SOAC
STATE-OF-THE-ART CAR
DEVELOPMENT PROGRAM
FINAL TEST REPORT
VOLUME 5: POST-REPAIR TESTING

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

DECEMBER 1974
FINAL REPORT

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URBAN MASS TRANSPORTATION ADMINISTRATION
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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 presents the test results for the Post Repair testing of the State-of-the-Art Car. The SOAC has been developed under UMTA's Urban Rapid Rail Vehicle and Systems Program to enhance the attractiveness of rapid rail transportation to the urban traveller with transit vehicles that are comfortable, reliable, safe and economical.

The purpose of these tests was to show compliance with the SOAC Detail Specification IT-06-0026-73-2 following repairs to the No. 2 Car which had been damaged in an accident on August 11, 1973 at the DOT High Speed Ground Test Center, Pueblo, Colorado and to complete the Simulated Demonstration Testing which had been interrupted by the accident.

This document, Volume V 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 I - Component Testing
Volume II - Subsystem Functional Testing
Volume III - Acceptance Testing
Volume IV - Simulated Demonstration Test

These reports, as well as the SOAC Detail Specification, are available from the National Technical Information Service (NTIS), Springfield, Va. 22151.
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State-of-the-Art Cars
SOAC POST-REPAIR TESTING

1.0 INTRODUCTION

The U.S. Department of Transportation (DOT), 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 is an integrated program directed toward improving high speed, frequent stop urban rail systems. The overall objective is to enhance attractiveness of rail transportation to the urban traveller 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.

Testing of the SOAC cars at the UMTA Rail Transit Test Track at the Department of Transportation High Speed Ground Test Center (HSGTC) Pueblo, Colorado started in September 1972 and was interrupted by a collision of the SOAC cars with a standing gondola car on August 11, 1973. The accomplishments to that date included completion of the Acceptance Tests, Engineering Tests and 1312 miles of the 3000 miles of two car operation scheduled under the Simulated Demonstration Test Program.

This report presents the results of Post-Repair Testing of the SOAC Cars during the period January 30th to April 10, 1974 at HSGTC. The objectives were:

(a) Show compliance with the original acceptance criteria

(b) Establish test data continuity with the original HSGTC tests

(c) Complete Simulated Demonstration Testing

The tests were conducted in accordance with Reference (1) and included the following:

- Subsystem Functional Tests
- Acceptance Tests

2.0 CONFIGURATION

Acceptance tests were conducted on the two cars individually and as a two-car train. Both cars were ballasted to normal load (AWL)\(^2\) of 105,000 lb, representing light car plus 100 passengers at 150 lb each. The Engineering Tests were conducted at 90,000 lb, 105,000 lb and 130,000 lb car weights. All Simulated Demonstration testing was as a two-car train with each car ballasted to 105,000 lb.

3.0 INSTRUMENTATION

3.1 SUBSYSTEM FUNCTIONAL TESTS

The test and checkout equipment used for the subsystem functional tests were as follows:

<table>
<thead>
<tr>
<th>ITEM</th>
<th>MAKE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oscilloscope (1)</td>
<td>Tektronix</td>
</tr>
<tr>
<td>SOAC System Simulator (1)</td>
<td>Garrett/AiResearch</td>
</tr>
<tr>
<td>SOAC System Monitor (2)</td>
<td>Garrett/AiResearch</td>
</tr>
</tbody>
</table>

The SOAC System Monitors were installed in the cab of each car and remained in the cabs for the acceptance and engineering tests. The monitor panel contains features to perform several functions:

- Annunciator lights for indication of propulsion and braking events and modes.
- Fault indicator lights
- Calibrated meters for indication of the following:
  - Armature currents
  - Field currents
  - Capacitor bank voltage
  - Motor voltage
  - Car speed
  - Calculated tractive effort
  - Thyristor firing command
  - Tractive effort command
  - Plus additional internal system functions.
- Terminals for connecting the above parameters with a recording oscillograph (when required).

\(^2\) AWL - Normal Load Car Weight
3.2 ACCEPTANCE TESTING

Testing was conducted without any onboard data recording equipment; instead, a handheld stopwatch was used to obtain car speeds, accelerations and decelerations from trackside markers placed at 100 ft. intervals along the right-of-way. The data also served to calibrate the motorman's console-mounted speedometer and the accuracy of the Automatic Speed Maintaining System (ASMA).

3.3 ENGINEERING TESTING

The test data recording equipment included two (2) magnetic tape recorders and two (2) direct reading oscillographs. They were used to selectively record any 28 test parameters including: vertical, lateral and longitudinal accelerations, relative motions, structural strains, electrical voltages, electrical currents, and car wheel speeds. A separate temperature recorder was used for recording temperatures. Additional details may be obtained from Reference 2.

3.4 SIMULATED DEMONSTRATION TESTING

The SOAC propulsion and braking system performance was monitored through the use of the SOAC Monitor Panels installed in the cab of each car (see description in Section 3.1).

4.0 TEST PROCEDURES

4.1 SUBSYSTEM FUNCTIONAL TESTS

Tests were performed on those items specified in Table 4-1, along with additional functional tests of the Propulsion and Braking Systems, in accordance with Ref. (1)4 Section 3. The latter tests were performed on each of the two cars, separately, sitting in a static position using the SOAC Propulsion Simulator (Figure 4-1) to simulate the system electrical loads, and the SOAC Monitor Panel (Figure 4-2) to check proper functioning and sequence of propulsion control events by observing the event lights on the Annunciator Panel.

