>0</td>
</tr>
<tr>
<td>650</td>
<td>4.3</td>
<td>11.2</td>
<td>134</td>
<td>0.66</td>
</tr>
<tr>
<td>650</td>
<td>11.0</td>
<td>11.0</td>
<td>134</td>
<td>1.10</td>
</tr>
<tr>
<td>650</td>
<td>15.0</td>
<td>10.4</td>
<td>135</td>
<td>1.55</td>
</tr>
<tr>
<td>650</td>
<td>20.2</td>
<td>10.3</td>
<td>134</td>
<td>2.15</td>
</tr>
<tr>
<td>650</td>
<td>28.5</td>
<td>9.4</td>
<td>135</td>
<td>3.04</td>
</tr>
<tr>
<td>650</td>
<td>35.8</td>
<td>9.0</td>
<td>134</td>
<td>3.77</td>
</tr>
<tr>
<td>650</td>
<td>42.0</td>
<td>8.4</td>
<td>134</td>
<td>4.40</td>
</tr>
</tbody>
</table>

Fig 11-1(3) Sheet 159
<table>
<thead>
<tr>
<th>FIELD AMPS INCREASE</th>
<th>ARMATURE VOLTAGE</th>
<th>FIELD AMPS DECREASE</th>
<th>ARMATURE VOLTAGE</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>4.35</td>
<td>0</td>
<td>6.5</td>
</tr>
<tr>
<td>2</td>
<td>12.2</td>
<td>2</td>
<td>13.4</td>
</tr>
<tr>
<td>4</td>
<td>25.0</td>
<td>4</td>
<td>26.0</td>
</tr>
<tr>
<td>6</td>
<td>36.0</td>
<td>6</td>
<td>36.0</td>
</tr>
<tr>
<td>8</td>
<td>49.0</td>
<td>8</td>
<td>49.0</td>
</tr>
<tr>
<td>10</td>
<td>58.0</td>
<td>10</td>
<td>58.0</td>
</tr>
<tr>
<td>12</td>
<td>64.0</td>
<td>12</td>
<td>65.0</td>
</tr>
<tr>
<td>14</td>
<td>68.0</td>
<td>14</td>
<td>69.5</td>
</tr>
<tr>
<td>16</td>
<td>72.5</td>
<td>16</td>
<td>73.0</td>
</tr>
<tr>
<td>18</td>
<td>75.0</td>
<td>18</td>
<td>750+</td>
</tr>
</tbody>
</table>
OVERSPEED CONTROL SET: High 2060, Reset 1800.

OVERSPEED TEST RPM 2160, TIME 2 MINUTES.

Hi Pot A to GROUND. Volts 2500, TIME 1 MIN.

F1 to GROUND. Volts 1500, TIME 1 MIN.

T1 to GROUND. Volts 1500, TIME 1 MIN.

Exciter to GROUND. Volts 1800, TIME 1 MIN.
MA SET DEVELOPMENT TESTS (continued)

7. **Vibration and Shock**
   These tests were not run.

8. **Noise**
   This test was not run.

9. **Black Band**
   This test was run on the traction motors. Due to the limited speed range and reduced power required in this application, the motor will run entirely in the black.
APPENDIX II

IIA - TRUCK FRAME STATIC TEST

IIB - TRUCK BOLSTER STATIC TEST
STATE OF ART CAR
TRUCK FRAME STATIC TEST
FOUR WHEEL MOTOR TRUCK

Test Report T-34701-1

July 10, 1972
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<th>Page</th>
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<td>1</td>
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<tr>
<td>CONCLUSIONS</td>
<td>1</td>
</tr>
<tr>
<td>PERSONNEL</td>
<td>2</td>
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<tr>
<td>DATES OF TEST</td>
<td>3</td>
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<tr>
<td>PROCEDURE</td>
<td>3</td>
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<tr>
<td>RESULTS OF TEST</td>
<td>6</td>
</tr>
<tr>
<td>COMMENTS</td>
<td>7</td>
</tr>
</tbody>
</table>

T-34701-1
July 10, 1972

SHEET 171
S.O.A.C.
TRUCK FRAME STATIC TEST
FOUR WHEEL MOTOR TRUCK
TEST REPORT T-34701-1

Introduction:

This static test was conducted on the S.O.A.C. truck frame GSI 34701, Serial 1, cast date 3-72, to determine the structural adequacy of the truck frame. The loading forces and loading conditions were those set up in GSI's test procedure as modified in consultation with Boeing-Vertol before the start of the test. During the Stresscoat test a portion of the truck frame wheelpiece adjacent to the side bearing pad was determined to have a marginal stress level.

This section of the truck frame was reinforced on the other side and the test conducted on the pedestal openings on one side of the truck frame and the center portion of the truck frame on the other side.

Also the radius of the side bearer adjacent to the top surface of the truck frame was determined to be too sharp. This radius was chipped and ground to obtain a better blending of the side bearer into the top surface of the casting before conducting the strain gage test.

Object:

The object of this test was to determine the stresses in the truck frame under the above agreed upon loading conditions and to determine the deflection of the chevrons under vertical load.

Conclusions:

The recorded stresses and chevron deflections were satisfactory as agreed upon by Boeing-Vertol and GSI St. Louis Car Division and the Castings Division.

The maximum recorded stresses for the test under the agreed upon loading conditions were:
### Loading Condition

<table>
<thead>
<tr>
<th>Loading Condition</th>
<th>Applied Load Lbs.</th>
<th>Max. Recorded Stress 1000 P.S.I.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vertical Load With Tie Bars</td>
<td>47,760</td>
<td>+14.1</td>
</tr>
<tr>
<td>Loose Tie Bars</td>
<td>47,760</td>
<td>+15.0</td>
</tr>
<tr>
<td>Lateral Load Applied to Serial Side With Tie Bars</td>
<td>7,164</td>
<td>+2.7</td>
</tr>
<tr>
<td>Loose Tie Bars</td>
<td>7,164</td>
<td>+2.7</td>
</tr>
<tr>
<td>Lateral Load Applied to Non-serial Side With Tie Bars</td>
<td>7,164</td>
<td>+2.1</td>
</tr>
<tr>
<td>Loose Tie Bars</td>
<td>7,164</td>
<td>+2.1</td>
</tr>
<tr>
<td>Outward Longitudinal Load With Tie Bars</td>
<td>24,500</td>
<td>+4.8</td>
</tr>
<tr>
<td>Loose Tie Bars</td>
<td>24,500</td>
<td>+9.3</td>
</tr>
<tr>
<td>Downward Vertical Load on Motor</td>
<td>10,351</td>
<td>+4.8</td>
</tr>
<tr>
<td>Mount</td>
<td>17,811</td>
<td>+8.4</td>
</tr>
<tr>
<td>24,137</td>
<td>+11.3</td>
<td>-37.2</td>
</tr>
<tr>
<td>Upward Vertical Load on Motor</td>
<td>10,351</td>
<td>+18.6</td>
</tr>
<tr>
<td>Mount</td>
<td>17,811</td>
<td>+32.1</td>
</tr>
<tr>
<td>24,137</td>
<td>+43.8</td>
<td>-12.9</td>
</tr>
<tr>
<td>Lateral Load on Motor Mount Toward Non-Serial Side</td>
<td>6,720</td>
<td>-12.0</td>
</tr>
<tr>
<td>11,600</td>
<td>-20.8</td>
<td>+25.5</td>
</tr>
<tr>
<td>Lateral Load on Motor Mount Toward Serial Side</td>
<td>6,720</td>
<td>-13.5</td>
</tr>
<tr>
<td>11,600</td>
<td>-23.4</td>
<td>+21.3</td>
</tr>
</tbody>
</table>

### Personnel:

Present for the Stresscoat test were:

- Messrs. R. W. Moore
- G. C. Krause
- T. M. Herbert

GSI Castings Division

---

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Present for the strain gage test were:

Messrs. M. Dennis Boeing-Vertol
N. Bohm St. Louis Car (part time)
E. G. Dunlop St. Louis Car (part time)
J. Brinson St. Louis Car (part time)
D. G. K. Wilmot GSI (part time)
K. E. Spencer GSI
J. D. Burnett GSI
G. C. Krause GSI
R. W. Moore GSI
T. M. Herbert GSI

Dates of Test:

The test was conducted from 5-19-72 to 6-9-72.

Procedure:

A. Preparation

Prior to applying strain gages, one half of the truck frame was Stresscoated (see Photographs 1 and 2) and loads greater than the agreed upon loading conditions were applied to determine the points of maximum stress. At this time it was decided to reinforce the area of the truck frame between the brake support brackets. This reinforced area of the truck was Stresscoated (see Photograph 3) and the overload conditions repeated.

Stresscoat indications were developed at locations given in Table 1 and shown on Photographs 4 thru 11 and SG 34701.

Strain gages were located on the truck frame at these points and other points to determine the general stress distribution. See SG 34701 for strain gage locations.

B. Instrumentation

Except for strain gages 5, 6, 8, 9, 18, 18S, 37 and 37S which were SR-4 one-half inch gage length type A-5-56 and rosettes 56, 56S and 57S which were M-M rectangular rosettes type EA-06-125RA-120, all strain gages were SR-4 one-eighth
inch gage length type FAP-12-12S6. The strain gages were applied, waterproofed and wired to terminal blocks from which cables were run to a switching unit and read out on a strain indicator.

Loads were applied with hydraulic rams and read out on calibrated hydraulic gages or load cells. See Photographs 12 thru 19 for test setups.

For determining the chevron deflections under vertical load, scale readings were taken between the top of each dummy journal box at the centerline of the box and a prick punch mark on the truck frame directly over the centerline of the dummy journal box.

