Report No. UMTA-IT-06-0026-74-10

SOAC

STATE-OF-THE-ART CAR DEVELOPMENT PROGRAM FINAL TEST REPORT

VOLUME 3: ACCEPTANCE TESTING

Boeing Vertol Company

(A division of The Boeing Company)

Surface Transportation Systems Branch

Philadelphia, Pa. 19142

APRIL 1974

FINAL REPORT

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Prepared for

URBAN MASS TRANSPORTATION ADMINISTRATION

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This document, Volume III of SOAC Final Test Report D174-10024, presents the test results for the vehicle acceptance testing of two state-of-the-art transit cars. 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.

All Performance, Ride Quality, Noise and EMI Acceptance Tests were conducted by Boeing Vertol Company, St. Louis Car Division, and GSI Castings Division of General Steel Industries, Inc. at the High Speed Ground Test Center at Pueblo, Colorado.

This document, Volume III 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 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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MODEL SOAC CONTRACT DOT-UT-10007

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1. 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 railcar design, with two new improved cars using existing proven technology. Primary goals for the cars are passenger convenience and operating efficiency.

This report presents the results of acceptance tests performed on the SOAC low and high-density cars individually and as a two-car train. These tests were conducted on the two cars at the U.S. Department of Transportation High Speed Ground Test Center in Pueblo, Colorado during the period November 1972 to April 17, 1973. Final acceptance testing was initiated on March 9, 1973 and completed on April 12, 1973.

The 80 mph transit oval, 9.1 miles in length, was utilized for all performance tests. Third rail power at a nominal 650 VDC was provided by DOT Locomotive No. 001, and two 500 KW auxiliary generators.

The SOAC final acceptance tests are outlined in Table I. The test program plan and procedures are described in Boeing Vertol Report D174-10007-1. The acceptance test procedures and test instrumentation were designed to prove compliance with Section 2.2 of the SOAC Detail Specification IT-06-0026-73-2.

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

TABLE I

FINAL ACCEPTANCE TESTS

Car Weight 105,000 lb.
Nominal 600 Volts dc

TYPE OF TEST	TRAIN CONFIGURATION
o Visual	L-D and H-D Cars
o Acceleration - Initial Rate - Time-Speed-Distance	L-D Car; H-D Car; 2-Car Train-Both Directions
o Maximum Speed	L-D Car; H-D Car; 2-Car Train-Both Directions
o Automatic Speed Maintaining System	L-D Car; H-D Car
o Blended Braking - Deceleration Rate - Stopping Distance	L-D Car; H-D Car; 2-Car Train-Both Directions
o Dynamic Braking Only - Deceleration Rate - Stopping Distance	L-D Car; H-D Car; 2-Car Train-Both Directions
o Service Friction Braking -Deceleration Rate -Stopping Distance	L-D Car; H-D Car; 2-Car Train-Both Directions
o Emergency Braking - Deceleration Rate - Stopping Distance	L-D Car; H-D Car; 2-Car Train-Both Directions
o Service Duty Cycle - Blended Braking - Service Friction Braking	L-D Car H-D Car
o Ride Quality	H-D Car 2-Car Train
o Noise	L-D Car H-D Car
o EMI-Electromagnetic Interference	2-Car Train

2. SUMMARY OF TEST RESULTS

2.1 PERFORMANCE DATA

The results of the final acceptance performance tests are summarized in Table II for the low-density car, the high-density car, and the two-car train. The data contained in these summaries are the results of car performance averaged over several data records.

For example, the acceleration rates and times to 700 feet distance are based on a two-direction average (forward and reverse) with two data records in each direction. Braking rates and distances are based on two stops in each car direction from four separate initial speeds. In addition to averaging rates over several data records, both a longitudinal accelerometer and a time differentiation of the speedometer instrumentation were used for each record.

Test instrumentation is outlined in Section 4. As noted in Table II, the individual cars and the two-car train meet the specified acceleration and braking performance. Actual test data showing the cars' performance characteristics are contained in Section 6.

2.2 RIDE QUALITY DATA

Figures 2-1, 2-2 and 2-3 summarize the results of the ride quality measurements taken on the cars following structural modifications to the motor-alternator support structure. The complete ride quality acceptance data package is contained in the Appendix III Test Report. Results of the later engineering tests are reported in the Engineering Test Report, D174-10026-1.

Test data for a 90,000-lb. single car is shown in Figure 2-1. Data for a 105,000-lb. car singly and in a two-car train are shown in Figures 2-2 and 2-3 respectively. At the 90,000-lb. car weight (empty car) the SOAC essentially met the ride quality goal in the frequency range associated with the rigid body suspension frequencies: 1-2 Hz. In the higher frequency range associated with car body flexible modes: 7-15 Hz, the goal could not be met with the existing car body structural characteristics. The vibration investigation program reported in Appendix III did result in a reduction of the maximum vibration levels in the 15 Hz range from .26g to .10g. Although this exceeds the design goal of .055g at this frequency, the SOAC is considered satisfactory by passenger observations.

TABLE II

SOAC ACCEPTANCE TESTS

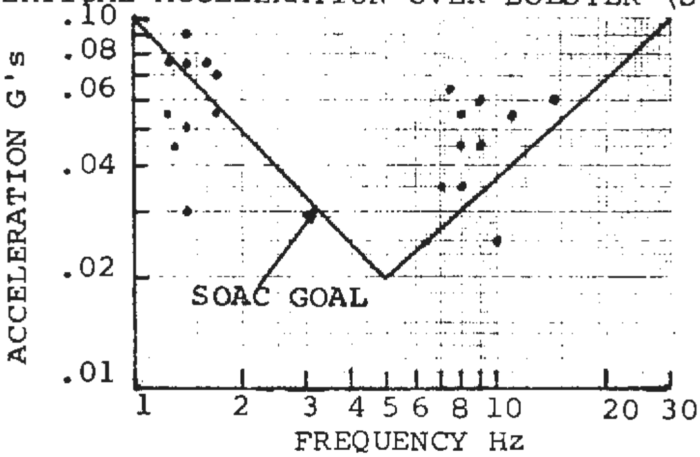
[105,000 LB CAR WEIGHT] 600 Volts

PERFORMANCE ITEM		SPECIFICATION REQUIREMENT	RESULTS		
			LOW-DENSITY	HIGH-DENSITY	2-CAR TRAIN
1. PEAK (INITIAL) ACCELERATION RATE		2.7-3.3 MPH/SEC	2.7 *	2.7 *	2.7 *
2. TIME TO TRAVEL 700' FROM A STANDING START-LEVEL TANGENT TRACK		20 SEC	19.4	19.0	20.0
3. SPEED ON A 3% ADVERSE GRADE		70 MPH	>75	>75	N/A
4. MAXIMUM SPEED		80 MPH	80	80	80
5. DECELERATION RATES (PEAK)	BLENDED SERVICE	2.7-3.3 MPH/SEC	3.2	3.2	3.2
	DYNAMIC ONLY	2.7-3.3 MPH/SEC	3.0	3.0	3.1
	SERVICE FRICTION	2.7-3.3 MPH/SEC	3.1	3.2	3.2
6. JERK RATE	ACCELERATION	2.5 MPH/SEC^2	1.9	2.3	1.8
	BRAKING	2.5 MPH/SEC^2	2.9	2.6	2.6
7. STOPPING DISTANCE (FROM 40 MPH)	BLENDED SERVICE	450 FT	430	445	430
	SERVICE FRICTION	450 FT	440	425	420
8. STOPPING DISTANCE (FROM 80 MPH)	BLENDED SERVICE	2250 FT	1650	1660	1660
	SERVICE FRICTION	2250 FT	1960	2000	1925
9. EMERGENCY BRAKING	STOP FROM 40 MPH	425 FT	365	350	335
	STOP FROM 80 MPH	2200 FT	1630	1600	1635
	DECELERATION RATE	2.88-3.52 MPH/SEC	3.5	3.4	3.5

* Initial rates of 3.0 mph/sec. were recorded during Acceptance Testing prior to final current limit adjustments.

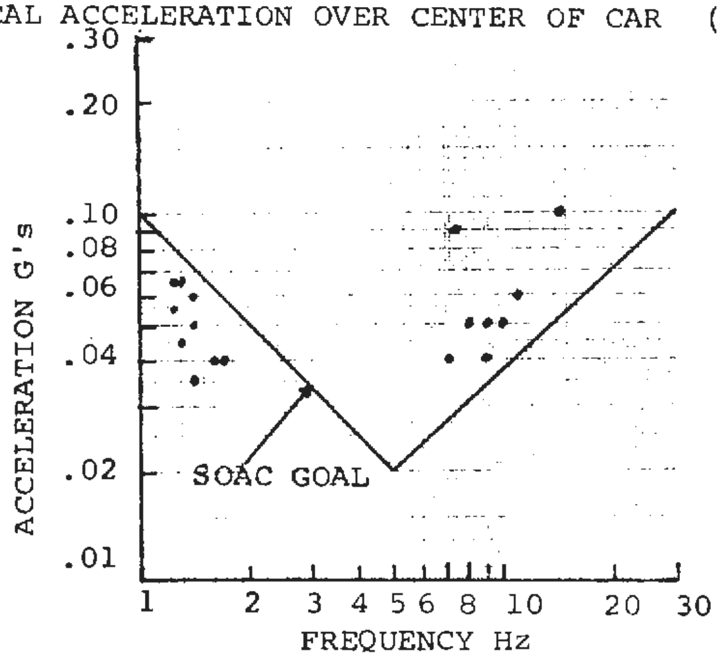
SOAC RIDE QUALITY
DATA COLLECTED AFTER MA SUPPORT STRUCTURAL MODIFICATION

VERTICAL ACCELERATION OVER BOLSTER (STA 108)



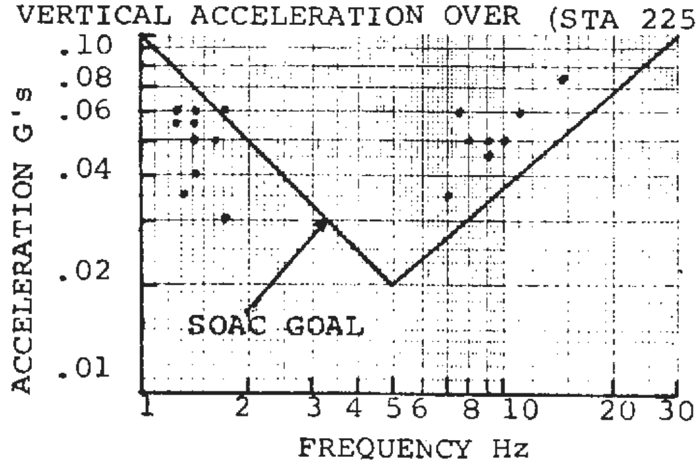
GROSS WEIGHT
90,000 LBS.

VERTICAL ACCELERATION OVER CENTER OF CAR (STA 450)



GROSS WEIGHT
90,000 LBS.

VERTICAL ACCELERATION OVER (STA 225)

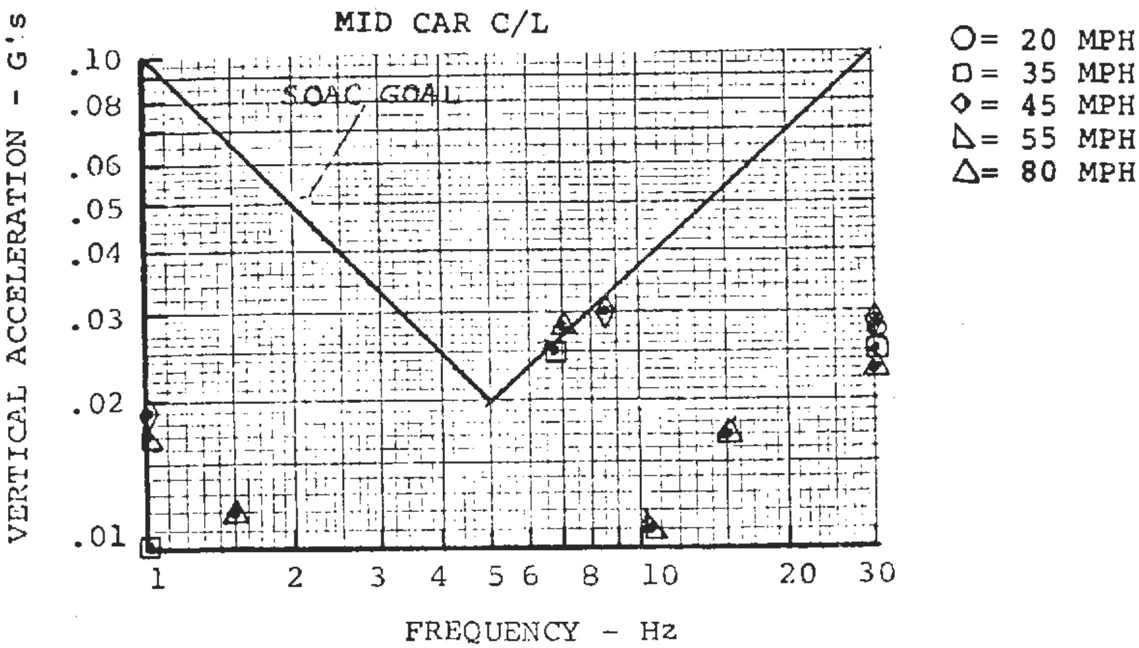


GROSS WEIGHT
90,000 LBS.

FIGURE 2-1

SOAC RIDE QUALITY

Resilient Wheels
Track Section = I
Gross Weight = 105,000 LBS.
High Density Car



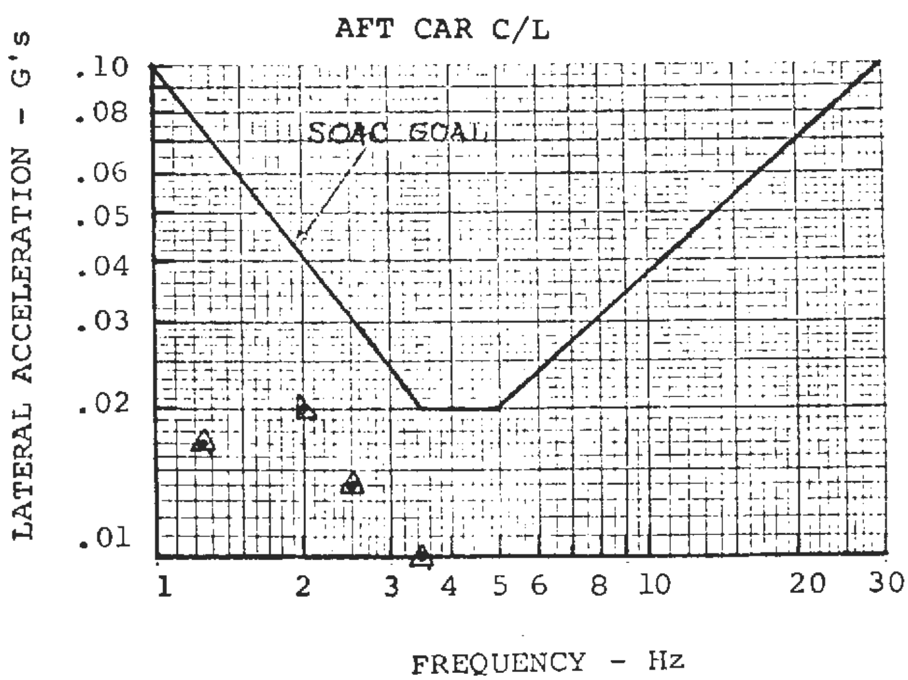
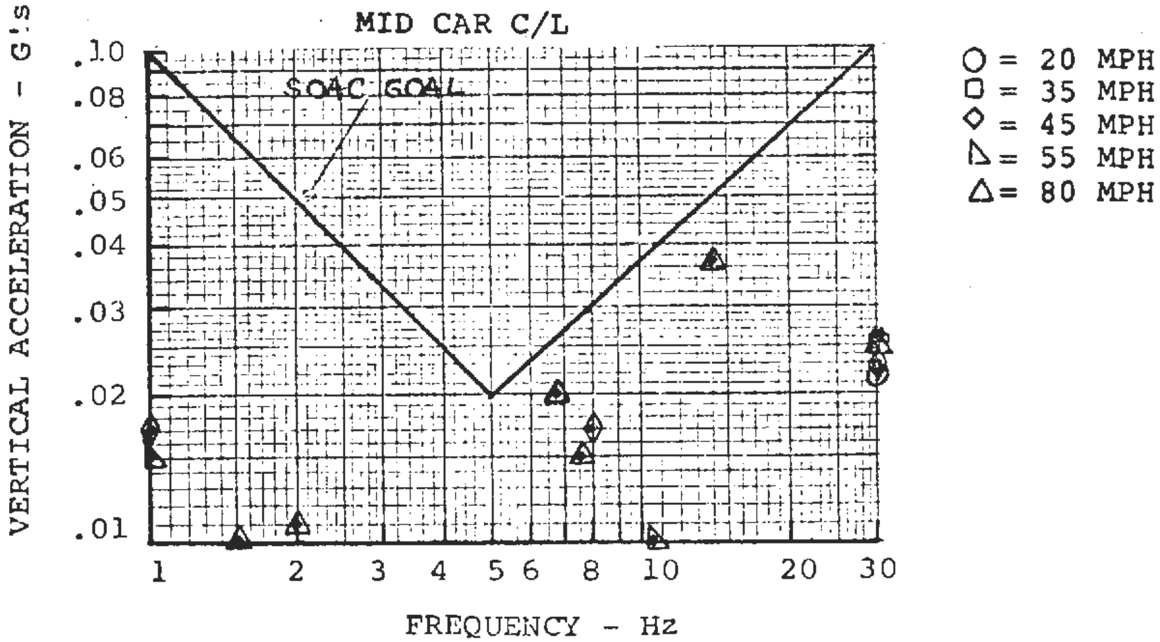


FIGURE 2-2

SOAC RIDE QUALITY

Resilient Wheels
Track Section = I
Gross Weight - 105,000LBS.
Train



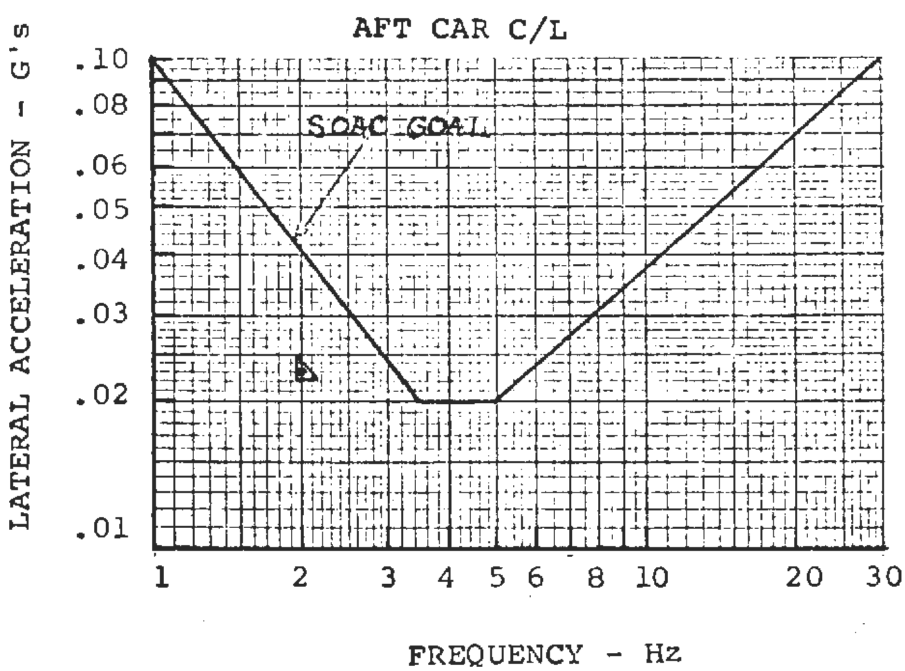


FIGURE 2-3

The results of testing the SOAC at the 105,000-lb. weight (100 passenger load) are shown in Figures 2-2 and 2-3. As noted in these figures the ride quality measurements show compliance with the SOAC goals over the frequency range at both mid and aft car centerlines. These data were obtained during later car tests and are based on the instrumentation system used during the Engineering Test Program.

Based on the above data the SOAC is capable of meeting all the ride quality goals under a loaded car condition representing normal operating car weights. The ride quality requirements were originally expressed as goals rather than as acceptance requirements due to the scope of the program which used a basic R44 car body.

2.3 NOISE DATA

Figure 2-4 presents a summary of interior and wayside noise data taken during the acceptance and engineering test programs on the SOAC. As noted in the upper portion of Figure 2-4, the interior noise measurements show that both cars meet the noise goal at all speeds. The SOAC also meets the wayside noise goal at speeds above 35 to 40 mph on Pueblo track Sections III to VI but only above 65 mph on Section I. Due to the increased rail roughness of this track section at speeds below those noted above, the car equipment noise level (cooling fans, motor-alternator set) results in a wayside sound level somewhat greater than the goal. A band of wayside noise levels for existing transit cars is also shown on Figure 2-4 for comparison with the SOAC data. As noted, the SOAC noise level is comparable to the lower level for contemporary equipment. The SOAC noise goal was based mainly on wheel-rail noise with little allowance for the actual car equipment required for the SOAC propulsion system (69 dBA at zero speed). Paragraph 6.10 presents a discussion of the noise tests.

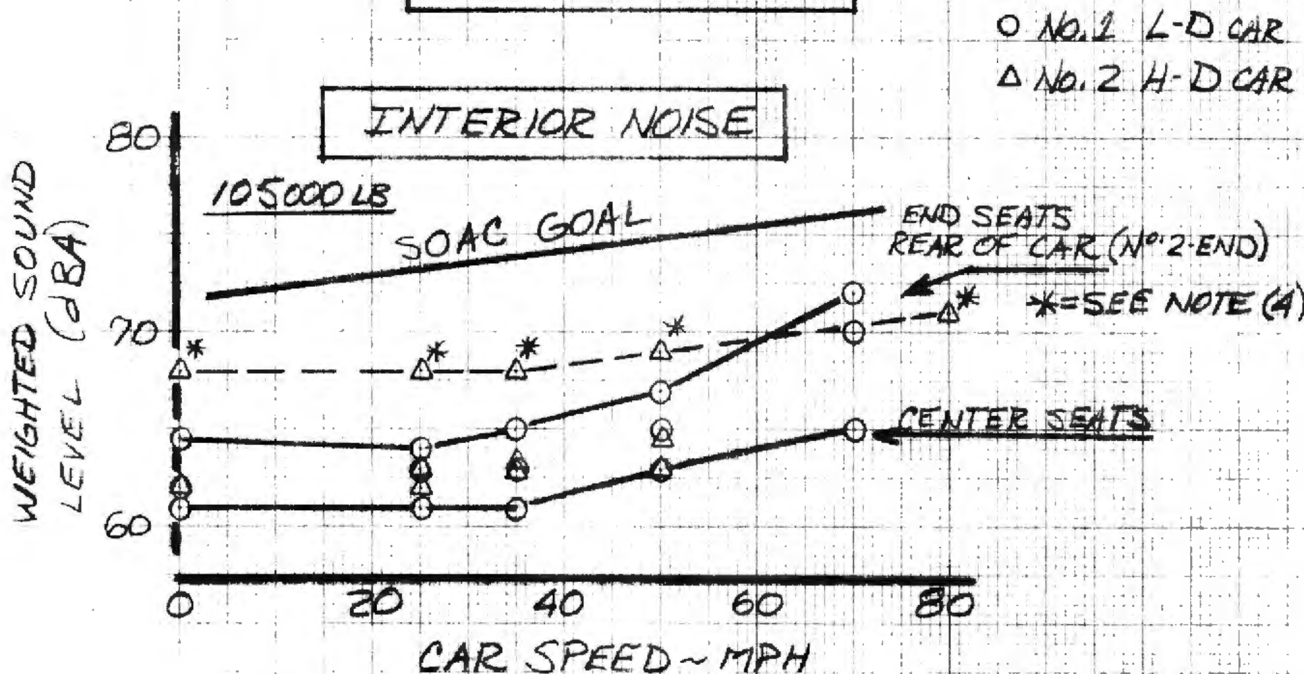
2.4 ELECTROMAGNETIC INTERFERENCE DATA (EMI)

Testing to determine the electromagnetic field strength inside the SOAC as well as at the wayside was performed at the HSGTC on April 2 and 3, 1973. As shown in Figure 2-5 test data indicate the SOAC is within field limits from a frequency range of 150 KHz to 400 MHz. Since there was no substantial noise peak within the car body, it was not necessary to track down corresponding sources.

FIGURE 2-4

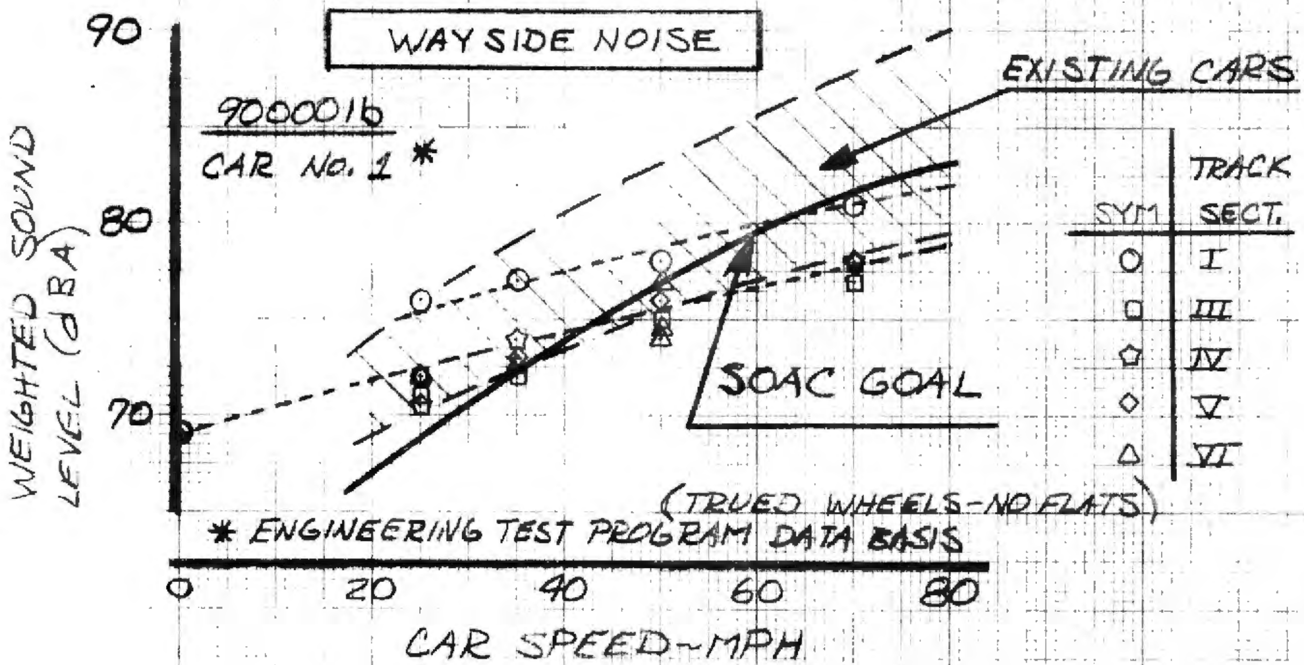
SOAC NOISE MEASUREMENT TESTS

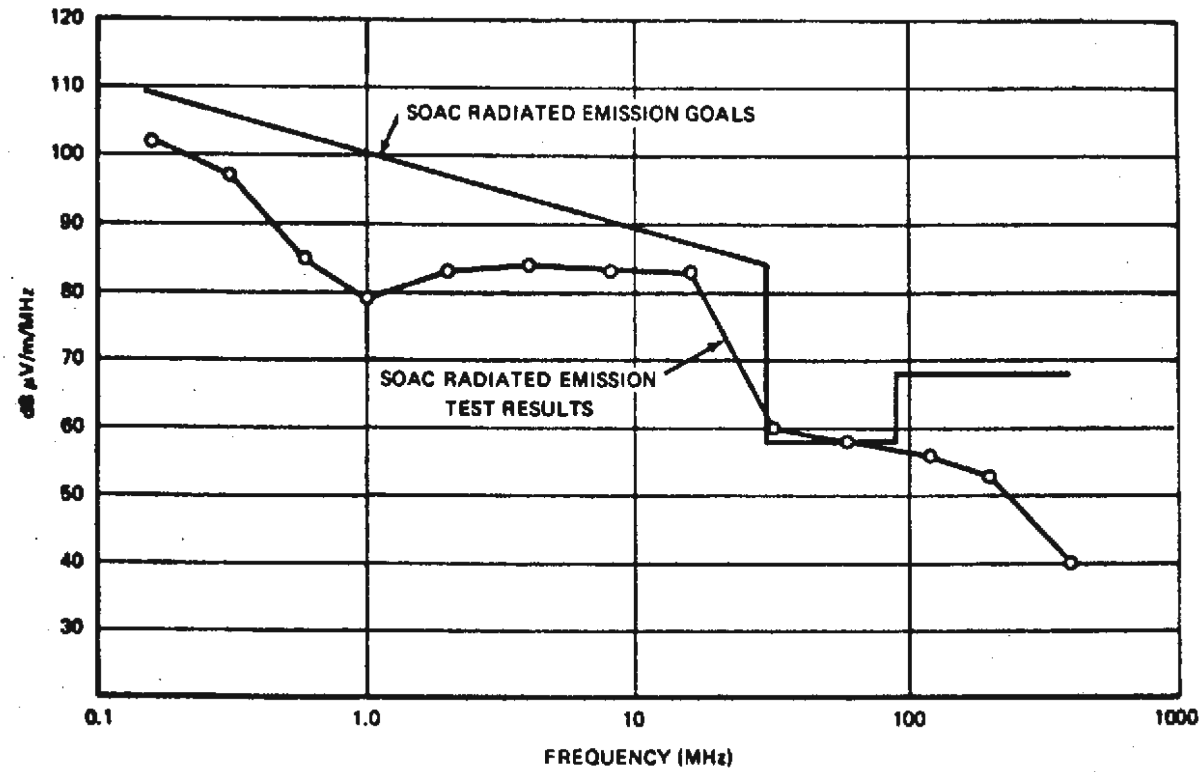
HSGTC-PUEBLO



NOTES:

1) TANGENT, WELDED RAIL, WOODEN TIES: SECTION I (INTERIOR)
2) SOLID STEEL WHEELS
3) MICROPHONE LOCATIONS: INTERIOR - EAR LEVEL OF SEATED PASSENGER: WAYSIDE - 50 FT FROM TRACK CENTERLINE
4) FRESH/RETURN AIR SPLITTER CONFIGURATION IN No. 2 CAR CREATES HIGHER INTERIOR NOISE LEVELS THAN No. 1 CAR.





SOAC Electromagnetic Field Test Data

FIGURE 2-5

3. CONFIGURATION

Acceptance tests were conducted on the low-density car (No. 1) and the high-density car (No. 2) individually and as a two-car train. Both cars were ballasted with lead weights to the normal load (AW1) of 105,000 lb., representing the light car plus 100 passengers at 150 lb. each. The weight breakdown for each car is presented in Table III.

TABLE III

CAR WEIGHTS - SOAC

	HDC	LDC
Light Weight at St. Louis Car	88,320#	89,080#
Pantograph Scale Weight, March 15, 1973	775#	775#
*Equipment Brackets added at Pueblo	320#	320#
Miscellaneous	169#	114#
Light Weight at Rail Ready to Run	89,584#	90,289#
Lead Bars (HDC 328) (LDC 313)	15,416#	14,711#
AW1	105,000#	105,000#

*Equipment Brackets - estimated weight.

HDC and LDC were loaded to AW1 night of March 13, 1973.

4. TEST EQUIPMENT AND INSTRUMENTATION

The following facilities, equipment and instrumentation were used during the acceptance testing.

4.1 FACILITIES AND EQUIPMENT

The 80 mph Rail Transit Test Track at the High Speed Ground Test Center consisting of 9.1 miles of running rails and electrified third rail was used for all performance, ride quality, noise, and EMI tests. The test track is powered by a modified General Electric U30C Diesel-Electric Locomotive rated at 3000 hp for traction or 3400 amps at 600 VDC. Two auxiliary caterpillar diesel-generator sets rated at 500 KW each (600-700 VDC) were positioned around the oval to minimize track voltage drops during high-power acceleration testing.

Figure 4-1 illustrates the basic electrical layout of the track and the locations of the power supplies.

Figure 4-2 illustrates the relationship of the running and third rails. The following additional facilities were also used:

- General Electric 44-ton, 380 hp switch engine and gondola-transition car.
- Transit maintenance building: 200 ft. long by 40 ft. wide with AC and 600 VDC power, and a 6 ft. maintenance pit.
- Office facilities in the Project Management Bldg.
- Track communications: Four-channel Motorola walkie-talkies.

4.2 INSTRUMENTATION - PERFORMANCE TESTS

4.2.1 Static test and checkout equipment used to modify and adjust the propulsion, brake components and systems at the test facility were as follows:

Equipment	Manufacturer
Oscilloscope Simulator	Tektronix
SOAC System Simulator	AiResearch (Figure 4-3)
SOAC System Monitor	AiResearch (Figure 4-4)

4.2.2 Carborne instrumentation used in the acceptance testing is outlined in the following paragraphs.

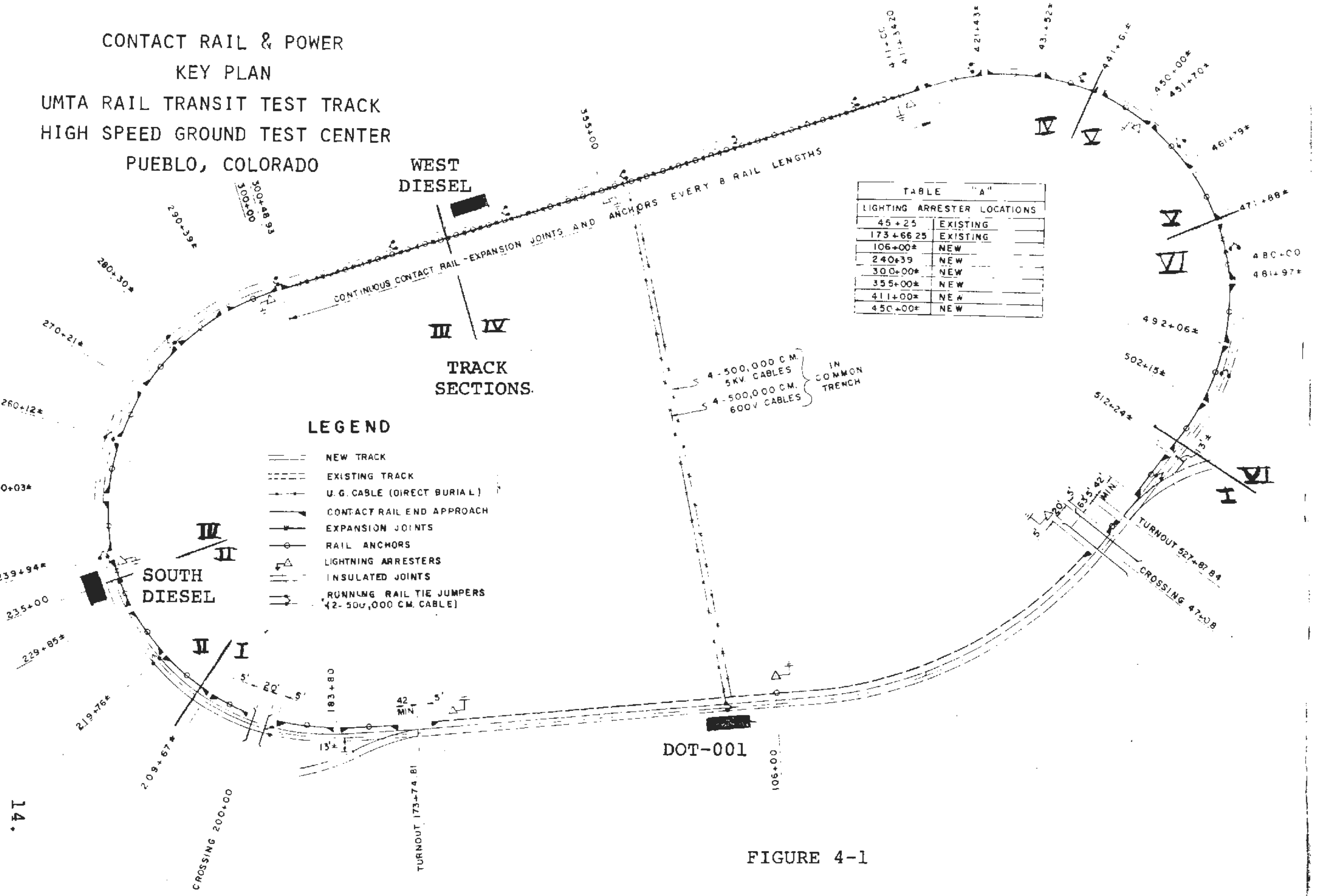
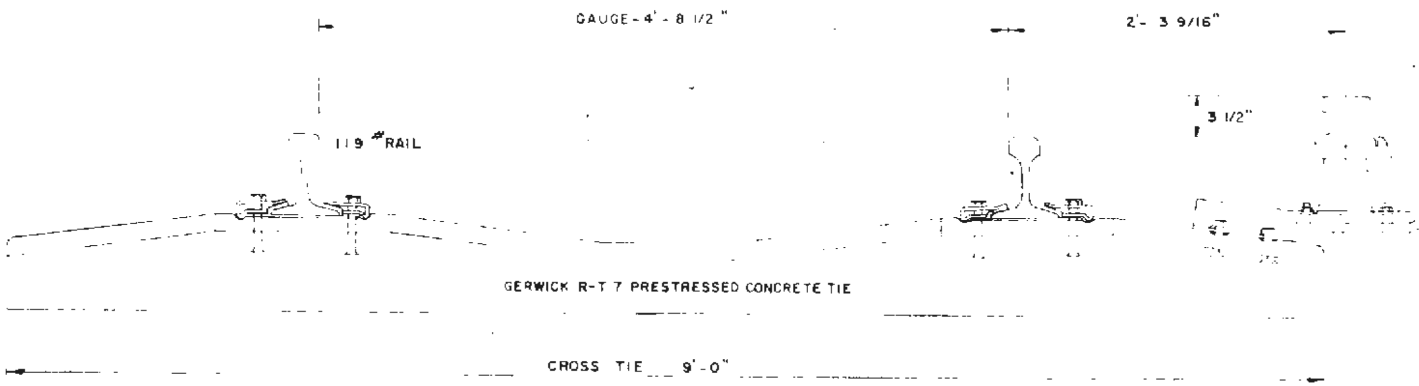

CONTACT RAIL & POWER
KEY PLAN
UMTA RAIL TRANSIT TEST TRACK
HIGH SPEED GROUND TEST CENTER
PUEBLO, COLORADO
WEST DIESEL
SOUTH DIESEL
DOT-001
TRACK SECTIONS
CONTINUOUS CONTACT RAIL - EXPANSION JOINTS AND ANCHORS EVERY 8 RAIL LENGTHS
4-500,000 C.M. 5KV. CABLES
4-500,000 C.M. 600V CABLES
IN COMMON TRENCH
LEGEND
NEW TRACK
EXISTING TRACK
U.G. CABLE (DIRECT BURIAL)
CONTACT RAIL END APPROACH
EXPANSION JOINTS
RAIL ANCHORS
LIGHTNING ARRESTERS
INSULATED JOINTS
RUNNING RAIL TIE JUMPERS (2-500,000 C.M. CABLE)
TABLE "A"
LIGHTING ARRESTER LOCATIONS
45+25 EXISTING
173+66.25 EXISTING
106+00± NEW
240+39 NEW
300+00± NEW
355+00± NEW
411+00± NEW
450+00± NEW
TURNOUT 527+87.84
CROSSING 47+08
CROSSING 200+00
TURNOUT 173+74.81
183+80
106+00
355+00
300+00
300+48.93
290+39±
280+30±
270+21±
260+12±
239+94±
235+00
229+85±
219+76±
209+67±
411+00
411+34.20
421+43±
431+52±
441+61±
450+00±
451+70±
461+79±
471+88±
480+00
481+97±
492+06±
502+15±
512+24±

FIGURE 4-1

UMTA RAIL TRANSIT TEST TRACK
HIGH SPEED GROUND TEST CENTER
PUEBLO, COLORADO



CROSS SECTION OF TRACK ASSEMBLY
SECTION IV, V & VI

FIGURE 4-2

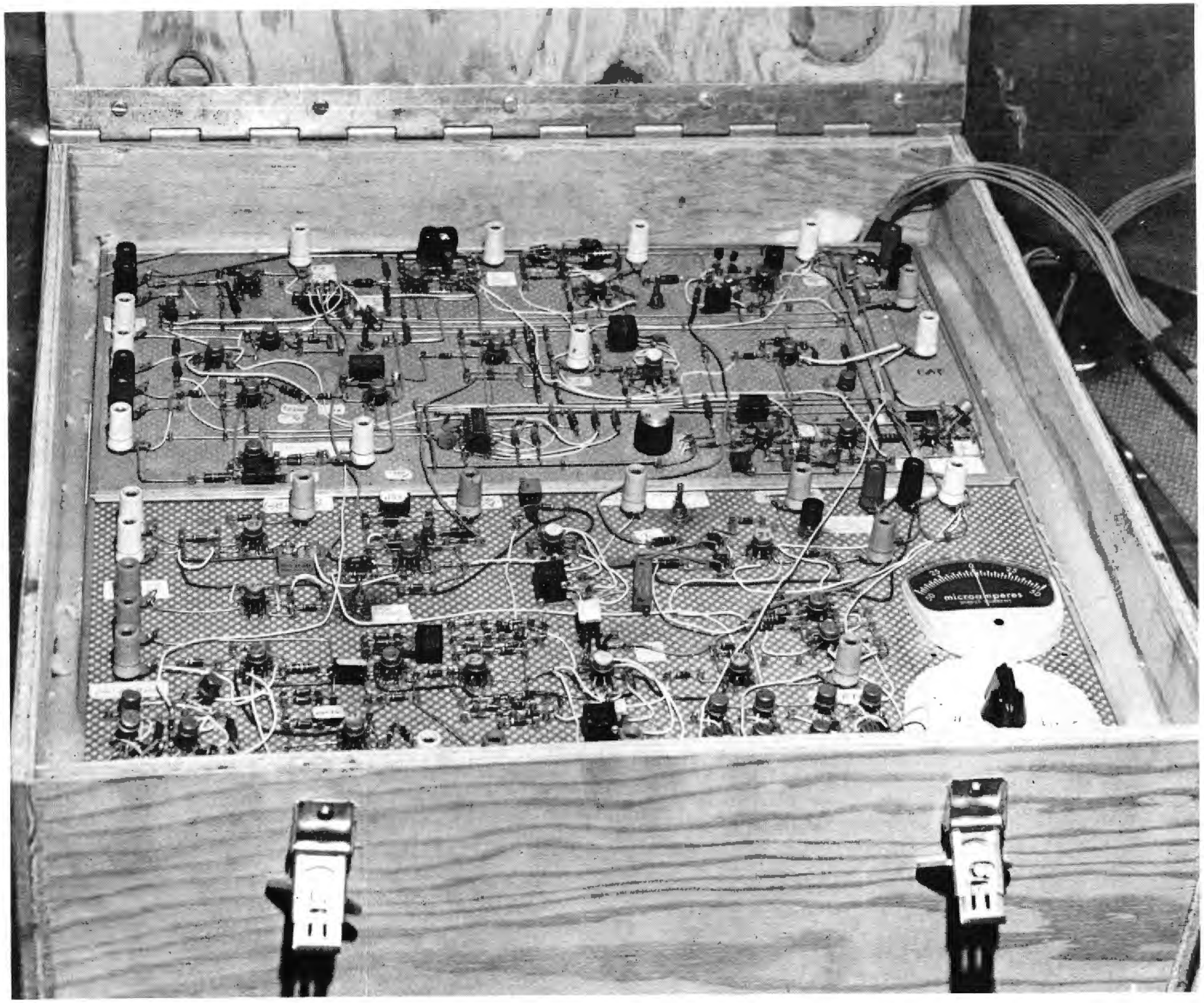


Figure 4–1. SOAC System Simulator

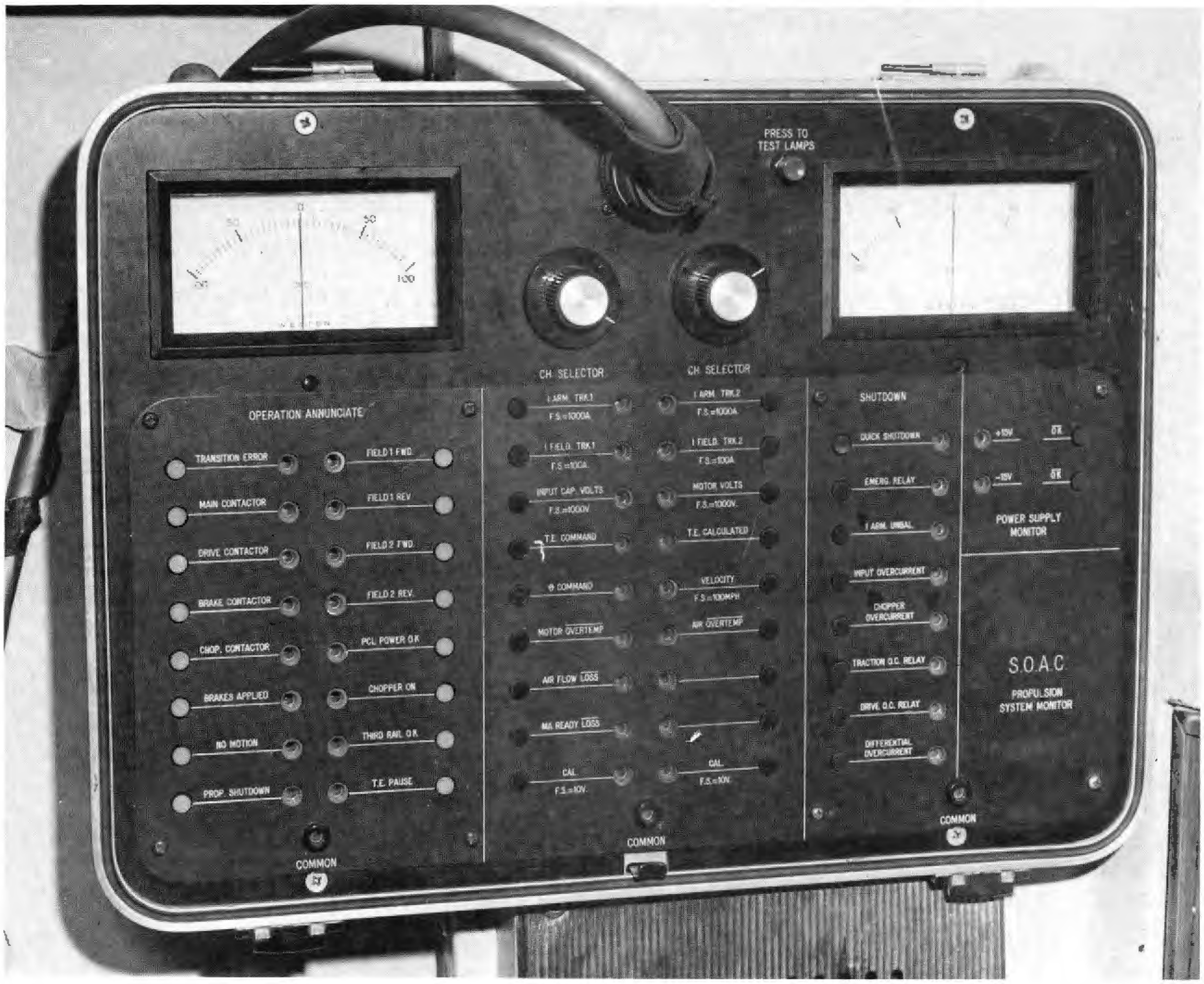


Figure 4–2. SOAC Monitor Panel

4.2.2.1 Garrett/SOAC Propulsion System Monitor Panel

This panel was temporarily mounted in the operator's cab of each car and was connected to the various low-voltage logic and feedback circuits contained in the SOAC propulsion control system.

The monitor panel performs several functions:

- o Annunciator lights for indication of propulsion and braking events and modes.

- o Fault indicator lights.

- o Calibrated meters for indication of the following:

Armature currents	Car speed
Field currents	Calculated tractive effort
Capacitor bank voltage	Thyristor firing (0) command
Motor voltage	Tractive effort command

Plus additional internal system functions.

- o Terminals for connecting the above parameters with a recording oscillograph.

4.2.2.2 CEC Recording Oscillograph (5-124A)

This recorder uses direct print, light-sensitive paper and has a maximum of 18 channels of output. Nine channels were utilized for data during the SOAC testing. Several data channels were taken directly from the output of the monitor panel with scale factors derived from the calibrated meters on the panel. The following parameters were recorded.

- o P-signal
- o Armature current (forward and aft)
- o Field current
- o Capacitor bank voltage (third rail)
- o Longitudinal acceleration
- o Car speed
- o Analog brake current (BCP command signal)

4.2.2.3 Accelerometer and Signal Conditioning Units

The longitudinal accelerometer for performance data and its power and signal conditioning unit were supplied by AiResearch. The accelerometer was secured to a 47-lb. ballast bar and oriented longitudinally in the car interior over the forward truck.

4.2.2.4 The Garrett/SOAC monitor panels remained in their respective cabs during all tests. The CEC oscillograph and accelerometer/signal conditioner were moved from car to car for the various tests. Scale factors remained essentially constant throughout the testing.

4.2.2.5 Calibration

As previously noted, the two armature currents, field current and capacitor bank voltage were calibrated from the monitor panel meters (±5 percent accuracy). The longitudinal accelerometer was calibrated using a level surface and angular displacement equivalent to several "g" values. Car speed was calibrated during constant speed runs over a measured distance. Both cab indicator error and oscillograph calibrations were determined in this manner.

The tractive effort reference or "P" wire was calibrated directly off the cab "P" wire meter. Analog brake current (BCP command) was referenced to the cab BCP gauge and gauge installed on the rear truck. The event mark was used both as a baseline reference for trace deflection and as a track distance or event reference.

The oscillograph was operated during each test record with a paper speed sufficient to detail the specific car characteristic being tested. Generally, paper speeds of .25 and 1.0 inches per second were used. Timing lines printed on the paper during recording were calibrated against a stopwatch, using the event marker.

Time and distance data were obtained using stopwatches and actual ground distance measurements.

4.3 INSTRUMENTATION - RIDE QUALITY

(See Appendix III)

4.4 INSTRUMENTATION - NOISE MEASUREMENTS

(See Paragraph 6.10)

4.5 INSTRUMENTATION - EMI TESTS

(See Appendix IV)

5. TEST PROCEDURES

Test procedures used during the SOAC acceptance tests generally follow the procedures outlined in Section V.C. of the D174-10007-1 SOAC Test Document. They are summarized as follows:

5.1 ACCELERATION (Maximum)

- o Position car on one end of the 400 ft. level tangent track (station 298 + 00 59 338 + 00).
- o Put master controller handle in full power position while still in "deadman" position.
- o Start recorder.
- o Twist handle from "deadman" to operating condition.
- o Record data as required.
- o Maintain controller position until maximum speed of 80 mph is attained.

5.2 AUTOMATIC SPEED MAINTAINING SYSTEM (ASMS)

- o Select speed limit of 3 mph.
- o Put master controller handle in full power position while still in "deadman" position.
- o Start recorder.
- o Twist handle from "deadman" to operating condition. Handle remains in full power position for remainder of ASMS Tests.
- o Record data as required.
- o Select additional speed limits in following sequence: 15, 25, 35, 50, 70, 80, 70, 50, 35, 25, 15, 3.
- o Maintain each above speed a sufficient time to record system speed accuracy.

5.3 BRAKING TESTS (Full Service Rates)

- Approach braking course (station 298 + 00 to 338 + 00) with tractive effort handle in position to stabilize at test speed.
- Start recorder.
- At the outer marker for the course release the handle to its "deadman" position for full service braking.
- Bring car to complete "hands-off" stop.
- Record time and distance to stop.

The above procedure is used for blended braking, dynamic braking only, and with slight modification for service friction braking only. For friction braking the dynamic brake must be cancelled by a switch (airflow "loss") for test purposes just prior to initiating braking.

5.4 BRAKING TESTS (Emergency)

- Procedure similar to paragraph 5.3 except at the outer marker for the course, activate the motorman's "Emergency Stop" pushbutton.

5.5 SERVICE DUTY CYCLES

The service duty cycles are repetitive driving cycles consisting of acceleration to 80 mph at maximum rate, immediate transition to full service braking followed by a 30-second station stop. The cycle is repeated 24 times with blended braking and 24 times with service friction braking only.

5.6 RIDE QUALITY

(See Appendix III)

5.7 NOISE TESTS - INTERIOR

5.8 NOISE TESTS - WAYSIDE

5.9 EMI TESTS

(See Appendix IV)

6. TEST RESULTS

6.1 VISUAL TESTS

The following visual and check tests were performed on each car prior to the start of the performance acceptance tests.

6.1.1 Place car on trucks over a pit which will allow safe access to undercar equipment. Set handbrake.

6.1.2 Remove motor cooling air exhaust covers, shipping covers, freight service adapters and coupler adapters.

6.1.3 Visually inspect for damage, loose parts or missing items.

6.1.4 Install traction motor brushes and disconnect traction motor flexible ducts. Tighten all drain plugs, drain cocks and inspection covers.

6.1.5 Turn on "BATT", "CAB LIT", "MAIN LT", "RADIO" circuit breakers on LVCBP and HVCBP. Observe that lighting and radio function.

6.1.6 Provide 600 VDC. Turn on one at a time the following, and check for function and unusual noise or vibration.

Alternator field
Motor alternator field
Dynamic brake
Battery charger
Traction motor cooling #1
Traction motor cooling #2
Air brake
Brake compressor

6.1.7 Turn on motor alternator and traction cooling blowers and allow to run for 15 minutes (or until traction cooling ducts are free of debris).

6.1.8 Disable third rail power and reconnect motor flexible ducts.

6.1.9 Restore third rail power and turn on all circuit breakers and observe the following:

- Motor alternator running
- Traction motor cooling blowers running
- Air compressor running
- All lights on
- Headlights and taillights function
- Side doors function
- Main reservoir pressure 150 psi
- Air conditioning blower running

- o Windshield wiper, washer and defroster function
- o Horn blows
- o Emergency valve functions
- o Track trip functions
- o Trainline functions for cars coupled
- o Hostling mode operation
- o Pantograph extension and retraction
- o End door operation

6.1.10 Set tread brakes (58-64 psi control pressure, 90,000-lb. and 91-97 psi control pressure, 132,000 lb. car).

6.1.11 Turn on instruments and release handbrake.

6.1.12 <u>Rolling Checkout Tests</u>

6.1.12.1 Put direction control switch in FORWARD.

6.1.12.2 Move controller to 1/4 power position. Accelerate to 10 mph; monitor motor current. Stop the test if motor current exceeds 500-amp peak.

6.1.12.3 Brake car by moving controller to 1/4 brake position. Motor current should not exceed 250 amps.

6.1.13 <u>Performance Setup Tests</u>

6.1.13.1 Accelerate car in full power position to 20 mph. Monitor motor current and acceleration rate. Stop test if:

- o Motor current exceeds 1700 amps.
- o Acceleration rate exceeds 3.0 mphps.
- o Peak acceleration rate is less than 2.5 mphps.
- o Any circuit breaker trips.
- o Wheels slide.

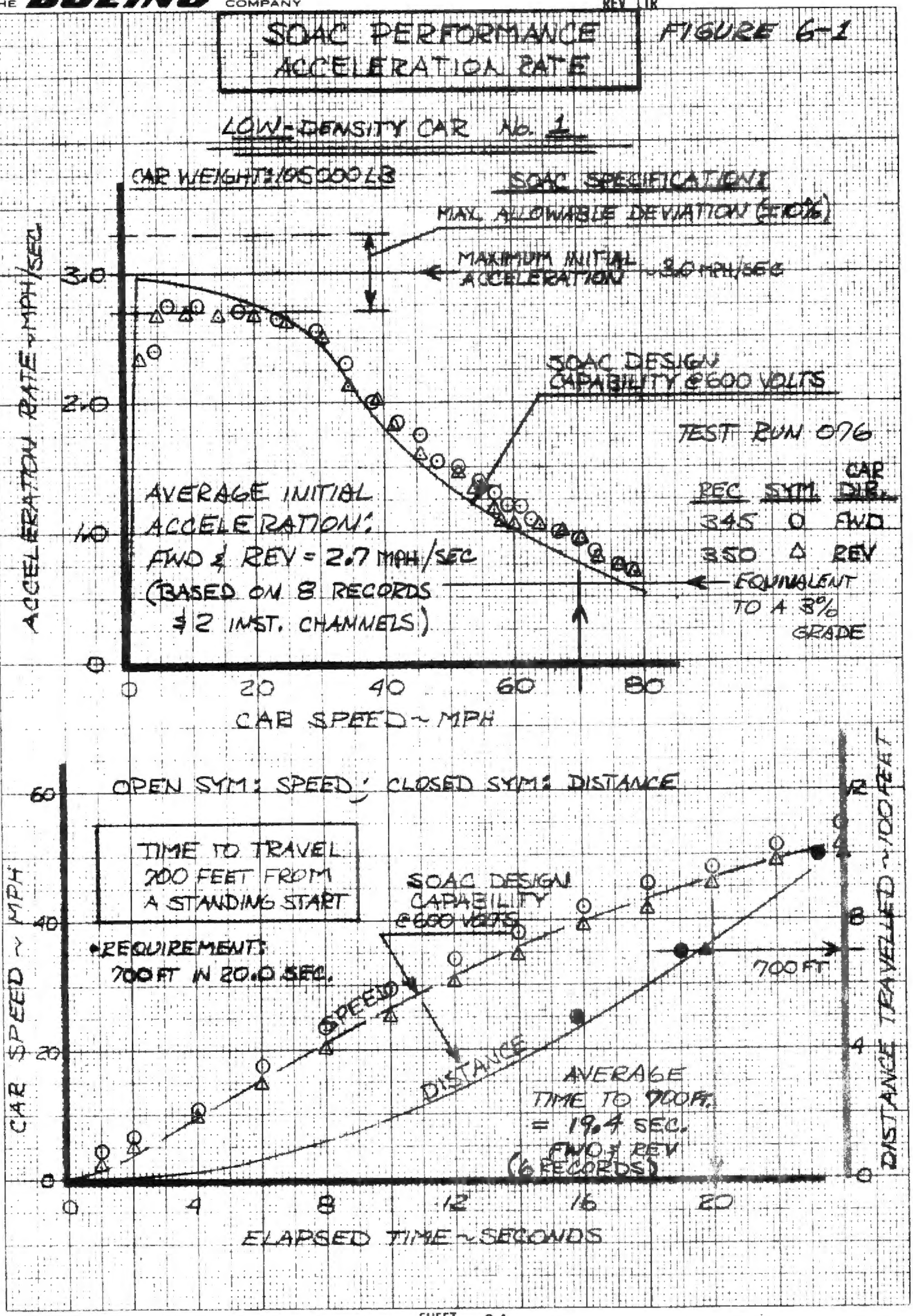
6.1.13.2 Brake car in full service position. Stop test if:

- o Motor current exceeds 1900 amps.
- o Motor current is zero.
- o Wheels slide; circuit test only.
- o Deceleration rate exceeds 3.0 mphps.
- o Deceleration rate is less than 2.0 mphps.

6.1.13.3 Repeat step 6.1.13 adjusting acceleration and deceleration rate to within 2.7 to 3.3 mphps peak values.

6.2 <u>ACCELERATION</u>

The acceleration performance and time to travel 700 feet from a standing start are shown on Figure 6-1 for the low-density car.


SOAC PERFORMANCE
ACCELERATION RATE
FIGURE 6-1
LOW-DENSITY CAR No. 1
CAR WEIGHT: 105000 LB
SOAC SPECIFICATION:
MAX. ALLOWABLE DEVIATION (±10%)
MAXIMUM INITIAL ACCELERATION - 3.0 MPH/SEC
SOAC DESIGN CAPABILITY @ 600 VOLTS
TEST RUN 076
REC SYM CAR DIR.
345 ○ FWD
350 △ REV
AVERAGE INITIAL ACCELERATION:
FWD & REV = 2.7 MPH/SEC
(BASED ON 8 RECORDS & 2 INST. CHANNELS)
EQUIVALENT TO A 3% GRADE
ACCELERATION RATE ~ MPH/SEC
CAR SPEED ~ MPH
OPEN SYM: SPEED; CLOSED SYM: DISTANCE
TIME TO TRAVEL 700 FEET FROM A STANDING START
REQUIREMENT: 700 FT IN 20.0 SEC.
SOAC DESIGN CAPABILITY @ 600 VOLTS
SPEED
DISTANCE
700 FT
AVERAGE TIME TO 700 FT. = 19.4 SEC. FWD & REV (6 RECORDS)
CAR SPEED ~ MPH
DISTANCE TRAVELLED ~ 100 FEET
ELAPSED TIME ~ SECONDS

Acceleration testing was completed on the 4000-ft. section of level tangent track with a maximum speed of 79 mph reached at the end of the section. During the test, third rail voltage was a nominal 620 volts (+). Tests were made in the forward and reverse car direction for two runs to the 700-ft. point and one run to 80 mph in each direction. Figure 6-2 presents a complete time-and-distance-to-speed characteristics for the low-density car.

The initial SOAC design capability is shown on Figures 6-1 and 6-2 as a comparison to the test data. The acceleration capability of the car is equal to or better than the initial design capability above the motor base speed of approximately 30 mph. The reduced acceleration rate below 30 mph is based on the revised current limits selected to maintain the braking rate within allowable tolerances.

The acceleration performance of the high-density SOAC is presented in Figures 6-3 and 6-4 in formats similar to Figures 6-1 and 6-2 previously shown for the low-density SOAC. The performance is essentially similar to the low-density car. The initial SOAC design capability is shown on Figures 6-3 and 6-4 for comparison.

Two-car train acceleration testing was performed to determine the peak initial rate and the time to 700 ft. distance. The large power demand of the two cars (3000-3200 amps) resulted in a large track voltage drop from the nominal 600-650 volts. Test run voltages of 500-550 volts were experienced which resulted in a reduced performance level above about 30 mph. Because of this fact the performance curves for the two-car train are not included in this report. The data of Table II verify that the initial acceleration rate and time to 700 ft. are within specifications and that the two-car train performance is similar to each car operated separately.

6.3 MAXIMUM SPEED AND ASMS

The service maximum speed of the cars is 80 mph based on the test data of Figures 6-1 and 6-3, an acceleration rate of approximately .65 mphps is available at 80 mph. Both cars have exceeded 90 mph in a two-car consist during controlled test conditions.

The Automatic Speed Maintaining System (ASMS) provides the capability to control and limit car speed to the 80 mph maximum or additional speeds of 3, 15, 25, 35, 50, or 70 mph. This system was tested using the procedures contained in paragraph 5.2.With the control handle in the full power position the car will accelerate to the selected speed at the maximum acceleration rate for the car's weight. (Rates for a 105,000-lb. car are shown in Figures 6-1 and 6-3.

