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Single-Unit Truck and Bus ABS Braking-In-A-Curve Performance Testing

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16. Abstract

This report documents the results of testing two buses and five straight trucks in braking-in-a-curve ABS performance tests. Federal Motor Vehicle Safety Standards (FMVSS) Nos. 105 and 121 do not currently require straight trucks and buses to meet braking-in-a-curve performance standards. Tractors are subject to these tests in FMVSS No. 121.

The braking-in-a-curve tests were conducted by finding the maximum drive-through speed, making four stops at 75 percent of the drive-through speed, as is specified for truck tractors, and then determining the maximum brake-through speed. Maximum drive-through speed is defined as the fastest constant speed that a vehicle can be driven through at least 200 feet of curve arc length without departing the lane on a 500-foot radius curve with a 0.5 peak friction coefficient surface, with the driver making steering corrections as necessary. Maximum brake-through speed is defined as the fastest speed at which a full brake application can be made while the vehicle is in the curve without the vehicle departing the lane, with the driver making steering corrections as necessary. Determination of the maximum brake-through speed provided data on the potential margin of compliance or non-compliance for the test vehicles.

Six out of the seven vehicles tested would comply with the performance requirements currently in effect for tractors of staying in the lane at 75 percent of the maximum drive-through speed (minimum required brake-through speed). These six vehicles remained in the lane during all four stops at the minimum brake-through speed and all had a significant margin of compliance. The seventh vehicle met the minimum requirement for the loaded condition, but did not pass the empty condition. It should be noted that while this vehicle had air brakes, it also had a gross axle weight rating greater than 29,000 pounds. Therefore, FMVSS No. 121 does not apply to this vehicle.

The results of testing show that the braking-in-a-curve test is practicable, repeatable, and safe to perform for single unit vehicles.

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TABLE OF CONTENTS

List of Figures

List of Tables

ACKNOWLEDGMENTS

The testing program documented in this report was a coordinated effort by the National Highway Traffic Safety Administration (NHTSA) Vehicle Research and Test Center (VRTC) and the Transportation Research Center Inc. (TRC) to evaluate the stability and control capabilities of seven bus and straight truck antilock brake systems (ABS) on a low coefficient of friction surface in a brake-in-a-curve scenario.

The authors wish to recognize the outstanding support of our research colleagues. Lyle Heberling was outstanding in performing the tests and rigging the loads. Don Thompson was instrumental in preparing the data acquisition systems and providing calibrations. Dave Dashner and Leslie Portwood performed data analysis and developed tables. Ed Parmer's perseverance provided excellent graphics and pictures.

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National Highway Traffic Safety Administration

TECHNICAL SUMMARY

Report Title: Single-Unit Truck and Bus ABS Braking-In-A-Curve Performance Testing	Date: February 1999
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Testing was conducted in 1996 and 1997 on two hydraulic braked buses and five air braked straight trucks, all equipped with ABS, to determine if the braking-in-a-curve performance test in FMVSS No. 121 for tractors could also be applied to single-unit vehicles. The vehicles were subjected to the road test requirements in the respective Federal Motor Vehicle Safety Standards (FMVSS), either No. 105 or No. 121, plus the braking-in-a-curve ABS performance tests, which are not currently included in FMVSS Nos. 105 or 121 for straight trucks and buses.

Six of the seven vehicles tested would comply with the performance requirements currently in effect for tractors by staying in the lane in at least three out of four consecutive stops, when subjected to a full treadle or pedal brake application, at 75 percent of the maximum drive-through speed (minimum required brake-through speed). In fact, these six vehicles remained in the lane during all four stops at the minimum brake-through speed and all had a significant margin of compliance.

The seventh vehicle, the Navistar 4x2 with a 148 inch wheelbase, met the minimum requirement for the loaded condition. Here, it achieved a maximum brake-through speed of 78 percent of the maximum drive-through speed, but did not pass the empty condition, where the maximum brake-through speed was only 61 percent of the maximum drive-through speed. It should be noted that this vehicle had a drive axle with a gross axle weight rating of 30,000 pounds, which was greater than the 29,000 pound maximum GAWR specified in FMVSS No. 121 section S3(b), and therefore is not required to pass FMVSS No. 121 test procedures.

In general, when determining the maximum drive-through speed, the test vehicle front end tended to plough out at the limit, departing the lane on the outside of the curve. When determining the maximum brake-through speed, the rear end of the test vehicle would tend to "walk out" at the limit, also departing the lane on the outside of the curve.

After the first two vehicles tested during this program (the two hydraulic braked school buses) had been tested and returned to their suppliers, a change was considered to the pedal application section of the proposed ABS brake-in-a-curve test procedure. The change was to require that when performing the brake-through stops, a brake pedal application force of 150 pounds be applied within 0.2 seconds of initial pedal movement. However, after further review of the data and extensive discussion with the driver, this change to the proposed standard was not made. The maximum initial pedal force achieved during the stops in this study typically ran in the 60 to 100 pound range. Full ABS cycling did occur at these levels. The requested application rate would be awkward for the driver to meet. The driver commented that it was very taxing to his abilities to watch his speed, apply a repeatable pedal effort, and negotiate the curve without any of the wheels going out of lane, all while looking ahead at where he was going. The additional driver workload of reading a precise pressure measurement could cause visual overload and reduction in safety during the test. The geometry of the seating position, steering wheel, and brake pedal also contribute to the difficulty of this task. A brake pedal actuator device to apply the 150 pound in 0.2 second brake force would be required to produce repeatable pedal applications at this high rate. This would increase the equipment needed to perform the test. The 150 pound application rate is probably higher than necessary since full ABS cycling was achieved at lower pedal forces.

In considering "apply times" for the pneumatic braked straight trucks, all of the test vehicles that had the appropriate instrumentation surpassed the FMVSS No. 121 required minimum control pressure of 85 psi (at the treadle valve) in less than 0.2 seconds as specified for tractors. This application time appears to be repeatable. In the authors' judgement, a simple data acquisition system with a 50 Hertz input filter, 100 Hertz or higher sample rate, with pre-trigger, and a brake pedal touch switch or motion sensor is appropriate for collecting this type of data. The 18 Hertz input filter used in this study was acceptable for measuring the transients associated with the initial brake application.

The results of testing show that the braking-in-a-curve test is practicable, repeatable, and safe to perform for single unit vehicles.

1.0 INTRODUCTION

1.1 - Focus of the Study

As indicated in the March 10, 1995, final rule to require antilock braking systems (ABS) on all commercial vehicles, NHTSA (National Highway Traffic Safety Administration) conducted extensive testing on tractors in support of implementing the braking-in-a-curve test to require adequate stability and control during braking. NHTSA indicated that it would not be appropriate at that time to require dynamic test requirements for other types of hydraulic or air-braked heavy vehicles since only a small amount of testing by NHTSA on these type vehicles had been conducted at the time of the final rule. NHTSA also indicated that it anticipated conducting additional testing on these vehicles and would consider the later implementation of dynamic test requirements for these vehicles to supplement the equipment requirements.

Testing was conducted in 1996 and 1997, at NHTSA's Vehicle Research and Test Center (VRTC), on two hydraulic-braked buses and five air-braked straight trucks, all equipped with ABS, to determine if the braking-in-a-curve performance test for tractors could also be applied to single-unit vehicles. The vehicles were leased from four suppliers for the purposes of conducting these tests. The vehicles were subjected to the road test requirements in the respective Federal Motor Vehicle Safety Standards (FMVSS), either No. 105 or No. 121, that are in effect on March 1, 1999, and March 1, 1998, respectively, with one exception. The exception was that the braking-in-a-curve ABS performance tests, which are not currently included in FMVSS Nos. 105 or 121 for straight trucks and buses, were included in this test program.

1.2 - Overview of the Report

This report contains ten sections that describe the various aspects of the brake-in-a-curve test program. Section 2.0 contains background material with a primary focus on FMVSS No's. 105 and 121 general test procedures. A general description of the buses and straight trucks tested comprises section 3.0. The instrumentation installed on each vehicle is described in section 4.0. A description of the brake-in-a-curve test area is listed in section 5.0. Section 6.0 covers the center of gravity (CG) heights and load frame apparatus. The general sequence-of-test schedules for each FMVSS No. 105 and No. 121 standard are listed in section 7.0. Test results are given in section 8.0. Section 9.0 reflects on the practicability of the brake-in-a-curve test and reviews a few unresolved issues of this procedure. Section 10.0, Appendices, contains individual vehicle data synopses, Roller Dynamometer effectiveness test results, vehicle information sheets, and pictures of the test vehicles, brake components, and the instrumentation packages.

2.0 BACKGROUND

FMVSS No.'s 105, 121, and 135 have the purpose of insuring safe braking performance under normal and emergency conditions. FMVSS No. 105 applies to hydraulic and electric brake systems, FMVSS No. 121 applies to air brake systems, and FMVSS No. 135 applies to light vehicle hydraulic brake systems. These standards have test procedures for various aspects of the brake systems. The road tests for FMVSS Nos. 105 and 121 are briefly described in the following two sections.

2.1 - FMVSS No. 105

FMVSS No. 105 outlines procedures for Effectiveness Tests, Burnishes, Partial Failure Tests, Inoperative Power Assist, Failed Antilock Brake Systems (ABS), Fade and Recovery, Water Recovery, and Spike Stops.

The Effectiveness Tests (a total of 4) are stopping distance requirements from 30 and/or 60 mph. The stopping distances are based on vehicle type/weight. The third effectiveness test is lightly loaded, while the others are at Gross Vehicle Weight Rating (GVWR). The First Effectiveness test was not performed in this study because the vehicles tested to FMVSS No. 105 were received with the initial Burnish already performed.

There is an initial Burnish and 3 Reburnishes. The initial Burnish consists of 500 snubs from a high speed to a lower speed at set deceleration rates. There are two possible test sequences that have different speed requirements for each snub. The Reburnish procedure is the same for all 3 Reburnishes and consists of 35 snubs.

The Partial Failure Test procedure requires that the remaining portions of the service brake system stop the vehicle from 60 mph when one of the subsystems is rendered inoperable. The required stopping distances are longer than those for the Effectiveness Tests and are also dependant on vehicle type/size. The Failed ABS test is the same as the Partial Failure Test with the ABS rendered inoperable.

The Inoperative Power Assist Test procedures are dependant on the type of power assist and the discretion of the manufacturer. The manufacturer can select from up to 3 choices of test procedures. All of the possible selections require minimum stopping distances from 60 mph with the power assist inoperable.

The Fade and Recovery stop or snub procedure is dependent on the vehicle GVWR. The fade portion of the procedure consists of a series of stops or snubs at a specified deceleration rate and initial brake temperature range. The time between stops or snubs is also specified. The vehicle is then driven for a specified distance and speed before the recovery portion starts. The recover portion of the procedure consists of a series of stops or snubs at a specified deceleration rate. The vehicle is driven for a specified distance between stops or snubs. The maximum control force is recorded for each snub.

The Water Recovery procedure is also dependent on the vehicle GVWR. The vehicle is driven through a water trough with a water depth of 6 inches for a specified period of time. A series of stops or snubs is performed at specified deceleration rates. The control force must fall within specified minimum and maximum limits.

Spike stops are required for vehicles with a GVWR less than 10,000 lbs. None of the vehicles in this study fell into this category.

This research is concerned with the addition of Stability and Control (Braking-in-a-Curve) tests to FMVSS No. 105. The Braking-in-a-Curve procedure consists of determining a maximum drive through speed (up to 40 mph) on a 500 foot radius, low coefficient of friction surface and then performing braking tests at initial speeds equivalent to 75 percent of the maximum drive-through speed. The driver should be able to maintain control of the vehicle (i.e. stay in the prescribed curve lane) while negotiating the curve. This test procedure is outlined in more detail in Section 7.2.

2.2 - FMVSS No. 121

The FMVSS No. 121 test procedure consists of a Burnish, Braking-in-a-Curve tests (Stability and Control tests) at GVWR and at Lightly Loaded Vehicle Weight (LLVW), Service Brake Stopping Distance at GVWR and LLVW, and Emergency Brake Stopping Distance at GVWR and LLVW. Manual brake adjustment is allowed several times during the course of the procedure.

The Burnish consists of 500 snubs between 40 mph and 20 mph. The deceleration rate is 10 ft/sec^2. After each snub, the vehicle is accelerated back to 40 mph and the speed is maintained for 1 mile past the previous snub at which point the next snub can be performed. Brake lining temperatures and brake application pressures should be recorded every 25^{th} brake snub. Up to three brake adjustments can occur during the burnish and an adjustment is performed after the burnish is complete.

The FMVSS No. 121 Braking-in-a-Curve test is the same as that for FMVSS No. 105 described in Sections 2.1 and 7.2. The tests are conducted at GVWR and LLVW. A manual brake adjustment is performed at the end of this test procedure.

The Service Braking Stopping Distance tests procedure consists of six stops from 60 mph trying to achieve the shortest stopping distance. The driver is to maintain the vehicle within the prescribed straight lane. The test procedure is performed with the manual controlled driveline retarders in both the on and off positions. To reduce the size of the test matrix, tests were only run with the retarders in the "off" position for this study. Running with the retarders in the "off" position is the worst case condition. Wheel lockup provisions are given. The stopping distance requirement is a function of the type of vehicle and loading condition.

The Emergency Braking Stopping Distance is basically the same test procedure as that for the Service Braking Stopping Distance test, but with primary and secondary system failures simulated. The primary system failure is simulated by activating a solenoid valve to vent pressure to atmosphere on the primary air reservoir. The stop is initiated within 5 seconds after the low pressure warning is activated. This procedure is performed with the manual controlled driveline retarders in the on and off position. Only "off" position tests were performed in this study. The secondary system failure test is the same as the primary system failure test except the secondary reservoir is vented to atmosphere.

The Service Braking and Emergency Braking stopping distance tests are first performed at GVWR. A brake adjustment is then performed before the test procedures are repeated at LLVW.

3.0 TEST VEHICLES

3.1 - Hydraulic Braked Buses

Two school buses, leased from General Motors Corporation and Freightliner/ Thomas Built Buses, were the only hydraulically braked units tested. No hydraulic braked straight trucks were tested as part of this program. Each bus was equipped with an ABS system that meets the equipment requirements of S5.5.1 of FMVSS No. 105. These requirements are effective March 1, 1999, for all hydraulic-braked vehicles with a GVWR greater than 10,000 lbs.

One long and one short length bus were selected to determine the effect of wheelbase on braking-in-a-curve performance. The wheelbase measurements were 193 inches for the GMC (unit A) and 252 inches for the Freightliner/Thomas Built (unit B). Vehicle specifications for the buses and the straight trucks (described in Section 3.2) are given in Table 3.1. The brake type, vehicle configuration, wheelbase, Gross Axle Weight Ratings (GAWR), and Gross Vehicle Weight Rating (GVWR) are listed.

Since the buses were received as complete vehicles, not just chassis-cabs, no load frame was added. The buses were tested with all fuel tanks and fluid reservoirs filled to normal capacity. VRTC added instrumentation and a data acquisition system (see section 4.0). The test instrumentation and driver added approximately 300 pounds to the unloaded vehicle weight. With the sum of these components, the vehicle was referenced as being in the "lightly loaded", or "empty" configuration.

The two buses were received at VRTC with brakes that were in good condition.

Table 3.1: Vehicle Specifications for VRTC Brake-In-A-Curve Tests - 1996-1997

Vehicle Manufacturer	GMC	Freight-liner	Freight-liner	Peterbilt	Navistar	Navistar	Navistar
Vehicle ID Code	A	B	C	D	E	F	G
Vehicle Type	Bus	Bus	Straight Truck	Straight Truck	Straight Truck	Straight Truck	Straight Truck
Brake Type	Hydraulic	Hydraulic	Air	Air	Air	Air	Air
Vehicle Configuration	4x2	4x2	6x4	6x4	6x4	4x2	4x2
Wheelbase (in)	193	252	180	311	238	152	148
GAWR front (lb)	8100	7560	12000	20000	15000	14600	20000
GAWR rear (lb)	19000	17940	40000	40000	46000	21000	30000
GVWR total (lb)	27100	25500	52000	60000	61000	35600	50000

3.2 - Pneumatic Braked Straight Trucks

Five straight trucks were leased from Freightliner, Navistar, and Peterbilt (PACCAR) as bare chassis-cabs supplied without bodies or equipment that would normally be installed by a second-stage manufacturer. Each had pneumatically operated brakes, and were equipped with ABS systems.