C. Loading Conditions

The following loading conditions were applied to the truck frame:

<table>
<thead>
<tr>
<th>Loading Condition</th>
<th>Load for Stress Determination Lbs.</th>
<th>Maximum Load Applied Lbs.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vertical load applied equally on two side bearers (total). (See Photograph 12 for test setup).</td>
<td>47,760</td>
<td>74,000</td>
</tr>
<tr>
<td>Lateral load applied at the centerline of the truck and reacted at each axle. (See Photograph 13 for load application and Photograph 14 for load reaction).</td>
<td>7,164</td>
<td>20,000</td>
</tr>
<tr>
<td>Outward longitudinal load applied to each axle (See Photograph 15 for load application and Photograph 16 for load reaction).</td>
<td>24,500</td>
<td>30,000</td>
</tr>
<tr>
<td>Vertical downward load applied on each motor mount (See Photograph 17 for test setup).</td>
<td>10,351</td>
<td>25,000</td>
</tr>
</tbody>
</table>

SHEET 176
### Load for Stress Determination

<table>
<thead>
<tr>
<th>Loading Condition</th>
<th>Applied Lbs.</th>
<th>Maximum Load Lbs.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vertical upward load applied on one motor mount</td>
<td>10,351</td>
<td>25,000</td>
</tr>
<tr>
<td>(See Photograph 18 for test setup).</td>
<td>17,811</td>
<td></td>
</tr>
<tr>
<td></td>
<td>24,137</td>
<td></td>
</tr>
<tr>
<td>Lateral load applied in each direction on each motor</td>
<td>6,722</td>
<td>12,500</td>
</tr>
<tr>
<td>mount (See Photograph 19 for test setup).</td>
<td>11,600</td>
<td></td>
</tr>
</tbody>
</table>

This truck was set up for test using chevrons, dummy axles & dummy boxes. The dummy axles were supported by stands at each end. These stands were located equidistant from the centerline of the journal. Side bearing pads and a dummy bolster were used for vertical load applications to the truck frame. All loads for stress determination are for a car weight of 41,500# on the air springs.

The vertical load of 47,760# due to the load on journal boxes was applied equally to the side bearing pads thru the dummy bolster by communicated hydraulic jacks with a load cell and ball seat. This load was reacted at the supports for the axles. See Photograph 12 for test setup.

For the lateral and longitudinal loading conditions applied to the truck frame a constant vertical load was applied at the center of the dummy bolster by an air spring and reacted near the end of each dummy axle. The reaction was thru ball bearings placed between two hardened steel plates. The vertical load was necessary to maintain the chevrons in place under lateral or longitudinal load. The air spring and ball bearings were used to reduce external resistance to lateral and longitudinal motion to a minimum.

The lateral load of 7,164 lbs. due to 15% of the weight on journals was applied at the centerline of the truck at the centerline of journal height and reacted at the end of each dummy axle. This load was applied to one side of the truck and then reversed to the other side of the truck. See Photograph 13 for load application and Photograph 14 for load reaction.

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The longitudinal load of 24,500 lbs. which was applied at the centerline on one axle and reacted at the centerline of the other axle is due to a maximum full service brake shoe force of 10,280 lbs. per wheel plus an adhesion factor of 15% of the weight at rail. See Photograph 15 for load application and Photograph 16 for load reaction.

The motor mount bracket loads were specified by Garrett. (See Comments). The vertical downward motor mount bracket load of 24,137 lbs. was applied thru a rubber pad to each motor mount bracket. The load (48,274 lbs) was applied to the center of a beam supported on each rubber pad. The load was reacted at the supports for the axles. See Photograph 17 for the test setup.

The vertical upward motor mount bracket load of 24,137 lbs. was applied thru a rubber pad to the strain gaged motor mount. This load was reacted at the side bearing pads and the supports for the axles. See Photograph 18 for the test setup.

The lateral motor mount bracket load of 11,600 lbs. was applied thru a rubber pad to each motor mount bracket. The load (23,200 lbs) was applied to the centerline of a beam connected to a plate on top of the rubber by a tension member. The load on the plate placed the rubber pads in compression. The load (23,200 lbs) was reacted at the centerline of the truck. See Photograph 19 for the test setup.

Results of Test:

Tables 1 and 2 contain the stresses for the truck frame.

Sketch A is a plot of the average chevron deflection versus applied vertical load.

Photographs 4 thru 11 show the Stresscoat indications.
**Comments:**

All truck frames were reinforced per Photograph 3, and had the radius at the side bearers blended before shipment.

For vertical, lateral and longitudinal loading conditions, the tests were conducted in the pedestal areas with the tie bolts with an initial torque of 30 ft.lbs. and at the request of Boeing-Vertol with the tie bolts loose. Spacers were not used for the test.

The following data was supplied by Garrett based on their assumptions:

<table>
<thead>
<tr>
<th>Condition</th>
<th>Vertical</th>
<th>Lateral</th>
<th>No. Cycles</th>
</tr>
</thead>
<tbody>
<tr>
<td>11</td>
<td>10,351#</td>
<td>11,600#</td>
<td>6</td>
</tr>
<tr>
<td>12</td>
<td>17,811#</td>
<td>6,722#</td>
<td>10³</td>
</tr>
<tr>
<td>13</td>
<td>17,811#</td>
<td>11,600#</td>
<td>10</td>
</tr>
<tr>
<td>14</td>
<td>24,137#</td>
<td>6,722#</td>
<td>10</td>
</tr>
</tbody>
</table>

Due to the fact that this truck has primary springing, it is very doubtful that the 17,811# vertical force generated by a 15G vertical acceleration or the 11,600# lateral force generated by a 10G lateral acceleration would be obtained. Therefore we feel that the motor test loads are high, the motor bracket was very conservatively tested and recorded stresses are acceptable for the test conditions imposed.

T. M. Herbert  
Engineer of Tests
LIST OF ATTACHMENTS

SG 34701 LOCATION AND NUMBERS OF STRAIN GAGES ON THE TRUCK FRAME.

TABLE 1 RECORDED STRESSES IN THE TRUCK FRAME FOR DESIGNATED LOAD CONDITIONS.

TABLE 2 EVALUATION OF ROSETTES ON THE TRUCK FRAME FOR DESIGNATED LOAD CONDITIONS.

SKETCH A AVERAGE CHEVRON DEFLECTION VS. VERTICAL LOAD.

PHOTOGRAPH 1 STRESSCOAT AREA OF THE TOP SIDE OF THE TRUCK FRAME.

PHOTOGRAPH 2 STRESSCOAT AREA OF THE BOTTOM SIDE OF THE TRUCK FRAME.

PHOTOGRAPH 3 STRESSCOAT AREA OF THE REVISION TO THE TRUCK FRAME IN THE AREA OF THE SIDE BEARER.

PHOTOGRAPH 4 STRESSCOAT INDICATIONS IN THE SIDE WALL OF THE WHEELPIECE UNDER VERTICAL OVER LOAD. ROSETTES 56 AND 56S WERE PLACED AT THESE INDICATIONS.


PHOTOGRAPH 6 STRESSCOAT INDICATIONS IN THE AREA OF THE SIDE BEARER UNDER VERTICAL OVER LOAD. THIS AREA WAS GROUND TO INCREASE THE RADIUS AND STRAIN GAGES 44 AND 44S WERE PLACED AT THESE INDICATIONS.

PHOTOGRAPH 7 STRESSCOAT INDICATIONS IN THE TOP OF THE WHEELPIECE UNDER VERTICAL OVER LOAD INBOARD OF THE BRAKE BRACKET. STRAIN GAGES 39 AND 39S WERE PLACED AT THESE INDICATIONS.

PHOTOGRAPH 8 STRESSCOAT INDICATIONS IN MOTOR MOUNT BRACKET UNDER VERTICAL MOTOR MOUNT LOAD. STRAIN GAGES 16 AND 17 WERE PLACED AT THESE INDICATIONS.

PHOTOGRAPH 9 STRESSCOAT INDICATIONS IN MOTOR MOUNT BRACKET UNDER VERTICAL MOTOR MOUNT LOAD. STRAIN GAGES 11 AND 12 WERE PLACED AT THESE INDICATIONS.

T-34701-1
LIST OF ATTACHMENTS (continued)

PHOTOGRAPH 10  STRESSCOAT INDICATIONS IN MOTOR MOUNT BRACKET UNDER VERTICAL MOTOR MOUNT LOAD. STRAIN GAGES 50 AND 51 WERE PLACED AT THESE INDICATIONS.

PHOTOGRAPH 11  STRESSCOAT INDICATIONS IN MOTOR MOUNT BRACKET UNDER LATERAL LOAD. STRAIN GAGES 13, 14, 52 AND 54 WERE PLACED AT THESE INDICATIONS.

PHOTOGRAPH 12  VERTICAL LOAD TEST SETUP. LOAD APPLIED TO DUMMY BOLSTER AND REACTED BY DUMMY AXLES.

PHOTOGRAPH 13  LATERAL LOAD APPLICATION AT THE CENTERLINE OF THE TRUCK AT CENTERLINE OF JOURNAL HEIGHT. SEE PHOTOGRAPH 14 FOR LOAD REACTION. NOTE AIR SPRING TO APPLY VERTICAL LOAD TO RETAIN CHEVRONS IN PLACE. BALL BEARINGS ARE PLACED BETWEEN HARDENED STEEL PLATES UNDER THE AXLES SO THAT THE TRUCK FRAME CAN MOVE LATERALLY FREELY.

PHOTOGRAPH 14  LATERAL LOAD REACTION AT THE ENDS OF THE AXLE. SEE PHOTOGRAPH 13 FOR LOAD APPLICATION.

PHOTOGRAPH 15  LONGITUDINAL LOAD APPLICATION AT THE CENTERLINE OF AXLE. THE SAME SETUP FOR VERTICAL LOAD TO RETAIN CHEVRON IN PLACE AS SHOWN IN PHOTOGRAPH 13 WAS USED. SEE PHOTOGRAPH 16 FOR LOAD REACTION.

PHOTOGRAPH 16  LONGITUDINAL LOAD REACTION AT THE CENTERLINE OF AXLE. SEE PHOTOGRAPH 15 FOR LOAD APPLICATION.

PHOTOGRAPH 17  VERTICAL DOWNWARD LOAD MOTOR MOUNT TEST SETUP. BOTH MOTOR MOUNTS WERE LOADED. REACTION TO THESE LOADS IS AT THE AXLES.

PHOTOGRAPH 18  VERTICAL UPWARD MOTOR MOUNT TEST SETUP. ONE MOTOR MOUNT WAS LOADED. REACTION IS AT SIDE BEARERS AND AXLES.

PHOTOGRAPH 19  LATERAL LOAD TEST SETUP. LOAD IS APPLIED TO BOTH MOTOR MOUNTS AND REACTED AT THE CENTERLINE OF THE TRUCK FRAME.