FIGURE 6-2

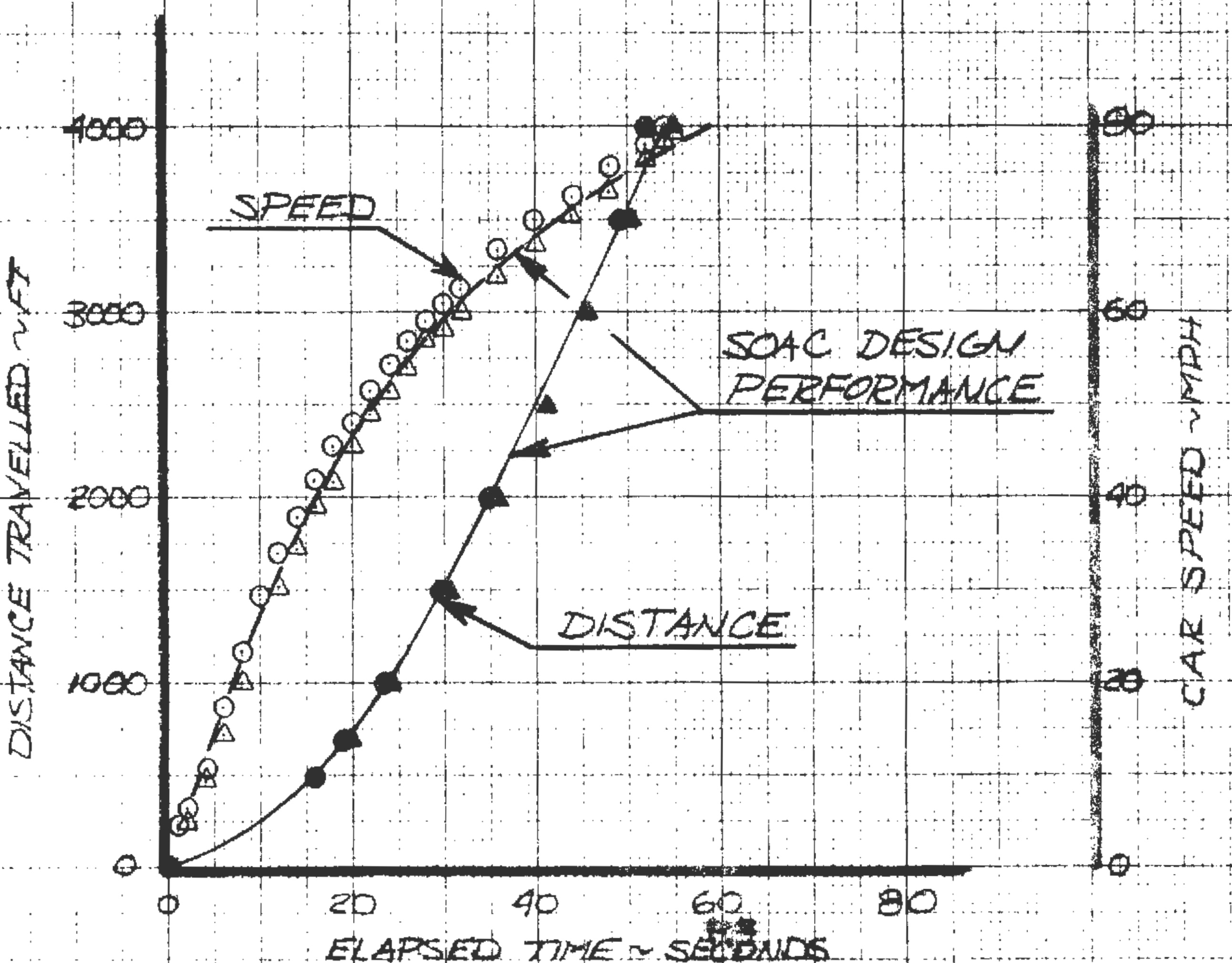
SOAC PERFORMANCE
TIME AND DISTANCE TO SPEED

LOW DENSITY CAR (No. 1)

DATA BASIS:
1) HSGTC TEST RUN NO. 076
2) THIRD RAIL VOLTAGE GREATER THAN OR EQUAL TO 600Vdc EXCEPT AS NOTED.
3) TEST LOCATION: TRACK STA. 298+00 to 338+00 LEVEL-TANGENT TRACK

CAR WEIGHT: 105000 LB

SYM.	CAR DIRECTION
O	FORWARD
Δ	REVERSE



SOAC PERFORMANCE ACCELERATION RATE

FIGURE 6-3

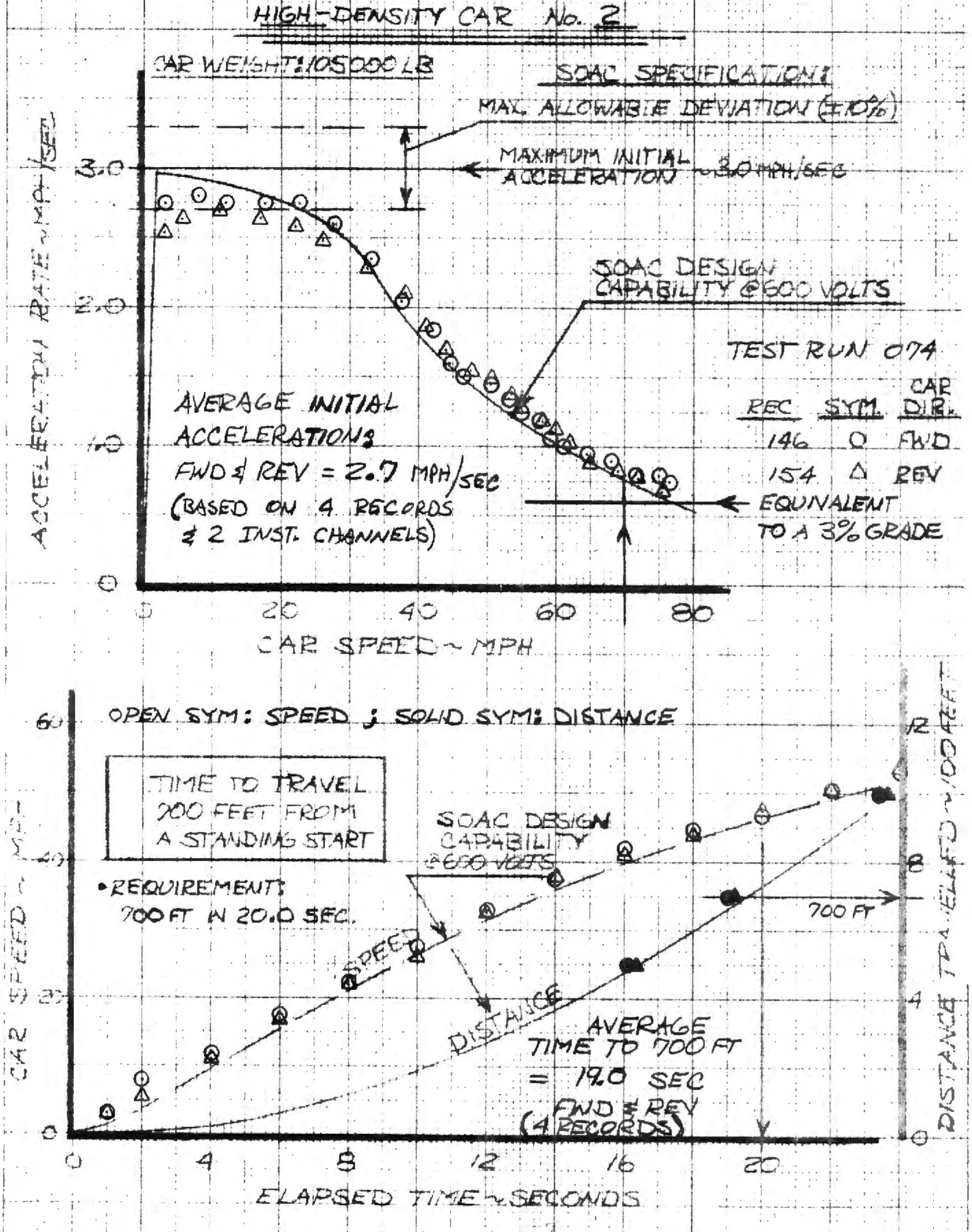


FIGURE 6-4

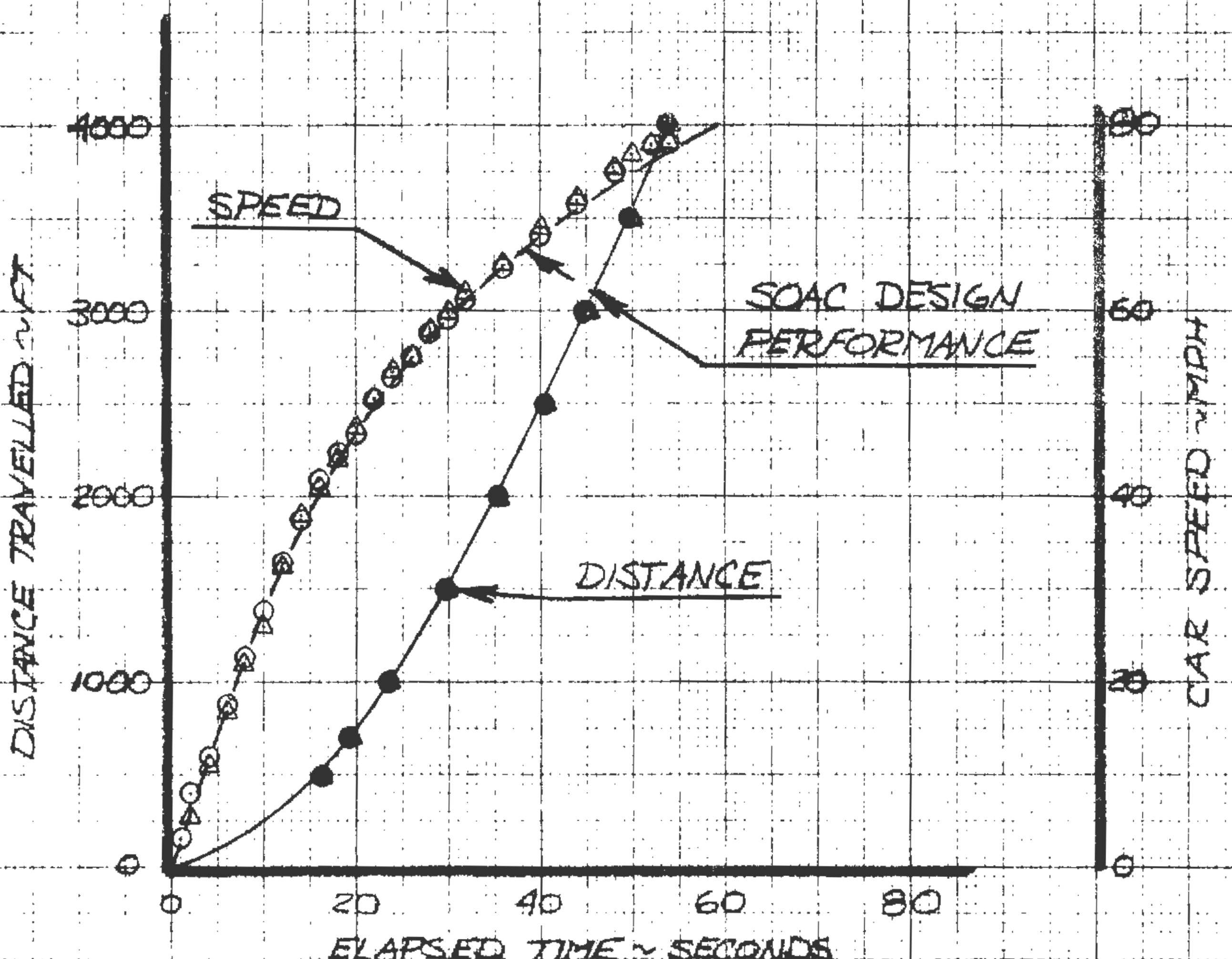
SOAC PERFORMANCE
TIME AND DISTANCE TO SPEED

HIGH DENSITY CAR (No. 2)

DATA BASIS:
1) HSGTC TEST RUN No. 074
2) THIRD RAIL VOLTAGE GREATER THAN OR EQUAL TO 600Vdc EXCEPT AS NOTED.
3) TEST LOCATION: TRACK STA. 298+00 to 338+00 LEVEL-TANGENT TRACK

CAR WEIGHT: 105000 LB

SYM.	CAR DIRECTION
O	FORWARD
Δ	REVERSE



As the selected speed is approached within 2 to 3 mph the tractive effort reference signal ("P" signal) is automatically reduced until the desired speed is maintained to within ±1 mph. The P signal is then adjusted automatically to regulate the tractive (or brake) effort required to maintain the selected speed on various track grades or curves. The control handle may remain in the full power position at all times, or it may be set at a reduced level which results in at least the P signal required to produce the "balancing" tractive effort. The P signal meter in the cab reads the P value associated with the ASMS and not the actual control handle position. The band for speed regulation enlarges as the controller is decreased from the P = 1.0 amp position: ±1 mph at P = 1.0 to approximately -2 to -3 mph at "balancing" P value.

The ASMS pushbuttons may also be used to decrease speed from a previously selected value. With the control handle still in the full power position, activating a command for a lower speed will automatically aupply full service blended braking until the car speed has been reduced to the selected value. Speed regulation about the new value is again ±1 mph.

A speedometer calibration curve for the low density car is shown in Figure 6-5. The actual speed was determined over a timed, measured course on level tangent track.

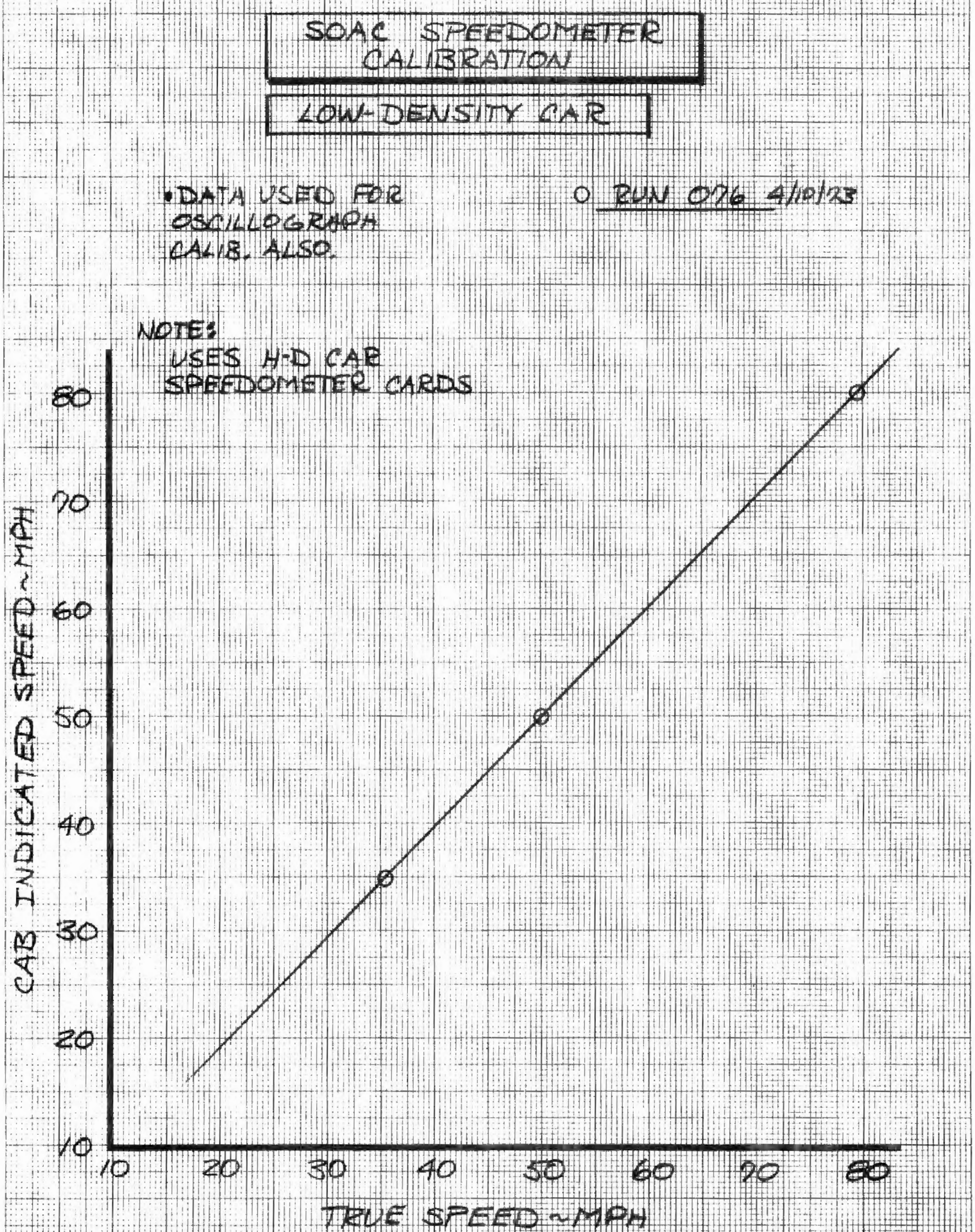
The ASMS on the high-density car performs similarly to that on the low-density car as previously stated. The complete range of tests noted for the low-density car were conducted on the high-density car; speed regulation was again within ±1 mph of selected speed with the tractive effort handle in the full power position. A speedometer calibration for the high-density car is shown in Figure 6-6.

6.4 BLENDED AND DYNAMIC BRAKING

Figure 6-7 presents the blended service braking and dynamic braking (only) capability for the low-density car in terms of deceleration rate and stopping distance. The upper scale illustrates the blended and dynamic brake rates during two test records from 80 mph. The design characteristics of the dynamic brake system are shown on this upper scale in comparison to the test data.

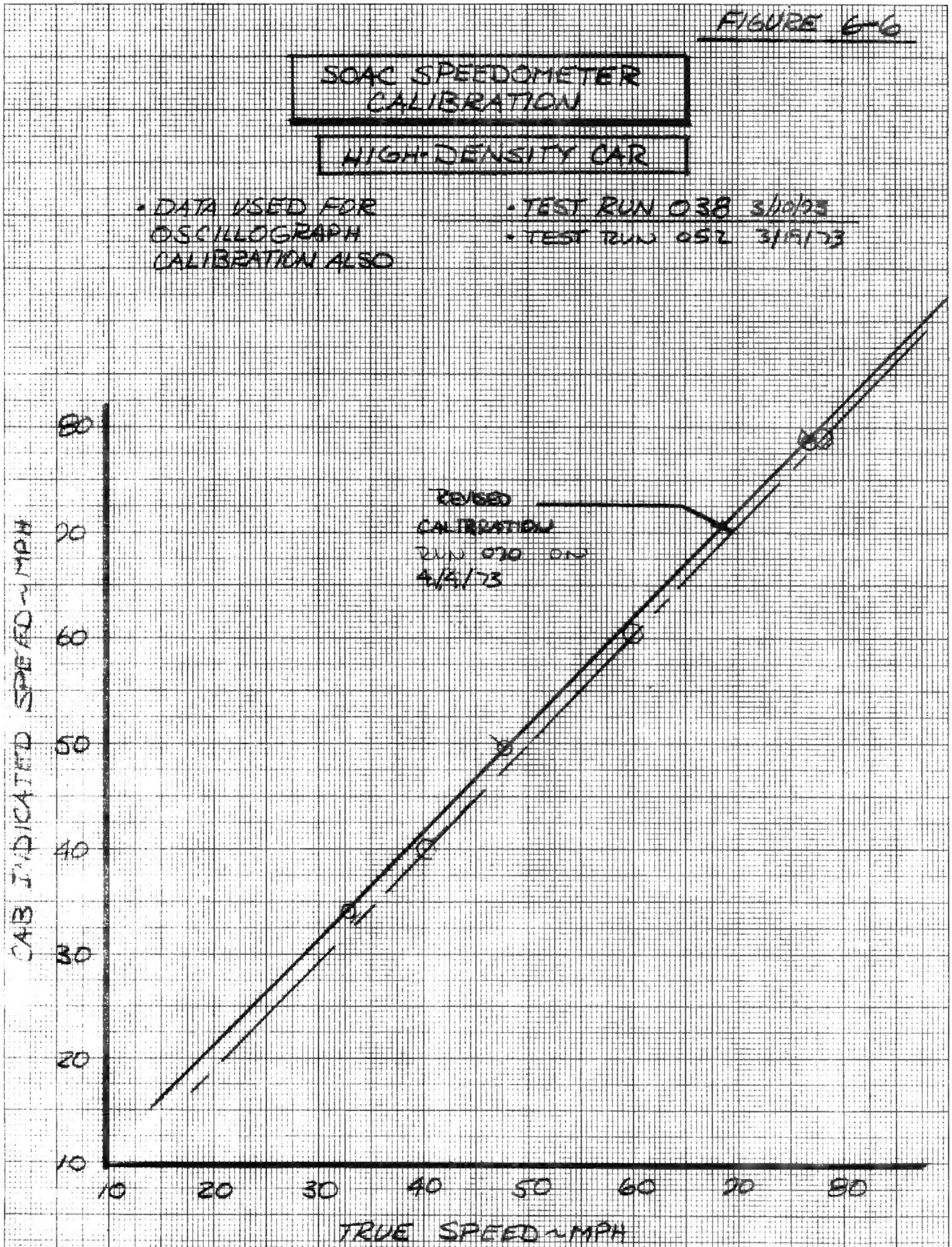
The dynamic brake alone, without service friction braking, is capable of providing the SOAC's nominal deceleration rate of 3 mphps (±10%) down to a speed of approximately 3 mph. The increased brake rate associated with the normal configuration of blended dynamic/friction braking is due to the inshot pressure of approximately 8 psi sent to the friction brake cylinders under all braking commands.

FIGURE 6-5



P. Brown
4/10/73

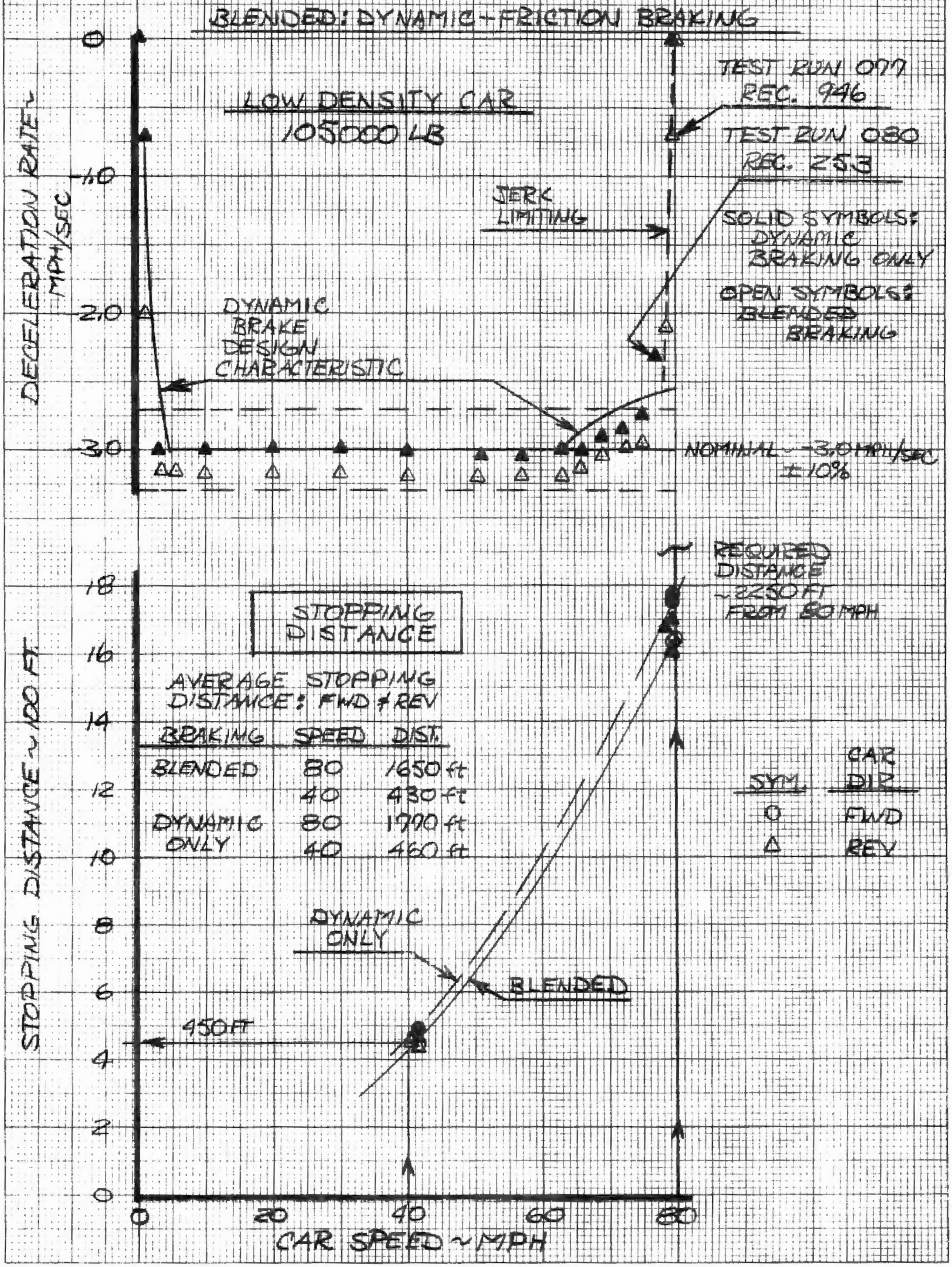
FIGURE 6-6



P. Brown
3/10/73

SOAC PERFORMANCE SERVICE BRAKING

FIGURE 6-7



Stop distances from speeds of 40 mph and 80 mph are shown on the lower scale of Figure 6-7. Data was taken at the specification speeds of 40 and 80 mph for the final acceptance test. The shape of the stopping distance curves is based on additional preliminary data when the propulsion system was adjusted to a lower braking rate (armature current).

Figure 6-8 presents the results of the blended braking and dynamic braking (without friction brakes) tests, or the high-density cars; Figure 6-9 for the two-car train.

6.4.1 System Response Characteristics - Blended Braking

Figure 6-10 illustrates a typical transition from the propulsion mode to the blended braking mode at 40 mph car speed. At time t = 0, the master controller "deadman" handle is released, providing a step input to the traction system. In the next .5 second, the jerk rate limiting circuit removes the tractive effort at a rate of 425 amps per second until zero armature current is attained.

During the .7 second "control dead time" the field current is reduced to zero, the "drive" contactors open, the "brake" contactors close, and the motor field current is reversed in sense by the field control. After the "dead time", the jerk limit circuitry again limits the rate of change of (braking) current, the field current is ramped to maximum value, and the chopper controls the armature current to achieve the selected braking effort (deceleration rate). Full service rate is attained approximately 2.5 seconds after release of the "deadman". The stopping distances shown in the performance plots reflect the jerk rates and dead times as shown in Figure 6-10.

6.4.2 Dynamic Brake Failure Simulation

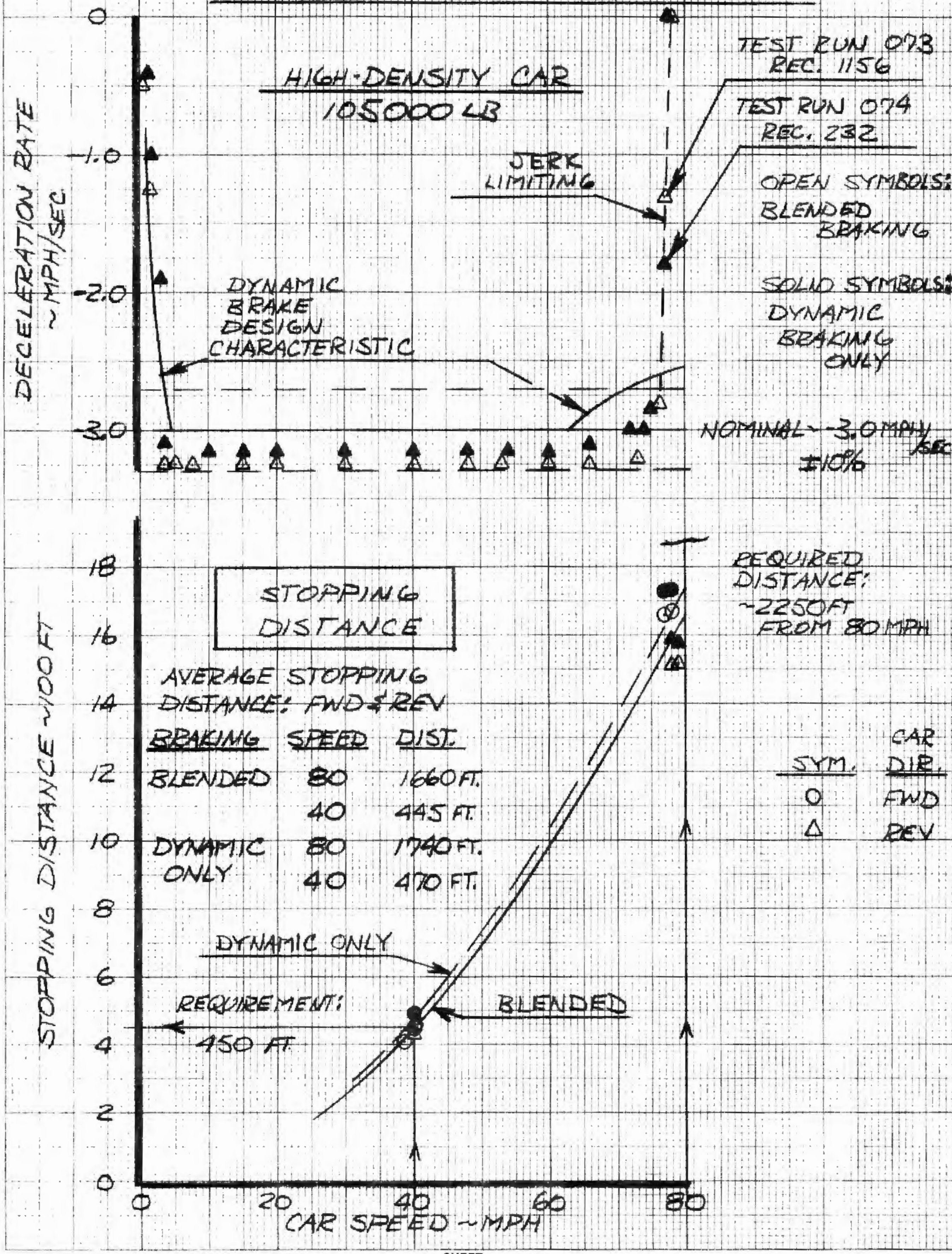
During the test program, but prior to the final adjustment of blended braking rates, several simulated dynamic brake failures during normal blended braking from 80 mph were completed. These tests were accomplished to determine the time and rate response of the friction brake backup system and the impact on stopping distance. These tests were performed on the high-density car and Figure 6-11 illustrates a time history of one simulated dynamic brake failure. Since this data was obtained during testing prior to the final adjustments of the dynamic brake current limits, the performance thus reflects slightly lower deceleration rates and slightly longer stopping distances than the data of Table II and Figure 6-8.

Two stops with simulated dynamic brake failures were accomplished; both stops within the 2250 ft. required distance from 80 mph. The following table outlines the test results.

SOAC PERFORMANCE SERVICE BRAKING

FIGURE 6-8

BLENDED: DYNAMIC + FRICTION BRAKING

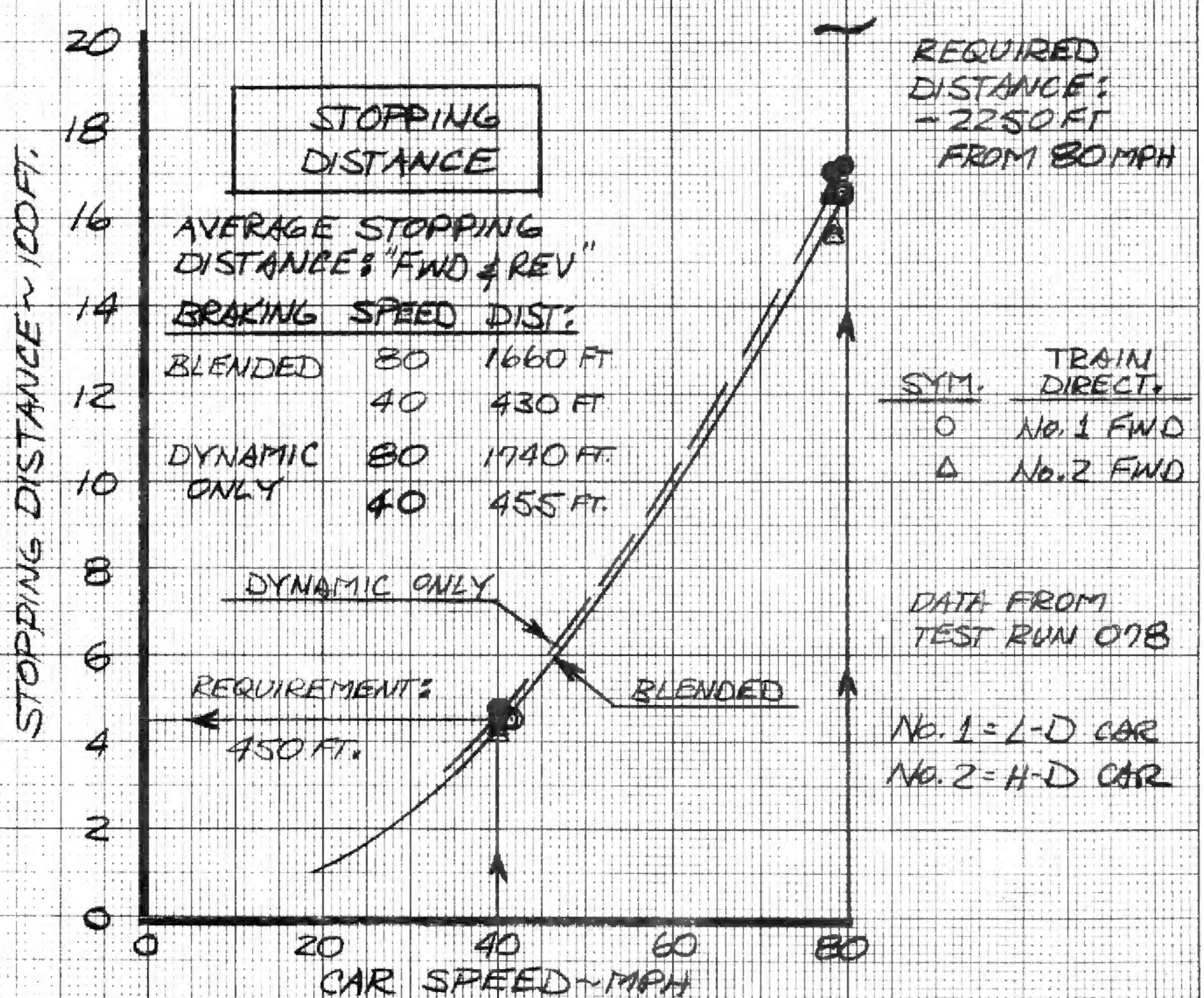


SOAC PERFORMANCE SERVICE BRAKING

FIGURE 6-9

BLENDED: DYNAMIC + FRICTION BRAKING

TWO-CAR TRAIN
105000 LB



TIME CONSTANTS FOR BLENDED BRAKING APPLICATION

SOAC TWO-CAR TRAIN DATA
105,000 LB

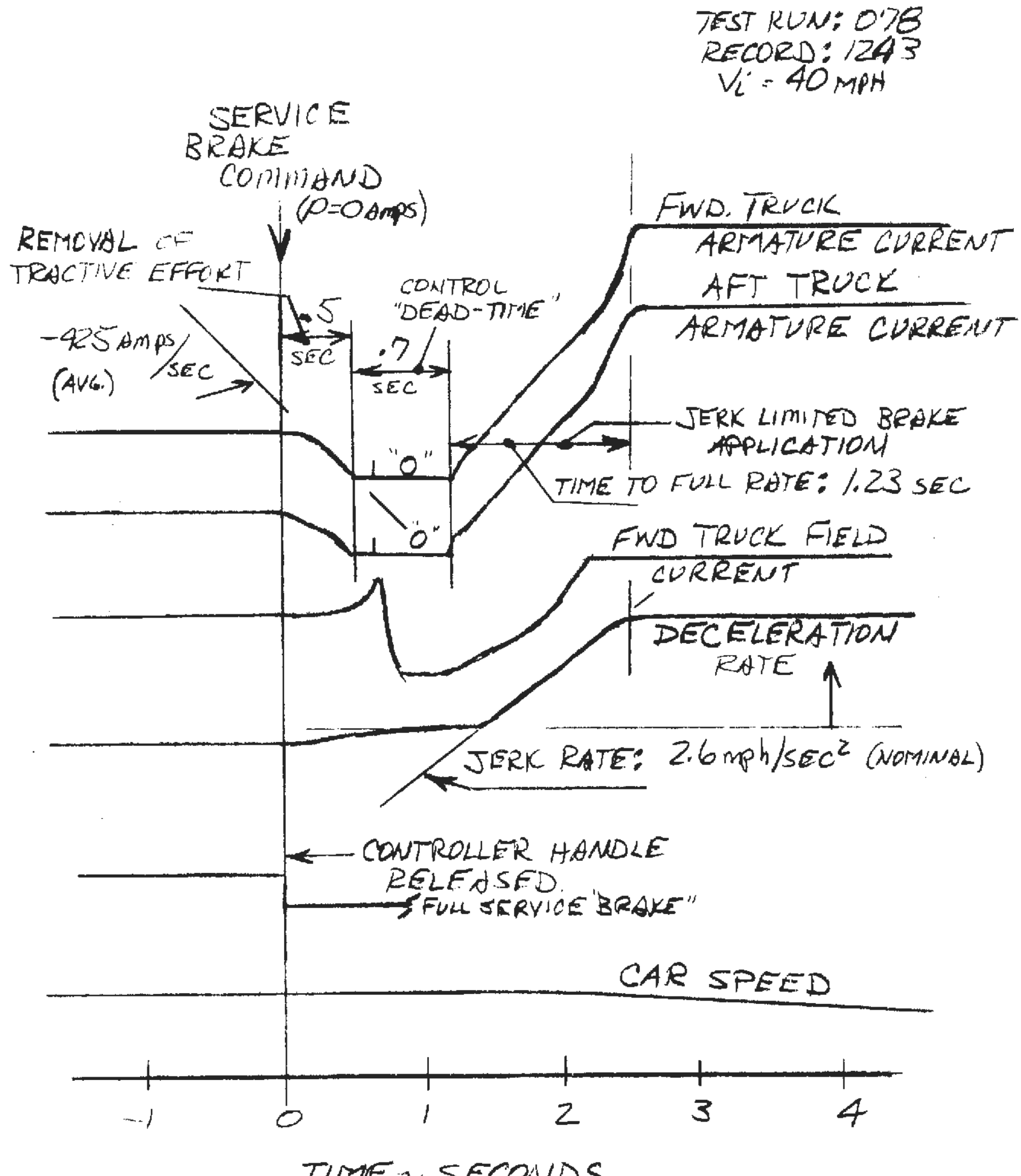


FIGURE 6-10

TIME CONSTANTS FOR TRANSITION FROM DYNAMIC TO SERVICE FRICTION BRAKING

SOAC H-D CAR 105000LB

TEST RUN: 041
RECORD: 146

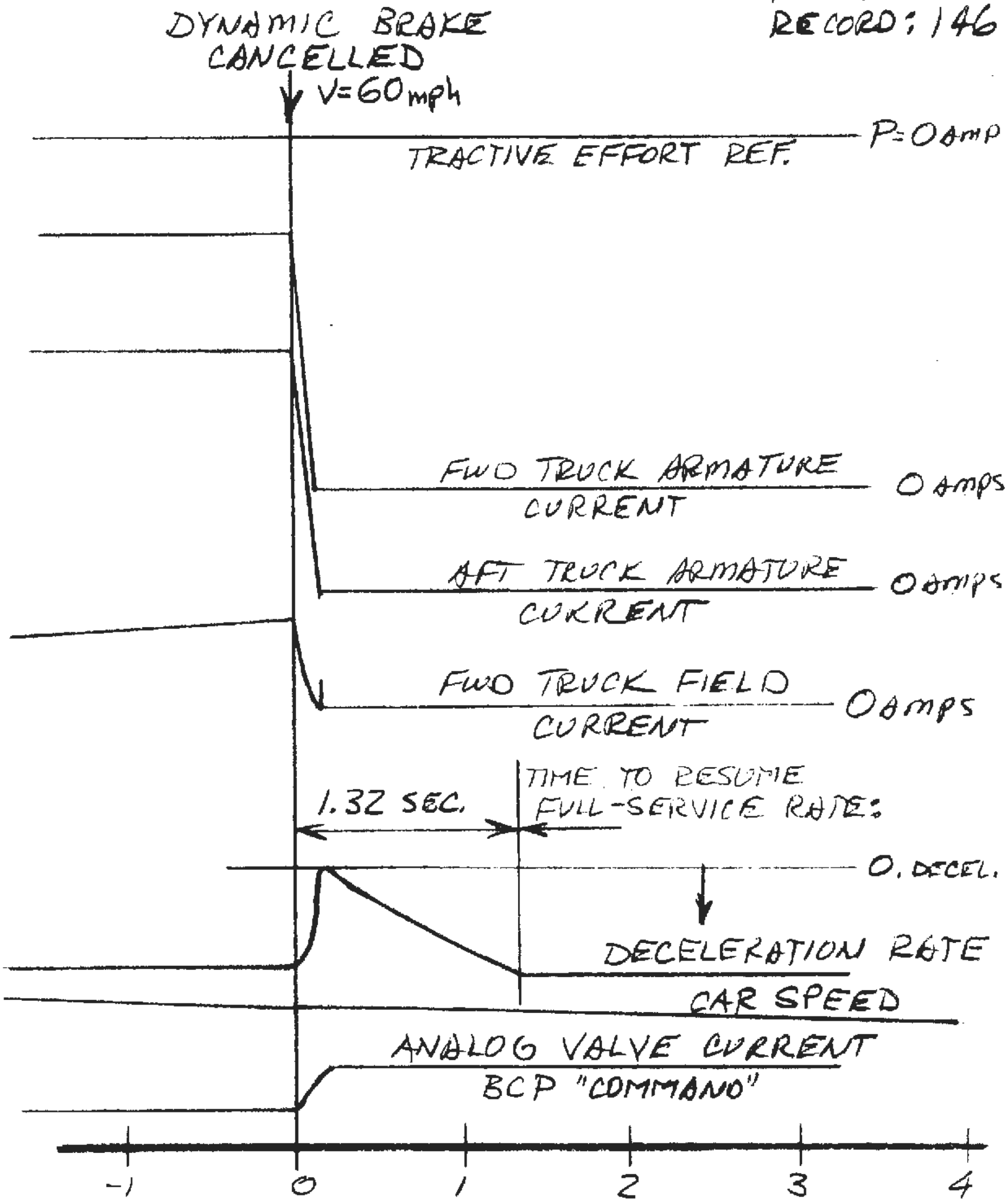


FIGURE 6-11

INITIAL SPEED (TRUE)	FAIL DYNAMIC BRAKE @ SPEED	TIME TO STOP	DISTANCE TO STOP
	FORWARD DIRECTION		
76 mph	59 mph	29.0 sec.	1852 ft.
76 mph	Blended Svc.	29.3 sec.	1698 ft.
	REVERSE DIRECTION		
77 mph	60 mph	28.8 sec.	1766 ft.
77.5 mph	Blended Svc.	29.2 sec.	1719 ft.

In each of the above car directions, the stop with the simulated failure is compared with a similar stop with blended braking. As noted above, the stopping distance is increased by approximately 50 to 150 ft. from 76-77 mph. The reduced time-to-stop noted on the "failure" stops may be attributed to the different brake rate vs. speed characteristic between blended and friction brake systems (see Figures 6-8 and 6-12). Test procedure for the simulated dynamic brake failures was similar to the procedure used for friction braking (paragraph 5.3) except that the dynamic brake was cancelled at 60 mph instead of just prior to initiating braking at 80 mph. The stops were completed using service friction brakes only following the simulated dynamic brake failure at 60 mph.

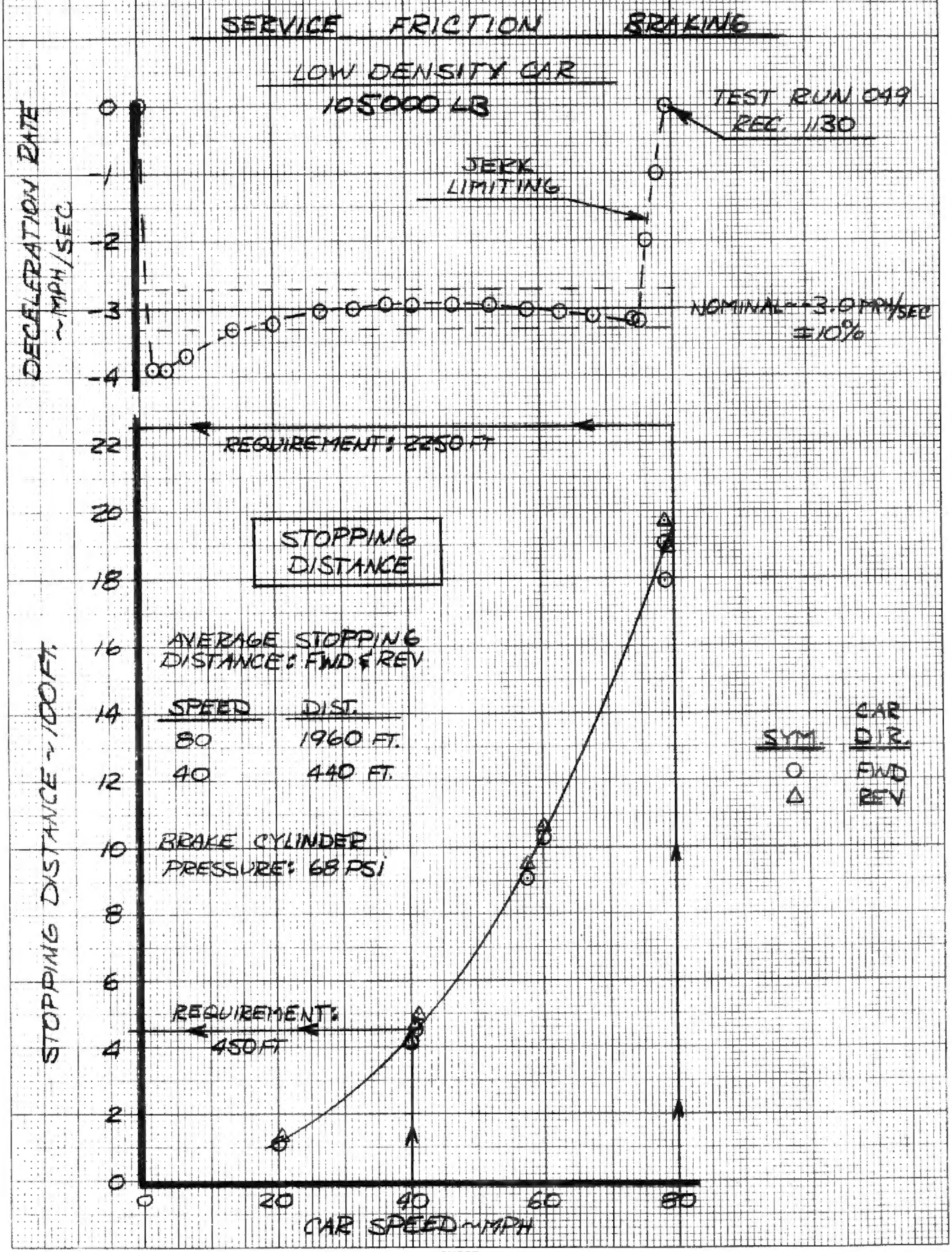
6.5 SERVICE FRICTION BRAKING

The service friction brake capability (without dynamic brake) is shown in Figure 6-12 for the low-density car. Sample test data from a stop from 80 mph is shown on the upper scale and stopping distances from speeds of 20, 40, 60 and 80 mph are shown on the lower scale. Two stopping tests in each direction from each speed were used to determine the specification compliance at 40 and 80 mph and the general shape of the stopping distance curve. Brake cylinder pressure is set to 68 psi as measured on the cab pressure indicator. Figures 6-13 and 6-14 present similar data for the high-density car and the two-car train.

The deceleration rates shown on Table II are based on average over the speed range of all test points shown in Figures 6-12, 6-13 and 6-14. The deceleration rate for each stop was determined using both the accelerometer and by differentiating the calibrated speedometer channel on the oscillograph. A time period of 10 seconds or greater was used where possible to determine the average deceleration rate during a test record.

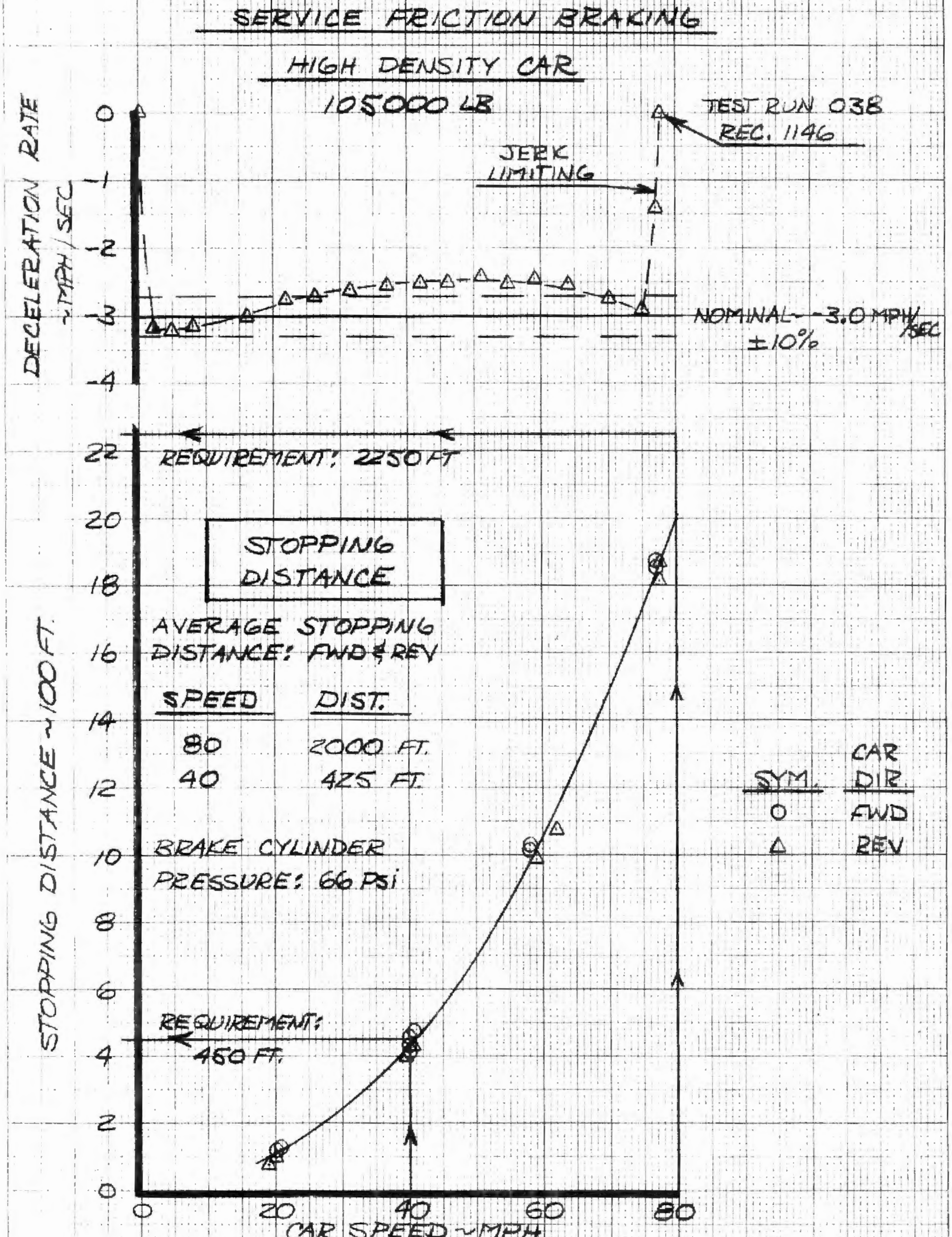
SOAC PERFORMANCE FRICTION BRAKING

FIGURE 6-12



SOAC PERFORMANCE
FRICTION BRAKING

FIGURE 6-13



SOAC PERFORMANCE FRICTION BRAKING

FIGURE 6-14

SERVICE FRICTION BRAKING

TWO-CAR TRAIN
105000 LB

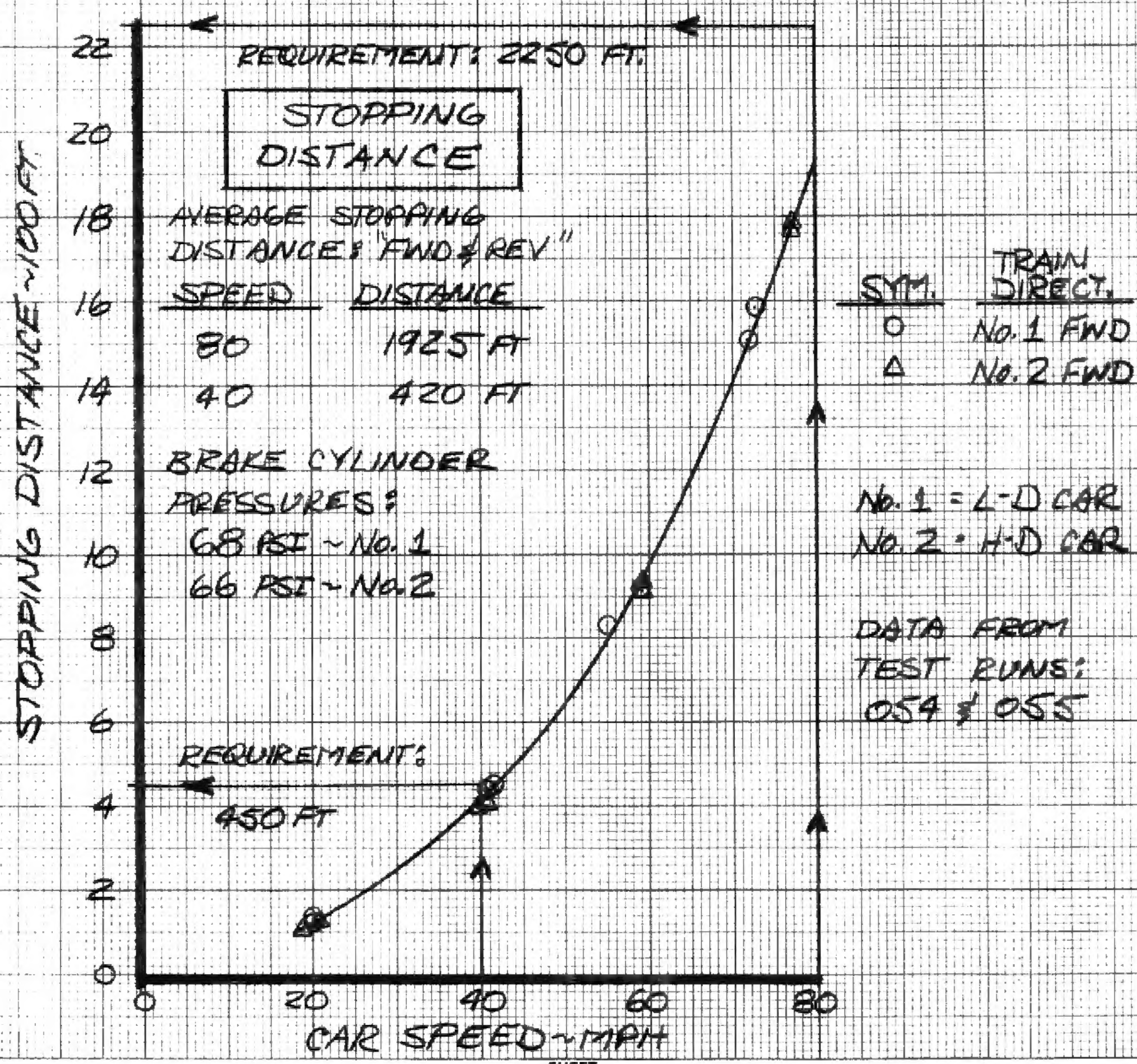


Figure 6-15 illustrates the time constants and jerk rates associated with application of full service friction braking using a step input command.

6.6 EMERGENCY FRICTION BRAKING

Figure 6-16 presents the results of brake on the low-density car tests using the emergency brake system which consists of friction brakes only. As before, the upper scale illustrates a typical test stop from 80 mph while the lower scale shows the resulting stopping distances for the 14 emergency stops performed during the tests. Emergency brake cylinder pressure is set at 78 psi for both cars.

Test results for the high-density car and the two-car train are shown in Figures 6-17 and 6-18 respectively. As with the service friction and blended braking data, the deceleration rate shown in Table II is an average of all runs shown in Figures 6-16, 6-17 and 6-18.

The time constants associated with an emergency brake application are shown in Figure 6-19. As noted, full brake pressure (and deceleration rate) are reached in seconds.

6.7 JERK RATE

The time rate of change of acceleration or deceleration while under control of the jerk rate limiting system was determined by evaluating the time-slope of the accelerometer channel on the oscillograph. Jerk rate measurements were made on all acceleration and service blended braking tests for both cars, and an average rate for each mode is shown on Table II. Illustrations of jerk rate limiting are shown in Figures 6-10 and 6-15 for the braking mode.

6.8 SERVICE DUTY CYCLE

The SOAC traction system was designed for a duty cycle of repetitive 0 to 80 mph to 0 runs with a 30-second dwell time after each stop as shown in Figure 6-20. At the design weight of 105,000 lb. these repeated cycles resulted in an RMS armature current of 637 amps. The design continuous current is 460 amps; the one-hour current is 600 amps. Thus the duty cycle represents operation at a performance level somewhat above the one-hour rating of the traction motors, but well below the peak current rating of 750 amps.