Various length trucks were selected to determine the effect of wheelbase on braking-in-a-curve performance. The three longer trucks had a 6x4 wheel configuration. The two shorter trucks had a 4x2 wheel configuration. The wheelbase (WB) measurements were: Freightliner 6x4 (unit C) 180 inch WB, Peterbilt 6x4 (unit D) 311 inch WB, Navistar 6x4 (unit E) 238 inch WB, Navistar (unit F) 152 inch WB, and Navistar (unit G) 148 inch WB (see Table 3.1 for vehicle specifications).

Load frames were installed on each of the straight trucks to simulate the unloaded condition of completed vehicles (see section 6.0). Fluid levels and data acquisition weights were similar to those described for buses in the previous section.

The brakes were all in good condition. A burnish was performed on each unit in the fully laden GVWR condition prior to performing the vehicle stability brake-in-a-curve tests. Since only the brake-in-a-curve tests for the Navistar units "F" & "G" were performed by VRTC, the conditioning burnish procedures were performed by Navistar prior to their arrival. Navistar also ran and provided the data for the other FMVSS No. 121 tests for these vehicles. These tests were performed at the same test site, but not under VRTC observation.

4.0 INSTRUMENTATION

Six of the seven test vehicles incorporated similar VRTC data acquisition systems. The seventh unit, the 4x2 Navistar truck (unit F), was instrumented by Navistar. The data acquisition system's main function was to log key physical parameters of the driver input, vehicle response, and braking performance, all with respect to elapsed time.

4.1 - Data Acquisition Overview

The major components of the VRTC data systems were: a laptop PC with two AT-type expansion slots, an internally mounted digitizer, a signal conditioning breakout box, various cables, parameter measurement transducers, and three monitors for the driver, including a Labeco Performance Monitor, a Fluke Thermocouple Monitor, and a GSE Pedal Force Monitor.

The laptop PC controlled the acquisition of the data. The system functions were manipulated through "DACS" data acquisition routines, written at VRTC. Inside the laptop was an Analog Devices RTI-815, 12-bit digitizer. The digitizer was configured to acquire analog data from up to twenty channels. Data were collected at a digitizing rate of 20 samples per second. on each channel, for the buses and the first two straight trucks. After reviewing this data. it was determined that finer time precision was necessary, so the sample rate was raised to 100 samples per second. A twenty-six conductor ribbon cable connected the digitizer to the signal conditioning breakout box.

The breakout box contained several types of subsystems. The first subsystem comprised the power switching and voltage regulation controls for the various components of the data system. These ensured that all components of the entire data acquisition system were referenced to the same groundplane. The second subsystem contained the signal conditioners. An Analog Devices 3B01, 16-channel backplane, formed the base for the signal conditioners. Analog Devices 3B18 amplifiers were chosen as cost-effective signal conditioners. Each 3B18 provided three essential functions: 1) a stable 10 volts DC excitation for the transducers requiring a power source, 2) adjustable gain, with a range from x1 to x1000, and 3) an adjustable frequency, 2-pole low pass, Butterworth filter, which was set for 10 Hz on the early bus tests, and raised to 18 Hz for the later straight truck tests running with higher sample rates. Brake temperature signals were conditioned through Analog Devices 3B47 amplifiers. The 3B47's provided cold junction compensation, linearization, and magnetic isolation for the readings of the individual brake temperatures that were measured at the brake linings. The final section of the breakout box contained an array of suitable bulkhead connectors, which accommodated the numerous cables from the various transducers and thermocouples.

For Unit E, the 6x4 Navistar 238-in wheelbase truck, for which a full 20 channels of data were recorded, an additional eight channel backplane and bus adapter cables were added to the breakout box.

4.2 - Transducer Information

Transducers were used to measure vehicle speed, brake line pressures, control pressure (on pneumatic braked vehicles) and pedal force (on hydraulic braked vehicles), deceleration, stopping distance, and brake temperatures, during the testing of each vehicle. A complete list of the data channels measured for each vehicle is given in Table 4.1.

Table 4.1: Data Acquisition Channel List for FMVSS No. 105 & FMVSS No. 121 VRTC Brake-In-A-Curve Tests - 1996-1997

Veh. ID Code	A	B	C	D	E	F	G	
Manufacturer	GMC	Freight -liner	Freight -liner	Peter- bilt	Navi- star	Navi- star	Navi- star	
Type	BUS	BUS	6x4	6x4	6x4	4x2	4x2	
Wheelbase (in)	193	252	180	311	238	152	148	
Number of Data Channels	13	13	10	10	20	NA	13	
Sample Rate (Hz)	25/20 *	20	20	20	100	NA	100	
Channel Name								Description
EVENT	X	X	X	X	X	NA	X	brake event
VHSPD	X	X	X	X	X	NA	X	vehicle speed
DECEL	X	X	X	X	X	NA	X	deceleration
PDFRCE	X	X				NA		pedal force (105 only)
PDTRVL	X	X				NA		pedal travel (105 only)
CTLPRS			X	X	X	NA	X	control pressure (121)
1CHPS					X	NA	X	LF brake pressure (121 only)
2CHPS					X	NA	X	RF brake pressure (121 only)
3CHPS					X	NA	X	LR brake pressure (121 only)
4CHPS					X	NA	X	RR brake pressure (121 only)
1WHSPD	X	X	X	X	X	NA	X	left wheel speed-axle 1
2WHSPD	X	X	X	X	X	NA	X	right wheel speed-axle 1
3WHSPD	X	X	X	X	X	NA	X	left wheel speed-axle 2
4WHSPD	X	X	X	X	X	NA	X	right wheel speed-axle 2
5WHSPD			X	X	X			left wheel speed-axle 3
6WHSPD			X	X	X			right wheel speed-axle 3
1TEMP	X	X			X	NA		brake temperature-axle1L
2TEMP	X	X			X	NA		brake temperature-axle1R
3TEMP	X	X			X	NA		brake temperature-axle2L
4TEMP	X	X			X	NA		brake temperature-axle2R
5TEMP					X			brake temperature-axle3L
6TEMP					X			brake temperature-axle3R
TEST							X	second event / spare channel

Notes:

1) 25/20 * = 25 Hz for the GVWR test, 20 Hz for the empty (lightly loaded) test.
2) Vehicle F was instrumented by Navistar and a channel list is Not Available (NA).
3) Vehicles A through E were instrumented and tested to the appropriate FMVSS standard by VRTC.
4) Vehicles F and G were only tested for the brake-in-a-curve sequence at VRTC.

A Labeco TrackTest 5th Wheel assembly was attached to the rear or underside frame of the truck. The 5th wheel was used to obtain a free-rolling, independent vehicle velocity at the lateral centerline of the vehicle. The Labeco 5th Wheel was calibrated daily on the precisely measured skid pad lane #6 "1000-foot cal pad". The air pressure in the wheel was adjusted until the Labeco display indicated a concurrent reading of 1000 +/- 2 feet. Coupled to the fifth wheel was a TTL pulse encoder.

The fifth wheel pulse output signal was fed to the Labeco Performance Monitor. The timing of the Labeco Performance monitor was verified daily by reading an internal 2048 Hz calibration standard with a clock test value of "62.0 - 62.1 mph". Variance from this reading would require that the unit be removed from service for factory re-calibration. Before each test run, the driver would reset this unit, which in sequence self-armed. The tail light circuit was tapped, whereupon applying force to the brake pedal energized the vehicle brake lamp circuit, triggering the Labeco. An alternate method of taping a contact closure ribbon switch to the brake pedal to trigger the Labeco was also used. After each brake test, the read-out retained the display, indicating the distance the vehicle covered during the stop, starting at the trigger signal, and ending within 0.6 mph of the complete cessation of forward vehicle motion. It was noted that the total distance traveled in slowing from <0.6 mph to zero was less than the accuracy of the fifth wheel, so no effort was made to account for the negligible difference. This early dropout also prevented the system from continuing to increment distance falsely as the vehicle pitched back and forth at the end of the stop.

A tachometer-generator device mounted on the same 5th wheel unit measured the rotational velocity of the 5th wheel, producing 7.0 volts of output for every 1000 revolutions per minute. The voltage sensitivity of this independent vehicle velocity measuring system calculated to 16.38 ft/sec/volt (11.168 mph per volt).

Strain Gage type pressure transducers were plumbed into the pneumatic supply lines that led to each wheel, or to the two port valve supplying the brakes on two wheels simultaneously. An additional pressure transducer was installed in the control line to measure the input effort for the FMVSS No. 121 pneumatic systems. The transducers selected had a range of 0-200 psi.

On FMVSS No. 105 hydraulic systems, a GSE brake pedal load cell was mounted on the brake pedal to log driver input effort. The transducers selected for the buses were capable of measuring a force range of 0-200 pounds. Additionally, the pedal travel was monitored, as this test series was searching for new methods of determining driver braking input. A string-pot (a potentiometric displacement measuring device with a retractable steel cable) was attached to the backside of the brake pedal and whose base was fastened to the floor of the bus. The string-pot was set to give a relative percent of total pedal travel for an input force of 150 pounds. While these string-pot systems were used for both of the hydraulically braked buses, their data provided very limited information as the total distance varied with vehicle operating conditions, invalidating their calibration.

A Setra #141B accelerometer was mounted parallel to the longitudinal axis of the truck, near the vehicle CG (center of gravity), to measure the deceleration of the vehicle during each braking maneuver. The accelerometer measuring range was scaled to +/- 1 G.

For both of the FMVSS No. 105 buses, J-type plug thermocouples were installed in the brake pads as described in section S6.11 of the standard. For Unit E, the 6x4 Navistar 238-inch wheelbase truck with pneumatic brakes, J-type plug thermocouples were already installed when the vehicle arrived at VRTC. Suitable low resistance extension cables connected each of the thermocouples to the data system. The temperature range capability was 0 to 1000 degrees F.

4.3 - Driver Feedback Devices

For the speed and pressure subsystems described in Section 4.2, separate readouts provided feedback to the driver. The Labeco #625 Performance Monitor provided vehicle speed updates to the driver every 100 mS. At the end of each stop, the driver tabulated the stopping distance readings from the Labeco. For hydraulic brakes, a GSE Pedal Force Monitor provided realtime analog dial indications of the applied pedal force. For pneumatic brakes, the input parameter was indicated by an analog dial pressure gauge installed in the control line from the treadle valve. In accordance with the test specifications, the driver adjusted his pedal effort with the feedback from these visual aids.

An additional driver readout was included to monitor the thermocouple temperatures of the brake pads. A ten channel, Fluke #2166A Digital Thermometer was connected to the individual thermocouples through "tee" connectors at the data system. The channel selector was switched between the active channels, and then maintained, on the channel displaying the highest reading, for the next test run.

4.4 - Weight of Instrumentation

The weight of the data acquisition system did not significantly affect the performance of the test vehicles, since the equipment was light (compared to the weight of the test vehicles) and mounted so that its center of gravity was located near the center of gravity of each vehicle. Typical weights for the various components are listed in Table 4.2.

Table 4.2: Weight of Typical VRTC Instrumentation Components for FMVSS No. 105 & FMVSS No. 121 Brake-In-A-Curve Tests

Instruments Installed:	Weight of Typical Instrumentation Components: (lbs)
Ruggedized PC Computer (Laversab)	19.6
16-ch signal conditioning breakout box	18.1
GSE Pedal Force Display with transducer	4.3
Fluke 10-ch digital thermometer	4.1
Setra Accelerometer with mounting platform	1.4
Wheel Tachometer with mounting hardware	2.3 each (use 4 or 6 per truck)
Labeco 625 Performance Monitor	6.1
Labeco 5th wheel, frame, encoder, & tachometer	35.0
Miscellaneous Cables and Connectors	7.0
Total Weight of typical 6x4 Truck Instrumentation	109.4

Note: Total instrumentation weight for a typical 4x2 truck would be approximately 5 pounds less.

5.0 BRAKING-IN-A-CURVE TEST AREA

The braking-in-a-curve tests were conducted on a low coefficient of friction surface on the Transportation Research Center proving grounds in East Liberty, Ohio. The test area was located inside the fifty acre asphalt rectangle, the Vehicle Dynamics Area (VDA), which provided a safety run-off area if the test vehicle needed to abort a braking maneuver. The coefficient of friction for most of the VDA was a relatively high 0.9. This provided excellent traction for accelerating to test speed. The layout of the VDA provides a relatively quick means of repeating test cycles with minimal milage accumulation on the tires and brakes.

Located on the southern section of the VDA was the Braking-In-A-Curve area. This section of the VDA was coated with Jennite (a driveway sealer) and wetted with water to provide the reduced (0.5 nominal peak) coefficient of friction surface for the brake tests. A curved, 12-foot-wide lane was laid out (12 feet between the inside edges of painted eight-inch squares), with the center of the lane having a 500-foot radius of curvature, and an arc length of over 500-feet. The squares were painted on radials corresponding to every 20 foot of centerline arc length. Traffic cones were placed on each painted square, maintaining twelve feet of spacing between the base of the sides facing the lane. This provided a clear lane reference without solidly painting a lane line that would cause a variance in the surface's coefficient of friction.

For drainage purposes, the surface had a cross slope of one percent, at the mid-point of the curve, and approximately zero longitudinal slope. The effect of the cross slope was such that the test condition was considered to be worst case, since the outside of the curve was on the downslope side.

The peak coefficient of friction (PFC) of the surface during the time of the testing ranged from 0.34 to 0.39. The effect of the lower PFC, compared to the 0.5 PFC as specified in FMVSS No. 121, was also considered a worst-case test condition.

An excerpt from the TRC periodic report of "Monitored Test Surfaces" is given in Table 5.1. A partial history of the surface friction coefficients for 1996 - 1997 is shown. It includes coefficients for the wet Jennite pad (#8) used for vehicle stability brake-in-a-curve tests and for the dry concrete skid pad (#3) used to run high speed braking maneuvers for the other test procedures (see Section 7.0).

Table 5.1: "Monitored Test Surfaces" Information for 1996-1997

Location	Skid Pad-Lane 3	VDA
Pad#	3	8
Pavement	Polished Concrete	Jennite over Asphalt
Type of Tests Run on Surface	High Speed Braking Maneuvers	Brake-In-A-Curve Tests
Condition as Tested	Dry	Wet
Peak/Slide Coefficients	Peak Brake Coefficient / Slide Number Coefficient	Peak Brake Coefficient
Nominal Coefficient #'s	90 / 75	30
Date	Peak mu / Slide mu	Peak mu
06/28/96	87 / 80	36
08/21/96	90 / 78	37
10/28/96	95 / 78	34
12/04/96	96 / 79	38
01/07/97	94 / 81	37
04/01/97	96 / 81	39
05/20/97	87 / 81	37

Peak Brake Coefficient measured per ASTM E1337 with an ASTM E1336 standard tire.
Slide Number Coefficient measured per ASTM E274 with an ASTM E501 standard tire.

To obtain the reduced coefficient of friction in the braking area, water was sprinkled onto the Jennite just before each test run. A suitable truck was fitted with a 5000 gallon water tank. Gravity fed the water from the 72-inch, inside height, oval tank to a 208-inch wide horizontal spray bar. The bottom of the water tank was 48 inches above the ground. The bottom of the spray bar was 27 inches above the ground. The 2-1/2-inch inside diameter spray bar sprinkled from 196 holes, each 3/8-inch diameter, spaced 1-inch longitudinally over the length of the bar, and alternately bored 28.6 degrees in front of, and 28.6 degrees following, vertical downward. When this water truck was driven across the Jennite area at 10-15 miles per hour, the water would bead up to approximately 1/8-inch thick, providing a wetness lasting one or two minutes until the test vehicle was driven across it. If the test vehicle was delayed in making a test pass, the surface was re-wetted. To provide an additional margin of safety, the water truck made one or two passes over the surface on each side of the test lane. This extended the area of low coefficient surface and created a safe run-out-of-lane option without side-tripping the vehicle onto a higher coefficient surface.

6.0 VEHICLE LOADING AND LOAD FRAMES

6.1 - Bus Loading Conditions

The two school buses supplied by General Motors Corporation and Freightliner/Thomas Built Buses were received as complete vehicles so no load frame or ballast was added for testing in the unloaded condition. The buses were tested with all fuel tanks and fluid reservoirs filled to normal capacity. The test instrumentation and driver added approximately 300 pounds to the unloaded vehicle weight.

The loaded tests on the two school buses were conducted by placing sand bags on the floor and seats of the bus such that the total vehicle weight was equal to the GVWR, with the axle loads in proportion to the GAWRs.