SHEET 181

T-34701-1
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**TABLE I**  
**S.O.A.C. TRUCK FRAME STRESSES UNDER DESIGN LOAD CONDITIONS - PATTERN NO. 3401; SERIAL NO. 1; CAPT DATE 3-72**

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**TABLE I page 1**

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<td>-4.8</td>
<td>-1.5</td>
<td>-1.5</td>
<td>+2.1</td>
<td>+1.8</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>43C</td>
<td>-6.3</td>
<td>-1.5</td>
<td>N.R.</td>
<td>+1.5</td>
<td>+1.5</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>44</td>
<td>+14.6</td>
<td>+1.2</td>
<td>+1.2</td>
<td>+1.2</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>44C</td>
<td>+16.1</td>
<td>+1.2</td>
<td>+1.2</td>
<td>+1.2</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>45</td>
<td>+14.6</td>
<td>+12.6</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>45C</td>
<td>+14.6</td>
<td>+12.6</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>46</td>
<td>+16.1</td>
<td>+1.2</td>
<td>N.R.</td>
<td>-1.2</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>46C</td>
<td>+16.1</td>
<td>+1.2</td>
<td>N.R.</td>
<td>-1.2</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>
**TABLE I**

<table>
<thead>
<tr>
<th>Gage No.</th>
<th>Tie Bars Torqued to 30 ft. lb.</th>
<th>Tie Bars Loose to 30 ft. lb.</th>
<th>Tie Bars Torqued to 30 ft. lb.</th>
<th>Tie Bars Loose to 30 ft. lb.</th>
<th>Tie Bars 10,351# 17,811# 24,137#</th>
<th>Stress due to a Vertical Load of 47,760 ft. total applied equally at the serial no. side of the truck</th>
</tr>
</thead>
<tbody>
<tr>
<td>50</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>-6.3 -10.6 -14.7 +6.9 +11.7 +15.9</td>
</tr>
<tr>
<td>51</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>-8.1 -14.0 -18.9 -9.3 +16.1 +21.9</td>
</tr>
<tr>
<td>52</td>
<td>-2.3</td>
<td>-1.2</td>
<td>-1.2</td>
<td>0</td>
<td>0</td>
<td>-2.1 -3.6 -4.8 -2.7 -4.5 -6.3</td>
</tr>
<tr>
<td>53</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>54</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>55</td>
<td>-6.9</td>
<td>+1.2</td>
<td>-1.5</td>
<td>+0.9</td>
<td>+2.1</td>
<td>0</td>
</tr>
<tr>
<td>555</td>
<td>-12.8</td>
<td>+4.7</td>
<td>-2.6</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

**Note:**

B.O. = Bad Order Strain Gage  
N.R. = Not Recorded  
* = Stresscoat indications at these strain gage locations

**S.O.A.C. TRUCK FRAME STRESSES UNDER DESIGN LOADING CONDITIONS**  
**PATTERN NO. 34**  
**SERIAL NO. 1**  
**CAST DATE 3-72**

---

**TABLE I**

**Page 3**

**SHEET 189/190**
TABLE 2
S.O.A.C. TRUCK FRAME PATTERN NO. 34701 SERIAL NO. 1 CAST DATE 3-72
EVALUATION OF ROSETTES UNDER DESIGN LOADING CONDITIONS
STRESS IN 1000 PSI + DESIGNATES TENSION - DESIGNATES COMPRESSION

<table>
<thead>
<tr>
<th>LOAD CONDITION</th>
<th>RECORDED VALUES</th>
<th>MAJOR VALUE</th>
<th>STRESS AXIS</th>
<th>MINOR VALUE</th>
<th>STRESS AXIS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stress due to a vertical load of 47,750# total applied equally to the side bearers</td>
<td>Gage 56a Gage 56b Gage 56c</td>
<td>+105 +410 +160</td>
<td>+12.1 2.8°</td>
<td>-0.8 92.8°</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Gage 56sa Gage 56sb Gage 56sc</td>
<td>0 +250 +150</td>
<td>+7.6 168.4°</td>
<td>-1.2 78.4°</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Gage 57sa Gage 57sb Gage 57sc</td>
<td>+205 +320 +30</td>
<td>+9.8 13.4°</td>
<td>-2.2 103.4°</td>
<td></td>
</tr>
<tr>
<td>Stress due to an outward longitudinal load of 24,500# per axle</td>
<td>Gage 56a Gage 56b Gage 56c</td>
<td>0 -50 0</td>
<td>+1.2 90°</td>
<td>-1.2 0°</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Gage 56sa Gage 56sb Gage 56sc</td>
<td>0 -60 -30</td>
<td>+0.4 90.8°</td>
<td>-1.7 170.8°</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Gage 57sa Gage 57sb Gage 57sc</td>
<td>-50 -75 0</td>
<td>+0.2 13.2°</td>
<td>-2.4 103.2°</td>
<td></td>
</tr>
<tr>
<td>Stress due to a lateral load of 7,164# applied to the non-serial no. side of the truck</td>
<td>Gage 56a Gage 56b Gage 56c</td>
<td>-60 0 -15</td>
<td>-0.6 -15.4°</td>
<td>-2.6 105.4°</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Gage 56sa Gage 56sb Gage 56sc</td>
<td>-30 +20 0</td>
<td>0 168.4°</td>
<td>-1.3 78.4°</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Gage 57sa Gage 57sb Gage 57sc</td>
<td>+15 +20 -40</td>
<td>+0.4 20.1°</td>
<td>-1.5 110.1°</td>
<td></td>
</tr>
<tr>
<td>Stress due to lateral load of 7,164# applied to serial no. side of the truck</td>
<td>Gage 56a Gage 56b Gage 56c</td>
<td>+45 0 +15</td>
<td>+2.0 17.5°</td>
<td>+0.5 107.5°</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Gage 56sa Gage 56sb Gage 56sc</td>
<td>+40 -15 -15</td>
<td>+1.5 67.5°</td>
<td>-0.4 157.5°</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Gage 57sa Gage 57sb Gage 57sc</td>
<td>-15 -15 +30</td>
<td>+1.1 17.5°</td>
<td>-0.4 107.5°</td>
<td></td>
</tr>
</tbody>
</table>

NOTE: Angle measured counter-clockwise from Strain Gage B T-34701-1
S.O.J.A.C. TRUCK 34700
CHEVRON DEFLECTION
vs.
VERTICAL LOAD
CHEVRON GSI 345, 3-4

VERTICAL LOAD ON SIDE BEAMS - LBS. X 1000

50

60

40

30

20

10

0

0.0

0.4

0.8

1.2

1.6

2.0

AVERAGE CHEVRON DEFLECTION - IN.

WITH-TIE BARS
STRESSCOAT AREA OF THE BOTTOM SIDE OF THE TRUCK FRAME

T-34701-1  PHOTOGRAPH  2
STRESSCOAT AREA OF THE REVISION TO THE TRUCK FRAME IN THE AREA OF THE SIDE BEARER.

T-34701-1

PHOTOGRAPH 3
STRESSCOAT INDICATIONS IN THE SIDE WALL OF THE WHEELPIECE UNDER VERTICAL OVER-LOAD. ROSETTES 56 AND 56S WERE PLACED AT THESE INDICATIONS.
T-34701-1

PHOTOGRAPH 4

T-34701-1

PHOTOGRAPH 5
STRESSCOAT INDICATIONS IN THE AREA OF THE SIDE BEARER UNDER VERTICAL OVER-LOAD. THIS AREA WAS GROUND TO INCREASE THE RADIUS AND STRAIN GAGES 44 AND 445 WERE PLACED AT THESE INDICATIONS.

T-34701-1

PHOTOGRAPH 6
STRESSCOAT INDICATIONS IN THE TOP OF THE WHEELPIECE UNDER VERTICAL OVER-LOAD INBOARD OF THE BRAKE BRACKET. STRAIN GAGES 39 AND 39S WERE PLACED AT THESE INDICATIONS.

T-34701-1

PHOTOGRAPH 7

SHFFT 200
STRESSCOAT INDICATIONS IN MOTOR MOUNT BRACKET UNDER VERTICAL MOTOR MOUNT LOAD. STRAIN GAGES 16 AND 17 WERE PLACED AT THESE INDICATIONS.

T-34701-1
STRESSCOAT INDICATIONS IN MOTOR MOUNT BRACKET UNDER VERTICAL MOTOR MOUNT LOAD. STRAIN GAGES 11 AND 12 WERE PLACED AT THESE INDICATIONS.

T-34701-1

PHOTOGRAPH 9
STRESSCOAT INDICATIONS IN MOTOR MOUNT BRACKET UNDER VERTICAL MOTOR MOUNT LOAD. STRAIN GAGES 50 AND 51 WERE PLACED AT THESE INDICATIONS.

T-34701-1
STRESSCOAT INDICATIONS IN MOTOR MOUNT BRACKET UNDER LATERAL LOAD.
STRAIN GAGES 13, 14, 52 AND 54 WERE PLACED AT THESE INDICATIONS.

T-34701-1

PHOTOGRAPH 11
VERTICAL LOAD TEST SETUP. LOAD APPLIED TO DUMMY BOLSTER AND REACTED BY DUMMY AXLES.

T-34701-1

PHOTOGRAPH 12

SHEET 205
LATERAL LOAD APPLICATION AT THE CENTER LINE OF THE TRUCK AT CENTER LINE OF JOURNAL HEIGHT. SEE PHOTOGRAPH 14 FOR LOAD REACTION. NOTE AIR SPRING TO APPLY VERTICAL LOAD TO RETAIN CHEVRONS IN PLACE. BALL BEARINGS ARE PLACED BETWEEN HARDENED STEEL PLATES UNDER THE AXLES SO THAT THE TRUCK FRAME CAN MOVE LATERALLY FREELY.

PHOTOGRAPH 13

T-34701-1

SHEET 206
LATERAL LOAD REACTION AT THE ENDS OF THE AXLE. SEE PHOTOGRAPH 13 FOR LOAD APPLICATION.

T-34701-1

PHOTOGRAPH 14

SHEET 207
LONGITUDINAL LOAD APPLICATION AT THE CENTER LINE OF AXLE. THE SAME SET-UP FOR VERTICAL LOAD TO RETAIN CHEVRON IN PLACE AS SHOWN IN PHOTOGRAPH 13 WAS USED. SEE PHOTOGRAPH 16 FOR LOAD REACTION.

PHOTOGRAPH 15

SHEET 208
LONGITUDINAL LOAD REACTION AT THE CENTER LINE OF AXLE. SEE PHOTOGRAPH 15 FOR LOAD APPLICATION.

PHOTOGRAPH 16

SHEET 209
VERTICAL DOWNWARD LOAD MOTOR MOUNT TEST SET-UP. BOTH MOTOR MOUNTS WERE LOADED. REACTION TO THESE LOADS IS AT THE AXLES.

PHOTOGRAPH 17

T-34701-1
VERTICAL UPWARD MOTOR MOUNT TEST SET-UP. ONE MOTOR MOUNT WAS LOADED. REACTION IS AT SIDE BEARERS AND AXLES.