6.8.1 Blended Braking Cycles - Service Configuration

Table IV summarizes the results of the 24 cycles of blended braking performed on each car. A summary duty cycle plot is shown in Figure 6-21 based on measured car performance on level tangent track. The cycle of Figure 6-21 differs from Figure 6-20 due to the higher level of performance measured

TIME CONSTANTS FOR SERVICE FRICTION BRAKE APPLICATION

SOAC HIGH-DENSITY CAR
105,000 LB

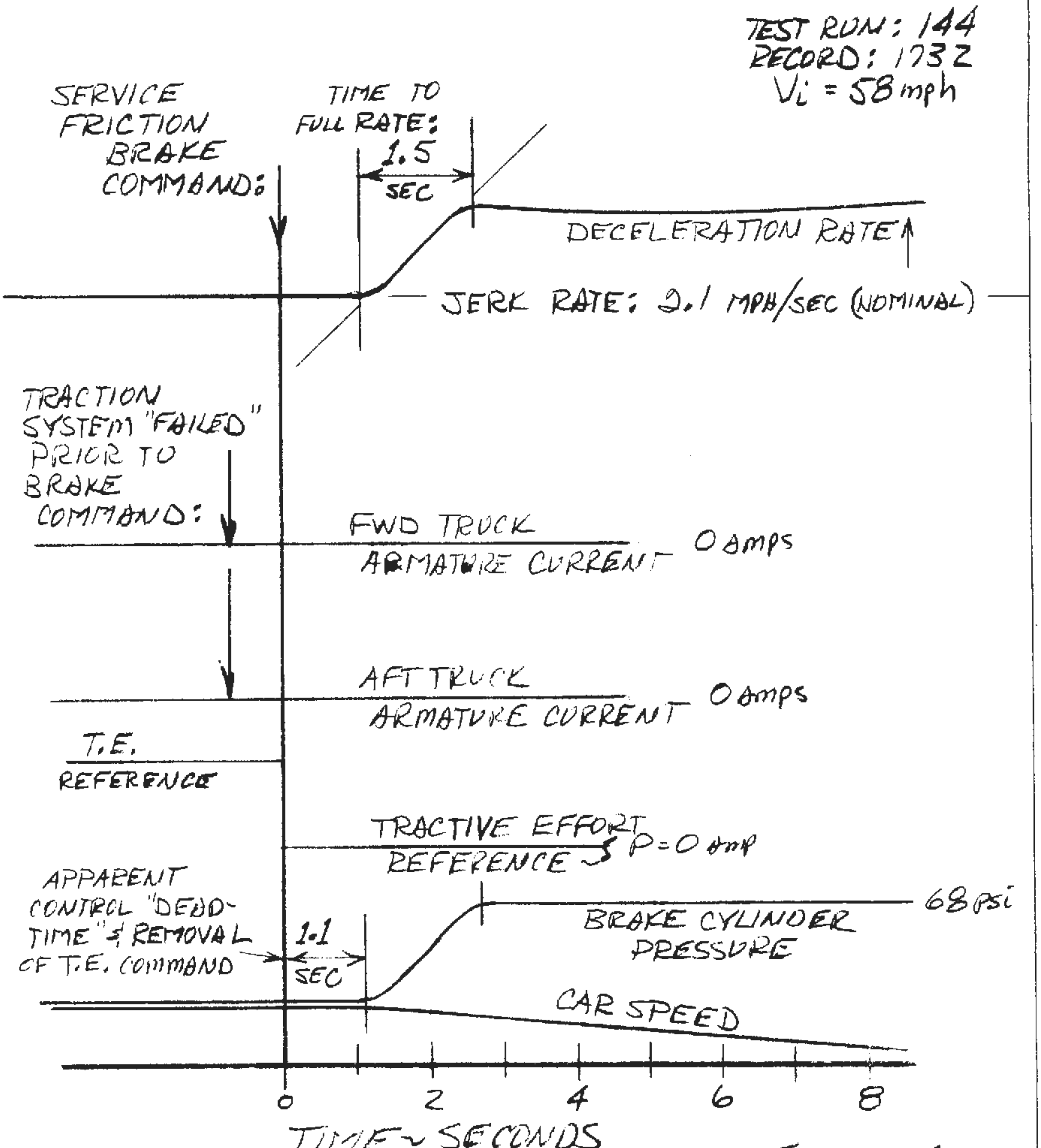
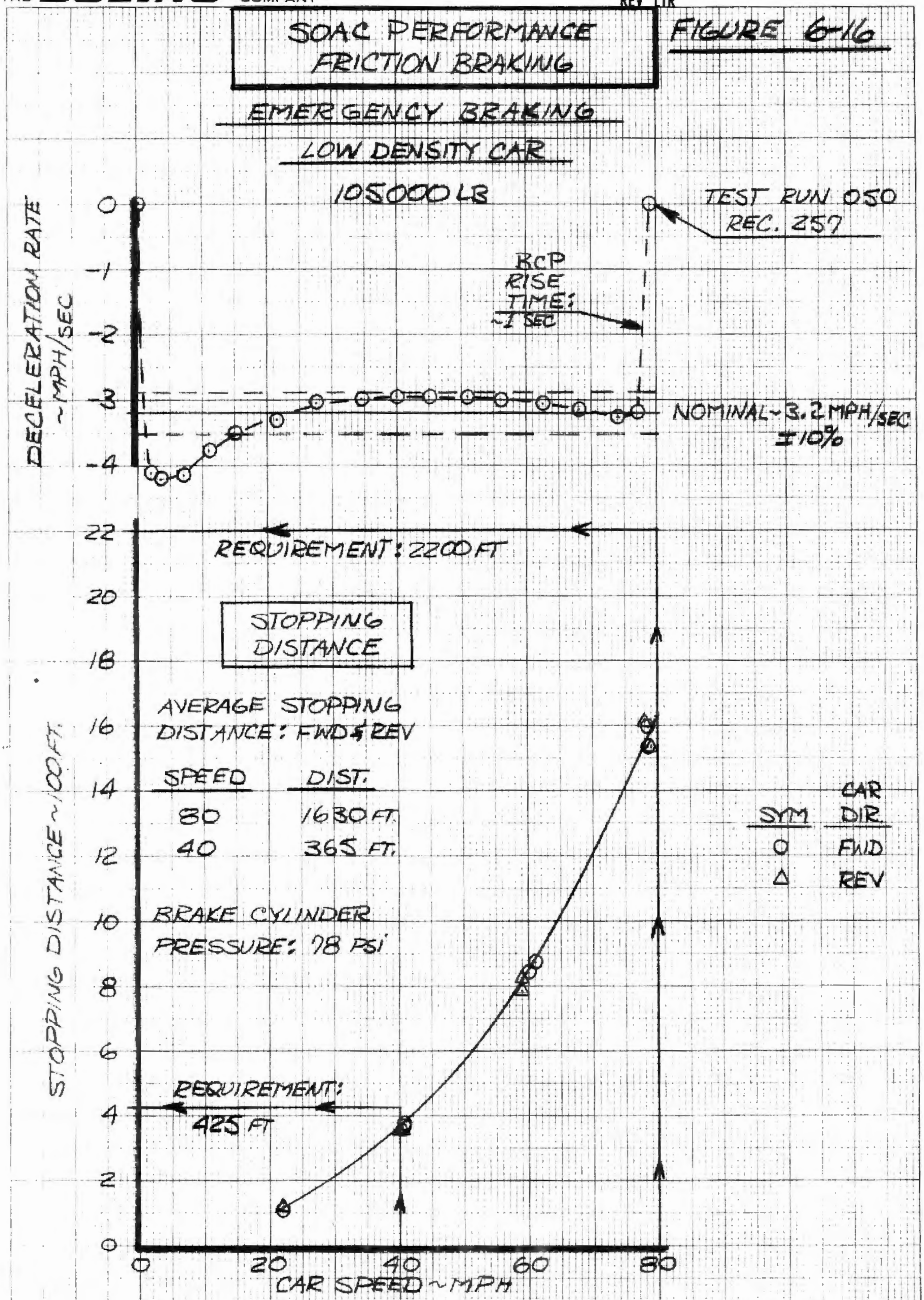
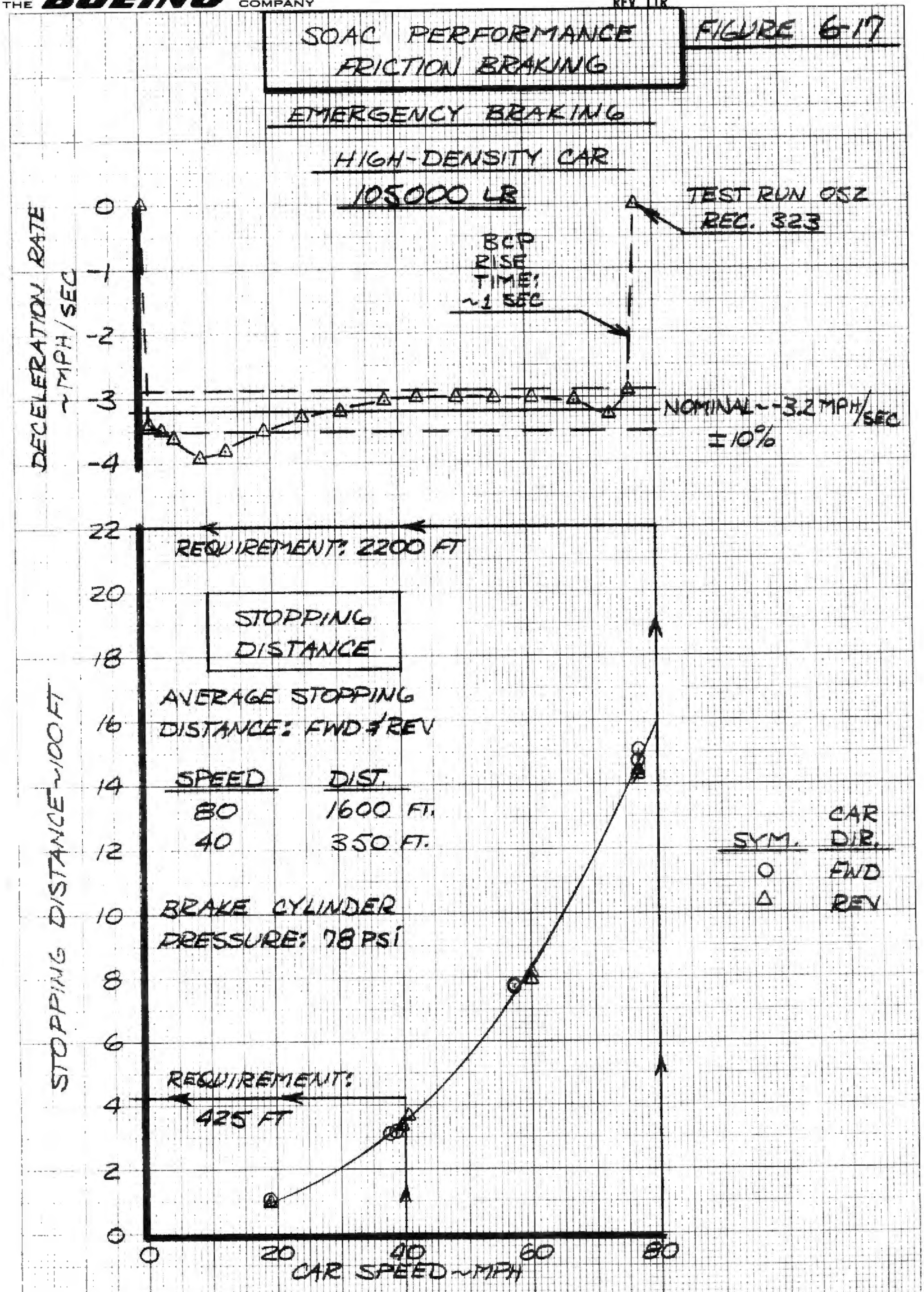


FIGURE 6-15


SOAC PERFORMANCE
FRICTION BRAKING
FIGURE 6-16
EMERGENCY BRAKING
LOW DENSITY CAR
105000 LB
TEST RUN 050
REC. 257
BCP
RISE
TIME:
~1 SEC
NOMINAL ~3.2 MPH/SEC
±10%
DECELERATION RATE ~MPH/SEC
0
-1
-2
-3
-4
22
REQUIREMENT: 2200 FT
20
STOPPING
DISTANCE
18
AVERAGE STOPPING
DISTANCE: FWD & REV
16
SPEED
DIST.
80
1630 FT.
40
365 FT.
14
12
SYM
CAR DIR.
FWD
REV
10
BRAKE CYLINDER
PRESSURE: 78 PSI
8
6
REQUIREMENT:
425 FT
4
2
0
STOPPING DISTANCE ~100 FT.
0
20
40
60
80
CAR SPEED ~MPH

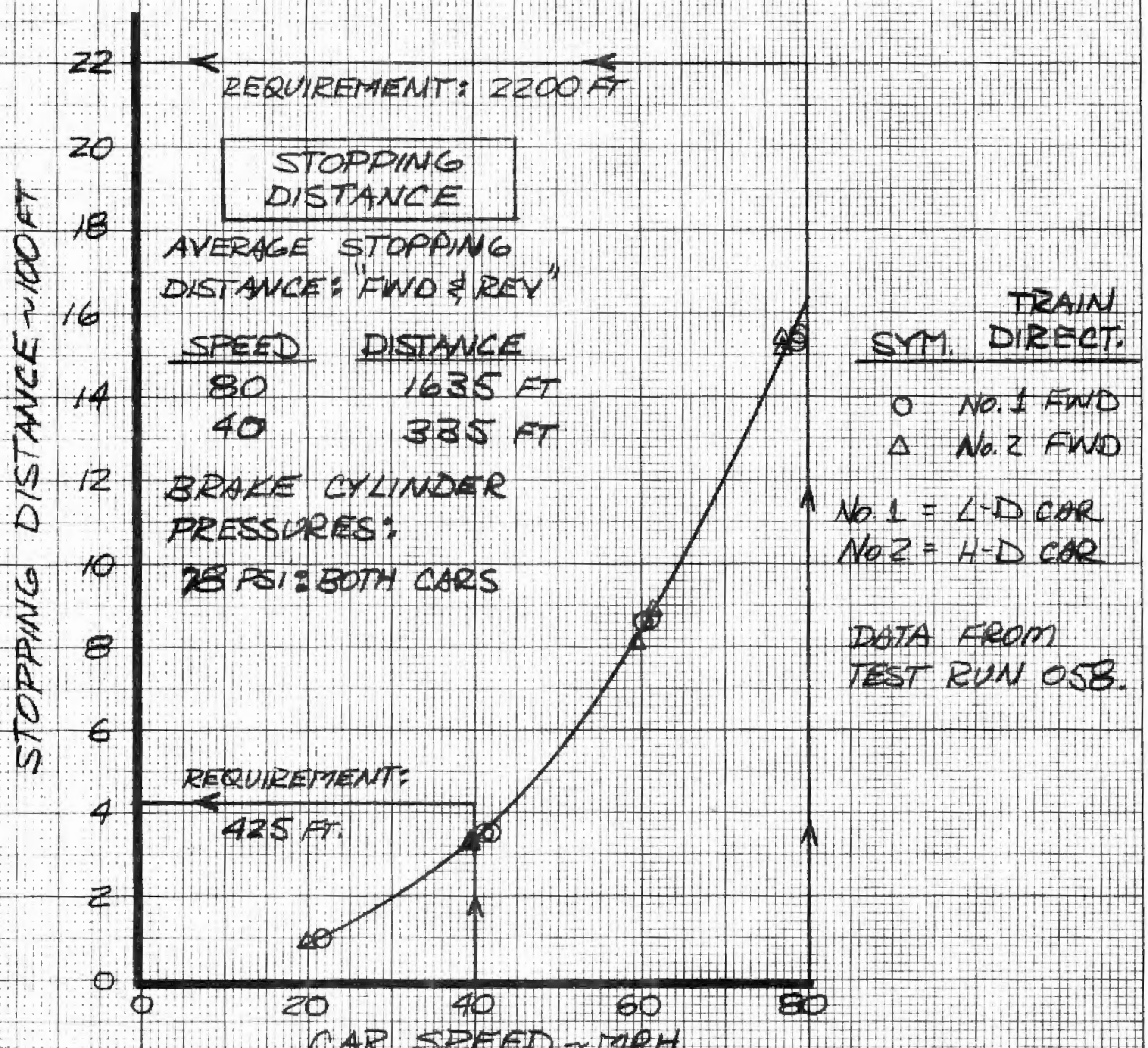

SOAC PERFORMANCE
FRICTION BRAKING
FIGURE 6-17
EMERGENCY BRAKING
HIGH-DENSITY CAR
105000 LB
TEST RUN 052
REC. 323
BCP RISE TIME: ~1 SEC
NOMINAL ~ -3.2 MPH/SEC ±10%
DECELERATION RATE ~MPH/SEC
0
-1
-2
-3
-4
22
REQUIREMENT: 2200 FT
20
STOPPING DISTANCE
18
AVERAGE STOPPING DISTANCE: FWD & REV
16
SPEED DIST.
14
80 1600 FT.
40 350 FT.
12
10
BRAKE CYLINDER PRESSURE: 78 PSI
8
6
REQUIREMENT: 425 FT
4
2
0
SYM. CAR DIR.
○ FWD
△ REV
STOPPING DISTANCE ~100 FT
0
20
40
60
80
CAR SPEED ~MPH

SOAC PERFORMANCE FRICTION BRAKING

FIGURE 6-18

EMERGENCY BRAKING

TWO-CAR TRAIN
105000 LB



THE BOEING COMPANY

PREPARED BY:
CHECKED BY:
DATE:

NUMBER
REV LTR
MODEL NO.

TIME CONSTANTS FOR EMERGENCY BRAKE APPLICATION

SOAC HIGH-DENSITY CAR
105,000 LB

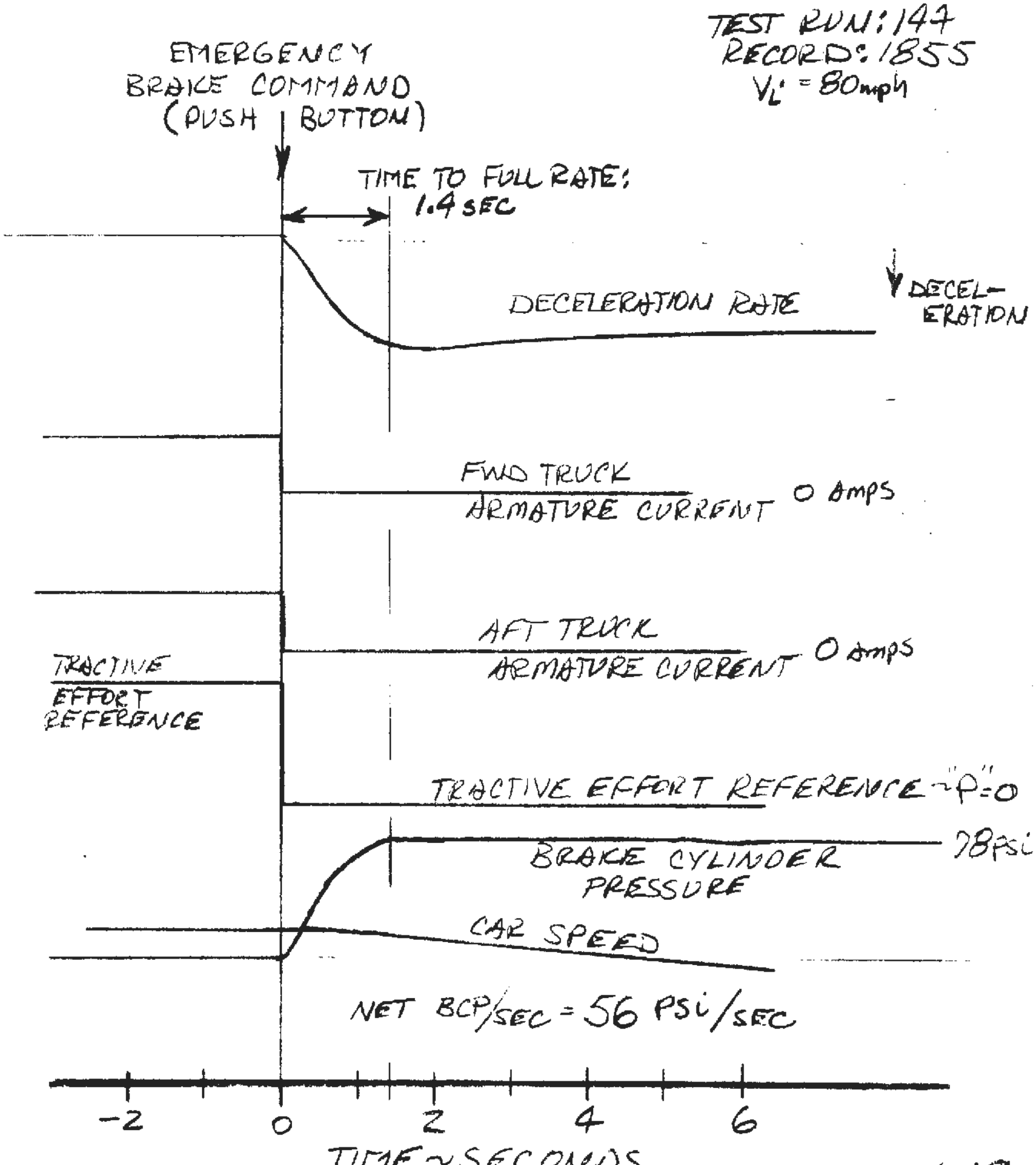


FIGURE 6-19

FORM 11180 (6/67)

FIGURE 6-20

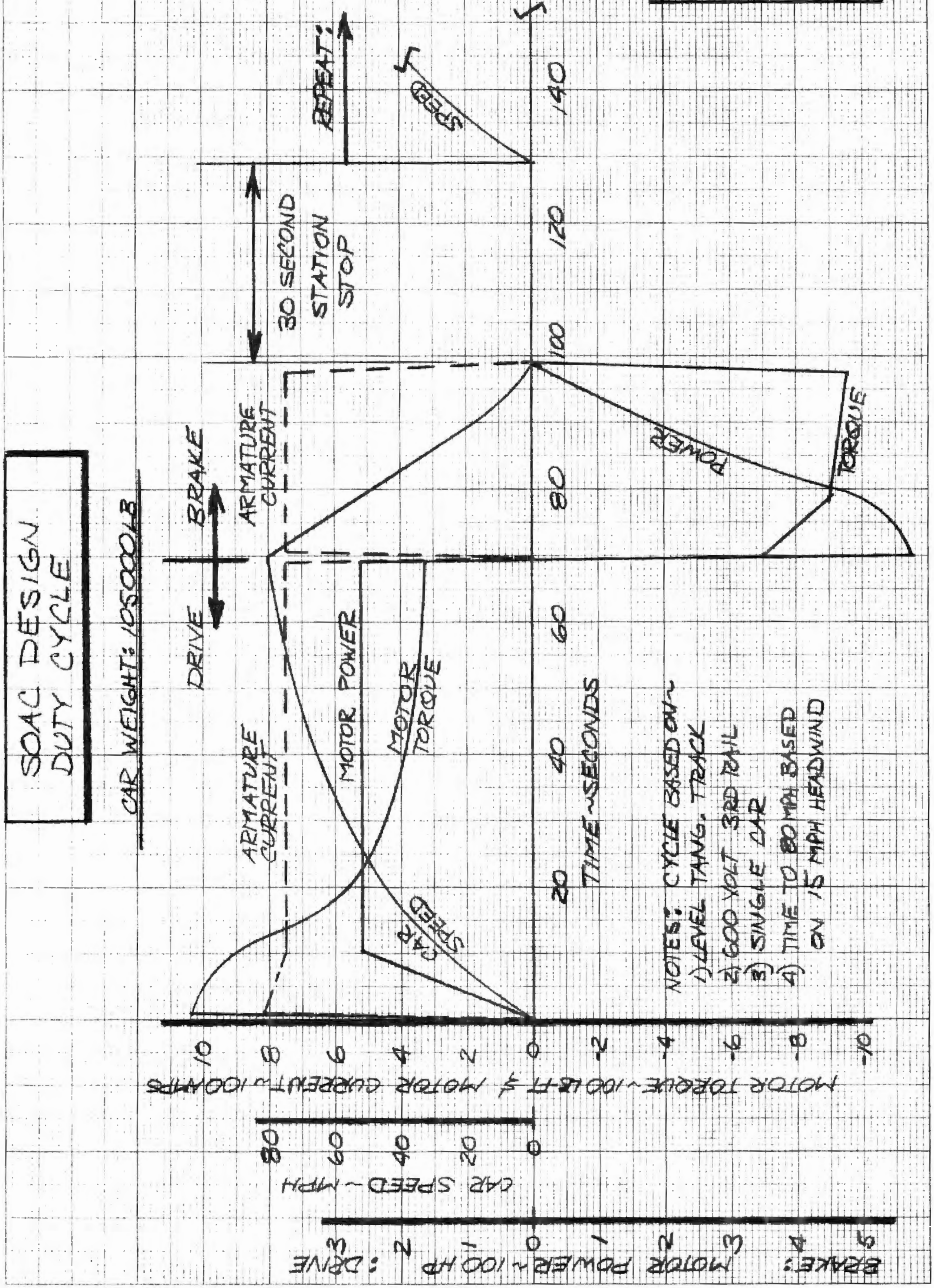

SOAC DESIGN
DUTY CYCLE
CAR WEIGHT: 105000 LB
DRIVE
BRAKE
ARMATURE CURRENT
MOTOR POWER
MOTOR TORQUE
CAR SPEED
SPEED
POWER
TORQUE
30 SECOND STATION STOP
REPEAT:
TIME ~ SECONDS
20
40
60
80
100
120
140
NOTES: CYCLE BASED ON~
1) LEVEL TANG. TRACK
2) 600 VOLT 3RD RAIL
3) SINGLE CAR
4) TIME TO 80 MPH BASED ON 15 MPH HEADWIND
MOTOR TORQUE ~ 100 LB-FT & MOTOR CURRENT ~ 100 AMPS
10
8
6
4
2
0
-2
-4
-6
-8
-10
CAR SPEED ~ MPH
80
60
40
20
0
BRAKE: MOTOR POWER ~ 100 HP : DRIVE
3
2
1
0
1
2
3
4
5

TABLE IV

SERVICE DUTY CYCLES - BLENDED BRAKING

I. LOW-DENSITY CAR

24 CYCLES (STOP TO 80 MPH TO STOP) WITH A 30-SECOND STOP TIME.

RESULTS:	DISTANCE TRAVELED	28.9 MILES
	TOTAL TIME	47.0 MINUTES
	MILES PER CYCLE	1.2 MILES
	MINUTES PER CYCLE	1.9 MINUTES
	SCHEDULED SPEED	37.0 MPH

(RUN COUNTERCLOCKWISE ON TEST OVAL)

II. HIGH-DENSITY CAR

24 CYCLES (STOP TO 80 MPH TO STOP) WITH A 30-SECOND STOP TIME.

RESULTS:	DISTANCE TRAVELED	26.0 MILES
	TOTAL TIME	42.9 MINUTES
	MILES PER CYCLES	1.08 MILES
	MINUTES PER CYCLE	1.8 MINUTES
	SCHEDULE SPEED	36.0 MPH

(RUN CLOCKWISE ON TEST OVAL)

ACCEPTANCE TEST

Car Weight: AW1 = 105,000 Lbs.

NOTES
1. Single car.
2. Level tangent track.
3. Zero wind.
4. Gear ratio: 4.78
5. Wheel Dia.: 30 in. (new)
6. Gear losses included.
7. Data Basis: HSGTC Acceptance tests - 4/73.

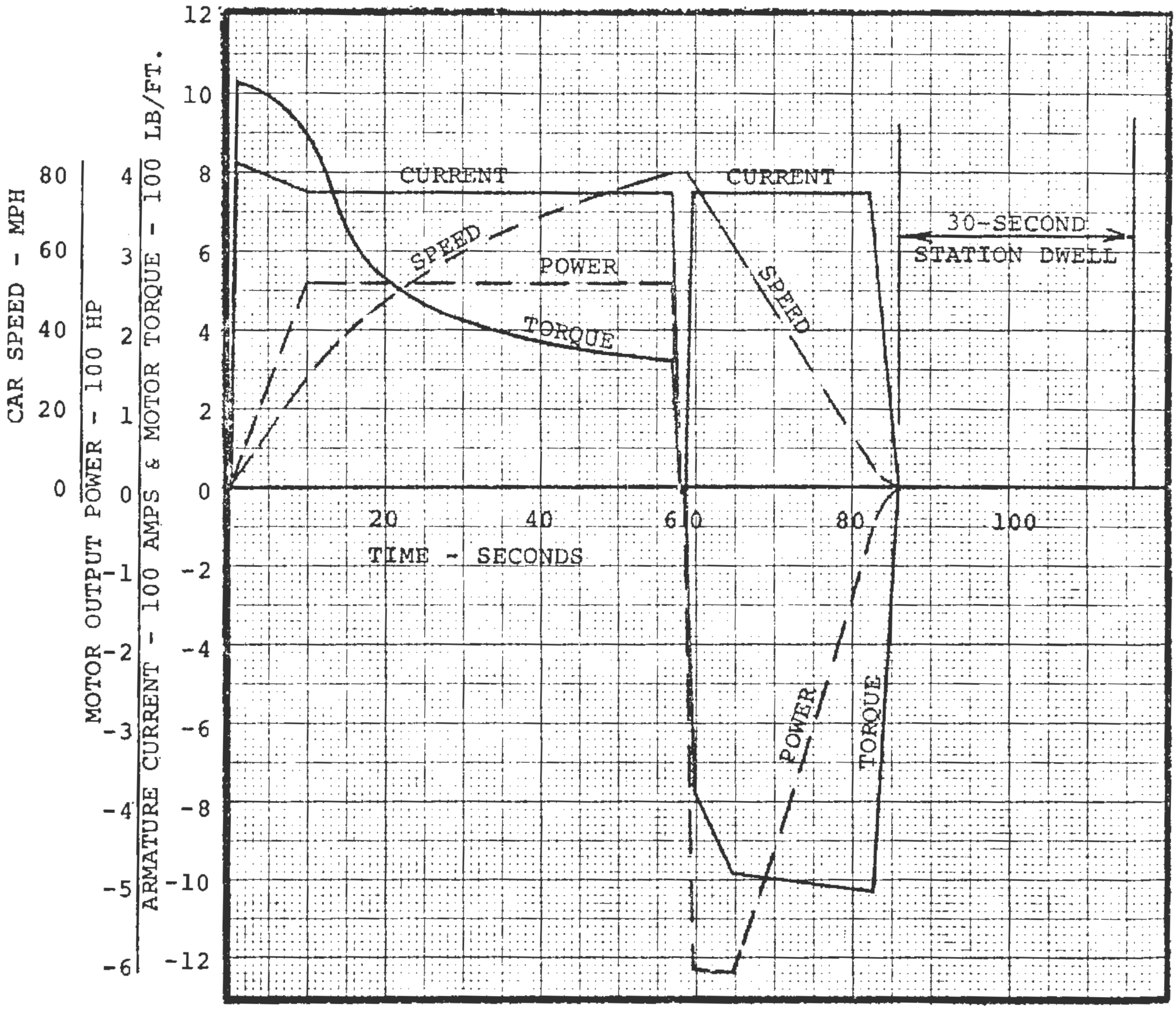


FIGURE 6-21

on the cars and the deletion of the 15 mph wind condition (not included in test data). The RMS armature current resulting from Figure 6-21 is 623 amps compared to 637 amps for Figure 6-20 and the 600 amp one-hour rating. No propulsion system problems were encountered during the duty cycle tests.

6.8.2 Service Friction Braking Cycles - No Dynamic Brake

Table V presents a summary of the 24 cycles of friction braking performed on each car following the tests of paragraph 6.8.1 The friction braking cycles were run to determine the effects of operating a car with the electric traction system cutout but with service friction brakes in operation. This condition simulates the worst case operation of a two-car train with one dead car (propulsion system).

Wheel tread temperatures were measured following several stops using an infrared pyrometer. The tabulated temperatures were recorded following the stop and thus do not represent a peak temperature. Stopping rates and distances measured at the end of the 24 cycles were within the specifications shown in Table II.

Brake pad smoking and some pad ignition were noted on the last four or five cycles. The stopping distance on the last stop with the low-density car was measured at 2010 ft. compared to an average 1960 ft. distance recorded earlier in the same car direction. The friction characteristics of the SOAC cobra composition brake show results in relatively consistent stopping performance throughout the temperature range generated by the severe duty cycles tested.

6.9 RIDE QUALITY

The results of the ride quality testing are summarized in paragraph 2.2 and detailed in the Appendix III report and the D174-10026-1 Engineering Test Report.

TABLE V

SERVICE DUTY CYCLES FRICTION BRAKING

I. Low-Density Car

-24 Cycles - (Stop to 80 mph to stop) with a 30 second stop time.

RESULTS:	Distance Travelled -	32.9	Miles
	Total Time -	58.0	Minutes
	Miles Per Cycle -	1.37	Miles
	Minutes Per Cycle -	2.4	Minutes
	Schedule Speed -	33.0	MPH
	Energy Per Stop -	22.4	Million Ft.-Lb.
	Maximum Tread Temp. -	320°	F
	Maximum Rim Temp. -	280°	F

(Run counter-clockwise on test oval)

II. High-Density Car

-24 Cycles - (Stop to 80 mph to stop) with a 30 second stop time.

RESULTS:	Distance Travelled -	27.4	Miles
	Total Time -	51.0	Minutes
	Miles Per Cycle -	1.14	Miles
	Minutes Per Cycle -	2.1	Minutes
	Scheduled Speed -	32.0	MPH
	Energy Per Stop -	22.4	Million Ft.-Lb.
	Maximum Tread Temp. -	250°	F
	Maximum Rim Temp. -	170°	F

(Run clockwise on test oval)

6.10 NOISE MEASUREMENTS

Noise level tests were completed on the two SOAC vehicles in November 1972. All measurements were made with a Bruel & Kjaer Precision Sound Level Meter Type 2203, using the I.E.C. "A" weighting network scales, with manual recording of meter readings.

For the interior noise tests, the vehicles were ballasted to 105,000 pounds and operated at a steady speed around the UMTA transit test track. No significant differences were noted for track construction types. Interior measurements were made at a standing and seated passenger ear level for three car locations: over the front truck, over the rear truck, and in the center of the car. Exterior noise measurements were made at a height of 3 ft. above the rail and 50 ft. from the car side.

Data for the low-density car, SOAC No. 1, was completed during Test Run 5 and is shown on Table VI. Data for the high-density car, SOAC No. 2 was completed during Test Run 10 and is shown on Table VII.

Wayside noise data is from Test Runs 87, 89 and 110, for Pueblo Track Sections I, III, IV, V and VI. The data of Figure 6-22 show compliance of the SOAC vehicles with the interior noise goal at all speeds, and the wayside goal at speeds above 35 to 40 mph. Also shown on Figure 6-22 is the band of wayside noise levels for contemporary transit cars for comparison to the SOAC goal and the test data. As noted on the figure, the wayside data for Section I is approximately 3 dBA higher than that for Sections III through VI. This lower level is used to show compliance above 35 to 40 mph and also as a favorable comparison with the lower level for existing cars. The wayside noise data was taken with "trued" solid steel wheels at a car weight of 90,000 lbs.

Figure 6-22 presents a summary of SOAC noise levels in comparison to the SOAC goals. As noted, the measured interior noise data band is significantly lower than the SOAC goal. Figure 6-22 also presents the results of the wayside noise tests conducted at the beginning of the Engineering Test Program. As noted, at zero car speed the wayside noise level of the traction motor cooling fans (2) and the self-ventilated motor alternator set are higher than the SOAC goal which was primarily based on wheel-rail noise. Analysis of equipment noise data is contained in the Engineering Test Report D174-10026-1, parts 10 and 11. As previously noted in the summary, the SOAC noise requirements were considered a goal rather than an acceptance criterion.

TABLE VI - INTERIOR NOISE LEVELS

SOAC #1 LOW DENSITY CAR

'A' WEIGHTED SOUND LEVEL dB(A)

ALL EQUIPMENT OPERATING

WT = 105 Klb.
Run #5 - 11/16/72

		FRONT OVER #1 Trk.	CENTER	REAR OVER #2 Trk.	
SEATED (Ear Level)	ACCELERATION	63	62.5	65	(2)
	0	62	61	64.5	
	25	63	61	64	
	35	63	61	65	
	50	65	63	67	
	70	72	65	70	
STANDING (Ear Level)	ACCELERATION	63	62.5	66	(2)
	0	62	62	65	
	25	63	61.5	64	
	35	63	62	65	
	50	65	63	67	
	70	72	65	70	

(1) Effect of track location not considered.
(2) Acceleration noise levels are a function of speed.

TABLE VII - INTERIOR NOISE LEVELS

SOAC #2 HIGH DENSITY CAR

'A' WEIGHTED SOUND LEVEL dB(A)

ALL EQUIPMENT OPERATING

WT = 105,000 Lb.
Run #10 - 11/29/72

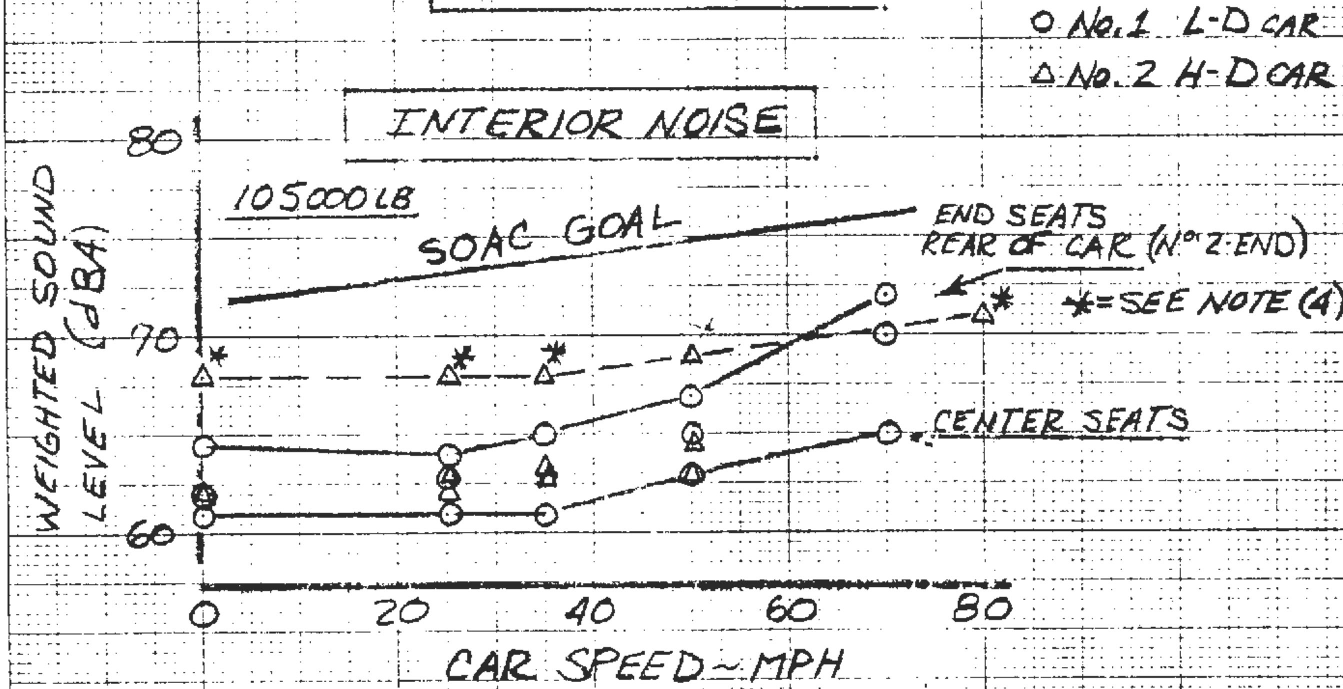
		FRONT OVER #1 Trk.	CENTER	REAR OVER #2 Trk.
SEATED (Ear Level)	ACCELERATION	(2)	(2)	(2)
	0	-	62	68
	25	63	62	68
	35	63.5	63	68
	50	64.5	63	69
	80	-	-	71
STANDING (ear Level)	ACCELERATION	(2)	(2)	(2)
	0	-	62	64
	25	63	62	65
	35	63	63	67
	50	64	63	66
	80	-		71

(1) Effect of track location not considered.
(2) Acceleration Noise levels were determined to be a function of speed.

FIGURE 2-4

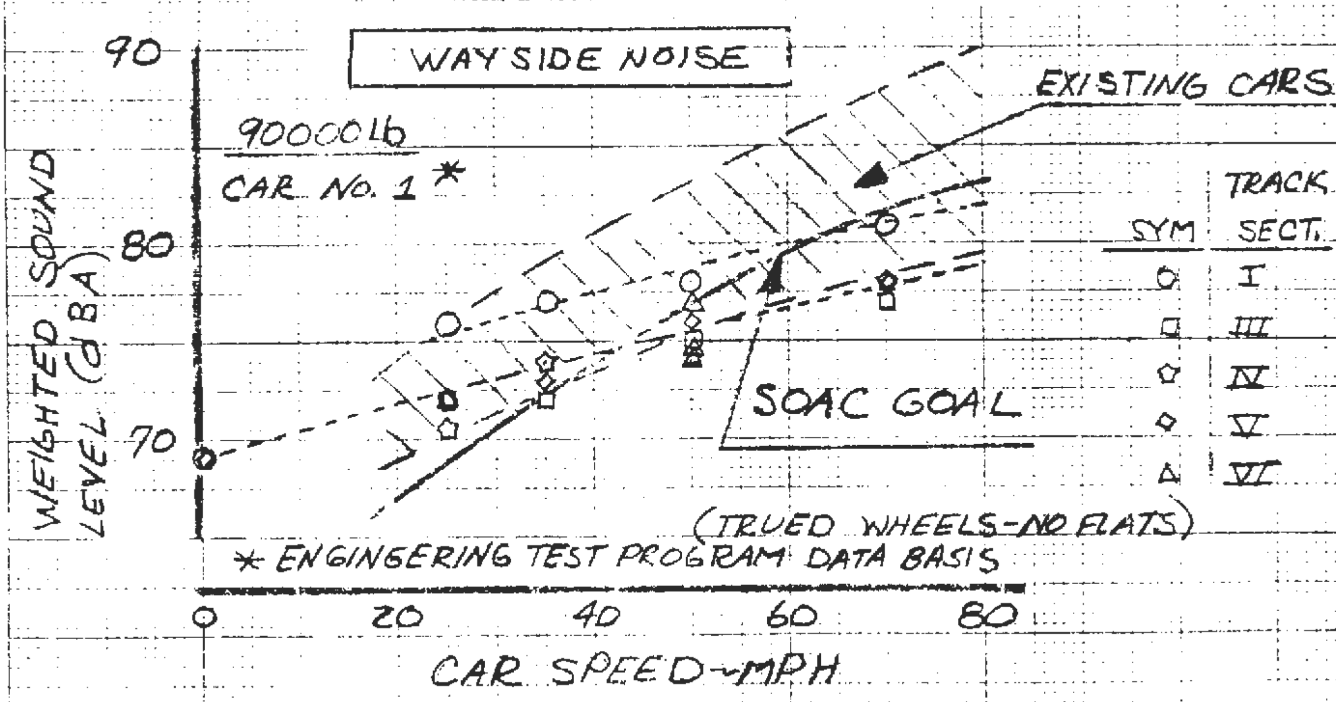
SOAC NOISE MEASUREMENT TESTS

HSGTC-PUEBLO



NOTES:

1) TANGENT, WELDED RAIL, WOODEN TIES; SECTION I (INTERIOR)
2) SOLID STEEL WHEELS
3) MICROPHONE LOCATIONS: INTERIOR - EAR LEVEL OF SEATED PASSENGER; WAYSIDE - 50 FT FROM TRACK CENTERLINE
4) ~~FRESH/RETURN AIR SPLITTER CONFIGURATION IN No 2 CAR CREATES~~ HIGHER INTERIOR NOISE LEVELS THAN No. 1 CAR.



6.11 ELECTROMAGNETIC INTERFERENCE

Results of the EMI testing are summarized in paragraph 2.4 and detailed in the Appendix IV EMI Test Report.

7. CONCLUSIONS

7.1 PERFORMANCE

The SOAC cars, individually and as a two-car train, met all specification performance goals for acceleration and braking. Test results are summarized in Table II, page

7.2 RIDE QUALITY

Initial ride quality acceptance testing confirmed an observed mild vibration near 64 MPH and a severe vibration near 80 MPH. Car body vertical accelerometer wave forms indicated that the severe vibration near 80 MPH was caused by a high amplitude vibration with a 9 second beat at the center of the car. Subsequent diagnostic tests and analyses (Appendix III) led to a structural beef-up of the motor alternator support structure.

The modification to the motor alternator support structure eliminated the vibration near 64 MPH and the beating phenomenon near 80 MPH. Data taken at the light car weight (90,000 lbs.) show maximum vibration levels at the higher frequencies (15 Hz) reduced from .26 g's to .1 g. Although this exceeds the design goal of .055 g's at this frequency, this is probably the result of manual reduction of the 90,000 lb. data as explained in Appendix III, Section 2.4 Data taken at the Normal Load Car Weight (100 passengers - 105,000 lbs.) using the Engineering Test instrumentation system meet or better the design goals for all frequencies at both mid and aft car centerlines.

7.3 NOISE DATA

Interior noise level measurements show that both cars meet the interior noise level goals at all speeds.

The SOAC also meets the wayside noise goal at speeds above 35 to 40 mph and is comparable to the quietest of existing transit cars. Below 35 mph the SOAC noise level exceeds the design goal. This is attributable to the noise generated by the under-car equipment in comparison to a noise goal based mainly on wheel-rail noise. The magnitude of the equipment noise level is illustrated by a 69 dBA level measured at zero car speed.

7.4 ELECTRO MAGNETIC INTERFERENCE (EMI)

The wayside and interior test data results plotted as a composite graph in Figure 2-5 demonstrate compliance with the specified limits of Section 9.9.2 (Figure 9-2) of the SOAC Detail Specification. Appendix IV presents the EMI test report and the recorded data.

APPENDIX I

TEST RUN LOG

SOAC TEST LOG

DATE	RUN No.	PURPOSE - CONFIGURATION	ODOMETER READING
11-14-72	001	105,000 LB CARS: TWO CAR TRAIN NO. 1 (L-D) CAR UNDER POWER: NO. 2 (H-D) NO POWER	
11-14-72	002	105,000 LB CARS: TWO CAR TRAIN - VIP RUN NO. 1 POWER: NO. 2 NO POWER	
11-15-72	003	105,000 LB CAR: NO. 2 CAR ONLY SPEEDOMETER CALIBRATION	
11-15-72	004	105,000 LB CAR: NO. 2 CAR ONLY BRAKING TESTS	
11-16-72	005	105,000 LB CAR: NO. 1 CAR ONLY: ACCEL. & DECEL. & NOISE TESTS: MOTOR FLASH-OVER EVALUATION (#2 CAR PDR)	
11-16-72	006	105,000 LB CARS: TWO CAR TRAIN - VIP RUN NO. 1 POWER: NO. 2 NO POWER	
11-17-72	007	105,000 LB CAR: NO. 1 CAR ONLY: MOTOR EVAL. AT HIGH SPEED: SET-UP THIRD RAIL SHOES	
11-25-72	008	105,000 LB CAR: NO. 2 CAR ONLY: THEN 2 CAR TRAIN: RUN-IN BRUSHES (LOST THIRD RAIL SHOE-ADJUSTED) CHECK TRAIN	
11-26-72	009	105,000 LB CARS: TWO CAR TRAIN: NO. 1 CAR DRIVING, (FAILED PDR) THEN NO. 2 CAR DRIVING-VIP RUNS	
11-29-72	010	105,000 LB CARS: TWO CAR TRAIN THEN NO. 2 CAR ONLY: VIP RUNS: SPEED LIMITING, RIDE QUALITY, NOISE TESTS	

NO. 1 CAR (LOW DENSITY): NO. 2 CAR (HIGH DENSITY)

SOAC TEST LOG

DATE	RUN No.	PURPOSE - CONFIGURATION	ODOMETER READING
11-30-72	011	105,000 LB CAR: NO. 2 CAR ONLY: RIDE QUALITY AND NOISE TESTS	
12-1-72	012	105,000 LB CAR: NO. 2 CAR ONLY: BRAKING PERFORMANCE	
2-8-73	013	105,000 LB CAR: NO. 2 CAR ONLY: INSTRUMENTATION CHECK OUT: MOTOR FLASH-OVER INVESTIGATION	
2-9-73	014	105,000 LB CAR: NO. 2 CAR ONLY: FLASH-OVER INVESTIGATION	
2-12-73	015	105,000 LB CAR: NO. 1 CAR ONLY: EVALUATE INSTALLATION OF NEW MOTORS	
2-13-73	016	105,000 LB CAR: NO. 1 CAR ONLY: EVALUATE MOTORS AND MOTOR INSTABILITY	
2-13-73	017	105,000 LB CAR: NO. 1 CAR ONLY: INVESTIGATE MOTOR INSTABILITY	
2-14-73	018	105,000 LB CAR: NO. 1 CAR ONLY: MOTOR INSTABILITY TESTING, EVALUATE SPEED LIMITING	
2-20-73	019	105,000 LB CAR: NO. 1 CAR ONLY: VARIOUS SYSTEM CHECKS AND BRUSH RUN-IN	
2-21-73	020	105,000 LB CAR: NO. 1 CAR ONLY: VARIOUS SYSTEM CHECKS	

NO. 1 CAR (LOW DENSITY): NO. 2 CAR (HIGH DENSITY)

SOAC TEST LOG

DATE	RUN No.	PURPOSE - CONFIGURATION	ODOMETER READING
2-21-73	021	105,000 LB CAR: NO. 1 CAR ONLY: SPIN-SLIDE SYSTEM CHECKS: PRELIMINARY BRAKE TESTS	
2-22-73	022	105,000 LB CAR: NO. 1 CAR ONLY: MAX. ACCELERATION CAPABILITY CHECKS	
2-22-73	023	105,000 LB CAR: NO. 1 CAR ONLY: MAX. ACCELERATION CAPABILITY CHECKS	
2-26-73	024	105,000 LB CAR: NO. 1 CAR ONLY: RUN-IN NEW SET OF BRUSHES, MONITOR MOTOR VIBRATION	
2-27-73	025	105,000 LB CAR: NO. 1 CAR ONLY: ACCEPTANCE TESTING-BLENDED BRAKING (INCOMPLETE)	
2-28-73	026	105,000 LB CAR: NO. 2 CAR ONLY: RUN-IN NEW SET OF BRUSHES: MANY PROPULSION TRIPS: CHOPPER PROBLEM	
2-28-73	027	105,000 LB CAR: NO. 1 CAR ONLY: BRAKING TESTS, FRICTION, BLENDED, DYNAMIC: SPIN-SLIDE PROBLEMS	
3-1-73	028	105,000 LB CAR: NO. 1 CAR ONLY: MOTOR VIBRATION TESTS: FRICTION BRAKING: SPIN-SLIDE PROBLEMS	
3-1-73	029	105,000 LB CAR: NO. 2 CAR ONLY: CONTROLS PROGRAM CHECK-OUT: LURCHING AT BASE SPEED AND LOW CURRENT	
3-2-73	030	105,000 LB CAR: NO. 2 CAR ONLY: BRUSH RUN-IN PROGRAM: ACCEL. & DECEL. TESTS: SPIN-SLIDE IS OK	

NO. 1 CAR (LOW DENSITY): NO. 2 CAR (HIGH DENSITY)

SOAC TEST LOG

DATE	RUN No.	PURPOSE - CONFIGURATION	ODOMETER READING
3-2-73	031	105,000 LB CAR: NO. 1 CAR ONLY: CHECK CAR FOR CHOPPER LURCH PROBLEM (RUN 029): NOT FOUND	
3-5-73	032	105,000 LB CAR: NO. 2 CAR ONLY: BRUSH RUN-IN: FULL SERVICE BLENDED BRAKE TESTS: SEEMS OK	
3-6-73	033	105,000 LB CAR: NO. 1 CAR ONLY: TROUBLESHOOT SPIN-SLIDE SYSTEM: INDICATES SLIDES ABOVE 50 MPH	
3-6-73	034	105,000 LB CARS: TWO CAR TRAIN: CHECK-OUT TRAINLINES: DRIVE FROM NO. 2: MANY PROPULSION TRIPS	
3-7-73	035	105,000 LB CARS: TWO CAR TRAIN: CHECK TRAINLINES, C/S RELAY PROBLEM, CHOPPER LURCHES AT V BASE, CURRENT UN-BALANCE TRIPS IN NO. 1 DRAGGED NO. 1 HANDBRAKE	
3-8-73	036	105,000 LB CARS: TWO CAR TRAIN: SPEED CALIB. E&I CHECK WITH LOCO, HOSTLER OPS, COUPLE/UNCOUPLE, CURRENT UN-BALANCE TRIPS IN BRAKING (WET RAILS)	2241
3-9-73	037	105,000 LB CAR: NO. 2 CAR ONLY: BLENDED BRAKING ACCEL. TESTS (0 TO 700 FT.)	
3-10-73	038	105,000 LB CAR: NO. 2 CAR ONLY: BLENDED BRAKING, FRICTION BRAKING, SPEEDOMETER CALIBRATION	2345
3-10-73	039	105,000 LB CAR: NO. 2 CAR ONLY: BRAKING TESTS, FRICTION AND DYNAMIC ONLY	
3-12-73	040	105,000 LB CAR: NO. 2 CAR ONLY: ASMS TESTING IN DRIVE AND BRAKE: ACCEL. TESTS (0 TO 700 FT.)	

NO. 1 CAR (LOW DENSITY): NO. 2 CAR (HIGH DENSITY)

SOAC TEST LOG

DATE	RUN No.	PURPOSE - CONFIGURATION	ODOMETER READING
3-12-73	041	105,000 LB CAR: NO. 2: DYNAMIC BRAKE "FAILURES" FROM 80 MPH - EMERGENCY BRAKING	
3-13-73	042	130,000 LB CAR: NO. 2: CHECK-OUT OF 130K LB. V_{MAX} = 50 MPH WET RAIL S/SLIDES, INITIAL ACCEL. (CHECK AND SERVICE BRAKE FROM 40 MPH	
3-14-73	043	105,000 LB CAR: NO. 1: CHECK-OUT PROPULSION SYSTEM MODIFICATIONS - INOPERATIVE FIELD PDR AT END, REDUCED DEAD TIME TO .7 SEC.	
3-14-73	044	105,000 LB CAR: NO. 1: CHECK-OUT NEW PDR FIELD SUPPLY: CHECK NEW SLIP/SLIDE SETTING (UNSTABLE FIELD SUPP.)	
3-15-73	045	105,000 LB CAR: NO. 1: SPEED-CALIB: TRAIL RUNS FOR BLENDED BRAKING, INITIAL ACCEL. MANY SLIP/SLIDES	
3-15-73	046	105,000 LB CAR: NO. 1: CHECK-OUT SLIP/SLIDE PROBLEMS BY INTERCHANGING CARDS IN PCU - FOUND NOISY S/S CARD: BLENDED BRAKE	
3-16-73	047	105,000 LB CAR: NO. 1: DYNAMIC BRAKE ONLY TESTS: FRICTION BRAKING: BCP TOO HIGH - S/SLIDES	
3-16-73	048	105,000 LB CAR: NO. 1: INITIAL ACCEL. & TIME TO 700 FT. AT 600 VOLT LINE FRICTION AND EMERGENCY BRAKING AT VARIOUS BCP SETTINGS	
3-17-73	049	105,000 LB CAR: NO. 1: FRICTION BRAKING WITH REVISED BCP'S SIMILAR TO NO. 2 CAR: ASMS TESTS	
3-17-73	050	105,000 LB CAR: NO. 1: EMERGENCY BRAKING: CHECK OUT NEW PDR: BLENDED BRAKING CHECKS: INITIAL ACCEL.	

SOAC TEST LOG

DATE	RUN No.	PURPOSE - CONFIGURATION	ODOMETER READING
3-19-73	051	105,000 LB CAR: NO. 2: CHECK-OUT PROPULSION MODS: CHECK LOW I, BASE-SPEED CHOPPER LURCHING: CHECK EMERG. BCP	
3-19-73	052	105,000 LB CAR: NO. 2: INITIAL ACCEL. TIME TO 700 FT. 0-V_{MAX}: BRAKING-EMERGENCY AND BLENDED, SPEED CALIBRATION	
3-20-73	053	105,000 LB CAR: TWO CAR TRAIN: CHECKED OUT 2-CAR TRAIN CONFIGURATION COMPATIBILITY, CHECKED ACCEL. & BRAKE FUNCTION - OPER. FROM #1 & 2 CAB, LOCO OFF LINE,	
3-20-73	054	105,000 LB CAR: TWO CAR TRAIN: RUN FROM #1 CAB - BRAKE TESTS BLENDED, FRICTION AND EMERGENCY - NO 80 MPH DATA: WEST DIESEL ONLY. RUN FROM #2 CAB-BRAKE TESTS-BLENDED 80MPH	
3-21-73	055	105,000 LB CAR: TWO CAR TRAIN: BRAKE TESTS FROM BOTH DIRECTIONS, COMPLETED BLENDED AND FRICTION	
3-21-73	056	105,000 LB CAR: TWO CAR TRAIN: BLENDED, FRICTION & DYN. BRAKING FOR BOTH DIRECTIONS - ONE ACCELERATION RUN	
3-22-73	057	105,000 LB CAR: TWO CAR TRAIN: ASMS RUNS AND RIDE QUALITY TESTS FOR GSI	
3-22-73	058	105,000 LB CAR: TWO CAR TRAIN: TWO CAR EMERGENCY BRAKE TESTS & TWO ACCEL. RUNS-COMPLETED RIDE QUALITY RUNS FOR GSI	
3-26-73	059	105,000 LB CAR: TWO CAR TRAIN: CHECK-OUT OF CHOPPER MOD. & PDR STABILITY CHECKS	
3-26-73	060	105,000 LB CAR: TWO CAR TRAIN: CONTINUED CHECK OUT OF CHOPPER FIXES & INITIAL BUMP (LURCH) ELIMINATION	

SOAC TEST LOG

DATE	RUN No.	PURPOSE - CONFIGURATION	ODOMETER READING
3-28-73	061	105,000 LB CAR: NO. 1 CAR: ARMATURE CURRENT CHECKS ON FWD & AFT TRUCKS IN BOTH DIRECTIONS &BRAKE. GRID TEMP.DATA	
3-28-73	062	105,000 LB CAR: NO. 2 CAR: ARMATURE CURRENT CHECKS ON FWD & AFT TRUCKS IN BOTH DIRECTIONS & RIDE QUALITY TESTS FOR GSI WITH 3" SHIMS REMOVED FROM TRUCKS	
3-29-73	063	105,000 LB CAR: NO. 2 CAR: STARTING LURCH CHECK AND ADDITIONAL RIDE QUALITY DATA FOR GSI	3100
3-29-73	064	105,000 LB CAR: NO. 2 CAR: CONTINUED RIDE QUALITY TESTING FOR GSI WITH 3" SHIMS REMOVED	
3-31-73	065	105,000 LB CAR: NO. 1 CAR: MEASURED FWD TRUCK ARMATURE CURRENTS FOR ACCELERATION FIX	
4-3-73	066	105,000 LB CAR: TWO CAR TRAIN: EMI TESTS AND ARMATURE CURRENT DATA	
4-2-73	067	105,000 LB CAR: TWO CAR TRAIN: MEASURED ARMATURE CURRENTS ON ALL TRUCKS WITH SHUNT- CONTINUED EMI TESTS	
4-3-73	068	105,000 LB CAR: TWO CAR TRAIN: EMI TESTS COMPLETED	
4-4-73	069	105,000 LB CAR: NO. 2 CAR: CHECKED OUT INCREASE CHOPPER CURRENT LIMIT PROBLEMS WITH PROPULSION TRIPS - DIFFERENTIAL CURRENT TRIP LIGHT	3401
4-4-73	070	105,000 LB CAR: NO. 2 CAR: CONTINUED CHECK OUT WITH DIFF. CURRENT RELAY DISABLED AND RUN ACCEL. & BRAKE CHECK	

SOAC TEST LOG

DATE	RUN No.	PURPOSE - CONFIGURATION	ODOMETER READING
4-6-73	071	105,000 LB CAR: NO. 2 CAR: SHUNT ON FWD TRUCK: CURRENT SENSOR CHECKS	
4-6-73	072	105,000 LB CAR: NO. 2 CAR: SHUNT ON AFT TRUCK: CURRENT SENSOR CHECKS	
4-9-73	073	105,000 LB CAR: NO. 2 CAR: SHUNT ON AFT: THEN FWD TRUCK CURRENTS OK: BLENDED BRAKING: INITIAL ACCEL. RATES	
4-9-73	074	105,000 LB CAR: NO. 2 CAR: SHUNTS OFF: INITIAL ACCEL'S & TIME TO 700 FT: 0-80 MPH (3) DIESELS ON-LINE: DYNAM. BRAKING: DUTY CYCLE	
4-10-73	075	105,000 LB CAR: NO. 1 CAR: CURRENT CALIBRATION CHECK S/ SLIDE: LURCHING AT 20 MPH: TROUBLESHOOT PROP. TRIPS	
4-10-73	076	105,000 LB CAR: NO. 1 CAR: CURRENT CALIBRATION AND TROUBLESHOOTING	
4-11-73	077	105,000 LB CAR: NO. 1 CAR: BLENDED BRAKING TESTS	
4-11-73	078	105,000 LB CAR: TWO CAR TRAIN: ACCEL. & BLENDED BRAKING TESTS	
4-11-73	079	105,000 LB CAR: NO. 1 CAR: DYNAMIC BRAKING;SERVICE DUTY CYCLE	
4-12-73	080	105,000 LB CAR: NO. 1 CAR: DYNAMIC BRAKING,BLENDED/ FRICTION DYNAMIC BRAKING ONLY	

SOAC TEST LOG

DATE	RUN No.	PURPOSE - CONFIGURATION	ODOMETER READING
4-16-73	081	90,000 LB CAR: TWO CAR TRAIN: MINOR TRAIN CHECKS: PANTOGRAPH OPERATION	
4-16-73	082	90,000 LB CAR: TWO CAR TRAIN: PANTOGRAPH CHECKS RADIO AND P-WIRE CHECKS	
4-17-73	083	90,000 LB CAR: TWO CAR TRAIN: LT. WT. DEMO RUN AND CHECK OUT	
4-17-73	084	90,000 LB CAR: TWO CAR TRAIN: DEMO. TO TRANSIT AUTHORITY PERSONNEL: ACCEPTANCE DEMO.	
4-17-73	085	90,000 LB CAR: TWO CAR TRAIN: DEMO. TO TRANSIT AUTHORITY SPECIAL RUNS & TRANSIT DRIVERS	
4-19-73	086	90,000 LB CAR: TWO CAR TRAIN: VOLTAGE MEASUREMENTS (ENGINEERING TEST PROGRAM: ETP)	
4-24-73	087	90,000 LB CAR: CAR NO. 1: NOISE TESTING SINGLE CAR INTERNAL-WAYSIDE (ETP) (ACCEPTANCE)	
4-24-73	088	90,000 LB CAR: NO. 2 CAR: NOISE TESTING SINGLE CAR INTERIOR-WAYSIDE (ETP)	
4-26-73	089	90,000 LB CAR: CAR. NO. 1: NOISE TESTING - STRUCTURAL INTERNAL-WAYSIDE (ETP)	
4-26-73	090	90,000 LB CAR: NO. 1 & NO. 2 CARS: VIBRATION ACCEPTANCE ONE CAR DEAD - INSTR. NO. 2 CAR (ETP)	

SOAC TEST LOG

DATE	RUN No.	PURPOSE - CONFIGURATION	ODOMETER READING
4-27-73	091	90,000 LB CAR: TWO CAR TRAIN: VIBRATION INVESTIGATION - VERT. DAMPERS REMOVED (ACCEPTANCE)	
4-27-73	092	90,000 LB CAR: TWO CAR TRAIN: VIBRATION INVESTIGATION - WITH AND WITHOUT SHIMS (ACCEPTANCE)	
5-18-74	110	90,000 LB CAR: NO. 1 CAR ONLY: (WAYSIDE NOISE TEST (ETP AND ACCEPTANCE)	
7-5-73	129	90,000 LB CAR: NO. 2 CAR ONLY: CAR CHECK OUT AND RIDE QUALITY TESTS (GSI)	
7-5-73	130	90,000 LB CAR: NO. 2 CAR ONLY: CAR CHECK OUT AND RIDE QUALITY TESTS (GSI)	5996

APPENDIX II

TEST RUN SHEETS

Section 1: Performance Tests

Section 2: Ride Quality Tests

Section 3: Noise Measurement Tests

Section 4: EMI Tests

SOAC ACCEPTANCE TESTS

PERFORMANCE

LOW DENSITY CAR (No. 1)

PERFORMANCE	CAR DIRECTION	TEST RUN	RECORD NUMBERS	NOTES
Acceleration: & 700 ft. T & D to 80 mph	Forward Reverse Forward Reverse	076 076 076 076	345; 353; 421 350; 356; 422; 437; 443 345 350	Also: Jerk rates
V max.	Forward Reverse	076 & others		Also: ASMS
Braking:				Jerk Rates
Blended:	Forward Reverse Forward Reverse	076 076 077 077	40 mph → 404; 458 40 mph → 415; 453 80 mph → 920; 928 80 mph → 940; 946	" "
Dynamic only	Forward Reverse	080 080	231 thru 247) 253 thru 307) 40 & 80 mph	
Service Friction	Forward Reverse	049 049	1059 thru 1125 1134 thru 1201	" "
Emergency Braking	Forward Reverse	050 050	235 thru 315 320 thru 341	
Duty Cycles	Forward	080	311 thru 358 (Blended) 411 thru 509 (Friction)	

SOAC ACCEPTANCE TESTS

PERFORMANCE

HIGH DENSITY CAR (No. 2)

PERFORMANCE	DIRECTION	TEST RUN	RECORD NUMBERS	NOTES
Acceleration	Forward	074	146; 200	Also:
& 700 Ft.	Reverse	074	154; 202	Jerk
T & D to 80 mph	Forward	074	146	Rates
" " " " " "	Reverse	074	154	"
V Max.	F & R	074	Various Runs	Also: ASMS
Braking:				Jerk Rates
Blended:	Forward	073	1116 thru 1145	"
	Reverse	073	1156 thru 1211	"
Dynamic only:	Forward	074	213 thru 228	
	Reverse	074	232 thru 246	
Service Friction:	Forward	039	159 thru 254	
	Reverse	038	1116 thru 1154	
Emergency Braking:	Forward	052	346 thru 407	
	Reverse	052	318 thru 340	
Duty Cycles:	Forward	074	252 thru 336 (Blended)	
			346 thru 437 (Friction)	

SOAC ACCEPTANCE TESTS

PERFORMANCE

TWO-CAR TRAIN (No. 1 & 2)

Forward = #1 Forward; Reverse = #2 Forward.

PERFORMANCE	CAR DIRECTION	TEST RUN	RECORD NUMBERS	NOTES
Acceleration:	Forward	078	1123; 1131	Also:
& 700 Ft.	Reverse	078	1209; 1215	Jerk
T & D to 80 mph	Forward	078	1123 (less than 600 volts)	Rate
	Reverse	078	1209	
V Max.	F & R	078	Various	
Braking:				
Blended:	Forward	078	1141 thru 1157	"
	Reverse	078	1229 thru 1246	"
Dynamic only:	Forward	078	115 thru 132	
	Reverse	078	1254 thru 108	
Service Friction:	Forward	054	330 thru 430	"
	Reverse	055	1043 thru 1118	
Emergency Braking:	Forward	058	312 thru 350	
	Reverse	058	223 thru 302	
Duty Cycles:		Not done	(Low track voltage with 2-car train.)	

SOAC ACCEPTANCE TESTS

RIDE QUALITY, NOISE, EMI

TEST TYPE	CAR NO.	TEST RUNS	LBS. CAR WEIGHT
RIDE QUALITY	2 (H-D)	10, 11	105,000
(Section 2)	1&2 Train	57, 58	105,000
	2 (H-D)	62, 63, 64	105,000
	1&2 Train	90, 91, 92	90,000
	2 (H-D)	129, 130	90,000
NOISE MEASUREMENT			
Interior/Wayside	1 (L-D)	005	105,000
Interior/Wayside	2 (H-D)	010	105,000
	2 (H-D)	087, 089	90,000
(Section 3)	2 (H-D)	110	90,000
EMI TESTS (Section 4)	1&2 Train	66, 67, 68	105,000

SECTION 1. PERFORMANCE TESTS

SOAC TEST RUN 038

DATE: 3/10/73

TIME: START 9:15 STOP 12:15

PURPOSE: SPEED INDICATOR CHECK.
BLENDED BRAKING CCW
FRICTION BRAKING CCW

WEATHER CONDITION:

WIND SPEED 5-15

DIRECTION ?

BAROMETRIC PRESSURE

AMBIENT AIR TEMPERATURE START 46° STOP

CREW:

TEST CONTROLLER R. PARKER

OPERATIONS DIRECTOR R. OREN

DATA CONTROLLER P. BROWN

INSTRUMENTATION

MOTORMAN Bill Curran

GROUND CONTROLLER Dick Haskill

REAR MONITOR Gary Davis

ADDITIONAL PERSONNEL

VEHICLE CONFIGURATION:

CAR 1 CAR 2 (circled) 105000 LB ±.5%
2345 ODOMETER

THE FOLLOWING PAGES CONTAIN THE METHOD, 'QUICK-LOOK INDICATORS, TEST DATA AND RECORD NUMBERS FOR RECORDED DATA.

