SOAC
STATE-OF-THE-ART CAR
ENGINEERING TESTS AT
DEPARTMENT OF TRANSPORTATION
HIGH SPEED GROUND TEST CENTER

Volume III: Ride Quality Tests

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Editors

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FINAL REPORT

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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 six-volume report presents the technical methodology, data samples, and results of tests conducted on the SOAC on the Rail Transit Test Track at the High Speed Ground Test Center in Pueblo, Colorado during the period April to July 1973. The UMTA-sponsored Urban Rail Supporting Technology Program, for which TSC is Systems Manager, emphasizes three major development task areas: facilities, technology and test program. Test program development comprises three sub-areas: vehicle testing, ways and structures testing and track geometry measurement. The objective of the SOAC program is to demonstrate the current state of the art in rail rapid transit vehicle technology, with passenger convenience and operating efficiency as primary goals. The objectives of the Engineering Test program are to provide a set of SOAC engineering data and to further develop the methodology for providing transit vehicle comparisons. These objectives were met with the presentation of the test results in this report and the incorporation of the refinement of the testing methodology into the General Vehicle Test Plan, GSP-064. In this series, Vol. I contains a description of the SOAC test program and vehicle, and a summary of the test results; Vol. II, Performance Test data; Vol. III, Ride Quality Test data; Vol. IV, Noise Test data; Vol. V, Structural, Voltage, and Radio Frequency Interference Test data; and Vol. VI, a description of the Instrumentation System used for performance, ride quality and structural testing.
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This test report, presenting the results of engineering tests on the State-of-the-Art Cars (SOAC), derives from the efforts of two agencies of the U.S. Department of Transportation: the Rail Programs Branch of the Urban Mass Transportation Administration's Office of Research and Development and the Transportation Systems Center.

The report is presented in six volumes. Volume I is a description of the program and a summary of the test results. Volumes II through V are organized to technical disciplines, as follows: Volume II, Performance; this volume, Volume III, Ride Quality; Volume IV, Noise; and Volume V, Structures, Voltage, and Radio Frequency Interference. Volume VI contains a description of the SOAC Instrumentation System used for Performance, Ride Quality, and Structural Testing.
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Section 1

SUMMARY

1.1 TEST SEQUENCE

Table 1-1 presents the test sequence run numbers.

TABLE 1-1. TEST SEQUENCE RUN NUMBERS

<table>
<thead>
<tr>
<th>Car Weight (lb)</th>
<th>Single Car Run Numbers</th>
<th>Two-Car Train Run Numbers</th>
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<tbody>
<tr>
<td>90,000</td>
<td>132</td>
<td>-</td>
</tr>
<tr>
<td>105,000</td>
<td>120, 140</td>
<td>139</td>
</tr>
<tr>
<td>113,000</td>
<td>147</td>
<td>-</td>
</tr>
<tr>
<td>130,000</td>
<td>148</td>
<td>-</td>
</tr>
</tbody>
</table>

1.2 TEST PROCEDURES

Test procedures used for ride quality testing were: SOAC-R-2001-TT, SOAC-R-3001-TT, and SOAC-R-4001-TT.

1.3 OBJECTIVES

The objectives of ride quality testing were to expand and improve the General Vehicle Test Plan (GSP-064) and to provide vehicle ride quality baseline engineering data for the State-of-the-Art car at the Department of Transportation’s High Speed Ground Test Center (HSGTC), Pueblo, Colorado. This data will be used for comparison with data recorded at five transit properties in New York, Boston, Cleveland, Chicago, and Philadelphia.
1.4 STATUS

Ride quality data at seven car body locations and five truck locations has been recorded and collected over the six types of track construction on the 9-mile UMTA test track. The processed data is presented in 167 sets, each set containing spectrum analysis and power spectral density curves. The processed data was selected to obtain baseline comparison plots showing the effect of speed, track section, car weight, and train consist on vehicle vibration levels.

Data was collected for both resilient and steel wheels. However, the steel wheel data was taken prior to a car body structural modification and is therefore no longer valid.

It should be noted that wheel flats may have existed on the SOAC during the ride quality tests with resilient wheels. This may have proved erroneous data at the wheel fundamental rotational frequency. Previous ride quality testing indicated that the vehicle was sensitive to wheel flats near 80 mph.
2.1 VIBRATION LEVEL READINGS

Ride quality tests were conducted on the SOAC vehicles (single-car and two-car train) for speeds of 20, 35, 45, 55, and 80 mph over the six sections of the DOT test track. Table 1-1 presents a list of the weights and train consist used during the testing.

To delineate the rigid body and flexible modes of vibration of the vehicle during this test series, car body and journal box vertical, lateral, and longitudinal vibration levels were measured using accelerometers. The output of the accelerometers was recorded on magnetic tape, and readings were made at selected locations.

2.2 ACCELEROMETER LOCATIONS

The following rationale was applied to the selection of car body accelerometer locations:

1. Forward, mid and rear car centerline vertical accelerometers were located to obtain the effect of car body vertical flexible modes, and vertical/pitch rigid body modes on car body vibration.
2. Forward, mid and rear car centerline lateral accelerometers were located to obtain the effect of flexible and rigid lateral/yaw modes on car body vibration.
3. It was assumed that there was no longitudinal flexibility of the car, therefore only one longitudinal pickup was necessary to measure the rigid body motion.
4. Vertical mid-car centerline, mid-car righthand and mid-car lefthand accelerometers were used to determine the effect of the rigid body roll modes on vibration.
5. Forward car centerline lateral and forward car ceiling lateral were used to determine the effect of frame racking or car body torsion modes on vibration.
6. The location of journal box accelerometers was selected to determine truck response from track vertical, lateral, and cross level alignments.

Data was monitored on the vehicle by a test engineer using a strip chart recorder to ensure that each accelerometer was functioning properly and to provide a "quick look" of selected pickups.

Instrumentation, calibration, and data reduction were performed by Garrett AiResearch Co.

2.3 BANG TEST

A bang test of the journal box accelerometer brackets was performed to determine their resonant frequencies. A summary of this data is presented in Table 2-1.

<table>
<thead>
<tr>
<th>Accelerometer Bracket Location</th>
<th>Resonant Frequency (Hz)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fwd Axle, RH Journal Box, Front Truck, Vertical</td>
<td>250</td>
</tr>
<tr>
<td>Fwd Axle, RH Journal Box, Front Truck, Lateral</td>
<td>250</td>
</tr>
<tr>
<td>Aft Axle, RH Journal Box, Front Truck, Lateral</td>
<td>375</td>
</tr>
<tr>
<td>Fwd Axle, LH Journal Box, Front Truck, Vertical</td>
<td>400</td>
</tr>
<tr>
<td>Aft Axle, LH Journal Box, Front Truck, Vertical</td>
<td>300</td>
</tr>
<tr>
<td>Fwd Axle, RH Journal Box, Rear Truck, Lateral</td>
<td>300</td>
</tr>
<tr>
<td>Aft Axle, RH Journal Box, Rear Truck, Lateral</td>
<td>300</td>
</tr>
<tr>
<td>No. 1 Forward Traction Motor Housing Vertical</td>
<td>250</td>
</tr>
<tr>
<td>No. 1 Forward Traction Motor Housing Lateral</td>
<td>350</td>
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2.4 SINGLE-CAR COUPLER VIBRATION

During the ride quality testing, a vibration problem was observed in the rear of the high-density car. This problem, attributed to the coupler impacting the structure, was temporarily eliminated by installing wooden shims near the coupler anchor. Data illustrating the effect of the shims is shown in Figure 2-1. The coupler centering mechanism on Cars No. 1 and
Figure 2-1. Sample Accelerometer Outputs for Car Body Vertical Acceleration (90,000-pound Gross Weight, 80 MPH Speed)

NOTE
ALL PICKUPS .5G/IN.
2 was not operative and permitted the couplers to vibrate. This condition will not exist when the coupler centering mechanism is activated.
Schaevitz LSBC accelerometers were selected to measure vibration levels because they have an effective measurement capability in the desired frequency range of 0.1 to 30 Hz.