T-34701-1

PHOTOGRAPH 18

SHEET 211
LATERAL LOAD TEST SET-UP. LOAD IS APPLIED TO BOTH MOTOR MOUNTS AND REACTED AT THE CENTER LINE OF THE TRUCK FRAME.

T-34701-1

PHOTOGRAPH 19
APPENDIX IIB

TRUCK BOLSTER

GSI REPORT T34702-1
STATE OF ART CAR
BOLSTER STATIC TEST
FOUR WHEEL MOTOR TRUCK

TEST REPORT T-34702-1
August 30, 1972
# Table of Contents

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
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<tr>
<td>Introduction</td>
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<tr>
<td>Object</td>
<td>1</td>
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<tr>
<td>Conclusions</td>
<td>1</td>
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<td>Personnel</td>
<td>2</td>
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<tr>
<td>Dates of Test</td>
<td>2</td>
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<tr>
<td>Procedure</td>
<td>2</td>
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<tr>
<td>Results of Test</td>
<td>5</td>
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</tbody>
</table>

Test Report T-34702-1

August 30, 1972

SHEET 217
Introduction:

This static test was conducted on S.O.A.C. bolster, GSI 34702 serial 2 cast date 4-72, to determine the structural adequacy of the bolster. The loading forces and loading conditions were those set up on GSI's test procedure as modified in consultation with Boeing-Vertol before the start of the test.

Object:

The object of this test was to determine the stresses in the bolster under the above agreed upon loading conditions.

Conclusions:

The recorded stresses were satisfactory.

The maximum recorded stresses for the test under the agreed upon loading conditions were:

<table>
<thead>
<tr>
<th>Loading Condition</th>
<th>Applied Load</th>
<th>Maximum Recorded Stress - 1000 p.s.i.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vertical Load</td>
<td>42,600 lbs.</td>
<td>+16.8 Tension</td>
</tr>
<tr>
<td>Lateral Load</td>
<td>6225 lbs.</td>
<td>+14.1 Tension</td>
</tr>
<tr>
<td>Normal Car Height</td>
<td></td>
<td>-8.1 Compression</td>
</tr>
<tr>
<td>Lateral Load</td>
<td>6225 lbs.</td>
<td>+ 7.5 Tension</td>
</tr>
<tr>
<td>Shimmed Car Height</td>
<td></td>
<td>-13.5 Compression</td>
</tr>
<tr>
<td>Longitudinal</td>
<td>6390 lbs.</td>
<td>+ 4.8 Tension</td>
</tr>
<tr>
<td></td>
<td></td>
<td>-5.7 Compression</td>
</tr>
</tbody>
</table>
Personnel:

Present for the Stresscoat test were:

R. W. Moore          GSI
G. C. Krause         GSI
T. M. Herbert        GSI

Present for the strain gage test were:

J. Brinson           St. Louis Car (part time)
G. C. Krause         GSI
R. W. Moore          GSI
T. M. Herbert        GSI

Dates of Test:

The test was conducted from 6-15-72 to 6-22-72.

Procedure:

A. Preparation

Prior to applying strain gages, one half of the bolster was Stresscoated (see Photographs 1 and 2) and loads greater than the agreed upon loading conditions were applied to determine the points of maximum stress.

Stresscoat indications were developed at locations given in Tables 1 and 2, and shown on Photographs 3 thru 7 and SG 34702.

Strain gages were located on the bolster at these points and other points to determine the general stress distribution.
B. Instrumentation

Strain gages 3, 4, 22, 23, and 36 thru 41 were SR-4 one-half inch gage length type A-5-86. Rosettes 42, 43, 44, 47 and 48 were M-M rectangular rosettes type EA-06-125RA-120. All other strain gages were SR-4 one-eighth inch gage length type FAP-12-12S6. The strain gages were applied, water-proofed and wired to terminal blocks from which cables were run to a switching unit and read out on a strain indicator. The lateral and longitudinal loads were applied with hydraulic rams and read out on calibrated hydraulic gages. The vertical load was applied by the air springs and read out on load cells for the strain gage test. For the Stresscoat test the vertical load was applied with hydraulic rams and read out on a load cell. See Photographs 8 thru 11 for test setups.

C. Loading Conditions

The following loading conditions were applied to the bolster:

<table>
<thead>
<tr>
<th>Loading Condition</th>
<th>Load for Stress Determination</th>
<th>Maximum Load Applied</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vertical load applied on two air spring seats (total). See Photograph 8 for test setup.</td>
<td>42,600</td>
<td>70,000</td>
</tr>
</tbody>
</table>
Loading Condition | Load for Stress Determination | Maximum Load Applied |
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Lateral load applied to two lateral stops (total) for normal car height. See Photograph 9 for test setup.</td>
<td>6,225</td>
<td>16,800</td>
</tr>
<tr>
<td>Lateral load applied to two lateral stops (total) for shimmed car height. (Test setup same as for above except lateral load test rigging raised)</td>
<td>6,225</td>
<td>16,800</td>
</tr>
<tr>
<td>Longitudinal load applied to two bolster anchor brackets. See Photographs 10 &amp; 11 for test setup.</td>
<td>6,390</td>
<td>14,000</td>
</tr>
</tbody>
</table>

All loads for stress determination are for a car weight of 41,500# on the air springs.

The vertical load of 42,600# due to the load on the side bearing pads was applied to two communicated air springs, one on each air spring seat. The load on the air springs was read out with load cells placed between the air spring and a strongback. During this test the air pressure in the bolster was taken to 100 p.s.i. This vertical load applied to the air spring seats was reacted at the side bearing pads. See Photograph 8 for test setup.

The lateral load of 6,225# (total) is due to 15% of the car body weight on the air springs. This lateral load was applied equally to the two lateral stops on one end of the bolster thru communicated rams and reacted at the two lateral stops on the
other end of the bolster. This lateral load was applied both at normal car height and at shimmed car height. See Photograph 9 for test setup.

The longitudinal load of 6,390# (total) is due to 15% of the weight on the side bearing pads. This longitudinal load was applied equally to the two bolster anchor brackets and reacted at the central spigot. See Photographs 10 & 11 for load application and reaction.

Results of Test:

Tables 1 and 2 contain the recorded stresses.

Photographs 3 thru 7 show the Stresscoat indications.

T. M. Herbert
Engineer of Tests
LIST OF ATTACHMENTS

SG 34702 LOCATION AND NUMBERS OF STRAIN GAGES ON THE TRUCK FRAME.

TABLE 1 RECORDED STRESSES IN THE TRUCK FRAME.

TABLE 2 ROSETTE ANALYSIS.

PHOTOGRAPH 1 STRESSCOAT AREA OF THE TOP OF THE BOLSTER.

PHOTOGRAPH 2 STRESSCOAT AREA OF THE BOTTOM OF THE BOLSTER.

PHOTOGRAPH 3 STRESSCOAT INDICATIONS IN THE BOTTOM OF THE BOLSTER. ROSETTES 42, 43 AND 44 WERE LOCATED AT THESE INDICATIONS.

PHOTOGRAPH 4 STRESSCOAT INDICATIONS IN THE BOTTOM OF THE BOLSTER AT THE KING PIN OPENING. STRAIN GAGES 3 & 4 WERE LOCATED AT THESE INDICATIONS.

PHOTOGRAPH 5 STRESSCOAT INDICATIONS IN LATERAL BRACKET. ROSETTES 47 & 48 WERE LOCATED AT THESE INDICATIONS. ALSO STRAIN GAGES 32 & 33 WERE LOCATED AT INDICATIONS IN BACKGROUND.

PHOTOGRAPH 6 STRESSCOAT INDICATIONS IN LATERAL BRACKET. STRAIN GAGES 12 & 19 WERE LOCATED AT THESE INDICATIONS.

PHOTOGRAPH 7 STRESSCOAT INDICATIONS IN THE TOP OF THE BOLSTER OUTBOARD OF THE LATERAL BRACKET. STRAIN GAGES 5, 6, 7 AND 29 WERE LOCATED AT THESE INDICATIONS.

PHOTOGRAPH 8 TEST SETUP FOR VERTICAL LOAD APPLIED BY AIR SPRINGS. NOTE LOAD CELLS FOR MONITORING THE LOAD AND REACTIONS AT SIDE BEARERS.

PHOTOGRAPH 9 TEST SETUP FOR APPLYING AND REACTING LATERAL LOAD.

PHOTOGRAPH 10 TEST SETUP FOR APPLYING LONGITUDINAL LOAD. LOAD APPLIED TO OTHER BOLSTER ANCHOR WITH A COMMUNICATED RAM. SEE PHOTOGRAPH 11 FOR REACTION POINT.

PHOTOGRAPH 11 REACTION FOR LONGITUDINAL LOAD AT BOLSTER SPIGOT.
TABLE I
S.O.A.C. BOLSTER PATTERN NO. 34702 SER. NO. 2 CAST DATE 4-72
RECORDED STRESSES UNDER DESIGN LOADING CONDITIONS
STRESS IN 1000 PSI + DESIGNATES TENSION - DESIGNATES COMPRESSION

<table>
<thead>
<tr>
<th>Gage No.</th>
<th>Vertical Load of 42,600# Total load applied by two air springs</th>
<th>Lateral Load of 6225# Total load applied to bolster stops on one end of bolster at normal car height</th>
<th>Lateral Load of 6225# Total load applied to bolster stops on one end of bolster at shimmed car ht.</th>
<th>Longitudinal Load of 6390# Total load applied to bolster anchor brackets</th>
</tr>
</thead>
<tbody>
<tr>
<td>3*</td>
<td>+ 9.9</td>
<td>+0.6</td>
<td>+1.6</td>
<td>-1.5</td>
</tr>
<tr>
<td>4*</td>
<td>+14.4</td>
<td>+2.0</td>
<td>+2.4</td>
<td>+2.7</td>
</tr>
<tr>
<td>5*</td>
<td>+16.8</td>
<td>0</td>
<td>0</td>
<td>+4.8</td>
</tr>
<tr>
<td>6</td>
<td>+ 5.0</td>
<td>0</td>
<td>-0.6</td>
<td>+4.8</td>
</tr>
<tr>
<td>7*</td>
<td>+14.6</td>
<td>0</td>
<td>0</td>
<td>-5.1</td>
</tr>
<tr>
<td>12*</td>
<td>+ 2.1</td>
<td>+5.0</td>
<td>+7.5</td>
<td>0</td>
</tr>
<tr>
<td>19*</td>
<td>+ 2.4</td>
<td>+4.5</td>
<td>+7.5</td>
<td>0</td>
</tr>
<tr>
<td>22</td>
<td>+ 5.4</td>
<td>+1.4</td>
<td>+2.0</td>
<td>+1.2</td>
</tr>
<tr>
<td>23</td>
<td>+ 5.1</td>
<td>+1.4</td>
<td>+1.8</td>
<td>-0.9</td>
</tr>
<tr>
<td>29*</td>
<td>+17.1</td>
<td>+0.6</td>
<td>-0.6</td>
<td>-5.7</td>
</tr>
<tr>
<td>30*</td>
<td>+2.1</td>
<td>+3.0</td>
<td>+4.5</td>
<td>0</td>
</tr>
<tr>
<td>31*</td>
<td>+2.1</td>
<td>+3.3</td>
<td>+4.8</td>
<td>0</td>
</tr>
<tr>
<td>32*</td>
<td>+1.8</td>
<td>-8.1</td>
<td>-13.5</td>
<td>0</td>
</tr>
<tr>
<td>33*</td>
<td>+0.9</td>
<td>-6.3</td>
<td>-10.5</td>
<td>0</td>
</tr>
<tr>
<td>36</td>
<td>-5.7</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>37</td>
<td>-4.2</td>
<td>0</td>
<td>0</td>
<td>0</td>
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Rosette