4. See footnote 1 on p 1.
<table>
<thead>
<tr>
<th>TEST</th>
<th>TEST DATA SHEET NO.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coupler Function and Gathering Range (No. 1 end only)</td>
<td>A-2</td>
</tr>
<tr>
<td>Electric Couplers</td>
<td>A-3</td>
</tr>
<tr>
<td>Camber</td>
<td>A-4</td>
</tr>
<tr>
<td>Air Comfort</td>
<td>A-5</td>
</tr>
<tr>
<td>End Door</td>
<td>A-6</td>
</tr>
<tr>
<td>Side Door</td>
<td>A-7</td>
</tr>
<tr>
<td>Windshield</td>
<td>A-8</td>
</tr>
<tr>
<td>Lighting, Head and Tail Lights</td>
<td>A-9</td>
</tr>
<tr>
<td>Cab Lights</td>
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<tr>
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<tr>
<td>Emergency Lights</td>
<td>A-12</td>
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<td>Main Lights</td>
<td>A-13</td>
</tr>
<tr>
<td>Wiring, High Pot</td>
<td>A-14</td>
</tr>
<tr>
<td>Main Power Application</td>
<td>A-15</td>
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<td>Trainlines</td>
<td>A-16,-17</td>
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<tr>
<td>Windshield Wiper</td>
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<tr>
<td>Horn</td>
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<tr>
<td>Public Address</td>
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</tr>
<tr>
<td>Radio</td>
<td>A-21</td>
</tr>
<tr>
<td>Side Sign</td>
<td>A-22</td>
</tr>
<tr>
<td>Main Propulsion Control &amp; Motor Rotation</td>
<td>A-23</td>
</tr>
<tr>
<td>Main/Emergency Brake</td>
<td>A-24,-25</td>
</tr>
<tr>
<td>Handbrake</td>
<td>A-26</td>
</tr>
<tr>
<td>Snow Brake</td>
<td>A-27</td>
</tr>
<tr>
<td>Propulsion Auxiliaries</td>
<td>A-28</td>
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<tr>
<td>Car Weight</td>
<td>A-29</td>
</tr>
<tr>
<td>Air Compressor</td>
<td>A-30</td>
</tr>
<tr>
<td>Hostling Panel</td>
<td>A-31</td>
</tr>
<tr>
<td>Visual</td>
<td>A-32</td>
</tr>
</tbody>
</table>

5. These sheets are contained in Appendix A of this report.
Figure 4-2. SOAC Monitor Panel
4.2 ACCEPTANCE TESTS

This phase of the test program included the following:

- Speedometer Calibration
- Acceleration
- Deceleration
- Automatic Speed Maintaining System
- Ride Quality

4.2.1 Speedometer Calibration

The true car speeds were obtained from the measured times required for the car to travel a measured course using handheld stopwatches. The desired test car speeds were set by pushing one of the ASMS Push Button controls on the control console. The car speed over the test track was monitored and recorded for the Speedometer and the SOAC Monitor Panel Speed Indicator.

4.2.2 Acceleration Tests

Tests were conducted in forward and reverse on each car individually with car weights of 105,000 lb. The test car or train was accelerated on the level tangent track at full power (P-signal = 1.0 amp). Stopwatches were used to measure the time to reach 700 ft. and the time to reach 60 mph from a standing start, and the time to accelerate from 5 to 25 mph. Maximum speed was recorded at the end of the course. Additional monitored data included line voltage, armature and field currents from the SOAC monitor panel. Testing with the two-car train was prevented by failure of one of the two auxiliary generators which allowed track line voltage to drop below the minimum required 600 volts.

4.2.3 Deceleration Tests

Tests were conducted in forward and reverse on both cars and the two-car train with car weights of 105,000 lb. The test car or train was decelerated at full service rate for blended and friction only braking, and with emergency braking on the level tangent track. Stops were made from 40 and 80 mph. Stopwatches were used to measure time required to stop for each braking mode and initial test speed, and the time to decelerate from 60 to 30 mph.
4.2.4 Automatic Speed Maintaining System

Tests were conducted in forward and reverse on both cars and the two car train with car weights of 105,000 lb. The ASMS was cycled through all push button speed settings with the Controller in the full power setting (P-signal - 1.0 amp) from 3 to 80 and back to 3 mph. The test data included the indicated speeds from the speedometer and SOAC Monitor Panel, and the Armature Current and Field Current for each ASMS speed setting.

4.2.5 Ride Quality Tests

The measurement of the car body vibrations related to Ride Quality by Reference 3 was accomplished under the Engineering Test Program.

4.3 SIMULATED DEMONSTRATION

This portion of the SOAC Test Program included scheduled inspection/maintenance procedures and daily two-car train operation over the test track following a composite route profile of the routes in the five cities where SOAC would be demonstrated: New York, Boston, Cleveland, Chicago and Philadelphia. The route consisted of "station" stops averaging approximately 1/2 mile apart (ranging from 1/4 mile to 1-1/4 miles) where the train stopped, opened the doors, 20 second dwell, closed the doors, and travelled to the next station at the average speeds shown in Figure 4-3. This sequence (in general) was repeated for two circuits of the oval transit track, then two laps were run at 80 mph. The cars were operated at 105,000 lb car weight (AWL).

4.4 CAB SIGNALLING

Cab signalling equipment supplied by Massachusetts Bay Transportation Authority (MBTA) and AiResearch Manufacturing Company under separate contract was installed and functionally checked out during normal maintenance during the Simulated Demonstration testing. A tape recording of the signals supplied through the MBTA running rails was played to a receiver coil mounted ahead of the forward truck and automatic train control response was evaluated. The SOAC Propulsion Control System automatically responded to the signals by accelerating, decelerating and maintaining speed of the train as called for by the signals.