FRICTION BRAKING SOAC #2

COUNTER CLOCKWISE RUN 022 28

INITAL SPEED ~~(ASMS)~~	ACTUAL INDICATED	DEAD TIME SEC	TIME TO STOP (SEC)	DISTANCE TO STOP (FT)	RECORD NUMBER OR TIME OF DAY	JERK RATE MPH/SEC²
20	19		6.3	78 -.28	1116 ~~1113~~ BAD SPOT	
20	21		6.6	100	1121	
40	42		13	431	1124	
40	41 37		12.2 11.8	398 BAD SPOT. S/S	1132 1130	
60	64		22.2	1079	1136	
60	61		21.	987	1141	
80	79		31.5	1873	1146	
80	79		30.5	1819	1154	

338
320

338
319

1900
-27
1873

338
22
316

[illegible]
32[illegible]

21

1079

SOAC BRAKING

PREPARED BY: P. BROWN PAGE NO. (1)
CHECKED BY: REPORT NO.
DATE: CAR No. 2
TYPE: HI-DEN

ACCEPTANCE TEST DATA

EST. CAR WT = 105000 LB

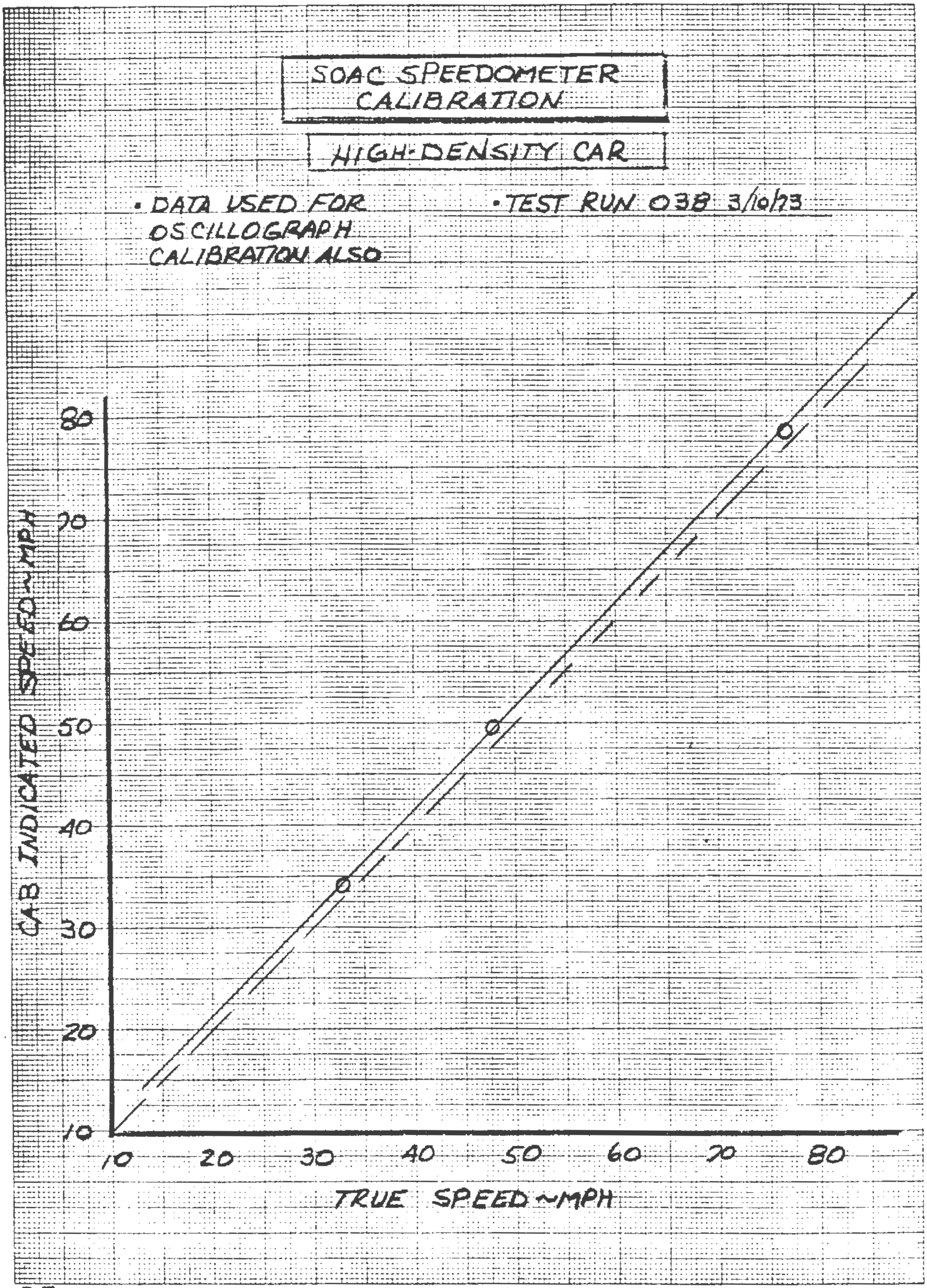
TEST	REC. No.	DIRECTION CAR	TRACK	INITIAL SPEED IND mph	STOPPING DATA AVG TRUE SPEED mph	TIME SEC	DIST. ft	DEAD TIME ? SEC	JERK RATE mph/sec²	DECEL RATE INITIAL	PEAK	MEAN DECEL. RATE	ΔV/Δt Δt CONST RATE	SPEED TRACE ΔV/Δt	Δt SEC	ARMATURE CURRENT FWD TRK Amp	AFT TRK Amp	D.T. + 1/2 Δt JERK SEC + JERK - TE ↓ ≤ 5 SEC	ACCEPT ? NOT DEAD TIME
037	444	FWD	CW	78	76	29.3	1698	1.4	2.6	2.5	3.0	2.7	10+	2.8	10	790	755	2.4	✓
BLENDED	452	"	"	79	77.5	30.3	1822	1.4	2.6	2.6	3.1	2.75	10+	2.8	10	780	750	2.9	✓
	502	"	"	60	58	22.8	1043	1.4	3.0	3.0	3.0	2.8	10+	2.9	8	785	750	2.7	✓
	507	"	"	60	58	22.8	1020	1.4	3.0	3.0	3.2	2.8	10+	2.8	8	790	755	2.6	✓
	512	"	"	41	39.5	15.6	488*	1.2	3.1	3.0	3.25	2.95	10+	2.95	8	790	750	2.2	NO*
	515	"	"	42	40.5	15.9	497*	1.3	3.1	3.0	3.2	2.8	10+	2.8	8	790	750	2.0	NO*
	518	"	"	20	19	8.5	123	.6	2.6	3.0	3.4	3.0	4	2.95	4			1.9	✓
	521	"	"	22	20	9.2	134	.6	2.7	3.0	3.2	3.0	4.5	2.95	4	800	750	1.6	✓
038	1033	REV	CCW	80	78	28.7	1670	1.5	2.5	3.0	3.1	3.0	10+	2.9	10	790	780	2.5	✓
BLENDED	1042	"	"	79.5	77.5	29.2	1719	1.6	2.6	3.05	3.1	3.05	10+	2.95	10	790	790	2.6	✓
	1048	"	"	60	58.5	22.1	962	.6	2.0	—	—	3.0	10+	2.9	8	780	780	1.1	✓
	1052	"	"	60	58.5	21.7	971	1.4	3.1	—	3.3	3.05	10+	2.9	8	790	790	2.3	✓
	1056	"	"	40	38.5	14.5	419*	1.3	3.5*	—	—	3.15	10+	3.05	8			1.8	NO*
	1102	"	"	41	39.5	15.0	449*	1.4	4.1*	—	—	3.1	10+	3.1	8	790	790	2.0	NO*
	1105	"	"	21	20	9.1	118	.1	2.2	—	—	2.9	5+	2.9	4	790	780	.6	✓
	1108	"	"	21	20	8.5	116	1.3	4.4*	—	4.0	3.2	4+	3.1	3	790	790	1.8	NO*
038	1116	REV	CCW	19	18	6.3	78	.4	3.0	3.5	4.7	4.2	0	3.9	3	—	—	1.5	
F TION ONLY	1121	"	"	21	20	6.6	100	.4	2.6	3.6	4.7	4.2	0	4.1	3	—	—	1.5	
	1124	"	"	42	40.5	13.0	431	.9	3.1	3.3	5.0	3.4	6	3.35	8	—	—	1.9	✓
	1132	"	"	41	39.5	12.2	398	.9	2.8	3.4	4.8	3.5	6	3.4	5	—	—	1.9	✓
	1136	"	"	64	62	22.2	1079	1.1	2.5	3.3	4.0	3.0	13+	2.9	10	—	—	2.2	✓
	1141	"	"	61	59	21.0	987	1.0	2.0	3.3	4.1	3.0	13	2.9	10	—	—	2.1	✓
	1146	"	"	79	77.5	31.5	1823	1.3	1.9	3.0	3.3	2.7	20+	2.5	20	—	—	2.2	✓
	1154	"	"	79	77.5	30.5	1819	1.2	2.4	2.9	3.3	2.6	20+	2.5	20	—	—	2.2	✓

BLENDED BRAKING — SOAC #2

COUNTERCLOCKWISE — RUN ~~03~~ 38

INITAL SPEED (ASMS)	DEAD TIME (SEC)	TIME TO STOP (SEC)	DISTANCE TO STOP (FT)	RECORD NUMBER OR TIME OF DAY	JERK RATE MPH/SEC²
20 21		8.5	116	1108	
~~20~~ 21		9.1	118	1105	
~~40~~ 41		15.0	449	1102	
40		14.5	419	1056	
60		21.7	971	1052	
60		22.1	962	1048	
~~80~~ 79.5		29.2	1719	1042	
80		28.7	1670	1033	

338
18
320



P. Brown
3/10/73

945 SPEED INDICATOR CHECK

DIST	TIME	IND	TRUE	RECORD
2000'	41.7	34	32.7	946
2000'	28.6	49.5	47.7	951
3500	31.1	78.5	76.7	957

SOAC TEST RUN 039

DATE: 3/10/73 TIME: START 1:30pm STOP

PURPOSE: FRICTION BRAKING CW
DYNAMIC BRAKING CW
" " CCW

WEATHER CONDITION:

WIND SPEED 15+

DIRECTION

BAROMETRIC PRESSURE

AMBIENT AIR TEMPERATURE START STOP

CREW:

TEST CONTROLLER R PARKER

OPERATIONS DIRECTOR Roy Oren

MOTORMAN BILL CORRAN

DATA CONTROLLER P. Brown

GROUND CONTROLLER Dick Haskell

INSTRUMENTATION

REAR MONITOR Gary Davis

ADDITIONAL PERSONNEL

VEHICLE CONFIGURATION:

CAR 1 (CAR 2) 105000 LB ±.5%

THE FOLLOWING PAGES CONTAIN THE METHOD, QUICK-LOOK INDICATORS, TEST DATA AND RECORD NUMBERS FOR RECORDED DATA.

FRICTION BRAKING SOAC #2

CLOCKWISE RUN 039 A.M.

INITAL SPEED (ASMS)	DEAD TIME (SEC)	TIME TO STOP (SEC)	DISTANCE TO STOP (FT)	RECORD NUMBER OR TIME OF DAY	JERK RATE MPH/SEC²
79		29.5	1851	159	
79		30.3	1878	206	
60		22	1015	214	
60		21.5	1028	219	
42		14.4	478	228 ~~223~~	
41		14.2	455	234	
42 41		13.5 14.0	446 417	238 242	
41 21		13.7 7.5	431 719	246 ~~249~~ 252	
22		7.1	125	254	

START 318

298
20
218

DYNAMIC BRAKING SOAC #2

COUNTERCLOCKWISE RUN # ~~21~~ 39

INITAL SPEED (ASMS)	DEAD TIME (SEC)	TIME TO STOP (SEC)	DISTANCE TO STOP (FT)	RECORD NUMBER OR TIME OF DAY	JERK RATE MPH/SEC²
~~20~~ 21		8.3	119	435	
~~20~~ 21		9.1	107	433	
~~40~~ 42		17.5	522	430	
40 42		17.8	528	426	
60 64		25.8	1197	422	
60 62		25.0	1136	~~413~~ 417	
80 79.5		31.6	1819	408	
80		31.1	1826	400	

DYNAMIC BRAKING SOAC #2

CLOCKWISE RUN #21 039

INITAL SPEED (ASMS)	DEAD TIME SEC	TIME TO STOP (SEC)	DISTANCE TO STOP (FT)	RECORD NUMBER OR TIME OF DAY	JERK RATE MPH/SEC²
~~20~~ 21		9.4 avg 9.2 cor 9.5	120	3:55	
~~20~~ 23		10.3 AVG 10.5 cor 10.0	150	3:52	
~~40~~ 41		17.5 ~~18.5~~	539	345	
40 41.5		17.5	545	338	
~~60~~ 61		25.4	1121	332	
60 60		24.7	1085	~~324~~ 326	
~~80~~ 78		32.7	1877	317	
80 ~~X~~		33.2	1915	308	

BY: P. BROWN
CHECKED BY:
DATE: CAR No: 2
TYPE: HI-DEN

PAGE NO.
REPORT NO.
MODEL NO.

ACCEPTANCE TEST DATA

EST. CAR WEIGHT = 105000 LB

Mode	Test Run	Rec. No.	Direction: Car	Direction: Track	Initial Speed: Ind. (mph)	Initial Speed: Avg. True (mph)	Stopping Data: Time (sec)	Stopping Data: Dist (ft)	Dead Time ? (sec)	Jerk Rate (mph/sec²)	Decel. Rate: Initial (mph/sec)	Mean Decel.: Peak (mph/sec)	Mean Decel.: Rate (mph/sec)	Δt Const. Rate (sec)	ΔV/Δt Speed Trace ΔV/Δt	Δt_c (sec)	Armature Current: Fwd Trk (amp)	Armature Current: Aft Trk (amp)	D.T. + ½Δt; + Δt; − Te (Σsec)	Accep? Not Dead Time
FRICTION ONLY	039	159	FWD	CW	79	77	29.5	1851	1.5	1.7	3.0	3.4	2.5	10+	2.6	10	—	—	2.7	✓
		206	"	"	79	77	30.3	1818	1.7	1.9	2.6	3.3	2.5	10+	2.6	10	—	—	2.9	✓
		214	"	"	60	58	22.0	1015	1.2	2.0	2.8	3.7	2.8	10+	2.9	10	—	—	2.5	✓ S/
		219	"	"	60	58	21.5	1028	1.3	2.8	2.9	3.8	2.8	10+	2.8	10	—	—	2.2	✓
		228	"	"	42	40.5	14.4	478*	1.0	2.2	3.0	3.8	3.2	6+	3.1	5	—	—	2.1	NO*
		234	"	"	41	40	14.2	455*	.9	2.6	3.2	4.1	3.2	7+	3.3	5	—	—	2.2	?* S/
		238	"	"	42	40.5	13.5	446	.8	2.4	3.3	4.3	3.4	6+	3.3	5	—	—	2.2	✓ S/
		242	"	"	41	40	14.0	417	1.0	2.5	3.4	4.5	3.4	6	3.4	5	—	—	2.3	✓ S/S
		246	"	"	41	40	13.7	431	.9	2.5	3.3	4.3	3.4	6+	3.4	5	—	—	2.1	✓ S/S
		252	"	"	21	20	7.5	119	.6	2.4	3.2	4.7	4.0	—	4.1	3	—	—	1.7	✓ S/
		254	"	"	22	20.5	7.1	125	.4	2.9	3.3	4.9	3.9	—	4.2	2	—	—	1.5	✓ S/
DYNAMIC ONLY	039	308	FWD	CW	80	78	33.2	1915	1.4	1.6	2.2	2.6	2.5	10+	2.6	15	795	745	3.0	
		317	"	"	78	76	32.7	1877	1.5	1.5	2.3	2.6	2.5	10+	2.6	15	795	740	2.6	
		326	"	"	60	58	24.7	1085	1.4	2.1	2.6	2.6	2.6	10+	2.65	10	800	745	2.8	
		332	"	"	61	59	25.4	1121	1.4	1.9	2.65	2.65	2.55	10+	2.6	10	795	750	2.8	
		338	"	"	41.5	40	12.5	545	1.4	1.9	2.6	2.6	2.55	10+	2.55	10	795	750	2.6	
		345	"	"	41	40	17.5	539	1.2	1.8	2.6	2.6	2.55	10+	2.6	10	795	745	2.6	
		352	"	"	23	21.5	10.3	150	.5	2.5	2.6	2.6	2.6	7	2.6	5	795	740	1.5	
		355	"	"	21	20	9.4	120	.6	2.4	2.55	2.55	2.55	6	2.65	5	790	745	1.6	
DYN[AM]IC ONLY	039	400	REV	CCW	80	78	31.1	1826	1.5	2.0	2.6	2.9	2.9	10+	2.8	10	790	780	2.6	✓
		408	"	"	79.5	72.5	31.6	1819	1.4	1.7	2.4	2.9	2.9	10+	2.8	10	795	795	2.5	✓
		417	"	"	62	60	25.0	1136	1.4	2.0	2.9	2.9	2.9	10+	2.8	10	790	800	2.7	✓
		422	"	"	64	62	25.8	1197	1.5	2.1	2.8	2.9	2.9	10+	2.8	10	785	785	2.8	✓
		426	"	"	42	40.5	17.8	528	1.3	1.8	2.9	2.9	2.9	10+	2.8	10	790	770	2.5	✓
		430	"	"	42	40.5	17.5	522	1.3	2.1	2.8	2.8	2.8	10+	2.8	10	790	780	2.6	✓
		433	"	"	21	19.5	9.1	107	.6	2.2	2.8	2.9	2.9	5	2.8	3	790	770	1.4	✓
		435	"	"	21	19.5	8.3	119	.2	2.9	2.8	2.9	2.9	5	2.8	3	790	770	1.4	✓

TIME AND DISTANCE TO STOP
DYNAMIC BRAKING ONLY
[CAR WEIGHT CW1 105,000 LBS]

NOTES:
1) LEVEL TANGENT TRACK
2) TRAIN RESISTANCE INCLUDED (ZERO WIND)
3) GEAR RATIO 4.78
4) WHEEL DIAMETER 30 IN.
5) JERK LIMITS AND DEAD TIME NOT INCLUDED

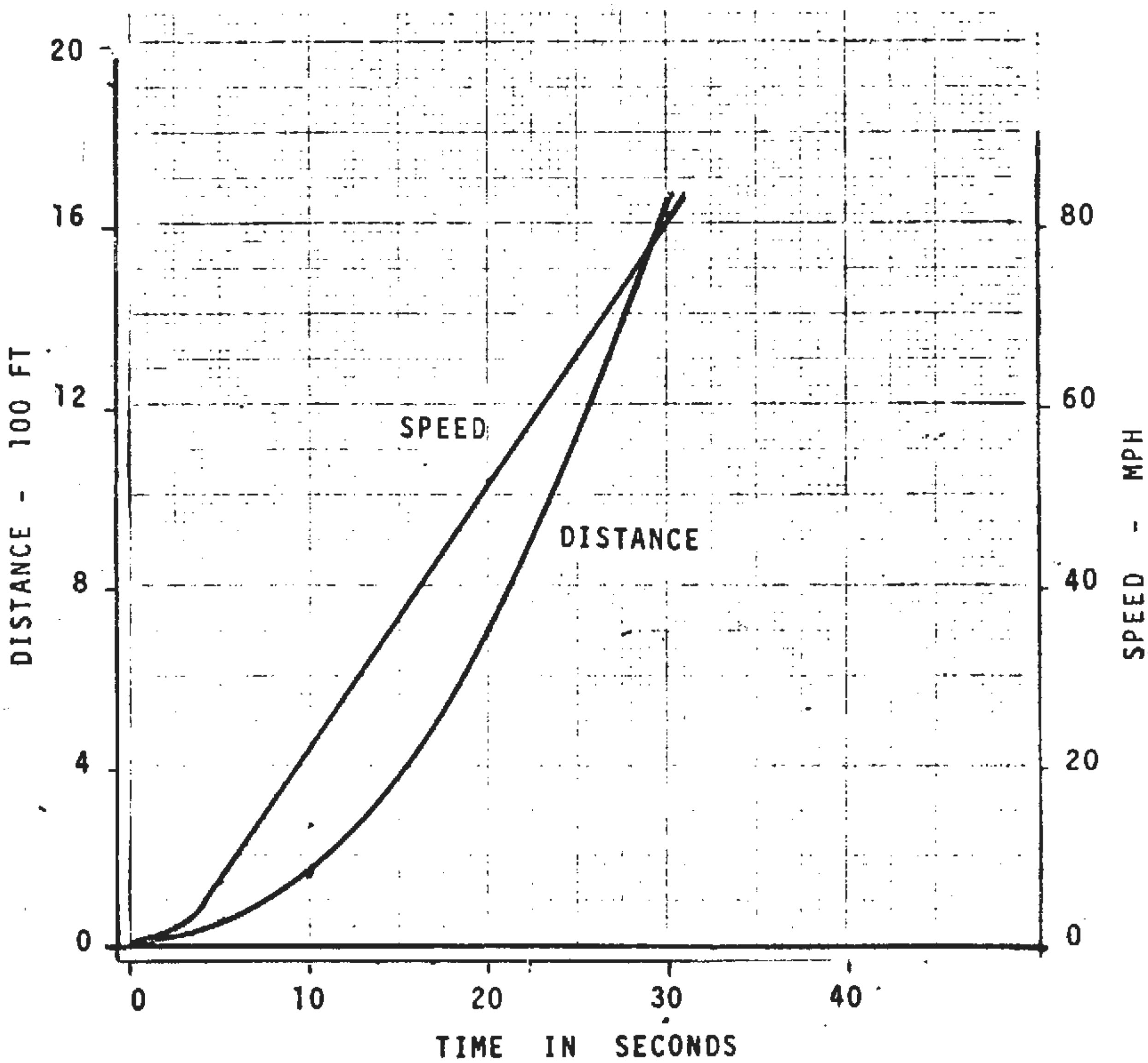


FIG. 2-7 SOAC SPEC.

TIME AND DISTANCE TO STOP
SERVICE AND EMERGENCY FRICTION BRAKING

NOTES:
1) LEVEL TANGENT TRACK
2) INCLUDES JERK LIMITS AND DEAD TIME

CAR WEIGHT: AW1 ~ 105000 LB

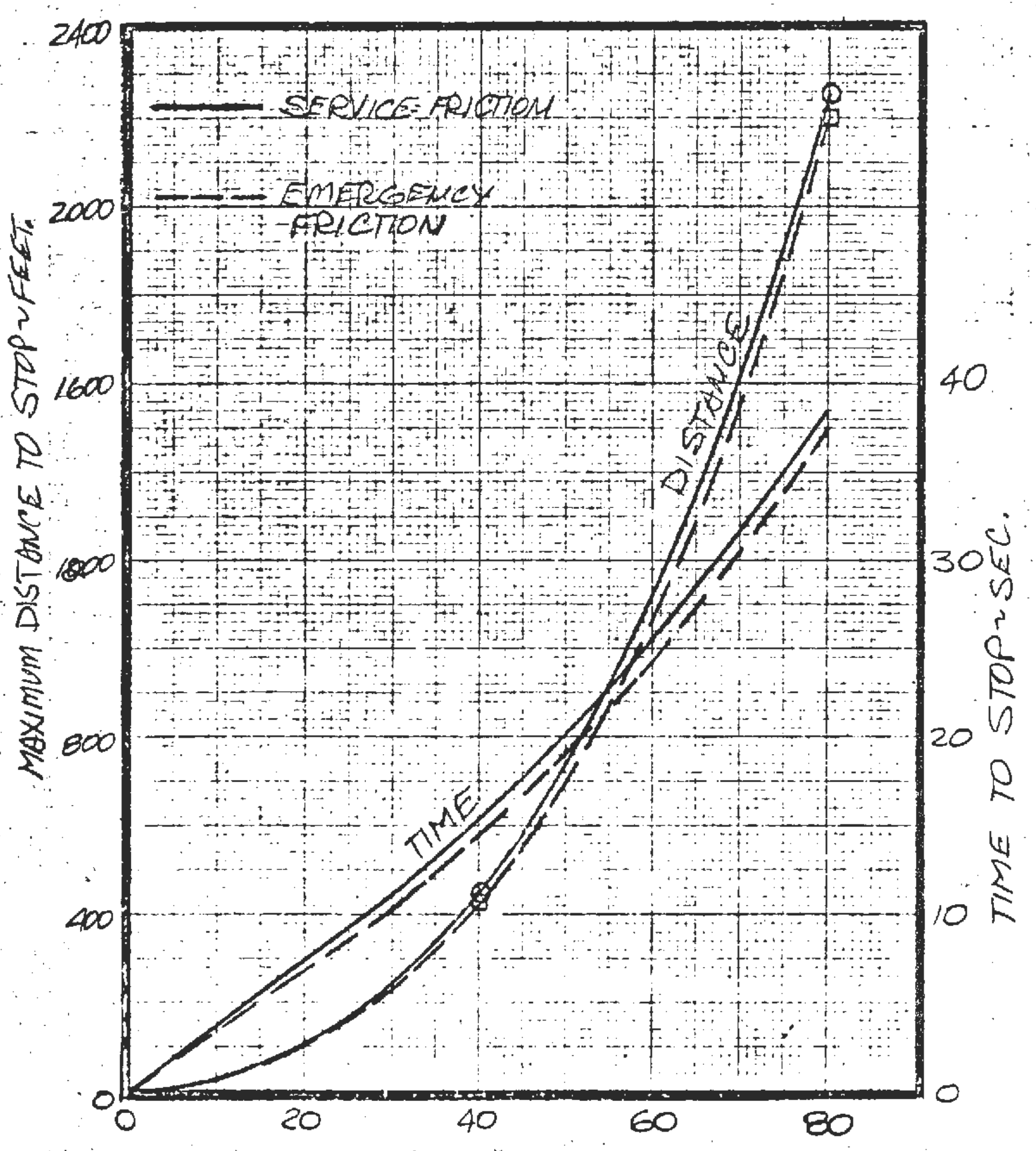


FIGURE Z-8

SOAC TEST RUN **049**

DATE: 3/17/23 TIME: START 1000 am STOP 1233 p.m.

PURPOSE: - FRICTION BRAKING WITH ADJ. BCP'S (FWD & REV)
- ASMS ~ FWD - CCW

WEATHER CONDITION:

WIND SPEED —
DIRECTION
BAROMETRIC PRESSURE
AMBIENT AIR TEMPERATURE START STOP

CREW:

TEST CONTROLLER R. BRUSH

OPERATIONS DIRECTOR J. HAZLEY MOTORMAN W. CURRAN
DATA CONTROLLER P. BROWN GROUND CONTROLLER
INSTRUMENTATION REAR MONITOR R. HASKELL

ADDITIONAL PERSONNEL J. FOGEL

VEHICLE CONFIGURATION:

(CAR 1) CAR 2 105000 LB

EMERG. TIME DELAY RECHARGE: 27.2 SEC TO START: 32.5 SEC TO 110 PSI & TRIP LIGHT "OUT"

THE FOLLOWING PAGES CONTAIN THE METHOD, QUICK-LOOK INDICATORS, TEST DATA AND RECORD NUMBERS FOR RECORDED DATA.

BCP's FWD 60.5/AFT 60.5 SERVICE FIRST @1000 82/ EMERG.

1033 { ADJ. TO 66/66 — SERVICE
ADJ. TO 78/76 — EMERGENCY }

FRICTION BRAKING SOAC #1 LD

COUNTERCLOCKWISE-FWD 049

INITIAL SPEED	ACT. IND.	TIME TO STOP (SEC)	DISTANCE TO STOP (FT)	RECORD NUMBER	BCP
40	41	15.6	475	1122	1122
20					
20	21	7.0	108	1125	
40	40.5	12.5	414	1118	68
40	41.5	13.5	453	1115	67/67 AFTER
60	58	19.2	907	1112	69/
~~60~~	61	21.0	1032	1106	69
80	80	29.0	1293	1130	69
80	80	30.2	1901	1059	69

END-
ED

33800
31899
1901

33800
31893
907

33800
33347
453

33800
33386
414

33800
32007
1793

FRICTION BRAKING SOAC #1 L-D

CLOCKWISE - REV. 049

INITAL SPEED	IND.	TIME TO STOP (SEC)	DISTANCE TO STOP (FT)	RECORD NUMBER
20	21	7.8	139	1134
~~40~~ 40	40	13.1	416	1140
40	41	14.0	470	1136.
40	42.5	14.4	500	1138
60	58	20.4	953	1144
60	61	21.9	1066	1146
80	80	30.6	1887	1153
80	80	31.8	1970	1201

BCP

32270
31800
470

32753
31800
953

32866
31800
1066

31800

P BROWN SOAC NO. 1 2 CAR

TEST RUN: 049 3/17/73

FRICTION BRAKING 105000 LB

REC. No.	DIRECTION: TRACK	DIRECTION: CAR	INITIAL SPEED: IND. mph	INITIAL SPEED: TRUE mph	STOPPING DATA: TIME SEC	STOPPING DATA: DIST ft	DEAD TIME SEC.	"JERK" mph/sec²	DECEL. RATE: INITIAL	DECEL. RATE: PEAK	DECEL. AVG. ACCELEROMETER mph/SEC	DECEL. ΔV/Δt SPEED TRACE mph/sec		ACCEPT ?
1059	CCW	FWD	80	78.5	30.2	1901	1.0	1.7	3.0	3.9	2.25	2.7		✓
1130	"	"	80	78.5	28.0	1793	1.0	2.1	3.0	3.9	3.0	2.9		✓
1106	"	"	61	60	21.0	1032	.9	2.0	3.1	4.5	3.1	3.0		✓
1112	"	"	58	57.5	19.2	907	.7	2.0	3.1	4.6	3.1	3.0		✓
1115	"	"	41.5	40.5	13.5	453	.6	2.1	3.1	4.5	3.4	3.5		✓
1118	"	"	40.5	40	12.5	414	.7	2.1	3.3	4.7	3.5	3.4		✓
1125	"	"	21	20	7.0	108	.3	2.5	3.5	4.7	3.6	3.4		✓
1134	CW	REV	21	20.5	7.8	139	.6	2.2	3.0	4.3	3.5	3.4		✓
1136	"	"	41	40.5	14.0	470	.7	2.2	3.0	4.3	3.3	3.4		
38	"	"	42.5	41	14.4	500	.7	2.2	2.8	4.6	3.3	3.4		
1140	"	"	40	39	13.1	416	.6	2.5	3.1	4.5	3.4	3.45		✓
1144	"	"	58	57.5	20.4	953	.8	1.9	2.8	3.8	3.0	3.05		✓
1146	"	"	61	60	21.9	1066	1.0	1.9	2.8	3.6	2.9	2.85		✓
1153	"	"	80	79	30.6	1887	1.1	1.8	2.6	3.1	2.7	2.6		✓
1201	"	"	80	78.5	31.8	1970	1.0	1.9	2.5	3.0	2.5	2.5		✓

4.3 Automatic Speed Maintaining System

4.3.1. Accelerate car to each of the following pre-selected speeds with Controller Handle in Full Power position. Monitor parameters as in paragraph 4.1. Evaluate capability of the speed maintaining system over a 15-30 second time period.

RUN NO. 049 3/17/73

FWD - CCW

RECORD NO.	SPEED SETTING	INDICATED SPEED
1215	3	
1217	15	
1218	25	25
1219	35	36
1220	50	51
1221	70	70
1222	80	80

4.3.2. From an initial pre-selected speed of 80 mph perform the following speed reductions using speed select inputs with Controller Handle in Full Power position. Monitor parameters as in paragraph 4.1. Hold reduced speeds for at least 15 seconds. Evaluate speed maintaining capability at each reduced speed. Record data per performance test instrumentation configuration given in Table II.

RUN NO. 049 3/17/73

RECORD NO.	SPEED	FINAL INDICATED SPEED
1223	80-70	70
1224	70-50	50
1225	50-35	
1226	35-25	
1227	25-15	
1228	15-3	

SOAC TEST RUN **050**

DATE: 3/17/73 TIME: START 2:20 P.M. STOP 4:00 P.M.

PURPOSE: - EMERGENCY BRAKING
- CHECK BLENDED BRAKING WITH LOWERED BCP'S
- CHECK OUT NEW "PRODUCTION" PDR ACCEL. & BRAKE

WEATHER CONDITION:

WIND SPEED

DIRECTION

BAROMETRIC PRESSURE

AMBIENT AIR TEMPERATURE START STOP

CREW:

TEST CONTROLLER R. BRUSH

OPERATIONS DIRECTOR J. HAZLEY MOTORMAN W. CURRAN
DATA CONTROLLER P. BROWN GROUND CONTROLLER
INSTRUMENTATION REAR MONITOR R. HASKELL

ADDITIONAL PERSONNEL J. VOGEL (2 GUESTS)-BRUSH

VEHICLE CONFIGURATION:

(CAR 1) CAR 2 105000 LB L-D CAR

THE FOLLOWING PAGES CONTAIN THE METHOD, QUICK-LOOK INDICATORS, TEST DATA AND RECORD NUMBERS FOR RECORDED DATA.

CHANGES: REPLACED "OLD-STYLE" PDR WITH "PRODUCTION" PDR
- SWITCHED 2 CARDS DURING RUN @ 3:50 P.M.
→ ARM OSCILL. IN REV-DR & BRK WITH BOTH CARD SETS; LESS WITH SECOND SET.

BLENDED SOAC #1 L-D

COUNTERCLOCKWISE-FWD 050

INITAL SPEED	IND.	TIME TO STOP (SEC)	DISTANCE TO STOP (FT)	RECORD NUMBER
20				
20				
COAST 40	40.5	15.7	451	355
ACCEL. 1+.7 40	40	16.3	514	352
60				
60				
80				
80	80	30.5	1805	346

31995 370

33800 − 31995 = 1805

33800

REC 900 700 ft IN 20.4 SEC → STOPWATCH

21.0 SEC → OSCILLOGRAPH

CCW-FWD DIRECTION.

EMERGENCY BRAKING SOAC #1
105 Klb L-D

CLOCKWISE - REV RUN ~~013~~ 050

INITAL SPEED	IND.	TIME TO STOP (SEC)	DISTANCE TO STOP (FT)	RECORD NUMBER
20	22	7.0	115	320
20				
40	41	12.0	359	322
40	41.5	11.4	359	324
60	59.5	17.4	785	327
60	60	18.0	826	330
80	80	25.8	1533	336
80	80	27.0	1614	341

BCP

31800

32159 − 31800 = 359

32159 − 31800 = 359

32585 − 31800 = 785

32626 − 31800 = 826

33333 − 31800 = 1533

33414 − 31800 = 1614

EMERGENCY BRAKING SOAC #1 L-D

CCW - FWD 050

INITAL SPEED		TIME TO STOP (SEC)	DISTANCE TO STOP (FT)	RECORD NUMBER
20				
20	23	6.8	109	315
40	42	11.7	376	313
40	41.5	12.1	376	311
60	62	18.4	875	308
60	61	18.3	847	304
80	80	25.3	1534	257
80	80	25.8	1595	235

BCP

F
08/

33800 − 32205 = 1595

33800 − 32266 = 1534

33800 − 32953 = 847

33800 − 32925 = 875

33800 − 33424 = 376

33800 − 33691 = 109

SOAC NO. 1-2 DATA

P. BROWN

TEST RUN: 050 3/17/73

EMERGENCY BRAKING
105000 LB

EC. No.	DIRECTION TRACK	DIRECTION CAR	INITIAL SPEED IND. mph	INITIAL SPEED TRUE mph	STOPPING DATA TIME SEC	STOPPING DATA DIST ft	DEAD TIME SEC	"JERK" mph/sec²	DECEL. RATE INITIAL	DECEL. RATE PEAK	DECEL. AVG. ACCELEROMETER mph/sec	DECEL. ΔV/Δt SPEED TRACE mph/sec		ACCEPT. ?
235	CCW	FWD	80	78.5	25.8	1595	—	2.0	3.4	4.3	3.0	2.90		✓
257	"	"	80	78.5	25.3	1534	—	3.1	3.4	4.4	3.2	3.0		✓
304	"	"	61	60	18.3	847	—	2.8	3.4	4.7	3.5	3.4	S/S	✓
308	"	"	62	61	18.4	875	—	2.7	3.3	4.8	3.4	3.3		✓
311	"	"	41.5	40.5	12.1	376	—	2.8	3.5	5.0	3.6	3.7	S/S	✓
313	"	"	42	40.5	11.7	376	—	3.1	3.6	5.0	3.8	3.8		✓
315	"	"	23	22	6.8	109	—	3.2	3.6	5.0	4.4	3.9	S/S	✓
320	CW	REV	22	22	7.0	115	—	4.0	3.3	4.5	3.8	3.6	S/S	✓
322	"	"	41	40	12.0	359	—	3.6	3.5	4.7	3.7	3.8	S/S	✓
324	"	"	41.5	40.5	11.4	359	—	3.6	3.7	5.0	3.9	3.9		✓
327	"	"	59.5	59	17.4	785	—	3.4	3.2	4.3	3.4	3.35		✓
330	"	"	60	59	18.0	826	—	3.7	3.1	4.4	3.3	3.25		✓
336	"	"	80	79	25.8	1533	—	2.7	3.2	3.7	3.1	3.05		✓
341	"	"	80	78	27.0	1614	—	2.5	3.2	3.5	3.0	3.1		✓
					BLENDED	BRAKING CHECK								
346	CCW	FWD	80	78	30.5	1805	.8	2.2	2.7	3.0	2.95	2.8		✓
352	"	"	40	39.5	16.3	514	.6	2.8	3.0	3.1	3.0	2.8	1.6 SEC	—
355	"	"	40.5		15.7	451	.6	2.8	3.0	3.1	3.0	2.8	.6 SEC time @ ZERO RATE	✓

SOAC TEST RUN | 052

DATE: 3/19/73 TIME: START 2:24 p.m. STOP 5:17

PURPOSE: — CHOPPER BASE SPEED; LOW I CHECK
— BLENDED BRAKING 40 & 80 mph
— EMERGENCY BRAKING
— INITIAL ACCELERATIONS: 0-700 ft

WEATHER CONDITION:

WIND SPEED

DIRECTION

BAROMETRIC PRESSURE

AMBIENT AIR TEMPERATURE START STOP

CREW:

TEST CONTROLLER P. PARKER

OPERATIONS DIRECTOR J. HAZLEY MOTORMAN W. CURRIN
DATA CONTROLLER W. BALLMER GROUND CONTROLLER P. BROWN
INSTRUMENTATION ______ REAR MONITOR R. HASKELL

ADDITIONAL PERSONNEL

VEHICLE CONFIGURATION:

CAR 1 (CAR 2 circled) 105000 LB H-DCAR

THE FOLLOWING PAGES CONTAIN THE METHOD, QUICK-LOOK INDICATORS, TEST DATA AND RECORD NUMBERS FOR RECORDED DATA.

M/A "OSCILLATES" DURING CHOPPER LURCHES

	ACCELS DIR	TIME TO 700'	ACCEL	Vmax
253	FWD-CW	?		77 mph
257	REV-CCW	20.0		78 mph
305	FWD-CW	21.1		700'
307	FWD-CW	20.5 or 21.5		700'

EMERGENCY — CAR #2 H-D

REV ~ CCW — 052

INITAL SPEED		TIME TO STOP (SEC)	DISTANCE TO STOP (FT)	RECORD NUMBER
	IND			
20				
20		7.25 / 8.4?	95	340
40	41	~~[illegible]~~ / 11.5	335	338
40	42	12 / 12	361	335
60	62	17.9 / 18.1	812	331
60	62	18 / 18.6	798	328
80	79	23.4 / 24.4	1439	323
	79	24.15 / 24.6	1433	318
BLEND, 80	79	28.5	1780	310

77#

33002

32400 − 39 = 33361

32400 − 32 = 32368

33800 − 32120 = 1780

33800 − 32367 = 1433

33800 − 32361 = 1439

33800 − 33002 = 798

33800 − 32088 = 812

33800 − 33439 = 361

33800 − 33465 = 335

33800 − 33705 = 95

EMERGENCY CAR No 2 H-D

FWD - CW 052

INITAL SPEED		TIME TO STOP (SEC)	DISTANCE TO STOP (FT)	RECORD NUMBER
20				
20		7/ 7.3	105	407
40		10.8/ —	315	405
40	39	11.1 / 10.5	312	402
60	59	17.4 / 17.2	769	359
60	59	17. / 19.55	766	355
80	79	25.5/ 25.6	1508	350
80	79	24.75/24.8	1477	346

33277 − 31800 = 1477 | 33308 − 31800 = 1508 | 32566 − 31800 = 766 | 569 − 31800 = 769

32112 − 31800 = 312 | 32115 − 31800 | 31905 − 31800

BLENDED — CAR No 2 HD

REV - CCW — 052

INITAL SPEED	IND	TIME TO STOP (SEC)	DISTANCE TO STOP (FT)	RECORD NUMBER
20				
20				
40	~~41~~ 44	~~15.5 15.5~~ — / 15.5	~~455~~ 519	~~429~~ 426
40	41	14.9 / 14.5	436	423
60				
60				
80				4 418 SCRATCH
80	79	28.2 / 29.0	1718	411

32100
16
32082

33800 (79)
32082
1718

33800
3

BLENDED CAR No 2 H-D

FWD - CW 052

INITAL SPEED		TIME TO STOP (SEC)	DISTANCE TO STOP (FT)	RECORD NUMBER
20				
20				
40	~~40~~	~~14.6 / 15.0~~	~~448~~	~~453~~
	41	14.7 / 14.6	456	450
40	41	14.6 / 15.3	477	445
60				
60				
80	79	29 / 29	1742	439
80	79	29 / 29.3	1736	435

31800

SPEED CALIB

RECORD No	SPEED	TIME	TRUE
500	~~49.~~ 51 MPH	28.5/28.6	47.8
			-1.7
504	34	91.7/91.7	32.7
			-1.3
510	79	17.17 / 35.5 (2000 / 4000)	77/76.8
			-2.1
511	CHECK RUN ON		

SOAC No 2 CAR (A-D) ACCELERATION
TEST RUN 052 3/20/73

REC No	TIME SEC	ACCEL MPH/SEC	CURRENTS FWD	CURRENTS AFT	VOLTAGE (CAP BANK)	CAR SPEED	COMMENTS
							FWD - CW
253	0	1.05	854	811	605	1	Vmax = 77 MPH
	.35	1.72	869	822	600	1	
	2.35	2.53	873	822	593	7.2	T TO 700 = ?
	4.35	2.44	873	807	575	10.5	
	6.35	2.44	854	801	563	15	T_0 = FIRST MOTION
	8.35	2.32	838	790	556	20	
	10.35	2.32	814	770	556	23.5	RL
	12.35	2.27	787	760	545	28.6	
	14.35	1.89	783	749	550	33.4	
	16.35	1.77	773	737	550	36.6	
	18.35	1.67	783	749	545	39.9	
	20.35	1.56	783	755	550	42.5	
→	20.98	1.39	778	755	550	43.8	700 ft.
57							REV - CCW
a max		2.40					
V min					575		
T 700	25.54						
S max 700						30.4	
305							FWD - CW
a max		2.52					
V min					550		
T 700	21.6						
S 700						43.8	
07							FWD - CW
a max		2.56					
V min					575		
T 700	21.47						
S 700						43.2	

TEST RUN: 052 3/20/73

BRAKING TESTS 105,000 LB

REC NO	DIRECTION TRACK	DIRECTION CAR	INITIAL SPEED IND MPH	INITIAL SPEED TRUE MPH	STOPPING DATA TIME SEC	STOPPING DATA DIST FT	DEAD TIME SEC	JERK MPH/SEC²	DECEL RATE INITIAL	DECEL RATE PEAK	DECEL AVG ACCELEROMETER MPH/SEC	DECEL ΔV/Δt SPEED TRACE MPH/SEC		ACCEPT ?
EMERGENCY BRAKING														
318	CCW	REV	79	77	24.4	1433	–	3.22	3.36	4.21	2.9	3.14		✓
323	"	"	79	77	24.4	1439	–	3.49	3.29	4.00	3.07	3.14	S/S	✓
328	"	"	62	60	18.3	798	–	2.99	3.41	4.13	3.37	3.29	S/S	✓
331	"	"	62	60	18.0	812	–	3.26	3.36	4.42	3.41	3.27	S/S	✓
335	"	"	42	40.5	12.0	361	–	3.41	3.58	4.46	3.66	3.66	S/S (2)	✓
338	"	"	41	39.5	11.5	335	–	3.32	3.62	4.67	3.83	3.80	S/S LONG	✓
340	"	"	20	18.75	7.25	95	–	4.38	4.12	4.34	—	3.28	S/S	✓
46	CW	FWD	79	77	24.8	1477	–	3.24	3.24	3.83	3.08	2.94		✓
350	"	"	79	77	24.5	1508	–	2.36	3.24	3.66	3.03	2.88		✓
355	"	"	59	57.25	17.3	766	–	2.52	3.45	4.21	3.36	3.28		✓
359	"	"	59	57.25	17.3	769	–	3.12	3.45	4.21	3.70	3.20	PAPER SPEED CHANGED	✓
402	"	"	39	37.5	10.8	312	–	4.63	3.62	4.72	3.75	3.47		✓
405	"	"	40	38.5	10.8	315	–	4.00	3.66	4.67	3.75	3.80	S/S	✓
407	"	"	20	18.75	7.2	105	–	4.28	3.75	4.28	–	4.57	S/S	
BLENDED BRAKING														
310	CCW	REV	79	77	28.5	1780	1.36	2.32	2.65	3.16	2.95	2.81		✓
411	"	"	79	77	28.6	1718	1.40	2.10	2.57	3.41	2.82	2.95		✓
423	"	"	41	39.5	14.7	436	1.0	2.23	3.07	3.16	3.03	2.94		✓
426	"	"	44	39.5	15.5	519	1.24	2.69	2.78	2.98	2.89	2.88		?
429	"	"	41	39.5	15.5	485	.68	1.77	2.78	2.91	2.74	2.68		?

SOAC ACCEPTANCE TESTS
BRAKING

[illegible]

RUN Nº: 052 CONFIG: Nº 2 CAR (H-D)

DATE: 3/20/73 WT: 105 K LB/CAR

REC Nº	DIRECT. TRACK	DIRECT. CAR	INITIAL SPEED IND	INITIAL SPEED TRUE	STOPPING DATA TIME SEC	STOPPING DATA DIST FT	DEAD TIME SEC	"JERK" MPH/SEC²	DECEL RATE INITIAL	DECEL RATE PEAK	DECEL AVG (ACCELOMETER) MPH/SEC	DECEL ΔV/Δt (SPEED TRACE) MPH/SEC	COMMENTS	ACCEPT.
					BLENDED BRAKING									
435	CW	FWD	79	77	29.15	1736	1.48	2.48	2.69	2.94	2.94	2.75		✓
439	"	"	79	77	29	1742	1.60	2.73	2.65	2.95	2.95	2.75		✓
445	"	"	41	39.5	14.95	477	1.16	2.82	2.95	2.95	2.95	2.82		—
450	"	"	41	39.5	14.65	456	.6	2.44	2.95	2.95	2.95	2.88		—
453	"	"	40	38.5	14.6	448	.6	1.86	2.91	2.91	2.91	2.88		—

No 2 CAR (H-D) SPEED CALIB

3/29/73

RUN 052

REC No	SPEED IND	TIME FOR 2000 ft	SPEED TRUE CALC	SPEED-TRUE TRACE
500	49.5	28.5/28.6	47.8/47.7 (47.75)	47.75
504	34	41.7/41.7	32.7/32.7 (32.7)	32.7
510	79	17.7 (2000 ft) / 35.5 (4000 ft)	77 / 76.9 (76.95)	76.5

SOAC TEST RUN 054

DATE: 3/20/73

TIME: START 2100 STOP 3530

PURPOSE: • CONTINUE RUNNING 2-CAR CHECKS AND
• BRAKE TESTS – BLENDED
FRICTION
DYNAMIC
EMERGENCY

WEATHER CONDITION:

WIND SPEED

DIRECTION

BAROMETRIC PRESSURE

AMBIENT AIR TEMPERATURE

START

STOP

CREW:

TEST CONTROLLER ~~BOB BRUSH~~ (EVERT BOTLS)

OPERATIONS DIRECTOR JACK NOZLEY

MOTORMAN BILL CURRAN

DATA CONTROLLER WALT BALLAUDL

GROUND CONTROLLER

INSTRUMENTATION GARY DAVIS

REAR MONITOR DICK HASKEL

ADDITIONAL PERSONNEL GARY WOLEY (SLC)

VEHICLE CONFIGURATION:

CAR 1 CAR 2 105K LB.

THE FOLLOWING PAGES CONTAIN THE METHOD, QUICK-LOOK INDICATORS, TEST DATA AND RECORD NUMBERS FOR RECORDED DATA.

NR 2 CAR H-D OVER CIRCUIT SET UP TO 300% OF MA SET

RUN 054

BLENDED BRAKES
2 CAR TRAIN
CCW - No 1 FWD

217 ROLL CHECK & INITIAL "SLOW" ACCEL

INITAL SPEED	IND	TIME TO STOP (SEC)	DISTANCE TO STOP (FT)	RECORD NUMBER
20	21.5	8.8/8.6	141	324
20	21.5	9.0/9.5	141	321
40	~~41.5~~ 43	~~15.6/16.0~~ 16.7/16.3	~~500~~ 543	~~317~~ 312
40	41	15.3/14.9	483	307
60	61	22.3/23.2	1032	300
60	60	22. /22.2	1000	250
80	70	25.6/ —	1374	238
80	71	26.5/26.6	1441	224

33800 − 32359 = 1441
33800 − 32426 = 1374
33800 − 32800 = 1000
33800 − 32768 = 1032
33800 − 33317 = 483

33800 − 32757 = 543
33800 − 33300 = 500
33800 − 33659 = 141

RUN 054

FRICTION BRAKING — No 1 COIL FWD

CCW No 2 FWD

INITAL SPEED	IND	TIME TO STOP (SEC)	DISTANCE TO STOP (FT)	RECORD NUMBER
20	23	8/7.7	135	330
20	20	7.5/7.0	127	334
40	41	13/13.2	440	339
40	42	13/13.1	449	344
60	56	18.2/18.1	831	350
60	60	19.2/19.2	921	406
80	74	26.8/26.9	1587	416
80	73	25.5/25.6	1508	430

33800 − 33665 = 135
33800 − 33673 = 127
33800 − 33360 = 440
33800 − 32969 = 831
33800 − 32879 = 921
33800 − 32213 = 1587
33800 − 32292 = 1508

33300 − 8 = 32292
32900 − 21 = 32879
33000 − 31 = 32969
33700 − 35 = 33665
33700 − 27 = 33673
33400 − 40 = 33360
33400 − 45

RUN 054 3/20/73

2 CAR TRAIN 105K LB EMERGENCY	No1 CAR FWD CCW DIRECTION

INITAL SPEED		TIME TO STOP (SEC)	DISTANCE TO STOP (FT)	RECORD NUMBER
20				
20				
40				
40				
60				
60	62	19.3/19.8	859	440
80				
80				

33800
32941
859

RUN 054 3/20/73

BLENDED BRAKING CONTROL [illegible] No 2 CAR
2-CAR TRAIN
CW No 2 FWD

INITAL SPEED		TIME TO STOP (SEC)	DISTANCE TO STOP (FT)	RECORD NUMBER
20	20	8.2/7.9	121	527
20	20	8.4/	117	523
40	41.5	15.9/15.8	492	517
40	41	15.8/15.6	480	511
50	49	18.20/18.0	666	504
60	53	19.2/19.3	778	453
30				
30				

32600
22
32578

32500
34
32466

31917

32578
31800
778

32466
31800
666

31917
31800

SOAC ACCEPTANCE TESTS
BRAKING

WRALLACE

RUN Nº: 054 CONFIG: 2-CAR TRAIN

DATE: 3/20/73 WT: 105K LB

REC Nº	DIRECT. TRACK	DIRECT. CAR	INITIAL SPEED IND	INITIAL SPEED TRUE	STOPPING DATA TIME SEC	STOPPING DATA DIST FT	DEAD TIME SEC	"JERK" MPH/SEC²	DECEL RATE INITIAL	DECEL RATE PEAK	DECEL AVG (ACCELOMETER) MPH/SEC	DECEL ΔV/Δt (SPEED TRACE) MPH/SEC	COMMENTS	ACCEPT.
BLENDED BRAKING														
224	CCW	FWD	71	69.75	26.5	1441	1.36	2.61	2.86	3.62	3.11	2.94		✓
238	"	"	70	69	25.6	1374	1.32	2.82	2.86	3.20	2.99	2.94		✓
250	"	"	60	59	22.1	1000	1.0	2.98	3.03	3.03	2.99	2.82		✓ $\bar{a}$ = 2.97
300	"	"	61	60	22.7	1032	.92	2.69	3.15	3.15	3.07	3.01		✓ $\bar{d}$ = .92
307	"	"	41	40.25	15.1	483	1.04	3.15	2.98	3.20	2.94	2.95		$\bar{j}$ = 2.7
312	"	"	43	42.25	16.5	543	.60	2.02	2.86	2.86	2.86	2.94		
317	"	"	41.5	40.75	15.8	500	.64	2.23	2.80	2.80	2.86	2.82		
321	"	"	21.5	20	9.25	141	.68	2.94	3.71	3.71	3.07	2.94		
324	"	"	21.5	20	8.7	141	.72	2.94	3.36	3.36	3.07	3.08		
FRICTION BRAKING														$\bar{a}$ = 3.1
430	CCW	FWD	73	71.75	25.5	1509	1.12	1.98	2.95	4.25	2.94	2.81		✓ w/o
41[illegible]	"	"	74	72.75	26.8	1587	1.28	2.14	3.24	4.04	2.82	2.68		✓ 20 mph
406	"	"	60	59	19.2	921	.76	2.22	2.82	4.54	3.49	2.55		✓
350	"	"	56	55	18.2	831	1.20	2.44	3.32	4.97	3.32	3.34		✓ $\bar{a}$ 3.4
344	"	"	42	41.25	13.1	449	.76	2.48	3.45	5.05	3.37	3.80		✓ $\bar{d}$ .9
339	"	"	41	40.25	13.1	440	.84	2.69	3.49	4.59	3.74	3.60		✓ $\bar{j}$ 2
334	"	"	20	20	7.3	127	.60	—	—	4.75	4.21	3.92	LATE SHUTDOWN OF DYNAMIC BKS.	✓
330	"	"	21	20.5	7.8	135	1.00	2.73	3.49	5.05	4.21	3.92		✓
BLENDED BRAKING														
453	CW	REV	53	51	19.2	778							WILL USE RUN 055 DATA (IT IS COMPLETE)	
504	"	"	49	47	18.1	666								
511	"	"	41	39.5	15.7	460								
517	"	"	41.5	40	15.8	492								
523	"	"	20	18.75	8.4	117								
527	"	"	20	18.75	8.0	121								

SOAC TEST RUN 055

DATE: 3/21/73

TIME: START 9:40 STOP 12:35

PURPOSE:
- CONTINUE 2-CAR TRAIN BRAKING TEST -
  - HIGH SPEED (80 MPH) BLENDED, FRICTION, ... IN CCW DIRECTION NO 1 CAB
  - BLENDED, FRICTION, EMERGENCY FROM NO 2 CAB

WEATHER CONDITION:

WIND SPEED

DIRECTION

BAROMETRIC PRESSURE

AMBIENT AIR TEMPERATURE START STOP

CREW:

TEST CONTROLLER BOB BRUSH

OPERATIONS DIRECTOR JACK HARLEY

MOTORMAN GARY DAVIS

DATA CONTROLLER WALT BALLAUER

GROUND CONTROLLER BOB HASKEL

INSTRUMENTATION FRANK DOSCHER (GSI)

REAR MONITOR GARY WOLFY

ADDITIONAL PERSONNEL GUS KEWSKE (GSI), DENNIS (GROUND CONTROL)

VEHICLE CONFIGURATION:

CAR 1 CAR 2 105 K LB

THE FOLLOWING PAGES CONTAIN THE METHOD, QUICK-LOOK INDICATORS, TEST DATA AND RECORD NUMBERS FOR RECORDED DATA.

NO CHANGES -

FOUND ONE BRAKE GRID CONNECTION ON NO 1 CAR LOOSE - REPLACED BOLT & FIXED.

TRACK CONDITIONS VERY GOOD TO DAY

RUN 055

BLENDED BRAKING — NK2 CAB CONTINUE
2-CAR TRAIN
CW DIRECTION - REV

INITIAL SPEED	IND	TIME TO STOP (SEC)	DISTANCE TO STOP (FT)	RECORD NUMBER	
					319
20	22	9.3/ —	133	1040	32300 41 32259
20	21	8.5/8.3	119	1036	32300 12 32264
40	43	15.8/15.3	484	1031	
40	42	15.5/15.5	459	1028	33600 35 33565
60	60	22.6/22.4	1008	1024	33600 43
60	61	23.0/22.7	1055	1018	33557
80	79	29.6/29.5	1757	1010	32900 4? 855
80	79.5	29.2/29.6	1765	1001	328
	75	28.7/29.5?	—	957	

33565 − 31800 = 1765 33557 − 31800 = 1757 32787 − 31800 = 9 31800

RUN 055

BLENDED BRAKING — NO 2 CAR CONTROL
2-CAR TRAIN
CW DIRECTION - REV

INITAL SPEED	IND	TIME TO STOP (SEC)	DISTANCE TO STOP (FT)	RECORD NUMBER	
					319
20	22	9.3/ —	133	1040	32300 41 32259
20	21	8.6/8.3	119	1036	32300 16 32264
40	43	15.8/15.3	484	1031	
40	42	15.5/15.5	459	1028	33600 35 33565
60	60	22.6/22.4	1008	1024	33600 43
60	61	23.0/22.7	1055	1018	33557
80	79	29.6/29.5	1757	1010	32900 45 855
80	79.5	29.2/29.6	1765	1001	328
	75	28.7/25.5?	—	957	

33565 − 31800 = 1765   33557 − 31800 = 1757   32284 − 31800 = 4   31800

RUN 055

FRICTION BRAKING
2-CAR TRAIN
CW - REV NO 2 CAB

INITAL SPEED		TIME TO STOP (SEC)	DISTANCE TO STOP (FT)	RECORD NUMBER
20	20	6.8/16.9	103	1043
20	22	7.3/7.3	123	1047
40	42	13.0/12.9	400	1050
40	41	13.3/13.0	399	1054
60	61	20.1/20.	938	1057
60	61	19.5/20.	915	1102
80	79	28.6/28.6	1763	1111
80	79	29.2/29.2	1784	1118

32738
31800
938

33563
31800
1763

BCP = 65/66 40/40

RUN 055

BLENDED BRAKING
CCW FWD
2-CAR TRAIN NO1 COB

INITAL SPEED		TIME TO STOP (SEC)	DISTANCE TO STOP (FT)	RECORD NUMBER
20				
20				
x 40	42	15.1/15.3	477	1129
x 40	43	16.2/16.0	508	1134
60				
60				
x 80	80	29.5/29.9	1709	1143
x 80	80	29.4/30.2	1704	1201

33323
33314
33252

32000
31991

32000
31996

33800 − 33323 = 477

33800 − 33252 = 508

33800 − 31991 = 1709

33800 − 31996 = 1704

RUN 055

FRICTION BRAKING
ECW - FWD
2-CAR TRAIN No1 CAB

INITAL SPEED		TIME TO STOP (SEC)	DISTANCE TO STOP (FT)	RECORD NUMBER
20				
20				
40				
40				
60				
60				
80	80	25.2/28.8	1791	1220
80	80	31./31.2	1923	1210

31900
+23
31877

33800
31877
1923

33800
32009
1791

SOAC ACCEPTANCE TESTS
BRAKING

W BALLAST

RUN Nº: 055 CONFIG: 2-CAR TRAIN

DATE: 3/28/73 WT: 105 K LB

REC Nº	DIRECT. TRACK	DIRECT. CAR	INITIAL SPEED IND	INITIAL SPEED TRUE	STOPPING DATA TIME SEC	STOPPING DATA DIST FT	DEAD TIME SEC	JERK MPH/SEC²	DECEL RATE INITIAL	DECEL RATE PEAK	DECEL AVG (ACCELOMETER) MPH/SEC	DECEL AV/AT (SPEED TRACE) MPH/SEC	COMMENTS	ACCEPT.
BLENDED BRAKING														
	CW	REV												
1001	"	"	79.5	77.5	29.4	1765	1.36	2.86	2.78	2.86	2.86	2.82		✓
1010	"	"	79	77	29.5	1757	1.28	2.86	2.82	2.86	2.86	2.82		✓
1018	"	"	61	59.25	22.8	1065	1.36	2.82	2.90	2.90	2.90	2.88		✓
1024	"	"	60	58.25	22.5	1008	1.16	2.35	2.94	2.94	2.94	2.88		✓
~~1028~~	"	"	42	40.5	15.5	459	0	1.85	2.86	2.86	2.86	2.75	[illegible] too early	—
1031	"	"	43	41.5	15.5	484	.56	2.94	2.86	2.86	2.86	2.90		—
1036	"	"	21	20	8.4	119		2.69	2.86	2.86	2.86	3.01		✓
1040	"	"	22	20.75	9.3	133	0	2.94	2.86	2.86	2.86	3.01		✓
FRICTION BRAKING														
1118	CW	REV	79	77	29.2	1764	1.08	1.52	2.82	3.66	2.82	2.88		
1111	"	"	79	77	28.6	1763	1.12	1.72	2.95	3.74	2.55	2.68		
[illegible]	"	"	61	59.25	19.7	915	.64	2.35	3.15	4.62	3.36	3.27		
1057	"	"	61	59.25	20.	938	.84	2.52	3.24	4.63	3.24	3.27		
1054	"	"	41	39.5	13.2	399	.68	2.78	3.62	4.45	3.74	3.50		
1050	"	"	42	40.5	12.9	400	.46	2.52	3.49	4.88	3.53	3.60		
1047	"	"	22	20.75	7.3	123	.40	2.65	3.2	4.80	4.21	4.44		
1043	"	"	20	18.75	6.8	103	.52	2.31	3.2	4.54	3.83	3.92		
BLENDED BRAKING														
1201	CCW	FWD	80	78.75	29.8	1704	1.04	2.18	2.99	2.99	2.99	3.01		
1143	"	"	80	78.75	29.7	1709	1.0	2.68	2.86	2.86	2.86	3.01		
1134	"	"	43	42.25	16.1	506	—	2.32	2.99	2.99	2.99	2.88		
1129	"	"	42	41	15.2	477	.32	2.23	2.9	2.9	2.9	3.08		
FRICTION BRAKING														
1210	CCW	FWD	80	78.75	31.1	1923	.92	1.77	3.03	3.66	—	2.62		
1220	"	"	80	78.75	29.0	1791	.96	1.68	2.95	3.95	2.82	2.82		

ā = 3.22
w/o
20 mph.
[illegible]

SOAC TEST RUN 058

DATE: 3/22/73 TIME: START 2:02 STOP 9:30

PURPOSE: • EMERGENCY BRAKE TESTS 2 CAR TRAIN BOTH DIRECTIONS
• SPEED SWEEPS ON ROUGH SECTION OF TRACK (V: 40-50 & 80)

WEATHER CONDITION:

WIND SPEED 15-25 KNTS @3:45

DIRECTION SW

BAROMETRIC PRESSURE

AMBIENT AIR TEMPERATURE START STOP

CREW:

TEST CONTROLLER Bob Brush

OPERATIONS DIRECTOR J Nazley

MOTORMAN Gary Davis

DATA CONTROLLER Walt Ballamer

GROUND CONTROLLER Dick Haskell

INSTRUMENTATION Mark Doscher

REAR MONITOR

ADDITIONAL PERSONNEL Gary Woley, Gus Krause, Keith Jackson

VEHICLE CONFIGURATION:

(CAR 1 CAR 2) 105 K LB

THE FOLLOWING PAGES CONTAIN THE METHOD, QUICK-LOOK INDICATORS, TEST DATA AND RECORD NUMBERS FOR RECORDED DATA.

RUN 056

EMERGENCY BRAKING
2-CAR TRAIN
CW - REV Nº 2 CAB

INITAL SPEED		TIME TO STOP (SEC)	DISTANCE TO STOP (FT)	RECORD NUMBER
20				
20	21	8.4/7.5	86	302
40	41	11.3	325	256
40	41	12.5	337	248
60	61	18.0/17.6	806	242
60	63	18.8/18.9	881	235
80	79	25.7/25.5	1520	230
80	79	27/26.5	1541	223
	80			219

327 / 15 / 32681

31500 / 14 / 31886

33341 / 31800 / 1541

32606 / 31800 / 806

32681 / 31800 / 881

32137 / 31800 / 337

32225 / 3

319

EMERGENCY BRAKING
CCW - FWD
2 CAR - TRAIN No 1 CAB

INITAL SPEED		TIME TO STOP (SEC)	DISTANCE TO STOP (FT)	RECORD NUMBER
20				
20	22	7.4/7.5	100	350
40				
	42	11.2/11.5	347	346
40	41	12.3 / —	350	342
60	61	18.4/18.65	860	335
60	62	18.7/18.7	864	328
80	80	25.5/25.0	1527	320
80	80	25.8 / 25.9	1555	312

MISSED FIRST COUPLE SECONDS.

33800
32245
1555

33800
32273
1527

33800
32936
864

38000
32940
60

33800
33450
350

3

3

RECORD 357

ACCEL IN CCW (FWD)

TIME TO 700 = 20.1 / 20.4 SEC

SPEED @ 4000 ft = 72 MPH

\# 417

TIME @ 700 ft = 20.4 / 20.4

SPEED @ 4000 ft = 72

SOAC ACCEPTANCE TESTS
BRAKING

RUN Nº: 058 CONFIG: 2-CAR TRAIN
DATE: 3/22/73 WT: 105K LB.