6.2 - Straight Truck Loading Conditions

To simulate the unloaded condition of completed vehicles, a load frame was installed on the chassis cab straight trucks for the performance tests conducted in the unloaded condition. Two trucks, the Freightliner 6x4 (unit C) and the Navistar 6x4 (unit E), were fitted with a 2600 pound load frame built by VRTC. The long wheelbase Peterbilt (unit D) was fitted with two VRTC load frames, placed end to end. Navistar supplied the load frame with a weight of approximately 3,560 pounds, which was used for both the 152" (unit F) and 148" (unit G) wheelbase 4x2 trucks. Each of the load frames used to secure ballast to the vehicles for testing in the loaded condition included an integral roll bar to protect the test driver in the event of rollover during the tests.

To achieve a fully laden condition for the straight trucks, ballast was added (See Table 6.1). This condition was accomplished by adding steel and/or concrete weights to the load frame such that the total weight of the vehicle was equal to the GVWR (gross vehicle weight rating) and the axle loads were in proportion with the front and rear GAWRs (gross axle weight ratings).
For two of the straight trucks (units C and G), the load was situated so the center of gravity (CG)

of the ballast was approximately 32 inches above the top of the frame rails of the truck. TP121V-03 "Laboratory Test Procedures for FMVSS No. 121," specifies a twenty-four inch maximum load-CG height above the fifth wheel on a tractor-trailer combination. This was modified for straight trucks by allowing eight inches for the equivalent height of the fifth wheel above the frame rail. This resulted in a total of 32 inches above the top of the frame rail. The CG height of the load frame was included in the calculated CG height of the truck in the lightly loaded or "Empty" condition.

For two other straight trucks (units E and F), the tests were conducted with the ballast elevated to approximately 50 inches above the truck frame rails, which was near the maximum height specified by the manufacturer in their final-stage manufacturer's guidelines. These two elevated ballast CG tests were conducted to give some indication of the effect of center of gravity height on braking performance in the braking-in-a-curve test.

The fifth straight truck (unit D) was tested with the ballast CG at twenty inches above the truck frame rails. Here, the truck frame was quite high above the ground, due to the two liftable axle mountings, and installing the two load frames raised the empty CG height even more. It was determined that the ballast raised the combined CG to the maximum height that was felt to be safe for this test. Any additional elevation might have caused a roll stability problem.

VRTC load frame no. 1, used on units C, D, and E, was fabricated from steel angle, tubing, and box beams. The dimensions were 13 feet 4 inches long, 6 feet 6 inches high, and 7 feet 11.5 inches wide. The longitudinal CG was 59.3 inches behind the front of the roll bar. The vertical CG was 17.1 inches above the surface that rests on the truck frame rails. The second load frame installed on the Peterbilt (unit D) was of similar construction and dimensions.

Table 6.1: Ballast CG Height Calculations for FMVSS No. 121

Brake-In-A-Curve Straight Truck Tests

Manufacturer	**Freightliner**	**Peterbilt**	**Navistar**	**Navistar**	**Navistar**
Vehicle ID Code	**C**	**D**	**E**	**F**	**G**
Axle Configuration	6x4	6x4	6x4	4x2	4x2
GVWR Configuration (lb)	52000	60000	61000	35600	50000
Wheelbase	180 in	311 in	238 in	152 in	148 in
Bare chassis-cab CG height (CG height above ground, without the load frame installed)	40 in factory estimated	41 in factory estimated	estimate not available	estimate not available	estimate not available
Load Frame weight (lb)	2602	5204 *	2602	3560	3560
Load Frame vertical CG height above truck frame rails	17.1 in	17.1 in	17.1 in	height not available	height not available
Weight Lightly Loaded includes load frame (lb)	17960	32600	21370	15760	18700
Lightly Loaded vehicle CG height (CG height above ground after installing the load frame)	42.5 in VRTC estimated	43.7 in VRTC estimated	38 in Navistar calculated	35.3 in Navistar calculated	38.8 in Navistar calculated
Ballast Weight (lb)	34230	27440	39390	19820	30320
Ballast CG height above truck frame rails	30.5 in	20.5 in	51.1 in	48.3 in	34.6 in
Combined Load Frame and Ballast Weight (lb)	36832	32644	41992	23380	33880
Combined Load Frame and Ballast CG height above truck frame rails	29.6 in	20.0 in	49.0 in	height not available	height not available
Weight Laden (lb)	52190	60040	60760	35580	49020
Laden Vehicle estimated vertical CG height above ground	height not available **	height not available **	76 in Navistar calculated	62.2 in Navistar calculated	60.2 in Navistar calculated

5204 * = the Peterbilt truck (unit D) had two VRTC load frames installed.

** = Laden CG height not available due to a lack of information on suspension compression under load.

7.0 TEST PROCEDURE AND TEST SEQUENCE

7.1 - General Test Procedures and Test Sequence

Prior to testing, for safety reasons, a suitable load frame with an integral safety rollbar was installed on the chassis frame vehicles (see section 6.0 - Vehicle Loading). Instrumentation was installed (see section 4.0 - Instrumentation). Before the vehicle was weighed, and again before each major step in the test sequence, all fuel tanks and fluid reservoirs were filled to normal capacity. This maximized test repeatability.

The driver was briefed before each test sequence. The sequence of tests performed under each standard (FMVSS No. 105 and FMVSS No. 121) are listed on the following page. One deviation from the standard test procedures was that after the Initial Burnish, all of the vehicles were tested for brake effectiveness at slow speed on a Hans Herman BM Roller Dynamometer (see Appendix No. 8 for the Roller Dynamometer description and brake force plots). FMVSS No. 105 also specifies a First Effectiveness test that was not performed for this study because the vehicles tested to this standard were received with the Initial Burnish already performed.

A brief explanation for the various test procedures is given in Section 2.0. Detailed procedures for each test are contained in the respective FMVSS. A detailed explanation of the braking-in-a-curve tests are contained in the next section.

FMVSS No. 105 - 4x2 School Bus - Test Sequence

1. Initial Burnish
2. Second Effectiveness
3. *Proposed* Stability and Control, Brake-in-a-curve Loaded - at GVWR
4. First Reburnish
5. Third Effectiveness
6. *Proposed* Stability and Control, Brake-in-a-curve Empty - at LLVW
7. Partial Failures Empty
8. Partial Failures Loaded
9. Inoperative Power Assist Loaded
10. Failed ABS Loaded
11. First Fade and Recovery
12. Second Reburnish
13. Second Fade and Recovery
14. Third Reburnish
15. Water Recovery

FMVSS NO. 121 - 4x2 and 6x4 Straight Truck - Test Sequence

1. Burnish
2. *Proposed* Stability and Control, Brake-in-a-curve Loaded - at GVWR
3. *Proposed* Stability and Control, Brake-in-a-curve Empty - at LLVW
4. Manual Brake Adjustment Allowed
5. Service brake stopping distance test at GVWR.
6. Emergency brake stopping distance test for single unit truck only at GVWR.
   - Primary system failure.
   - Secondary system failure.
7. Manual Brake Adjustment Allowed
8. Service brake stopping distance test at LLVW.
9. Emergency brake stopping distance test at LLVW.
   - Primary system failure.
   - Secondary system failure.

7.2 - Stability and Control, Braking-In-A-Curve Test Procedure

The "braking-in-a-curve tests" (BIC) were conducted by finding the maximum drive-through speed, making four stops at 75 percent of the maximum drive-through speed (minimum required brake-through speed), as is specified for truck tractors, and then also determining the maximum brake-through speed. Maximum drive-through speed is defined as the fastest constant speed that a vehicle can be driven through at least 200 feet of curve arc length without departing the lane on a 500-foot radius curve (see section 5.0 - Braking-In-A-Curve Test Area) with a 0.5 peak friction coefficient surface, with the driver making steering corrections as necessary. Maximum brake-through speed is defined as the fastest speed at which a full brake application can be made while the vehicle is in the curve without the vehicle departing the lane, with the driver making steering corrections as necessary. Determination of the maximum brake-through speed provided data on the potential margin of compliance or non-compliance for the test vehicles.

In conducting the tests, the driver was instructed to begin the test in the center of the lane and to steer as necessary to keep the vehicle within the lane. If any cones were hit, the vehicle was considered to have gone out of the lane. The maximum drive-through speed was determined by making passes through the lane at a constant speed and increasing or decreasing the speed slightly on each successive pass to determine the maximum speed at which the vehicle would remain within the lane. Once this speed was determined, two or three additional passes were made to verify that the speed determined was the maximum speed at which the vehicle would remain in the lane. Next, four stops were made at the minimum required brake-through speed (75 percent maximum drive-through). The vehicle must stay within the lane on at least three of four consecutive tests. If a unit failed this requirement, the speed was lowered in one mph increments to a speed where three of the four stops resulted with the vehicle staying in the lane. Finally, the maximum brake-through speed was determined by making successive stops increasing the speed appropriately to find the maximum speed at which the vehicle would remain in the lane. For these stops, the brake was applied as rapidly as possible to a full pressure application or full travel condition and held until the end of the stop.

As currently specified in FMVSS No. 121 for truck-tractors, the required minimum brake-through speed to be used in the braking-in-a-curve test is either 75 percent of the drive-through speed or 30 mph, whichever is lower. Calculated from these requirements, in order for a 30 mph brake-through speed to be used, the drive-through speed would have to be 40 mph or greater. The straight trucks and buses tested in this program had maximum drive-through speed ranging between 32 and 37 mph, therefore, the 75 percent of drive-through speed, rather than the 30 mph speed, applied to each of these vehicles.

8.0 TEST RESULTS

8.1 - Braking-in-a-Curve Test Results

The Braking-in-a-Curve test results are summarized in Table 8.1. The vehicle identification code (A-G for vehicle, 1 or 2 for loading condition), vehicle manufacturer, type of vehicle, wheelbase, loading condition, drive-through speed, required minimum brake-through speed, maximum brake-through speed, and maximum brake-through/maximum drive-through ratio are tabulated. Six of the seven vehicles were able to achieve a maximum brake-through speed that was well above the proposed 75 percent minimum requirement. The first six tabulated vehicles had at least an 88 percent ratio for both empty and fully loaded conditions. The seventh vehicle, the Navistar 4x2 - 148 inch wheelbase, met the minimum requirement for the loaded condition (78 percent), but did not pass the empty condition (61 percent). It should be noted that this vehicle had a drive axle with a gross axle weight rating of 30,000 pounds, which was greater than the 29,000 pound maximum GAWR specified in FMVSS No. 121 section S3(b), and therefore is not required to pass FMVSS No. 121 test procedures. However, vehicle manufacturers using axles with the higher weight ratings can opt to certify to this standard.

The maximum drive-through and maximum brake-through speeds are plotted for each vehicle in Figure 8.1. The maximum brake-through/drive-through ratio is plotted in Figure 8.2. Both of these figures show that Vehicles A-F have brake-through/drive-through ratios that are well above the 75 percent minimum requirement. As stated previously, Vehicle G (Navistar 148 inch wheelbase) met the minimum requirement for the loaded condition, but did not meet it for the unloaded condition.

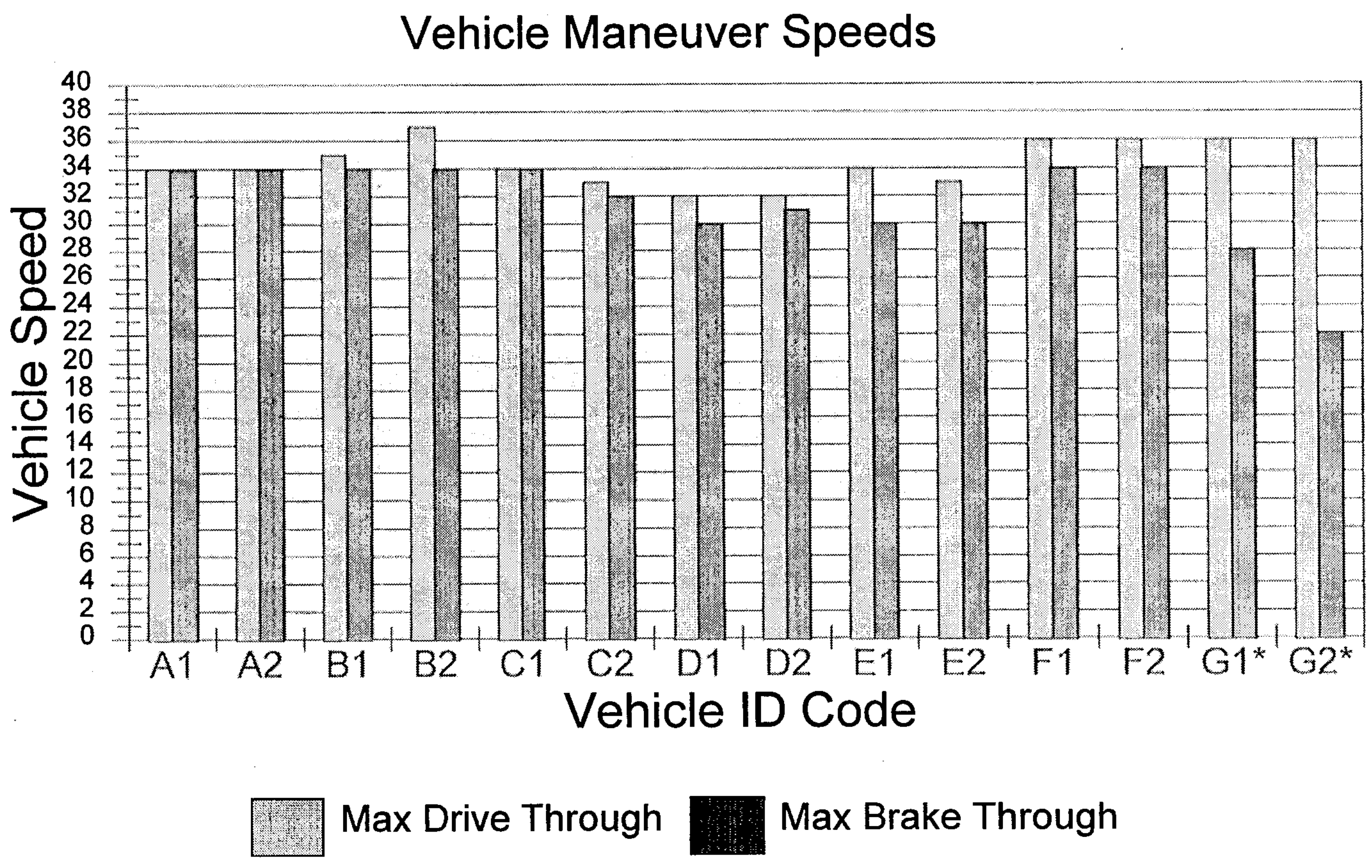
For safety reasons, the maximum test speed permitted by the test procedure was 40 mph. None of the vehicles were able to achieve this high a value. When determining the maximum drive-through speed, the test vehicle front end tended to plough at the limit, departing the lane on the outside of the curve. When determining the maximum brake-through speed, the rear end of the test vehicle would tend to "walk out" at the limit, also departing the lane on the outside of the curve.