Figure 4-3. 1974 Simulated Demonstration Route at HSGTC
4.5 ENGINEERING TESTS

An abbreviated Engineering Test Program was conducted in accordance with Reference (1)\(^7\) as follows:

- Acceleration
- Deceleration-Blended Braking
- Power Consumption/Undercar Equipment Temperatures
- Ride Quality
- Structures
- Interior Noise
- Wayside Noise

The number of recorded test data points was greatly reduced from the total obtained during the original test program.

5.0 TEST RESULTS

5.1 SUBSYSTEM FUNCTIONAL TESTS

The test results for the items specified in Table 4-1 were recorded on the applicable test data sheets along with approved signatures. These are presented in Appendix A.

---

7. See footnote 1 on p 1.
5.2 ACCEPTANCE TESTS

5.2.1 Speedometer Calibration

The maximum deviation between the speedometer indicated speed and the calculated speed was 1.5 mph at 80 mph, see Figures 5-1 and 5-2.

5.2.2 Acceleration Tests

Acceleration from a standing start to 700 ft. ranged from 18.8 to 19.5 seconds with average acceleration from 5 to 25 mph of 2.78 and 2.74 mphps, respectively. Both cars were tested individually and both met or exceeded the specification and/or previous test data, see Table 5-1.

<table>
<thead>
<tr>
<th>TABLE 5-1</th>
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</thead>
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<tr>
<td>SUMMARY OF SOAC ACCELERATION TEST DATA</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>TEST PARAMETER</th>
<th>SOAC SPEC.</th>
<th>CAR NO. 1</th>
<th>CAR NO. 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Avg. Acceleration (mphps)*</td>
<td>2.74 **</td>
<td>2.74</td>
<td>2.78</td>
</tr>
<tr>
<td>Time to travel 0 to 700 ft. from stand'g. start (secs.)</td>
<td>20</td>
<td>19.5</td>
<td>18.8</td>
</tr>
<tr>
<td>Time 0 to 60 mph (secs.)</td>
<td>34 **</td>
<td>33.8</td>
<td>31.2</td>
</tr>
<tr>
<td>Maximum Speed (mph)</td>
<td>80</td>
<td>80</td>
<td>79</td>
</tr>
</tbody>
</table>

*From 5 to 25 mph
**Previous Data (not a spec. item)

5.2.3 Deceleration Tests

Table 5-2 summarizes the deceleration rates and stopping distances together with the specification requirements or previous acceptance test data. The data for extended service braking, service friction braking and emergency friction braking modes are plotted in Figures 5-3, 5-4 and 5-5 respectively.
Figure 5–1. SOAC Speedometer Calibration – Low Density Car No. 1
Figure 5-2. SOAC Speedometer Calibration – High Density Car No. 2
### TABLE 5-2

<table>
<thead>
<tr>
<th>BRAKING MODE</th>
<th>SOAC SPEC. Deceleration Rates*</th>
<th>PREVIOUS DATA</th>
<th>CAR NO. 1</th>
<th>CAR NO. 2</th>
<th>2 CAR TRAIN</th>
</tr>
</thead>
<tbody>
<tr>
<td>Blended Service (mphps) **</td>
<td>3.1</td>
<td>3.3</td>
<td>3.4</td>
<td>3.5</td>
<td></td>
</tr>
<tr>
<td>Service Friction (mphps) **</td>
<td>2.7</td>
<td>2.9</td>
<td>3.3</td>
<td>2.8</td>
<td></td>
</tr>
<tr>
<td>Emergency (mphps) **</td>
<td>3.2</td>
<td>-</td>
<td>3.0</td>
<td>3.3</td>
<td></td>
</tr>
</tbody>
</table>

#### STOPPING DISTANCE FROM 40 MPH

<table>
<thead>
<tr>
<th>BRAKING MODE</th>
<th>Blended Service (feet)</th>
<th>Service Friction (feet)</th>
<th>Emergency (feet)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Blended Service (feet)</td>
<td>450</td>
<td>430-445</td>
<td>455</td>
</tr>
<tr>
<td>Service Friction (feet)</td>
<td>450</td>
<td>420-440</td>
<td>457</td>
</tr>
<tr>
<td>Emergency (feet)</td>
<td>425</td>
<td>335-365</td>
<td>365</td>
</tr>
</tbody>
</table>

#### STOPPING DISTANCE FROM 80 MPH

<table>
<thead>
<tr>
<th>BRAKING MODE</th>
<th>Blended Service (feet)</th>
<th>Service Friction (feet)</th>
<th>Emergency (feet)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Blended Service (feet)</td>
<td>2250</td>
<td>1650-1660</td>
<td>1700</td>
</tr>
<tr>
<td>Service Friction (feet)</td>
<td>2250</td>
<td>1925-2000</td>
<td>1967</td>
</tr>
<tr>
<td>Emergency (feet)</td>
<td>2200</td>
<td>1600-1635</td>
<td>1680</td>
</tr>
</tbody>
</table>

*Average from 60 to 30 mph (Car Weight 105,000 lb)

**Not a Spec. Item

---

#### 5.2.4 Automatic Speed Maintaining System

ASMS functioned satisfactorily on both cars. All speeds were maintained within one (1) mph of the button setting.