REC Nº	DIRECT. TRACK	DIRECT. CAR	INITIAL SPEED IND	INITIAL SPEED TRUE	STOPPING DATA TIME SEC	STOPPING DATA DIST FT	DEAD TIME SEC	"JERK" MPH/SEC²	DECEL RATE INITIAL	DECEL RATE PEAK	DECEL AVG (ACCELOMETER) MPH/SEC	DECEL ΔV/Δt (SPEED TRACE) MPH/SEC	COMMENTS	ACCEPT.
					EMERGENCY BRAKING									
223	CW	REV	79	77	27.7	1541	–	2.73	3.49	3.91	2.99	2.81		
230	"	"	79	77	25.6	1520	–	2.69	3.36	4.21	2.94	2.88		
235	"	"	63	61.25	18.8	881	–	2.86	3.36	4.79	3.41	3.20		a=3.5
242	"	"	61	59.25	17.8	846	–	3.41	3.28	5.00	3.36	3.40		
248	"	"	41	39.5	12.5	337	–	3.94	3.57	4.54	3.89	3.99		
256	"	"	41	35.5	11.3	325	–	3.87	3.83	5.00	4.03	3.99		
302	"	"	21	15.75	7.9	86	–	3.87	3.95	4.71	4.33	4.32		
					EMERGENCY BRAKING									
312	CCW	FWD	80	78.75	25.8	1555	–	2.65	3.41	4.08	2.74	2.88		
320	"	"	80	78.75	25.2	1527	–	2.69	3.20	4.08	2.94	3.01		a=3.
323	"	"	62	61	18.7	864	–	3.20	3.03	4.25	3.15	3.27		
335	"	"	61	60	18.4	860	–	2.94	3.30	4.84	3.24	3.34		
342	"	"	41	40.25	12.3	352	–	3.45	3.36	4.67	3.82	3.86		
346	"	"	42	41.25	11.5	347	–	–	–	5.34	3.78	4.18		
350	"	"	22	21.5	7.4	100	–	4.21	3.57	4.83	4.08	4.32		

RUN 058

3/22/73

TC NO	TIME	ACCEL	VOLTAGE	SPEED IND	SPEED TRUE	JERK
357	20.0 20.4	2.52	510	72		2.52
417	20.4 20.4	2.56	496	72		1.85
AVG	20.3	2.54	503	72		2.18

SOAC TEST RUN 072

DATE: 4-9-73

TIME: START 9:35 STOP 12:20

WIND SPEED

DIRECTION

PURPOSE: (1) CHECK OUT MONITOR/SHUNT CURRENT AFT & FWD TRUCK
(2) DIFF. I TRIPS INVESTIG. ~NO TRIPS/LIGHTS
(3) BLENDED BRAKING
(4) INITIAL ACCEL TO 900 FT. @ < 600 VOLTS (DOT-001 ONLY)

AMBIENT AIR TEMPERATURE

VEHICLE CONFIGURATION: CAR 1 (CAR 2) 105000 LB.

CURRENT SHUNT ON AFT TRUCK INITIALLY
MOVED TO FWD TRUCK @ 10:20
REMOVED COMPLETELY AFTER TEST.

CREW:

TEST CONTROLLER F. THOMPSON

OPERATIONS DIRECTOR R. OREN

MOTORMAN J. HIX.

DATA CONTROLLER P. BROWN

GROUND CONTROLLER

INSTRUMENTATION

REAR MONITOR

ADDITIONAL PERSONNEL GENE BROWN, BILL SEARLY

CONFIG: NOTES –

1. REDUCED I_A ≈ 11% FROM FRIDAY 4/6 (NOW ≈ 1-2% ↑ FROM OLD LEVEL)
2. PCL & A/B START UP SLOWLY
3. PROB. → DIFF. I X'FORM. GIVES OUTPUT (ON EVENT MARK) –DISCONNECTED FROM TRIPPING–
4. REMOVED MONITOR & REPLACED PWR SUPPLY TO LITE BULBS
5. OVERCURRENT LITE ON WITHOUT TRIP – FOUND LOOSE CARD.
6. HAVE TO FIX #2 TO ALLOW RESET OF PROP. ON THE FLY

← STILL GOT OVERCURRENT LIGHT DURING RUN 073 (refers to 5)

[illegible] #2
[illegible]
[illegible]

4/9/73 Monday 9:40 AM
(REAR TRUCK)

Run #1			2ND	ACT
FWD	13.5 MU	[illegible]	300 AMPS	275.4 AMPS
"	19.5 MU	BRAKE	420 AMPS	398 AMPS
"	24.5 MU	BRAKE	520 AMPS	500 AMPS
"	33.3 MU	DR	700 AMPS	683 "
"	34.5	DR	750 AMPS	744 "
"	38.0	DR	800 AMPS	775 "
"	18.0	DR	380 AMPS	367 "

4/9/73 (FRONT TRUCK) 10:30 AM
RUN #2

FWD	24.5	DR	500 AMPS	499 AMPS
	25.0	DR	510 "	510 "
	37.5	DR	750 "	765 "
	37.0	DA	755 "	755 "
	39.5	BRAKE	800	806 "
	41.0	"	825	836 "

BLENDED BRAKING   #2 H-D
FWD-CW   RUN 023

INITAL SPEED	FWD	TIME TO STOP (SEC)	DISTANCE TO STOP (FT)	DECEL: APPROX.	RECORD NUMBER
20					
40 ~~20~~	40	14.3	457	-3.2	1145
40	40	14.2	459	-3.25	1140
40	38	13.8	407	-3.2	1137
60					
60					
80	79	27.3	1670	-3.1	1125
80	78	27.3	1660	-3.0	1116

29800

29800

NO WEST/SOUTH DIESEL
700' — CW — 1153 — 19.2 SEC (2 WATCHES)

BLENDED BRAKING REV-CCW

#2 H-D RUN 073

INITAL SPEED	IND	TIME TO STOP (SEC)	DISTANCE TO STOP (FT)	RATE APPROX.	RECORD NUMBER
20					
20					
40	40	13.6	428	3.25	1211
40	40	14.0	428	3.25	1207
60					
60					
80	80	25.7	1516	3.25	1202
80	79	25.4	1508	3.25	1156

33800

SOAC TEST RUN 077

DATE: 4/9/73 | 074 RUN | TIME: START 1:35 STOP 4:45 | WIND SPEED | DIRECTION

PURPOSE: (1) ACCELERATIONS - 0-200 ft & 0-80 mph
(2) DYNAMIC BRAKING ONLY
(3) DUTY CYCLE -

AMBIENT AIR TEMPERATURE

VEHICLE CONFIGURATION: CAR 1 CAR 2 (circled) 105000 LB
CURRENT SHUNT REMOVED

CREW:

TEST CONTROLLER F. THOMPSON

OPERATIONS DIRECTOR R. OREN
MOTORMAN J. HIX
DATA CONTROLLER P. BROWN
GROUND CONTROLLER
INSTRUMENTATION
REAR MONITOR

ADDITIONAL PERSONNEL

NOTES: ACCELERATIONS

DIR.	TIME TO 200 ft	MAX. SPEED 4000 ft	RECORD No.	INITIAL RATE } OSCILLOGRAPH DATA.
FWD-CW	19.0 SEC. 18.9 "	INDICATED. 79 mph	146	2.80 ACCEL/2.89 ΔV/Δt 19.2 SEC OSC.
REV-CCW	19.0 19.4	79 mph	154	2.60 ACCEL./2.76 ΔV/Δt
FWD-CW	18.9 " 19.1 "	200' ONLY	200	2.75/2.75 ΔV/Δt
REV-CCW	18.9 " 19.4 "	200' ONLY	202	2.70/2.75 ΔV/Δt

SOAC HI-DENSITY CAR (#2)
TEST RUN 074 (4/9/73)
ACCELERATION DATA.

C. No.	DIRECTION	INITIAL RATE (mph/sec)	TIME @ INITIAL RATE (SEC)	ΔV/Δt mph/sec (5 SEC)	VOLTS @ PEAK ACCEL	VOLTS @ BASE SPEED	TIME TO 700 ft SEC WATCH	TIME TO 700 ft OSCILL. (SEC)	SPEED @ 700 ft mph	VOLTS @ 700 ft
46	FWD-CW	2.80	~7	2.89	615	584	19.0 18.9	19.2	47.2	584
54	REV-CCW	2.60	~7	2.76	628	604	19.0 19.4	19.5	47.2	604
200	FWD-CW	2.75	~6	2.75	615	592	18.9 19.1	19.2	46.0	584
202	REV-CCW	2.70	~7	2.75	628	615	18.9 19.4	19.5	46.6	603

REC. No.	PEAK SLOPE JERK RATE (mph/sec) .5 SEC	1.0 SEC Δa/Δt JERK RATE (mph/sec) 1.0 SEC
146	4.5	2.4
154	3.1	2.3
200	3.7	2.5
202	3.3	2.2

DYNAMIC BRAKING ONLY | #2 SOAC H-D CAR | FWD - CW | RUN 004

INITAL SPEED	IND.	TIME TO STOP (SEC)	DISTANCE TO STOP (FT)	RATE	RECORD NUMBER
20					
20					
40	40	15.7	484	3.0	228
40	40	15.8	484	3.0	224
60					
60					
80	78	29.7	1722	3.0	218
80	79	29.5	1734	3.0	213

31536
29800
1736

DYNAMIC BRAKING ONLY #2 SOAC H-D CAR

REV - CCW RUN 074

INITAL SPEED	IND	TIME TO STOP (SEC)	DISTANCE TO STOP (FT)	RATE	RECORD NUMBER
20					
20					
40	40	14.6	449	3.1-	246
40	40	15.0	450	3.1	242
60					
60					
80	79	26.6	1585	3.1+	239
80	80	26.5	1577	3.1	232

33800
-450
33350

CAR #2
HI-DEN.

ACCEPTANCE TESTS
RUNS: 073 & 074

10500OLB

TEST RUN	REC	INITIAL SPEED IND (mph)	INITIAL SPEED TRUE (mph)	STOPPING DATA TIME (SEC)	STOPPING DATA DIST (ft)	DEAD TIME (SEC)	JERK (mph/sec²)	DECEL. RATE ACCELEROMETER	DECEL RATE ΔV/Δt	Σ D.T. + 1/2 JERK + ΔTE/Δt
				BLENDED BRAKING: FWD-CW						
073	1116	78	77	27.3	1660	—	—	3.0	3.21	N.A.
↓	1125	79	78	27.3	1670	.8	2.4	3.1	3.06	↓
↓	1137	38	38.5	13.8	407	.6	2.1	3.2	3.28	↓
↓	1140	40	40	14.2	459	.7	2.4	3.2	3.28	↓
↓	1145	40	40	14.3	457	.7	2.3	3.1	3.30	↓
				BLENDED BRAKING: REV-CCW						
073	1156	79	78	25.4	1508	.9	2.9	3.2	3.28	N.A.
↓	1202	80	79	25.7	1516	.9	2.4	3.3	3.28	↓
↓	1207	40	40	14.0	428	.8	2.7	3.2	3.36	↓
↓	1211	40	40	13.6	428	.8	3.2	3.3	—	↓
				DYNAMIC BRAKING ONLY: FWD-CW						
074	213	79	78	29.5	1734	.8	2.4	2.95	3.01	2.1
↓	218	78	77	29.7	1722	.8	1.7	2.95	3.01	2.4
↓	224	40	40	15.8	484	.75	2.2	3.00	3.01	1.9
↓	228	40	40	15.7	484	.8	2.0	3.00	3.08	1.9
				DYNAMIC BRAKING ONLY: REV-CCW						
074	232	80	79	26.5	1577	.9	2.3	3.25	3.15	2.0
↓	239	79	78	26.6	1585	.8	2.5	3.25	3.18	2.1
↓	242	40	40	15.0	450	.8	2.4	3.20	3.14	1.7
↓	246	40	40	14.6	449	.8	2.3	3.10	3.08	1.8

SERVICE DUTY CYCLE

CAR No. 2
-HIGH DENSITY-
FWD-CW DIRECTION

BLENDED ~~Motor~~

FRICTION
~~TR~~ FLANGE/RIM
WHEEL ~~TR~~EAD

CYCLE		~~TEMPERATURE~~ TIME	STA. #	
1	✓	2:52	3:350	START.
2	✓			
3	✓			
4	✓			
5	✓		10000	
6	✓			
7	✓			
8	✓			250°(RED)
9	✓			
10	✓			
11	✓	[illegible]		
12	✓	3/3		
13	✓		7100	
14	✓			1 370°(RED)
15	✓			
16	✓			
17	✓			370° RED 200° END.
18	✓			
19	✓	3:26		
20	✓			
21	✓			
22	✓	3:32		
23	✓			
24	✓	3:36:55	264	5

2 LAPS (cycles 16–17)

2 LAPS $ 33500 → 26400

	CYCLE		TEMPERATURE STA.	
3:46	1	✓	298	
	2	✓		
	3	✓		
	4	✓	N.G.	
5	5	✓	N.G. ✓	
	6	✓		
	7	✓		
4:00	8	✓	140/150°	
1 LAP 4:05	9	✓		
	10	✓		4:05
	11	✓		4:06.5
	12	✓	150/165°	
	13	[illegible]		200°
	14	✓		
	15	✓	F.B.I.F.	
	16	✓	SC [illegible]	
LTT	17	✓	CUT ~ 5/5 ?	
	18	✓		
	19	✓	[illegible]	
	20	✓		
PAD FIRE	21	✓	RESIDUE ON WHEELS	
	22	✓	SLIP/SLIDES	
51.14	23	✓		STA.
437 PAD FIRE	24	✓	250/170°	300

3 LAPS + 30000
→ + → Δ = 200 FT,

1 52796
33500
19296'

26400
4625
21775
19296
41,071 =

1 LAP ≈ 9.12 MILES

9.12
9.12
7.79
26.03 MILES
IN 42.92 min
$\bar{V}$ = 36.4 mph

9.12
9.12
9.12
.04
27.40 MILES
IN 51.0 MINUTES
$\bar{V}$ = 32.2 mph

WEATHER CONDITION.

SOAC TEST RUN 076

WIND SPEED

DATE: 4/10/73 TIME: START 1:38 STOP 5:15

DIRECTION

PURPOSE: ① TROUBLE SHOOT PROPULSION TRIPS
② FIND BAD SPEEDO-CARD (22 mph LURCH) S/S
③ PUT CURRENT SHUNT ON FWD TRUCK
④ ACCELS TO 200 ft
⑤ BLENDED BRAKING ⑥ SPEEDOMETER CALIB.

AMBIENT AIR TEMPERATURE

VEHICLE CONFIGURATION: (CAR 1) CAR 2 105000 LB
— LOGIC CARD SWAPPING TO LOCATE PROP. TRIPS & 22 mph
S/S LURCHING
— PUT CURRENT SHUNT ON FWD TRUCK @ 1:47

CREW:
TEST CONTROLLER F. THOMPSON

OPERATIONS DIRECTOR R. OREN
MOTORMAN G. BROWN
DATA CONTROLLER P. BROWN
GROUND CONTROLLER
INSTRUMENTATION
REAR MONITOR

ADDITIONAL PERSONNEL J. HIX

RUN NOTES:

① REPLACED J34 WITH #2 A-D CAR J34; REPLACED TOP SPEEDO-CARD 46 WITH ORIGINAL THAT WAS IN L-D CAR (ONLY 49 IS SWAPPED NOW) NEED TO REWORK ARM. VOLTAGE FEEDBACK CIRCUIT IN BOTH CARS: FIELD TOO STRONG ABOVE V_{BASE}! (1:38)

② RAN WITH #① MODS ABOVE: GOT S/S @ 20 mph BAD CARD WAS CARD 46 TOP SPEEDO CARD: AXLE #1 DID NOT GET TRIPS — CARD J34 IS PROB. BAD. (1:47)

③ REPLACE ORIGINAL NO. 1 CAR CARDS: J25; J37; J35 & LEFT J34 FROM NO. 2 IN. PUT CARD 46 FROM OTHER CAR BACK IN.

RUN NOTES:

(4) SHUNT ON FWD TRUCK - MODS. FROM #(3) ABOVE @ 2:03: NO S/S LURCHING @ 20 mph ∴ CARD 46 WAS BAD. "(H-D46)" NO TRIPS IN TRANSITION;

MODE	I MON	I SHUNT		DIR	V A/B / V BASE	REC
		FWD TRUCK				
DR	625	315	622	FWD		
	640					
DR	650	325	663	FWD		

SPEEDOMETER CALIBRATION:

V IND	COURSE	TIME	MPH TRUE	REC.
80	4000'	34.25	79.6	211
50	2000'	27.25	50.0	219
35	2000'	38.55	35.4	223

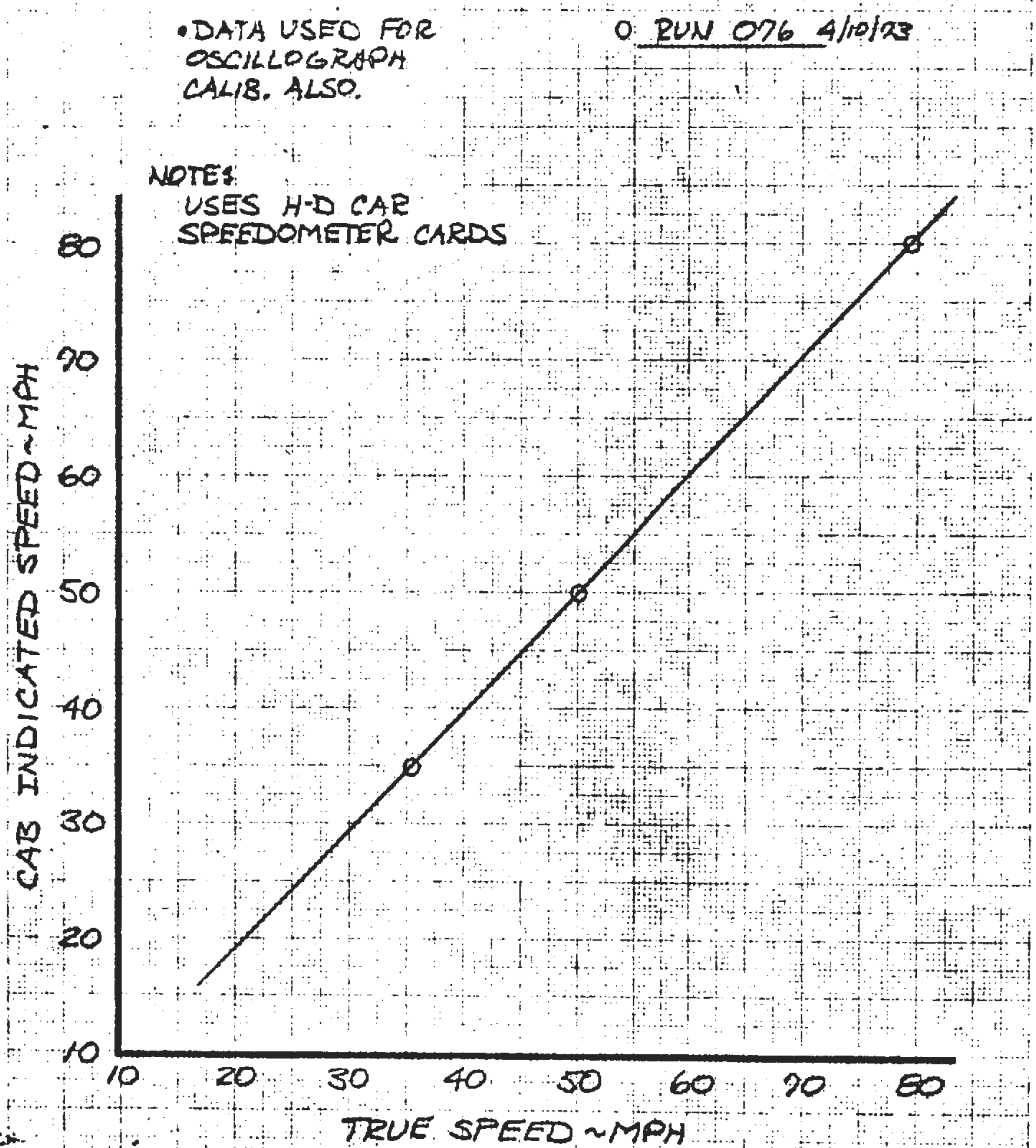
200 amps/TRUCK FOR 80 mph ON LEV. LAN.

STOP TO FIX CARD J34 @ 2:37
& ALSO CHECK ARMATURE VOLTS FEEDBACK → FIELD.

FINDINGS: FEEDBACK WIRE FOR ARM. VOLTS CONNECTED WRONG - MONITOR IS READING THE GENERATED VOLTAGE OF A DIODE COOLING FAN WHICH WAS

SOAC SPEEDOMETER CALIBRATION

LOW-DENSITY CAR



P. Brown
4/10/73

NOT EVEN CONNECTED. (DIODES ADDED TO BALANCE THE TWO TRUCK ARMATURE CURRENTS.) THIS IS THE SAME AS ON #2 H-D CAR ALSO & WE RUN THE FULL DUTY CYCLE ON UNCOOLED DIODES. GOOD DESIGN MARGIN..... OR THE TWO DIODES IN PARALLEL STILL FUNCTION WITH ONE BLOWN -- TO BE DETERMINED ON #2 CAR; #1 LOOKS OK.

BACK ON LINE @ 3:35
- SMALL FIX ON CARD #J34 REPLACED TRANSISTOR (DAMAGE FROM 600 VOLT)
- FAN CONNECTED ON DIODES
- ARM. VOLT FEEDBACK INSTALLED
- NO TRIPS

	MONITOR	SHUNT ON FWD TRUCK	
DR	700 I_F,	35.0 mV → 714	B
"	700 I_F	" → "	A
BR	760 I_F	38.0 → 775	CHOP ON.

ACCELERATION RUNS

DIR	$t_{700'}$	V_{max}, 4000'	REC. No.	ACCEL. RATE
FWD.	19.0	79 mph	3:45	~2.75
REV.	19.7 19.9	79 mph	350	<2.50?
FWD	19.2 19.3	700' ONLY	353	~2.75
REV	19.5 19.7	700' ONLY	356	~2.50

SOAC LOW-DENSITY CAR
TEST RUN 076

ACCELERATION DATA
(3) DIESELS ON-LINE
S.+W. + DOT-001

REC. No.	DIRECTION	INITIAL RATE (mph/SEC)	TIME @ INITIAL RATE (SEC)	ΔV/Δt mph/SEC (5 SEC)	VOLTS @ PEAK ACCEL	VOLTS @ BASE SPEED	TIME TO 200 ft (SEC) WATCH	TIME TO 200 ft (SEC)	SPEED @ 200 FT (mph)	VOLTS @ 200 ft
345	FWD	2.75	~8	2.80	640	600	19.0 19.0	19.1	47.4	600
350	REV.	2.5	~6	2.66	650	600	19.7 19.9	20.	45.4	595
[illegible]3	FWD	2.75	~6	2.78	645	605	19.2 19.3	19.2	46	610
356	REV	2.50	~6	2.66	650	610	19.5 19.7	19.7	45.3	615
121	FWD	2.70	~6	2.67	645	600	—	—	—	—
122	REV	2.55	~6	2.66	645	—	—	—	—	—
MADE ONE LAP IN REV (CW) AT 80 MPH										
437	REV	2.65	~5	2.66	650	600	19.4 19.4	19.5	45.3	600
443	REV	2.6	~5	2.73	650	600	19.4 19.2	19.5	44.7	600
	AVG RATES ACCEL + ΔV/Δt	FWD 2.74	REV 2.62	TOTAL AVG. 2.68						

TEST RUN 076

ACCELERATION DATA

JERK RATES (MPH/SEC²)

REC NO.	PEAK SLOPE .5 SEC	Δa/Δt (1.0 SEC) 1.0 SEC.
345	3.1	2.1
350	2.5	1.5
353	3.1	2.0
356	2.7	1.8
421	3.1	2.0
422	2.5	2.0
437	2.6	1.8
443	2.6	2.0

TIME 502: LOST FWD TRUCK CURRENT: AFT TRUCK WORKS BUT NO PROPULSION

BLENDED BRAKING #1 L-D
FWD-CCW & REV-CCW RUN 076

	INITAL SPEED	IND	TIME TO STOP (SEC)	DISTANCE TO STOP (FT)	RATE	RECORD NUMBER
	20					
	20					
FWD	40	41	~14.1	443	~3.1	458
FWD	40	40.5	14.9	461	~3.0	404
REV	~~60~~ 40	40	14.3	453	~3.2	415
REV	~~60~~ 40	41	14.6	446	~3.25	453
	80					
	80					

33800

REC	DIR	MODE	RATE
421	FWD	ACCEL	~2.75
422	REV	ACCEL	~2.50

IN	437	REV	19.4/19.4 sec → 700'	
LDP @ 80	443	REV	19.4/19.2	700'

CAR 1-2 ACCEPTANCE TESTS RUN 076 105000LB.

RECORD NO.	INITIAL SPEED IND. (mph)	INITIAL SPEED TRUE (mph)	STOPPING DATA TIME (SEC)	STOPPING DATA DIST (ft)	DEAD TIME (SEC)	JERK RATE mph/sec²	DECEL RATE ACCELEROMETER (mph/sec)	DECEL RATE ΔV/Δt (mph/sec)	RATE AVG FOR DIRECTION (mph/sec)
			BLENDED BRAKING FORWARD DIRECTION						
404	40.5	41	14.9	461	.7	2.6	3.05	3.20	3.19
458	41	41.4	14.1	443	.7	3.0	3.20	3.32	
			REVERSE DIRECTION						
415	40	40.5	14.3	453	.7	3.0	3.25	3.32	3.30
453	41	41.4	14.6	446	.7	3.5	3.3	3.33	

WEATHER CONDITIONS

SOAC TEST RUN 077

WIND SPEED

DATE: 4/11/73

TIME: START 8:58 STOP 10:00

DIRECTION

PURPOSE: (1) BLENDED BRAKING
(2) CHECK OUT MOTOR CONNECTION

AMBIENT AIR TEMPERATURE

VEHICLE CONFIGURATION: (CAR 1) CAR 2 105000 LB
REPAIRED MOTOR CONNECTION ON FWD TRUCK
SAME CARDS AS LAST RECORD OF RUN 076
CARDS J34 & 46 ARE FROM #2 A-D CNR.

CREW:

TEST CONTROLLER F. THOMPSON

OPERATIONS DIRECTOR R. OREN

MOTORMAN J. HIX

DATA CONTROLLER P. BROWN

GROUND CONTROLLER

INSTRUMENTATION

REAR MONITOR

ADDITIONAL PERSONNEL

NOTES:

(1) DOT-001 NOT ON LINE (ON PURPOSE) WEST & SOUTH DIESELS ONLY ~650 VOLTS OPERATION IS OK.

(2) GOT SOME CURRENT SPIKES DURING TRANSITION IN SPEED LIMITING - RECORDS AVAILABLE

BLENDED BRAKING — #1 L-D CAR

FWD & REV — RUN 077

amps	INITAL SPEED	IND	TIME TO STOP (SEC)	DISTANCE TO STOP (FT)	RATE	RECORD NUMBER	DIR.
	20						
	20						
	40						
	40						
750/760	80 ~~60~~	80	26.3	1614	~3.3	946	REV
750/760	80 ~~60~~	80	26.5	1606	~3.3	940	REV
760/710	80	81	27.0	1648	~3.05	928	FWD
750/700	80	80	26.5	1636	~3.0	920	FWD

CAR #1 L-D ACCEPTANCE TESTS
RUN 076
105000 LB.

RECORD NO.	INITIAL SPEED IND. (mph)	INITIAL SPEED TRUE (mph)	STOPPING DATA TIME (SEC)	STOPPING DATA DIST (ft)	DEAD TIME (SEC)	JERK RATE mph/sec^2	DECEL RATE ACCELEROMETER (mph/sec)	DECEL RATE $\Delta V/\Delta t$ (mph/sec)	RATE AVG FOR DIRECTION (mph/sec)
			BLENDED BRAKING FORWARD DIRECTION						
404	40.5	41	14.9	461	.7	2.6	3.05	3.20	3.19
458	41	41.4	14.1	443	.7	3.0	3.20	3.32	
			REVERSE DIRECTION						
415	40	40.5	14.3	453	.7	3.0	3.25	3.32	3.30
453	41	41.4	14.6	446	.7	3.5	3.3	3.33	
			TEST RUN 077 FORWARD DIRECTION						
920	80	79.5	26.5	1636		3.0	3.0	3.2	3.14
928	81	80.4	27.0	1648		—	3.15	3.2	
			REVERSE DIRECTION						
940	80	79.5	26.5	1606		2.9	3.25	3.26	3.22
946	80	79.5	26.3	1614		2.9	3.20	3.16	
						2.9 AVG			F & R AVG = 3.21 mph/sec

SOAC TEST RUN 078

WIND SPEED

DATE: 4/11/73

TIME: START 1048 STOP 1:41 PM.

DIRECTION

PURPOSE: ① CHECK OUT 2-CAR CONSIST
② ACCELERATION
③ BLENDED BRAKING
④ DYNAMIC BRAKING ONLY

AMBIENT AI TEMPERATUR

VEHICLE CONFIGURATION: CAR 1 CAR 2 105000 LB

#1 CAR SAME AS RUN 077
#2 CAR BROUGHT UP TO #1 CARDS BUT SAME PERF. AS LAST #2 CAR RUN. 074?

CREW: VARIOUS

TEST CONTROLLER F. THOMPSON

OPERATIONS DIRECTOR R. OREN

MOTORMAN J. HIX

DATA CONTROLLER P. BROWN

GROUND CONTROLLER T. WEST

INSTRUMENTATION ______

REAR MONITOR ______

ADDITIONAL PERSONNEL PURVIS DUNLAP G. BROWN
G. DAVIS, W. COBB + FRIENDS & R. BRUSH

NOTES:

① 1048 DRIVE FROM No. 1 N.G. AIR LEAKS.
1106 START AGAIN.
61mph #1 = 62mph #2

REC	DIR	CONTR.	TIME TO 700'	V@4000'	
1123	FWD	#1	20.0/20.0	75 mph	NO PRELOAD
1128	"	"	20.3/20.4	700' ONLY	WRONG PRELOAD
1131	"	"	19.4/19.9	700'	PRELOAD

— LESS THAN 600 VOLTS PRIOR TO 700' —

② 1202 SWITCH CONTROL TO #2 H-D CAR
DATA STILL IN #1 CAR → BLEND BRK: ACCEL & DYNAM. ONLY

③ CONTROL BACK IN #1 L-D @ 1:10 PM

L-D FWD

BLENDED BRAKING #1 & #2 SOAC

FWD AIR ON L-D CAR RUN 078

TRACK: CCW

Ia

INITAL SPEED	IND.	TIME TO STOP (SEC)	DISTANCE TO STOP (FT)	RATE	RECORD NUMBER
20					
20					
40	41	~14.3	454	~3.0	1157
32 40"/	41-42 41	14.0	453	~3.0	1154
60					
60					
80	80 80	27.0	1659	~3.0	1148
80	80	27.1	1664	~3.0	1141

BLENDED BRAKING #1 & #2 CARS
#2 H-D FWD DIR. (TRACK (CW)) RUN 078

INITAL SPEED	H-D IND CAB 2	TIME TO STOP (SEC)	DISTANCE TO STOP (FT)	RATE ACCELEROMETER	RECORD NUMBER
20					
20					
40	40	~14.3	417	~3.3	1246
40	40	14.2	423	~3.25	1243
60					
60					
80	79	26.3	1557	~3.3	1236
80	CAB #2 79	26.5	1579	~3.3	1229

REC	DIR	CAR	TIME 700	RATE	PRECOND	DIST
1209	CW FWD	#2	20.2/20.3	~2.55	YES	4000'
1215	"	"	20.2/20.1	~2.55	"	700'

DYNAMIC BRAKING ONLY #1 & #2 SOUC
#2 H-D FWD DIR'S (CW) RUN 018

INITAL SPEED	H-D IND	TIME TO STOP (SEC)	DISTANCE TO STOP (FT)	RATE	RECORD NUMBER
20					
20					
40	40	15.0	447	~3.15	108
40	40	14.5	453	~3.15	105 pm
60					
50					
80	79	28.3	1644	~3.15	100 pm
80	79	28.6	1646	~3.2	1254 pm

CONTROL TO #1 L-D CAB @ 1:10 pm.

DYNAMIC BRAKING ONLY. #1 & #2 SOAC
#1 L-D FWD (CCW) RUN 098

INITAL SPEED	L-D #1 IND	TIME TO STOP (SEC)	DISTANCE TO STOP (FT)	RATE	RECORD NUMBER
20					
20					
40	41	~15.2	463	~2.95	132
40	40	14.4	467	~2.95	128
60					
60					
80	80	28.2	1720	~2.95	124
80	79.5	28.4	1706	~2.95	115

SOAC TEST RUN 080

WIND SPEED

DATE: 4/12/23

TIME: START 1:35 STOP 5:15

DIRECTION

PURPOSE: ① CHECK OUT FIXES ON CAP. BANK & CHOPPER
② DYNAMIC BRAKING ONLY
③ DUTY CYCLES & BLEND./FRICT.

AMBIENT AIR TEMPERATURE

VEHICLE CONFIGURATION: (CAR 1) CAR 2 105000 LB
① PUT ALL (4) SPARE DRAWERS IN CHOPPER
② PUT FUSES FROM #2 (H-D) CAR INTO L-D CAP. BANK (11)
③ CHANGED OP. AMP. & SOME "GATE" PARTS

CREW:

TEST CONTROLLER F. THOMPSON

OPERATIONS DIRECTOR R. OREN

MOTORMAN G. BROWN

DATA CONTROLLER G. DAVIS

GROUND CONTROLLER

INSTRUMENTATION

REAR MONITOR

ADDITIONAL PERSONNEL PURVIS, P. BROWN

NOTES:

① RADIO TRANSMIT & LOSE "P" SIGNAL POSSIBLE RFI INTO 'P' GEN.

② NO TRIPS OR ARMATURE SPIKES: D.B. ONLY TEST @ 2:37

③ ON CYCLE 9 AND FRICT. ONLY L/H DOOR WOULD NOT INDICATE "CLOSED" RUN ON "BYPASS SWITCH. (RELEASE MEANS PROPULSION TRIP). HAVE TO HOLD DOWN. CYCLED DOOR CIRCUIT BREAKERS & PROBLEM WENT AWAY CONTINUED CYCLE WITH LITTLE OR NO DWELL TIME TO CATCH-UP. DATA LOOKS OK. GOT ONE TMA TRIP IN S.E. RAIL GAP-CAME BACK BY ITSELF.

DYNAMIC BRAKING ONLY #1 L-DOOR

FWD & REV DIRECTION RUN 080

INITAL SPEED	IND	TIME TO STOP (SEC)	DISTANCE TO STOP (FT)	RATE	RECORD NUMBER	DIR.
40 ~~20~~	41	15.4	466	~3.1	307	REV
40 ~~30~~	41	15.4	457	~3.1	304	REV
40	41	~16.3	494	~~~2.5~~ *	247	FWD
40	41	15.8	491	~~~2.5~~	243	FWD
80 ~~50~~	79	28.4	1679	~3.1	258	REV
80 ~~50~~	80	28.0	1700	~3.1	253	REV
80	80	28.7	1759	~~~2.6~~	239	FWD
80	80	28.9	~~1774~~	~~~2.6~~	231	FWD

REC FULL
240 ACCEL IN REV.
250 " " FWD

* ACCELEROMETER IS INCORRECT IN BRK-FWD DATA; INTERMITTANT PROBLEM. — SEE FINAL TABULATED DATA FOR RATES.

TEST RUN 080   DYNAMIC ONLY   CAR No. 1 L-D

REC. NO.	INITIAL SPEED IND mph	INITIAL SPEED TRUE mph	STOPPING DATA TIME SEC	STOPPING DATA DIST. ft	DEAD TIME SEC	JERK RATE mph/SEC²	DECEL RATE ACCELEROMETER mph/SEC	DECEL RATE ΔV/ΔT mph/SEC	Σ D.T. + 1/2 JERK + ΔV/ΔT	
			FORWARD –			CCW ON TRACK				
231	80	79.5	28.9	1794	.7	2.5	N.G.	2.90	1.5	AVG. =
239	80	79.5	28.7	1759	.8	2.1	N.G.	2.93	1.7	2.96 mph/SEC
243	41	41.4	15.8	491	.8	2.3	N.G.	3.03	1.8	
247	41	41.4	16.3	494	.7	2.2	N.G.	2.97	1.7	
			REVERSE –			CW ON TRACK				AVG. =
253	80	79.5	28.0	1700	.8	2.2	3.05	3.00	1.9	3.04
258	79	78.4	28.4	1679	.8	2.3	3.00	3.07	2.3	mph/SEC
304	41	41.4	15.4	457	.7	2.5	3.05	3.07	1.8	2-WAY AVG. =
307	41	41.4	15.4	466	.7	2.5	3.05	3.00	1.3	3.00 mph/SEC

RECORD 253 TIME HISTORY

REF. TIME	DECEL RATE	SPEED
0	0	79.5
1	2.3	77
2	2.75	75
3	2.85	72
4	2.90	69
5	3.00	66
6	3.00	63
8	3.05	57
10	3.05	51
26	3.00	3
27	.70	1
28	0	0

TIME	RATE	SPEED
26.5	1.50	1.5

SOHC L-D CAR
SERVICE DUTY CYCLE
RDN 4/ /73

BLENDED ~~MOTOR~~ FWD ~ CCW DIRECTION FRICTION ONLY

CYCLE	TEMPERATURE TIME	TEMPERATURE STATION
1 ✓	3:11	323
2 ✓		
3 ✓		
4 ✓	s 3:18	
5 ✓		
6 ✓		
7 ✓		
8 ✓		
9 ✓		296?
10 ✓		
11 ✓		
12 ✓		
13 ✓		
14 ✓		
15 ✓		
16 ✓		
17 ✓	3:43	
18 ✓		
19 ✓		
20 ✓		
21 ✓	3:52	
22 ✓		
23 ✓		
24 ✓		

(margin: 1 LAP at cycle 8; 2 LAPS at cycle 16; 3 LAPS at cycle 23)

STOP: 3:58 24/200

3LAPS + 32300 TO 24200
24200
→ 8100 FT

TIME: 47 min.
1.96 min./STOP

9.12
9.12
9.12
1.53
28.89 mi DIST

V̄ = 36.9 mph

WHEEL TREAD

CYCLE	TEMPERATURE	
1 ✓	4:11	127
2 ✓		
3 ✓		
4 ✓		
5 ✓		LTT
6 ✓		
7 ✓		130 SEC
8 ✓		130
9 ✓		
10 ✓	4:40 DOOR PROB	34
11 ✓	35 SEC STOP LT TIME TO STC	
12 ✓		
13 ✓		
14 ✓		
15 ✓		
16 ✓		
17 ✓	250°	
18 ✓	33 SEC STOP	
19 ✓	~~30 SEC DWELL~~	
20 ✓		
21 ✓	3 LAPS	
22 ✓	"FIRE" SEC. CLARD	
23 ✓	68 PSI	
24 ✓	9 mph IND	

(margin: 1 LAP at cycle 8; 68 PSI, NO 30 SEC DWELL from cycle 10 to 17; MA TRIP IN SE GAP → 2 LAPS at cycle 14; STOP at cycle 17; LOST OSC. PWR CONTINUE TEST at cycle 19; 30 SEC DWELL)

31.6 SEC
5:09 2010 FT
STA: 318
3LAPS + 127 TO 318

320°/280°
TREAD/RIM

31800
12700
19100
-3.62
9.12
5.50
9.12
9.12
9.12
32.86 mi

TIME: 58 min.
2.42 min/STOP
V̄ = 32.9 mph

SOAC #1 L-D CAR
TEST RUN 080

- INSTRUMENTATION CHECK -

ACCELERATION & BRAKING RATES

REC.	MODE	DIR-ECT.	ACCEL. ACCELER-OMETER	K=66.7 ΔV/Δt SPEEDO-METER	DUTY CYCLE NUMBER
239	BRAKE	FWD	-2.75	-2.93	—
240	ACCEL	REV	2.45	2.67	—
253	BRAKE	REV	-3.05	-3.00	—
250	ACCEL.	FWD	2.80	2.78	—
STOPPING			AVERAGES		FRICTION:
	BRAKE	FWD	-2.30	-2.22	#5
	↓	↓	-2.50	-2.47	#11
2010			-2.75	-2.73	#24
DIST.					ALL ON LEV. TANG. TRK

NOTE: BASED ON ABOVE DATA THE ACCELEROMETER APPEARS TO BE IN ERROR FOR FWD-BRAKE & REV-ACCEL ON CAR No. 1. DATA VALIDATED BY SPEEDOMETER TRACE. THIS IS AN INTERMITTANT PROBLEM & SOME DATA IS OK.

MAX. RECORDED BRAKE TEMPS: 320° TREAD
FRICTION CYCLE #24. : 280° RIM

- CAR MEETS BRAKE SPEC. RATE & DIST. ON FINAL STOP.

SECTION 2. RIDE QUALITY TESTS

SOAC TEST RUN 011

DATE 11/30/72

TIME

START	STOP
1:00 PM	4:00 PM

Motorman:

Crew:

CONFIGURATION

CAR 1 (CAR 2) 105 Klb

REASON

Continued Ride Quality & Noise Data

METHOD:

(a) Operate car around loop at ~~continuous~~ constant speed 50 MPH
(b) Reset damping
(c) Repeat 50 MPH Run
(d) When satisfied with settings (3 or 4 runs) take ride data at other speeds 25, 35, 80

* Noise Data Interior at 80 MPH.

Check or walk thru expansion joint at Loc. 339+30

DATA:

* SPEED LIMIT; TEST CANCELLED

SOAC TEST RUN | 057

DATE: 3/22/73   TIME: START 11:20 STOP 12:30

PURPOSE: 2-CAR TRAIN TESTS -
• RUN ASMS TEST AND OBTAIN TRUCK MOTION DATA FOR GSI
•

WEATHER CONDITION:

WIND SPEED [ ] DIRECTION [ ]   BAROMETRIC PRESSURE [ ]   AMBIENT AIR TEMPERATURE START [ ] STOP [ ]

CREW:

TEST CONTROLLER ~~B~~ LOCO BRUSH CAR (REGGIE PAILEY)

OPERATIONS DIRECTOR J. HOLLEY   MOTORMAN GARY DAVIS

DATA CONTROLLER WALT BALLAUER   GROUND CONTROLLER DICK HASKEL

INSTRUMENTATION [illegible]   REAR MONITOR ______

ADDITIONAL PERSONNEL ~~GARY~~ D ~~[illegible]~~ (SLC) GUS KRAUSE; (GSI)

VEHICLE CONFIGURATION:

(CAR 1 CAR 2) 105K LB

THE FOLLOWING PAGES CONTAIN THE METHOD, QUICK-LOOK INDICATORS, TEST DATA AND RECORD NUMBERS FOR RECORDED DATA.

• INSTALLED TRUCK MOTION INSTRUMENTATION
• NO CHANGES TO CARS FROM YESTERDAY

RUN 056 3/22/93 ASMS TESTS.

DIRECTION: CW (REV)
CAB Nº 2 (HIDEN)

TREC Nº	SPEED COMMAND	SPEED IND
1135/1137	3	3
	15	15
	25	25
1140	35	35
1143	50	50
1145	70	70
1147	80	80
1150	70	70
1153	50	50
1154	35	35
↓	25	25
	15	14
	3	—

DIRECTION:
CAB Nº

TREC Nº	SPEED COMMAND	SPEED IND
1200	3	
	15	15/16
	25	26/25
	35	35/36
	50	51
	70	70
	80	79
	70	70
	50	50
	35	35
	25	25
	15	15
	3	—
1215	70	70
1216	70→50	50

TRACK SECTION	TEST STATION	REF
I	1	205
II	2	230
III	3a	250
	3b	315
IV	4a	365
	4b	428
V	5	467
VI	6	490
	↑	

SOAC TEST RUN | 062

DATE: 3/28/73 TIME: START 3:50 STOP 5:30

PURPOSE: • MEASURE ARMATURE CURRENTS on Nº 2 (H+D) CAR.
• MEASURE RIDE QUALITY FOR GST WITH 3" BLOCK OUT

WEATHER CONDITION:

WIND SPEED

DIRECTION

BAROMETRIC PRESSURE

AMBIENT AIR TEMPERATURE START STOP

CREW:

TEST CONTROLLER REGGIE PARKER

OPERATIONS DIRECTOR TROY BOMAR
DATA CONTROLLER WALT BALLAVCK
INSTRUMENTATION

MOTORMAN GARY DAVIS
GROUND CONTROLLER
REAR MONITOR DICK HASKEL

ADDITIONAL PERSONNEL GUS KRAUSE, MASON BAUM,

VEHICLE CONFIGURATION: CAR 1 CAR 2 (circled)

105K LB

THE FOLLOWING PAGES CONTAIN THE METHOD, 'QUICK-LOOK INDICATORS, TEST DATA AND RECORD NUMBERS FOR RECORDED DATA.

• REMOVED 3" SPACER BLOCKS FROM EACH TRUCK ON Nº 2 CAR.
• ADJUSTED SPEED SENSOR CARDS TO SPEC TO TRY & ELIMINATE STARTING LURCH

RUN ... 3/28/73

No 2 CAR FWD TRUCK
CW (FWD)

MODE	MOTOR	V	I	↑/↓ BASE SPEED
D	650	1.67	668	↑
	600	1.65	660	↑
	300	.74	296	↑
	150	.25	100	↑
	125	.14	56	↑
B	770	2.20	820	
	800	2.15	900	
	800	2.25	900	
D	350	.85	340	↓
	410	1.04	416	↓
	510	1.40	560	↑
	500	1.33	532	↑
	650	1.73	692	↑
	600	1.65	660	↑
	750	2.12	848	↑
	200	.43	172	↑
	100	.10	40	↑
B	200	.38	120	
	300	.72	288	
	400	1.01	404	
	500	1.28	512	
	650	186	744	
D	800	2.22	888	↓
	750	2.02	808	↓
	725	2.01	804	↑↓
	800	2.21	884	↓
	500	1.33	532	↓
	400	.97	388	↑↓

No 2 H-D Fwd Truck
Rev (CCW)

Run 063
3/28/73

MOD	MONITOR	V	I	↓/↑ BASE SPEED
D	800	2.19 (2.19)	876	↓
	500	1.31	524	↓
	600	1.65	660	↓
	700	1.98	792	↓
	200	.37	148	↓
	300	.72	288	↓
	400	1.05	420	↓
	110	.15	60	↑
	200	.42	168	↑
	300	.75	300	↑
	400	1.04	416	↑
	500	1.35	540	↑
	740	2.09	836	↑
B	760	2.10	840	
	100	.08	32	
	200	.39	156	
	300	.77	302	
	400	1.06	424	
	500	1.37	548	
	600	1.64	656	
	750	2.10	840	

No 2 CAR AFT TRUCK
FWD (CW)

RUN 061
3/28/63

MODE	MOTOR	V	I	↓/↑ BASE SPEED
D	100	.07	28	↓
	150	.10	40	↓
	200	.16	64	↓
	300	.37	148	↓
	400	.58	232	↓
	500	.81/.78	324/312	↓
	600	1.03	412	↓
	800	1.42	568	↓
	750	1.39	556	↓
	725	1.38	552	↓
	735	1.40	560	↑
	600	1.14	456	↑
	100	.02	8	↑
	200	.26	104	↑
	300	.46	184	↑
	400	.68	272	↑
	510	.92	368	↑
	625	1.10	440	↑
B	100	.04	16	
	200			
	300	.42	168	
	400	.66	264	
	500	.86	344	
	700	1.35/37	540	
	740	1.41	564	
D	800	1.40	566	↓
	750	1.33	532	↓
B	200	.27	108	
	600	1.08	432	

Nº 2 CAR (A-D) AFT TRUCK
REV (CCW)

RUN 062
3/28/73

MODE	MONITOR	V	I	↓/↑ BASE SPEED
D	100	.06	24	↓
	200	.27	108	↓
	300	.53	212	↓
	400	.75/.77	300	↓
	500	.95/.93	380	↓
	600	1.14	456	↓
	700	1.42	568	↓
	800	1.60	640	↓
	750	1.43	572	↑↓
	100	.03	12	↑
	200	.22	88	↑
	300	.42	168	↑
	400	.63	252	↑
	500	.84	336	↑
	600	1.06	424	↑
	740	1.36	544	↑
B	800	1.42	568	
	100	.03	12	
	200	.18	72	
	300	.40	160	
	400	.62	268	
	500	.80	320	
	600	1.03	412	
	700	1.38	552	

SOAC TEST RUN **063**

DATE: 3/29/78 TIME: START 9:30 STOP 11:00

PURPOSE:
- CHECK-OUT STARTING LURCH FIX
- OBTAIN ADDITIONAL RIDE QUALITY DATA
- REHEARSE DUTY CYCLE TEST TECHNIQUE

WEATHER CONDITION:

WIND SPEED

DIRECTION

BAROMETRIC PRESSURE

AMBIENT AIR TEMPERATURE START STOP

CREW:

TEST CONTROLLER BOB BRUSH

OPERATIONS DIRECTOR ROY BOMAR

MOTORMAN GARY DAVIS

DATA CONTROLLER WALT BALLMAN

GROUND CONTROLLER

INSTRUMENTATION

REAR MONITOR DICK NASKEL

ADDITIONAL PERSONNEL GUS KRAUSE (GSI), TED PETTEAM(?) (GSI)

VEHICLE CONFIGURATION: CAR 1 (CAR 2)

105 K LB.

THE FOLLOWING PAGES CONTAIN THE METHOD, 'QUICK-LOOK INDICATORS, TEST DATA AND RECORD NUMBERS FOR RECORDED DATA.

ODOMETER READING 3100 MILES.

938 - DECEL FROM STOP - SPIN-SLIDE

NO SPIN-SLIDE LITE INDICATION

942 - LURCH CHECK } NO LURCH

945 - " "

- ELIMINATED LURCH AT START BY RE-CALIBRATION OF SPEED SENSOR CARDS
- SLIP-SPIN LIGHT IN CAB (NR2 CAR) NOT WORKING.
- HORN IS AWFUL NEEDS TO BE LOOKED AT.

SOAC TEST RUN **064**

DATE: 3/29/73 TIME: START 350 STOP 4:35

PURPOSE: • RIDE QUALITY DATA FOR GSI WITH 3" SHIM REMOVED

WEATHER CONDITION: SNOWING –

WIND SPEED

DIRECTION

BAROMETRIC PRESSURE

AMBIENT AIR TEMPERATURE START STOP

CREW:

TEST CONTROLLER BOB TSUSIJ

OPERATIONS DIRECTOR WALT BALLAUX

MOTORMAN GARY DAVIS

DATA CONTROLLER

GROUND CONTROLLER

INSTRUMENTATION

REAR MONITOR DICK HASKEL

ADDITIONAL PERSONNEL GUS KRAUSE

VEHICLE CONFIGURATION: CAR 1 (CAR 2 circled)

105K LB.

THE FOLLOWING PAGES CONTAIN THE METHOD, QUICK-LOOK INDICATORS, TEST DATA AND RECORD NUMBERS FOR RECORDED DATA.

RAN ABOUT 1 HR. NO PROBLEMS – GUS KRAUSE GOT ALL THE DATA HE REQUIRED.

WEATHER CONDITIONS

SOAC TEST RUN 090

WIND SPEED

DATE: 4-26-73

TIME: START 14-16 STOP 15 00

1607 1840

DIRECTION

PURPOSE: 1 VIBRATION — CAR 2 INSTR

2/ WAYSIDE NOISE

AMBIENT AIR TEMPERATURE

VEHICLE CONFIGURATION: CAR 1 CAR 2

Hyden Cabb 3rd railcar Fwd HK

HYDEN - INSTR TRUCK

CARBODY

PANTO — UP & DOWN

CREW:

TEST CONTROLLER THOMPSON

#1 #2

OPERATIONS DIRECTOR HAZLEY

MOTORMAN HASKALL

DATA CONTROLLER SPENCER

GROUND CONTROLLER

INSTRUMENTATION VLAMINCK

KRAUSE

REAR MONITOR MURPAY

ADDITIONAL PERSONNEL G DAVIS, CORE

RAD JAMIE

WINESTEIN

NO NOISE ~ NOISE

1 SPEED SWEEP — 25, 35, 50, 60, 64, 70, 75, 80 — SECT I

NORMAL

2 SPEED SWEEP — #1 DEAD CAR — 50, 60, ~64, 70, 75, 80

(SECT I) #2 DEAD CAR — 50, 60, 64, 70, 80

3 VERT DAMPER OFF — SPEEDSWEEP — 50, 60, 65, 70, 75, 80

PANTO OK

4 SPEED SWEEP — 25 etc SECT 14

SOAC 092, 091, 090

RUN	VEL	VERT DAMPER CONFIG	CAR CONFIG	SHIMS
1	25	IN	# 2 PWD.	NONE
2	35			
3	50			
4	60			
5	65			
6	70			
7	76			
8	80		#2 PWD	
9	62		# 1 PWD	
10	65			
11	70			
12	80	IN	# 1 PWD	NONE
13	80	OUT	# 2 PWD	WOOD
14	75			
15	70			
16	66			
17	60			
18	55			
19	50		#2 PWD	
20	50		# 1 PWD	
21	70		# 1 PWD	
22	80	OUT	# 1 PWD	WOOD
23	80		# 2 PWD	METAL
24	70			
25	50			METAL
26	70			NONE
2[illegible]	50			NONE
28	80	OUT	#2 PWD	NONE

WEATHER CONDITIONS

SOAC TEST RUN 091

WIND SPEED

DATE: 4-27-73

TIME: START 11:00 STOP 12:35

DIRECTION

PURPOSE: 1. VIBRATION INVESTIGATION
2 WAYSIDE NOISE

AMBIENT AIR TEMPERATURE

VEHICLE CONFIGURATION: CAR 1 CAR 2
VERT DAMPER-DISCONNECTED - BOTH CARS
MA SHOCKS - LOCKED OUT - HYDEN ONLY
P wire Problem not resolved

CREW:

TEST CONTROLLER THOMPSON

OPERATIONS DIRECTOR HAZLEY
MOTORMAN DAVIS/HASKAL
DATA CONTROLLER VLAMINCK
GROUND CONTROLLER MURPHY
INSTRUMENTATION KRAUSE, SPENCER
REAR MONITOR HIX
ADDITIONAL PERSONNEL CURE, PODGAJNY

1 SPEED SWEEP - ~~25, 35,~~ 50, 55, 60/65/70, 75, 80
#2 Car Power SECT I
MA LOCKED

2 SPEED SWEEP - MA UNLOCKED - 50, 70, 80

✓ 3 PANTO UP SPEED SWEEP 50, 70, 80,

4 UNCOUPLE - RUN HYDEN

5 SPeed sweep - #2 Powered -

WEATHER CONDITIONS

SOAC TEST RUN 092

WIND SPEED

DATE: 4-27-73

TIME: START 15:30 STOP 10:45

DIRECTION

PURPOSE: 1/ VIBRATION INVESTIGATION. 2/ WAYSIDE NOISE

AMBIENT AIR TEMPERATURE

VEHICLE CONFIGURATION: CAR 1 CAR 2

VERTICAL DAMPER - DISCONNECTED - BOTH CARS
MA SHOCKS - LOCKED OUT - HYDEN ONLY
"P" WIRE PROBLEM -

CREW:

TEST CONTROLLER THOMPSON

OPERATIONS DIRECTOR HAELEY

MOTORMAN DAVIS/HASKILL

DATA CONTROLLER VLAMINCK

GROUND CONTROLLER

INSTRUMENTATION KRAUSE SPENCER

REAR MONITOR HIX

ADDITIONAL PERSONNEL

1/ SPEED SWEEP - VIB - 50 ~~55, 60, 65~~ 70 ~~75~~, 80

2 WAYSIDE EQUIPMENT NOISE - PLATFORM TEST

3/ SECT I - 50 POWER, 25 COAST, 50 POWER, 35 COAST 50 POWER 50 COAST

4/ SPEED SWEEP AT SECT II III IV V VI

70 MPH, 30, 80 MPH

Coupler Problem
P Wire Problem
CS Breaker #1 Car -

WEATHER CONDITION

SOAC TEST RUN 129

DATE: 7/5/73

TIME: START 9:48 STOP 11 30

WIND SPEED

DIRECTION

PURPOSE: CAR No 2 CHECK RUN AFTER LAY UP

90+ AMBIENT AIR TEMPERATURE

VEHICLE CONFIGURATION: CAR 1 CAR 2 (circled)

90 000 # G.W.

CREW:

TEST CONTROLLER A. VOLLWECKE

OPERATIONS DIRECTOR ________ MOTORMAN GARRY DAVIS

DATA CONTROLLER GENE BROWN GROUND CONTROLLER [illegible]

INSTRUMENTATION ________ REAR MONITOR [illegible]

ADDITIONAL PERSONNEL ________

HAND BRAKE RELEASE OK

VIBRATION. CHECK WALK THROUGH

40 OK

45 OK VERY SLIGHT @ CAB END

50 OK VERY SLIGHT @ CAB EN

55 OK

60 OK

65 OK

70 OK

75 OK

80 VIBRATION CAME IN ON SECT I WAS LOCAL TO STA 670 OVER REAR MOTOR BLOWER LEVEL "MED-HIGH"

NOTE CAR ACTION ITEMS

(1) MA TRIP THROUGH GAP NO INDICATOR LIGHT. RECYCLED OK AFTER RESET.

(2) FWD TRUCK ANALOG BRAKE VALVE LEAKING — REPLACE WITH SPARE

(3) INSPECT REAR END UNDERCAR FOR NOISE (IMPACT OR LOOSE PART)

WEATHER CONDITION:

SOAC TEST RUN | 130

WIND SPEED

DATE: 7/5/73

TIME: START 15:30 STOP 17:00

DIRECTION

PURPOSE:

RIDE QUAL CHECK AFTER BEEF UP

100 AMBIENT AIR TEMPERATURE

CAR & INSTRUMENTATION CHECK OUT

VEHICLE CONFIGURATION: CAR 1 (CAR 2) — START ODOMETER 5954

89.KLB — END ODOMETER 5996

CREW:

TEST CONTROLLER F. Thompson

OPERATIONS DIRECTOR A. Vollmecke — MOTORMAN Gary Davis

DATA CONTROLLER Gus Krause/S Shapiro — GROUND CONTROLLER " "

INSTRUMENTATION R. McCammon — REAR MONITOR D. Haskill

ADDITIONAL PERSONNEL R Oren W. Cobb, Dave Burnes

G.S.I. Ride Quality measurements.

Engineering Instrumentation Checkout.

SECTION 3. NOISE MEASUREMENT TESTS

29

SOAC TEST RUN 005

DATE 11-16-72 **TIME** START 10^{45} STOP 12^{45}

CONFIGURATION

CAR 1 LOW DENSITY | CAR 2 HIGH DENSITY | RUN SINGLE @ 105,000LB

REASON ~~LOST~~

ACCEL, DECEL, MOTOR FLASH OVER
OBTAIN NOISE

METHOD: SET-UP DISTANCE COURSE
STA 298 TO STA 338

1 RUN CAR FWD DIRECTION TO VMAX
EVALUATE MOTOR FLASH OVER
2/ RUN CAR AFT DIRECTION TO VMAX
EVALUATE MOTOR FLASH OVER

3/ ACCEL CAR 20, 40, 60 MPH
RECORD TIME TO SPEED AND DISTANCE

4/ DECEL CAR FROM 20, 40, 60 MPH
RECORD TIME AND DISTANCE
BLENDED BRAKE, DYNAMIC ONLY
FRICTION ONLY

DATA:

5/ NOISE DATA:
Three Interior locations @ accel, 0, 20, 40, 60 MPH
Two Exterior Positions @ 0, 20, 40, 60 MPH passing speed
All equipment operating

INTERIOR NOISE LEVELS – SOAC #1; LOW DENSITY CAR
'A' WEIGHTED SOUND LEVEL – dbA
CAR @ 105 Klb; empty
All EQUIPMENT OPERATING

11/16/72; RUN 005

		FRONT over #1 TRK	CENTER	REAR over #2 TRK	
SEATED (EAR LEVEL)	Acceleration	63	62.5	65	*
	0	62	61	64.5	
	25	63	61	64	
	35	63	61	65	
	50	65	63	67	
	70	72	65	70	
STANDING (EAR LEVEL)	Acceleration	63	62.5	66	*
	0	62	62	65	
	25	63	61.5	64	
	35	63	62.	65	
	50	65	63	67	
	70	72	65	70	

Only two exterior Noise level data points obtained this date:

5' from car; 3' above rail, car at
0 MPH 84 dbA
80 MPH 114 dbA

• Effect of track location not considered

* Acceleration Noise levels are a function of speed

RUN 5

INTERIOR NOISE LEVELS - SOAC ~~#2~~ #1

'A' WEIGHTED Sound Level ~ dbA

Car at 105 Klb

· LIGHTS OFF

(·) LIGHTS ON

		FRONT (TRK #1)	CENTER	REAR (TRK #2)
SEATED (EAR LEVEL)	ACCELERATION	(63) 63	(62.5) ~~64~~ 62.5	(65) 64
	~~20~~ 25		(61)	(64)
	~~40~~ 35 / 50	(63) (65)	(63)	(65) (67)
	70	~~68~~ (72)	(65) 63	(70) 70
	0	(62) 62	(61) ~~63~~ 61	(64.5) 64
STANDING (EAR LEVEL)	ACCELERATION	(63) 63	(62.5) ~~64~~ 62.5	(66) 65
	~~20~~ 25	(63)	(61.5)	(64)
	~~40~~ 35 / 50	(63) (65)	(62) (63)	(65) (67)
	70	~~68~~ (72)	(65) 64	(70) 71
	0	(62) 62	(62) ~~63~~ 61	(65) 65

EXTERNAL NOISE LEVELS - SOAC #1

'A' Weighted Sound Level ~ dbA

RUN 005/006

Car at 105 Klb

	SPEED (MPH)	MAX. SOUND LEVEL
50' from Car; 5' Above Rail	0	
	20	
	40	
	60	
5' from Car; ~~5~~ 3' Above Rail	0	84
	21 ~~20~~	[illegible]
	40	>00
	61 ~~60~~	<110
	80	114

SOAC TEST RUN 010

DATE 11/29/72

TIME

START	STOP
930AM	NOON

MOTORMAN ______

CREW

CONFIGURATION

CAR 1 CAR 2 105Klb (a) Car 2 Driving Train (b) Car 2 alone

REASON

(a) VIP Tour (b) Speed Limiting, Ride Quality & Noise

METHOD: 9:30 to 10:30 : Check operation & walk thru

(a) : VIP Run

un couple, remove #1 CAR to barn

(b) Run loop at steady speeds with ASMS. 25, 35, 50, 70

Record: Ride Quality
Noise Data

DATA: 9:30 - ON TRACK
PICK UP, MAIN AIR RESORVUR VALVE FROZEN & LEAKING. CLEARED WITH HEAT; VALVE HEAT NOT ON DURING LAYOVER DUE TO LACK OF BATTERY CHARGING POWER IN BARN.

2 RUNS FOR CHECKOUT

VIP RUN COMPLETED

SHUTDOWN @ 12 NOON

(b) RUNS IN AFTERNOON

(CONT. COMMENTS OVER)

NOTE:

Rail Switch at main junction ~~2~~ is loose & bent. Cause uncertain. Must not pass thru switch at more Than 15 MPH and must be in CCW direction

P.M. Ride Quality & Noise Data started 25, 35, 50, MPH; Tripped or shutdown at 80 MPH. on return to start point new problems noted. Shut down at 2:30 PM.

INTERIOR NOISE LEVELS - SOAC #2

'A' Weighted Sound Level ~ dbA

Car at 105 Klb ; EMPTY ; RUN BACKWARDS (CCW) 11/29/72 RUN #10

		FRONT (TRK #1)	CENTER	REAR (TRK #2)
SEATED (EAR LEVEL)	ACCELERATION			
	20 25	63	62	68
	35 40 50	63.5 64.5	63 63	68 69
	80			71
	0		62	68
STANDING (EAR LEVEL)	ACCELERATION			
	20 25	63	62	65
	35 40 50	63 64	63 63	67 66
	80			71
	0		62	64

EXTERNAL NOISE LEVELS - SOAC #2

'A' Weighted Sound Level ~ dbA

Car at 105 Klb

	SPEED (MPH)	MAX. SOUND LEVEL	
50' from Car; 5' Above Rail			
5' from Car; 5' Above Rail	20	84	93 92
	40	90 91	
			92
	60	93	92

SECTION 4. EMI TESTS

SOAC TEST RUN | 066

DATE: 4-2-3 TIME: START 9:40 STOP 12:30

PURPOSE: RECORD CURRENTS FROM CURRENT SHUNT, (HALL) CURRENT SENSOR + ARMATURE CURRENT SENSOR
TAKE EMI DATA

WEATHER CONDITION:

WIND SPEED

DIRECTION

BAROMETRIC PRESSURE

AMBIENT AIR TEMPERATURE START STOP

CREW:

TEST CONTROLLER R. PARKER

OPERATIONS DIRECTOR T. BOMAR MOTORMAN LARY DAVIS

DATA CONTROLLER CLIFF HALL/M. BECHER GROUND CONTROLLER

INSTRUMENTATION CLIFF HALL/R. SPENCER REAR MONITOR DICK HASKEL

ADDITIONAL PERSONNEL

VEHICLE CONFIGURATION: CAR 1 + CAR 2

105 K LB CARS AT ORIGINAL HT.

THE FOLLOWING PAGES CONTAIN THE METHOD, QUICK-LOOK INDICATORS, TEST DATA AND RECORD NUMBERS FOR RECORDED DATA.