TABLE 8.1 VRTC Brake-In-A-Curve Test Results for FMVSS No. 105 and FMVSS No. 121 - 1996-1997

Vehicle ID Code	Manufacturer	Type	Wheel-base (in)	Test Condition	Max Drive-Through (mph)	Required Minimum Brake-Through (mph)	Max Brake-Through (mph)	Max Brake-Through/ Max Drive-Through % (75% Min.)
A1	GMC	Bus	193	loaded	34	26	34	100
A2	GMC	Bus	193	empty	34	26	34	100
B1	Freightliner	Bus	252	loaded	35	26	34	97
B2	Freightliner	Bus	252	empty	37	28	34	92
C1	Freightliner	6 x 4	180	loaded	34	26	34	100
C2	Freightliner	6 x 4	180	empty	33	25	32	97
D1	Peterbilt	6 x 4	311	loaded	32	24	30	94
D2	Peterbilt	6 x 4	311	empty	32	24	31	97
E1	Navistar	6 x 4	238	loaded	34	26	30	88
E2	Navistar	6 x 4	238	empty	33	25	30	91
F1	Navistar	4 x 2	152	loaded	36	27	34	94
F2	Navistar	4 x 2	152	empty	36	27	34	94
G1*	Navistar	4 x 2	148	loaded	36	27	28	78
G2*	Navistar	4 x 2	148	empty	36	27	22	61

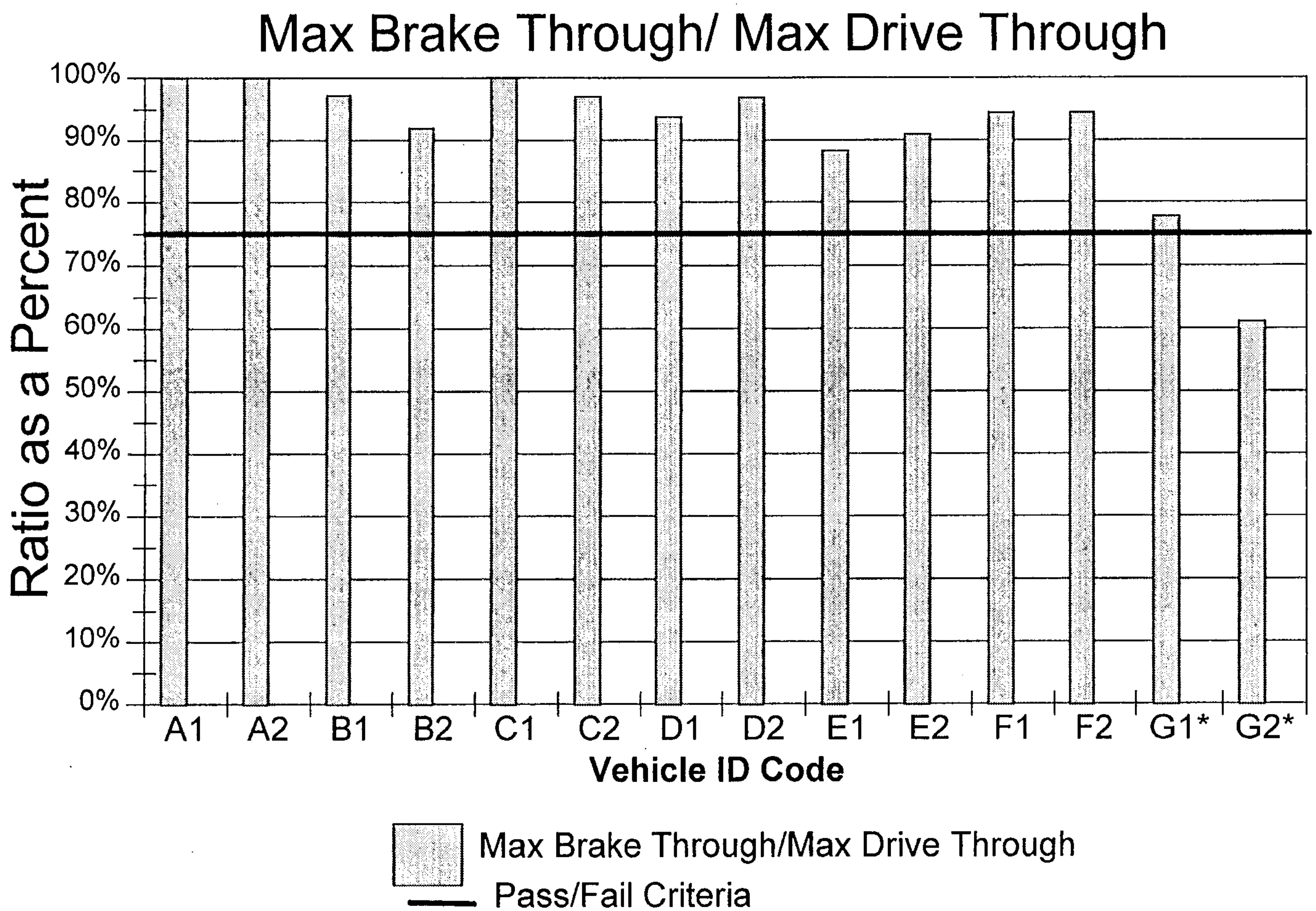
Notes: Required Minimum Brake-Through speeds listed are 75 percent of the Maximum Drive-Through speed.
Vehicle ID Code suffix "1" indicates the vehicle tested in the GVWR loaded condition.
Vehicle ID Code suffix "2" indicates the vehicle tested in the empty condition.
The "*" for vehicle "G" indicates that this unit has a rear axle that exceeds the 29,000 pound maximum axle rating to which FMVSS No. 121 applies .

Figure 8.1: Brake-in-a-Curve



* indicates that this unit has a rear axle that exceeds the 29,000 pound maximum axle rating to which FMVSS No. 121 applies

Figure 8.2: Brake-in-a-Curve



* indicates that this unit has a rear axle that exceeds the 29,000 pound maximum axle rating to which FMVSS No. 121 applies

The proposed FMVSS additions for Braking-in-a-Curve testing require that a minimum brake-through speed equal to 75 percent of the maximum drive-through speed, or 30 mph, whichever is less, be repeated four times. The vehicle must be able to maintain the lane for three of the four consecutive test runs. The six vehicles that passed both the empty and loaded conditions remained in the lane during all four stops at the required minimum brake-through speed and all had a significant margin of compliance as noted by Brake-Through/Drive-Through percentages being higher than 75 percent. The seventh vehicle (unit G) stayed in the lane in all four of the stops at the required minimum brake-through speed in the loaded condition.

For a few of the test vehicles, the braking-in-a-curve test series was repeated to determine if the drive-through and brake-through speeds obtained could be reproduced. The speeds were reproducible to within a half mile per hour, for each tested load condition. Therefore, the braking-in-a-curve scenario produced repeatable results.

For the two trucks tested at GVWR, with the ballast center-of-gravity raised to nearly 50 inches above the frame rails of the truck (Vehicles E and F), comparison tests showed that the increased height did not have an appreciable effect on the performance of the vehicle (i.e. similar brake-through and drive-through speeds were achieved), compared with the lower 32-inch above truck frame rail ballast elevation. However, the test driver did comment that this test condition caused an unsettling feeling during the testing with regard to the vehicle's roll stability. To observers who watched the testing, there were no apparent indications that the vehicles were nearing rollover, such as lifting of an inside tire. No data on these two vehicles are available for the testing conducted at the lower 32-inch height.

During the period this program was in the "vehicle test" phase, there was discussion as to adding a requirement to the FMVSS No. 105 braking-in-a-curve test for a pedal force input application time. After the two school buses were tested and returned to their suppliers, a proposed application time was decided upon. It was proposed that a full pedal application of 150 pounds be applied within 0.2 seconds of initial pedal movement. Upon reviewing the data for the buses, there was no pre-trigger time allotted by the DACS data software, and the twenty Hertz sample rate was insufficient to post process adequate timing data. Therefore, it is impossible to determine the application times for these vehicles. The maximum initial pedal force achieved during the stops in this study typically ran in the 60 to 100 pound range. Full ABS cycling did occur at these levels.

This change in the proposed ABS braking-in-a-curve test procedure was not made for the testing covered by this report. The reasons for not implementing this change in the proposed test procedure are as follows. The requested application rate would be awkward for the driver to meet. The driver commented that it was very taxing to his abilities to watch his speed, apply a repeatable pedal effort, and negotiate the curve without any of the wheels going out of lane, all while looking ahead at where he was going. The additional driver workload of reading a precise pressure measurement could cause visual overload and reduction in safety during the test. The geometry of the seating position, steering wheel, and brake pedal also contribute to the difficulty of this task. A mechanical brake pedal actuator device to apply the 150 pound in 0.2 second brake force would be required to produce repeatable pedal applications at this high rate. This would increase the equipment needed to perform the test. This application rate is probably higher than necessary since full ABS cycling was achieved at a lower pedal force.

In considering "apply times" for three of the pneumatic braked straight trucks, all three surpassed the FMVSS No. 121 required minimum control pressure of 85 psi (at the treadle valve) in less than 0.2 seconds as specified for tractors. The three 6x4 trucks were from Freightliner, Peterbilt, and Navistar. The two 4x2 Navistar straight trucks were not instrumented for this measurement. This application time is repeatable, and easy to measure for the FMVSS No. 121 standard using a simple data acquisition system with a 50 Hertz input filter, 100 Hertz sample rate and a brake pedal touch switch or motion sensor. The 18 Hertz input filter used in this study was acceptable for measuring the transients associated with the initial brake application.

The results of testing at VRTC show that the braking-in-a-curve test is practicable, repeatable, and safe to perform for single unit vehicles.

8.2 - Summary of Other FMVSS No. 105 Test Results

The two school buses had hydraulic brakes and were therefore subject to the other FMVSS No. 105 test procedures. Loaded and empty effectiveness test results (full system) and failed system test results are summarized in Tables 8.2 and 8.3 for the GMC and Freightliner/Thomas school buses. The effectiveness test results are from the Second Effectiveness Test. They are the lowest value from six tests. The failed system test results are the lowest value from four tests. All stopping distances were corrected per SAE J288.

The stopping distances for the failed circuit tests were much greater than those for the full system, but were well below the required stopping distance specified by FMVSS No. 105. ABS failure tests resulted in somewhat shorter stopping distances than those for the full system for both buses. This is not surprising. Professional drivers have demonstrated that they can outperform ABS in straight-line braking tests on high coefficient of friction surfaces. The Power Assist failure tests also resulted in somewhat shorter stopping distances. It is not clear at this time why this would be the case. There are at least two possible explanations. If the buses were outfitted with a back up power assist system, it is only required that one system be failed at a time and therefore the stopping distances should not be affected. Another possible explanation is that some power assist systems have a reserve that provide assist for a few more brake applications after the power assist fails. FMVSS No. 105 requires that this reserve be depleted before power assist failure testing, but this might not have occurred during this study.

A summary of Fade and Recovery test results for the GMC and Freightliner/Thomas school buses are given in Tables 8.4 and 8.5 respectively. The maximum, average, maximum allowable, and minimum allowable pedal forces are listed. The maximum pedal forces are the highest values for three tests for the baseline, ten tests for heating, and four tests for Recover 1-4. The average pedal forces are the lowest average values for the same tests. Both buses had maximum and average pedal force values that fell between the minimum and maximum allowable pedal forces and therefore pass the requirement.

Tables 8.6 and 8.7 contain a summary of Water Recovery tests for the GMC and Freightliner/Thomas school bus respectively. The maximum, average, maximum allowable, and minimum allowable pedal forces are listed. The maximum pedal forces are the highest values from three tests for the baseline and four tests for the Recover 1-4. The average pedal forces are the lowest average value for the same tests. Both buses had maximum and average pedal force values that fell between the minimum and maximum allowable pedal forces and therefore pass the requirement.

TABLE 8.2: Summary of Effectiveness and Failed System Testing Results for GMC School Bus

Spring Suspension, Hydraulic Brakes, 193" Wheelbase, GAWR Front 8100, GAWR Rear 19000

	Loaded		Empty	
	Measured Stopping Distance (ft)	Allowed Maximum (ft)	Measured Stopping Distance (ft)	Allowed Maximum (ft)
Full System - stops from indicated speeds				
30 mph	61	70	52	70
60 mph	182	280	162	280
Failed System - stops from 60 mph				
Circuit 1	360	613	265	613
Circuit 2	360	613	382	613
Power Assist	175	613	NA	NA
ABS	165	613	NA	NA

TABLE 8.3: Summary of Effectiveness and Failed System Testing Results for Freightliner / Thomas Built School Bus

Spring Suspension, Hydraulic Brakes, 252" Wheelbase, GAWR Front 7560, GAWR Rear 17940

	Loaded		Empty	
	Measured Stopping Distance (ft)	Allowed Maximum (ft)	Measured Stopping Distance(ft)	Allowed Maximum (ft)
Full System - stops from indicated speeds				
30 mph	63	70	49	70
60 mph	217	280	178	280
Failed System - stops from 60 mph				
Circuit 1	404	613	401	613
Circuit 2	541	613	380	613
Power Assist	204	613	NA	NA
ABS	212	613	NA	NA

TABLE 8.4: Summary of Fade and Recovery Test Results for GMC School Bus

	Maximum Pedal Force (lbs)	Average Pedal Force (lbs)	Allowed Minimum (lbs)	Allowed Maximum (lbs)
First Fade and Recovery				
Baseline	42	30	10	90
Heating	43			150
Recover 1-4	41	27	18	150
Recover 5	39	31	18	50
Second Fade and Recovery				
Baseline	47	35	10	90
Heating	54			150
Recover 1-4	45	36	21	150
Recover 5	39	33	21	55

TABLE 8.5: Summary of Fade and Recovery Test Results for Freightliner/Thomas Built School Bus

	Maximum Pedal Force (lbs)	Average Pedal Force (lbs)	Allowed Minimum (lbs)	Allowed Maximum (lbs)
First Fade and Recovery				
Baseline	72	49	10	90
Heating	77			150
Recover 1-4	50	39	29	150
Recover 5	57	42	29	69
Second Fade and Recovery				
Baseline	66	48	10	90
Heating	78			150
Recover 1-4	59	45	29	150
Recover 5	49	38	29	68

Table 8.6: Summary of Water Recovery – GMC School Bus

	Maximum Pedal Force (lbs)	Average Pedal Force (lbs)	Allowed Minimum (lbs)	Allowed Maximum (lbs)
Water Recover				
Baseline	66	57	10	90
Recover 1-4	69	51	34	150
Recover 5	66	60	34	110

Table 8.7: Summary of Water Recovery – Freightliner / Thomas Built School Bus

	Maximum Pedal Force (lbs)	Average Pedal Force (lbs)	Allowed Minimum (lbs)	Allowed Maximum (lbs)
Water Recover				
Baseline	61	49	10	90
Recover 1-4	62	45	29	150
Recover 5	56	45	29	109

8.3 - Summary of Other FMVSS No. 121 Test Results

The five straight trucks had air brake systems and therefore were subject to the requirements of FMVSS No. 121. Summaries for the Service Brake and Emergency Brake Stopping Distance tests for the five straight trucks are contained in Tables 8.8 through 8.12. Service Brake stopping distances are the lowest values from six tests. The same is true for the failed primary and failed secondary tests. The stopping distances have been corrected per SAE J288.

All of the trucks had Service Brake (fully functioning systems) stopping distances that met the requirements of FMVSS No. 121. The Emergency Brake (partially failed systems) stopping distances for the failed primary and secondary reservoirs also met the FMVSS No. 121 requirements.

Typically for air-braked vehicles the primary reservoir controls the brakes for the drive axles, while the secondary reservoir controls the brakes for the steer axle. The drive axles also have a spring brake system that primarily acts as parking brakes for the vehicle. Additional valving can be added to allow modulation of the spring brakes if the primary reservoir fails, therefore acting as a back-up system. The steer axles do not have a back-up system.

The failed system tests generally resulted in longer stopping distances than those for the full system with a few notable exceptions. The primary reservoir failed system tests for the Freightliner 6x4 (unit C) and for the Navistar 4x2 - 152 inch wheelbase (unit F) straight trucks had similar stopping distances to the full system in the lightly loaded condition. The spring brake system, in conjunction with the steer axle brakes, for these vehicles must have provided similar braking capability to the full system when the vehicles were light loaded. This was not the case when the vehicles were fully loaded.