#### 5.2.5 Ride Quality Tests

A comparison of the original and the re-test vibration levels, together with the SOAC design goals for vertical and lateral vibrations at mid-car and aft car center line locations respectively are presented
NOTES:
1. Level Tangent Track
2. Zero Wind
3. Deceleration per Figure 2-4 of Detail Spec.
4. Jerk Limits and Dead Time Included

Single Car
Car Weight: AW1 = 105,000 lb

Figure 5-3. Comparison of Time and Distance to Stop Blended Service Braking with Original Tests.
Single Car

Car Weight: AW1 = 105,000 lb

Notes:
1. Level Tangent Track
2. Zero Wind
3. Jerk Limits and Dead Time Included
4. Data Basis: HSGTC Acceptance Test

<table>
<thead>
<tr>
<th>Distance (feet)</th>
<th>Time (sec)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Car No. 1</td>
<td>□</td>
</tr>
<tr>
<td>Car No. 2</td>
<td>+</td>
</tr>
<tr>
<td>2 Cars</td>
<td>×</td>
</tr>
</tbody>
</table>

Figure 5–4. Comparison of Time and Distance to Stop Service Friction Braking with Original Tests
Single Car Car Weight: AW1 = 105,000 lb

Notes:
1. Level Tangent Track
2. Zero Wind

<table>
<thead>
<tr>
<th>Car No. 1</th>
<th>Distance</th>
<th>Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>Car No. 2</td>
<td>□</td>
<td>+</td>
</tr>
<tr>
<td>2 Cars</td>
<td>◊</td>
<td>×</td>
</tr>
</tbody>
</table>

Figure 5–5. Comparison of Time and Distance to Stop Emergency Friction Braking with Original Tests
in Figure 5-6. All vibration levels are below the SOAC
design goals with the exception of the vertical accel­
ration at 15 Hz. This exception at 15 Hz was measured
at a corrected true car speed of 94 mph instead of 80
mph as originally programmed. This 15 Hz bending mode
is sharply dependent upon speed and a very small differ­
eence in speed between the original tests and the re­
tests could account for the differences.

5.3 SIMULATED DEMONSTRATION

The first part of the Simulated Demonstration program was
conducted from February 27th to March 13, 1974 with
1555 miles of two-car train operation accumulated in eight
(8) days of testing. The second part of the program was
conducted from March 29th to April 10, 1974 with 1456
miles of two-car train operation accumulated in five (5)
days of testing. See Table 5-3 and Figure 5-7.

The only significant discrepancies were encountered dur­
ing the first part of the program. They were:

(1) Broken motor brushes due to high commutator bars.
Corrected by grinding the commutator.
(2) One slip-slide circuit card failure.
(3) One B (+) short to ground in the airflow circuit.
(4) One (intermittent) short in the P-wire cable.

It was further noted that there was no gearbox oil leakage
through the labyrinth seals. This indicates that the leakage
problem noted during the original test program was solved by
installation of the drains as originally shown on the gear­
box drawings.

5.4 CAB SIGNALLING

An operational checkout of the MBTA cab signalling equip­
ment was conducted April 5, 1974. Both cars were checked
individually using a tape recorder input to the signal
receivers. The SOAC propulsion control system automatically
responded to the signals by accelerating, decelerating and
maintaining speed of the train as called for by the signals.

A signal noise problem was encountered when in the vicinity
of the diesel electric locomotive providing track power.
The electrical noise generated caused intermittent brake
applications. Since this type of 600 v power source will
not be encountered on the transit properties where cab
signalling will be used, this was not a cause for concern.
Figure 5–6. Comparison of High-Density Car Ride Quality and Goals
<table>
<thead>
<tr>
<th>RUN NO.</th>
<th>DATE</th>
<th>MILES RUN</th>
</tr>
</thead>
<tbody>
<tr>
<td>208</td>
<td>Feb. 27</td>
<td>82</td>
</tr>
<tr>
<td>209</td>
<td>Feb. 27</td>
<td>182</td>
</tr>
<tr>
<td>210</td>
<td>Feb. 28</td>
<td>118</td>
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<tr>
<td>211</td>
<td>Feb. 28</td>
<td>164</td>
</tr>
<tr>
<td>212</td>
<td>March 5</td>
<td>172</td>
</tr>
<tr>
<td>213</td>
<td>March 6</td>
<td>82</td>
</tr>
<tr>
<td>214</td>
<td>March 8</td>
<td>82</td>
</tr>
<tr>
<td>215</td>
<td>March 8</td>
<td>182</td>
</tr>
<tr>
<td>216</td>
<td>March 11</td>
<td>118</td>
</tr>
<tr>
<td>217</td>
<td>March 12</td>
<td>118</td>
</tr>
<tr>
<td>218</td>
<td>March 12</td>
<td>219</td>
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<td>219</td>
<td>March 13</td>
<td>36</td>
</tr>
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</table>

<table>
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<tr>
<th>PART (2)</th>
<th>DATE</th>
<th>SUB-TOTAL</th>
<th></th>
</tr>
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<tbody>
<tr>
<td>233</td>
<td>March 29</td>
<td>155</td>
<td></td>
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<tr>
<td>234</td>
<td>April 1</td>
<td>364</td>
<td></td>
</tr>
<tr>
<td>238</td>
<td>April 8</td>
<td>364</td>
<td></td>
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<tr>
<td>239</td>
<td>April 9</td>
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<td>April 10</td>
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<table>
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<th>SUB-TOTAL</th>
<th>1456</th>
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</thead>
</table>

<table>
<thead>
<tr>
<th>TOTAL</th>
<th>3011 MILES</th>
</tr>
</thead>
</table>

TABLE 5-3
TEST RUN LOG-SOAC SIMULATED DEMONSTRATION 1974
Figure 5–7. Daily Mileage Accumulation During Simulated Demonstration 1974
5.5 ENGINEERING TESTS

The Engineering Tests were conducted under Contract DOT-TSC-580 to show continuity with the original engineering test data. Results of these tests are reported in "State-of-the-Art Car (SOAC) Post-Repair Engineering Tests at Department of Transportation High Speed Ground Test Center", Report No. UMTA-MA-06-0025-75-7. The following paragraphs present brief descriptions of the test results:

5.5.1 Acceleration Tests

The test results for the post-repair tests are sufficiently close to those obtained from the original tests to conclude that there was no appreciable change due to the repairs.