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<th>Gage No.</th>
<th>Stresscoat indications at these gage locations.</th>
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<tr>
<td>42*</td>
<td>+15.0</td>
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<tr>
<td>43*</td>
<td>+15.2</td>
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<tr>
<td>44*</td>
<td>+15.8</td>
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<tr>
<td>47*</td>
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<tr>
<td>48*</td>
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* Stresscoat indications at these gage locations.
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<tr>
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<th>STRESS</th>
<th>MINOR VALUE</th>
<th>STRESS</th>
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<tr>
<td><strong>STRESS DUE TO A VERTICAL LOAD OF 42,600#/TOTAL ON THE AIR SPRINGS</strong></td>
<td>+330</td>
<td>+15.0</td>
<td>169.9°</td>
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<tr>
<td>Gage 42a Gage 42b Gage 42c</td>
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<tr>
<td>Gage 43a Gage 43b Gage 43c</td>
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<td>Gage 43a Gage 43b Gage 43c</td>
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<td><strong>STRESS DUE TO A LATERAL LOAD OF 6225#/BOLSTER APPLIED EQUALLY TO EACH BRACKET</strong></td>
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<td><strong>STRESS DUE TO A LATERAL LOAD OF 6225#/BOLSTER AT SHIMMED CAR HEIGHT APPLIED EQUALLY TO EACH BRACKET</strong></td>
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**Notes:**
- All stress axis measured counter clockwise from Gage A.
- Stresscoat indications at all of these Rosette locations.
STRESSCOAT AREA OF THE TOP OF THE BOLSTER
T-34702-1
PHOTOGRAPH 1
STRESSCOAT AREA OF THE BOTTOM OF THE BOLSTER.
T-34702-1
PHOTOGRAPH 2
STRESSCOAT INDICATIONS IN THE BOTTOM OF THE BOLSTER.
ROSETTES 42, 43 AND 44 WERE LOCATED AT THESE INDICATIONS.
T-34702-1
PHOTOGRAPH 3
STRESSCOAT INDICATIONS IN THE BOTTOM OF THE BOLSTER AT THE KING PIN OPENING. STRAIN GAGES 3 & 4 WERE LOCATED AT THESE INDICATIONS.

T-34702-1

PHOTOGRAPH 4
STRESSCOAT INDICATIONS IN LATERAL BRACKET. ROSETTES 47 AND 48 WERE LOCATED AT THESE INDICATIONS. ALSO STRAIN GAGES 32 AND 33 WERE LOCATED AT INDICATIONS IN BACKGROUND.

T-34702-1

PHOTOGRAPH 5

SHEET 233
STRESSCOAT INDICATIONS IN LATERAL BRACKET. STRAIN GAGES 12 AND 19 WERE LOCATED AT THESE INDICATIONS.
T-34702-1
PHOTOGRAPH 6.
STRESSCOAT INDICATIONS IN THE TOP OF THE BOLSTER OUTBOARD OF THE LATERAL BRACKET. STRAIN GAGES 5, 6, 7 AND 29 WERE LOCATED AT THESE INDICATIONS.

T-34702-1

PHOTOGRAPH 7

SHEET 235
TEST SETUP FOR VERTICAL LOAD APPLIED BY AIR SPRINGS. NOTE LOAD CELLS FOR MONITORING THE LOAD AND REACTIONS AT SIDE BEARERS.

T-34702-1

PHOTOGRAPH 8
TEST SETUP FOR APPLYING LONGITUDINAL LOAD. LOAD APPLIED TO OTHER BOLSTER ANCHOR WITH A COMMUNICATED RAM. SEE PHOTOGRAPH 11 FOR REACTION POINT.
T-34702-1

PHOTOGRAPH 10
APPENDIX III

WINDSHIELD TESTS
QUALIFICATION TEST REPORT FOR THE WINDSHIELD ASSEMBLY-ATTENDANTS CAB FOR SAN FRANCISCO BAY AREA RAPID TRANSIT VEHICLES

REVISION INFORMATION (DATES, ETC.) LIST AMENDMENTS HERE

SWEDLOW APPROVALS

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<td>A</td>
<td>A. Domonovic 12-9-70</td>
<td>H. Stanbury 11/29/70</td>
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CUSTOMER APPROVALS (IF REQUIRED)

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<td></td>
</tr>
<tr>
<td>B</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>C</td>
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<tr>
<td>D</td>
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# TABLE OF CONTENTS

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<td>Summary</td>
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<td>Vertical Impact Test</td>
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<td>Horizontal Impact Test</td>
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<td>7</td>
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<td>11</td>
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<td>Wyle Certified Data Sheet Report</td>
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1.0 INTRODUCTION

This document has been prepared to fulfill the requirements of the Qualification Test Procedure QTP-002 and Rohr Technical Specification S 82125, Paragraph 3.3.5, Windshield Tests.

This document describes those tests required to demonstrate design feasibility and to qualify transparencies manufactured to this design.

2.0 SUMMARY

All of the required tests were performed in accordance with the Qualification Test Procedure (QTP-002) at the Western Avenue Facility of Swedlow, Inc. and were witnessed by the Swedlow, Inc. Quality Control Department, with one exception. The Horizontal Impact Test was performed at Wyle Laboratories, Norco Facility. This test was witnessed by Swedlow, Rohr, PBTB, and Wyle representatives. No failures occurred as the result of testing. Photographs were taken of each test showing the setup and the test specimens after testing. These photographs are presented in Section 9.0 of this report.

3.0 VERTICAL IMPACT TEST

3.1 Place and Date of Test

The vertical impact test was performed on July 21, 1970 at the Western Avenue Facility of Swedlow, Inc. in the Reinforced Plastics Building.

3.2 Test Witnesses

The test was witnessed by J. G. Stansbury and R. Nitta of the Quality Control Department and by D. Holdridge, N. G. Nixon, M. Munoz and A. Domaszewicz from the Engineering Department of Swedlow, Inc.

3.3 Facilities and Equipment Used

A 20-ft. high drop tower, a 12" x 12" x 2 x 4 wooden frame, a wall thermometer, a calibrated gram scale, a 20-ft. scale, and a drop bag per USAS 226.1 - 1966, were used during this test.

3.4 Test Specimens

Test specimen numbers 3, 7, 8, 9 and 10 per Figure 1 of QTP-002 were used for this test.

3.5 Equipment Calibration

An 0-4500 gram scale built by Pennsylvania Scale Co. was used to weigh the drop bag. This scale was serviced on May 6, 1970 by Western Scale Service and calibrated on July 9, 1970 by the Swedlow Quality Control Department.
3.6 **Test Method**

The panels were stabilized at 76°F prior to testing. The drop bag was filled with lead shot on a gram scale until the bag, shot, drawstring, and binding cord weighed 11.0 pounds. The bag was then suspended by a cord from the drop tower in order to align the wooden holding fixture. The drop bag was then raised to the 16-ft. mark on the tower and released onto panel number 5. The test was repeated on panel number 5. The panel showed no signs of damage and was photographed. Panels number 2, 7, 8 and 10 were then tested per the test procedure. The maximum temperature during testing was 82°F.

3.7 **Results**

No glass or acrylic fractures occurred in any of the panels tested. Panels number 7, 8 and 10 delaminated upon impact, but the panels remained completely intact. Photographs are presented in Section 9.0 showing the test facility and each of the test panels immediately after impact.

4.0 **HORIZONTAL IMPACT TEST**

4.1 **Place and Date of Test**

The horizontal impact test was performed at the Noroo Test Facility of Wyle Laboratories on August 13, 1970.

4.2 **Test Witnesses**

The test was witnessed by Messrs. Holdridge and Tomko from Swedlow, Inc., Messrs. Hancock and Mann from Rohr Corporation, Messrs. Baeck and Weigle from PBTB, and Messrs. Alterman and Heeseman from Wyle Laboratories.

4.3 **Facilities and Equipment Used**

A 48-ft. centrifuge, a standard clock, 1.1 lb. ± .1 lb. and 5.1 ± .1 lb. balls, a yardstick, a frame to support the window and a Fastax high speed camera (1000 frames/sec. with 60-cycle timing mark) were used during the tests.

4.4 **Test Specimens**

Two full-size laminated panels (SWU No.'s 103 and 104) were tested.

4.5 **Equipment Calibration**

Both of the balls were weighed on a 0 - 4500 gram scale built by Pennsylvania Scale Co., calibrated on July 9, 1970. The centrifuge speed was calibrated using a magnetic pickup, a digital counter, and a Standard clock. A pool ball and a paper target were used during calibration shots to align the frame for mid-panel impact.
4.6 Test Method

The aluminum balls simulating stones were weighed prior to testing. Windshield Number SWU 103 was clamped in the steel frame (Figure 3 of Test Procedure). A 1.1 ± .1 lb. ball (1.1067 lbs) was fired at the windshield at 80 ± 3 mph (63.3 rpm @ 212.2 inch radius). The ball was released from the centrifuge by severing the attachment cord with a blasting cap. Impact occurred two inches to the right of center and one inch below center. The second windshield (No. SWU 104) was installed in the frame and a 5.1 ± .1 (5.0794) pound ball was fired at 50 ± 3 mph (39.4 rpm at 213.1 inch radius). Impact occurred one-half inch to the left of center and on center vertically. High-speed photographs were taken of both impacts.