SOAC TEST RUN **067**

DATE: 4-7-3

TIME: START 2:00 STOP 5:30

PURPOSE: RECORD CURRENTS FROM CURRENT SHUNT, HALL CURRENT SENSOR & ARMATURE CURRENT SENSOR TAKE EMI DATA.

WEATHER CONDITION:

WIND SPEED

DIRECTION

BAROMETRIC PRESSURE

AMBIENT AIR TEMPERATURE START STOP

CREW:

TEST CONTROLLER F. THOMPSON

OPERATIONS DIRECTOR T. BOMAR MOTORMAN G. DAVIS

DATA CONTROLLER C. HALL/M. RECHIR GROUND CONTROLLER

INSTRUMENTATION C. HALL/P. SPENCER REAR MONITOR D. HASKEL

ADDITIONAL PERSONNEL

VEHICLE CONFIGURATION: CAR 1 & CAR 2

105 K LB CARS AT ORIGINAL HT.

THE FOLLOWING PAGES CONTAIN THE METHOD, QUICK-LOOK INDICATORS, TEST DATA AND RECORD NUMBERS FOR RECORDED DATA.

SOAC TEST RUN 068

DATE: 4-3-2

TIME: START 0900 STOP 12:45

PURPOSE: TAKE EMI DATA

WEATHER CONDITION:

WIND SPEED

DIRECTION

BAROMETRIC PRESSURE

AMBIENT AIR TEMPERATURE START STOP

CREW:

TEST CONTROLLER F. THOMPSON

OPERATIONS DIRECTOR T. BOMAR

MOTORMAN G. DAVIS

DATA CONTROLLER M. RICHER

GROUND CONTROLLER

INSTRUMENTATION P. SPENCER

REAR MONITOR B. HASKELL

ADDITIONAL PERSONNEL

VEHICLE CONFIGURATION: CAR 1 + CAR 2

105 K LB

THE FOLLOWING PAGES CONTAIN THE METHOD, 'QUICK-LOOK INDICATORS, TEST DATA AND RECORD NUMBERS FOR RECORDED DATA.

APPENDIX III

RIDE QUALITY REPORT
D174-10025-1

REV LTR

THE BOEING COMPANY

VERTOL DIVISION · MORTON, PENNSYLVANIA

CODE IDENT. NO. 77272

NUMBER D174-10025-1

TITLE SOAC RIDE QUALITY IMPROVEMENT PROGRAM

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

MODEL ______ CONTRACT ______

ISSUE NO. ______ ISSUED TO: ______

PREPARED BY R. Vlaminck
R. Vlaminck

PREPARED BY S. Shapiro
S. Shapiro

APPROVED BY D. Bevan
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K. Jackson
Director of Engineering
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ABSTRACT

A ride quality test program on the State-of-the-Art Car uncovered vertical vibrations near 80 MPH. Shake tests of the SOAC identified the major vertical modes of the primary car structure and significant secondary structure. The secondary structure supporting the motor alternator was analyzed and modified. Subsequent shake tests and ride quality tests verified that the structural changes produced the desired improvement in ride quality.

KEY WORDS

Rail Vehicle Dynamics
Ride Quality Test
Urban Rapid Rail Vehicle
State-of-the-Art Car

LIMITATIONS

This document is controlled by Department 2791

All revisions to this document shall be approved by the above noted organization prior to release.

ACTIVE SHEET RECORD

SHEET NUMBER	REV LTR	ADDED SHEETS SHEET NUMBER	REV LTR	ADDED SHEETS SHEET NUMBER	REV LTR	SHEET NUMBER	REV LTR	ADDED SHEETS SHEET NUMBER	REV LTR	ADDED SHEETS SHEET NUMBER	REV LTR
1						41					
1.1						42					
1.2						43					
1.3						44					
2						45					
3						46					
4						47					
5						48					
6						49					
7						50					
8						51					
9						52					
10						53					
11						54					
12						55					
13						56					
14						57					
15						58					
16						59					
17						60					
18						61					
19						62					
20						63					
21						64					
22						65					
23						66					
24						67					
25						68					
26						69					
27						70					
28						71					
29											
30											
31											
32											
33											
34											
35											
36											
37											
38											
39											
40											

FORM 46283 (7/67)

REVISIONS			
LTR	DESCRIPTION	DATE	APPROVAL

FORM 46282 (3/67)

TABLE OF CONTENTS

LIST OF FIGURES

Figure

SUMMARY

This report presents the results of a vibration reduction program conducted on the State-of-the-Art Car (SOAC) to improve ride quality. The testing included two ride quality vibration surveys, two vehicle shake tests, and a wheel concentricity test. All tests were performed at the DOT High Speed Ground Test Center (HSGTC) during the period April through July 1973.

This program of testing and analysis indicated the structure supporting the motor alternator should be modified. This modification was designed by Boeing Vertol and installed on the vehicle at HSGTC. A shake test verified the predicted structural response and a follow-up ride quality survey substantiated that the objectionable vibrations had been eliminated.

1.0 INTRODUCTION

During acceptance testing of the SOAC on the Urban Mass Transit Authority's (UMTA) 80-mph test oval, passenger observations indicated a vertical ride quality vibration problem existed on the vehicle. The most noticeable vibration occurred near 80 mph, although car body vibrations were evident at other speeds. Vibration near 80 mph was characterized by motions of the floor, ceiling panels and seats. These observations and passenger comments precipitated a diagnostic and corrective program which included: a diagnostic ride quality vibration survey, vehicle shake test, analysis, subsequent structural modification, verification shake test, ride quality survey, and a wheel concentricity test. These tests were performed at the HSGTC, Pueblo, Colorado, in parallel with the acceptance testing.

The vibrations of interest were at frequencies higher than are normally treated by a truck builder; that is, higher than the rigid body suspension frequencies. However, the services and test equipment of the truck supplier (GSI) were used in the diagnostic testing. Since the frequency of vibration was associated with car body flexible modes, St. Louis Car Company requested the assistance of the Boeing Vertol Company to conduct the diagnostic testing, associated analysis, and detailed design of the necessary structural modifications.

2.0 INITIAL RIDE QUALITY TEST

2.1 PURPOSE OF TEST

The main purpose of this diagnostic test was to provide a quantitative evaluation of any vibration problems of the vehicle and investigate in detail the observed 80 mph problem.

2.2 TEST EQUIPMENT

Six Statham linear accelerometers of the unbonded strain gage type were used to record the ride quality characteristics of the vehicle. Three vertical car body accelerometers were used: one located over the bolster (Station 108); one located over the center of the car (Station 450); and one over a point in between (Station 225). An exploded view of the SOAC identifying the station numbers of the vehicle is presented in Figure 3.

One longitudinal accelerometer was used and placed in the car over the bolster. The other two vertical accelerometers were located on the truck bolster and on the No. 1 traction motor. Data were collected on a six-channel Honeywell Visicorder Model 906-C. All of this instrumentation was supplied by General Steel Industries.

2.3 TEST PROCEDURES

The facilities at the HSGTC were used for this ride quality test. Data were recorded on UMTA's 80-mph test oval, traveling at various planned speeds with the car moving in forward and reverse directions over track section 1, Station 160, a straight and level track with wooden ties and welded rail. Figure 5 identifies the track section and station number. Data were collected on the No. 2 SOAC, the high density car, at the 90,000 lbs. light car weight.

All data records were of at least 10 seconds duration and were reduced manually. Visual observations were made of the interior of the car throughout the duration of the test to detect any other vibration problems which may not have been recorded by the instrumentation available.

2.4 RESULTS OF TEST

The results of the ride quality test provided a quantitative substantiation of the severe vibration problem evident near 80 mph in the SOAC. Figures 1 and 2 show a summary of car body vertical vibration data at 25, 35, 50, 60, 65, 70, 76 and 80 mph. The data in both figures are presented for three different car body locations: at the car centerline over the forward bolster (Station 108); at the center of the car (Station 450); and at a point in between (Station 225).

Figure 3 shows an exploded view of the SOAC vehicle illustrating the car body locations under discussion. Figure 1 presents the vertical vibration data as g's versus frequency plotted against the SOAC goal. These data show there are two frequency ranges: 1.2 Hz to 1.7 Hz and 7 Hz to 15 Hz. These bands correspond to rigid body suspension modes and car body flexible modes respectively. The worst vibration levels occur in the center of the car at 14.5 Hz where there is a band extending from .10 g's to .26 g's. Figure 2 presents the same ride quality data as Figure 1, except the g levels are plotted against speed. This includes only data taken from the higher frequency range (7 Hz to 15 Hz).

Observers commented the ride was generally smooth but defined three speeds with particularly noticeable vibration. A mild vibration was reported between 35 mph and 45 mph and the data of Figure 2 show some evidence of this at the mid-car location. More noticeable to observers was the vibration near 64 mph which is seen in the data of Figure 2 at each of the three car body stations. A severe vibration involving amplitude modulation (beating) was evident near 79 mph.

Car body vertical accelerometer waveforms indicated a high amplitude vibration with a 9-second beat was present in the data measured over the center of the car (Station 450). This beat produced an amplitude modulation of the vertical acceleration between .10 g's and .26 g's at approximately 15 Hz at this location. A sample accelerometer trace showing the beating that occurred is shown in Figure 4A.

The data of Figures 1 and 2 indicate that, in the higher frequency ranges, the accelerations exceed the SOAC goal. In fact, observers were satisfied with the ride quality over the whole speed range with the exception of 64 and 80 mph. An explanation of this acceptance is that the manual reduction of response data may have resulted in incomplete separation of frequencies and consequent "lumping" or summing of acceleration values near selected frequencies. This resulted in the large test values shown at the higher frequencies.

Part of this vibration survey was devoted to determining the effect of the secondary suspension vertical hydraulic dampers on car body acceleration levels. A comparison of vibrations with dampers connected vs. dampers removed for car body longitudinal, mid-car vertical, motor alternator vertical, traction motor vertical, car cab vertical, and truck bolster vertical vibration levels, is shown in Figure 6. It can be concluded that except for car body longitudinal, the levels in the higher frequency range were reduced with dampers off.

The effect of car body-mounted equipment was considered in light of the findings of NASA TN D-6735 "Dynamic Responses of Railroad Car Models to Vertical and Lateral Rail Inputs" by Sewall, Parris, and Darling. The largest of these is a flexibly-mounted motor alternator supported on secondary structure at mid-car. To determine the effect of the motor alternator suspension frequency on car body vibration levels, shims between the motor alternator mounting brackets and the motor alternator hard points were also evaluated. These shims were intended to lock out the motor alternator isolation mounts. Two shim materials were used: wood and steel.

The results of this testing are also shown on the lower section of Figure 6 and indicated that car body vibration levels were significantly lower with wood shims and significantly higher with steel shims. The predominant frequency content of the waveforms analyzed was approximately 15 Hz for this 80 mph test condition.

2.5 CONCLUSIONS

The results of the ride quality test provided a quantitative substantiation of the severe vibration evident near 80 mph in the SOAC. Mild vibration was reported between 35 mph and 45 mph and near 64 mph. Car body vertical accelerometer waveforms indicated a high amplitude vibration with a 9-second beat was present in the data measured over the center of the car near 80 mph.

Testing to this point did not provide an understanding of the measured ride quality results. In addition, the frequencies of vibration observed in the test data could not be correlated with any car body vibration modes since there were no analytical predictions of car body flexible modes and frequencies. To understand the dynamics of the vehicle in the frequency range above the rigid body suspension frequencies, it was concluded the best course of action would be to perform a shake test of the SOAC.

3.0 INITIAL VEHICLE SHAKE TEST

A clear definition of the dynamic characteristics of the vehicle was necessary to understand the results of the ride quality vibration survey discussed in Section 2.4. In addition, many of the physical parameters required for an analytical study of the SOAC were not readily available and could be expediently determined from measurements recorded during a shake test.

3.1 PURPOSE OF TEST

The purpose of the initial SOAC shake test was threefold:

1. Determine the car body vertical bending modes and frequencies.
2. Determine truck modes and frequencies.
3. Determine the effect of the motor alternator on car body vibration.

3.2 TEST EQUIPMENT

Six Statham linear accelerometers were used to record the dynamic response of the test car. These were mounted to rigid metal brackets which could be conveniently moved and attached to the structure with "C" clamps or secured to the car body floor with lead weights. Excitation forces were supplied by an electric-driven Lazan Model LA1 Shaker. Accelerometer outputs were recorded on a six-channel Honeywell Visicorder Model 906C. This instrumentation was supplied by General Steel Industries.

3.3 TEST PROCEDURES

The test was conducted at HSGTC on the No. 1 SOAC (low density car) at the 90,000 lbs. light car weight.

Car No. 2 had been used in the initial ride quality test but was not available for these shake tests. The cars are identical structurally and the results are applicable to both.

During the test a shaker was used to apply a sinusoidal exciting force to either the car body or truck frame. When exciting the car body, the shaker was attached to the anticlimber at the R end of the car. Both a vertical and longitudinal shake of the car body were conducted. Figures 7a and 7b show the vertical and longitudinal shaker configurations. For truck excitations, the shaker was attached with clamps to the underside of the truck frame cross transom.

For each test configuration, frequency sweeps were obtained over the band extending from 6 Hz to 20 Hz in .5 Hz increments. When a natural mode was located the shaker frequency was fine-tuned to determine the frequency and amplitudes at resonance. In addition, detailed probes of the structure were carried out to determine the mode shapes. No attempt was made to shake the car body at the rigid body suspension frequencies because of the limited force output of the shaker at low frequencies.

The characteristics of the Lazan Model LA1 shaker is shown in Figure 8. The force output of the shaker increased with the square of the exciting frequency. To obtain data which would be representative of a constant force input, all data were scaled to a 500-lb. input force. Dynamic time histories were obtained but no attempt was made to determine the phase angle between pickups except at the natural modes. After the frequency sweeps for a particular configuration were completed, these plots were studied for resonant amplitudes. The test program defining shaker alignment, pickup locations, and excitation frequencies used in the shaker diagnostic testing was suggested by Boeing Vertol and executed by General Steel Industries.

3.4 RESULTS OF CAR BODY SHAKE TEST

Frequency response curves for car body vertical excitation at the R end of the car are shown in Figures 9 through 12. Pickup locations are at the R end of the car, Station 450, Station 673, and on the motor alternator. All data are for a vehicle weight of 90,000 lbs. and a shaker force of 500 lbs. A diagram showing the car body locations identified on these figures is presented in Figure 3.

A review of these curves indicates there are four car body flexible modes in the frequency range of 6 Hz to 20 Hz and they occur at 8.1 Hz, 12.25 Hz and two between 15 Hz and 15.2 Hz. The fact that there are two modes in the 15 Hz to 15.2 Hz range is not readily evident from examination of the frequency response curves. However, during the test, attemps to fine-tune the shaker in this frequency range proved difficult and it was noted there were actually two peaks within approximately .2 Hz. The data of Figure 9 taken at the R end of the car exhibit a large vertical response near 8 Hz which was later found to be the first vertical bending mode as shown in Figure 13. There is also a suggestion of a mode near 12 Hz and a major response near 15 Hz.

Figure 10, data taken at the center of the car (Station 450), substantiates the presence of a resonance near 12 Hz. Figure 11 is dominated by the 15 Hz peak and, as can be seen in Figure 13, the pickup was near the antinode of the 15 Hz peak and close to the node of the 8 Hz primary vertical bending mode. Figure 12 shows the response of the motor alternator itself is similar to the response of the car body floor over this component for the entire frequency range explored.

The mode shapes were determined as shown in Figures 13, 14 and 15. Detailed probing of the car body at the major resonances revealed the 8.1 Hz mode is the first vertical bending of the car body. The two modes between 15 Hz and 15.2 Hz involved localized bending of the three motor alternator lateral support beams and a higher order car body bending mode. Continued probing disclosed there was substantial bending of the motor alternator lateral support beams at approximately 15 Hz, but no bending was detected of any other equipment support beams. The mode shapes of the motor alternator lateral support beam and traction motor cooling fan support beam are shown in Figures 14 and 15.

As a result of the ride quality testing described in Section 1.0 it was evident the mounting of the motor alternator had a large effect on the mid-car body vibration. Therefore frequency response curves were also determined with steel shims between the motor alternator support brackets and the motor alternator hard points to lock out the isolation. These results are presented in Figures 16 through 19. From these data several significant conclusions were evident:

1. Vibration levels at the R end of the car were not affected by shims but the levels at mid-car (Station 450) were increased by a factor of 2:1 at the 15 Hz - 16 Hz range when shims were in place.

2. Vibration levels over the R end traction motor cooling fan (Station 673) were higher by a factor of 2:1 at the 15 Hz - 16 Hz range without shims.

3. Vibration levels on the motor alternator were not significantly affected by shims.

4. There was no effect of shims on the 12.25 Hz mode.

Additional curves were obtained by orienting the shaker in the longitudinal direction on the R car end and these data are presented in Figures 20 through 23. Pickup locations are Station 673 (vertical), motor alternator, R car end, and mid-car seat back. From these curves it was noted:

1. Figure 20 shows there is coupling between the longitudinal and vertical directions in the 12.25 Hz and 15 - 15.2 Hz modes. A longitudinal excitation of the car body results in significant vertical response of the structure at Station 673. This coordinate coupling was noted during the ride quality vibration survey, during which the 15 Hz vertical vibration was accompanied by substantial car body longitudinal vibration. The response was tabulated in Figure 6.

2. The 12.25 Hz mode was found to be the motor alternator oscillating on its support beams in the longitudinal direction, moving out of phase with the car body. The frequency response curves are shown in Figures 21 and 22.

3. The mid-car seatback exhibits a resonance in the longitudinal direction at 15.4 Hz. This response curve, shown in Figure 23 is for an unloaded test. This seat, when empty, had been noted to exhibit large longitudinal motion.

3.5 RESULTS OF TRUCK SHAKE TEST

Shaking the truck frame vertically, the response curves shown in Figures 24 through 27 were determined. These data indicate the truck frame vertical frequency is at 9.8 Hz with the vertical hydraulic dampers off (Figure 24) and 10.4 Hz with dampers on (Figure 25). The validity of this shift is in question since it was observed that there was virtually no damper motion at the small shake test amplitudes and all relative motion between the truck frame and bolster was being taken up by the elastomer bushing at the upper end of the damper link. The effect on R car end vibration with and without dampers is shown by comparing Figure 26 (dampers off) with Figure 27 (dampers on). This data would indicate the car body levels are reduced by having the hydraulic dampers in place, but again this may be invalidated by the above-mentioned factors.

3.6 CONCLUSIONS

Four car body flexible modes were identified in the frequency range of 6 Hz to 20 Hz, and they occur at 8.1 Hz, 12.25 Hz and two between 15 Hz - 15.2 Hz. Detailed probing of the car body at the major resonances revealed the 8.1 Hz mode is the first vertical bending of the car body. The mode at 12.25 Hz was the motor alternator oscillating on its support beams in the longitudinal direction. The two modes between 15 Hz and 15.2 Hz involved localized bending of the three motor alternator lateral support beams and a higher order car body bending mode. The truck frame vertical frequency is approximately 9.8 Hz.

From the shake test data it was concluded that the two modes between 15 Hz and 15.2 Hz were the cause of the vibration problem identified in the ride quality surveys described in Section 2.4. The presence of these two modes in close proximity would cause beating of the car body vibration at a frequency equal to the difference of the two modal frequencies.

Since a major structural modification to the vehicle underframe would be required to shift the car body mode, the decision was made to stiffen the motor alternator support structure to separate the car body bending mode from the motor alternator support beam bending mode.

4.0 MOTOR ALTERNATOR SUPPORT STRUCTURE ANALYSIS

The results of the shake test described in Section 3.5 indicated the close proximity of two natural frequencies; the higher order car body bending mode, 15 Hz, and the motor alternator on its support structure, 15.2 Hz. It was decided to design a modification to the motor alternator support structure to introduce a sufficient degree of decoupling of the two modes.

4.1 DESCRIPTION OF ANALYSIS

To optimize the structural modification of the motor alternator support beams a finite element model was developed and is shown in Figure 28. Clock springs representing the side sill torsional stiffness were included to simulate the actual end conditions of the lateral beams. Additional node points were eventually added to the model to permit a detailed representation of the stiffening material. The final model of the proposed modification, with the values of beam bending inertia required to obtain the desired frequency shift, is also shown in Figure 28.

4.2 RESULTS OF ANALYSIS

Figure 29 shows a plot of the dynamic amplification factor of the motor alternator beam bending mode to the wheel rotational frequency for the baseline configuration and several frequencies up to 19.5 Hz, the objective for the modification. 19.5 Hz was selected by making a tradeoff between a practical structural modification of minimum weight and an acceptable dynamic amplification factor from the wheel rotational frequency. A frequency spread of approximately 4.5 Hz between the higher order car body bending mode and the motor alternator lateral beam bending mode would eliminate the possibility of beating.

In addition to separating the two vertical modes, an analysis was performed to optimize the structural modification required to shift the 12.25 Hz mode above 20 Hz. The necessary longitudinal stiffness was provided by four canted struts providing axial stiffness.

Photographs showing details of the lateral and longitudinal stiffening of the motor alternator support structure installed on the SOAC cars are presented in Figures 30 through 32. This installation was performed under Boeing Vertol supervision at the DOT HSGTC.

5.0 SECOND VEHICLE SHAKE TEST

Following the modification to the motor alternator support structure a second shake test was conducted.

5.1 PURPOSE OF TEST

The purpose of the second vehicle shake test was to determine the actual, as-built characteristics of the structural modification to the motor alternator support beams.

5.2 TEST EQUIPMENT

The test equipment was the same as described in Section 3.2.

5.3 TEST PROCEDURES

The test procedures were similar to those described in Section 3.3. The shaker was located at the R car end and only a vertical shake was performed.

5.4 RESULTS OF TEST

Frequency response curves for car body excitation are shown in Figures 33 and 34. All data presented are for a car weight of 90,000 lbs. and a shaker force of 500 lbs. A diagram showing the car body locations identified on these figures is presented in Figure 3.

From these curves several conclusions were determined:

1. As expected, the structural modification did not change the frequency of the first vertical bending mode.

2. The motor alternator longitudinal mode, previously at 12.25 Hz, has been shifted above 20 Hz as planned.

3. The higher order car body bending mode at approximately 15 Hz was unaffected.

4. Stiffening the motor alternator support beams shifted the beam bending mode to 19.4 Hz, close to the value predicted by the analysis of the modification. (See Figures 33 and 34.)

New mode shapes of the car body and motor alternator support beams are shown in Figures 35 and 36 respectively.

It should be noted that the coupler vibrated substantially at approximately 15 Hz and was shimmed throughout the test.

5.5 CONCLUSIONS

The structural modification to the motor alternator lateral support beams shifted the 15.2 Hz mode to 19.4 Hz. The motor alternator longitudinal mode, previously at 12.25 Hz, has been shifted above 20 Hz as planned. The 4.4 Hz frequency differential between the higher order car body bending mode (15 Hz) and the motor alternator lateral beam bending mode (19.4 Hz) insures there will not be beating between these two modes. This change in frequency should alleviate the vibration problem near 80 mph. Shifting the longitudinal mode above 20 Hz should eliminate the 12 Hz vibration previously noted near 64 mph.

6.0 SECOND RIDE QUALITY TEST

6.1 PURPOSE OF TEST

The purpose of the second SOAC ride quality test, also conducted at the HSGTC, was to determine the actual effectiveness of the motor alternator modification on ride quality.

6.2 TEST EQUIPMENT

The test car and instrumentation were the same as that described in Section 2.2. Resilient wheels had been installed on both SOAC cars in preparation for acoustic testing. The spring rates of the resilient wheels are several orders of magnitude higher than either the primary or secondary suspension system spring rates and would not be expected to influence vibration in the 0 Hz to 20 Hz frequency range.

6.3 TEST PROCEDURES

The procedures were the same as in Section 2.3.

6.4 RESULTS OF TEST

The ride quality summary of Figure 37 when compared with Figure 1 indicates the vibration at or near the rigid body suspension frequencies is virtually unchanged. At the higher frequencies there is little or no change over the bolster but significant improvement, from an average value of .07 g's to an average value of .05 g's, was measured at mid-car (Station 450) and at Station 225.

Comparison of Figure 38 with Figure 2 substantiates the improvement near 65 mph and 80 mph reported by observers. The mild vibration near 40 mph noticed in the initial ride quality test remains relatively unchanged. The frequency of vibration near 40 mph is associated with the first vertical bending mode and is unaffected by changes to secondary structure. At speeds between 40 mph and 70 mph, vibration at the center of the car and at Station 225 has been improved from .075 g's to .050 g's. No effect is noted over the bolster. The vibration previously observed near 65 mph is no longer evident. The beating of the vertical vibration observed near 80 mph has been eliminated.

Maximum acceleration levels are now about .10 g's near 15 Hz vs. .26 g's in the initial ride quality test. These levels are related to the higher mode of the primary structure which was unchanged. As predicted by the analysis, the response from the mode involving bending of the motor alternator support structure was eliminated.

Figures 4a and 4b show accelerometer waveforms of car body vertical accelerations at the center of the car before and after the change to the motor alternator support structure was made. These data indicated the beating phenomenon was eliminated by separating these two modes. Several circuits of the test track were made at 80 mph to insure the beat phenomenon did not occur on other track sections.

During the test a local vibration at 15 Hz was observed in the rear of the car. The data indicated the possibility of a car body-mounted component impacting the undercar structure. As noted in Section 5.4, the coupler vibrated considerably during the shake test at this frequency. This information led to the decision to temporarily install wooden shims near the coupler anchor. Data showing the improvement by shimming the coupler appears in Figure 39. The coupler centering mechanisms on Car 1 and Car 2 were not operative, thus permitting the couplers to vibrate. This condition will not exist with the coupler centering mechanism activated.

6.5 CONCLUSIONS

Ride quality characteristics of the vehicle were altered by modification of secondary support structure while characteristics influenced by primary structure were unchanged. Vibration levels decreased from .07 g's to .05 g's at mid-car (Station 450) and Station 225. The mild vibration near 40 mph noticed in the initial ride quality test remains relatively unchanged but the vibration previously observed near 65 mph is no longer evident. The beating of the vertical vibration observed near 80 mph has been eliminated. Maximum acceleration levels are now about .10 g's near 15 Hz vs .26 g's in the initial ride quality test.

7.0 WHEEL CONCENTRICITY TEST

7.1 PURPOSE OF TEST

The purpose of the wheel concentricity test was to obtain a quantitative measure of the wheel flats, concentricity, and degree of lateral wheel runout. These data could then be compared to AAR Standards and wheel specifications for various transit authorities.

7.2 TEST EQUIPMENT AND PROCEDURES

During the test a fixture was attached to the axle centerline and four dial gages were mounted to this fixture in such a way that they made contact with the wheel. Figures 40 and 41 show a picture of the test apparatus. Two gages were used to measure the concentricity and two to measure the lateral wheel runout. The measurement of concentricity was made at the tape line, the specified location for measurement of wheel diameter. This tape line is 2-13/32 inches from the outside rim.

After the fixture and gages were in position, a forklift was used to pull the car so that ten or more measurements could be taken for one wheel revolution. This process was repeated for all wheels on both SOAC cars. For data collection purposes each wheel was designated an identification number. Figure 42 presents this information.

7.3 RESULTS OF TEST

This test was performed after the initial ride quality vibration survey indicated high car body vibration levels. During that time it is believed wheel wear reduced the magnitude of the flats. This theory is substantiated by observation that the "wheel click" was reduced substantially over this time period. Journal box accelerometer data taken after the braking and performance tests showed a spike at the wheel rotational frequency. This spike was not evident in journal box data collected shortly before the concentricity test.

A summary of the wheel concentricity and lateral runout test results is presented in Figure 43. Total Indicator Reading (TIR) for these parameters is shown for all eight wheels of both SOAC 1 and SOAC 2. Tabulated data of all concentricity measurements made during the test are shown in Figures 44 through 47. Measurement of wheel flat and buildup data are shown in Figure 48. A maximum buildup of .007 inch on the SOAC 1 occurred on the No. 3 wheel. Wheel No. 7 on SOAC 2 had a maximum buildup of .011 inch. Wheel flat data indicated a maximum depth of .018 inch (No. 3 and No. 4 wheels) and .010 inch (No. 2, 6 and 7 wheels) on SOAC No. 1 and SOAC No. 2 respectively.

7.4 CONCLUSIONS

A comparison of TIR for all eight wheels of both SOAC 1 and 2 with AAR Standards and several transit authorities' standards (see Figure 43) indicates the eccentricity of the SOAC wheels is well within these specifications.

8.0 CONCLUSIONS

8.1 INITIAL RIDE QUALITY TEST

The results of the ride quality test provided a quantitative substantiation of the severe vibration evident near 80 mph in the SOAC. Mild vibration was reported between 35 mph and 45 mph and near 64 mph. Car body vertical accelerometer waveforms indicated that a high amplitude vibration with a nine-second beat was present in the data measured at the center of the car near 80 mph.

8.2 INITIAL VEHICLE SHAKE TEST

Four car body flexible modes were identified in the 6 to 20 Hz range. From the test data it was concluded that the two modes between 15 Hz and 15.2 Hz were the cause of the vibration problem identified in the initial ride quality test. These two modes involved localized bending of the three motor alternator lateral support beams and a car body bending mode. The presence of these two modes in close proximity would cause beating of the car body vibration at a frequency equal to the difference between the two modal frequencies.

8.3 MOTOR ALTERNATOR SUPPORT STRUCTURE ANALYSIS

A finite element model was developed to optimize the structural modification of the motor alternator support beams. Structural members were sized to shift the 15.2 Hz mode to 19.5 Hz. This frequency was selected by making a tradeoff between a practical structural modification of minimum weight and an acceptable dynamic amplification factor from the wheel rotational frequency.

8.4 SECOND VEHICLE SHAKE TEST

The structural modification to the motor alternator lateral support beams shifted the 15.2 Hz mode to 19.4 Hz. The 4.4 Hz frequency differential between the higher order car body bending mode (15 Hz) and the motor alternator beam bending mode (19.4 Hz) insures against beating between these two modes. This change in frequency should alleviate the vibration problem near 80 mph. Shifting the longitudinal mode above 20 Hz will reduce the 12 Hz vibration levels near 64 mph.

8.5 SECOND RIDE QUALITY TEST

The modification to the motor alternator support structure eliminated the objectionable vibration near 64 mph and the beating phenomenon near 80 mph. Maximum vibration levels at the higher frequencies (15 Hz) have been reduced from .26 g's to .1 g. Although this exceeds the design goal of .055 g's at this frequency, this is probably the result of data reduction technique as explained in Section 1.4. The SOAC is considered satisfactory by passenger observers.

8.6 WHEEL CONCENTRICITY TEST

All eight wheels of both SOAC 1 and 2 were well within the AAR and several transit authority standards for wheel concentricity and lateral runout.

9.0 RECOMMENDATIONS

A review of the SOAC shake test and ride quality test procedures, equipment and data collection techniques have prompted the inclusion of this section of the report. Its purpose is to document pertinent facts learned during these tests and to make recommendations to improve future testing.

9.1 SHAKE TESTING

When performing a rail car shake test, the following should be considered:

9.1.1 - Utilize a continuous sweep oscillator to control the shaker frequency. Simultaneously obtain accelerometer output, amplitude and phase vs. frequency and automatically record these data with an X-Y plotter. If this equipment is not available, frequency sweeps should be performed manually in sufficiently small increments to define accurately the system frequency response curves. If manual tuning of the shaker is required, a fine adjustment of the frequency should be made in the region of a resonant amplitude to precisely determine the modal frequency.

9.1.2 - An accelerometer should be located on the structure adjacent to the shaker location to determine amplitude and phase at the input source. These data are helpful in providing a check on the recording instrumentation.

9.1.3 - A sufficient number of accelerometers should be used to expediently determine the flexible mode shapes. If the number of available accelerometers is limited, probes of the structure must be undertaken to accurately determine details of the mode shapes.

9.1.4 - Car body equipment mounts should be checked to insure that they are not bottoming at any frequency or amplitude.

9.1.5 - Throughout the duration of the test, visual observations should be made to detect any panel or equipment resonances.

9.1.6 - To determine the car body modes and frequencies, excitation should be applied in three directions: vertical, lateral and longitudinal. The shaker should be placed at two locations on the structure to insure that one of the locations is not a node point of a mode. It is recommended that one point lie off the car centerline to obtain ample excitation of the car body lateral/torsion modes.

9.1.7 - Excitation should be applied to the truck frame to determine vertical/pitch/roll modes and frequencies.

9.1.8 - Frequency response curves should be generated for any massive car body-mounted equipment.

9.1.9 - On-site data reduction should be performed so that modes and frequencies can be identified while the test is still in progress in the event further investigatory testing is required.

9.2 RIDE QUALITY TESTING

For ride quality testing:

1. Any speed sweeps should be made over the same track section.

2. Periodically walk through the vehicle to note any panel, seat, door or floor motion.

3. Relate frequencies observed in the ride quality testing to modes and frequencies determined in the shake test in order to establish which mode is the primary contributor to the vibration levels at each speed.

4. Monitor the "quick look" outputs to insure that paper speed and gains yield meaningful and easily readable data.

9.3 GENERAL

9.3.1 - A relationship between car body modal frequencies and primary excitation frequencies throughout the speed range should be obtained to optimize the design of the vehicle to achieve superior ride quality characteristics.

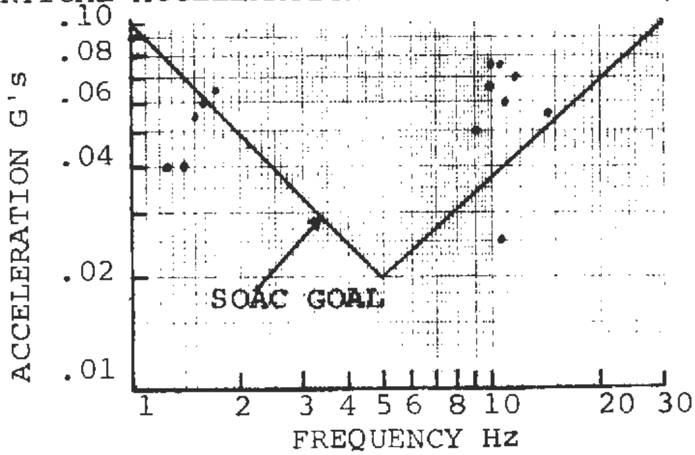
9.3.2 - A three-dimensional finite element analytical model of the car body should be developed and include primary and secondary structural elements to calculate the coupled natural modes and frequencies. These results should be compared to the relationships described in Item 9.3.1 to determine if any modification to the structure is required.

9.3.3 - Analytical predictions of the car body and truck modes and frequencies should be correlated with shake test data to confirm the validity of the idealization techniques.

9.3.4 - A ride quality test should be performed to confirm the relationships established in 9.1.1 above.

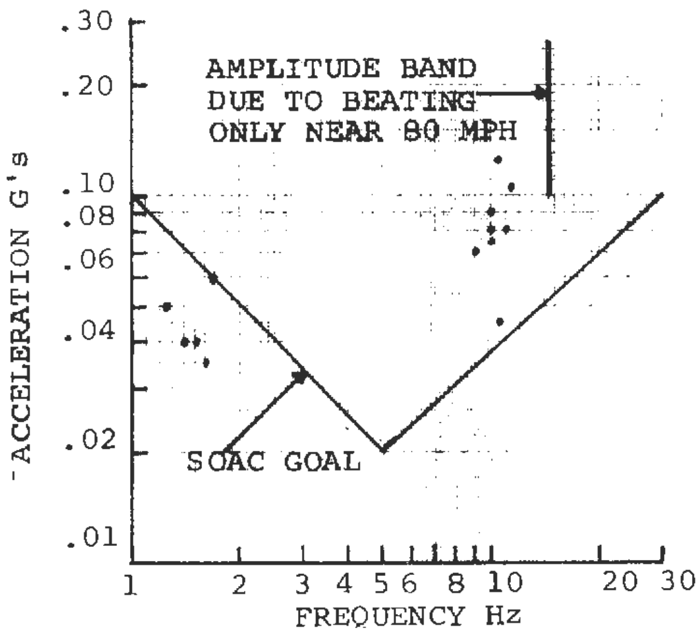
SOAC RIDE QUALITY
DATA COLLECTED DURING INITIAL RIDE QUALITY TEST

VERTICAL ACCELERATION OVER BOLSTER (STA 108)



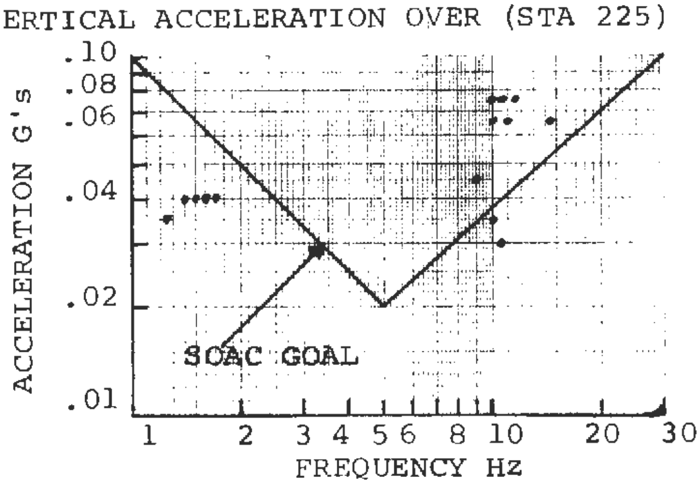
GROSS WEIGHT
90,000 LBS.

VERTICAL ACCELERATION OVER CENTER OF CAR (STA 450)



GROSS WEIGHT
90,000 LBS.

VERTICAL ACCELERATION OVER (STA 225)



GROSS WEIGHT
90,000 LBS.

FIGURE 1

SOAC RIDE QUALITY
DATA COLLECTED DURING INITIAL RIDE QUALITY TEST
VERTICAL ACCELERATION

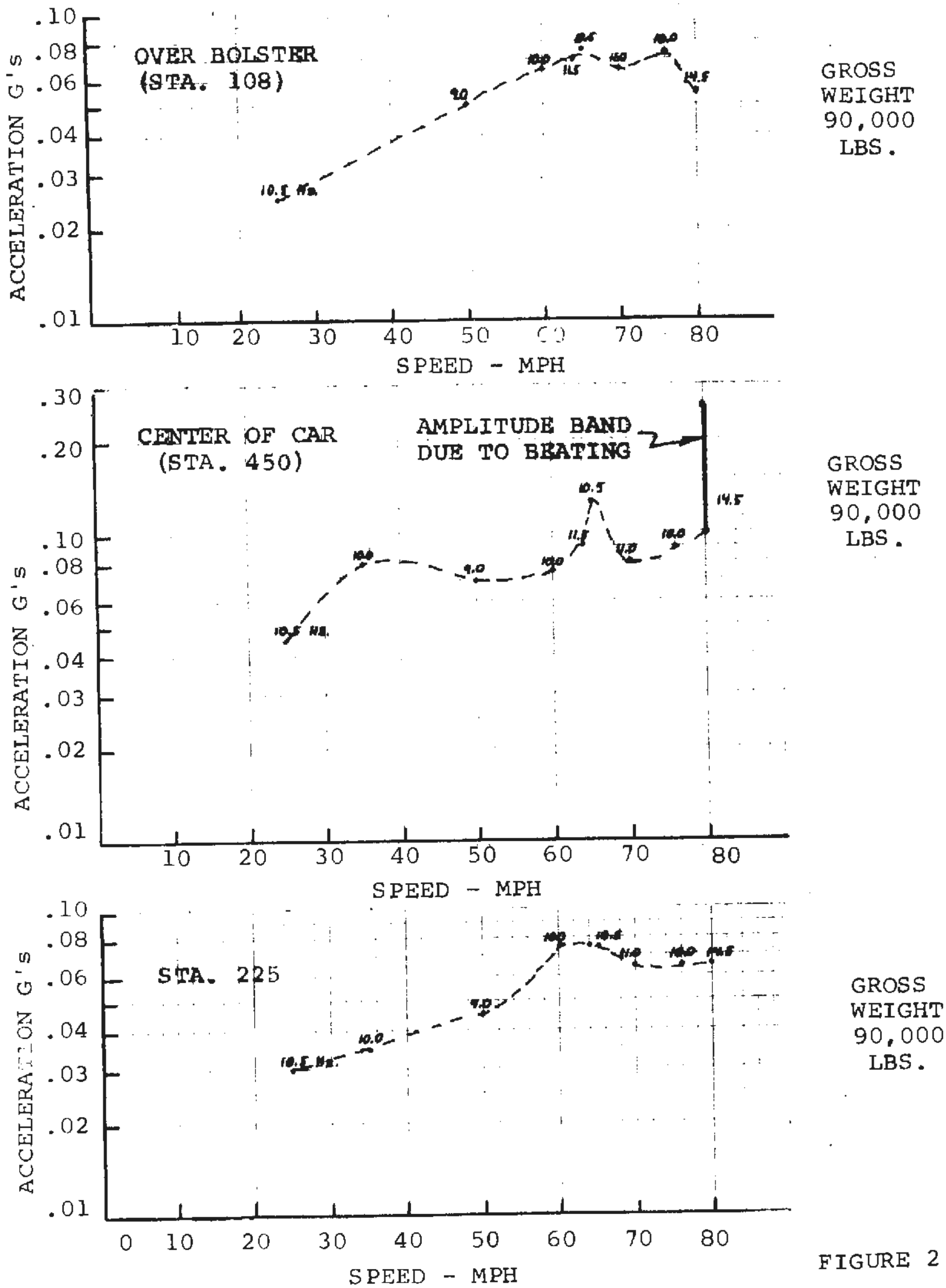


FIGURE 2

SOAC EXPLODED VIEW

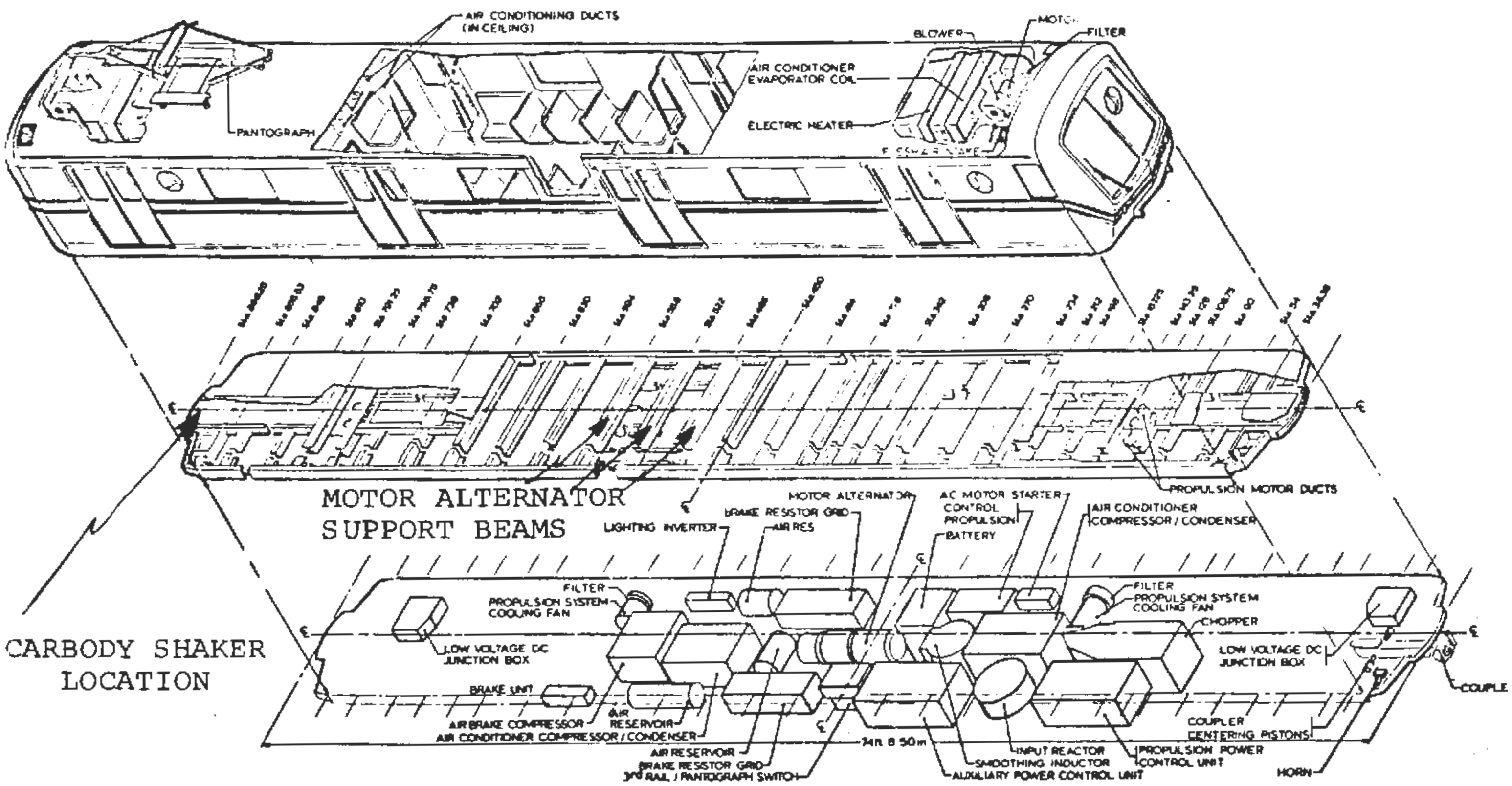


FIGURE 3

CARBODY VERTICAL ACCELERATION

CENTER OF CAR (STA 450)

SAMPLE ACCELEROMETER OUTPUT

GROSS WEIGHT = 90,000 LB.
SPEED 80 MPH

INITIAL RIDE QUALITY TEST
.5 g's/In.

PEAK ACCELERATION = .26 g's

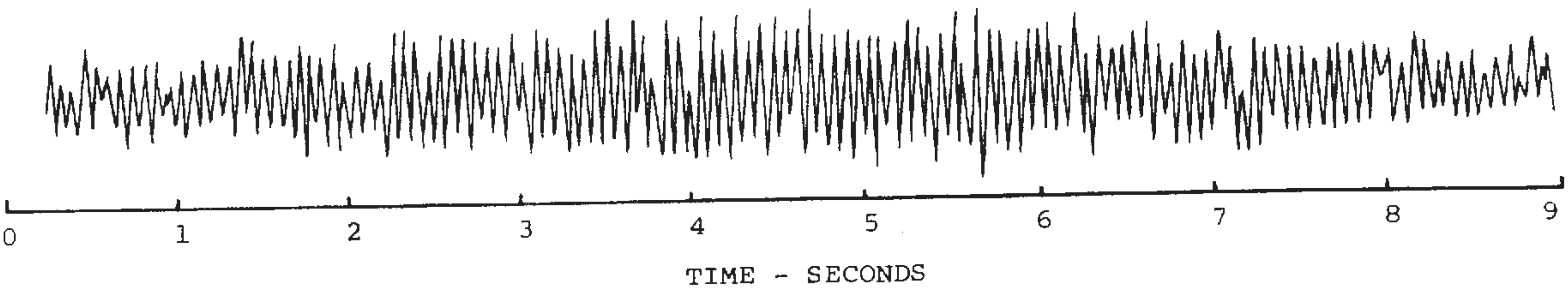


FIGURE 4a

RIDE QUALITY TEST AFTER MOTOR ALTERNATOR STRUCTURAL MODIFICATION
.5 g's/In.

PEAK ACCELERATION = .10 g's

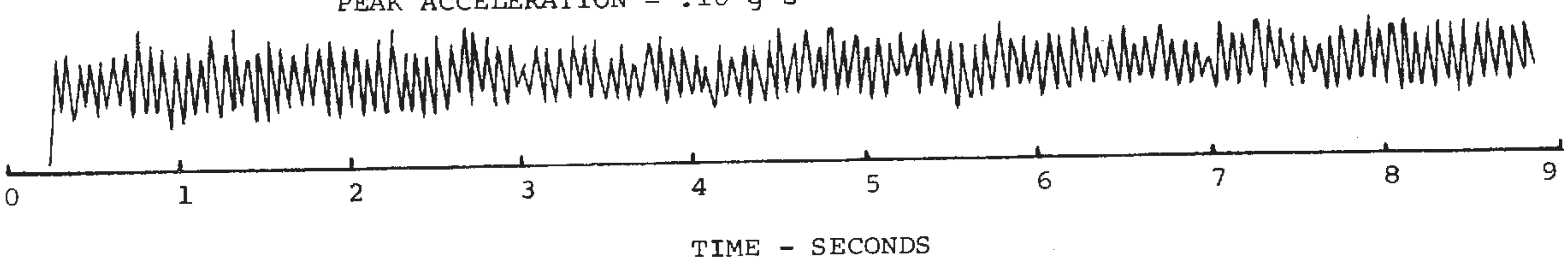


FIGURE 4b

THE BOEING COMPANY

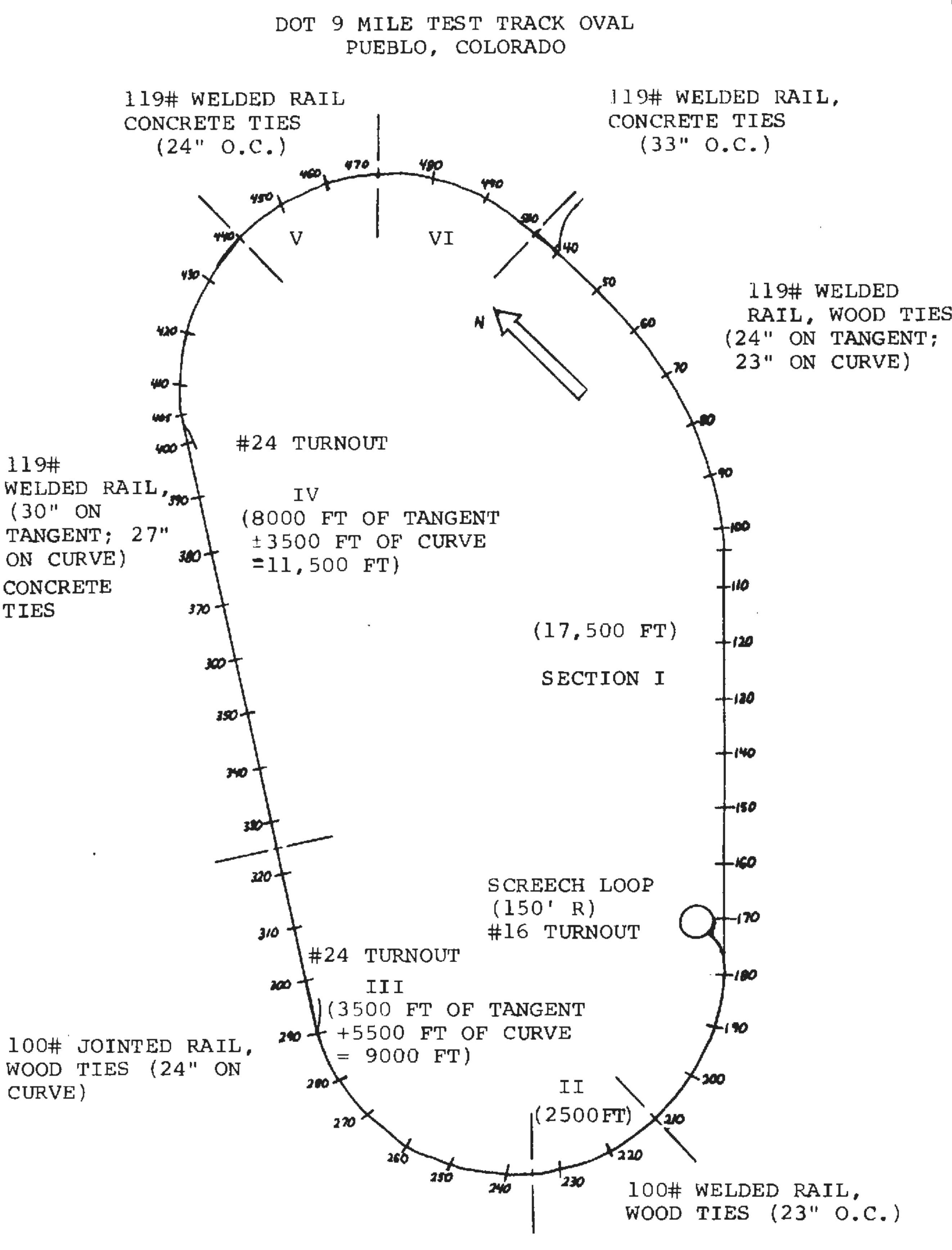


FIGURE 5

SOAC VIBRATION DATA

Gross Weight = 90,000 Lb. Speed = 80 MPH
Welded Rail

Effect of Secondary Suspension Houdaille Vertical Dampers

Pickup	Dampers On	Dampers Off
Car Longitudinal	.037 g @ 14.5 cps	.05 g @ 14 cps
Mid Car Vertical	.125 g @ 14.5 cps	.05 g @ 14 cps
Motor Alternator Vert.	Not Available	.10 g @ 14 cps
Traction Motor Vert.	.75 g @ 11 cps	.5 g @ 11 cps
Car Cab Vertical	.05 g @ 1.5 cps	.037 @ 1.25 cps
Truck Bolster Motion Vertical	± .2 Inches	± .2 Inches
Truck Bolster Vertical	.35 g @ 15.5 cps	Not Available

Effect of Motor Alternator Shims

Pickup	Wood Shims	Steel Shims	No Shims
Car Longitudinal	.015g @ 14 cps	.062g @ 14.5cps	.05g @ 14cps
Mid Car Vertical	.037g @ Random	.09g @ 14.5cps	.05g @ 14cps
Motor Alternator Vertical	.075g @ 14 cps	.15g @ 14.5cps	.10g @ 14cps
Traction Motor Vertical	.25g @ 14 cps	1g @ 11.5cps	.5g @ 11cps
Car Cab	.075g @ 1.25 cps	.062g @ 1.25cps	.037g@1.25cps
Truck Bolster Motion Vertical	± .2 Inches	±.25 Inches	±.2 Inches

FIGURE 6

VERTICAL SHAKER CONFIGURATION

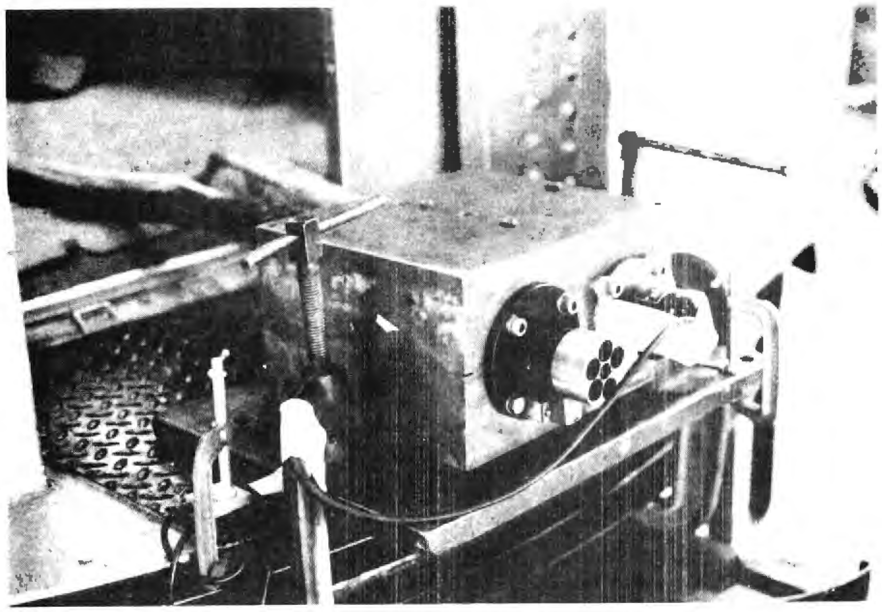


FIGURE 7a

LONGITUDINAL SHAKER CONFIGURATION

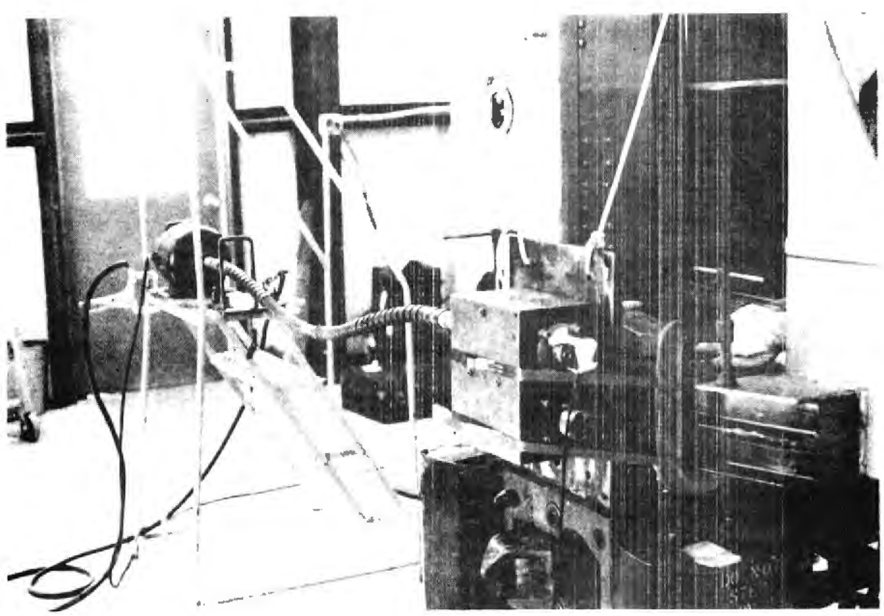


FIGURE 7b

EFFECT OF FREQUENCY

ON

SHAKER FORCE OUTPUT

LAZAN MODEL LA1 SHAKER
OUTPUT CHARACTERISTICS

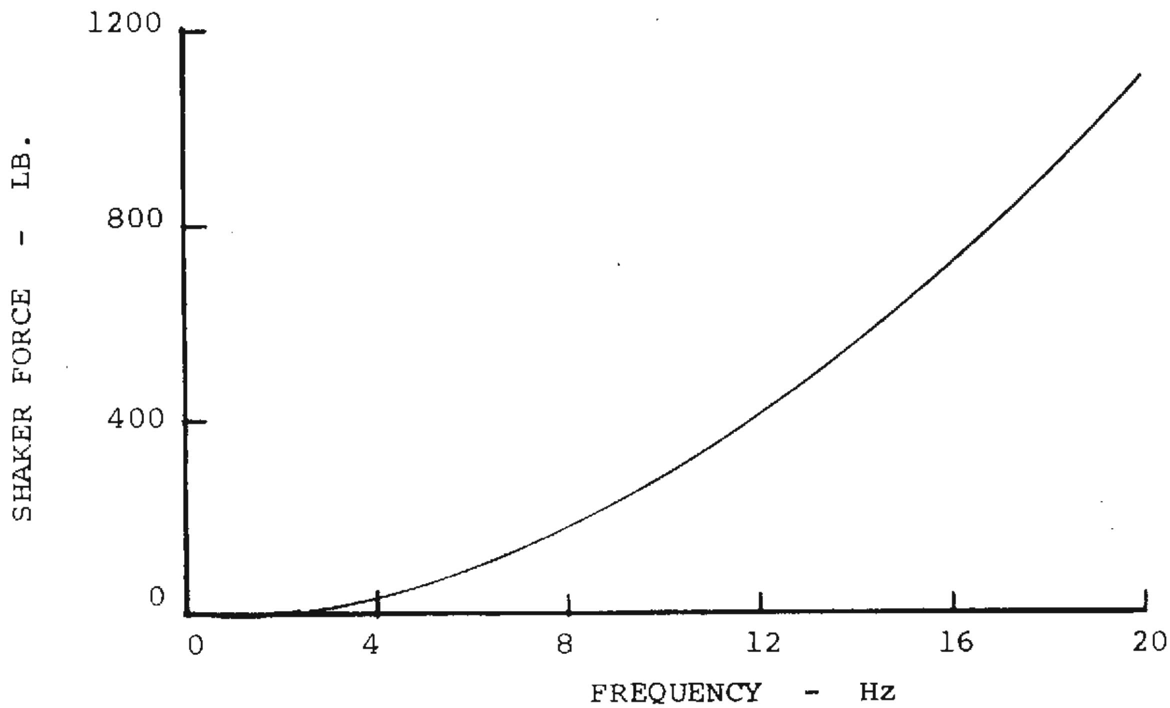


FIGURE 8

SOAC SHAKE TEST

Frequency Response Curves

Shaker Location: B CAR END
Shaker Force: 500 LB
Shaker Direction: VERT
Gross Weight: 90000 LB
Vertical Damper Config.: OFF
Motor Alternator Config.: NO SHIMS
Pick-Up Location: B CAR END ~ VERT

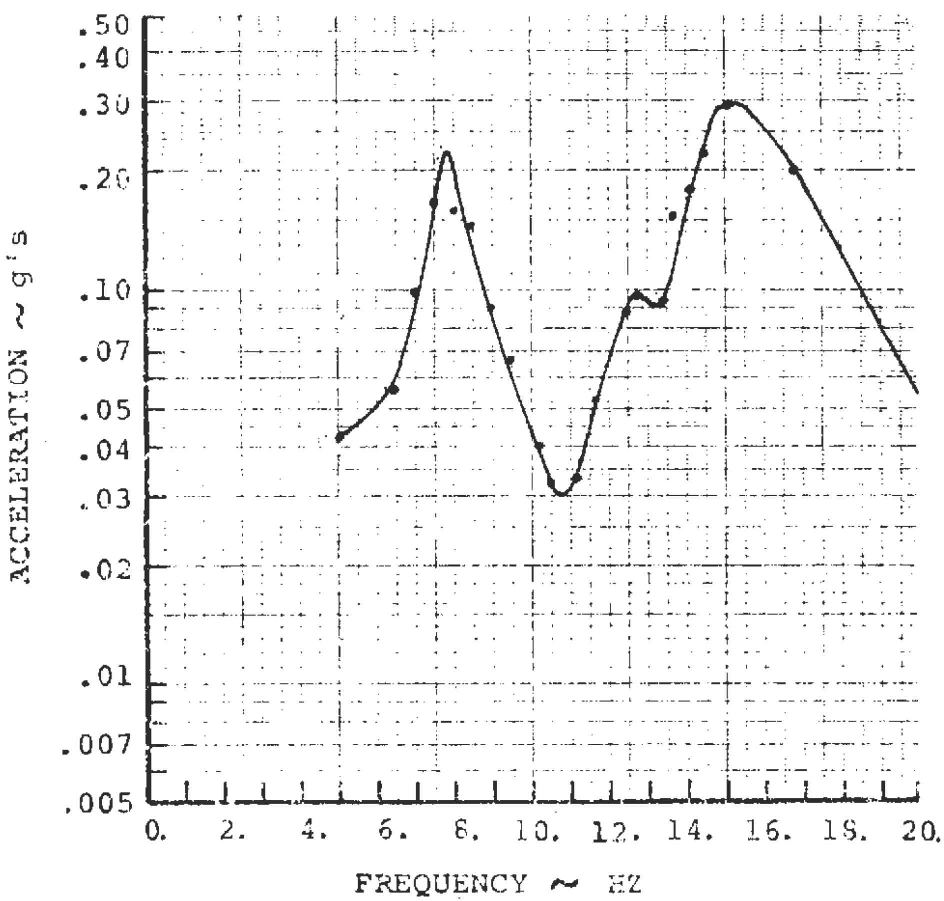


FIGURE 9

SOAC SHAKE TEST

Frequency Response Curves

Shaker Location R CAR END
Shaker Force 500 LB
Shaker Direction VERT
Gross Weight 90000 LB
Vertical Damper Config. OFF
Motor Alternator Config. NO SHIMS
Pick-Up Location STA 450 ~ VERT