5.5.2 Deceleration Tests

The deceleration rates for all the post-repair tests exceeded those measured during the original tests. Even though they exceeded the SOAC specification rates, it was not considered necessary to make any system changes prior to starting demonstration testing.

5.5.3 Power Consumption and Undercar Equipment Temperature Tests

The test data showed that the current and rms values for the motor armature and field at the 90,000 lb car weight were slightly less than for the 105,000 lb car weight. A comparison between the post-repair tests and the original tests shows the former to be approximately 12% less than the latter.

5.5.4 Ride Quality Tests

See Paragraph 5.2.5.

5.5.5 Interior Noise Tests

The post-repair measured sound levels, without the air conditioning duct silencer installation, fall within the total envelope of data measured on both SOAC cars; therefore, the interior noise baseline data base obtained during the original test program is still valid. Additionally, it is concluded that the air conditioning air duct silencer installation did have a beneficial effect in providing more uniform sound levels throughout the car.
5.5.6 Wayside Noise Tests

The comparison of post-repair and original test results for the No. 2 SOAC at 90,000 lb car weight with resilient wheels shows substantial agreement after normalizing to a standard condition.

5.5.7 Structure Tests

A comparison of post-repair test results with those from the original tests shows the following:

- The relationships of load levels and phasing are similar to the original test data. No significant differences were noted.

- One of the truck frame strain gages showed strain levels at 80 mph slightly higher than the original data but well below the design criteria for truck loads.

6.0 CONCLUSIONS

6.1 SUBSYSTEM FUNCTIONAL TESTS

All subsystems met specification requirements as shown by the signed data sheets.

6.2 ACCEPTANCE TESTS

- The Speedometer Calibration, Acceleration, and Automatic Speed Maintaining System test results showed that the SOAC cars met or exceeded the SOAC specification requirements.

- The Deceleration tests showed the measured deceleration rates to be somewhat higher than those from the original tests; however, the increases were not considered significant. Stopping distances were within the SOAC specification requirements.

- The Ride Quality test results showed peak acceleration to be in good agreement with previous test data except for the 15 Hz point which was taken at a speed of 94 mph instead of the programmed 80 mph speed. SOAC Ride Quality Performance is considered satisfactory.

6.3 SIMULATED DEMONSTRATION TESTING

The SOAC Performance during the Simulated Demonstration Operations totaling more than 3000 miles of two-car train operation was satisfactory with only four discrepancies of a random nature.
6.4 ENGINEERING TESTS

The test data obtained from the Engineering Tests shows satisfactory continuity between the data obtained during the original tests and the post-repair tests.

6.5 SOAC POST-REPAIR TEST PROGRAM

In conclusion, the overall results for the post-repair testing were as follows:

(a) Compliance with the original SOAC acceptance criteria was demonstrated.

(b) Test data continuity between the original and the post-repair tests was established.

(c) The 3000 mile two-car operation goal for the Simulated Demonstration testing was satisfactorily reached.
REFERENCES

1. State-of-the-Art Car Test Program


APPENDIX A

ACCEPTANCE TESTS

SUBSYSTEM FUNCTIONAL TEST DATA SHEETS


A-1
GATHERING RANGE AND COUPLE/UNCouple

Test Results

Test Date: 3-17-71

Conclusions:

Couplers have sufficient gathering range. Yes

Test Data:

1. Couple cars with couplers displaced to "A" side of Center
   #2 End C

2. Couple cars with couplers displaced to "B" Side of Center
   #2 End C

3. Couple cars with #2 car rotated 5°.
   
Tested By: [Signature]

Approved By (Engr.): [Signature]

Approved By (Q. A.): [Signature]
c. ELECTRIC COUPLERS
Test Results
Test Date: 2/25/74
Car # 2

Conclusion:
1. #1 End Hook Operates YES
2. #2 End Hook and Contact Pins Operate YES

Test Data:
1. Time between operation of uncouple button and operation of the hook 10.1 Seconds.

Tested By: [Signature] Date: 2/5/74
Approved By(Engr.): [Signature] Date: 2/5/74
Approved By(Q.A.): [Signature] Date: _______
Camber (Contd.)