Accelerometers used to measure car floor accelerations were rigidly mounted directly to the underside of the floor support structure. The lateral accelerometer at the ceiling was mounted to a stanchion. Truck accelerometers were mounted to brackets rigidly attached to the journal boxes and traction motors.

Car body and journal box locations are shown in Table 3-1.

**TABLE 3-1. RIDE QUALITY ACCELEROMETER LOCATIONS**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Direction</th>
<th>Range</th>
<th>Frequency</th>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Linear Accelerations</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Fwd car floor, truck centerline</td>
<td>Vertical</td>
<td>±.30 G</td>
<td>30 Hz</td>
</tr>
<tr>
<td>Fwd car floor, truck centerline</td>
<td>Lateral</td>
<td>±.30 G</td>
<td>30 Hz</td>
</tr>
<tr>
<td>Fwd car floor, truck centerline</td>
<td>Longitudinal</td>
<td>±.30 G</td>
<td>30 Hz</td>
</tr>
<tr>
<td>Centerline car floor, rear end</td>
<td>Vertical</td>
<td>±.30 G</td>
<td>30 Hz</td>
</tr>
<tr>
<td>Centerline car floor, rear end</td>
<td>Lateral</td>
<td>±.30 G</td>
<td>30 Hz</td>
</tr>
<tr>
<td>Fwd car floor LH, truck centerline</td>
<td>Vertical</td>
<td>±.30 G</td>
<td>30 Hz</td>
</tr>
<tr>
<td>Centerline car floor, mid-car</td>
<td>Vertical</td>
<td>±.30 G</td>
<td>30 Hz</td>
</tr>
<tr>
<td>Centerline car floor, mid-car</td>
<td>Lateral</td>
<td>±.30 G</td>
<td>30 Hz</td>
</tr>
<tr>
<td>Car floor RH, mid-car</td>
<td>Vertical</td>
<td>±.30 G</td>
<td>30 Hz</td>
</tr>
<tr>
<td>Car floor LH, mid-car</td>
<td>Vertical</td>
<td>±.30 G</td>
<td>30 Hz</td>
</tr>
<tr>
<td>Centerline car ceiling, mid-car</td>
<td>Lateral</td>
<td>±.30 G</td>
<td>30 Hz</td>
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### TABLE 3-1. Continued

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<td>Pitch</td>
<td>±0.4</td>
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<td>Roll</td>
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<td>Yaw</td>
<td>Rad/Sec</td>
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<tr>
<td><strong>Linear Accelerations</strong></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Fwd RH wheel, front</td>
<td>Vertical</td>
<td>±25 G</td>
<td>30 Hz</td>
</tr>
<tr>
<td>Fwd RH wheel, front</td>
<td>Lateral</td>
<td>±25 G</td>
<td>30 Hz</td>
</tr>
<tr>
<td>Aft RH wheel, front</td>
<td>Vertical</td>
<td>±25 G</td>
<td>30 Hz</td>
</tr>
<tr>
<td>Aft RH wheel, front</td>
<td>Lateral</td>
<td>±25 G</td>
<td>30 Hz</td>
</tr>
<tr>
<td>Fwd LH wheel, front</td>
<td>Vertical</td>
<td>±25 G</td>
<td>30 Hz</td>
</tr>
<tr>
<td>Aft LH wheel, front</td>
<td>Vertical</td>
<td>±25 G</td>
<td>30 Hz</td>
</tr>
<tr>
<td>Fwd RH wheel, rear</td>
<td>Lateral</td>
<td>±25 G</td>
<td>30 Hz</td>
</tr>
<tr>
<td>Aft RH wheel, rear</td>
<td>Lateral</td>
<td>±25 G</td>
<td>30 Hz</td>
</tr>
<tr>
<td>Fwd motor housing at cg</td>
<td>Vertical</td>
<td>±15 G</td>
<td>30 Hz</td>
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<tr>
<td>Fwd motor housing at cg</td>
<td>Lateral</td>
<td>±15 G</td>
<td>30 Hz</td>
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</table>
Section 4
TEST PROCEDURES

The procedures followed during ride quality testing were as follows:

1. Steady Speed Runs (SOAC-R-4001-TT)
   a. Patch in ride quality instrumentation.
   b. Accelerate to and maintain test point speed.
   c. Prior to entering a test section, start recorders and mark tapes and data sheet with record number.
   d. Provide event mark on tapes at beginning of test section (see attached test section locations).
   e. Provide event mark at end of 20 seconds of record.
   f. Stop recorders.
   g. Proceed to next section or speed and repeat the above steps.

2. Acceleration Run (SOAC-R-2001-TT)
   a. Proceed to start location and stop vehicles, location 120 CW or 150 CCW.
   b. Start recorders and provide record number.
   c. Initiate and maintain full acceleration.
   d. Provide event mark at first motion.
   e. Provide event mark at 40 mph indicated speed.
   f. Stop recorders.
   g. Stop vehicle.
3. **Deceleration Run** (SOAC-R-3001-TT)
   
   a. Proceed to start location at 60 mph, location 120 CW or 150 CCW.
   
   b. Start recorders and provide record number.
   
   c. Initiate full service braking.
   
   d. Provide event mark at initiation of braking.
   
   e. Provide event mark at complete stop.
   
   f. Stop recorders.
5.1 DATA COLLECTION

The ride quality vibration data was recorded on analog tapes and later digitized to obtain spectrum analysis and power spectral density curves. These data reduction techniques are the most useful means of analyzing a deterministic process. Spectrum analysis and a power spectral density permit identification of vibration contribution from modal characteristics of the car body structure.

Figure A-79 shows spectrum analysis and power spectral density curves. Both curves indicate that peak amplitudes occur at frequencies of 1.5, 7.5, 15, and 30 Hz, and are associated with response from a rigid body suspension mode, the first car body vertical bending mode, a higher order car body flexible mode, and component induced vibration, respectively. The filter bandwidth for the spectral density and spectrum analysis was 0.20 Hz in the 0 to 10 Hz range and 1.0 Hz for frequencies above 10 Hz. A listing and the curves of the processed data are presented in Appendix A (Figures A-1 through A-167).