4.7 Results

There were no fractures or ejected spalling of the acrylic structural ply. After impact, vision through the windshield was not impaired. The Wyle Certified Data Sheet Report and photographs taken during testing are presented in Section 9.0.

5.0 LIMIT LOAD PRESSURE TEST

5.1 Place and Date of Test

The limit load pressure test was performed at the Western Avenue Facility of Swedlow, Inc., in the Reinforced Plastics Building on July 22, 1970.

5.2 Test Witness

This test was witnessed by R. Nitta of the Quality Control Department, and D. Holdridge, A. Tomko, N. G. Nixon, M. Munoz and A. Domaszewicz of the Engineering Department.

5.3 Facilities and Equipment

A thirty-inch water manometer, three dial micrometers, a pressurized gas bottle, a 0 - 60 psi pressure regulator, and the pressure test fixture (Figure 4 of Test Procedure) were used during this test.

5.4 Test Specimen

A full-size panel assembly (SWU 101) was used as the test specimen.

5.5 Test Method

The test specimen was installed in the test fixture and all the joints sealed. The regulator was then checked to determine the sensitivity of adjustment in controlling the required pressure.
The dial micrometers were then placed along the narrow span of the window at the center, at 1/4 span, and at 3/4 span. The micrometers were all adjusted to read zero deflection with the hands pointing up. The system was pressurized to check out the system. After the system had come back to equilibrium, the first pressure test was performed.

The outer micrometers were then moved to within 1/2-inch of the edge of the frame. A second pressure test was performed. The pressure deflection data is tabulated in Section 5.6 and photographs of the second pressure test are presented in Section 9.0.
## 5.6 Data Tabulation – Pressure Deflection

<table>
<thead>
<tr>
<th>TEST NUMBER</th>
<th>TIME (min)</th>
<th>PRESSURE (in. H₂O)</th>
<th>DEFLECTION (inches)</th>
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<td>EDGE</td>
<td>1/4 SPAN</td>
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</table>

SHEET 251
5.6 PRESSURE DEFLECTION

DEFLECTION (inches)
5.7 **Results**

There were no fractures, delaminations, or permanent deformations of the test specimen as a result of the pressure test. The mid-panel deflection at 10.1 inches of water (52.53 psf) was 0.160 inches, which is well below the 0.257 inch deflection that would constitute a failure.

6.0 **LIGHT TRANSMISSION AND REFLECTANCE TESTS**

6.1 **Place and Site of Test**

The light transmission tests were performed at the Western Avenue Facility of Swedlow, Inc., in the Test Laboratory on July 16, 1970.

The reflectance tests were performed at Perkin-Elmer Corporation, Costa Mesa, California on October 2, 1970.

6.2 **Test Witnesses**

The light transmission test was witnessed by M. Bullinger and R. Nitta of the Quality Control Department and by D. Holdridge of the Engineering Department of Swedlow, Inc.

The reflectance test was witnessed by Dr. R. Bell, Supervisor of the Swedlow Thin Films Department and by Joe Keish of Perkin-Elmer Corporation.

6.3 **Facilities and Equipment Used**

A Gardner Large Sample Hazometer Model HG1230, Serial No. 102, a Bausch and Lomb Spectronic 505 Spectrophotometer, and a Perkin-Elmer Spectrophotometer were used.

6.4 **Test Specimens**

Test specimen numbers 1, 2 and 3 per Figure 5 of QTP-002 were tested.

6.5 **Test Method**

The test specimens were cleaned before testing. The zero and full-scale readings of the test equipment were adjusted. The mid-panel reflectance and light transmission were then recorded.

6.6 **Results**

The light transmission and haze data for specimens numbered 1 thru 11 are listed in Section 6.8. The reflectance test data is presented in Section 6.7 of this report. The mean IR transmission between .7 and 2.5 microns is determined from the equation

\[ T = \frac{\int_{\lambda=0.7}^{\lambda=2.5} I_{\lambda}s T_{\lambda} d\lambda}{\int_{\lambda=0.7}^{\lambda=2.5} I_{\lambda}s d\lambda} \]
where $I_{\lambda\delta}$ is the percent intensity of the sunlight reaching the earth on a clear day at wave lengths between .7 and 2.5 microns. $T_{\lambda}$ is the percent light transmission of the sample in the same wave length range. The mean transmission is 25.9%.

Light transmission values are marginal based on 70 percent. A request has been made to change the minimum light transmission requirement to 65 percent.
6.7.1 SOLAR SPECTRAL ENERGY DISTRIBUTION AT SEA LEVEL

PLEXIGLASS HANDBOOK
ROHM & HAAS
1952

DMIC MEMO 72
NOV 10, 1960

PERCENT TRANSMITANCE

WAVELENGTH (MILLIMICRONS)
### 6.8 Light Transmission and Haze Data

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7.0 DEVIATION AND DISTORTION TEST

7.1 Place and Date of Test

Both the deviation and distortion tests were performed at the Western Avenue Facility of Swedlow, Inc. The deviation test was performed on July 23, 1970 and the distortion test was performed on August 12, 1970.

7.2 Test Witnesses

The tests were witnessed by R. Nitta from the Swedlow Quality Control Department and by D. Holdridge and B. Sarno from the Engineering Department.

7.3 Facilities and Equipment Used

An illuminated box and a lantern slide projector per USAS Z26.1 - 1966 were used during this test.

7.4 Test Specimens

Test specimens one through five and seven through twelve were used for this test.

7.5 Test Method - Deviation Test

The light box was placed against a grid board in the inspection area. All of the test specimens were viewed normal to the line of vision for deviation of the light source.

7.6 Test Method - Distortion Test

A clean white piece of paper was placed against the screen in the distortion test area. The projector was located 25 feet from the screen. With the projector on, the test specimens were cleaned and checked for distortion patterns on the screen by slowly moving the specimens away from the screen. The samples were checked over a distance of zero to five feet from the screen.

7.7 Results

There was no shift in the secondary image outside of a 1-1/2 inch diameter circle on the illuminated box in the deviation test. No light and dark patches appeared on any of the test samples after the outside surfaces were cleaned. Photographs showing the test setup, secondary image and projected images are presented in Section 9.0.

8.0 CONCLUSIONS

All of the tests were performed in accordance with the Qualification Test Procedure (QTP-002). No failures occurred as the result of testing. The feasibility of the BART windshield design has been demonstrated. Upon approval, all windshields manufactured to this design will be considered qualified.
9.0 APPENDIX
VERTICAL DROP TEST
11.0 L.B. BAG
16 FT DROP
PANEL NO. 7
VERTICAL DROP TEST
TEST METHOD
DEVIATION TEST
DATA SHEET REPORT

WYLE LABORATORIES

25 August 1970

Swedlow, Inc.
12605 Beach Boulevard
Carden Grove, California

ATTENTION: A. Domasewica

TEST TITLE: Horizontal Impact Test

REFERENCES: Your Purchase Order No. 23162
Wyle Laboratories Job No. NS 52212
Government Contract No. N/A
Wyle Laboratories Report No. 52212

Gentlemen:

This is to certify that the enclosed Test Data Sheets contain true and correct data obtained in
the performance of the test program as set forth in your purchase order.

Where applicable, instrumentation used in obtaining this data has been calibrated using standards
which are traceable to the National Bureau of Standards.

Test Results:

Test results are presented on the data sheets enclosed
in this report.
SPECIMEN 103 AND 104 WERE SET UP 114 INCHES FROM POINT OF RELEASE OF 1 POUND \& 5 POUND BALL RESPECTIVELY. SPECIMENS WERE POSITIONED IN SUCH A MANNER THAT SUBJECT BALLS IMPACTED WITHIN A 1/2" SQUARE TO CENTER OF SPECIMEN. THE FOLLOWING ACCELERATION TEST WAS PERFORMED.

I. ONE POUND BALL SPECIMEN SW 103.
   A. Speed = 80 MPH \pm 3 MPH
   B. RPM = 63.3

II. FIVE POUND BALL SPECIMEN SW 104
   A. Speed = 50 MPH \pm 3 MPH
   B. RPM = 39.4
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<th>MODEL NO.</th>
<th>RANGE</th>
<th>WYLE NO.</th>
<th>LAST</th>
<th>DUE</th>
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<td>30725</td>
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TEST: ACCELERATION TEST.
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<th>Date</th>
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<th>Temp. (F)</th>
<th>Level (g)</th>
<th>Rg</th>
<th>RPM</th>
<th>Axis</th>
<th>Direct.</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>8-13</td>
<td>1140</td>
<td>AMB</td>
<td>BOPH 200'</td>
<td>63.2</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8-13</td>
<td>1500</td>
<td>AMB</td>
<td>DOPH 200'</td>
<td>39.4</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Test By:**

**Approved By:**

Date: 8-13-70
APPENDIX IV

SEAT STRENGTH
STATE OF THE ART
HIGH DENSITY CAR SEATING
STRENGTH AND PERFORMANCE DATA
APRIL 14, 1972
STATE OF THE ART
HIGH DENSITY CAR SEATING

AMERICAN SEATING COMPANY

TITLE: STRENGTH AND PERFORMANCE DATA

Compiled by: A. J. Hogan
A. J. Hogan
Senior Product Designer

Date 4-14-72

Approved by: C. J. Banacki
C. J. Banacki
Manager - Transportation Engineering

Date 4-14-72

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II. SEAT ASSEMBLY - DOWNWARD-VERITCAL FIXED PLUS VARIABLE STATIC LOAD

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FOUR PASSENGER TRANSVERSE SEAT

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C. VERTICAL DROP IMPACT TO SEAT TEST

DISCUSSION OF RESULTS
SCOPE:

Data contained herein deals with the technical aspects required for design, performance and tests for seat assemblies for the "STATE OF THE ART" vehicle.

The general design of the seat and its structure is based on requirements defined to obtain seating of good quality with superior product and functional values.

Product values are those construction features which insure strength, durability and satisfactory performance. These values are determined by means of strength analysis and relevant mechanical tests.

Functional values are the features which offer the passenger a maximum of postural comfort with seating unit requiring a minimum of repair and maintenance.

TECHNICAL DATA:

In supplement to the detailed drawings and seat prototypes, the contents has documents dealing with loading conditions, strain and deflections recorded in actual tests of representative seats.

The tests were conducted on equipment designed to determine the integrity of the seat assembly under various simulated conditions.