Test Results

Test Date: 10-11-73  Car #: 2

Test Conclusion:

1. Car has positive camber YES

<table>
<thead>
<tr>
<th>Side</th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>A+B</th>
<th>C - \frac{(A+B)}{2}</th>
<th>Camber</th>
</tr>
</thead>
<tbody>
<tr>
<td>B</td>
<td>23.410</td>
<td>23.410</td>
<td>23.415</td>
<td>23.415</td>
<td>1.240</td>
<td>1.240</td>
</tr>
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</table>

Tested By: **DUKERT/ GRIFFIN**  Date: 10-11-73

Approved By (Engr.)  **J. Omo**  Date: 12-10-73

Approved By (Q.A.)  Date:__
Test Results

Test Date: 2/25/74

Car # 2

Conclusion:

1. "A" End unit responds to thermostat

   "B" End unit responds to thermostat

Test Data:

<table>
<thead>
<tr>
<th>Condition</th>
<th>Overhead Thermo.</th>
<th>Duct Therm.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fresh Air</td>
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<td>76°</td>
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<tr>
<td>35° C</td>
<td>70° 72° 74° 75°</td>
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<tr>
<td></td>
<td></td>
<td>9 KW Overhead Heat ON Floor Heat ON.</td>
</tr>
<tr>
<td></td>
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<td></td>
<td></td>
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<td>0</td>
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<tr>
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<td></td>
<td>9 KW Overhead Heat ON Floor Heat ON.</td>
</tr>
<tr>
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<td>9 KW Overhead Heat ON Floor Heat ON.</td>
</tr>
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<tr>
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<td>9 KW Overhead Heat ON Floor Heat ON.</td>
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<tr>
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<td>9 KW Overhead Heat ON Floor Heat ON.</td>
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<td>9 KW Overhead Heat ON Floor Heat ON.</td>
</tr>
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<td>9 KW Overhead Heat ON Floor Heat ON.</td>
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<tr>
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<td>9 KW Overhead Heat ON Floor Heat ON.</td>
</tr>
</tbody>
</table>

Tested by: 

Approved by (Engr.) 

Approved by (Q.A.)
i. END DOOR

Test Results:

Test Date: 3-17-77

Conclusion:

1. End Door Lock Electrically

2. End Door Lock Mechanically

3. End Door Unlock Electrically or Mechanically

4. End Door Unlock Electrically from Outside

5. End Door Latches without assistance

Test Data:

1. Opening Force < 7 Lbs.

2. Closing Force < 8 Lbs.

Tested By: \\

Approved By (Eng.): \\

Approved By (Q.A.): \\

Date: 3-17-77

Date: 3-17-77

Date:
j. SIDE DOOR

Test Results

Test Date: 5/25/76

Conclusions:
2. "B" Side Doors respond to "B" Side Conductor's Panel.
3. Side Doors respond to trainline signals.
4. Trainlines respond to "A" and "B" Side Conductor's Panel.

Test Data:
1. Door Open Time. 1.6 Seconds.
2. Door Close Time. 2.0 Seconds.

Tested By: ___________________________ Date ____________

Approved by (Engr.) ______________________ Date 2/25/76

Approved by (Q.A.) ______________________ Date ____________
Test Result - SOAC - Windshield

Test Date: __/__/2021  Car #: __

Conclusions: Windshield can be opened as an emergency exit. YES

Test Data:

<table>
<thead>
<tr>
<th>Test</th>
<th>Top</th>
<th>Bottom</th>
</tr>
</thead>
<tbody>
<tr>
<td>Latch unlock force</td>
<td>26 lbs.</td>
<td>31 lbs.</td>
</tr>
<tr>
<td>Windshield open force</td>
<td>27.0 lbs.</td>
<td></td>
</tr>
<tr>
<td>Open Angle</td>
<td>70°</td>
<td>0°</td>
</tr>
</tbody>
</table>

Tested By: [Signature]  Date: __/__/2021
Approved by (Eng.): [Signature]  Date: __/__/2021
Approved by (QA.): [Signature]     Date: __/__/2021
a. HEAD AND TAIL LIGHTS

Test Results

Test Date: 2-1-74

Car # 2

Conclusions:

1. Headlights function
2. Headlights aimed
3. Back-up lights aimed
4. Back-up lights function
5. Taillights #1 End Function
6. Taillights #2 End Function

Approved By (Q.A.)

Approved By (Q.A.)

A-9
b. CAB LIGHTS

Test Results

Test Date: 8-18-74 Car #: 2

Conclusions:

1. Cab light function independently from car lights. YES
2. Cab light level is satisfactory. YES

Tested By: [Signature]
Date: 2/22/74

Approved by (Engr.): [Signature]
Date: 2/22/74

Approved by (Q.A.): [Signature]
Date: [Blank]
c. CONSOLE LIGHTS

Test Results

Test Date: 2.12.11

Car #

Conclusions:

1. All lamps function. Yes

Tested By: [Signature]

Date:

Approved by (Engr.) [Signature]

Date:

Approved by (Q.A.)

Date:

A-11
d. EMERGENCY LIGHTS

Test Result

Test Date: ___ 11 14 Car # 2

Conclusions:

1. Emergency Lights operate satisfactorily [YES]

Test Data:

1. Time from 600 V removal to emergency light operation 23 Seconds.
2. Emergency Light battery drain 0.68 Amps.

Tested By: Date: ___ 12 14

Approved By (Engr.) Date: ___ 12 14

Approved By (Q.A.) Date: ___ 12 14

(2000) General Motors accepted by

[Signature]

[Signature]
e. MAIN LIGHTING

Test Results

Test Date: 2/22/76 Car #: 2

Conclusions:

1. Overhead Lights operate satisfactorily

2. Inverter Output Voltage 55.0 VAC 60.0 Hz

3. Inverter Input Voltage 36 VDC

Tested By: [Signature] Date: 2/22/76

Approved By (Engr.): [Signature] Date: 2/22/76

Approved By (Q.A.): [Signature] Date: ______
Test Results

Test Date: __________________ Car # ______

Conclusions:

1. No. Breakdown in 32 VDC circuits
2. No. Breakdown in 600 VDC circuits
3. No. Breakdown in 230 VAC circuits

Test Data:

1. Minimum insulation resistance
2. Hipot Voltage 32 VDC circuits 1 kv
3. Hipot Voltage 600 VDC circuits 1.5 kv
4. Hipot Voltage 230 VAC circuits 1.5 kv

Tested By: __________________ Date: 12/16/73

Approved By (Engr.) __________________ Date: 12/19/73

Approved By (Q.A.) __________________ Date:
MAIN POWER APPLICATION

Test Results

Test Date: 12/25  Car # 2

Conclusions:

Motor Alternator Voltage is satisfactory: YES

Test Data:

1. Input Voltage
   1600 VDC

2. No Load Condition
   a. Input Current
      17 AMPS DC
   b. Phase A Voltage
      220 VAC
   c. Phase B Voltage
      220 VAC
   d. Phase C Voltage
      220 VAC
   e. Output Frequency
      60 Hz
   f. Rectifier Output Voltage
      37 VDC

3. Loaded Condition
   a. Input Current
      91 AMPS DC
   b. Phase A Voltage
      220 VAC
   c. Phase B Voltage
      220 VAC
   d. Phase C Voltage
      220 VAC
   e. Output Frequency
      60 Hz
   f. Rectifier Output Voltage
      35.5 VDC

Tested By: (Signature)

Approved By (Engr.): (Signature)

Approved By (Q.A.): (Signature)

Date: 12/25/84

Date: 12/25/84

Date: 12/25/84

A-15
c. TRAINLINES

Test Results

Test Date: 7/24 Car # 2

Conclusions:

1. There is continuity between #1 end junction box and #2 end junction box. 

2. There is continuity below #2 end junction box and #2 end coupler.

Test Data:

<table>
<thead>
<tr>
<th>Line</th>
<th>Continuity Checked</th>
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</thead>
<tbody>
<tr>
<td>Door Open &quot;A&quot;</td>
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</tr>
<tr>
<td>Door Closed &quot;A&quot;</td>
<td></td>
</tr>
<tr>
<td>Door Open &quot;B&quot;</td>
<td></td>
</tr>
<tr>
<td>Door Closed &quot;B&quot;</td>
<td></td>
</tr>
<tr>
<td>Traction Interlock.</td>
<td></td>
</tr>
<tr>
<td>EMV1</td>
<td></td>
</tr>
<tr>
<td>EMV2</td>
<td></td>
</tr>
<tr>
<td>Propulsion Trip Indicator</td>
<td></td>
</tr>
<tr>
<td>Snow Brake ON</td>
<td></td>
</tr>
<tr>
<td>Snow Brake Indicator</td>
<td></td>
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<tr>
<td>Friction Brake Indicator</td>
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</tr>
<tr>
<td>Handbrake Indicator</td>
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</tr>
<tr>
<td>Brake B+</td>
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<tr>
<td>Slip/Slide Indicator</td>
<td></td>
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<tr>
<td>CSR Control</td>
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<td>Crawl Mode</td>
<td>A-16</td>
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<tr>
<td>Reset</td>
<td></td>
</tr>
</tbody>
</table>
c. TRAINLINES (Contd.)

Test Results:

Forward
Reverse
"P" Signal
"P" Signal Return
SP2
SP1
Motorman Signal Light
Zone Light

Tested By: ____________________________ 
Date: ____________________________

Approved By: (Engr) ____________________________ 
Date: ____________________________

Approved By: (Q.A) ____________________________ 
Date: ____________________________
a. WINDSHIELD WIPER

Test Results

Test Date: __/2/21 Car # __

Conclusions:

1. Windshield Wiper Functions __ YES __
2. Windshield Washer Functions __ YES __

Test Data:

1. Wiping Frequency W.P.S. __ 2 __ Max.
2. Air Pressure P.S.I. __ 70 __

Tested By: ____________ Date: 2/22/74

Approved By (Engr.) ____________ Date: 2/22/74

Approved By (Q.A) ____________ Date: ____________

A-18
b. HORN

Test Results

Test Date: 2/26/71  Car # 2

Conclusions:
1. Horn functions properly  YES

Test Data:
1. Horn Pressure  PSI 15 Max.

Tested By:  Date: 2/26/71
Approved By(Engr.)  Date: 2/26/71
Approved By(Q.A.)  Date:
c. PUBLIC ADDRESS

Test Results

Test Date: 2-12-71  Car #

Conclusion:

1. All speakers balanced
   YES

2. Chime circuit functions
   YES

3. Motormans handset functions
   YES

Tested by:   Date: 2-12-71
Approved by (Engr.)  Date:
Approved by (Q.A.)  Date:
d. RADIO

Test Results

Test Date: 12/11/11 Car #: 2

Conclusion:

1. Car #1 receives from and transmits to Car #2 ✓

2. Car #2 receives from and transmits to Car #1 ✓

Tested by: ___________ Date: ___________

Approved by (Engr.): ___________ Date: ___________

Approved by (Q.A.): ___________ Date: ___________
f. SIDE SIGN

Side Sign Operation:

1. Place the following circuit breakers on the LVCBP to the position indicated:

   - 10A: On
   - 10B: On

2. Insert console key into sign key switch and observe that the curtain moves forward and reverse in response to key position.