The ride quality vibration data was further processed to produce the Ride Roughness data shown on the following baseline comparison plots. Ride roughness is a "figure-of-merit" to indicate the roughness of ride experienced by a typical passenger on a moving transit vehicle. The methodology for establishing this parameter is as defined in GSP-064, "General Vehicle Test Plans for Urban Rail Transit Cars." The specific equipment used for the SOAC data reduction is shown in Figure 5-1, with the main components being the GR 1/3 octave band shaper and the graphic level recorder. The actual response of the shaper for horizontal and vertical signal weighting is shown in Figures 5-2 and 5-3, respectively. The effective averaging time for the RMS weighted signal was 1 second. A summary of the baseline comparison plots is presented in Table 5-1 and the plots are shown in Figures 5-4 through 5-48.

All baseline comparison plots were generated with identical scales to emphasize the important vibration trends and the effect of key parameters. These comparison plots show the
Figure 5-1. Block Diagram for Ride Roughness Data Reduction System

- TAPE Recorder
- B&K 1024 Signal Generator
- B&K 2305 Graphic Level Recorder
- GR 1925 Multifilter
Figure 5-2. Weighting Network Frequency Response for Horizontal Ride Roughness
Figure 5-3. Weighting Network Frequency Response for Vertical Ride Roughness
<table>
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<tr>
<th>Figure No.</th>
<th>Describes Location*</th>
<th>Pickup Effect of Consist*</th>
<th>Car Weight (1000 lb)</th>
<th>Track Section</th>
<th>Speed (mph)</th>
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<td>5-4</td>
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<td>HDC</td>
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<td>I</td>
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TABLE 5-1 - Continued

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<th>Speed (mph)</th>
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<td>HDC,Train</td>
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</table>

*KEY: HDC, High-Density Car; JB, Journal Box; Trk, Truck
effect of speed, track section, car weight and train consist on vehicle ride roughness. The baseline processed data of Appendix A can be used to obtain absolute values of acceleration levels.

Ride quality data taken over track Section I at a 105,000-pound car weight for two train consists is compared to the SOAC goal in Figures 5-49 and 5-50.

Instrumentation, calibrations and data reduction were performed by Garrett AiResearch Company.

5.2 EFFECT OF SPEED (Figures 5-4 through 5-18)

The effect of vehicle speed on car body and journal box acceleration levels is shown in Figures 5-4 through 5-18. Data are presented for resilient wheels on track Section I at several speeds and two car weights (90,000 and 105,000 pounds). Two train consists were investigated: a high-density car and a two-car train.

Figure 5-4 shows that the aft car centerline (C/L) lateral ride roughness at a 90,000-pound car weight is not affected by varying speed. Figures 5-5 and 5-6 show the vertical ride roughness at the forward end and mid-car C/L locations, respectively. Both channels exhibit some resonance (peaking) at 45 mph. Examination of the peak-amplitude spectrum charts found in Appendix A reveals that the dominant frequency is at 8 Hz, the first vertical bending mode of the car body. At 45 mph with the 30-inch diameter SOAC wheels, the driving force is also at 8 Hz. The mid-car vertical ride roughness also shows a resonance at 80 mph. Again, from the spectrum plots of Appendix A, the dominant frequency is found to be the second car body bending mode, 15 Hz.

Figure 5-7 shows the effect of speed on aft car C/L lateral ride roughness at a 105,000-pound car weight. The ride roughness levels are similar to the 90,000-pound car. The forward car C/L vertical ride roughness levels shown in Figure 5-8 are similar to the levels of the 90,000-pound car. The mid-car C/L vertical ride roughness (Figure 5-9) shows that the resonance at 80 mph is somewhat damped out for the 105,000-pound car.

Data showing the effect of speed for a two-car train at a 105,000-pound car weight is presented in Figures 5-10 through 5-12. Car body lateral levels at the aft car C/L location are not significantly affected by speed (Figure 5-10). Figure 5-11 shows the effect of speed on forward car C/L vertical levels. Figure 5-12 shows the mid-car C/L vertical levels. As shown, the two-car train has very little effect on the ride roughness levels.

Comparison plots showing the effect of speed on journal box
vertical and lateral accelerations are shown in Figures 5-13 through 5-18, as frequency spectrum analysis plots. (Data are presented for speeds of 35, 45 and 80 mph.) Vertical journal box accelerations (Figures 5-14, 5-16 and 5-18) are not affected by speed. In contrast, lateral acceleration levels are significantly higher than vertical levels and reach peak amplitudes at 80 mph for the single high-density car at 90,000- and 105,000-pound car weights (Figures 5-13 and 5-15). For the 105,000-pound train, peak levels occur at 45 mph and are shown in Figure 5-17.

5.3 EFFECT OF TRACK SECTION (Figures 5-19 through 5-22)

The effect of track section on car body ride roughness levels is shown in Figures 5-19 through 5-22. Data are presented for the 105,000-pound high-density car with resilient wheels at speeds of 35 and 80 mph.

Figure 5-19 shows that forward car C/L vertical levels are higher at 35 mph on track Sections I and II (119-pound welded rail, wooden ties; 100-pound welded rail, wooden ties; respectively).

Figure 5-20 indicates that the mid-car C/L vertical levels are also higher on track Sections I and II. This trend is also evident for the forward car C/L vertical levels at 80 mph (Figure 5-21). Figure 5-22 shows the levels at the mid-car C/L location at 80 mph.

5.4 EFFECT OF CAR WEIGHT (Figures 5-23 through 5-39)

The effect of car weight on car body and journal box vertical and lateral acceleration levels is shown in Figures 5-23 through 5-39. Data are presented for the high-density car with resilient wheels on track Section I at 45, 55 and 80 mph speeds.

Figures 5-23 and 5-24 show that the lateral ride roughness at the aft end C/L of the car and the vertical C/L ride roughness at forward end are not significantly affected by gross weight at a 45 mph speed. At 45 mph the vertical contribution at the mid-car C/L (Figure 5-25) is lower at 113,000 and 105,000 pounds than at the empty weight of 90,000 pounds.

Figure 5-26 shows the aft car C/L lateral ride roughness as a function of car weight. At the forward end of the car C/L and at the mid-car C/L, vertical ride roughness levels are lower at the 130,000-pound car weight (Figures 5-27 and 5-28) at 55 mph.

Figure 5-30 shows the effect of car weight on the forward car C/L vertical ride roughness at 80 mph. Figure 5-31 shows that vertical ride roughness at the mid-car C/L is significantly reduced at 105,000 pounds at 80 mph.

5-8
The effect of car weight on journal box vertical and lateral acceleration levels is shown in Figures 5-32 through 5-39. Data presented indicate that there is little change in journal box motions with increasing car weights throughout the speed range investigated, except for lateral vibration levels at 45 mph, where the levels are noticeably higher for 105,000 pounds than for 90,000 pounds.

5.5 EFFECT OF TRAIN CONSIST (Figures 5-40 through 5-48)

The effect of train consist on car body and journal box acceleration levels is presented in Figures 5-40 through 5-48. Data are shown for resilient wheels on track Section I at a 105,000-pound car weight. Two train consists were evaluated: a single high-density car and a two-car train.