Table 8.8: Summary of Service Brake and Emergency Brake Stopping Distance for Freightliner 6×4 Straight Truck

Air Suspension, Air Brakes, 180" Wheelbase, GAWR Front 12000, GAWR Rear 40000

	Loaded		Empty	
	Measured Stopping Distance (ft)	Allowed Maximum (ft)	Measured Stopping Distance (ft)	Allowed Maximum (ft)
Full System - stops from 60 mph				
60 mph	285	310	229	335
Failed System - stops from 60 mph				
Primary	464	613	225	613
Secondary	336	613	328	613

Table 8.9: Summary of Service Brake and Emergency Brake Stopping Distance for Peterbilt 6×4 Straight Truck

Spring Suspension, Air Brakes, 311" Wheelbase, GAWR Front 20000, GAWR Rear 40000

	Loaded		Empty	
	Measured Stopping Distance (ft)	Allowed Maximum (ft)	Measured Stopping Distance (ft)	Allowed Maximum (ft)
Full System - stops from 60 mph				
60 mph	279	310	218	335
Failed System - stops from 60 mph				
Primary	324	613	247	613
Secondary	364	613	219	613

Table 8.10: Summary of Service Brake and Emergency Brake Stopping Distance for Navistar 6×4 Straight Truck

Spring Suspension, Air Brakes, 238" Wheelbase, GAWR Front 15000, GAWR Rear 46000

	Loaded		Empty	
	Measured Stopping Distance (ft)	Allowed Maximum (ft)	Measured Stopping Distance (ft)	Allowed Maximum (ft)
Full System - stops from 60 mph				
60 mph	269	310	190	335
Failed System - stops from 60 mph				
Primary	359	613	190	613
Secondary	325	613	284	613

Table 8.11: Summary of Service Brake and Emergency Brake Stopping Distance for Navistar 4×2 Straight Truck

Spring Suspension, Air Brakes, 152" Wheelbase, GAWR Front 14600, GAWR Rear 21000

Summary data provided by Navistar

	Loaded		Empty	
	Measured Stopping Distance (ft)	Allowed Maximum (ft)	Measured Stopping Distance (ft)	Allowed Maximum (ft)
Full System - stops from 60 mph				
60 mph	279	310	203	335
Failed System - stops from 60 mph				
Primary	422	613	306	613
Secondary	480	613	387	613

Table 8.12: Summary of Service Brake and Emergency Brake Stopping Distance for Navistar 4×2 Straight Truck

Spring Suspension, Air Brakes, 148" Wheelbase, GAWR Front 20000, GAWR Rear 30000

Summary data provided by Navistar

	Loaded		Empty	
	Measured Stopping Distance (ft)	Allowed Maximum (ft)	Measured Stopping Distance (ft)	Allowed Maximum (ft)
Full System - stops from 60 mph				
60 mph	261	310	171	335
Failed System - stops from 60 mph				
Primary	382	613	371	613
Secondary	277	613	317	613

9.0 SUMMARY

Testing was conducted in 1996 and 1997, at NHTSA's Vehicle Research and Test Center (VRTC), on two hydraulic-braked buses and five air-braked straight trucks, all equipped with ABS, to determine if the braking-in-a-curve performance test currently required for truck-tractors could also be applied to single-unit vehicles. The vehicles were subjected to the road test requirements in the respective Federal Motor Vehicle Safety Standards (FMVSS), either No. 105 or No. 121, plus the braking-in-a-curve ABS performance tests, which are not currently included in FMVSS Nos. 105 or 121 for straight trucks and buses. The results of testing show that the braking-in-a-curve test is practicable, repeatable, and safe to perform for single unit vehicles. The following list is a summary of pertinent findings and results:

1. The test results indicate that six out of the seven vehicles tested would comply with the performance requirements currently in effect for tractors of staying in the lane in at least three out of four consecutive stops, when subjected to a full treadle or pedal brake application, at 75 percent of the maximum drive-through speed. In fact, these six vehicles remained in the lane during all four stops at 75 percent of the drive-through speed and all had a significant margin of compliance.

2. The seventh vehicle, the Navistar 4x2 with a 148 inch wheelbase, met the minimum requirement for the loaded condition (78 percent), but did not pass the empty condition (61 percent). It should be noted that this vehicle had a drive axle with a gross axle weight rating of 30,000 pounds, which was greater than the 29,000 pound maximum specified in FMVSS No. 121 section S3(b), and therefore is not required to pass FMVSS No. 121 test procedures.

3. The maximum pedal force achieved during the first half second after the brake was applied typically ran in the 60 to 100 pound range. Full ABS cycling did occur at these levels.

4. In considering "apply times" for the pneumatic braked straight trucks, all the test vehicles that had the appropriate instrumentation surpassed the FMVSS No. 121 required minimum control pressure of 85 psi (at the treadle valve) in less than 0.2 seconds as specified for tractors. This application time is repeatable. It is the authors' judgement that using a simple data acquisition system with a 50 Hertz input filter, 100 Hertz sample rate, and a brake pedal touch switch or motion sensor would be appropriate for collecting this type of data. The 18 Hertz input filter used in this study was minimally acceptable for measuring the transients associated with the initial brake application.

5. When determining the maximum drive through speed, the test vehicle front end tended to plough-out at the limit, departing the lane on the outside of the curve. When determining the maximum brake-through speed, the rear end of the test vehicle would tend to "walk out" at the limit, also departing the lane on the outside of the curve.

6. For two of the straight trucks, the tests were conducted with the ballast elevated to approximately 50 inches above the truck frame rails, which was near the maximum height specified by the manufacturer in their final-stage manufacturer's guidelines. These two elevated ballast CG tests were conducted to give some indication of the effect of center of gravity height on braking performance in the braking-in-a-curve test. Comparison tests showed that the increased height did not have an appreciable effect on the performance of these vehicles, compared with the lower 32-inch above truck frame rail ballast elevation. However, the test driver did comment that this test condition caused an unsettling feeling during the testing with regard to the vehicle's roll stability, even though, to observers who watched the testing, there were no apparent indications that the vehicles were nearing rollover, such as lifting of an inside tire.

7. For a few of the test vehicles, the braking-in-a-curve test series was repeated to determine if the drive-through and brake-through speeds obtained could be reproduced. The speeds were reproducible to within a half mile per hour, for each tested load condition. Therefore, the braking-in-a-curve scenario produced repeatable results.

8. The two school buses had hydraulic brakes and were therefore subject to the other FMVSS No. 105 test procedures. Loaded and empty effectiveness test results (full system) and failed system test results were well below the required stopping distance specified by FMVSS No. 105. The stopping distances for the failed circuit tests were much greater than those for the full system, but power assist and ABS failures resulted in somewhat shorter stopping distances than those for the full system for both buses. The Fade and Recovery tests resulted in maximum and average pedal force values that fell between the minimum and maximum allowable pedal forces and therefore both buses passed the requirement. Both buses had maximum and average pedal force values for the Water Recovery test that fell between the minimum and maximum allowable pedal forces and therefore passed the requirement.

9. The five straight trucks had air brake systems and therefore were subject to the requirements of FMVSS No. 121. All of the trucks had Service Brake (fully functioning systems) stopping distances that met the requirements of FMVSS No. 121. The Emergency Brake (partially failed systems) stopping distances for the failed primary and secondary reservoirs also met the FMVSS No. 121 requirements.

10. This testing has shown that the braking-in-a-curve test is practicable, repeatable, and safe to perform for single unit trucks and buses.

10.0 Appendices - Index

Key:	GAWR =	Gross Axle Weight Rating (for each axle)
	GVWR =	Gross Vehicle Weight Rating (referred to as loaded)
	LLVW =	Lightly Loaded Vehicle Weight (referred to as empty)
	IBT =	Initial Brake Temperature (just before stop was initiated)
	fpsps =	Feet Per Second Per Second (deceleration rate)

10.1 Appendix 1

FMVSS 105 - GMC 4x2 School Bus
Test Sequence

Sequence	Test	Page
1.	Burnish	
2.	Second Effectiveness	A1-2A & B
3.	Brake-in-a-curve Loaded (@GVWR)	A1-3
4.	First Reburnish	
5.	Third Effectiveness	A1-5A & B
6.	Brake-in-a-curve Empty (@LLVW)	A1-6
7.	Partial Failures Empty	A1-7A & B
8.	Partial Failures Loaded	A1-8A & B
9.	Inoperative Power Assist Loaded	A1-9
10.	Failed ABS Loaded	A1-10
11.	First Fade and Recovery	A1-11A, B, & C
12.	Second Reburnish	
13.	Second Fade and Recovery	A1-13A, B, & C
14.	Third Reburnish	
15.	Water Recovery	A1-15

All 15 steps of this sequence were performed at VRTC.

FMVSS 105 — SERVICE BRAKE STOPPING TEST

Vehicle: GMC 4x2 School Bus ☒ GVWR ☐ LLVW

Date: 8-6-96 Driver: Lyle Observer:

TEST SPECIFICATIONS:

- Check Tire Pressure
- 30 mph Service Brake Stops
- IBT 150 to 200 °F
- Clutch Depressed or Transmission in Neutral
- Brakes Can Be Modulated, Brake Force Between 15 and 150 lb
- Vehicle in Center of Lane at Start
- Manually Controlled Retarder. ON____ OFF____ N/A ✓

30 mph Service Brake Stops

Stop	Application Force (lb)		Speed (mph)	Decel (fpsps)		Stop Dist. (ft)	Corrected Stopping Distance per SAE J299	In 12 ft Lane	Wheel Lock-up Indication
	Max	Avg		Peak	Avg				
1	149	99	30.5	22	17	71.1	69	yes	no
2	180	102	30.6	24	19	65.7	63	yes	no
3	125	96	30.1	23	18	63.9	63	yes	no
4	134	81	30.3	22	19	65.5	64	yes	no
5	94	78	30.2	22	19	66.3	65	yes	no
6	117	98	30.3	24	19	62.1	61	yes	no

Ambient Temp.: 85 Wind Speed: 5-7 Direction: 234

Comments

FMVSS 105 — SERVICE BRAKE STOPPING TEST

Vehicle: GMC 4x2 School Bus ☒ GVWR ☐ LLVW

Date: 8-6-96 Driver: Lyle Observer:

TEST SPECIFICATIONS:

- Check Tire Pressure
- 60 mph Service Brake Stops
- IBT 150 to 200 °F
- Clutch Depressed or Transmission in Neutral
- Brakes Can Be Modulated, Brake Force Between 15 and 150 lb
- Vehicle in Center of Lane at Start
- Manually Controlled Retarder. ON___ OFF___ N/A ✓

60 mph Service Brake Stops

Stop	Application Force (lb)		Speed (mph)	Decel (fpsps)		Stop Dist. (ft)	Corrected Stopping Distance per SAE J299	In 12 ft Lane	Wheel Lock-up Indication
	Max	Avg		Peak	Avg				
1	141	126	54.9	22	18	194.5	195	yes	no
2	140	109	55.1	24	20	195.4	195	yes	no
3	135	118	55.2	25	21	187.5	186	yes	no
4	142	118	55.0	25	21	182.0	182	yes	no
5	148	123	55.2	23	19	191.5	190	yes	no
6	190	76	55.2	24	20	184.7	183	yes	no

Ambient Temp.: 87 Wind Speed: 3-6 Direction: 144

Comments

FMVSS 105 — STABILITY & CONTROL TEST DATA SHEET

Vehicle: GMC 4x2 School Bus ☒ GVWR ☐ LLVW
Date: 8-7-96 Driver: Lyle Observer:

TEST SPECIFICATIONS:

- Check Tire Pressure
- Max. Drive-Through Speed (nearest whole mph):
- 75% of Max. Drive-Through Speed (nearest whole mph):
- Braking Runs at 30 mph or 75% Max. Drive-Through Speed:
- IBT 150 to 200 °F
- Clutch Depress or Transmission in Neutral
- Full Brake Application
- Vehicle Within Lane at Start
- Manually Controlled Retarder ON OFF
  N/A ✓

Maximum Drive Through Speed: 34 mph 75% of Max Drive Through Speed: 26 mph

Stop No.	Speed (mph)	Approx. Dist. Out of Lane (ft)	No. Markers Hit	Comments
1	26.0	0	0	
2	26.0	0	0	
3	26.0	0	0	
4	26.0	0	0	

Ambient Temp.: 86 Wind Speed: 4-6 Direction: 258

Comments Max Brake Through Speed - 34 mph

FMVSS 105 — SERVICE BRAKE STOPPING TEST

Vehicle: GMC 4x2 School Bus ☐ GVWR ☒ LLVW
Date: 8-8-96 Driver: Lyle Observer:

TEST SPECIFICATIONS:

- Check Tire Pressure
- 30 mph Service Brake Stops
- IBT 150 to 200 °F
- Clutch Depressed or Transmission in Neutral
- Brakes Can Be Modulated, Brake Force Between 15 and 150 lb
- Vehicle in Center of Lane at Start
- Manually Controlled Retarder. ON OFF
  N/A ✓

30 mph Service Brake Stops

Stop	Application Force (lb)		Speed (mph)	Decel (fpsps)		Stop Dist. (ft)	Corrected Stopping Distance per SAE J299	In 12 ft Lane	Wheel Lock-up Indication
	Max	Avg		Peak	Avg				
1	125	86	30.1	28	23	54.2	54	yes	no
2	135	99	30.3	28	24	53.4	52	yes	no
3	131	90	30.2	27	22	53.4	53	yes	no
4	113	95	30.1	30	22	54.1	54	yes	no
5	161	107	30.2	23	20	58.7	58	yes	no
6	85	77	30.3	26	22	56.6	55	yes	no

Ambient Temp.: 79 Wind Speed: 2-8 Direction: 253

Comments

FMVSS 105 — SERVICE BRAKE STOPPING TEST

Vehicle: GMC 4x2 School Bus ☐ GVWR ☒ LLVW

Date: 8-8-96 Driver: Lyle Observer:

TEST SPECIFICATIONS:

- Check Tire Pressure
- 60 mph Service Brake Stops
- IBT 150 to 200 °F
- Clutch Depressed or Transmission in Neutral
- Brakes Can Be Modulated, Brake Force Between 15 and 150 lb
- Vehicle in Center of Lane at Start
- Manually Controlled Retarder. ON ____ OFF ____ N/A ✓

60 mph Service Brake Stops

Stop	Application Force (lb)		Speed (mph)	Decel (fpsps)		Stop Dist. (ft)	Corrected Stopping Distance per SAE J299	In 12 ft Lane	Wheel Lock-up Indication
	Max	Avg		Peak	Avg				
1	131	113	55.0	26	22	164.0	164	yes	no
2	106	90	54.8	25	22	163.8	165	yes	no
3	136	97	55.2	25	21	172.3	171	yes	no
4	142	104	55.2	26	22	169.5	168	yes	no
5	136	112	55.2	24	20	175.9	175	yes	no
6	158	122	55.2	26	24	163.2	162	yes	no

Ambient Temp.: 81 Wind Speed: 6-7 Direction: 314

Comments

FMVSS 105 — STABILITY & CONTROL TEST DATA SHEET

Vehicle: GMC 4x2 School Bus ☐ GVWR ☒ LLVW

Date: 8-9-96 Driver: Lyle Observer:

TEST SPECIFICATIONS:

- Check Tire Pressure
- Max. Drive-Through Speed (nearest whole mph):
- 75% of Max. Drive-Through Speed (nearest whole mph):
- Braking Runs at 30 mph or 75% Max. Drive-Through Speed:
- IBT 150 to 200 °F
- Clutch Depress or Transmission in Neutral
- Full Brake Application
- Vehicle Within Lane at Start
- Manually Controlled Retarder ON____ OFF____ N/A ✓

Maximum Drive Through Speed: 34 mph 75% of Max Drive Through Speed: 26 mph

Stop No.	Speed (mph)	Approx. Dist. Out of Lane (ft)	No. Markers Hit	Comments
1	26.2	0	0	
2	25.8	0	0	
3	26.2	0	0	
4	26.4	0	0	

Ambient Temp.: 62 Wind Speed: NA Direction: NA

Comments Max Brake Through Speed - 34 mph

FMVSS 105 — EMERGENCY BRAKE STOPPING TEST

Vehicle: GMC 4x2 School Bus ☐ GVWR ☒ LLVW
Date: 8-9-96 Driver: Lyle Observer:

System Failed: ☒ MC Circuit #1 ☐ MC Circuit #2 ☐ Power Assist (GVWR Only) ☐ Antilock (GVWR Only)

TEST SPECIFICATIONS:

- Check Tire Pressure
- 60 mph Service Brake Stops
- IBT 150 to 200 °F
- Transmission in Gear
- Brakes Can Be Modulated, Brake Force Between 15 and 150 lb
- Vehicle in Center of Lane at Start
- Manually Controlled Retarder. ON____ OFF____ N/A ✓

60 mph Emergency Brake Stops

Stop	Application Force (lb)		Speed (mph)	Decel (fpsps)		Stop Dist. (ft)	Corrected Stopping Distance per SAE J299	In 12 ft Lane	Wheel Lock-up Indication
	Max	Avg		Peak	Avg				
1	131	118	55.2	16	14	279.2	277	yes	no
2	138	117	55.2	17	14	266.6	265	yes	no
3	108	88	55.4	17	14	276.4	272	yes	no
4	128	104	55.1	16	13	280.6	280	yes	no

Ambient Temp.: 71 Wind Speed: 6-8 Direction: 61
Comments Front Brakes Only, No Rear Brakes

FMVSS 105 — EMERGENCY BRAKE STOPPING TEST

Vehicle: GMC 4x2 School Bus ☐ GVWR ☒ LLVW
Date: 8-12-96 Driver: Lyle Observer:

System Failed: ☐ MC Circuit #1 ☒ MC Circuit #2 ☐ Power Assist (GVWR Only) ☐ Antilock (GVWR Only)

TEST SPECIFICATIONS:

- Check Tire Pressure
- 60 mph Service Brake Stops
- IBT 150 to 200 °F
- Transmission in Gear
- Brakes Can Be Modulated, Brake Force Between 15 and 150 lb
- Vehicle in Center of Lane at Start
- Manually Controlled Retarder. ON____ OFF____ N/A ✓