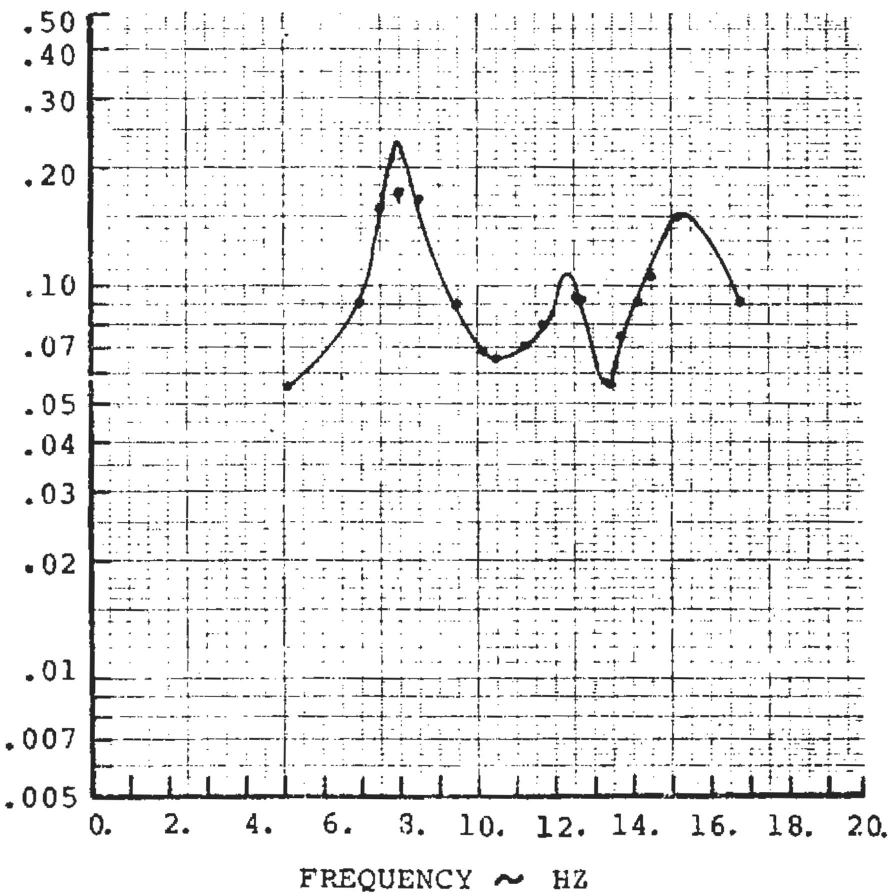


FIGURE 10

SOAC SHAKE TEST

Frequency Response Curves

Shaker Location R CAR END
Shaker Force 500 LB
Shaker Direction VERT
Gross Weight 90000 LB
Vertical Damper Config. OFF
Motor Alternator Config. NO SHIMS
Pick-Up Location STA 673 ~ VERT

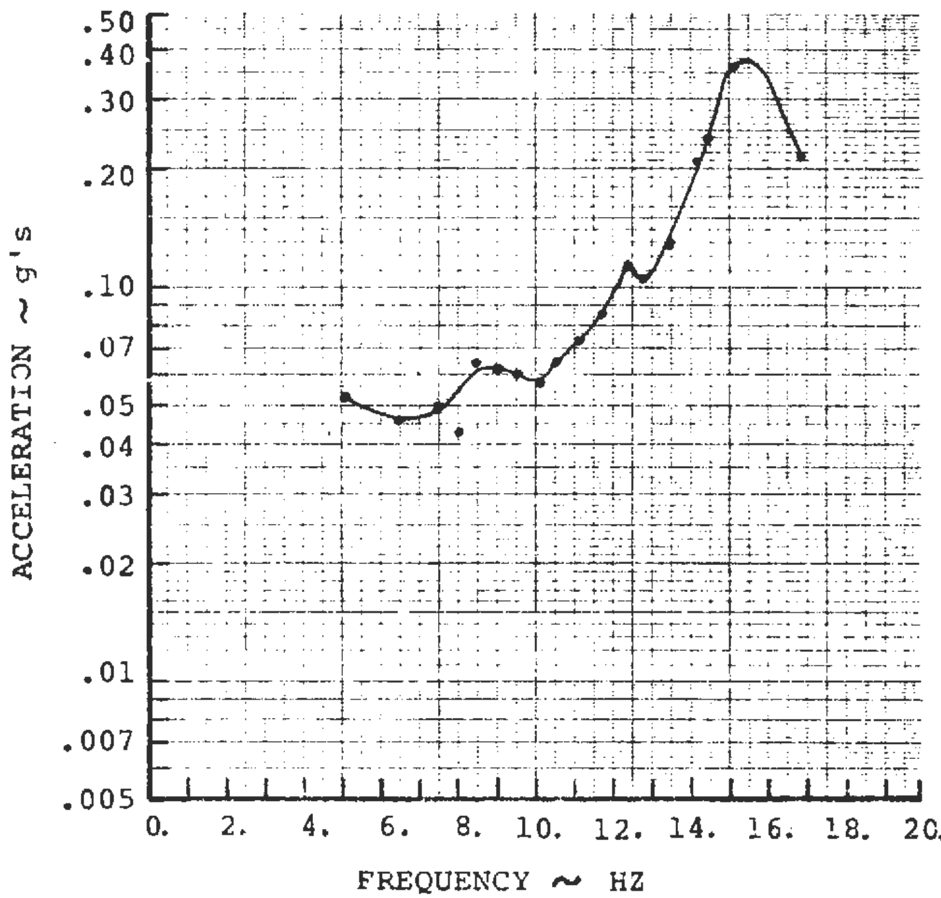


FIGURE 11

SOAC SHAKE TEST

Frequency Response Curves

Shaker Location R CAR END
Shaker Force 500 LB
Shaker Direction VERT
Gross Weight 90000 LB
Vertical Damper Config. OFF
Motor Alternator Config. NO SHIMS
Pick-Up Location MOTOR ALTERNATOR ~ VERT

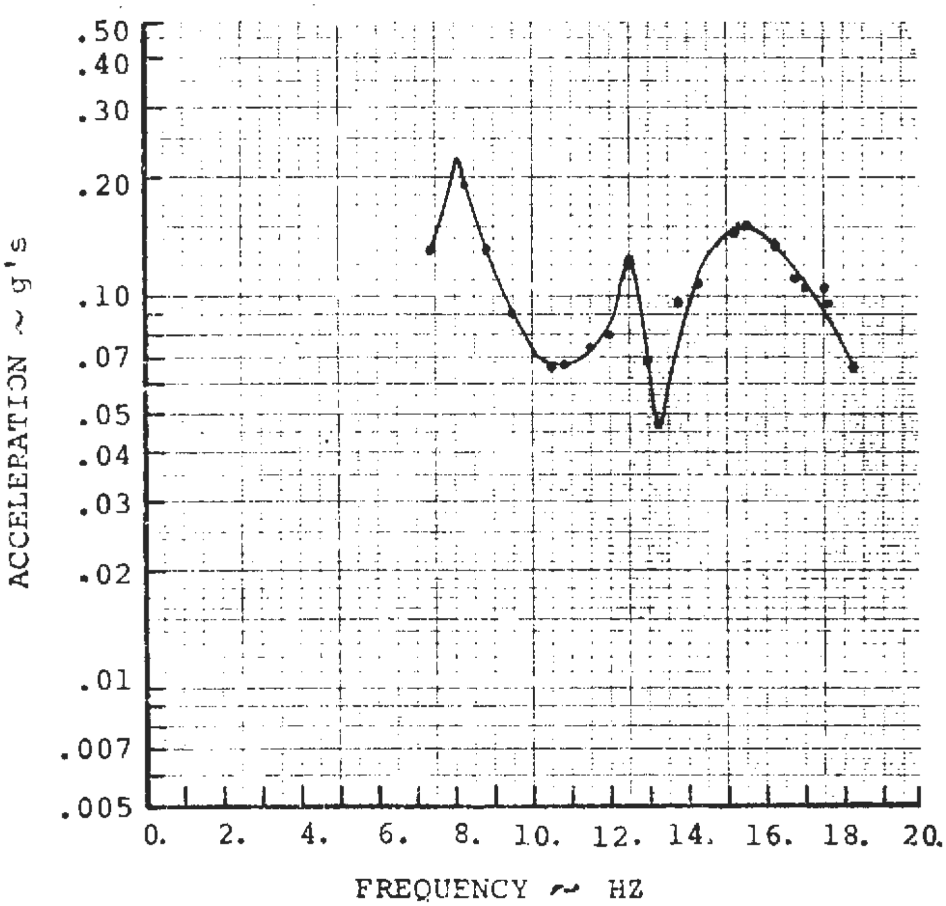


FIGURE 12

SOAC SHAKE TEST
VERTICAL
MODE SHAPES

CARBODY VERTICAL BENDING

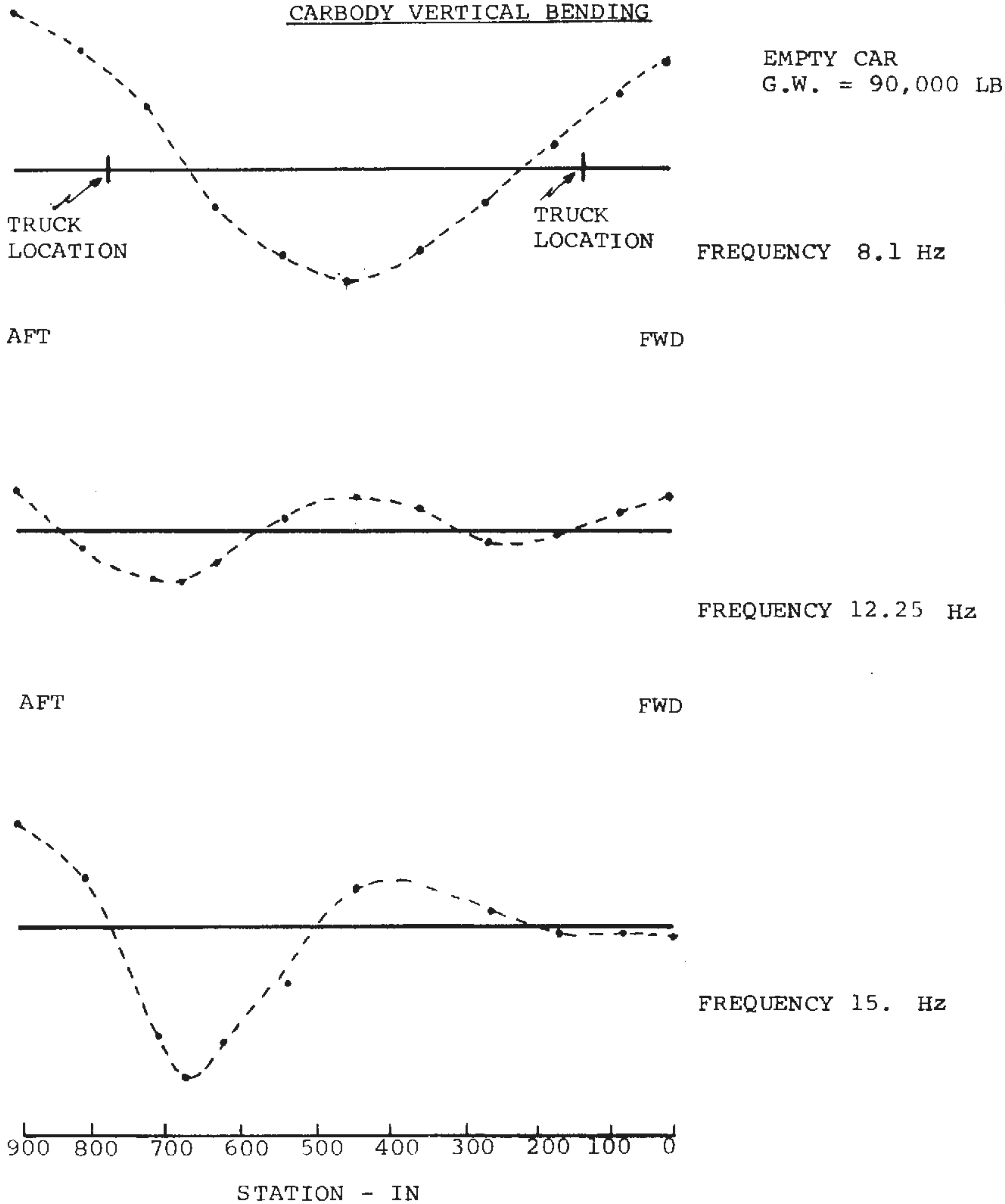
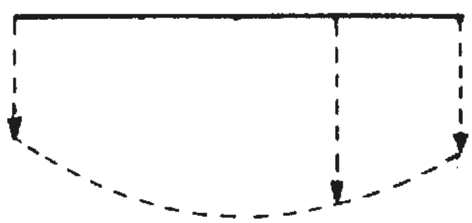


FIGURE 13

SOAC SHAKE TEST VERTICAL MODE SHAPES

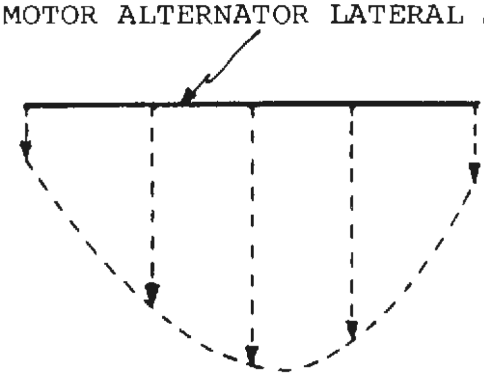
MOTOR ALTERNATOR LATERAL SUPPORT BEAM



FREQUENCY = 8.10 Hz

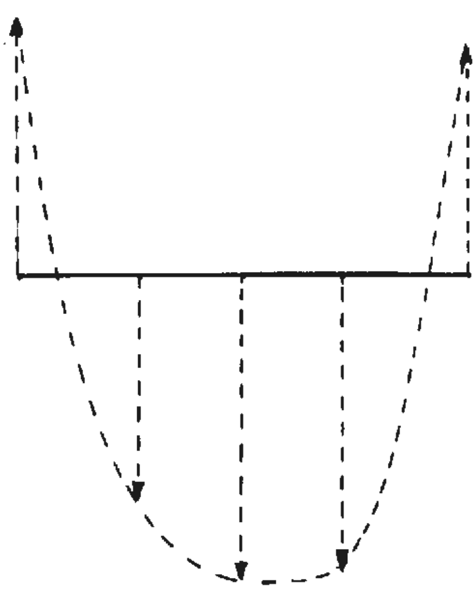
VIEW LOOKING AFT

MOTOR ALTERNATOR LATERAL SUPPORT BEAM



FREQUENCY = 12.25 Hz

VIEW LOOKING AFT



FREQUENCY = 15.2 Hz

FIGURE 14

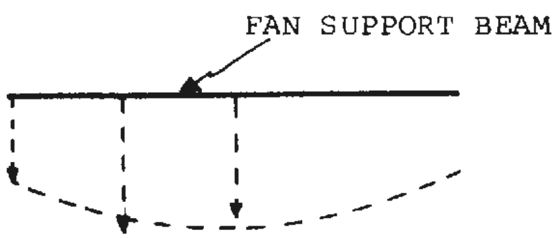
**SOAC SHAKE TEST
VERTICAL
MODE SHAPES**

MOTOR FAN SUPPORT BEAM

EMPTY CAR
G.W. = 90,000 LB.

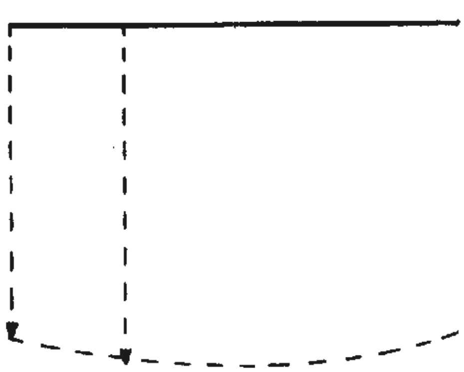
FREQUENCY = 8.10 Hz

VIEW LOOKING AFT



FREQUENCY = 12.25 Hz

VIEW LOOKING AFT



FREQUENCY = 15.2 Hz

FIGURE 15

SOAC SHAKE TEST

Frequency Response Curves

Shaker Location R CAR END
Shaker Force 500 LB
Shaker Direction VERT
Gross Weight 90000 LB
Vertical Damper Config. OFF
Motor Alternator Config. SHIMS
Pick-Up Location R CAR END ~ VERT

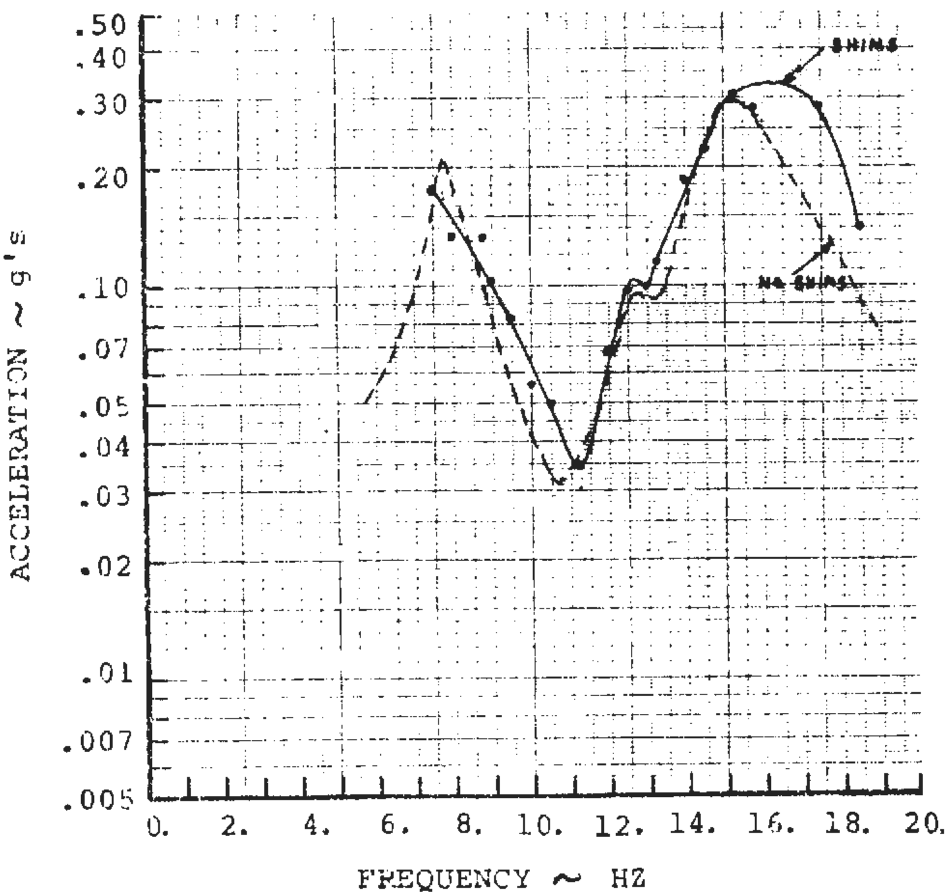


FIGURE 16

SOAC SHAKE TEST

Frequency Response Curves

Shaker Location R CAR END
Shaker Force 500 LB
Shaker Direction VERT
Gross Weight 90000 LB
Vertical Damper Config. OFF
Motor Alternator Config. SHIMS
Pick-Up Location STA 450 ~ VERT

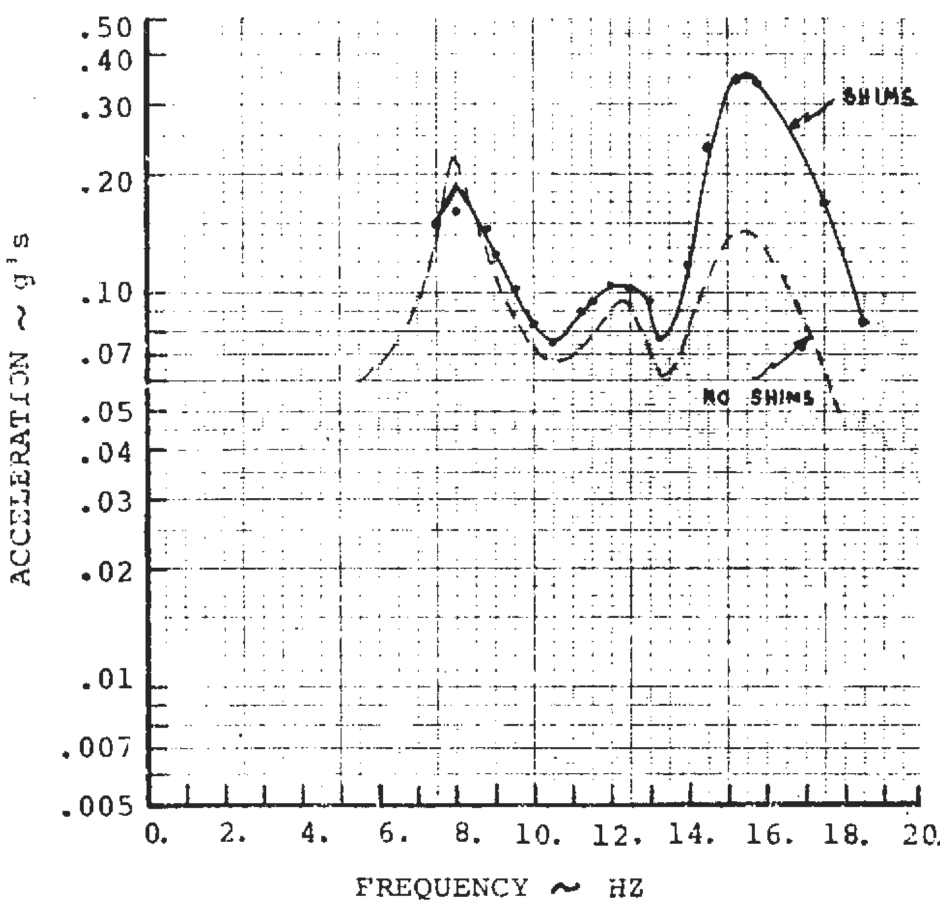


FIGURE 17

SOAC SHAKE TEST

Frequency Response Curves

Shaker Location R CAR END
Shaker Force 500 LB
Shaker Direction VERT
Gross Weight 90000 LB
Vertical Damper Config. OFF
Motor Alternator Config. SHIMS
Pick-Up Location STA 673~VERT

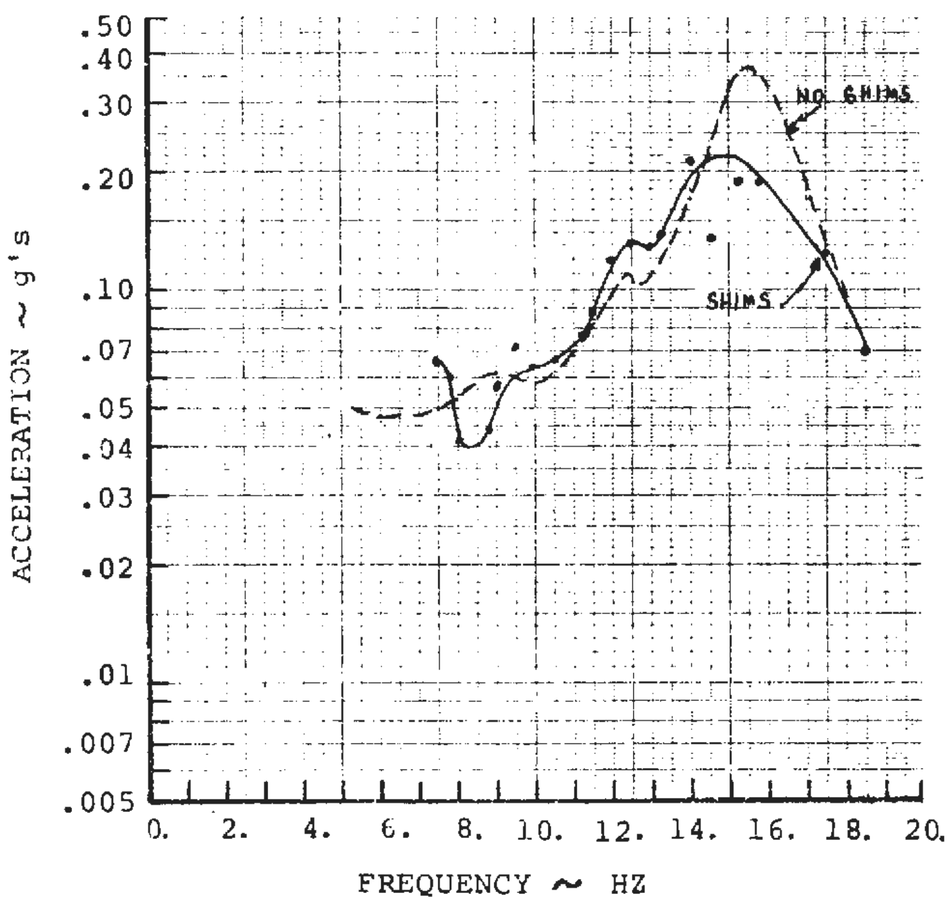


FIGURE 18

SOAC SHAKE TEST

Frequency Response Curves

Shaker Location R CAR END
Shaker Force 500 LB
Shaker Direction VERT
Gross Weight 90000 LB
Vertical Damper Config. OFF
Motor Alternator Config. SHIMS
Pick-Up Location MOTOR ALTERNATOR~VERT

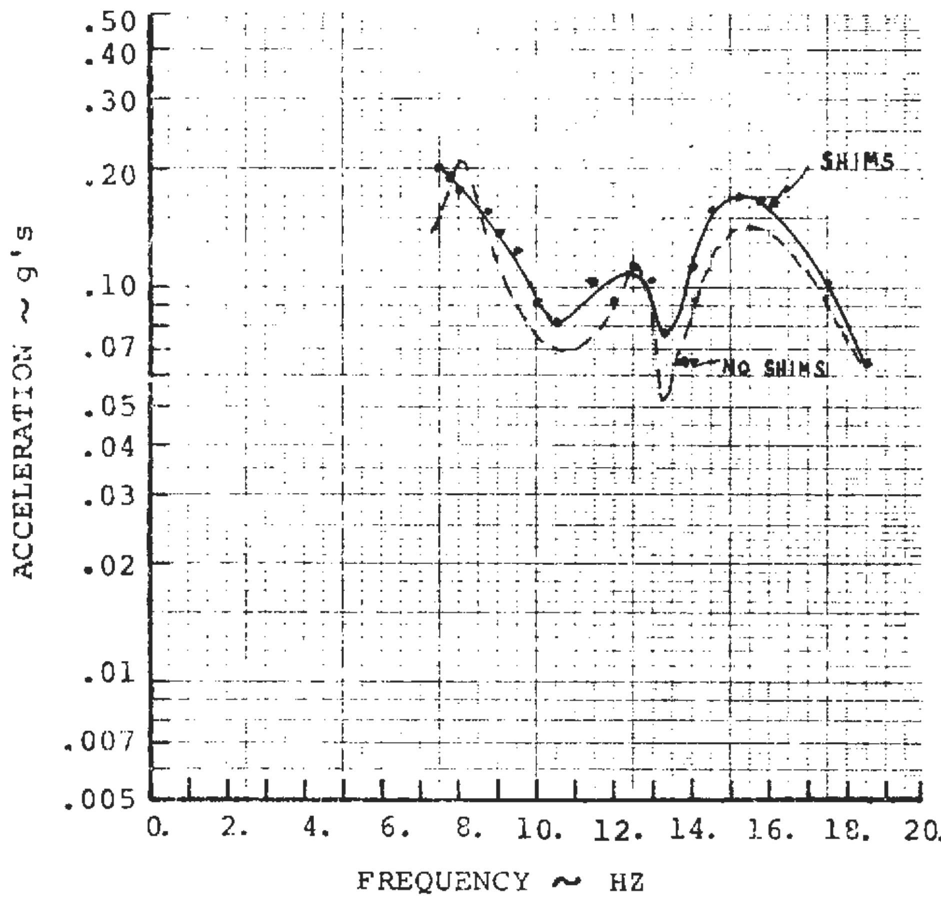


figure 19

SOAC SHAKE TEST

Frequency Response Curves

Shaker Location R CAR END
Shaker Force 500 LB
Shaker Direction LONG
Gross Weight 90000 LB
Vertical Damper Config. OFF
Motor Alternator Config. NO SHIMS
Pick-Up Location STA 673 ~ VERT

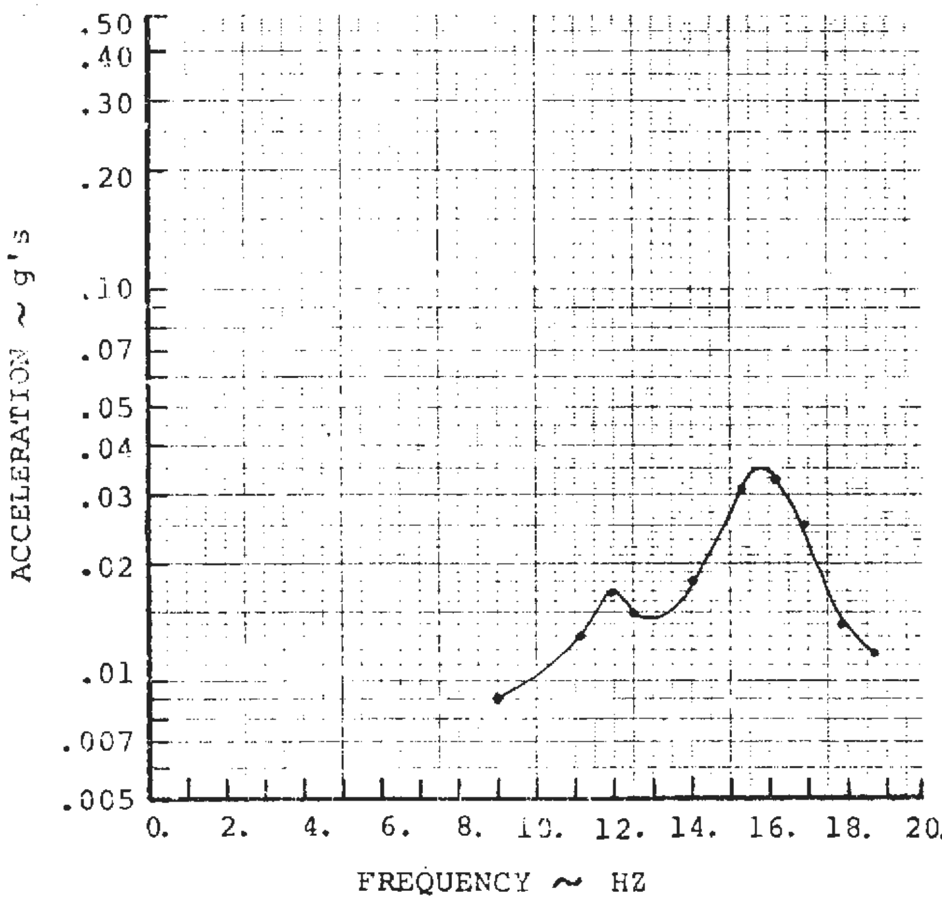


FIGURE 20

SOAC SHAKE TEST

Frequency Response Curves

Shaker Location R CAR END
Shaker Force 500 LB
Shaker Direction LONG
Gross Weight 90000 LB
Vertical Damper Config. OFF
Motor Alternator Config. NO SHIMS
Pick-Up Location MOTOR ALTERNATOR ~ LONG

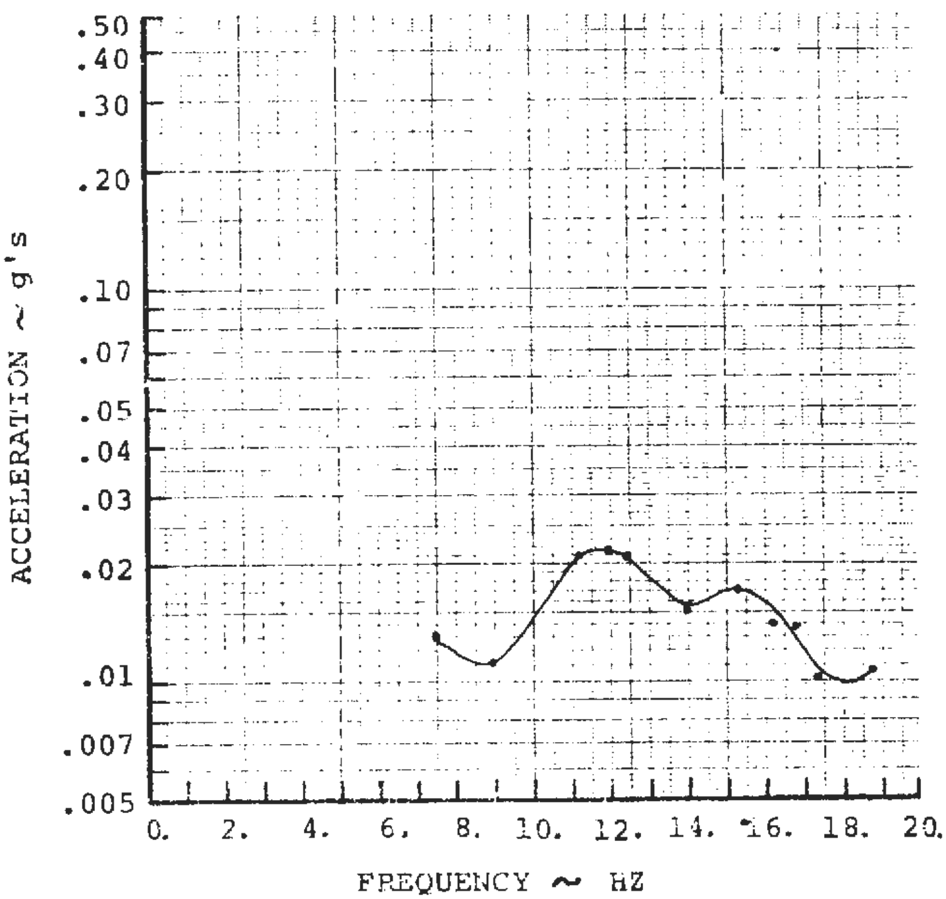


FIGURE 21

SOAC SHAKE TEST

Frequency Response Curves

Shaker Location R CAR END
Shaker Force 500 LB
Shaker Direction LONG
Gross Weight 90000 LB
Vertical Damper Config. OFF
Motor Alternator Config. NO SHIMS
Pick-Up Location R CAR END ~ LONG

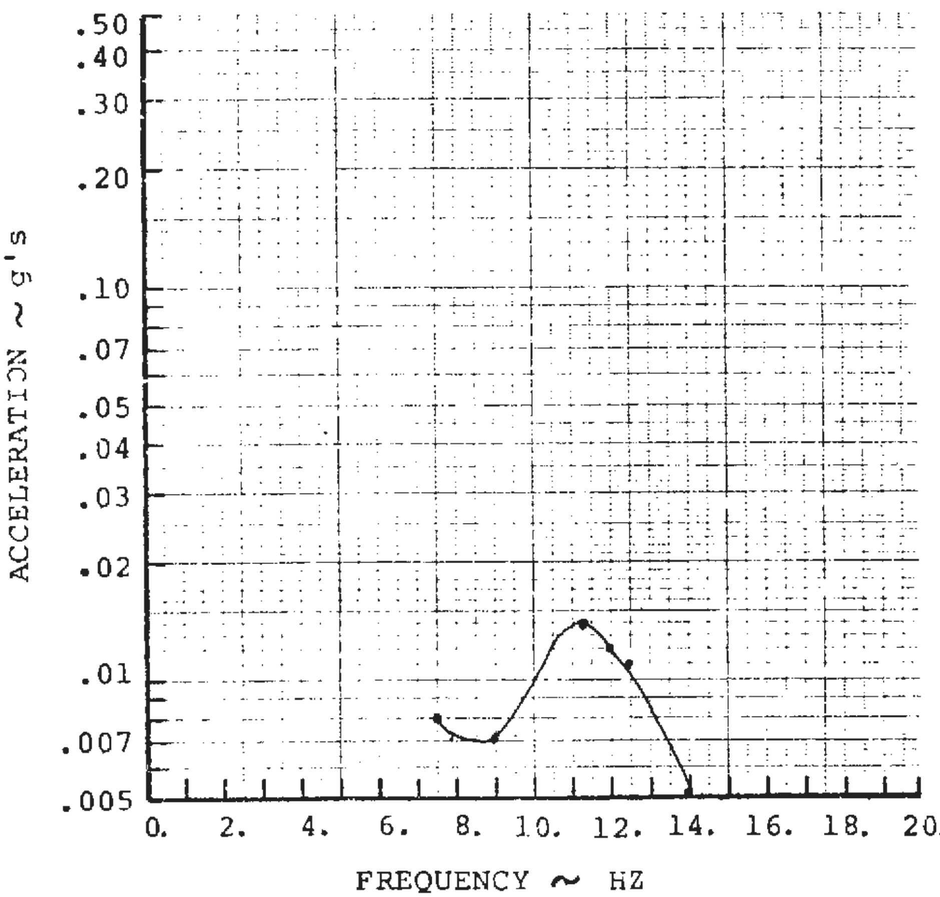


FIGURE 22

SOAC SHAKE TEST

Frequency Response Curves

Shaker Location B CAR END
Shaker Force 500 LB
Shaker Direction LONG
Gross Weight 90000 LB
Vertical Damper Config. OFF
Motor Alternator Config. NO SHIMS
Pick-Up Location MID CAR SEAT BACK~LONG

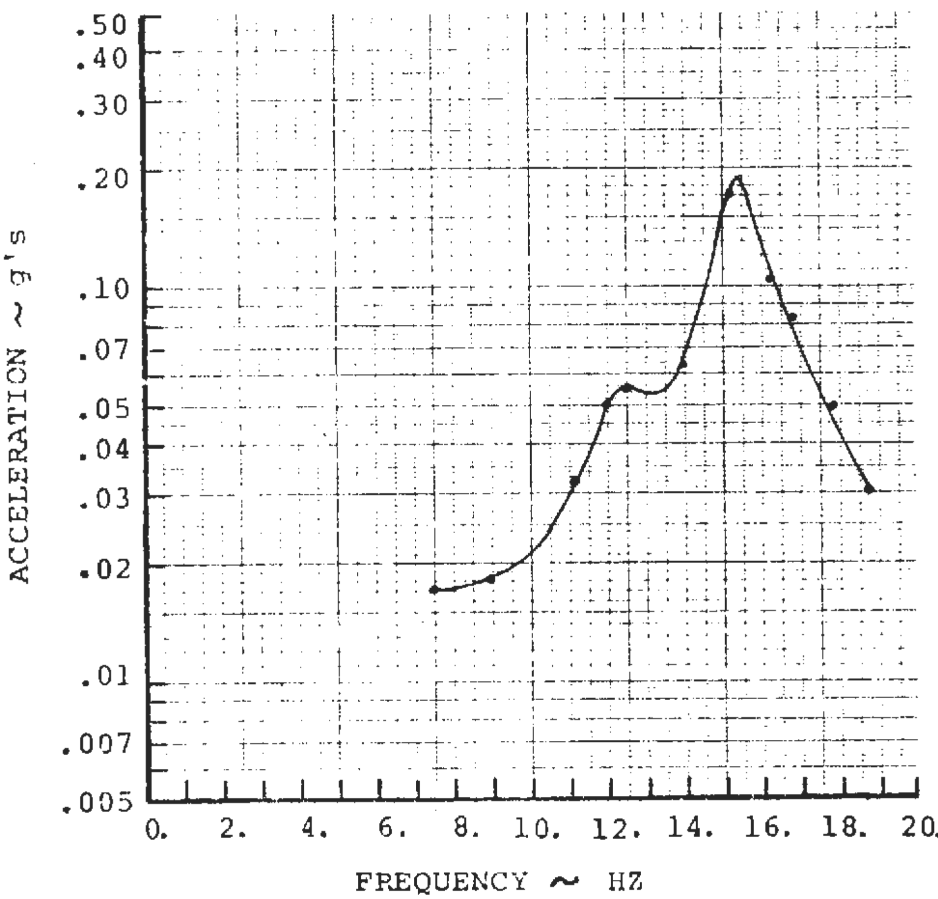


FIGURE 23

SOAC SHAKE TEST

Frequency Response Curves

Shaker Location TRUCK FRAME
Shaker Force 500 LB
Shaker Direction VERT
Gross Weight 90000 LB
Vertical Damper Config. OFF
Motor Alternator Config. NO SHIMS
Pick-Up Location TRUCK FRAME ~ VERT

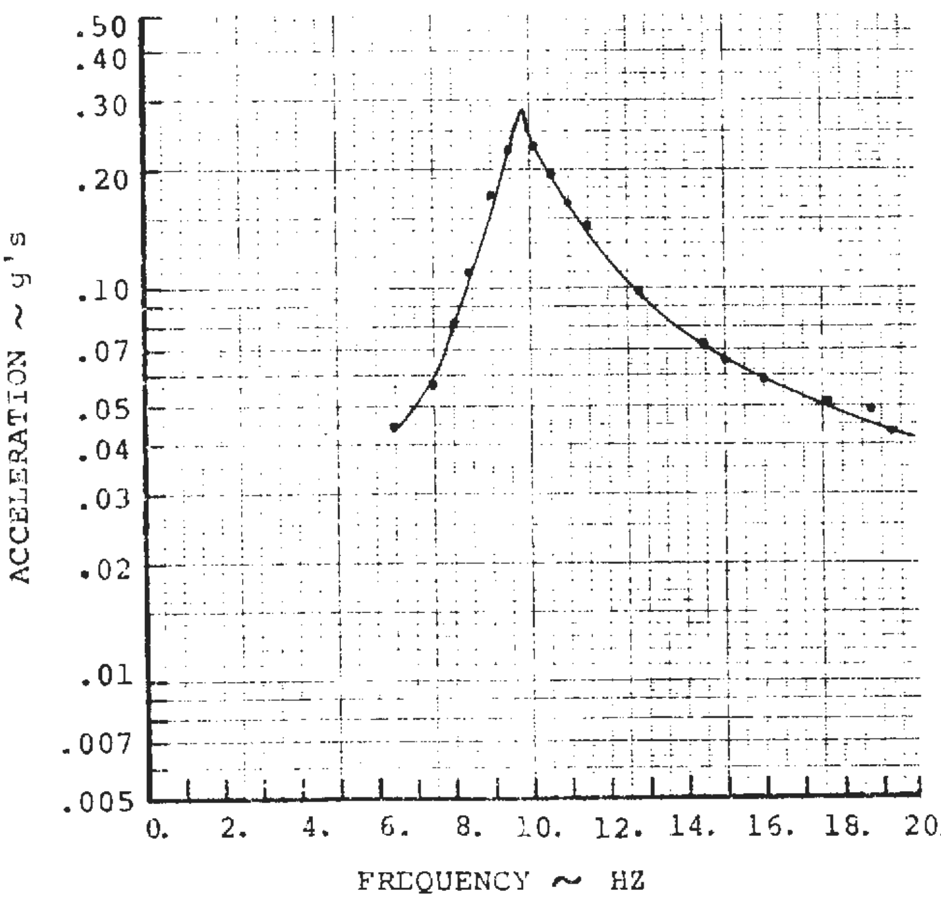


FIGURE 24

SOAC SHAKE TEST

Frequency Response Curves

Shaker Location TRUCK FRAME
Shaker Force 500 LB
Shaker Direction VERT
Gross Weight 90000 LB.
Vertical Damper Config. ON
Motor Alternator Config. NO SHIMS
Pick-Up Location TRUCK FRAME ~ VERT

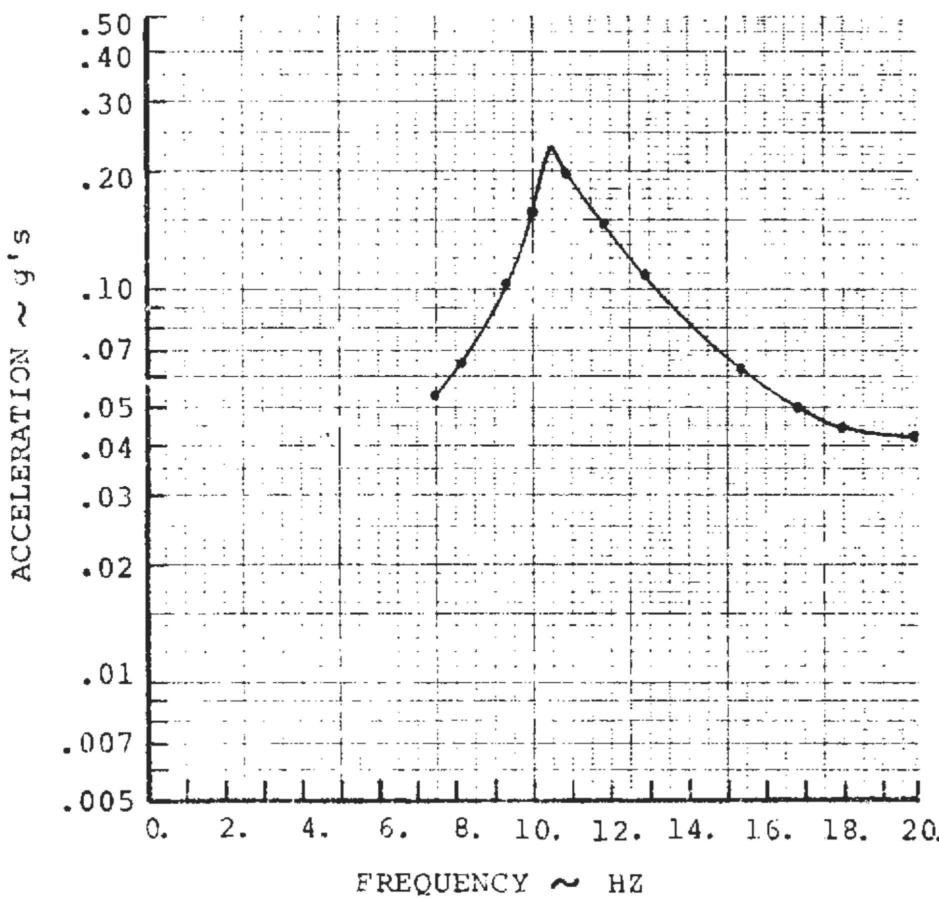


FIGURE 25

SOAC SHAKE TEST

Frequency Response Curves

Shaker Location TRUCK FRAME
Shaker Force 500 LB
Shaker Direction VERT
Gross Weight 90000 LB
Vertical Damper Config. OFF
Motor Alternator Config. NO SHIMS
Pick-Up Location B CAR END ~ VERT

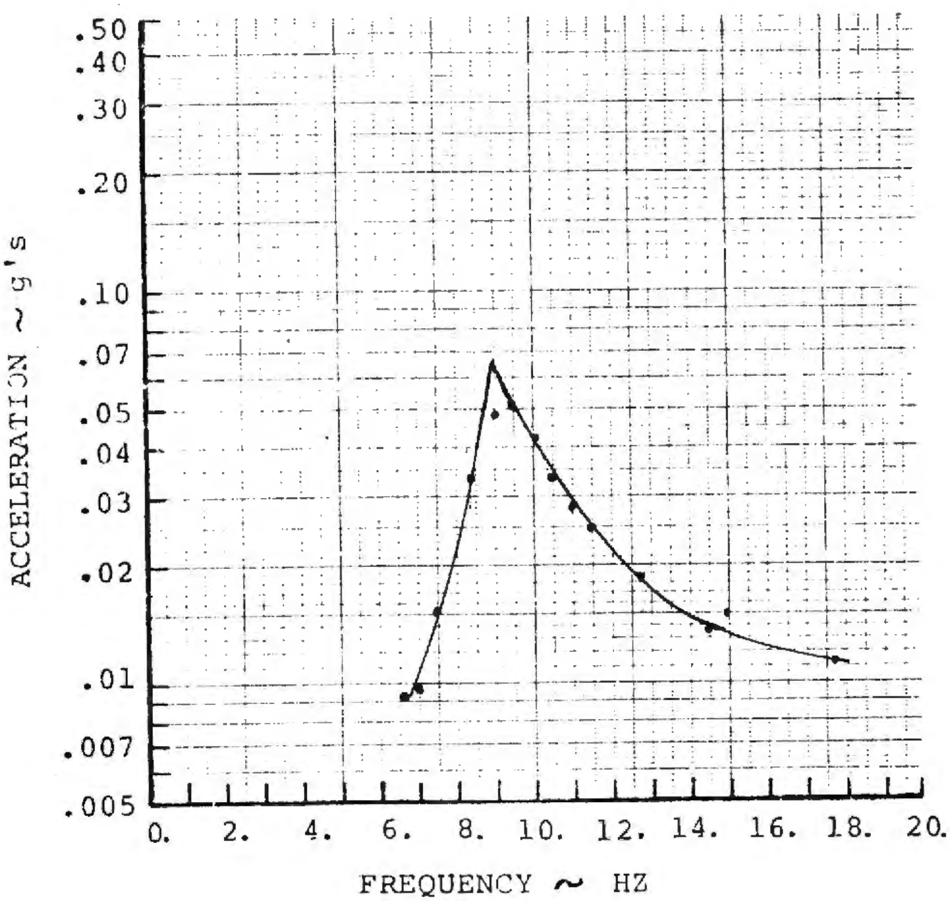


FIGURE 26

SOAC SHAKE TEST

Frequency Response Curves

Shaker Location TRUCK FRAME
Shaker Force 500 LB
Shaker Direction VERT
Gross Weight 90000 LB
Vertical Damper Config. ON
Motor Alternator Config. NO SHIMS
Pick-Up Location B CAR END ~ VERT

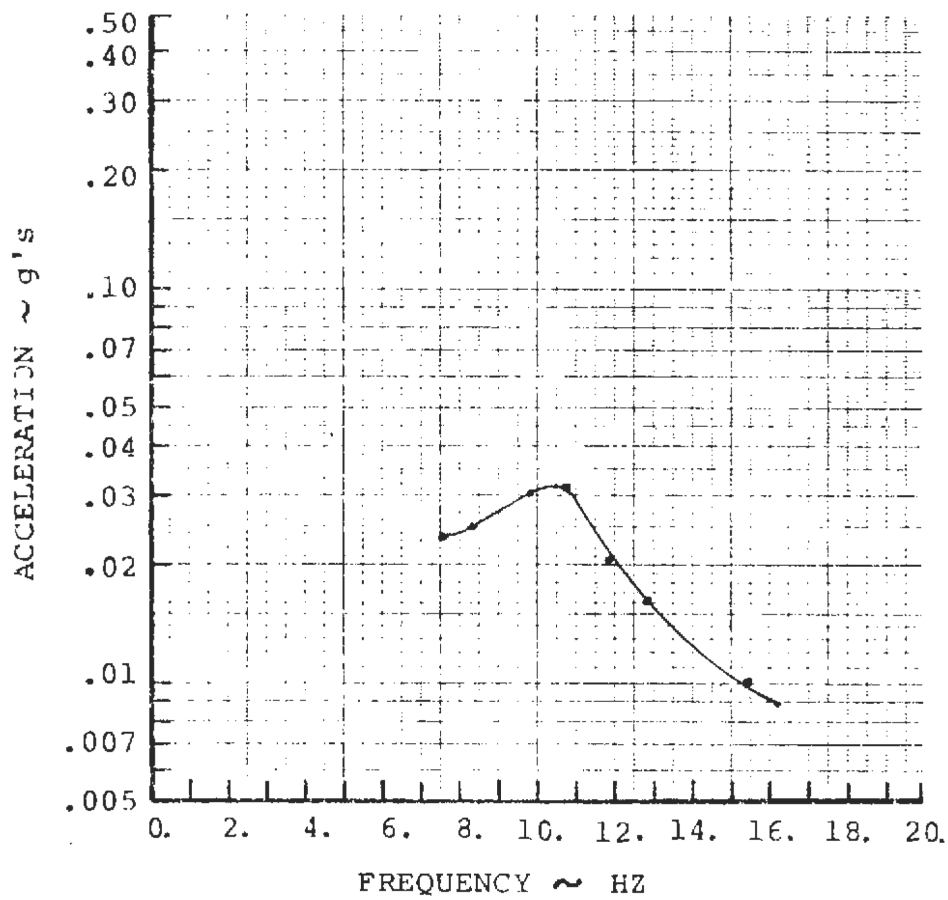
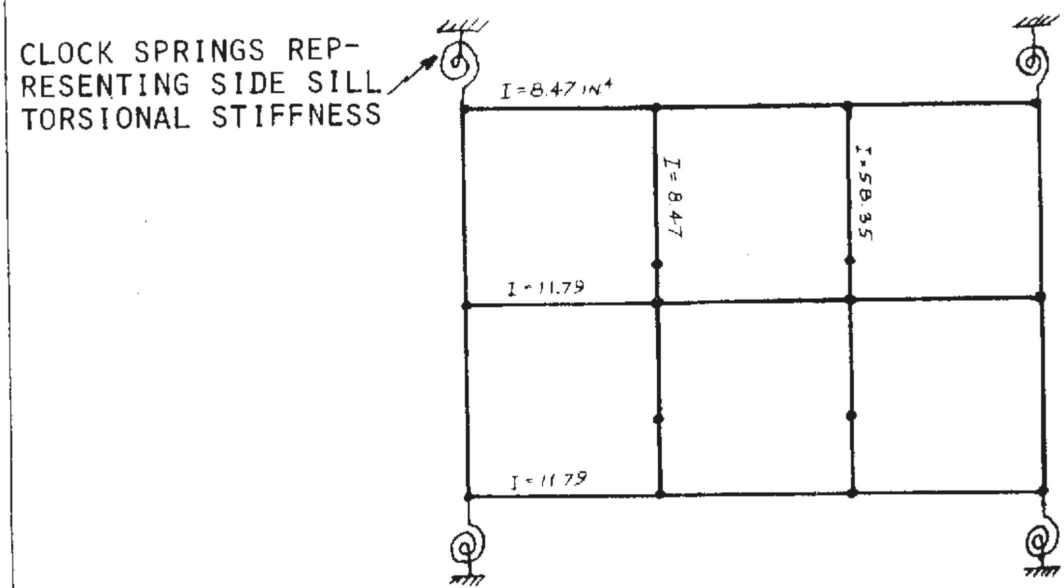


FIGURE 27

FINITE ELEMENT ANALYTICAL MODEL
SOAC MA SUPPORT STRUCTURE

BASELINE CONFIGURATION



STRUCTURAL MODIFICATION

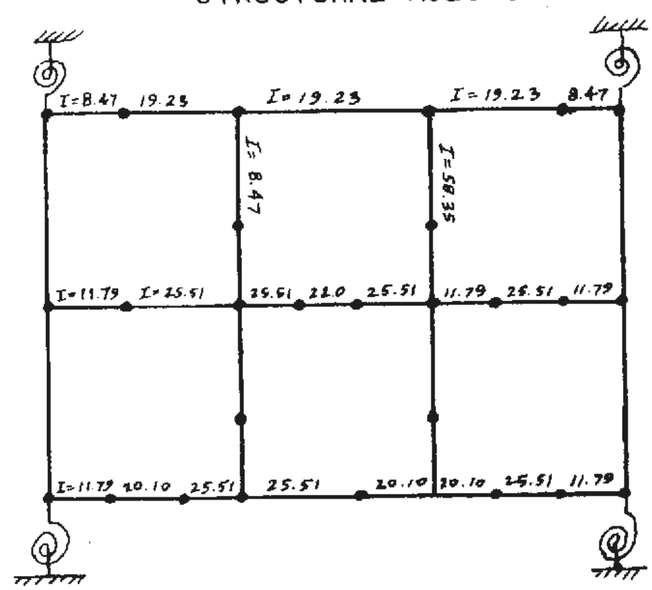


FIGURE 28

EFFECT OF CARBODY STRUCTURAL MODIFICATION ON DYNAMIC AMPLIFICATION

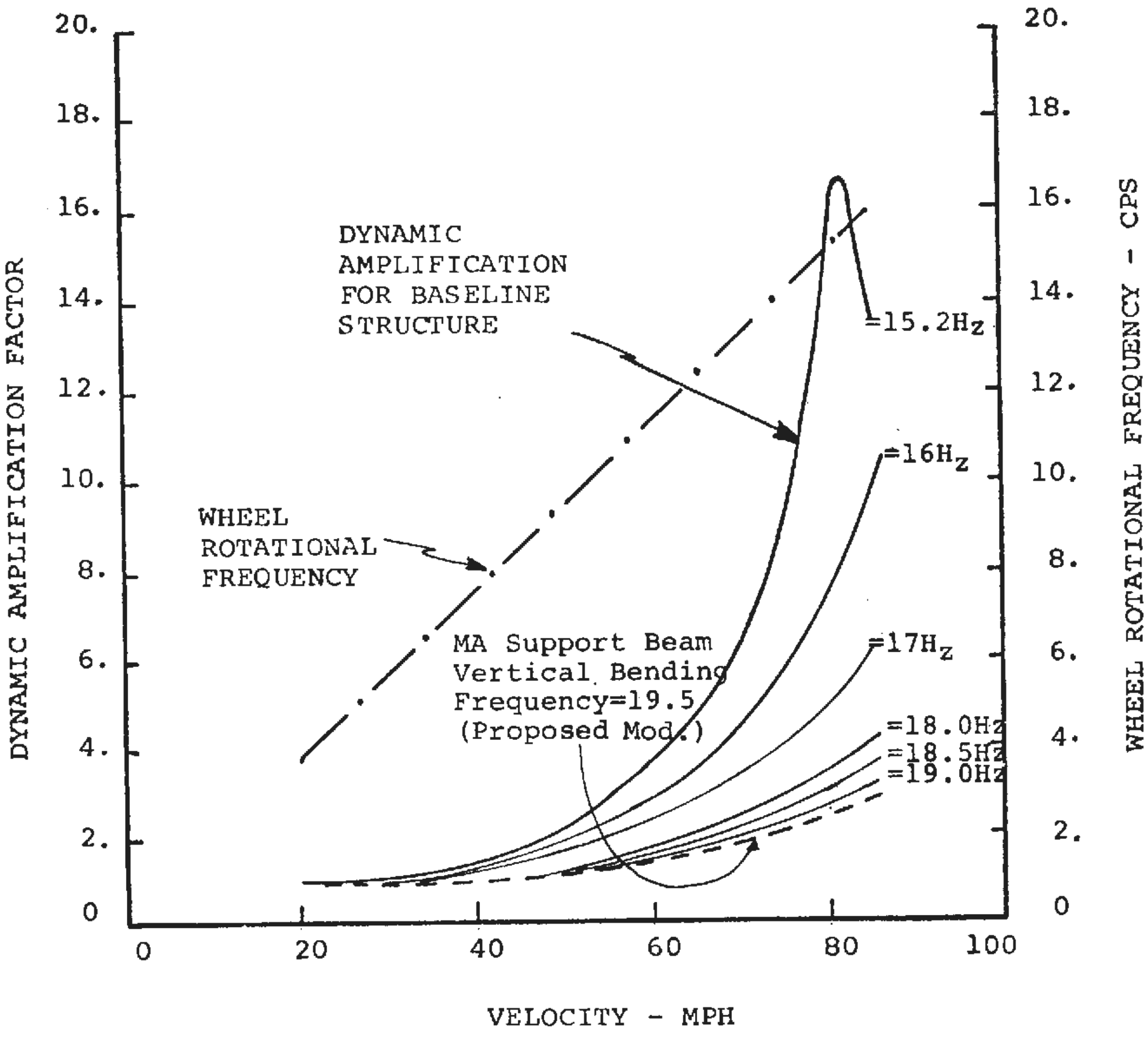


FIGURE 29

MOTOR ALTERNATOR STRUCTURAL MODIFICATION
IN PROGRESS

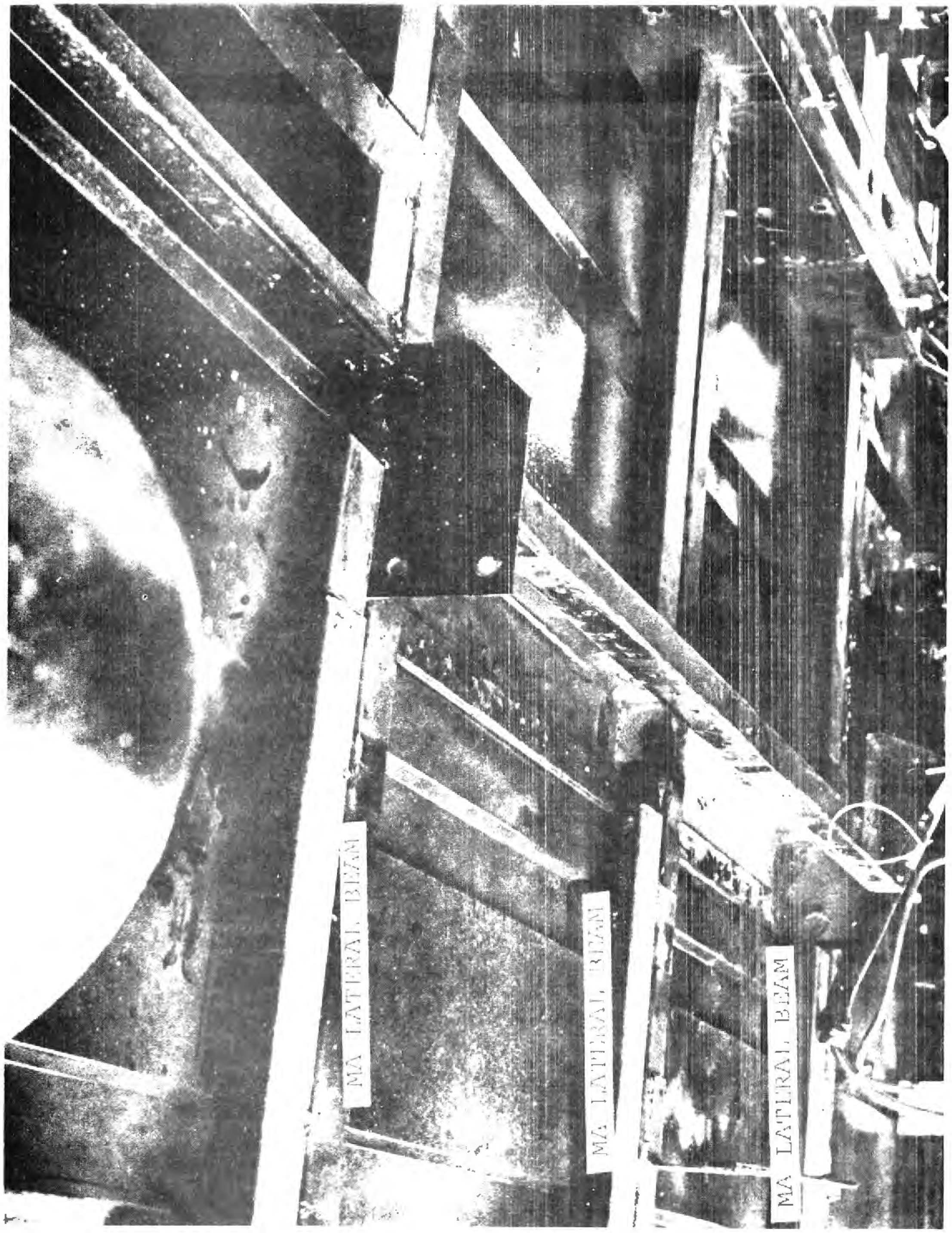


FIGURE 30

MOTOR ALTERNATOR STRUCTURAL MODIFICATION
(DETAIL OF LATERAL STIFFENING)

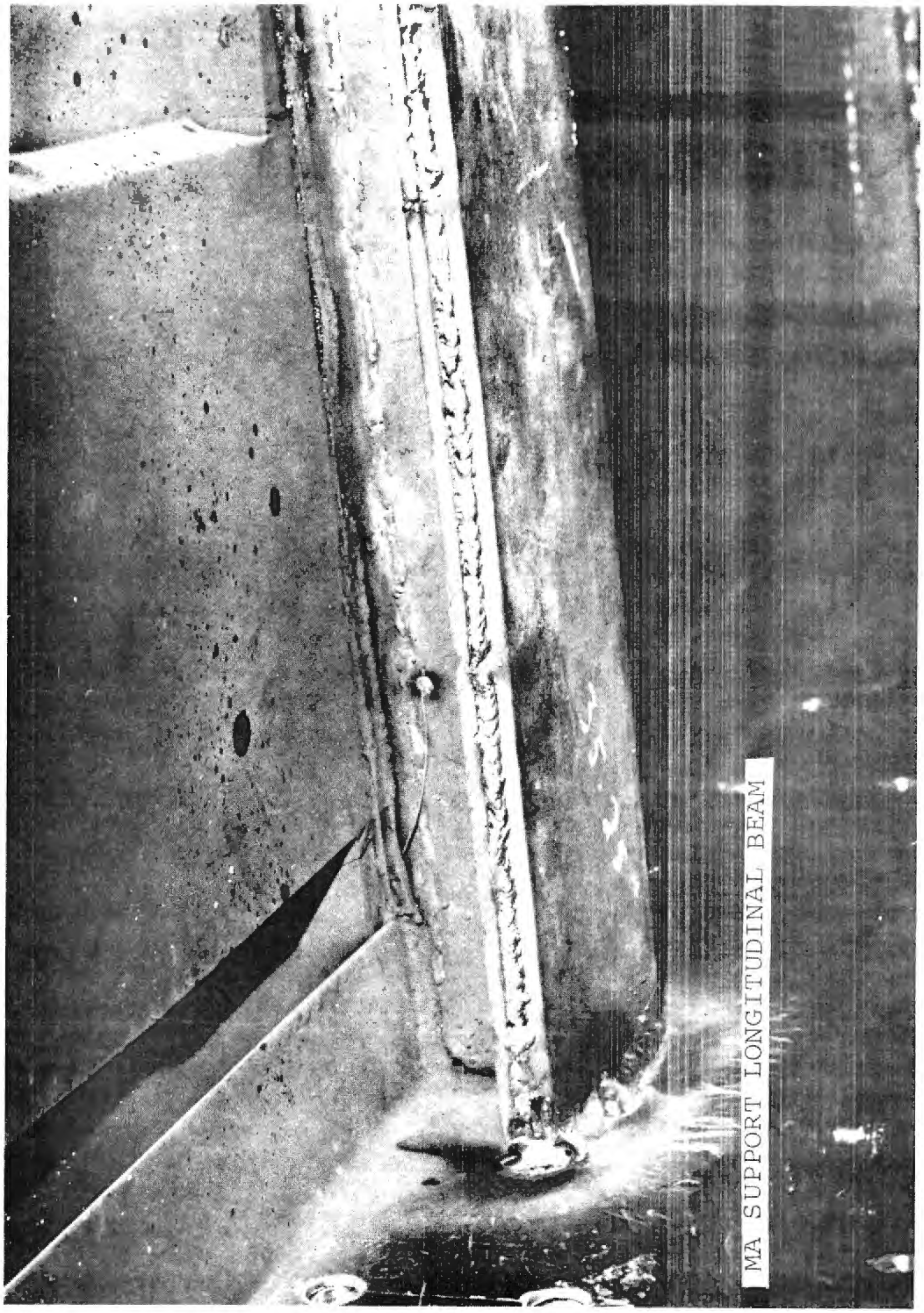


FIGURE 31

MOTOR ALTERNATOR STRUCTURAL MODIFICATION
(LONGITUDINAL STIFFENING)

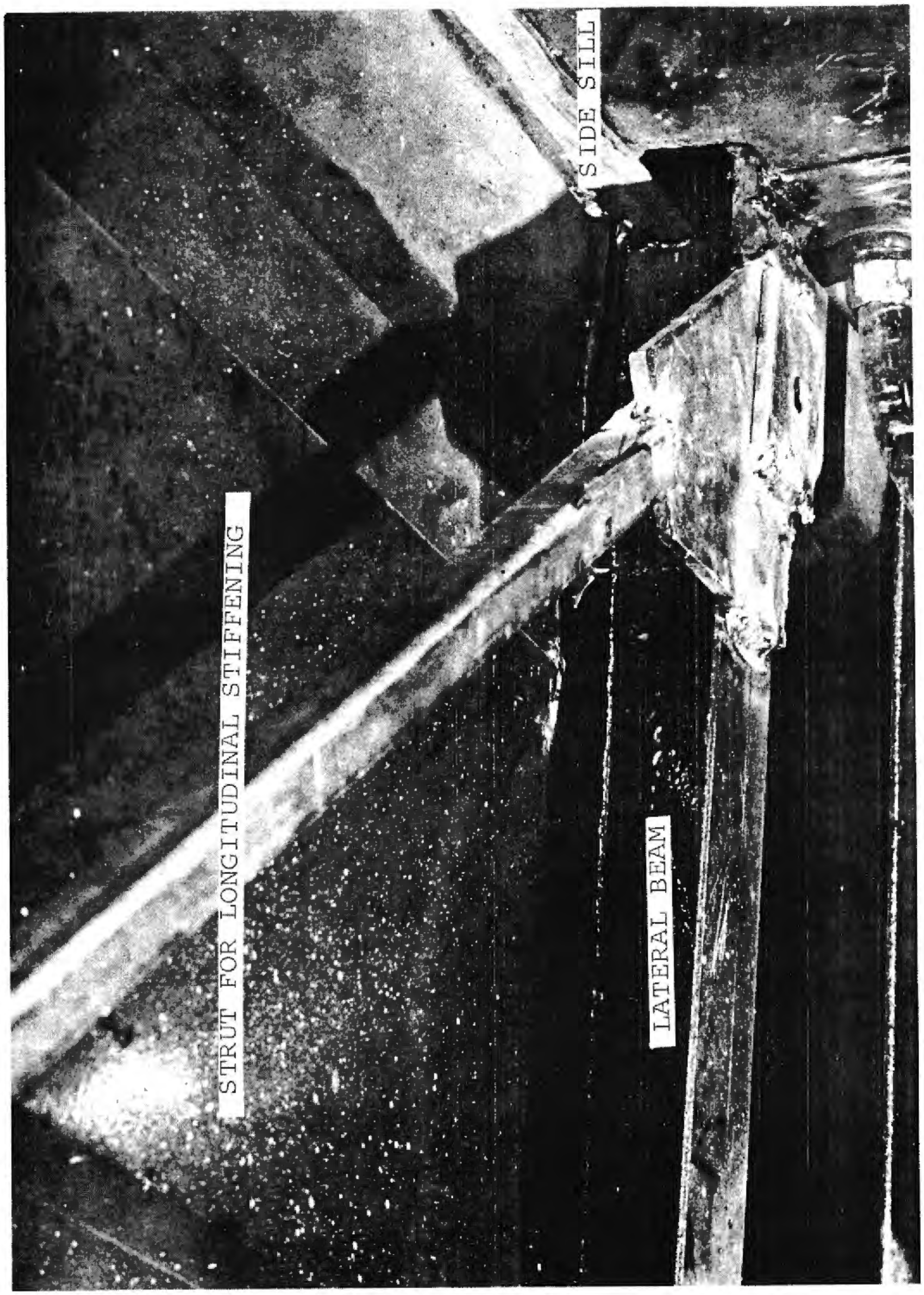


FIGURE 32

SOAC SHAKE TEST

Frequency Response Curves

Data Collected After Motor Alternator Support Modification

Shaker Location R CAR END
Shaker Force 500 LB
Shaker Direction VERT
Gross Weight 90,000 LBS.
Vertical Damper Config. OFF
Motor Alternator Config. NO SHIMS
Pick-Up Location R CAR END-VERT

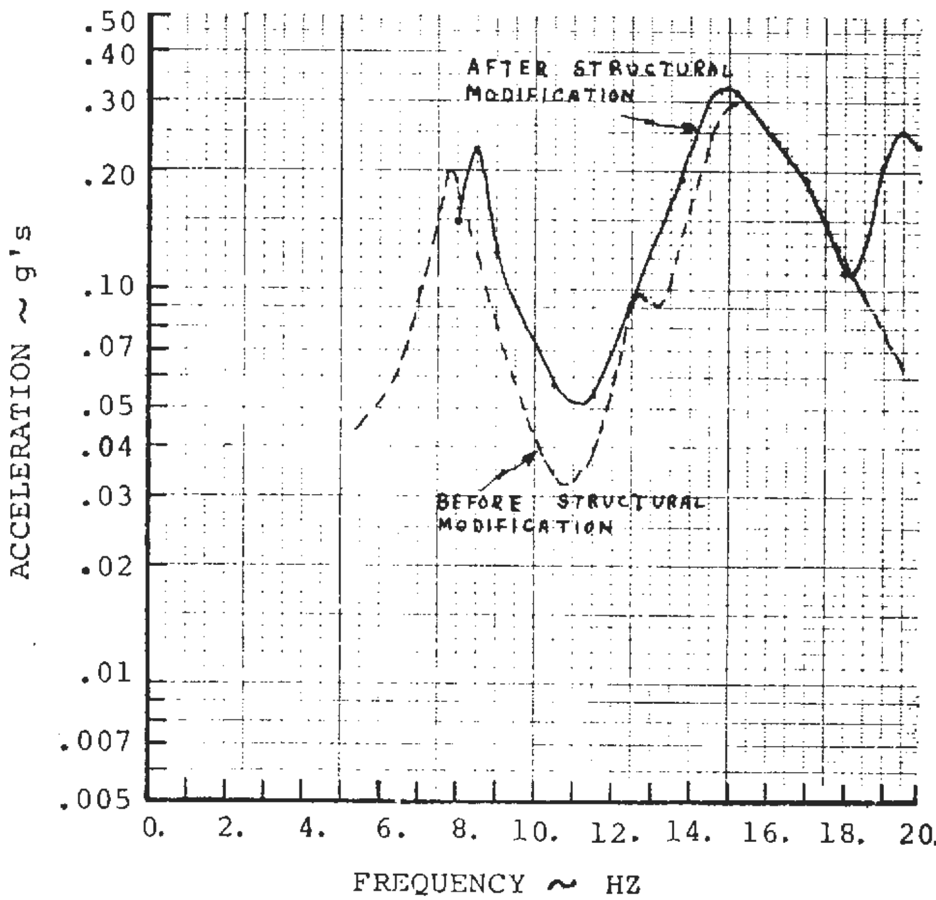


FIGURE 33

SOAC SHAKE TEST

Frequency Response Curves

Data collected After Motor Alternator Support Modification

Shaker Location R CAR END
Shaker Force 500 LBS.
Shaker Direction VERT
Gross Weight 90,000 LBS.
Vertical Damper Config. OFF
Motor Alternator Config. NO SHIMS
Pick-Up Location STA 673 VERT.