Figure 5-40 indicates that the aft car C/L lateral ride roughness levels are not affected by train consist. Figures 5-41 and 5-42 show that the vertical vibrations at 45 mph at the forward end C/L and mid-car locations, respectively, are not affected by train consist.

Comparison plots showing the effect of train consist on journal box vertical and lateral accelerations are presented in Figures 5-43 through 5-48. Data are presented for a single high-density car and a two-car train. Vertical journal box accelerations are not affected by train consist at speeds of 35, 45, and 80 mph (Figures 5-44, 5-46, and 5-48, respectively). Lateral acceleration levels are significantly higher than vertical levels.

Figure 5-43 indicates that at 35 mph the lateral journal box acceleration levels are substantially higher for the single car. At 45 mph (Figure 5-45) the levels are higher with the train, and at 80 mph (Figure 5-47) the levels are significantly higher for the single car.

5.6 COMPARISON OF SOAC RIDE QUALITY DATA WITH SOAC GOAL

Figures 5-49 and 5-50 compare SOAC ride quality data to the SOAC goals for both lateral and vertical accelerations. The plots of lateral levels versus frequency for the two train consists (high-density car and two-car train) at the normal car weight of 105,000 pounds show that the results are significantly lower than the design goal.

Data comparing vertical acceleration levels to frequency for the two train consists indicate that the vehicle meets the SOAC goal with respect to response from vertical rigid car body modes (1 to 2 Hz), a higher order car body flexible mode (15 Hz), and component induced vibration (30 Hz) substantially lower than the goal.
NOTES
1) RESILIENT WHEELS
2) 90,000-LB. GROSS WEIGHT
3) TRACK SECTION I

Figure 5-4. Effect of Speed on Aft Car Centerline Lateral Ride Roughness
(High-Density Car)
Figure 5-5. Effect of Speed on Forward Car Centerline Vertical Ride Roughness (High-Density Car)
NOTES
1) RESILIENT WHEELS
2) 90,000-LB. GROSS WEIGHT
3) TRACK SECTION I

Figure 5-6. Effect of Speed on Mid-Car Centerline Vertical Ride Roughness (High-Density Car)
NOTES
1) RESILIENT WHEELS
2) 105,000-LB. GROSS WEIGHT
3) TRACK SECTION I

Figure 5-7. Effect of Speed on Aft Car Centerline Lateral Ride Roughness (High-Density Car)
NOTES
1) RESILIENT WHEELS
2) 105,000-LB. GROSS WEIGHT
3) TRACK SECTION I

Figure 5-8. Effect of Speed on Forward Car Centerline Vertical Ride Roughness (High-Density Car)
NOTES
1) RESILIENT WHEELS
2) 105,000 LB. GROSS WEIGHT
3) TRACK SECTION I

Figure 5-9. Effect of Speed on Mid-Car Centerline Vertical Ride Roughness (High-Density Car)
NOTES
1) RESILIENT WHEELS
2) 105,000-LB. GROSS WEIGHT
3) TRACK SECTION I

Figure 5-10. Effect of Speed on Aft Car Centerline Lateral Ride Roughness (Two-Car Train)
NOTES

1) RESILIENT WHEELS
2) 105,000-LB. GROSS WEIGHT
3) TRACK SECTION I

Figure 5-11. Effect of Speed on Forward Car Centerline
Vertical Ride Roughness (Two-Car Train)
NOTES
1) RESILIENT WHEELS
2) 105,000-LB. GROSS WEIGHT
3) TRACK SECTION I

Figure 5-12. Effect of Speed on Mid-Car Centerline Vertical Ride Roughness (Two-Car Train)
NOTES
1) RESILIENT WHEELS
2) 90,000-LB GROSS WEIGHT

KEY
- 35 MPH
- - 45 MPH
- - - 80 MPH

Figure 5-13. Effect of Speed on No. 1 Axle Lateral Acceleration (High-Density Car)
NOTES
1) FRONT TRUCK, FORWARD AXLE
   RH JOURNAL BOX
2) RESILIENT WHEELS
3) 90,000-LB GROSS WEIGHT
4) TRACK SECTION I

KEY
- - 35 MPH
- - - 45 MPH
- - - - 80 MPH

Figure 5-14. Effect of Speed on No. 1 Axle Vertical Acceleration (High-Density Car)
NOTES
1) FRONT TRUCK,
   RH JOURNAL BOX
2) RESILIENT WHEELS
3) 105,000-LB GROSS WEIGHT
4) TRACK SECTION I

Figure 5-15. Effect of Speed on No. 1 Axle Lateral Acceleration (High-Density Car)
NOTES
1) FRONT TRUCK,
   RH JOURNAL BOX
2) RESILIENT WHEELS
3) 105,000-LB GROSS WEIGHT
4) TRACK SECTION I

KEY
- - - 35 MPH
- - - - 45 MPH
- - - - - 80 MPH

Figure 5-16. Effect of Speed on No. 1 Axle Vertical Acceleration (High-Density Car)
NOTES
1) FRONT TRUCK,
   RH JOURNAL BOX
2) RESILIENT WHEELS
3) 105,000-LB GROSS WEIGHT
4) TRACK SECTION I

KEY
--- 35 MPH
---- 45 MPH
---- 80 MPH

Figure 5-17. Effect of Speed on No. 1 Axle Lateral Acceleration (Two-Car Train)
NOTES
1) FRONT TRUCK, RH JOURNAL BOX
2) RESILIENT WHEELS
3) 105,000-LB GROSS WEIGHT
4) TRACK SECTION I

Figure 5-18. Effect of Speed on No. 1 Axle Vertical Acceleration (Two-Car Train)
NOTES
1) RESILIENT WHEELS
2) 105,000-LB. GROSS WEIGHT

Figure 5-19. Effect of Track Section on Forward Car Centerline Vertical Ride Roughness of High-Density Car at 35 MPH Speed
NOTES
1) RESILIENT WHEELS
2) 105,000-LB. GROSS WEIGHT

Figure 5-20. Effect of Track Section on Mid-Car Centerline Vertical Ride Roughness of High-Density Car at 35 MPH Speed
Figure 5–21. Effect of Track Section on Forward Car Centerline Vertical Ride Roughness of High-Density Car at 80 MPH Speed
NOTES
1) RESILIENT WHEELS
2) 105,000-LB. GROSS WEIGHT

Figure 5-22. Effect of Track Section on Mid-Car Centerline Vertical Ride Roughness of High-Density Car at 80 MPH Speed
NOTES

1) RESILIENT WHEELS
2) TRACK SECTION I

Figure 5-23. Effect of High-Density Car Gross Weight on Aft Car Centerline Lateral Ride Roughness at 45 MPH Speed
Figure 5-24. Effect of High-Density Car Gross Weight on Forward Car Centerline Vertical Ride Roughness at 45 MPH Speed
NOTES
1) RESILIENT WHEELS
2) TRACK SECTION I

Figure 5-25. Effect of High-Density Car Gross Weight on Mid-Car Centerline Vertical Ride Roughness at 45 MPH Speed
NOTES
1) RESILIENT WHEELS
2) TRACK SECTION I

Figure 5-26. Effect of High-Density Car Gross Weight on Aft Car Centerline
Lateral Ride Roughness at 55 MPH Speed