60 mph Emergency Brake Stops

Stop	Application Force (lb)		Speed (mph)	Decel (fpsps)		Stop Dist. (ft)	Corrected Stopping Distance per SAE J299	In 12 ft Lane	Wheel Lock-up Indication
	Max	Avg		Peak	Avg				
1	161	114	54.7	11	8	382.5	387	yes	no
2	130	95	54.9	11	8	419.5	421	yes	no
3	148	101	55.3	11	8	386.4	382	yes	no
4	138	101	55.0	11	8	393.2	393	yes	no

Ambient Temp.: 61 Wind Speed: 1-3 Direction: 68
Comments Rear Brakes Only, No Front Brakes

FMVSS 105 — EMERGENCY BRAKE STOPPING TEST

Vehicle: GMC 4x2 School Bus ☒ GVWR ☐ LLVW
Date: 8-12-96 Driver: Lyle Observer:

System Failed: ☒ MC Circuit #1 ☐ MC Circuit #2 ☐ Power Assist (GVWR Only) ☐ Antilock (GVWR Only)

TEST SPECIFICATIONS:

- Check Tire Pressure
- 60 mph Service Brake Stops
- IBT 150 to 200 °F
- Transmission in Gear
- Brakes Can Be Modulated, Brake Force Between 15 and 150 lb
- Vehicle in Center of Lane at Start
- Manually Controlled Retarder. ON____ OFF____ N/A ✓

60 mph Emergency Brake Stops

Stop	Application Force (lb)		Speed (mph)	Decel (fpsps)		Stop Dist. (ft)	Corrected Stopping Distance per SAE J299	In 12 ft Lane	Wheel Lock-up Indication
	Max	Avg		Peak	Avg				
1	131	105	55.1	11	10	391.2	390	yes	no
2	133	112	55.6	12	10	367.5	360	yes	no
3	138	106	55.2	11	9	390.8	388	yes	no
4	117	98	55.4	10	9	412.6	407	yes	no

Ambient Temp.: 67 Wind Speed: 2-5 Direction: 35
Comments Front Brakes Only, No Rear Brakes

FMVSS 105 — EMERGENCY BRAKE STOPPING TEST

Vehicle: GMC 4x2 School Bus ☒ GVWR ☐ LLVW

Date: 8-12-96 Driver: Lyle Observer:

System Failed: ☐ MC Circuit #1 ☒ MC Circuit #2 ☐ Power Assist (GVWR Only) ☐ Antilock (GVWR Only)

TEST SPECIFICATIONS:

- Check Tire Pressure
- 60 mph Service Brake Stops
- IBT 150 to 200 °F
- Transmission in Gear
- Brakes Can Be Modulated, Brake Force Between 15 and 150 lb
- Vehicle in Center of Lane at Start
- Manually Controlled Retarder. ON OFF
  N/A ✓

60 mph Emergency Brake Stops

Stop	Application Force (lb)		Speed (mph)	Decel (fpsps)		Stop Dist. (ft)	Corrected Stopping Distance per SAE J299	In 12 ft Lane	Wheel Lock-up Indication
	Max	Avg		Peak	Avg				
1	145	109	55.8	12	8	395.8	385	yes	no
2	133	105	55.1	12	10	363.6	362	yes	no
3	152	111	54.9	12	9	363.8	365	yes	no
4	133	105	55.8	13	8	370.6	360	yes	no

Ambient Temp.: 66 Wind Speed: 4-6 Direction: 88

Comments Rear Brakes Only, No Front Brakes

FMVSS 105 — EMERGENCY BRAKE STOPPING TEST

Vehicle: GMC 4x2 School Bus ☒ GVWR ☐ LLVW
Date: 8-13-96 Driver: Lyle Observer: ______

System Failed: ☐ MC Circuit #1 ☐ MC Circuit #2 ☒ Power Assist (GVWR Only) ☐ Antilock (GVWR Only)

TEST SPECIFICATIONS:

- Check Tire Pressure
- 60 mph Service Brake Stops
- IBT 150 to 200 °F
- Transmission in Gear
- Brakes Can Be Modulated, Brake Force Between 15 and 150 lb
- Vehicle in Center of Lane at Start
- Manually Controlled Retarder. ON ______ OFF ______
  N/A ✓

60 mph Emergency Brake Stops

Stop	Application Force (lb)		Speed (mph)	Decel (fpsps)		Stop Dist. (ft)	Corrected Stopping Distance per SAE J299	In 12 ft Lane	Wheel Lock-up Indication
	Max	Avg		Peak	Avg				
1	134	106	55.0	26	21	185.3	185	yes	no
2	131	101	55.4	27	21	180.9	178	yes	no
3	126	107	55.3	27	22	177.4	175	yes	no
4	129	104	55.1	26	20	181.4	181	yes	no

Ambient Temp.: 58 Wind Speed: NA Direction: NA
Comments ______

FMVSS 105 — EMERGENCY BRAKE STOPPING TEST

Vehicle: GMC 4x2 School Bus ☒ GVWR ☐ LLVW
Date: 8-13-96 Driver: Lyle Observer:

System Failed: ☐ MC Circuit #1 ☐ MC Circuit #2 ☐ Power Assist (GVWR Only) ☒ Antilock (GVWR Only)

TEST SPECIFICATIONS:

- Check Tire Pressure
- 60 mph Service Brake Stops
- IBT 150 to 200 °F
- Transmission in Gear
- Brakes Can Be Modulated, Brake Force Between 15 and 150 lb
- Vehicle in Center of Lane at Start
- Manually Controlled Retarder. ON___ OFF___ N/A ✓

60 mph Emergency Brake Stops

Stop	Application Force (lb)		Speed (mph)	Decel (fpsps)		Stop Dist. (ft)	Corrected Stopping Distance per SAE J299	In 12 ft Lane	Wheel Lock-up Indication
	Max	Avg		Peak	Avg				
1	123	93	55.2	32	25	166.3	165	yes	no
2	131	54	54.7	18	15	217.2	220	yes	no
3	113	86	55.3	30	24	176.9	175	yes	no
4	95	76	55.0	31	23	190.9	191	yes	no

Ambient Temp.: 67 Wind Speed: 2-4 Direction: 169
Comments

FMVSS 105 — FADE AND RECOVERY
Baseline Snubs

Vehicle: GMC 4x2 School Bus
Date: 8-13-96 Driver: Lyle Observer: Don

☒ First Fade
☐ Second Fade

TEST SPECIFICATIONS:

- Check Tire Pressure
- Vehicle at GVWR
- IBT 150 to 200 °F
- 40 to 20 mph Snubs at 10 ft/sec^2
- Clutch Depressed or Transmission in Neutral
- Manually Controlled Retarder Off

Stop	Maximum Pedal Force	Average Pedal Force	Decel (fpsps)	IBT (°F)				Comments
				1	2	3	4	
1	28	25	10	156	179	179	183	
2	42	33	10	149	165	196	206	
3	40	32	10	159	173	203	204	

Ambient Temp.: 73 Wind Speed: 5-8 Direction: 354
Comments

FMVSS 105 — FADE AND RECOVERY
Fade Snubs — First Fade

Vehicle: GMC 4x2 School Bus
Date: 8-13-96 Driver: Lyle Observer: Don

TEST SPECIFICATIONS:

- Check Tire Pressure
- Vehicle at GVWR
- IBT of First Snub 130 to 150 °F
- 40 to 20 mph Snubs at 10 ft/sec^2
- Clutch Depressed or Transmission in Neutral during Snubs
- 30 Second Interval Between Snubs
- 10 Snubs
- Manually Controlled Retarder Off

Stop	Maximum Pedal Force	Average Pedal Force	Decel (fpsps)		IBT (°F)				Comments
			Max	Avg	1	2	3	4	
1	42	34	9	8	140	149	137	149	
2	43	36	11	10	199	205	199	215	
3	39	33	11	9	250	264	255	268	
4	43	33	11	10	306	322	315	325	
5	34	28	10	8	342	367	362	368	
6	31	26	8	7	383	407	400	404	
7	32	26	9	8	422	451	440	443	
8	35	28	10	8	453	491	482	483	
9	36	31	10	9	489	534	526	526	
10	38	31	11	9	524	584	571	565	

Ambient Temp.: 64 Wind Speed: NA Direction: NA
Comments

FMVSS 105 — FADE AND RECOVERY
Recover Snubs

Vehicle: GMC 4x2 School Bus
Date: 8-13-96 Driver: Lyle Observer: Don

☒ First Fade
☐ Second Fade

TEST SPECIFICATIONS:

- 40 to 20 mph Snubs at 10 ft/sec^2
- 1.5 mile Interval
- Clutch Depressed or Transmission in Neutral
- Manually Controlled Retarder Off

Stop	Maximum Pedal Force	Average Pedal Force	Decel (fpsps)		IBT (°F)				Comments
			Max	Avg	1	2	3	4	
1	41	32	12	10	473	519	574	561	
2	33	27	10	8	443	483	565	560	
3	38	33	12	10	411	451	555	547	
4	37	29	10	9	383	427	550	536	
5	39	31	12	10	374	420	539	535	

Ambient Temp.: 64 Wind Speed: NA Direction: NA
Comments

FMVSS 105 — FADE AND RECOVERY
Baseline Snubs

Vehicle: GMC 4x2 School Bus
Date: 8-14-96 Driver: Lyle Observer: Mark

☐ First Fade
☒ Second Fade

TEST SPECIFICATIONS:

- Check Tire Pressure
- Vehicle at GVWR
- IBT 150 to 200 °F
- 40 to 20 mph Snubs at 10 ft/sec^2
- Clutch Depressed or Transmission in Neutral
- Manually Controlled Retarder Off

Stop	Maximum Pedal Force	Average Pedal Force	Decel (fpsps)	IBT (°F)				Comments
				1	2	3	4	
1	47	37	10	186	197	169	180	
2	44	33	10	187	196	189	198	
3	45	35	10	189	191	194	202	

Ambient Temp.: 79 Wind Speed: 6-12 Direction: 246
Comments

FMVSS 105 — FADE AND RECOVERY
Fade Snubs — Second Fade

Vehicle: GMC 4x2 School Bus
Date: 8-15-96 Driver: Lyle Observer: Mark

TEST SPECIFICATIONS:

- Check Tire Pressure
- Vehicle at GVWR
- IBT of First Snub 130 to 150 °F
- 40 to 20 mph Snubs at 10 ft/sec^2
- Clutch Depressed or Transmission in Neutral during Snubs
- 30 Second Interval Between Snubs
- 20 Snubs
- Manually Controlled Retarder Off

Stop	Maximum Pedal Force	Average Pedal Force	Decel (fpsps)		IBT (°F)				Comments
			Max	Avg	1	2	3	4	
1	54	45	14	11	127	132	133	136	
2	46	39	14	11	191	205	200	215	
3	48	39	13	11	250	269	260	270	
4	49	36	12	10	311	328	318	328	
5	43	32	12	9	363	382	365	382	
6	44	33	12	10	402	430	414	426	
7	NA	NA	NA	NA	NA	NA	NA	NA	
8	42	32	12	10	482	510	496	516	
9	42	35	14	11	511	554	537	560	
10	43	36	14	12	543	604	579	608	
11	45	37	15	12	580	642	628	652	
12	43	33	15	11	608	670	666	692	
13	41	36	14	12	637	695	694	723	
14	42	36	15	12	681	734	725	756	
15	49	37	15	12	700	761	758	784	
16	47	34	15	12	727	790	789	814	
17	45	34	15	12	748	810	814	841	
18	44	34	14	11	769	827	831	869	
19	38	31	14	11	787	853	852	896	
20	39	31	13	10	803	864	875	925	

FMVSS 105 — FADE AND RECOVERY
Recover Snubs

Vehicle: GMC 4x2 School Bus
Date: 8-15-96 Driver: Lyle Observer: Mark

☐ First Fade
☒ Second Fade

TEST SPECIFICATIONS:

- 40 to 20 mph Snubs at 10 ft/sec^2
- 1.5 mile Interval
- Clutch Depressed or Transmission in Neutral
- Manually Controlled Retarder Off

Stop	Maximum Pedal Force	Average Pedal Force	Decel (fpsps)		IBT (°F)				Comments
			Max	Avg	1	2	3	4	
1	45	39	16	12	680	729	800	836	
2	41	36	12	12	615	645	758	788	
3	42	36	14	11	534	582	700	743	
4	44	37	14	11	469	521	661	701	
5	39	33	12	10	435	487	639	682	

Ambient Temp.: 68 Wind Speed: NA Direction: NA
Comments

FMVSS 105 — WATER RECOVERY

Vehicle: GMC 4x2 School Bus

Date: 8-15-96 Driver: Lyle Observer:

Baseline

TEST SPECIFICATIONS:

- Check Tire Pressure
- Vehicle at GVWR
- IBT 150 to 200 °F
- 30 mph Stops at 10 ft/sec^2
- Clutch Depressed or Transmission in Neutral
- Manually Controlled Retarder Off
- Following Baseline Stops, Drive for 2 Minutes at 5 mph in Water Trough with 6 Inches of Water

Stop	Maximum Pedal Force	Average Pedal Force	Decel (fpsps)		Comments
			Max	Avg	
1	63	57	16	13	
2	66	57	16	13	
3	66	57	16	13	

Recovery

TEST SPECIFICATIONS:

- 30 mph Stops at 10 ft/sec^2
- Clutch Depressed or Transmission in Neutral
- Manually Controlled Retarder Off
- Following First Four Stops, Immediately Accelerate at Maximum Rate to 30 mph and Begin Next Stop

Stop	Maximum Pedal Force	Average Pedal Force	Decel (fpsps)		Comments
			Max	Avg	
1	69	52	14	12	
2	58	51	14	12	
3	61	52	14	13	
4	63	56	15	13	
5	66	60	16	14	

Ambient Temp.: 76 Wind Speed: 8-14 Direction: 219

Comments

10.2 Appendix 2

FMVSS 105 - Freightliner 4x2 School Bus
Test Sequence

Sequence	Test	Page
1.	Burnish	
2.	Second Effectiveness	A2-2A & B
3.	Brake-in-a-curve Loaded (@GVWR)	A2-3
4.	First Reburnish	
5.	Third Effectiveness	A2-5A & B
6.	Brake-in-a-curve Empty (@LLVW)	A2-6
7.	Partial Failures Empty	A2-7A & B
8.	Partial Failures Loaded	A2-8A & B
9.	Inoperative Power Assist Loaded	A2-9
10.	Failed ABS Loaded	A2-10
11.	First Fade and Recovery	A2-11A, B, & C
12.	Second Reburnish	
13.	Second Fade and Recovery	A2-13A, B, & C
14.	Third Reburnish	
15.	Water Recovery	A2-15

All 15 steps in this sequence were performed at VRTC.