3. Check operation of both side signs using key.

4. Place the following circuit breakers on the LVCDP to the position indicated:

   - 10A: Off
   - 10B: Off

Test Results

Test Date: 3/11/77

Car Number: 

Conclusions:

Side sign operation is satisfactory:

Tested by: 

Date: 

Approved by (Engr.):

Date: 

Approved by (OA):
MAIN PROPULSION CONTROL & MOTOR ROTATION

TEST RESULTS

TEST DATE: 2/12/74  CAR #: 2

CONCLUSION:

1. Propulsion System Operation Correct  YES

2. Motor Rotation Correct  YES

TEST DATA:

1. Direction of Car Movement when Master Controller Key
   is in Forward Position and Control Handle is in Power Position  Forward

2. Direction of Car Movement when Master Controller Key
   is in Reverse Position and Control Handle is in Power Position  Reverse

TESTED BY:  DATE: 2/12/74

APPROVED BY (ENC):  DATE: 2/12/74

APPROVED BY (Q.A.):  DATE:
a. MAIN BRAKE/EMERGENCY/BRAKE

Test Results

Test Date: 3/17/11  Car #: 2

Conclusion:

1. There are no leaks (piping) in pneumatic system  
2. Main reservoir pressure adequate

Test Data:

1. Time for compressor to build main reservoir pressure  
   (0 to modulate)  
   60.5 Seconds

2. Compressor Modulation  
   psi Cut-in  
   psi Cutout

3. Leak Test - Air  
   psi/Min.

4. Brake cylinder pressure:  
   #1 End Full Service 67 psi  
   #1 End Release Time 2 Seconds  
   #1 End Apply Time 17 Seconds  
   #2 End Full Service 66 psi  
   #2 End Release Time 2.1 Seconds  
   #2 End Apply Time 1.6 Seconds  
   #1 End Load sensor full load brake cylinder pressure 67 psi  
   #2 End load sensor full load brake cylinder pressure 66 psi

5. Trip Cock Functions:  
   Car goes into Emergency: yes  no  
   Trip cock automatically resets: yes  no
a. MAIN BRAKE (Contd.)

Test Results (Contd.)


7. Deadman functions: Car goes into Full Service brake when handle released ✓ yes no.

8. Emergency brake cylinder pressure.

   #1 End 15 psi
   #2 End 15 psi

   Time to recharge 40 Seconds

Tested By: [Signature] Date: 3/15/71

Approved By (Engr.) [Signature] Date: 3/12/71

Approved By (Q.A.) [Signature] Date:
b. HANDBRAKE

Test Results

Test Date: _______ Car #: _______

Conclusion:

1. Handbrake functions properly

Test Data:

1. Number of pumps for full service application

2. Number of pumps for full release

Tested By: _______________________________ Date: ____________

Approved By(Engr.): ___________________________ Date: ____________

Approved By(Q.A.): ___________________________ Date: ____________

A-26
d. SNOW BRAKING

Test Results

Test Date: 3/17/71 Car # 2

Conclusions:

1. Snow brake operated independently from "P" signal

Test Data:

1. Cylinder Pressure:

   A End __________ PSI.

   B End __________ PSI.

Tested By: III. COLL Date: 3-17-71

Approved By (Engr.) Date: 3-17-71

Approved By (Q.A.) Date: _______________
9. PROPULSION AUXILIARIES

Test Results

Test Date: 2-1-76 Car # 2

Conclusion:

1. There is sufficient cooling air to the motor alternator

2. There is sufficient cooling air to the traction motors

Test Data:

1. Motor Alternator starts properly

2. Motor Alternator load sheds properly

3. Motor Alternator cooling air pressure

4. Traction Motor cooling air pressure

<table>
<thead>
<tr>
<th>#</th>
<th>Pressure</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>6.1 psi</td>
</tr>
<tr>
<td>2</td>
<td>6.3 psi</td>
</tr>
<tr>
<td>3</td>
<td>6.3 psi</td>
</tr>
<tr>
<td>4</td>
<td>6.4 psi</td>
</tr>
</tbody>
</table>

Tested By: ___________________________ Date: ____________

Approved By (Engr.) __________________ Date: ____________

Approved By (Q.A.) __________________ Date: ____________
10. **CAR WEIGHT**

Test Results

Test Date: _______________ Car #_____________

Test Data:

Weight #1 End _______________ lbs.

Weight #2 End _______________ lbs.

Total Weight _______________ lbs.
12. **AIR COMPRESSOR**

Test Results

Test Date: 3/16/74  Car #

Conclusion:

1. Air compressor has sufficient capacity

Test Data:

1. Time for compressor to recharge system after four (4) successful brake applications

2. Main Reservoir air pressure after one (1) brake cylinder hose has been disconnected and brakes applied once

Tested By:  
Date: 3/16/74

Approved By (Engr.):  
Date: 3/16/74

Approved By (Q.A.):  
Date:
HOSTLING PANEL

Test Results

Test Date: ___________________________ Car #__________

Item 4. "Forward" Position:

4-a) Car moved forward when "Go" button was pressed.
-b) Car braked when "Go" button was released.
-c) Car continued to move forward without braking.
-d) Car braked when "Coast" button was released.

Item 5. "Reverse" Position:

5-a) Car moved backward when "Go" button was pressed.
-b) Car braked when "Go" button was released.
-c) Car continued to move backward without braking.
-d) Car braked when "Coast" button was released.


Tested By: ___________________________ Date: __________

Approved By (Engr.) _________________ Date: __________

Approved By (Q.A.) _________________ Date: __________
14. VISUAL

Test Results

Test Date: 4-12-74  Car # 2

Conclusion:

1. Car is complete and satisfactory for shipment.  

YES

Tested By:  
Date: __________

Approved By (Engr):  
Date: 4-12-74

Approved By (Q.A.):  
Date: __________