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NOTES
1) RESILIENT WHEELS
2) TRACK SECTION I

Figure 5-27. Effect of High-Density Car Gross Weight on Forward Car Centerline Vertical Ride Roughness at 55 MPH Speed
NOTES
1) RESILIENT WHEELS
2) TRACK SECTION I

Figure 5-28. Effect of High-Density Car Gross Weight on Mid-Car Centerline Vertical Ride Roughness at 55 MPH Speed
NOTES
1) RESILIENT WHEELS
2) TRACK SECTION I

Figure 5–29. Effect of High-Density Car Gross Weight on Aft Car Centerline Lateral Ride Roughness at 80 MPH Speed
NOTES
1) RESILIENT WHEELS
2) TRACK SECTION I

Figure 5-30. Effect of High-Density Car Gross Weight on Forward Car Centerline Vertical Ride Roughness at 80 MPH Speed
NOTES
1) RESILIENT WHEELS
2) TRACK SECTION I

Figure 5–31. Effect of High-Density Car Gross Weight on Mid-Car Centerline Vertical Ride Roughness at 80 MPH Speed
NOTES
1) FRONT TRUCK,
   RH JOURNAL BOX
2) RESILIENT WHEELS
3) TRACK SECTION I

KEY
- - - - GROSS WEIGHT 90,000 LBS
- - - - GROSS WEIGHT 105,000 LBS

Figure 5–32. Effect of Gross Weight on High-Density Car No. 1 Axle Lateral Acceleration at 35 MPH Speed
NOTES
1) FRONT TRUCK,  
   RH JOURNAL BOX
2) RESILIENT WHEELS
3) TRACK SECTION I

Figure 5-33. Effect of Gross Weight on High-Density Car No. 1 Axle Vertical Acceleration at 35 MPH Speed
NOTES
1) FRONT TRUCK,
   RH JOURNAL BOX
2) RESILIENT WHEELS
3) TRACK SECTION I

KEY
GROSS WEIGHT 90,000 LBS
GROSS WEIGHT 105,000 LBS

Figure 5-34. Effect of Gross Weight on High-Density Car No. 1 Axle Lateral Acceleration at 45 MPH Speed
NOTES
1) FRONT TRUCK,
   RH JOURNAL BOX
2) RESILIENT WHEELS
3) TRACK SECTION I

Figure 5-35. Effect of Gross Weight on High-Density Car No. 1 Axle Vertical Acceleration at 45 MPH Speed
NOTES
1) FRONT TRUCK, RH JOURNAL BOX
2) RESILIENT WHEELS
3) TRACK SECTION I

KEY
--- GROSS WEIGHT 90,000 LBS
--- GROSS WEIGHT 105,000 LBS
--- GROSS WEIGHT 130,000 LBS

Figure 5-36. Effect of Gross Weight on High-Density Car No. 1 Axle Lateral Acceleration at 55 MPH Speed
NOTES
1) FRONT TRUCK, RH JOURNAL BOX
2) RESILIENT WHEELS
3) TRACK SECTION I

KEY

--- GROSS WEIGHT 90,000 LBS
------------ GROSS WEIGHT 105,000 LBS
------------------ GROSS WEIGHT 130,000 LBS

Figure 5-37. Effect of Gross Weight on High-Density Car No. 1 Axle Vertical Acceleration at 55 MPH Speed
NOTES
1) FRONT TRUCK,
   RH JOURNAL BOX
2) RESILIENT WHEELS
3) TRACK SECTION I

KEY
--- GROSS WEIGHT 90,000 LBS
----- GROSS WEIGHT 105,000 LBS

Figure 5-38. Effect of Gross Weight on High-Density Car No. 1 Axle Vertical Acceleration at 80 MPH Speed
NOTES
1) FRONT TRUCK,
   RH JOURNAL BOX
2) RESILIENT WHEELS
3) TRACK SECTION I

KEY

--- GROSS WEIGHT 90,000 LBS
----- GROSS WEIGHT 105,000 LBS

Figure 5-39. Effect of Gross Weight on High-Density Car Axle Vertical Acceleration at 80 MPH Speed
NOTES
1) ○ HIGH-DENSITY CAR
2) △ TWO-CAR TRAIN
3) RESILIENT WHEELS
4) 105,000-LB. GROSS WEIGHT
5) TRACK SECTION I

Figure 5-40. Effect of Train Consist on Aft Car Centerline Lateral Ride Roughness
NOTES
1) ○ HIGH-DENSITY CAR
2) △ TWO-CAR TRAIN
3) RESILIENT WHEELS
4) 105,000-LB. GROSS WEIGHT
5) TRACK SECTION I

Figure 5-41. Effect of Train Consist on Forward Car Centerline Vertical Ride Roughness

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NOTES
1) ○ HIGH-DENSITY CAR
2) △ TWO-CAR TRAIN
3) RESILIENT WHEELS
4) 105,000-LB. GROSS WEIGHT
5) TRACK SECTION I

Figure 5-42. Effect of Train Consist on Mid-Car Centerline Vertical Ride Roughness
Figure 5-43. Effect of Train Consist on No. 1 Axle Lateral Acceleration at 35 MPH Speed
NOTES
1) FRONT TRUCK, RH JOURNAL BOX
2) RESILIENT WHEELS
3) 105,000-LB GROSS WEIGHT
4) TRACK SECTION I

Figure 5-44. Effect of Train Consist on No. 1 Axle Vertical Acceleration at 35 MPH Speed
NOTES
1) FRONT TRUCK, RH JOURNAL BOX
2) RESILIENT WHEELS
3) 105,000-LB GROSS WEIGHT
4) TRACK SECTION I

KEY

Figure 5-45. Effect of Train Consist on No. 1 Axle Lateral Acceleration at 45 MPH Speed
NOTES
1) FRONT TRUCK,
   RH JOURNAL BOX
2) RESILIENT WHEELS
3) 105,000-LB GROSS WEIGHT
4) TRACK SECTION I

Figure 5-46. Effect of Train Consist on No. 1 Axle Vertical Acceleration at 45 MPH Speed
NOTES
1) FRONT TRUCK,
   RH JOURNAL BOX
2) RESILIENT WHEELS
3) 105,000-LB GROSS WEIGHT
4) TRACK SECTION I

Figure 5-47. Effect of Train Consist on No. 1 Axle Lateral Acceleration at 80 MPH Speed
NOTES
1) FRONT TRUCK, RH JOURNAL BOX
2) RESILIENT WHEELS
3) 105,000-LB GROSS WEIGHT
4) TRACK SECTION I

KEY
--- HDC
---- TRAIN

Figure 5-48. Effect of Train Consist on No. 1 Axle Vertical Acceleration at 80 MPH Speed
NOTES
1) RESILIENT WHEELS
2) 105,000-LB GROSS WEIGHT
3) TRACK SECTION I

**Figure 5-49. Comparison of High-Density Car Ride Quality Vs. Goals**
NOTES
1) RESILIENT WHEELS
2) 105,000-LB GROSS WEIGHT
3) TRACK SECTION I