FMVSS 105 — SERVICE BRAKE STOPPING TEST

Vehicle: Freightliner 4x2 School Bus ☒ GVWR ☐ LLVW
Date: 8-21-96 Driver: Lyle Observer:

TEST SPECIFICATIONS:

- Check Tire Pressure
- 30 mph Service Brake Stops
- IBT 150 to 200 °F
- Clutch Depressed or Transmission in Neutral
- Brakes Can Be Modulated, Brake Force Between 15 and 150 lb
- Vehicle in Center of Lane at Start
- Manually Controlled Retarder. ON_____ OFF_____ N/A ✓

30 mph Service Brake Stops

Stop	Application Force (lb)		Speed (mph)	Decel (fpsps)		Stop Dist. (ft)	Corrected Stopping Distance per SAE J299	In 12 ft Lane	Wheel Lock-up Indication
	Max	Avg		Peak	Avg				
1	119	90	30.5	20	18	74.2	72	yes	no
2	126	91	30.5	21	19	70.7	68	yes	no
3	124	102	30.5	22	20	69.3	67	yes	no
4	123	104	30.3	22	19	69.8	68	yes	no
5	132	113	30.5	24	21	65.6	63	yes	no
6	131	112	30.2	24	21	64.9	64	yes	no

Ambient Temp.: 68 Wind Speed: NA Direction: NA

Comments

FMVSS 105 — SERVICE BRAKE STOPPING TEST

Vehicle: Freightliner 4x2 School Bus ☒ GVWR ☐ LLVW
Date: 8-21-96 Driver: Lyle Observer:

TEST SPECIFICATIONS:

- Check Tire Pressure
- 60 mph Service Brake Stops
- IBT 150 to 200 °F
- Clutch Depressed or Transmission in Neutral
- Brakes Can Be Modulated, Brake Force Between 15 and 150 lb
- Vehicle in Center of Lane at Start
- Manually Controlled Retarder. ON______ OFF______ N/A ✓

60 mph Service Brake Stops

Stop	Application Force (lb)		Speed (mph)	Decel (fpsps)		Stop Dist. (ft)	Corrected Stopping Distance per SAE J299	In 12 ft Lane	Wheel Lock-up Indication
	Max	Avg		Peak	Avg				
1	140	124	60.1	22	20	229.9	229	yes	no
2	167	111	60.4	24	21	220.6	218	yes	no
3	133	117	60.3	24	21	219.3	217	yes	no
4	166	111	60.3	25	20	219.2	217	yes	no
5	141	120	59.9	24	22	217.4	218	yes	no
6	141	120	60.2	23	21	222.5	221	yes	no

Ambient Temp.: 76 Wind Speed: 3-5 Direction: 295

Comments

FMVSS 105 — STABILITY & CONTROL TEST DATA SHEET

Vehicle: Freightliner 4x2 School Bus ☒ GVWR ☐ LLVW

Date: 8-21-96 Driver: Lyle Observer: ____________

TEST SPECIFICATIONS:

- Check Tire Pressure
- Max. Drive-Through Speed (nearest whole mph):
- 75% of Max. Drive-Through Speed (nearest whole mph):
- Braking Runs at 30 mph or 75% Max. Drive-Through Speed:
- IBT 150 to 200 °F
- Clutch Depress or Transmission in Neutral
- Full Brake Application
- Vehicle Within Lane at Start
- Manually Controlled Retarder ON ____________ OFF ____________
  N/A ✓

Maximum Drive Through Speed: 35 mph 75% of Max Drive Through Speed: 26 mph

Stop No.	Speed (mph)	Approx. Dist. Out of Lane (ft)	No. Markers Hit	Comments
1	26.0	0	0	
2	26.0	0	0	
3	26.1	0	0	
4	26.0	0	0	

Ambient Temp.: 82 Wind Speed: 4-7 Direction: 284

Comments Max Brake Through Speed - 34 mph

FMVSS 105 — SERVICE BRAKE STOPPING TEST

Vehicle: Freightliner 4x2 School Bus ☐ GVWR ☒ LLVW

Date: 8-22-96 Driver: Lyle Observer:

TEST SPECIFICATIONS:

- Check Tire Pressure
- 30 mph Service Brake Stops
- IBT 150 to 200 °F
- Clutch Depressed or Transmission in Neutral
- Brakes Can Be Modulated, Brake Force Between 15 and 150 lb
- Vehicle in Center of Lane at Start
- Manually Controlled Retarder. ON ______ OFF ______ N/A ✓

30 mph Service Brake Stops

Stop	Application Force (lb)		Speed (mph)	Decel (fpsps)		Stop Dist. (ft)	Corrected Stopping Distance per SAE J299	In 12 ft Lane	Wheel Lock-up Indication
	Max	Avg		Peak	Avg				
1	114	98	30.5	32	27	50.8	49	yes	no
2	138	104	30.4	31	27	53.3	52	yes	no
3	153	122	30.5	30	27	53.1	51	yes	no
4	133	118	30.2	30	28	52.2	52	yes	no
5	154	115	30.3	30	27	52.7	52	yes	no
6	114	98	30.0	30	27	53.0	53	yes	no

Ambient Temp.: 68 Wind Speed: NA Direction: NA

Comments

FMVSS 105 — SERVICE BRAKE STOPPING TEST

Vehicle: Freightliner 4x2 School Bus ☐ GVWR ☒ LLVW

Date: 8-22-96 Driver: Lyle Observer:________

TEST SPECIFICATIONS:

- Check Tire Pressure
- 60 mph Service Brake Stops
- IBT 150 to 200 °F
- Clutch Depressed or Transmission in Neutral
- Brakes Can Be Modulated, Brake Force Between 15 and 150 lb
- Vehicle in Center of Lane at Start
- Manually Controlled Retarder. ON________ OFF________ N/A ✓

60 mph Service Brake Stops

Stop	Application Force (lb)		Speed (mph)	Decel (fpsps)		Stop Dist. (ft)	Corrected Stopping Distance per SAE J299	In 12 ft Lane	Wheel Lock-up Indication
	Max	Avg		Peak	Avg				
1	136	117	60.4	31	27	188	186	yes	no
2	132	113	60.0	26	24	191	191	yes	no
3	139	114	59.9	31	24	183	184	yes	no
4	146	114	59.9	29	25	181	181	yes	no
5	147	124	60.1	28	25	183	182	yes	no
6	155	113	60.0	28	25	178	178	yes	no

Ambient Temp.: 69 Wind Speed: 3-4 Direction: 138

Comments ________

FMVSS 105 — STABILITY & CONTROL TEST DATA SHEET

Vehicle: Freightliner 4x2 School Bus ☐ GVWR ☒ LLVW
Date: 8-22-96 Driver: Lyle Observer:

TEST SPECIFICATIONS:

- Check Tire Pressure
- Max. Drive-Through Speed (nearest whole mph):
- 75% of Max. Drive-Through Speed (nearest whole mph):
- Braking Runs at 30 mph or 75% Max. Drive-Through Speed:
- IBT 150 to 200 °F
- Clutch Depress or Transmission in Neutral
- Full Brake Application
- Vehicle Within Lane at Start
- Manually Controlled Retarder ON____ OFF____
  N/A ✓

Maximum Drive Through Speed: 37 mph 75% of Max Drive Through Speed: 28 mph

Stop No.	Speed (mph)	Approx. Dist. Out of Lane (ft)	No. Markers Hit	Comments
1	28.2	0	0	
2	28.6	0	0	
3	28.2	0	0	
4	28.0	0	0	

Ambient Temp.: 74 Wind Speed: 6-8 Direction: 206

Comments Max Brake Through Speed - 34 mph

FMVSS 105 — EMERGENCY BRAKE STOPPING TEST

Vehicle: Freightliner 4x2 School Bus ☐ GVWR ☒ LLVW

Date: 8-28-96 Driver: Lyle Observer:

System Failed: ☒ MC Circuit #1 ☐ MC Circuit #2 ☐ Power Assist (GVWR Only) ☐ Antilock (GVWR Only)

TEST SPECIFICATIONS:

- Check Tire Pressure
- 60 mph Service Brake Stops
- IBT 150 to 200 °F
- Transmission in Gear
- Brakes Can Be Modulated, Brake Force Between 15 and 150 lb
- Vehicle in Center of Lane at Start
- Manually Controlled Retarder. ON OFF
  N/A ✓

60 mph Emergency Brake Stops

Stop	Application Force (lb)		Speed (mph)	Decel (fpsps)		Stop Dist. (ft)	Corrected Stopping Distance per SAE J299	In 12 ft Lane	Wheel Lock-up Indication
	Max	Avg		Peak	Avg				
1	134	112	60.1	15	11	406.2	405	yes	no
2	148	126	60.8	15	11	412.1	401	yes	no
3	139	119	60.1	14	11	408.0	407	yes	no
4	144	124	60.2	15	11	416.6	414	yes	no

Ambient Temp.: 68 Wind Speed: 4-7 Direction: 25

Comments Rear Brakes Only, No Front Brakes

FMVSS 105 — EMERGENCY BRAKE STOPPING TEST

Vehicle: Freightliner 4x2 School Bus ☐ GVWR ☒ LLVW
Date: 8-28-96 Driver: Lyle Observer:

System Failed: ☐ MC Circuit #1 ☒ MC Circuit #2 ☐ Power Assist (GVWR Only) ☐ Antilock (GVWR Only)

TEST SPECIFICATIONS:

- Check Tire Pressure
- 60 mph Service Brake Stops
- IBT 150 to 200 °F
- Transmission in Gear
- Brakes Can Be Modulated, Brake Force Between 15 and 150 lb
- Vehicle in Center of Lane at Start
- Manually Controlled Retarder. ON____ OFF____ N/A ✓

60 mph Emergency Brake Stops

Stop	Application Force (lb)		Speed (mph)	Decel (fpsps)		Stop Dist. (ft)	Corrected Stopping Distance per SAE J299	In 12 ft Lane	Wheel Lock-up Indication
	Max	Avg		Peak	Avg				
1	142	128	60.1	16	12	386.2	385	yes	no
2	139	116	60.2	15	12	382.5	380	yes	no
3	138	118	60.3	13	11	410.2	406	yes	no
4	144	110	60.0	15	10	409.6	410	yes	no

Ambient Temp.: 71 Wind Speed: 6 Direction: 350
Comments: Front Brakes Only, No Rear Brakes

FMVSS 105 — EMERGENCY BRAKE STOPPING TEST

Vehicle: Freightliner 4x2 School Bus ☒ GVWR ☐ LLVW
Date: 8-29-96 Driver: Lyle Observer:

System Failed: ☒ MC Circuit #1 ☐ MC Circuit #2 ☐ Power Assist (GVWR Only) ☐ Antilock (GVWR Only)

TEST SPECIFICATIONS:

- Check Tire Pressure
- 60 mph Service Brake Stops
- IBT 150 to 200 °F
- Transmission in Gear
- Brakes Can Be Modulated, Brake Force Between 15 and 150 lb
- Vehicle in Center of Lane at Start
- Manually Controlled Retarder. ON OFF
  N/A ✓

60 mph Emergency Brake Stops

Stop	Application Force (lb)		Speed (mph)	Decel (fpsps)		Stop Dist. (ft)	Corrected Stopping Distance per SAE J299	In 12 ft Lane	Wheel Lock-up Indication
	Max	Avg		Peak	Avg				
1	130	118	60.7	12	11	428.9	419	yes	no
2	133	121	60.4	13	11	410.5	405	yes	no
3	135	119	60.3	12	11	408.6	404	yes	no
4	133	118	60.4	12	11	414.8	409	yes	no

Ambient Temp.: 71 Wind Speed: 3-4 Direction: 68
Comments Rear Brakes Only, No Front Brakes

FMVSS 105 — EMERGENCY BRAKE STOPPING TEST

Vehicle: Freightliner 4x2 School Bus ☒ GVWR ☐ LLVW

Date: 8-29-96 Driver: Lyle Observer:

System Failed: ☐ MC Circuit #1 ☒ MC Circuit #2 ☐ Power Assist (GVWR Only) ☐ Antilock (GVWR Only)

TEST SPECIFICATIONS:

- Check Tire Pressure
- 60 mph Service Brake Stops
- IBT 150 to 200 °F
- Transmission in Gear
- Brakes Can Be Modulated, Brake Force Between 15 and 150 lb
- Vehicle in Center of Lane at Start
- Manually Controlled Retarder. ON___ OFF___ N/A ✓

60 mph Emergency Brake Stops

Stop	Application Force (lb)		Speed (mph)	Decel (fpsps)		Stop Dist. (ft)	Corrected Stopping Distance per SAE J299	In 12 ft Lane	Wheel Lock-up Indication
	Max	Avg		Peak	Avg				
1	138	120	60.5	8	8	551.8	543	yes	no
2	140	115	60.5	10	8	550.4	541	yes	no
3	145	120	60.3	10	8	564.7	559	yes	no
4	140	122	59.9	10	8	547.5	549	yes	no

Ambient Temp.: 61 Wind Speed: N/A Direction: N/A

Comments Front Brakes Only, No Rear Brakes

FMVSS 105 — EMERGENCY BRAKE STOPPING TEST

Vehicle: Freightliner 4x2 School Bus ☒ GVWR ☐ LLVW

Date: 8-29-96 Driver: Lyle Observer:

System Failed: ☐ MC Circuit #1 ☐ MC Circuit #2 ☒ Power Assist (GVWR Only) ☐ Antilock (GVWR Only)

TEST SPECIFICATIONS:

- Check Tire Pressure
- 60 mph Service Brake Stops
- IBT 150 to 200 °F
- Transmission in Gear
- Brakes Can Be Modulated, Brake Force Between 15 and 150 lb
- Vehicle in Center of Lane at Start
- Manually Controlled Retarder. ON ______ OFF ______ N/A ✓

60 mph Emergency Brake Stops

Stop	Application Force (lb)		Speed (mph)	Decel (fpsps)		Stop Dist. (ft)	Corrected Stopping Distance per SAE J299	In 12 ft Lane	Wheel Lock-up Indication
	Max	Avg		Peak	Avg				
1	126	96	60.4	25	22	226.7	224	yes	no
2	161	124	60.4	25	23	209.7	207	yes	no
3	140	121	60.3	25	22	206.1	204	yes	no
4	135	112	60.5	24	22	217.0	213	yes	no

Ambient Temp.: 76 Wind Speed: 2-4 Direction: 04

Comments

FMVSS 105 — EMERGENCY BRAKE STOPPING TEST

Vehicle: Freightliner 4x2 School Bus ☒ GVWR ☐ LLVW
Date: 8-29 & 30-96 Driver: Lyle Observer:

System Failed: ☐ MC Circuit #1 ☐ MC Circuit #2 ☐ Power Assist (GVWR Only) ☒ Antilock (GVWR Only)

TEST SPECIFICATIONS:

- Check Tire Pressure
- 60 mph Service Brake Stops
- IBT 150 to 200 °F
- Transmission in Gear
- Brakes Can Be Modulated, Brake Force Between 15 and 150 lb
- Vehicle in Center of Lane at Start
- Manually Controlled Retarder. ON____ OFF____ N/A ✓

60 mph Emergency Brake Stops

Stop	Application Force (lb)		Speed (mph)	Decel (fpsps)		Stop Dist. (ft)	Corrected Stopping Distance per SAE J299	In 12 ft Lane	Wheel Lock-up Indication
	Max	Avg		Peak	Avg				
1	86	58	60.2	21	16	259.8	258	yes	1 & 2
2	69	59	60.1	19	16	277.3	276	yes	no
3	104	85	60.0	26	21	220.3	220	yes	no
4	109	87	60.3	28	23	214.2	212	yes	no

Ambient Temp.: 77, 56 Wind Speed: 4-7 Direction: 41
Comments Stops 1&2 run on 8-29-96, Stops 3&4 run on 8-30-96

FMVSS 105 — FADE AND RECOVERY
Baseline Snubs

Vehicle: Freightliner 4x2 School Bus
Date: 8-30-96 Driver: Lyle Observer:

☒ First Fade
☐ Second Fade

TEST SPECIFICATIONS:

- Check Tire Pressure
- Vehicle at GVWR
- IBT 150 to 200 °F
- 40 to 20 mph Snubs at 10 ft/sec^2
- Clutch Depressed or Transmission in Neutral
- Manually Controlled Retarder Off

Stop	Maximum Pedal Force	Average Pedal Force	Decel (fpsps)	IBT (°F)				Comments
				1	2	3	4	
1	61	48	13	150	154	159	162	
2	72	55	15	172	198	189	197	
3	56	44	11	177	186	192	198	

Ambient Temp.: 61 Wind Speed: 1-3 Direction: 333
Comments

FMVSS 105 — FADE AND RECOVERY
Fade Snubs — First Fade

Vehicle: Freightliner 4x2 School Bus
Date: 8-30-96 Driver: Lyle Observer: Mark

TEST SPECIFICATIONS:

- Check Tire Pressure
- Vehicle at GVWR
- IBT of First Snub 130 to 150 °F
- 40 to 20 mph Snubs at 10 ft/sec^2
- Clutch Depressed or Transmission in Neutral during Snubs
- 30 Second Interval Between Snubs
- 10 Snubs
- Manually Controlled Retarder Off

Stop	Maximum Pedal Force	Average Pedal Force	Decel (fpsps)		IBT (°F)				Comments
			Max	Avg	1	2	3	4	
1	52	45	12	11	121	134	134	139	
2	77	48	13	12	181	190	196	201	
3	58	41	12	11	237	241	264	268	
4	55	40	12	11	288	286	321	326	
5	60	38	12	11	346	334	366	379	
6	46	36	12	10	373	366	401	411	
7	62	38	11	10	413	405	444	453	
8	47	42	13	11	452	443	484	496	
9	42	37	11	11	479	475	521	534	
10	50	40	13	11	514	512	564	577	

Ambient Temp.: 67 Wind Speed: 2-4 Direction: 98
Comments

FMVSS 105 — FADE AND RECOVERY
Recover Snubs

Vehicle: Freightliner 4x2 School Bus
Date: 8-30-96 Driver: Lyle Observer: Mark

☒ First Fade
☐ Second Fade

TEST SPECIFICATIONS:

- 40 to 20 mph Snubs at 10 ft/sec^2
- 1.5 mile Interval
- Clutch Depressed or Transmission in Neutral
- Manually Controlled Retarder Off