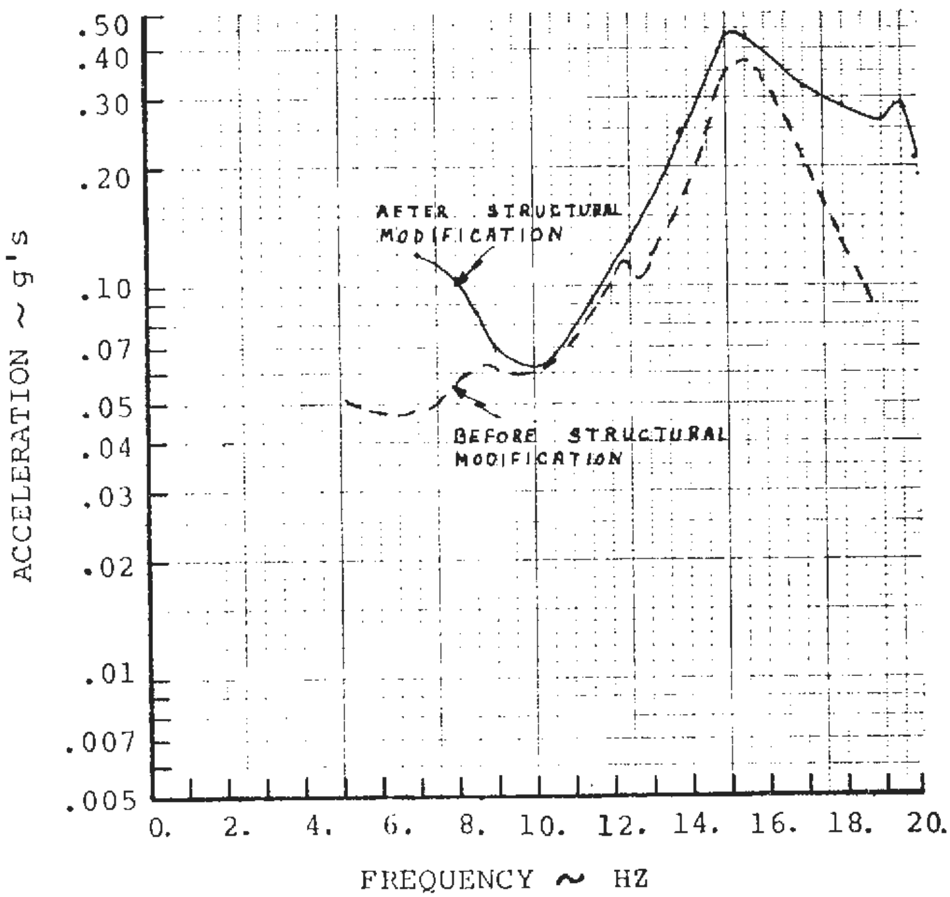


FIGURE 34

SOAC SHAKE TESTS

VERTICAL MODE SHAPES

CARBODY VERTICAL BENDING

DATA COLLECTED AFTER MOTOR ALTERNATOR SUPPORT MODIFICATION

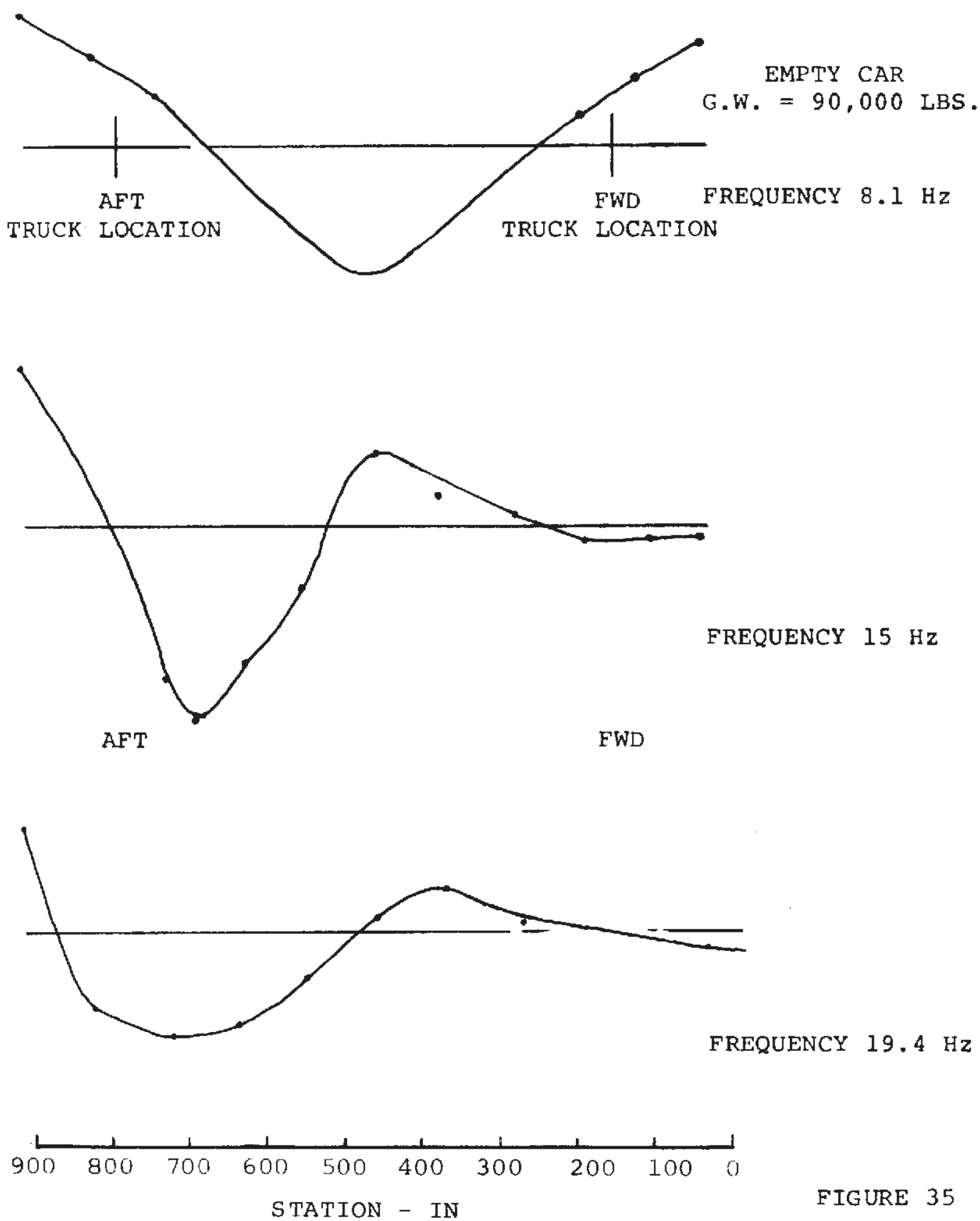


FIGURE 35

SOAC SHAKE TESTS

VERTICAL MODE SHAPES

MOTOR ALTERNATOR LATERAL SUPPORT BEAM

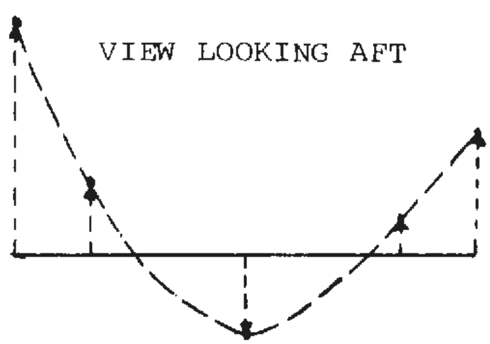
DATA COLLECTED AFTER MOTOR ALTERNATOR SUPPORT MODIFICATION

FREQUENCY = 8.1 Hz

VIEW LOOKING AFT

FREQUENCY = 15.2 Hz

VIEW LOOKING AFT

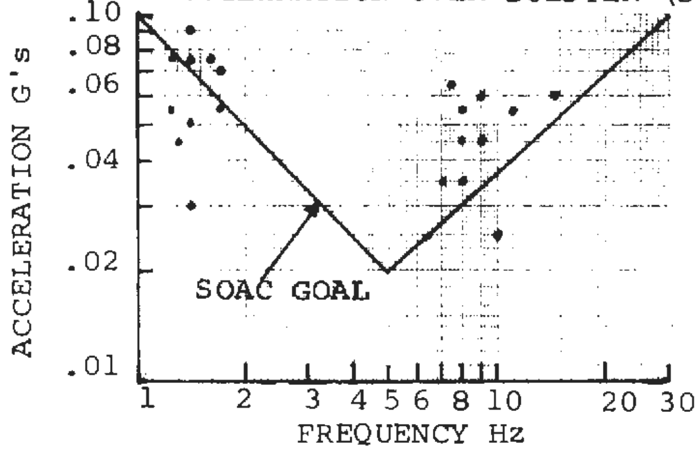


FREQUENCY = 19.4 Hz

FIGURE 36

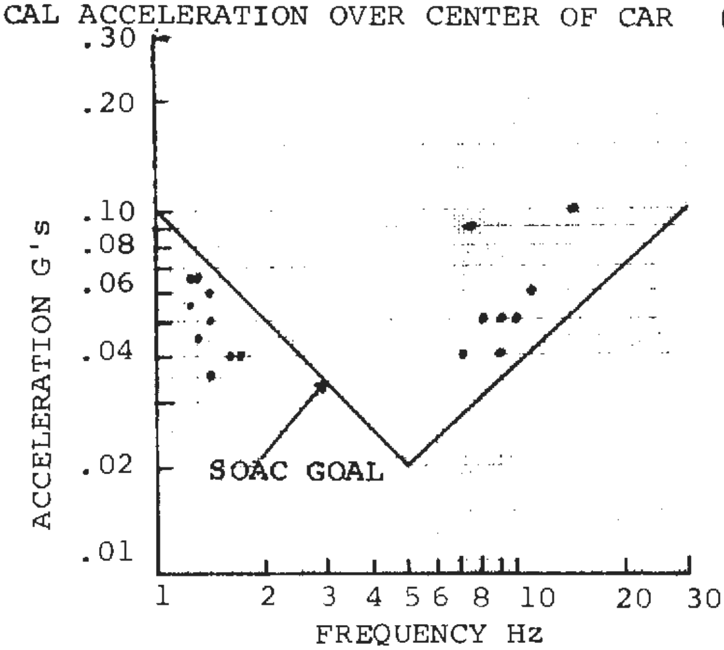
SOAC RIDE QUALITY
DATA COLLECTED AFTER MA SUPPORT STRUCTURAL MODIFICATION

VERTICAL ACCELERATION OVER BOLSTER (STA 108)



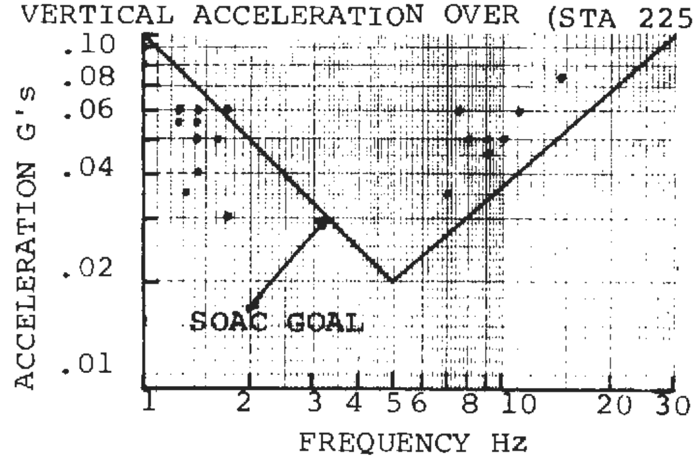
GROSS WEIGHT
90,000 LBS.

VERTICAL ACCELERATION OVER CENTER OF CAR (STA 450)



GROSS WEIGHT
90,000 LBS.

VERTICAL ACCELERATION OVER (STA 225)



GROSS WEIGHT
90,000 LBS.

FIGURE 37

SOAC RIDE QUALITY
DATA COLLECTED AFTER MA SUPPORT STRUCTURAL MODIFICATION

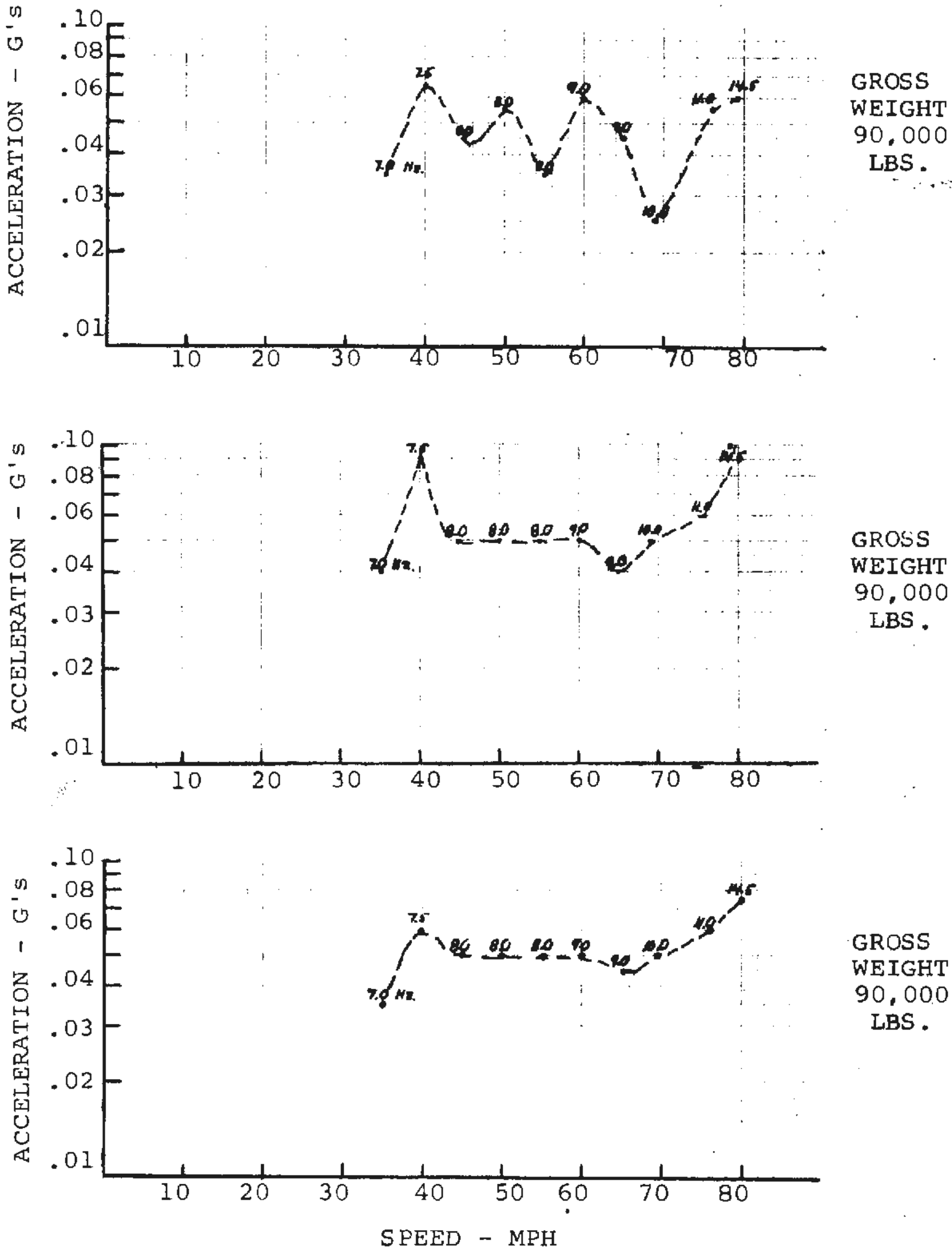
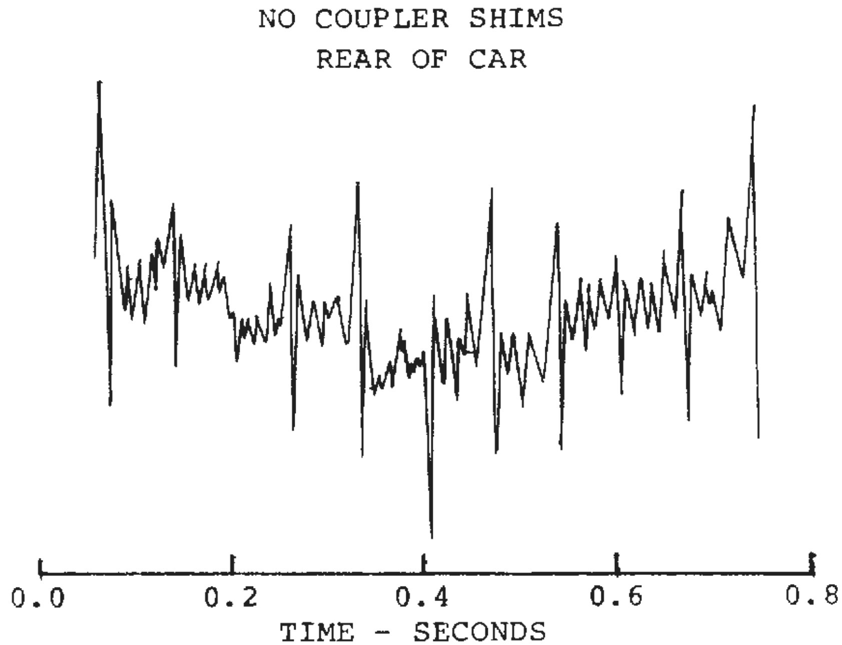


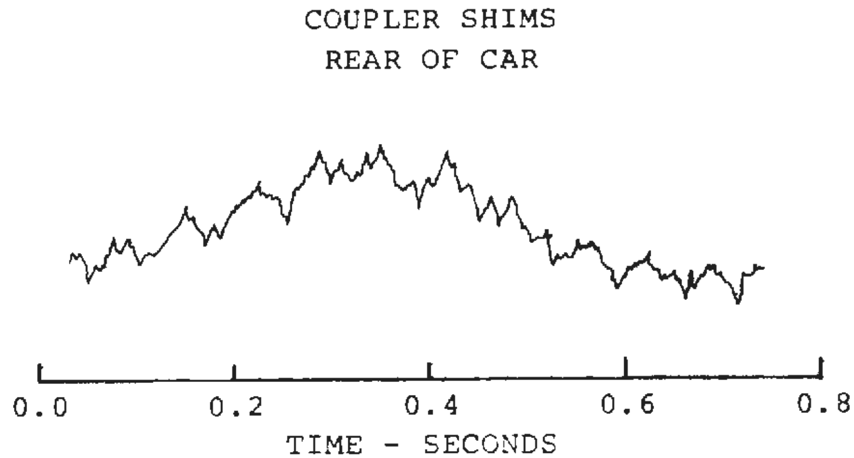
FIGURE 38

CARBODY VERTICAL ACCELERATION

SAMPLE ACCELEROMETER OUTPUTS

GROSS WEIGHT - 90,000 LBS., SPEED - 80 MPH

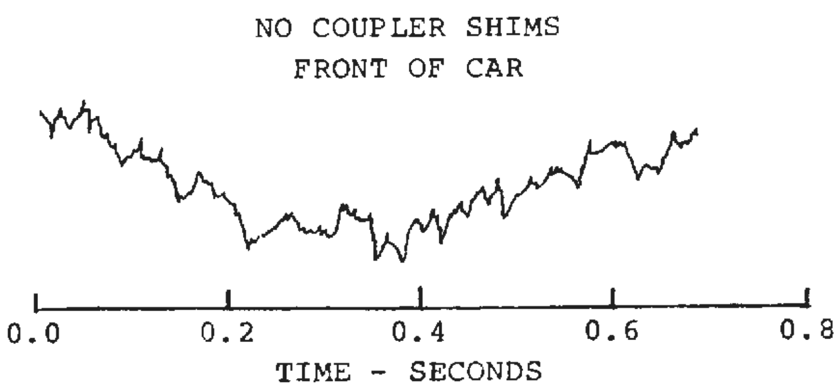




NOTE

ALL PICKUPS .5G/IN.

ALL PAPER SPEEDS FOR SHOWN OUTPUT ARE 5 IN/SEC.



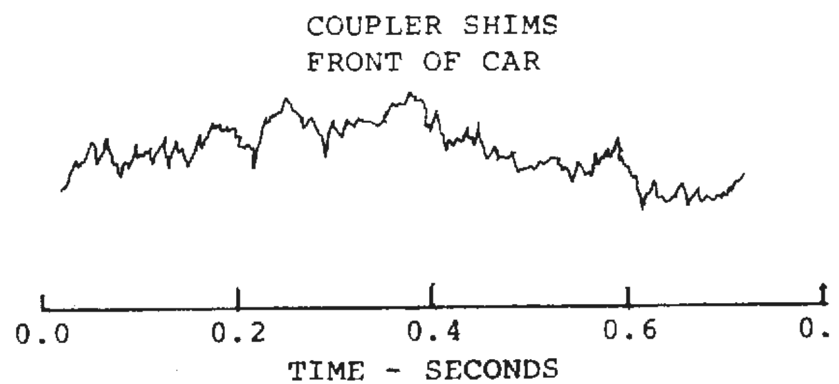


FIGURE 39

WHEEL CONCENTRICITY AND LATERAL RUN-OUT

FIGURE 40

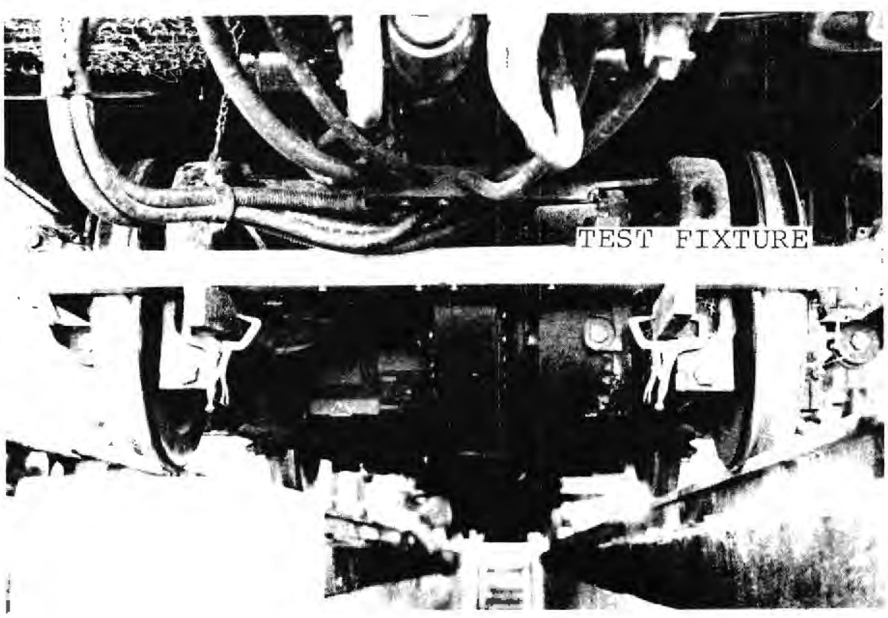


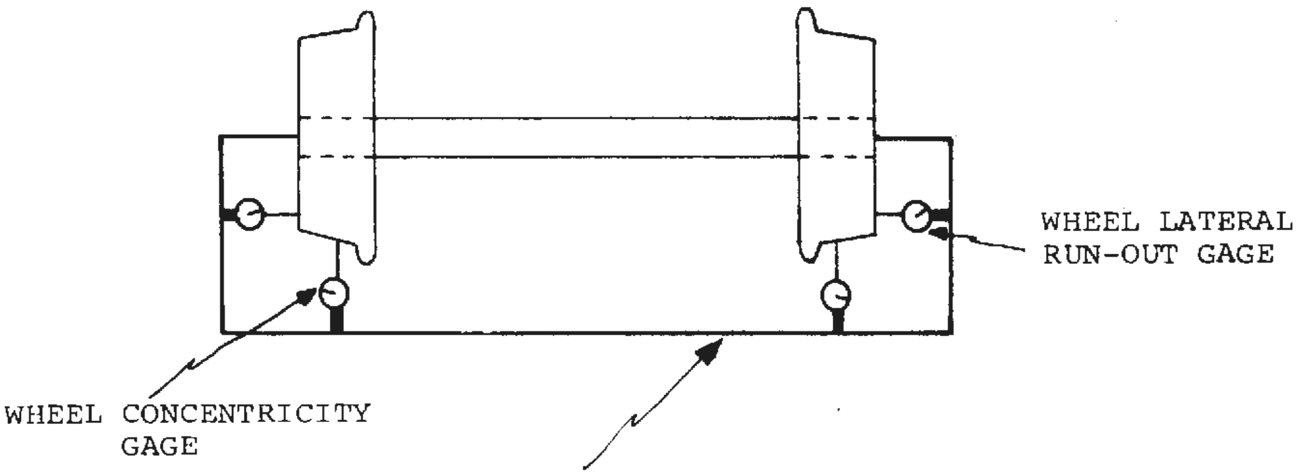
FIGURE 41

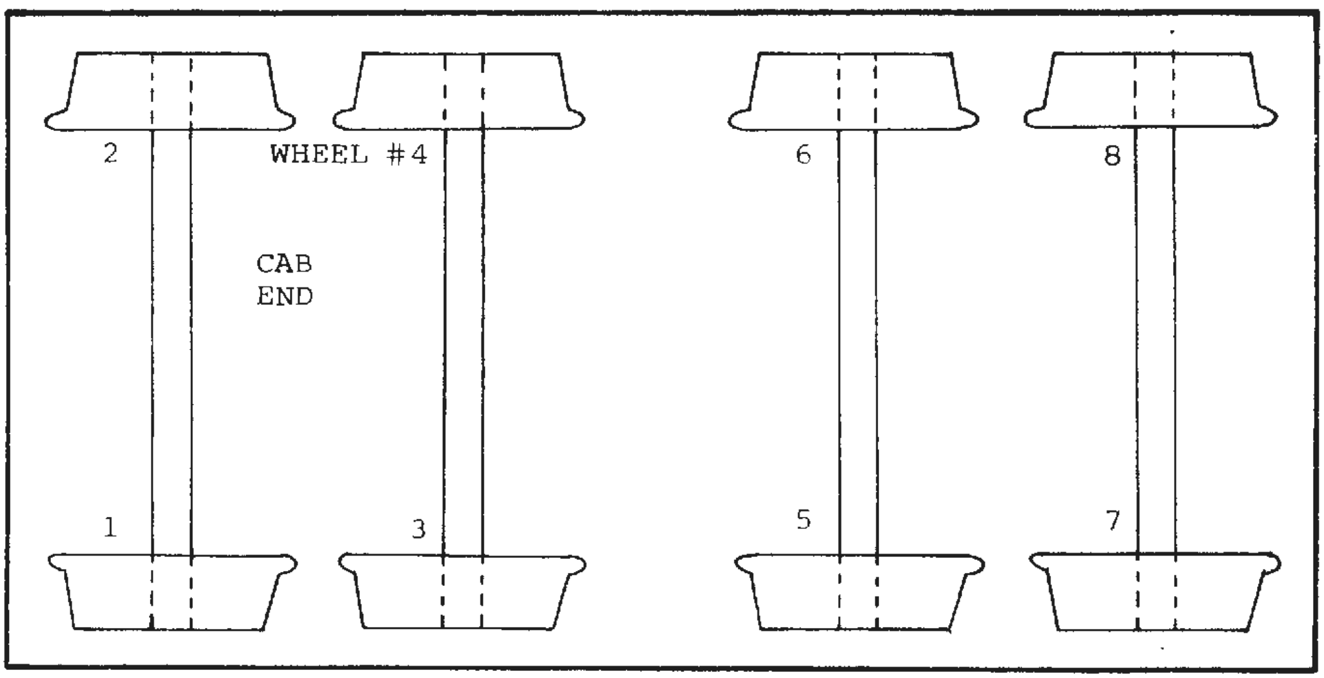
WHEEL CONCENTRICITY TEST APPARATUS

AND

WHEEL IDENTIFICATION DIAGRAM

VIEW LOOKING DOWN





WHEEL IDENTIFICATION DIAGRAM

FIGURE 42

SUMMARY OF TEST RESULTS

WHEEL CONCENTRICITY AND LATERAL RUN-OUT TEST

	WHEEL No.	T.I.R. Concentricity	T.I.R. Lateral Run Out
SOAC 1	1	.005	.012
	2	.008	.011
	3	.006	.012
	4	.005	.006
	5	.006	.005
	6	.004	.008
	7	.005	.008
	8	.003	.007
SOAC 2	1	.002	.021
	2	.003	.004
	3	.005	.014
	4	.003	.011
	5	.006	.006
	6	.010	.010
	7	.008	.007
	8	.007	.014

WHEEL SPECIFICATIONS

	AAR	SOAC	NORTH JERSEY	N.H.R.R.	SEPTA	I.C.
Eccentricity at Tread	.030	.0156	.007	.007	.030	.03
Unbalance at Rim	2. Lb	3 OZ.	-	-	-	2. Lb
Lateral Run-Out	.090	.032		.015	.090	.090

FIGURE 43

DATA - WHEEL CONCENTRICITY TEST

SOAC # 1

WHEEL 1			WHEEL 3		
Wheel Position (Clock)	Concentricity	Run Out	Wheel Position (Clock)	Concentricity	Run Out
9:00	0.0	0.0	4:00	.000	.000
7:30	-.003	-.002	3:00	-.002	-.001
3:00	.001	.008	2:30	-.002	-.003
6:00	-.001	.001	1:45	-.003	-.006
4:30	-.003	.003	1:00	-.003	-.009
12:00	.002	.010	11:30	-.006	-.012
2:00	.002	.010	10:30	-.005	-.012
11:00	.001	.007	9:15	-.004	-.011
7:30	-.001	.001	8:15	-.004	-.008
9:00	.000	.001	7:15	-.003	-.005
			6:00	-.003	-.001
			5:00	-.001	.000
			4:00	-.001	.000

WHEEL 2			WHEEL 4		
3:00	0.0	0.0	8:00	.000	.000
4:30	.002	.000	9:00	-.001	-.002
9:00	.008	- .010	9:30	-.001	-.003
6:00	.005	- .010	10:15	-.002	-.006
7:30	.008	- .011	11:00	-.003	-.005
12:00	.004	- .008	12:30	-.005	-.003
10:00	.006	- .011	1:30	-.004	.000
1:00	.001	- .004	2:45	-.004	.000
4:30	.002	- .002	3:45	-.004	-.001
3:00	.001	- .001	4:45	-.004	-.002
			6:00	-.001	-.002
			7:00	-.001	-.002
			8:00	.000	-.002

FIGURE 44

DATA - WHEEL CONCENTRICITY TEST

SOAC #1

WHEEL 5 / **WHEEL 6**

Wheel Position (clock)	Concentricity	Run Out	Wheel Position (clock)	Concentricity	Run Out
6:00	.000	.000	6:00	.000	.000
7:30	.002	-.002	4:30	-.001	-.003
8:00	.002	-.002	4:00	.000	-.005
9:00	.004	-.003	3:00	.001	-.004
10:00	.005	-.004	2:00	.003	-.006
11:00	.004	-.004	1:00	.003	-.003
12:00	.003	-.005	12:00	.003	-.002
1:00	.002	-.005	11:00	.003	-.002
2:00	.001	-.005	10:00	.002	-.001
3:00	.000	-.004	9:00	.002	.000
4:00	-.001	-.003	8:00	.001	.002
5:00	-.001	-.003	7:00	.000	.002
6:00	.000	-.003	6:00	.000	.001
7:30	.001	-.004	4:30	-.001	.000

WHEEL 7 / **WHEEL 8**

7:45	.000	.000	4:15	.000	.000
7:00	-.002	-.001	5:00	.000	.000
6:00	-.002	-.002	6:00	.001	-.002
5:00	-.003	-.003	7:00	.000	-.004
4:00	-.003	-.003	8:00	.000	-.006
3:00	.000	-.001	9:00	.000	-.007
1:45	.002	.002	10:15	.001	-.005
1:00	.002	.004	11:00	.000	-.005
12:00	.002	.004	12:00	.000	-.003
10:45	.001	.005	1:15	-.001	-.003
9:45	.001	.005	2:15	-.002	-.002
9:00	.000	.003	3:00	-.001	-.002
7:45	-.001	.001	4:15	.000	-.002
6:45	-.003	.000	5:15	.000	-.002

FIGURE 45

DATA - WHEEL CONCENTRICITY TEST

SOAC #2

WHEEL 1			WHEEL 2		
Wheel Position (clock)	Concentricity	Run Out	Wheel Position (clock)	Concentricity	Run Out
6:30	.000	.000	5:30	.000	.000
7:30	.001	-.001	4:30	.000	.000
8:30	.000	-.006	3:30	.000	-.002
10:00	.000	-.021	2:00	-.001	.000
11:00	.001	-.021	1:00	-.002	.002
12:15	-.001	-.016	11:45	-.002	.002
1:00	.001	-.012	11:00	-.002	.002
2:00	.001	-.007	10:00	-.003	.001
3:00	.000	-.004	9:00	-.003	.000
4:00	.000	-.001	8:00	-.002	.000
5:30	.000	-.003	6:30	-.002	-.001
6:30	.001	-.004	5:30	-.002	.000

WHEEL 3			WHEEL 4		
4:00	.000	.000	8:00	.000	.000
2:45	.002	-.010	9:15	.000	-.002
2:00	.002	-.010	10:00	.000	-.002
1:00	.002	-.014	11:00	.001	-.005
12:00	.001	-.013	12:00	.002	-.007
11:00	.000	-.012	1:00	.003	-.009
10:00	-.002	-.011	2:00	.003	-.010
9:00	-.003	-.009	3:00	.003	-.009
8:00	-.003	-.008	4:00	.002	-.007
7:00	-.002	-.006	5:00	.001	-.003
5:45	.000	-.004	6:15	.000	-.001
4:00	.001	-.004	8:00	.000	.001
3:30	.001	-.006	8:30	.000	.000

FIGURE 46

DATA - WHEEL CONCENTRICITY TEST

SOAC #2

WHEEL 5			WHEEL 6		
Wheel Position (Clock)	Concentricity	Run Out	Wheel Position (Clock)	Concentricity	Run Out
12:30	.000	.000	11:30	.000	.000
2:00	.001	-.002	10:00	-.002	-.002
3:30	.004	-.005	8:30	-.002	-.005
4:30	.006	-.004	7:30	.001	-.004
6:00	.006	-.003	6:00	.005	-.003
8:00	.004	.000	4:00	.008	.000
9:00	.002	-.001	3:00	.008	-.001
6:30	.006	-.002	5:30	.006	-.002
10:30	.000	-.001	1:30	.005	-.001
12:00	.000	.001	12:00	.001	.001

WHEEL 7			WHEEL 8		
3:00	.000	.000	9:00	.000	.000
1:30	-.001	-.002	10:30	-.002	.002
12:00	-.003	-.002	12:00	-.004	-.002
10:45	-.007	-.005	1:15	-.005	.000
9:00	-.008	-.007	3:00	-.003	-.005
7:30	-.007	-.006	4:30	-.001	-.008
6:00	-.005	-.002	6:00	.002	.006
4:30	-.002	.000	7:30	.002	-.003
3:00	.000	-.001	9:00	.001	.001

FIGURE 47

SUMMARY OF TEST RESULTS

WHEEL FLAT AND BUILD-UP DATA

SOAC #1

WHEEL #	WHEEL POSITION	FLAT	BUILD-UP
1	No Data		
2	No Data		
3	9:30 o'clock		.007
	11:00 o'clock	.018	
4	9:30 o'clock	.018	
	11:00 o'clock	.016	
5	12:00 o'clock	.010	
	8:00 o'clock	.005	
6	12:00 o'clock	.005	
	8:00 o'clock	.012	
7	5:00 o'clock	.005	
	12:00 o'clock	.012	
8	6:00 o'clock	.003	
	7:00 o'clock	.008	
	12:00 o'clock	.009	
	1:15 o'clock	.009	
	SOAC #2		
1	No Flats		
2	8:30 o'clock	.006	
	3:00 o'clock	.010	
3	11:00 o'clock	.008	
	8:00 o'clock	.007	
4	11:00 o'clock	.007	
5	No Flats		
6	3:30 o'clock	.010	
	4:30 o'clock	.005	
7	3:00 o'clock	.005	
	12:00 o'clock	.010	
	9:00 o'clock		.011
8	No Flats		

FIGURE 48

APPENDIX IV

EMI MEASUREMENT TEST REPORT

(Project W01152-T)
April 10, 1973
(Revised Edition)

RECEIVED
JUN 4 1973
STS SUBCONTRACT

FINAL TEST REPORT
ELECTROMAGNETIC INTERFERENCE
ON
STATE OF THE ART CAR (SOAC)
FOR
THE BOEING COMPANY, VERTOL DIVISION

GOVERNMENT CONTRACT NO. US/DOT-UT-10007

PROJECT: WO 1152-T

APRIL 10, 1973

ELECTRO MAGNETIC FILTER COMPANY, INC.
PALO ALTO, CALIFORNIA

NOTICES AND SIGNATURES

The test data presented herein, refer only to the particular test sample tested. Changes in circuit design, components, grounding, lead routing or bonding, regardless how insignificant they may seem, may negate the test results presented herein.

Prepared by: [signature]

Peter F. Spencer
Test Engineer
Electro Magnetic Filter Company, Inc.

Witnessed by: Mr. M. C. Becher
B - Y Engineer
The Boeing Company

ADMINISTRATIVE DATA

PURPOSE OF TEST: The purpose of this test was to determine the conformance of the described specimen to the electromagnetic interference requirements of the applicable specification.

TEST COORDINATOR: THE BOEING COMPANY, VERTOL DIVISION
Boeing Center
Philadelphia, Pennsyvlania 19142

MANUFACTURER'S MODEL NUMBER: State of the Art Car

SECURITY CLASSIFICATION: Unclassified

SPECIFICATION OR EXHIBIT: Boeing Purchase Order Number CT 885569, Appendix A

DATE TEST COMPLETED: April 3, 1973

NUMBER OF ITEMS TESTED: Two (2) cars operating as one unit

TEST CONDUCTED BY: ELECTRO MAGNETIC FILTER COMPANY, INC.
4083 Transport Street
Palo Alto, California 94303

TEST CONDUCTED FOR: THE BOEING COMPANY, VERTOL DIVISION
Boeing Center, Post Office Box 16867
Philadelphia, Pennsylvania 19142

ABSTRACT: The test described herein was performed at the High Speed Test Center, Pueblo, Colorado.

The results of this testing demonstrate complete conformance to the radiated emission requirements of the specification.

FACTUAL DATA

1.0 DESCRIPTION:

1.1 The test specimen was two state of the art cars coupled together and operating as a unit.

2.0 TEST INSTRUMENTATION:

2.1 Radio Interference Field Intensity Meter, Stoddart Model IM-37-PRM-1A, Serial Number 215. Next calibration due July 1, 1973.

2.2 Radio Frequency Field Intensity Meter, Stoddart Model IM-88/URM-47, Serial Number 33. Next calibration due June 1, 1973.

2.3 Dipole Antenna Stoddart, Model Number AB-371/U.

2.4 Biconical Antenna, per MIL-STD-461A, Paragraph 5.2.3.

3.0 TEST PROCEDURE:

3.1 The test equipment was first set up inside one of the SOAC cars, at approximately the midpoint. Test equipment power was provided by a small auxiliary generator situated in the other car. All SOAC systems and third rail power were deenergized, and a complete scan of the frequency range (150 KHz to 400 MHz) was performed for the purpose of selecting those frequencies (approximately four per decade) at which radio interference field intensity would be monitored throughout the remaining tests. A second frequency scan was performed after third rail power and all SOAC systems had been energized, in order to identify any emission frequencies (high interference peaks) for later checking during radiated emission tests with the instrumentation at a wayside location. There were none.

3.2 The test equipment was then set up adjacent to the tracks at a distance of 100 feet from the tracks on April 2 and 3, 1973, wayside measurements began at approximately 1:00 P.M. on the 2nd. Prior to testing the vehicle a complete scan of the frequency range was performed for the purpose of determining ambient interference levels.

3.3 Measurements were then performed with the test vehicle passing through a zone approximately 300 feet long directly in front of the antenna location at speeds of 20, 40 and 80 miles per hour. See Figure 1. One north and one south pass was made for each frequency speed combination, except at 80 miles per hour, all runs were made in a southerly direction to take advantage of the slight down grade.

3.3.1 Additional measurements were then performed under conditions of maximum acceleration and braking.

3.3.2 Since the revised specification limits are derived from Specification MIL-STD-461A, the antennas prescribed by that specification were used for this testing. The resulting corrected data is then in standard units of dB >1 μV/M/MHz.

3.4 Based on previous testing experience, obtained on similar transit cars, which indicated horizontally polarized interference levels from the vehicle to be higher than vertically polarized levels at all frequencies above 30 MHz, all testing performed on the SOAC was with the biconnical and dipole antennas horizontally polarized. Antennas were located approximately five feet above ground level and approximately twelve feet above track grade.

3.4.1 Toward the end of trackside measurements a powerful gust of wind toppled the biconical antenna and damaged it beyond repair. Further measurements were then performed using a 21" dipole antenna. Correction factors shown on data sheet 2 were found empirically in the lab by direct comparison of radiated fields using the two antennas.

4.0 TEST RESULTS:

4.1 Internal radiated emission measurements of ambient conditions and with all systems on were performed with the test equipment at only one location, for these reasons:

4.1.1 There were no substantial noise peaks to necessitate tracking down a source.

4.1.2 Because of the physical size and layout of the car, no significant differences could be expected between measurements that were taken in the middle of the car and measurements that might be taken elsewhere in the same car.

4.2 Internal and wayside radiated emission test results are presented in tabular form on data sheets 1 and 2. Wayside test results, plotted as a composite graph on Figure II, demonstrate complete conformance to specification limits.

4.2.1 Although readings at 32 MHz exceed specification limits by 2 dB, it should be noted that the ambient level corrected also exceeded the limit by the same amount. In addition, normal accepted tolerance limits for this type of testing are plus or minus 3 dB; therefore, the 32 MHz readings must be interpreted as complying with specification requirements.

5.0 CONCLUSIONS:

When tested as described herein, the SOAC demonstrated complete conformance to the radiated interference emission requirements of Boeing purchase order No. CT 885569, Appendix A.

REV.	DESCRIPTION OF CHANGES	CHANGE ORDER NO.	BY	CHK'D	DATE

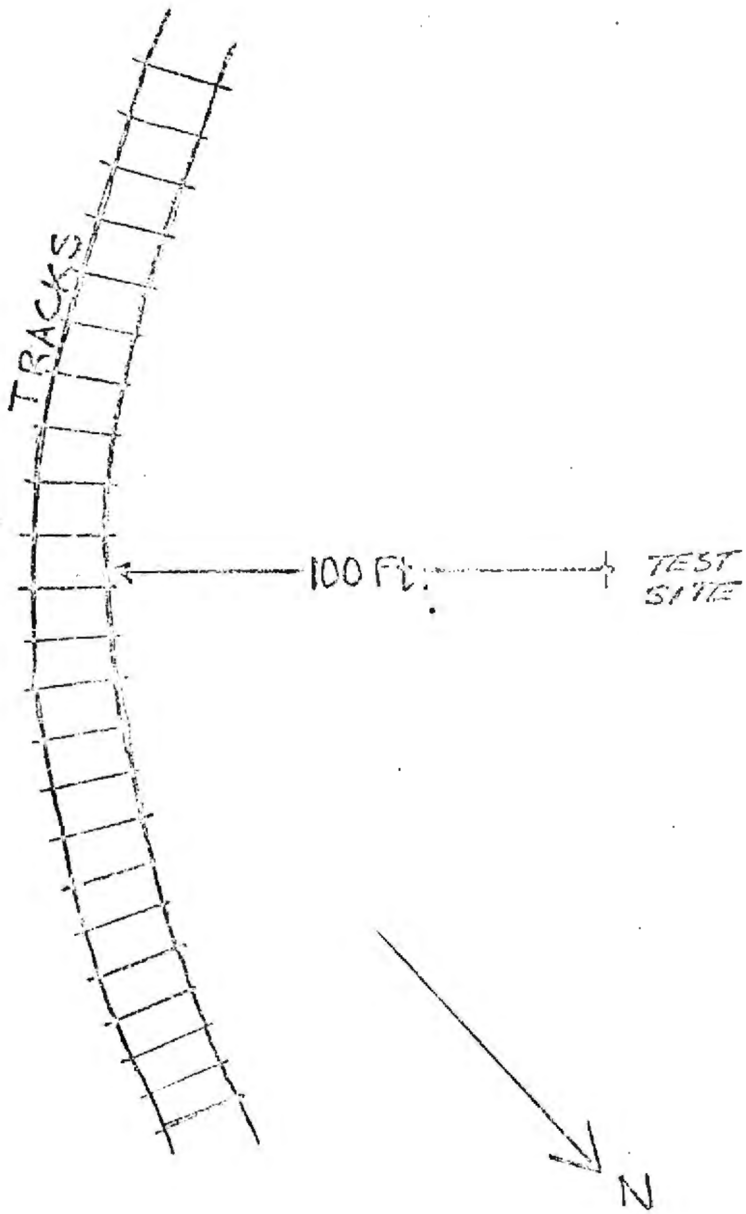


Figure 1

TOLERANCE

DECIMAL ±

FRACTIONAL ±

UNLESS OTHERWISE SPECIFIED

ALL THREADS CLASS 2 FIT

DO NOT SCALE

THIS PRINT SUPERSEDES OTHERS PRIOR TO

EMF CO. ELECTRO MAGNETIC FILTER CO.
PALO ALTO, CALIFORNIA

TEST SETUP

MATERIAL

FINISH

SCALE NONE	DATE 4-12-73
DRAWN BY [illegible]	DWG.
APPROVED BY [illegible] ENGINEER	ISSUE
APPROVED BY [illegible] CHIEF ENGINEER	

PRINTED ON DATAPRINT NO. 101-0

ELECTRO MAGNETIC FILTER COMPANY
231 SOUTH WHISMAN ROAD, MOUNTAIN VIEW, CALIFORNIA 94040
(415) 969-1050

Data Sheet 1

ENGINEERING TEST REPORT

RADIO FREQUENCY SUPPRESSION LABORATORY

PROJECT *STATE OF THE ART CAR (SOAC)* PAGE NO. *1*

DATE *4/2/73 - 4/3/73*

RADIATED EMISSION

FREQ. MC	AMBIENT dBµV/MHZ	ALL SYS. ON dBµV/MHZ	OUTSIDE AMBIENT dBµV/MHZ	20 MPH dBµV/MHZ N	20 MPH S	FREQ. MC	40 MPH dBµV/MHZ N	40 MPH S	80 MPH dBµV/MHZ S	80 MPH S	ACCEL. dBµV/MHZ N	ACCEL. N	DECEL. dBµV/MHZ N	DECEL. S
.16	91	96	91	<96	<96		<96	<96	<96	<96	<96	<96	<96	<96
.31	92	95	91	<91	<91		<91	<91	<91	<91	<91	<91	<91	<91
.6	90	94	87	77	77		77	77	79	79	79	79	79	79
1.0	94	92	72	65	65		72	73	73	73	73	67	69	69
2	94	97	72	71	72		73	73	75	77	76	75	76	77
4	81	86	66	70	74		76	77	78	76	77	77	75	75
8	86	94	71	70	73		72	72	71	76	74	73	77	75
16	89	83	62	73	71		76	75	77	73	74	76	71	73
32	43	52	47	43	42		44	43	42	43	42	45	47	47
60	54	61	39	35	35		44	38	c36	c33	c36	c34	40	36
120	52	53	30	33	38		37	33	c33	c35	c31	c34	40	38
200	22	31	35 *	34*	34*		36*	33*	c33	c37	c31*	c35*	36*	36*
400	48	48	32	32	32		32	32	32	32	35	35	31	31
				200A			200A	0A						
				UP	DN		UP	DN						
				BELOW BASE SPEED										
400				28										
16				73										
2				70										
.16				<96		100A								

c 21 inch dipole antenna

COMMENTS

Very high noise signal @ ≈ 195 MHZ (ambient)

*Readings @ 205 MHZ

Recorded levels at .16 & .31 MHz as <96 & <91 dB are ambient levels of DC to AC power converter.

SIGNED	DATE	ENGINEER	DATE	DEPT. ENG'R.	DATE	CHIEF ENGR	DATE

ELECTRO MAGNETIC FILTER COMPANY
231 SOUTH WHISMAN ROAD, MOUNTAIN VIEW, CALIFORNIA 94040
(415) 969-1050

Data Sheet 2

ENGINEERING TEST REPORT

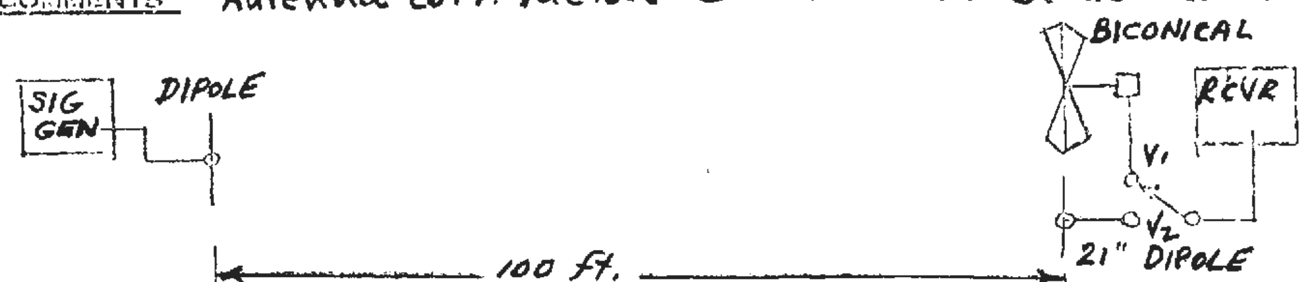
RADIO FREQUENCY SUPPRESSION LABORATORY

PROJECT STATE OF THE ART CAR (SOAC) PAGE NO. 2
DATE 4-10-73

RADIATED EMISSION CORRECTED

FREQ. MC	ANT. CORR FACTOR dB		AMBIENT CORR. dBμV/M/MHZ	20 MPH CORR. dBμV/M/MHZ N	20 MPH CORR. S	40 MPH CORR. dBμV/M/MHZ N	40 MPH CORR. S	FREQ. MC	80 MPH CORR. dBμV/M/MHZ S	80 MPH CORR. S	ACCEL. CORR. dBμV/M/MHZ N	ACCEL. CORR. N	DECEL. CORR. dBμV/M/MHZ N	DECEL. CORR. S	SPEC. LIMIT. dBμV/M/MHZ
.16	6		97	<102	<102	<102	<102		<102	<102	<102	<102	<102	<102	109
.31			97	<97	<97	<97	<97		<97	<97	<97	<97	<97	<97	106
.6			83	83	83	83	83		85	85	85	85	85	85	102
1.0			78	71	71	78	79		79	79	79	75	75	75	100
2			78	77	78	77	78		81	83	82	81	82	83	97
4			72	76	80	82	83		84	82	83	83	81	81	93
8			77	76	78	78	78		77	82	80	79	83	81	91
16			68	79	77	82	81		83	79	80	82	77	79	87
32	13 'c'		60	56	55	57	56		55	56	55	58	60	60	58
60	9	+5	48	44	44	53	47		49	49	58	52	49	45	58
120	16	-6	46	49	52	53	49		43	46	47	43	56	54	68
200	17	-2	52	51	51	53	50		49	49	51	47	51	51	68
400	0		32	32	32	32	32		32	32	35	35	31	31	68

COMMENTS Antenna corr. factors 'C' were obtained as follows.



SIGNED	DATE	ENGINEER	DATE	DEPT. ENG'R.	DATE	CHIEF ENGR'	DATE
				IV-9			

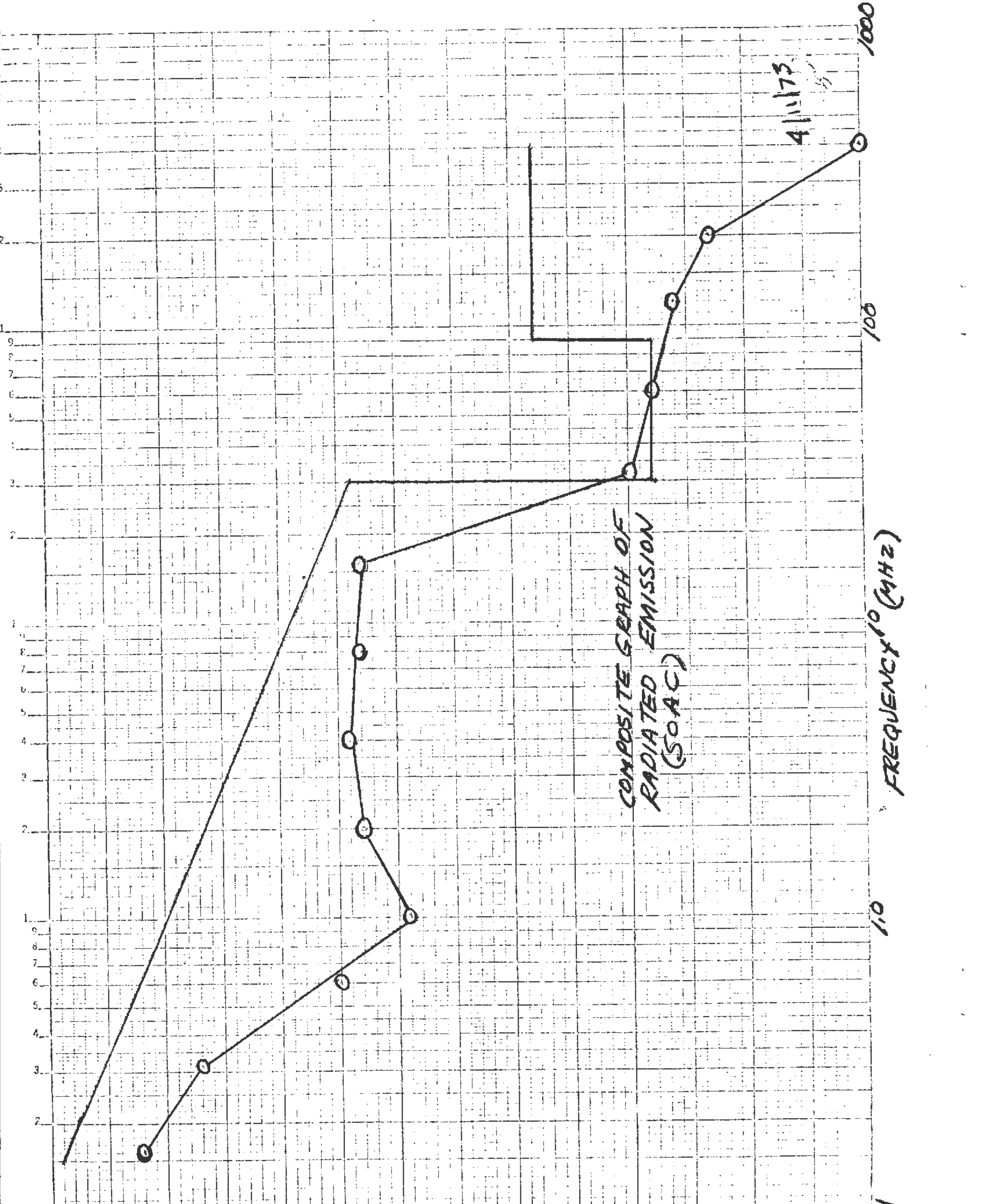

COMPOSITE GRAPH OF RADIATED EMISSION (SOAC)
FREQUENCY (MHz)
4/11/73
0.1
1.0
10
100
1000
110
100
90
80
70
60
50
40

Figure II