Figure 5-50. Comparison of Two-Car Train Ride Quality Vs. Goals

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Appendix

RIDE QUALITY POWER SPECTRAL DENSITY
AND PEAK AMPLITUDE MACHINE PLOTS

Table A-1 is an index to the power spectral density and peak amplitude machine plots contained in this appendix.
<table>
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<th>Track Section</th>
<th>Speed (MPH)</th>
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<td>Speed (MPH)</td>
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Figure A-1
Figure A-2

A-9
SOAC REQ 64 REC 1042
MID R/H VER

RESILIENT WHEELS

SPEED = 20 MPH
TRACK SECTION = 1
GROSS WEIGHT = 90,000 LBS
CAR CONFIG. = HIGH DENSITY CAR

Figure A-3
RESILIENT WHEELS

SPEED = 20 MPH
TRACK SECTION = I
GROSS WEIGHT = 90,000 LBS
CAR CONFIG. = HIGH DENSITY CAR

Figure A-5
RESILIENT WHEELS

SPEED = 20 MPH
TRACK SECTION = I
GROSS WEIGHT = 90,000 LBS.
CAR CONFIG. = HIGH DENSITY CAR

Figure A-6
Figure A-7

A-14
Figure A-8

SPEED = 20 MPH
TRACK SECTION = I
GROSS WEIGHT = 90,000 LBS
CAR CONFIG. = HIGH DENSITY CAR

Figure A-8

A-15
Figure A-9
Figure A-10
RESILIENT WHEELS

SPEED = 35 MPH
TRACK SECTION = I
GROSS WEIGHT = 90,000 LBS.
CAR CONFIG. = HIGH DENSITY CAR

Figure A-11
RESILIENT WHEELS

SPEED = 35 MPH
TRACK SECTION = 1
GROSS WEIGHT = 90,000 LBS
CAR CONFIG. = HIGH DENSITY CAR

Figure A-12
RESILIENT WHEELS

SPEED = 35 MPH
TRACK SECTION = I
GROSS WEIGHT = 90,000 LBS
CAR CONFIG = HIGH DENSITY CAR

Figure A-13
RESILIENT WHEELS

SPEED = 35 MPH
TRACK SECTION = I
GROSS WEIGHT = 90,000 LBS
CAR CONFIG. = HIGH DENSITY CAR

Figure A-14
RESILIENT WHEELS

SPEED = 35 MPH
TRACK SECTION = I
GROSS WEIGHT = 90,000 LBS
CAR CONFIG. = HIGH DENSITY CAR

Figure A-15
RESILIENT WHEELS

SPEED = 35 MPH
TRACK SECTION = 1
GROSS WEIGHT = 90,000 LBS
CAR CONFIG. = HIGH DENSITY CAR

Figure A-16

A-23
Figure A-17
FIGURE A-18

A-25
RESILIENT WHEELS

SPEED = 45 MPH
TRACK SECTION = 1
GROSS WEIGHT = 90,000 LBS
CAR CONFIG. = HIGH DENSITY CAR

Figure A-19
Figure A-20

A-27
Figure A-21
RESILIENT WHEELS

SPEED = 45 MPH
TRACK SECTION = I
GROSS WEIGHT = 90,000 LBS
CAR CONFIG = HIGH DENSITY CAR

Figure A-22
RESILIENT WHEELS

SPEED = 45 MPH
TRACK SECTION = I
GROSS WEIGHT = 90,000 LBS
CAR CONFIG = HIGH DENSITY CAR

Figure A-23
SOAC REQ 64 REC 1120
RESILIENT WHEELS

SPEED = 45 MPH
TRACK SECTION = 1
GROSS WEIGHT = 90,000 LBS
CAR CONFIG. = HIGH DENSITY CAR

Figure A-24

A-31
Figure A-25
SMAÇ REG 63 REC 1131
FND RH JB FRONT VER
RESTILENT WHEELS

SPEED = 55 MPH
TRACK SECTION = 1
GROSS WEIGHT = 90,000 LBS
CAR CONFIG. = HIGH DENSITY CAR

Figure A-26

A-33
RESILIENT WHEELS

SPEED = 55 MPH
TRACK SECTION = I
GROSS WEIGHT = 90,000 LBS
CAR CONFIG. = HIGH DENSITY CAR

Figure A-27
RESILIENT WHEELS

SPEED = 55 MPH
TRACK SECTION = I
GROSS WEIGHT = 90,000 LBS
CAR CONFIG. = HIGH DENSITY CAR

Figure A-28
RESILIENT WHEELS

SPEED = 65 MPH
TRACK SECTION = T
GROSS WEIGHT = 90,000 LBS
CAR CONFIG. = HIGH DENSITY CAR

Figure A-29
RESILIENT WHEELS

SPEED = 55 MPH
TRACK SECTION = I
GROSS WEIGHT = 90,000 LBS
CAR CONFIG. = HIGH DENSITY CAR

Figure A-30
Figure A-32
A-39
Figure A-33
Figure A-34
Figure A-36
RESILIENT WHEELS

SPEED = 30 MPH
TRACK SECTION = I
GROSS WEIGHT = 90,000 LBS
CAR CONFIG. = HIGH DENSITY CAR

POWER SPECTRAL DENSITY

FREQUENCY (HZ)

Figure A-38
RESILIENT WHEELS

SPEED = 80 MPH
TRACK SECTION = 1
GROSS WEIGHT = 90,000 LBS
CAR CONFIG. = HIGH DENSITY CAR

Figure A-39
RESILIENT WHEELS

SPEED = 80 MPH
TRACK SECTION = I
GROSS WEIGHT = 90,000 LBS
CAR CONFIG. = HIGH DENSITY CAR

Figure A-40
<table>
<thead>
<tr>
<th>Speed</th>
<th>20 MPH</th>
</tr>
</thead>
<tbody>
<tr>
<td>Track Section</td>
<td>1</td>
</tr>
<tr>
<td>Gross Weight</td>
<td>105,000 LBS</td>
</tr>
<tr>
<td>Car Config.</td>
<td>High Density Car</td>
</tr>
</tbody>
</table>

![Graph](image-url)

**Figure A-41**

A-48
Figure A-42

A-49
RESILIENT WHEELS

SPEED = 20 MPH
TRACK SECTION = 1
GROSS WEIGHT = 105,000 LBS
CAR CONFIG. = HIGH DENSITY CAR

Figure A-43
A-50
RESILIENT WHEELS

SPEED = 20 MPH
TRACK SECTION = I
GROSS WEIGHT = 105,000 LBS
CAR CONFIG. = HIGH DENSITY CAR

Figure A-45

A-52
RESILIENT WHEELS

SPEED = 20 MPH
TRACK SECTION = I
GROSS WEIGHT = 105,000 LBS
CAR CONFIG. = HIGH DENSITY CAR

Figure A-46
RESILIENT WHEELS

SPEED = 20 MPH
TRACK SECTION = I
GROSS WEIGHT = 105,000 LBS
CAR CONFIG. = HIGH DENSITY CAR

Figure A-47
RESILIENT WHEELS

SPEED = 20 MPH

TRACK SECTION = 1

GROSS WEIGHT = 105,000 LBS

CAR CONFIG. = HIGH DENSITY

CAR

Figure A-48
SOAC REQ 68 REC 1620
FWD RH JB FRONT LAT

RESILIENT WHEELS

SPEED = 35 MPH
TRACK SECTION #1
GROSS WEIGHT = 105,000 LBS
CAR CONFIG. = HIGH DENSITY CAR

FREQUENCY (HZ)