In addition to the specification prescribed for static load tests, this report contains supplemental static and performance tests applied as AmSeCo seat design criteria.
## SUMMARY ESTIMATED SEAT WEIGHTS

<table>
<thead>
<tr>
<th>I. THREE PASSENGER LONGITUDINAL SEAT</th>
<th>Quantity</th>
<th>Weight</th>
<th>Total in Pounds</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>16</td>
<td>78.9#</td>
<td>1262.4</td>
</tr>
<tr>
<td>II. FOUR PASSENGER TRANSVERSE SEAT</td>
<td>6</td>
<td>110.6#</td>
<td>664.8</td>
</tr>
<tr>
<td>III. MOTORMANS SEAT</td>
<td>1</td>
<td>36.5#</td>
<td>36.5</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>TOTAL 19.63.7 Pounds</td>
</tr>
</tbody>
</table>

SHEET 292
THREE PASSENGER LONGITUDINAL SEAT
STATIC LOAD TEST DATA

TEST I  SEAT ASSEMBLY - DOWNWARD VERTICAL STATIC LOAD.

TEST EQUIPMENT:

The seat assembly mounted on two angle uprights was placed on a Toledo scale.

A special motorized load device applied the vertical-downward load in the middle of the center sitting as shown.

\[
\begin{array}{ccc}
100 & 1/32 & 1/16 \\
200 & 1/16 & 7/64, 1/16 \\
300 & 3/32 & 5/32, 3/32 \\
400 & 1/8 & 7/32, 1/8 \\
500 & 5/32 & 9/32, 5/32 \\
600 & 3/16 & 3/8, 3/16 \\
700 & 7/32 & 7/16, 7/32 \\
800 & 17/64 & 1/2, 17/64 \\
\end{array}
\]

DEFLECTION (INCHES)

PERMANENT SET (INCHES)

\[
\begin{array}{ccc}
\#1 & \#2 & \#3 \\
1/32 & 1/16 & 1/32 \\
7/64 & 1/16 & - \\
5/32 & 3/32 & - \\
7/32 & 1/8 & - \\
9/32 & 5/32 & - \\
3/8 & 3/16 & - \\
7/16 & 7/32 & - \\
1/2 & 17/64 & - \\
\end{array}
\]

TEST RESULTS: After removal of load inspection found no failures or permanent deformation other than shown above.
Fixed load of 400# (200# in each outboard sitting) along with variable load.

**TEST EQUIPMENT:**

The seat assembly mounted on two angle uprights was placed on a Toledo scale. Fixed loads of 200# each were placed in the center of both outboard sitting position. A varying load of 800# was applied by means of a special motorized loading device.

<table>
<thead>
<tr>
<th>LOAD#</th>
<th>DEFLECTION (INCHES)</th>
<th>PERMANENT SET (INCHES)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>#1</td>
<td>#2</td>
</tr>
<tr>
<td>200+0+200</td>
<td>3/32</td>
<td>1/8</td>
</tr>
<tr>
<td>200+800+200</td>
<td>11/32</td>
<td>19/32</td>
</tr>
<tr>
<td>200+0+200</td>
<td>3/32</td>
<td>1/8</td>
</tr>
<tr>
<td>0+0+0</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

**TEST RESULTS:** After removal of loads no permanent set or deformation was found.
TEST A. VERTICAL DROP IMPACT TEST

TEST EQUIPMENT:

The seat assembly mounted on two angle uprights simulating actual car attachment, was subjected to a vertical drop impact test with a 40 lb. weight on the middle sitting. The weight impacted the fiberglass seat 1,000 times from heights of 6", 8", 10" & 12".

TEST RESULTS: Inspection during and after completion of test revealed no failures or deformation.
FOUR PASSENGER TRANSVERSE SEAT
STATIC LOAD TEST

Test III SEAT ASSEMBLY - VARIABLE VERTICAL STATIC LOAD

TEST EQUIPMENT: The seat assembly, mounted on a test fixture, was placed on a toledo scale.

A special motorized load device applied a vertical-downward load at center of aisle setting.

<table>
<thead>
<tr>
<th>LOAD (LBS.)</th>
<th>DEFLECTION (INCHES)</th>
<th>PERMANENT SET (INCHES)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1/32</td>
<td>1/32</td>
</tr>
<tr>
<td>100</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>1/16</td>
<td>1/16</td>
</tr>
<tr>
<td>200</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>5/32</td>
<td>1/32</td>
</tr>
<tr>
<td>300</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>7/32</td>
<td>1/8</td>
</tr>
<tr>
<td>400</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>5/32</td>
<td>1/32</td>
</tr>
<tr>
<td>500</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>15/64</td>
<td>3/16</td>
</tr>
<tr>
<td>600</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>9/32</td>
<td>3/16</td>
</tr>
<tr>
<td>700</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>9/32</td>
<td>3/32</td>
</tr>
<tr>
<td>800</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>3/8</td>
<td>1/32</td>
</tr>
<tr>
<td>900</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

A. Removed 2 & loosened 1/8" 2 stanchion overhead mounting bolts:

<table>
<thead>
<tr>
<th>LOAD (LBS.)</th>
<th>DEFLECTION (INCHES)</th>
<th>PERMANENT SET (INCHES)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1/16</td>
<td>1/32</td>
</tr>
<tr>
<td>100</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>1/8</td>
<td>1/32</td>
</tr>
<tr>
<td>200</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>3/16</td>
<td>3/32</td>
</tr>
<tr>
<td>300</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>15/64</td>
<td>1/8</td>
</tr>
<tr>
<td>400</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>9/32</td>
<td>3/16</td>
</tr>
<tr>
<td>500</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>3/8</td>
<td>1/32</td>
</tr>
<tr>
<td>600</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Point 5. is the stanchion bow measured with a 3 foot rule 18 inches from top seat back.

TEST RESULTS: After removal of load inspection found no failures; or deformation other than noted above.

SHEET 298
STATIC LOAD TEST

TEST IV SEAT ASSEMBLY - FIXED PLUS VARIABLE VERTICAL STATIC LOAD

TEST EQUIPMENT:

The seat assembly, mounted on a test fixture was placed on a Toledo scale. A fixed load of 415# was placed in aisle sitting of one side.

A special motorized load device applied a vertical-downward load at center of opposite aisle sitting.

<table>
<thead>
<tr>
<th>LOAD LBS.</th>
<th>DEFLECTION (INCHES)</th>
<th>PERMANENT SET (INCHES)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0+415</td>
<td>-3/32 -1/8 -1/16 -1/64 0</td>
<td>- - - - -</td>
</tr>
<tr>
<td>415+415</td>
<td>3/32 0 1/32 0</td>
<td>- - - - -</td>
</tr>
<tr>
<td>515+415</td>
<td>9/64 3/64 1/16 1/64 0</td>
<td>0 1/64 0 1/64</td>
</tr>
</tbody>
</table>

TEST RESULTS: After removal of load inspection revealed no failures; or deformation other than noted above.
**STATIC LOAD TEST**

**TEST V SEAT ASSEMBLY - VARIABLE HORIZONTAL STATIC LOAD.**

**TEST EQUIPMENT:**

The seat assembly mounted in the test fixture was subjected to a horizontal load applied to the stanchion.

A Martin-Decker (Dynamometer) and Readout Scale (0-6000#) was used to record the loading.

![Diagram of test fixture with load applied](image)

<table>
<thead>
<tr>
<th>LOAD LBS.</th>
<th>DEFLECTION (INCHES)</th>
<th>PERMANENT SET (INCHES)</th>
</tr>
</thead>
<tbody>
<tr>
<td>100</td>
<td>3/64 1/32 5/64 3/64 -</td>
<td>- - - - -</td>
</tr>
<tr>
<td>200</td>
<td>3/32 1/16 3/16 3/32 -</td>
<td>- - - - -</td>
</tr>
<tr>
<td>300</td>
<td>1/8 3/32 9/32 7/32 -1/64</td>
<td>- - - - -</td>
</tr>
<tr>
<td>400</td>
<td>3/16 1/8 7/16 19/64 -3/64 1/64 .010 1/32 1/64 0</td>
<td></td>
</tr>
<tr>
<td>500</td>
<td>7/32 5/32 19/32 13/32 -1/16 3/64 .010 1/32 1/32 0</td>
<td></td>
</tr>
</tbody>
</table>

**A. Load applied with loosened stanchion:**

<table>
<thead>
<tr>
<th>LOAD LBS.</th>
<th>DEFLECTION (INCHES)</th>
<th>PERMANENT SET (INCHES)</th>
</tr>
</thead>
<tbody>
<tr>
<td>100</td>
<td>3/64 1/32 3/32 1/16 -</td>
<td>- - - - -</td>
</tr>
<tr>
<td>200</td>
<td>3/32 1/16 7/32 11/64 -</td>
<td>- - - - -</td>
</tr>
<tr>
<td>300</td>
<td>5/32 7/64 11/32 1/4 -</td>
<td>- - - - -</td>
</tr>
<tr>
<td>400</td>
<td>13/64 9/64 1/2 11/32 -3/32 0 0 1/64 1/32 0</td>
<td></td>
</tr>
</tbody>
</table>

**TEST RESULTS:** After removal of load inspection revealed no failures; or other deformation.

Sheet 300
TEST B. SWINGING IMPACT TO BACK TEST

TEST EQUIPMENT:

The seat frame assembly mounted on a test fixture, simulating actual car attachment, was subjected to a horizontal swinging impact test with a 40 lb. weight. The weight impacted the fiberglass aisle back 10,000 times with strokes of 6", 8", 10" and 12" each.

TEST RESULTS: Inspection during and after completion of test revealed no failures or deformation.
PERFORMANCE TESTS

TEST C. VERTICAL DROP IMPACT TO SEAT TEST

TEST EQUIPMENT:

The seat assembly mounted on the test fixture simulating actual car attachment, was subjected to a vertical drop impact test with a 40 lb. weight on the aisle sitting. The weight impacted the fiberglass seat 1,000 times from heights of 6", 8", 10" and 12".

TEST RESULTS: Inspection during and after completion of test revealed no failures or deformation.
DISCUSSION OF RESULTS

The seat as proposed by the American Seating Company has undergone thorough testing by the AmSeCo Testing Laboratory. The results were very favorable and are listed herein as a matter of record.

Static tests have been supplemented by AmSeCo design test. In these tests, the load was applied incrementally as shown and then removed at each load to measure permanent set.

The static tests determine strength, deflection and any deformation of a representative unit. The loading established by AmSeCo requirements simulate possible shock condition induced by decelerative impact or rough usage in the car. Static tests determine strength and deflection whereas the performance test designed by AmSeCo determine approximate functional effectiveness and approximate life of the seat.

Impact test generate loads induced in drop or swinging fashion reveal possible weakness in component members, welds, failure due to deflection, torsion or fatigue.

It is, therefore, concluded that the seat structure and attachment system will retain structural integrity under typical loadings imposed by normal use conditions.
APPENDIX V

MATERIALS - FIRE RESISTANCE

SHEET 305
May 18, 1973

Mr. William W. Seary  
Assistant Manager of Quality Assurance  
Mail Drop P-4102  
Boeing-Vertol Company  
P.O. Box 16858  
Philadelphia, Pennsylvania 19142

Reference: State of the Art Cars  
G.R. Order No. 373358 (Low Density)  
373359 (High Density)

Dear Mr. Seary:

This is to confirm Jack R. Knoblauch and my telephone conversation with you earlier today.

The woven fabric was used in the low density car only and was Craftex No. K-16924N.

This fabric was ordered from the mills with specifications calling for compliance with FVMSS-302.

Enclosed is one-half yard of this same fabric in X-5575 Magenta Red. Also enclosed is a copy of the 302 Test we ran today on this same fabric. You can readily see that it more than meets all the 302 requirements.

At your request we are also enclosing a copy of FVMSS-302 which became effective September 1, 1972.

I believe the confusion centers around the fabric number you gave me as Craftex 140. We have no knowledge of any Craftex number like this and it does not relate to any Craftex fabric coding that we have ever seen at American Seating Company.

We are convinced that the SOAC order was furnished with Craftex K-16924N (in both the blue and red colors) and that it meets No. 302.

After you have had a chance to review this and there still may be any questions, please get in touch with me.

Very truly yours,

L. M. Wickman  
Manager of Special Products  
Transportation Products Division

Enclosures
**Flammability Test Report**

Federal Motor Vehicle Safety Standard 302

Woven Fabric: Craftex-K16924-N - #X3575 Magenta

**Date of Test:** 5-18-73

<table>
<thead>
<tr>
<th>Specimen No.</th>
<th>Size of Specimen (inches)</th>
<th>Thickness of Specimen (inches)</th>
<th>Distance of Flames Travel (inches)</th>
<th>Time Of Burning (Seconds)</th>
<th>Burn Rate (inches/Min.)</th>
<th>Flammability Rating</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-Pd-F 2</td>
<td>4&quot; x 14&quot;</td>
<td>As received</td>
<td>0</td>
<td>0</td>
<td>0.8&quot;</td>
<td>SE</td>
</tr>
<tr>
<td>2-Pd-F 3</td>
<td>4&quot; x 14&quot;</td>
<td>1/2&quot;</td>
<td>1 1/8&quot;</td>
<td>145 sec.</td>
<td>0.6&quot;</td>
<td>SE/20.4</td>
</tr>
<tr>
<td>3-Pd-F 4</td>
<td>1 1/4&quot;</td>
<td>1/2&quot;</td>
<td>1 1/4&quot;</td>
<td>93 sec.</td>
<td>0.4&quot;</td>
<td>SE/20.4</td>
</tr>
<tr>
<td>4-Pd-F 5</td>
<td>1 1/4&quot;</td>
<td>1/2&quot;</td>
<td>1 1/4&quot;</td>
<td>93 sec.</td>
<td>0.4&quot;</td>
<td>SE/20.4</td>
</tr>
<tr>
<td>5-Pd-F 6</td>
<td>1 1/4&quot;</td>
<td>1/2&quot;</td>
<td>1 3/8&quot;</td>
<td>180 sec.</td>
<td>0.7&quot;</td>
<td>SE/20.4</td>
</tr>
</tbody>
</table>

**O.M.E P.28-1-200**

<table>
<thead>
<tr>
<th>No. of Specimens Tested</th>
<th>Applicable Table</th>
<th>Maximum Burn Rate (inches/Min.)</th>
<th>Burn Rate Range (inches/Min.)</th>
<th>Acceptable or Rejectable Burn Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>1/8</td>
<td>0.8&quot;</td>
<td>0.4&quot;</td>
<td>Acceptable</td>
</tr>
</tbody>
</table>
### TEST RESULTS

<table>
<thead>
<tr>
<th>MATERIAL IDENTIFICATION</th>
<th>SPECIMEN</th>
<th>SPEC NO</th>
<th>AFTERTIME</th>
<th>AFTERTIME</th>
<th>CHAN LENGTH</th>
<th>REMARKS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Seats - Shell</td>
<td>Seats - Shell</td>
<td>1</td>
<td>214</td>
<td>0</td>
<td>0.1</td>
<td>Self-Extinguishing</td>
</tr>
<tr>
<td>Seats - Shell</td>
<td>Seats - Shell</td>
<td>2</td>
<td>320</td>
<td>0</td>
<td>0.1</td>
<td>Self-Extinguishing</td>
</tr>
<tr>
<td>Seats - Cushion</td>
<td>Seats - Cushion</td>
<td>1</td>
<td>6</td>
<td>0</td>
<td>5.0</td>
<td>Self-Extinguishing</td>
</tr>
<tr>
<td>Seats - Cushion</td>
<td>Seats - Cushion</td>
<td>2</td>
<td>6</td>
<td>0</td>
<td>4.5</td>
<td>Self-Extinguishing</td>
</tr>
<tr>
<td>Seats - Inmont Vinyl</td>
<td>Seats - Inmont Vinyl</td>
<td>1</td>
<td>7</td>
<td>0</td>
<td>4.5</td>
<td>Self-Extinguishing</td>
</tr>
<tr>
<td>Seats - Inmont Vinyl</td>
<td>Seats - Inmont Vinyl</td>
<td>2</td>
<td>6</td>
<td>0</td>
<td>4.3</td>
<td>Self-Extinguishing</td>
</tr>
<tr>
<td>Flooring-Met-L-Wood Fire Retard.</td>
<td>Flooring-Met-L-Wood Fire Retard.</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>Did not ignite</td>
</tr>
<tr>
<td>Flooring-Met-L-Wood Plain</td>
<td>Flooring-Met-L-Wood Plain</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>Did not ignite</td>
</tr>
<tr>
<td>Flooring-Vinyl Labeled Sheathing</td>
<td>Flooring-Vinyl Labeled Sheathing</td>
<td>1</td>
<td>86</td>
<td>79</td>
<td>9.0 (2)</td>
<td>Total Combustion</td>
</tr>
<tr>
<td>Flooring-Vinyl Labeled Sheathing</td>
<td>Flooring-Vinyl Labeled Sheathing</td>
<td>2</td>
<td>85</td>
<td>76</td>
<td>9.0 (2)</td>
<td>Total Combustion</td>
</tr>
<tr>
<td>Flooring-Underpad</td>
<td>Flooring-Underpad</td>
<td>1</td>
<td>5</td>
<td>0</td>
<td>0.5</td>
<td>Self-Extinguishing</td>
</tr>
<tr>
<td>Flooring-Underpad</td>
<td>Flooring-Underpad</td>
<td>2</td>
<td>3</td>
<td>0</td>
<td>0.4</td>
<td>Self-Extinguishing</td>
</tr>
<tr>
<td>Flooring-Carpeting</td>
<td>Flooring-Carpeting</td>
<td>1</td>
<td>38</td>
<td>0</td>
<td>0.25</td>
<td>Self-Extinguishing</td>
</tr>
<tr>
<td>Flooring-Carpeting</td>
<td>Flooring-Carpeting</td>
<td>2</td>
<td>35</td>
<td>0</td>
<td>0.2</td>
<td>Self-Extinguishing</td>
</tr>
<tr>
<td>Ceiling-Formica, B/V-A</td>
<td>Ceiling-Formica, B/V-A</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>Did not ignite</td>
</tr>
<tr>
<td>Ceiling-Formica, B/V-B</td>
<td>Ceiling-Formica, B/V-B</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>Did not ignite</td>
</tr>
<tr>
<td>Ceiling-Formica, B/V-C</td>
<td>Ceiling-Formica, B/V-C</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>Did not ignite</td>
</tr>
<tr>
<td>Ceiling-Formica, B/V-D</td>
<td>Ceiling-Formica, B/V-D</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>Did not ignite</td>
</tr>
<tr>
<td>Window Glass</td>
<td>Window Glass</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>Did not ignite</td>
</tr>
<tr>
<td>Insulation-Ultralite</td>
<td>Insulation-Ultralite</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>Did not ignite</td>
</tr>
</tbody>
</table>
## Material Identification

<table>
<thead>
<tr>
<th>Lab Log No.</th>
<th>Specimen</th>
<th>SPDC</th>
<th>After-Flame Time</th>
<th>After-Glow Time (Secs.)</th>
<th>Total Combustion</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>73B2436</td>
<td>Side Signs - Mylar</td>
<td>1</td>
<td>29</td>
<td>0</td>
<td>6.5 (2)</td>
<td>Total Combustion</td>
</tr>
<tr>
<td>73B2436</td>
<td>Side Signs - Mylar</td>
<td>2</td>
<td>28</td>
<td>0</td>
<td>6.5 (2)</td>
<td>Total Combustion</td>
</tr>
<tr>
<td>73B2437</td>
<td>Elastomeric Window Glazing Rubber</td>
<td>1</td>
<td>408</td>
<td>&gt;1600</td>
<td>10.5 (2)</td>
<td>Total Combustion</td>
</tr>
<tr>
<td>73B2438</td>
<td>Elastomeric Door Weather Seal/Door</td>
<td>1</td>
<td>100</td>
<td>&gt;1800</td>
<td>3.0</td>
<td>After-Glow Time Greater than 26 mins.</td>
</tr>
<tr>
<td>73B2439</td>
<td>Lights - Interior Lenses</td>
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<td>Did not ignite</td>
</tr>
<tr>
<td>73B2440</td>
<td>Electrical Wiring - Hypalon</td>
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<td>0</td>
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<td>Did not ignite</td>
</tr>
<tr>
<td>73B2441</td>
<td>Car Ends-Molded Reinforced Fiberglass</td>
<td>1</td>
<td>44</td>
<td>0</td>
<td>0.25</td>
<td>Self-Extinguishing</td>
</tr>
<tr>
<td>73B2441</td>
<td>Car Ends-Molded Reinforced Fiberglass</td>
<td>2</td>
<td>40</td>
<td>0</td>
<td>0.25</td>
<td>Self-Extinguishing</td>
</tr>
</tbody>
</table>

**Foot Notes:**

(1) Fed. Test Method Std. No. 191, Method 5903.2

(2) Total Length of Specimen