PERK. AMPLITUDE

Figure A-49
Figure A-51
Figure A-52

A-59
RESILIENT WHEELS

SPEED = 35 MPH
TRACK SECTION = I
GROSS WEIGHT = 105,000 LBS
CAR CONFIG. = HIGH DENSITY CAR

Figure A-53
RESILIENT WHEELS

SPEED = 35 MPH
TRACK SECTION = I
CROSS WEIGHT = 105,000 LBS
CAR CONFIG. = HIGH DENSITY CAR

Figure A-54
Figure A-55
RESILIENT WHEELS

-SPEED = 35 MPH
-TRACK SECTION = 1
-GROSS WEIGHT = 105,000 LBS
-CAR CONFIG. = HIGH DENSITY CAR

Figure A-56

A-63
Figure A-57

A-64
Resilient Wheels:

- Speed = 45 MPH
- Track Section = I
- Gross Weight = 105,000 LBS
- Car Config. = High Density Car

Figure A-58
RESILIENT WHEELS

SPEED = 45 MPH
TRACK SECTION = I
GROSS WEIGHT = 105,000 LBS.
CAR CONFIG. = HIGH DENSITY CAR

Figure A-59

A-66
RESILIENT WHEELS

SPEED = 45 MPH
TRACK SECTION = I
GROSS WEIGHT = 105,000 LBS
CAR CONFIG. = HIGH DENSITY CAR

Figure A-60

A-67
RESILIENT WHEELS

SPEED = 45 MPH
TRACK SECTION = 1
GROSS WEIGHT = 105,000 LBS
CAR CONFIG. = HIGH DENSITY CAR

Figure A-61
RESILIENT WHEELS

SPEED = 45 MPH
TRACK SECTION = I
GROSS WEIGHT = 105,000 LBS
CAR CONFIG. = HIGH DENSITY CAR

Figure A-62

A-69
RESILIENT WHEELS

Figure A-63

A-70
RESILIENT WHEELS

SPEED = 45 MPH
TRACK SECTION = 1
GROSS WEIGHT = 105,000 LBS
CAR CONFIG. = HIGH DENSITY CAR

Figure A-64

A-71
Figure A-65
SOAC Req 69 Rec 1655
MID R/H VER
RESILIENT WHEELS

SPEED = 55 MPH
TRACK SECTION = I
GROSS WEIGHT = 105,000 LBS
CAR CONFIG. = HIGH DENSITY CAR

Figure A-67
RESILIENT WHEELS

SPEED = 55 MPH
TRACK SECTION = I
GROSS WEIGHT = 105,000 LBS
CAR CONFIG = HIGH DENSITY CAR

Figure A-68
Figure A-69
RESILIENT WHEELS

SPEED = 55 MPH
TRACK SECTION = 1
GROSS WEIGHT = 105,000 LBS.
CAR CONFIG. = HIGH DENSITY CAR

Figure A-70
RESILIENT WHEELS

SPEED = 55 MPH
TRACK SECTION = I
GROSS WEIGHT = 104,000 LBS
CAR CONFIG. = HIGH DENSITY CAR

Figure A-72
Figure A-73
Figure A-75
Figure A-76
Figure A-77

A-84
RESILIENT WHEELS

SPEED = 80 MPH
TRACK-SECTION = I
GROSS WEIGHT = 105,000 LBS
CAR CONFIG. = HIGH DENSITY CAR

Figure A-78

A-85
RESILIENT WHEELS

SPEED = 80 MPH

TRACK SECTION = I

GROSS WEIGHT = 105,000 LBS

CAR CONFIG. = HIGH DENSITY CAR

Figure A-79
RESILIENT WHEELS:

SPEED = 80 MPH
TRACK SECTION = T
GROSS WEIGHT = 105,000 LBS
CAR CONFIG. = HIGH DENSITY CAR

Figure A-80
Figure A-81
Figure A-82

A-89
RESILIENT WHEELS

SPEED = 80 MPH
TRACK SECTION = 1
GROSS WEIGHT = 105,000 LBS
CAR CONFIG. = HIGH DENSITY
CAR

Figure A-84

A-91
Figure A-85

A-92
Figure A-86
SCIRC REQ 77 REC 1623
FWD C/L VERT
RESILIENT WHEELS

SPEED = 35 MPH
TRACK SECTION = II
GROSS WEIGHT = 105,000 LBS.
CAR CONFIG. = HIGH DENSITY CAR

Figure A-87
RESILIENT WHEELS

SPEED = 35 MPH
TRACK SECTION = II
GROSS WEIGHT = 105,000 LBS
CAR CONFIG. = HIGH DENSITY CAR

Figure A-88

A-95
SPEED = 35 MPH
TRACK SECTION = II
GROSS WEIGHT = 105,000 LBS
CAR CONFIG. = HIGH DENSITY CAR

Figure A-89
RESILIENT WHEELS

SPEED = 80 MPH
TRACK SECTION = II
GROSS WEIGHT = 105,000 LBS
CAR CONFIG. = HIGH DENSITY CAR

Figure A-90
SPEED = 80 MPH
TRACK SECTION = II
GROSS WEIGHT = 105,000 LBS
CAR CONFIG. = HIGH DENSITY CAR

Figure A-91
Figure A-92
Figure A-93
RESILIENT WHEELS

SPEED = 35 MPH
TRACK SECTION = III
GROSS WEIGHT = 105,000 LBS
CAR CONFIG. = HIGH DENSITY CAR

Figure A-94
SOREC REQ 77 REC 1624
AFT C/L VERT
RESILIENT WHEELS

SPEED = 35 MPH
TRACK SECTION = III
GROSS WEIGHT = 105,000 LBS
CAR CONFIG. = HIGH DENSITY CAR

Figure A-95

A-102
SOAC REQ 77 REC 1706
FWD. C/L VERT
RESILIENT WHEELS

SPEED = 80 MPH
TRACK SECTION = III
GROSS WEIGHT = 105,000 LBS
CAR CONFIG. = HIGH DENSITY CAR

Figure A-96
SOAC REQ 77 REC 1706
MID C/L VERT
RESILIENT WHEELS

SPEED = 80 MPH
TRACK SECTION = III
GROSS WEIGHT = 105,000 LBS
CAR CONFIG. = HIGH DENSITY CAR

Figure A-97
Figure A-98

A-105
SPEED = 35 MPH
TRACK SECTION = IV
GROSS WEIGHT = 105,000 LBS
CAR CONFIG. = HIGH DENSITY CAR

Figure A-99

A-106
Figure A-100
SOAC REQ 77 REC 1627
AFT C/L VERT
RESILIENT WHEELS

SPEED = 35 MPH
TRACK SECTION = IV
GROSS WEIGHT = 105,000 LBS
CAR CONFIG. = HIGH-DENSITY CAR

Figure A-101

A-108
Figure A-102
SOAC REQ 77 REC 1707
MID C/L VERT
-RESILIENT WHEELS

SPEED = 80 MPH
TRACK SECTION = IV
GROSS WEIGHT = 105,000 LBS
CAR CONFIG = HIGH DENSITY CAR

Figure A-103
A-110
SPEED = 80 MPH
TRACK SECTION = IV
GROSS WEIGHT = 105,000 LBS
CAR CONFIG. = HIGH DENSITY CAR

Figure A-104

A-111
Figure A-105
RESILIENT WHEELS

**SPEED = 35 MPH**

**TRACK SECTION = V**

**GROSS WEIGHT = 105,000 LBS**

**CAR CONFIG. = HIGH DENSITY CAR**
RESILIENT WHEELS

SPEED = 35 MPH
TRACK SECTION = V
GROSS WEIGHT = 105,000 LBS
CAR CONFIG. = HIGH DENSITY CAR

Figure A-107

A-114
RESILIENT WHEELS

SPEED = 80 MPH
TRACK SECTION = V
GROSS WEIGHT = 105,000 LBS
CAR CONFIG. = HIGH DENSITY CAR

Figure A-108
Figure A-109
SPEED = 80 MPH
TRACK SECTION = V
GROSS WEIGHT = 105,000 LBS
CAR CONFIG. = HIGH DENSITY CAR

Figure A-110
Figure A-111
SPEED = 35 MPH
TRACK SECTION = VI
GROSS WEIGHT = 105,000 LBS
CAR CONFIG. = HIGH DENSITY CAR

Figure A-112

A-119
SPEED = 35 MPH
TRACK SECTION = VI
GROSS WEIGHT = 105,000 LBS
CAR CONFIG. = HIGH DENSITY CAR

Figure A-113
SOAC REQ 77 REC 1710
M10 C/L VERT.
RESILIENT WHEELS

SPEED = 80 MPH
TRACK SECTION = VI
GROSS WEIGHT = 105,000 LBS
CAR CONFIG. = HIGH DENSITY CAR

Figure A-115

A-122
Figure A-116
Figure A-117
Figure A-118
SOPC REQ 77 REC 1711
AFT C/L VERT
RESILIENT WHEELS

SPEED = 80 MPH
TRACK SECTION = NORTH GAG
AND SWITCH
GROSS WEIGHT = 105,000 LBS
CAR CONFIG. = HIGH DENSITY CAR

Figure A-119

A-126
Figure A-120

A-127
Figure A-121

A-128
Figure A-122
RESILIENT WHEELS

SPEED = 55 MPH
TRACK SECTION = I
GROSS WEIGHT = 130,000 LBS
CAR CONFIG. = HIGH DENSITY CAR

Figure A-123
Figure A-124
Figure A-125
RESILIENT WHEELS

SPEED = 55 MPH
TRACK SECTION = I
GROSS WEIGHT = 130,000 LBS
CAR CONFIG. = HIGH DENSITY CAR

Figure A-126

A-133
Figure A-127

A-134
Figure A-128

A-135
Figure A-129

A-136
Figure A-130
RESILIENT WHEELS

SPEED = 20 MPH
TRACK SECTION = I
GROSS WEIGHT = 105,000 LBS
CAR CONFIG. = TRAIN

Figure A-132
Figure A-133
Figure A-134
Figure A-135
Figure A-136

A-143
Figure A-137
RESILIENT WHEELS

SPEED = 35 MPH
TRACK SECTION = I
GROSS WEIGHT = 105,000 LBS
CAR CONFIG = TRAIN

Figure A-139
RESILIENT WHEELS

SPEED = 35 MPH
TRACK SECTION = I
GROSS WEIGHT = 195,000 LBS
CAR CONFIG = TRAIN

Figure A-140
RESILIENT WHEELS

SPEED = 35 MPH
TRACK SECTION = I
GROSS WEIGHT = 105,000 LBS
CAR CONFIG = TRAIN

Figure A-141
RESILIENT WHEELS

SPEED = 35 MPH
TRACK SECTION = I
GROSS WEIGHT = 105,000 LBS
CAR CONFIG. = TRAIN

Figure A-142

A-149
RESILIENT WHEELS

SPEED = 35 MPH
TRACK SECTION = I
GROSS WEIGHT = 105,000 LBS
CAR CONFIG = TRAIN

Figure A-143
SOREC 66 REC 1431
EHD RH JB FRONT LAT
RESILIENT WHEELS

SPEED = 45 MPH
TRACK SECTION = 1
GROSS WEIGHT = 105,000 LBS.
CAR CONFIG. = TRAIN

Figure A-144

A-151
Figure A-145

A-152
RESILIENT WHEELS

SPEED = 45 MPH
TRACK SECTION = I
GROSS WEIGHT = 105,000 LBS
CAR CONFIG. = TRAIN

Figure A-146
Figure A-147

SOAC REQ 67 REC 1431
AFI C/L LAT

RESILIENT WHEELS

SPEED = 45 MPH
TRACK SECTION = I
GROSS WEIGHT = 105,000 LBS
CAR CONFIG. = TRAIN
S0AC RED 67 REC 1431
FWD C/L LONG
RESILIENT WHEELS

SPEED = 45 MPH
TRACK SECTION = 1
GROSS WEIGHT = 105,000 LBS
CAR CONFIG = TRAIN

Figure A-148

A-155
RESILIENT WHEELS

SPEED = 45 MPH
TRACK SECTION = 1
GROSS WEIGHT = 105,000 LBS
CAR CONFIG. = TRAIN

Figure A-149
Figure A-150
Figure A-151

A-158
Figure A-152
Figure A-153
Figure A-154

A-161
RESILIENT WHEELS.

SPEED = 55 MPH
TRACK SECTION = 1
GROSS WEIGHT = 105,000 LBS
CAR CONFIG. = TRAIN

Figure A-155
Figure A-156

A-163
RESILIENT WHEELS

SPEED = 55 MPH
TRACK SECTION = I
GROSS WEIGHT = 105,000 LBS
CAR CONFIG = TRAIN

Figure A-158
SOAC REQ 67 REC 1443
AFT C/L VER
RESILIENT WHEELS

SPEED = 55 MPH
TRACK SECTION = 1
GROSS WEIGHT = 105,000 LBS
CAR CONFIG. = TRAIN

Figure A-159
Figure A-160
Figure A-161

A-168
RESILIENT WHEELS

SPEED = 80 MPH
TRACK SECTION = I
GROSS WEIGHT = 105,000 LBS
CAR CONFIG. = TRAIN

Figure A-162
RESILIENT WHEELS

SPEED = 80 MPH
TRACK SECTION = I
GROSS WEIGHT = 105,000 LBS
CAR CONFIG. = TRAIN

Figure A-163

A-170
RESILIENT WHEELS

SPEED = 80 MPH
TRACK SECTION = I
GROSS WEIGHT = 105,000 LBS
CAR CONFIG. = TRAIN

Figure A-164
Figure A-165
SOAC REQ 67 REC 1452
MID.C/L.VER

RESILIENT WHEELS

SPEED = 80 MPH
TRACK SECTION = 1
GROSS WEIGHT = 105,000 lbs.
CAR CONFIG. = TRAIN

Figure A-166

A-173
Figure A-167

A-174