Stop	Maximum Pedal Force	Average Pedal Force	Decel (fpsps)		IBT (°F)				Comments
			Max	Avg	1	2	3	4	
1	47	40	12	11	453	458	525	508	
2	50	39	13	11	407	420	482	468	
3	50	43	13	12	378	397	444	439	
4	49	39	12	11	361	366	407	422	
5	57	42	13	12	341	366	401	399	

Ambient Temp.: 67 Wind Speed: 2-4 Direction: 98
Comments

FMVSS 105 — FADE AND RECOVERY
Baseline Snubs

Vehicle: Freightliner 4x2 School Bus
Date: 8-30-96 Driver: Lyle Observer:

☐ First Fade
☒ Second Fade

TEST SPECIFICATIONS:

- Check Tire Pressure
- Vehicle at GVWR
- IBT 150 to 200 °F
- 40 to 20 mph Snubs at 10 ft/sec^2
- Clutch Depressed or Transmission in Neutral
- Manually Controlled Retarder Off

Stop	Maximum Pedal Force	Average Pedal Force	Decel (fpsps)	IBT (°F)				Comments
				1	2	3	4	
1	63	51	11	155	151	170	172	
2	66	48	10	172	193	199	196	
3	57	46	10	179	190	189	196	

Ambient Temp.: 73 Wind Speed: 2-4 Direction: 75
Comments

FMVSS 105 — FADE AND RECOVERY
Fade Snubs — Second Fade

Vehicle: Freightliner 4x2 School Bus
Date: 8-30-96 Driver: Lyle Observer: Mark

TEST SPECIFICATIONS:
- Check Tire Pressure
- Vehicle at GVWR
- IBT of First Snub 130 to 150 °F
- 40 to 20 mph Snubs at 10 ft/sec^2
- Clutch Depressed or Transmission in Neutral during Snubs
- 30 Second Interval Between Snubs
- 20 Snubs
- Manually Controlled Retarder Off

Stop	Maximum Pedal Force	Average Pedal Force	Decel (fpsps)		IBT (°F)				Comments
			Max	Avg	1	2	3	4	
1	75	53	13	11	133	135	147	151	
2	74	46	12	11	177	196	202	204	
3	70	47	14	12	250	245	259	257	
4	51	41	11	10	295	297	315	308	
5	78	41	11	10	338	338	357	355	
6	62	41	12	10	377	378	397	401	
7	54	39	10	10	404	413	432	440	
8	58	42	11	10	439	424	473	475	
9	48	41	11	10	471	478	503	507	
10	52	40	11	10	503	510	542	554	
11	56	44	12	11	532	533	574	581	
12	47	41	11	10	571	572	607	629	
13	50	44	13	11	604	602	639	656	
14	52	42	12	11	628	626	664	687	
15	46	41	12	10	656	641	688	716	
16	48	43	11	11	669	670	708	743	
17	47	41	11	10	702	665	728	762	
18	51	40	10	9	728	710	752	770	
19	54	40	11	10	745	726	772	803	
20	46	40	11	10	755	736	779	819	

FMVSS 105 — FADE AND RECOVERY
Recover Snubs

Vehicle: Freightliner 4x2 School Bus
Date: 8-30-96 Driver: Lyle Observer: Mark

☐ First Fade
☒ Second Fade

TEST SPECIFICATIONS:

- 40 to 20 mph Snubs at 10 ft/sec^2
- 1.5 mile Interval
- Clutch Depressed or Transmission in Neutral
- Manually Controlled Retarder Off

Stop	Maximum Pedal Force	Average Pedal Force	Decel (fpsps)		IBT (°F)				Comments
			Max	Avg	1	2	3	4	
1	51	45	12	10	609	631	678	672	
2	59	50	12	11	509	560	571	569	
3	58	45	12	10	437	495	510	499	
4	59	46	12	11	403	436	472	458	
5	49	38	11	9	NA	NA	NA	NA	

Ambient Temp.: 74 Wind Speed: 4-6 Direction: 335
Comments

FMVSS 105 — WATER RECOVERY

Vehicle: Freightliner 4x2 School Bus
Date: 9-2-96 Driver: Lyle Observer:

Baseline

TEST SPECIFICATIONS:

- Check Tire Pressure
- Vehicle at GVWR
- IBT 150 to 200 °F
- 30 mph Stops at 10 ft/sec^2
- Clutch Depressed or Transmission in Neutral
- Manually Controlled Retarder Off
- Following Baseline Stops, Drive for 2 Minutes at 5 mph in Water Trough with 6 Inches of Water

Stop	Maximum Pedal Force	Average Pedal Force	Decel (fpsps)		Comments
			Max	Avg	
1	61	52	15	12	
2	53	47	13	12	
3	61	47	15	12	

Recovery

TEST SPECIFICATIONS:

- 30 mph Stops at 10 ft/sec^2
- Clutch Depressed or Transmission in Neutral
- Manually Controlled Retarder Off
- Following First Four Stops, Immediately Accelerate at Maximum Rate to 30 mph and Begin Next Stop

Stop	Maximum Pedal Force	Average Pedal Force	Decel (fpsps)		Comments
			Max	Avg	
1	62	52	12	11	
2	51	46	12	10	
3	59	48	12	11	
4	51	45	11	11	
5	56	45	12	11	

Ambient Temp.: 71 Wind Speed: 2-4 Direction: 120
Comments

10.3 Appendix 3

FMVSS 121 - Freightliner 6x4 Straight Truck
Test Sequence

Sequence	Test	Page
1	Burnish.	A3-1A & B
2	Stability and control test at GVWR.	A3-2
3	Stability and control test at LLVW.	A3-3
4	Manual Brake Adjustment Allowed.	
5	Service brake stopping distance test at GVWR.	A3-5
6	Emergency brake stopping distance test for single unit truck only at GVWR.	
	• Primary system failure.	A3-6A
	• Secondary system failure.	A3-6B
7	Manual Brake Adjustment Allowed.	
8	Service brake stopping distance test at LLVW.	A3-8
9	Emergency brake stopping distance test at LLVW.	
	• Primary system failure.	A3-9A
	• Secondary system failure.	A3-9B

All 9 steps in this sequence were performed at VRTC.

Vehicle: Freightliner 6x4 Straight Truck

BURNISH TEST WEIGHT
Axle 1: 12010
Axle 2: 40180
Axle 3: ______

Driver #1: R Heberling	Date: 9-13-96	Odo. Start: 23827.0	End: 24130.1
Driver #2: R Heberling	Date: 9-14-96	Odo. Start: 24130.2	End: 24334.5
Driver #3:	Date:	Odo. Start:	End:
Driver #4:	Date:	Odo. Start:	End:

Test Start
Date/Time: 9-13-96 1556
Odometer: 23827.0

Test Finish
Date/Time: 9-14-96 2218
Odometer: 24334.5

TEST SPECIFICATIONS:

- 500 Snubs
- Snubs are 40 to 20 mph
- 10 fps^2 Decel Rate in Gear Appropriate for Driving at 40 mph
- 1 Mile Interval (1.5 miles if needed to reach speed)
- Record IBT Every 25th Snub
- Manually Controlled Retarders Off
- Driver Breaks Only After 25 Snub Sequence
- Brakes May Be Adjusted up to 3 times During Burnish

Adjustment Levels

	1L	1R	2L	2R	3L	3R
Initial						
1st						
2nd						
3rd						
Final						

Snub #	Initial Speed mph	Average Cntrl Press. (Optional)	Decel fps^2	Initial Brake Temperatures °F						Ambient Temp °F	Comments	Driver Initials	Time
				1L	1R	2L	2R	3L	3R				
1	40			75	71	69	69	70	70	59			1556
25	40			332	330	342	341	374	409	59			1636
50	40			335	364	340	372	449	516	59			1716
75	40			342	405	354	380	483	543	59	break		1758
100	40			339	395	327	347	448	502	58			1858
125	40			348	413	340	355	474	532	58			1938
150	40			350	420	332	343	476	575	57	lunch		2018
175	40			336	387	292	301	420	462	55			2130
200	40			359	414	311	324	460	513	54			2210

Vehicle: Freightliner 6x4 Straight Truck

Snub #	Initial Speed mph	Average Cntrl Press. (Optional)	Decel fps^2	Initial Brake Temperatures °F						Ambient Temp °F	Comments	Driver Initials	Time
				1L	1R	2L	2R	3L	3R				
225	40			369	424	312	330	471	536	52	break		2250
250	40			369	401	288	303	444	502	53			2347
275	40			381	416	295	314	461	528	52			2026
300	40			380	420	290	306	464	527	52	end of shift		0107
325	40			366	387	265	275	356	397	62			1638
350	40			392	416	287	304	434	485	62			1717
375	40			388	418	284	304	450	510	62			1757
400	40			379	400	283	303	455	516	62			1837
425	40			389	418	287	308	467	531	61	break		1916
450	40			377	396	278	276	414	467	60			2054
475	40			394	410	293	305	475	534	60			2135
500	40			384	400	281	302	472	536	58			2215

Comments Refueled Snub 300 ODO 24130.1

Snub 500 ODO 24334.5

Brake squeal. Light rain snub 426, track damp

STABILITY & CONTROL TEST DATA SHEET

Vehicle: Freightliner 6x4 Straight Truck

Date: 10-3-96 Driver: Lyle Observer:

☒ GVWR ☐ LLVW

TEST SPECIFICATIONS:

- Check Tire Pressure
- Max. Drive-Through Speed (nearest whole mph):
- 75% of Max. Drive-Through Speed (nearest whole mph):
- Braking Runs at 30 mph or 75% Max. Drive-Through Speed: 26 mph
- IBT 150 to 200 °F
- Clutch Depress or Transmission in Neutral
- Full Brake Application
- Vehicle Within Lane at Start
- Manually Controlled Retarder ON____ OFF ✓ N/A____

Stop No.	Speed (mph)	Apply Time (sec)	Approx. Dist. Out of Lane (ft)	No. Markers Hit	Comments
1	26.1	0.15	0	0	
2	26.1	0.15	0	0	
3	25.9	0.10	0	0	
4	26.0	0.10	0	0	

Ambient Temp.: 51 Wind Speed: 8-10 Direction: 64

Comments Max drive through 34 mph, max brake through 34 mph

STABILITY & CONTROL TEST DATA SHEET

Vehicle: Freightliner 6x4 Straight Truck
Date: 10-3-96 Driver: Lyle Observer:

☐ GVWR ☒ LLVW

TEST SPECIFICATIONS:

- Check Tire Pressure
- Max. Drive-Through Speed (nearest whole mph):
- 75% of Max. Drive-Through Speed (nearest whole mph):
- Braking Runs at 30 mph or 75% Max. Drive-Through Speed: 25 mph
- IBT 150 to 200 °F
- Clutch Depress or Transmission in Neutral
- Full Brake Application
- Vehicle Within Lane at Start
- Manually Controlled Retarder ON____ OFF ✓
N/A____

Stop No.	Speed (mph)	Apply Time (sec)	Approx. Dist. Out of Lane (ft)	No. Markers Hit	Comments
1	26.6	0.10	0	0	
2	26.0	0.10	0	0	
3	26.3	0.10	0	0	
4	25.8	0.10	0	0	

Ambient Temp.: 55 Wind Speed: n/a Direction: n/a

Comments Max drive through 33 mph, max brake through 32 mph

SERVICE BRAKE STOPPING TEST

Vehicle: Freightliner 6x4 Straight Truck
Date: 10-4-96 Driver: Lyle Observer:
☒ GVWR ☐ LLVW

TEST SPECIFICATIONS:

- Check Tire Pressure
- 60 mph Service Brake Stops
- IBT 150 to 200 °F
- Clutch Depressed or Transmission in Neutral
- Brakes Can Be Modulated
- Vehicle in Center of Lane at Start
- Manually Controlled Retarder. ON____ OFF ✓
  N/A____

60 mph or--mph Service Brake Stops

Stop	Application Pressure	Speed (mph)	Decel (ft/sec^2)	Stop Dist. (ft)	Corrected Stopping Distance per SAE J299	In 12 ft Lane	Wheel Lock-up Indication
1	104	60.3	15	300.7	298	yes	no
2	100	60.5	15	306.0	301	yes	no
3	100	60.0	14	304.9	305	yes	no
4	100	60.2	14	301.3	299	yes	no
5	104	60.1	15	286.3	285	yes	no
6	102	60.2	15	293.2	291	yes	no

Ambient Temp.: 35 Wind Speed: 3-5 Direction: 49

Comments

EMERGENCY BRAKE STOPPING TEST

Vehicle: Freightliner 6x4 Straight Truck
Date: 10-4-96 Driver: Lyle Observer:____________
☒ GVWR ☐ LLVW

TEST SPECIFICATIONS:

- Check Tire Pressure
- 60 mph Service Brake Stops
- IBT 150 to 200 °F
- Clutch Depressed or Transmission in Neutral
- Brakes Can Be Modulated
- Vehicle in Center of Lane at Start
- Manually Controlled Retarder. ON____________ OFF ✓____________
  N/A____________

Primary System Failure
60 mph or--mph Emergency Brake Stops

Stop	Application Pressure	Speed (mph)	Decel (ft/sec^2)	Stop Dist. (ft)	Corrected Stopping Distance per SAE J299	In 12 ft Lane	Wheel Lock-up Indication
1	100	60.3	9	469.1	464	yes	no
2	100	59.5	9	478.2	486	yes	no
3	100	60.5	8	526.3	518	yes	no
4	102	60.1	9	495.9	494	yes	no
5	100	60.7	9	497.6	486	yes	no
6	98	59.8	9	503.9	507	yes	no

Ambient Temp.: 38 Wind Speed: 4-6 Direction: 70

Comments ____________

EMERGENCY BRAKE STOPPING TEST

Vehicle: Freightliner 6x4 Straight Truck

Date: 10-4-96 Driver: Lyle Observer:

☒ GVWR ☐ LLVW

TEST SPECIFICATIONS:

- Check Tire Pressure
- 60 mph Service Brake Stops
- IBT 150 to 200 °F
- Clutch Depressed or Transmission in Neutral
- Brakes Can Be Modulated
- Vehicle in Center of Lane at Start
- Manually Controlled Retarder. ON____ OFF ✓ N/A____

Secondary System Failure

60 mph or--mph Emergency Brake Stops

Stop	Application Pressure	Speed (mph)	Decel (ft/sec^2)	Stop Dist. (ft)	Corrected Stopping Distance per SAE J299	In 12 ft Lane	Wheel Lock-up Indication
1	94	61.0	12	365.4	354	yes	no
2	99	60.5	12	342.9	337	yes	no
3	100	60.7	12	350.9	343	yes	no
4	99	60.5	12	347.2	341	yes	no
5	99	59.9	12	346.6	348	yes	no
6	100	60.5	12	342.0	336	yes	no

Ambient Temp.: 46 Wind Speed: 8-12 Direction: 76

Comments

SERVICE BRAKE STOPPING TEST

Vehicle: Freightliner 6x4 Straight Truck
Date: 10-5-96 Driver: Lyle Observer:
☐ GVWR ☒ LLVW

TEST SPECIFICATIONS:

- Check Tire Pressure
- 60 mph Service Brake Stops
- IBT 150 to 200 °F
- Clutch Depressed or Transmission in Neutral
- Brakes Can Be Modulated
- Vehicle in Center of Lane at Start
- Manually Controlled Retarder. ON____ OFF ✓
  N/A____

60 mph or--mph Service Brake Stops

Stop	Application Pressure	Speed (mph)	Decel (ft/sec^2)	Stop Dist. (ft)	Corrected Stopping Distance per SAE J299	In 12 ft Lane	Wheel Lock-up Indication
1	106	60.1	18	235.2	234	yes	no
2	108	60.1	17	232.9	232	yes	no
3	106	60.2	17	236.4	235	yes	no
4	105	59.9	17	228.5	229	yes	no
5	106	60.4	18	232.6	230	yes	no
6	105	59.8	18	228.8	230	yes	no

Ambient Temp.: 35 Wind Speed: 0-1 Direction: 346

Comments

EMERGENCY BRAKE STOPPING TEST

Vehicle: Freightliner 6x4 Straight Truck
Date: 10-5-96 Driver: Lyle Observer:
☐ GVWR ☒ LLVW

TEST SPECIFICATIONS:

- Check Tire Pressure
- 60 mph Service Brake Stops
- IBT 150 to 200 °F
- Clutch Depressed or Transmission in Neutral
- Brakes Can Be Modulated
- Vehicle in Center of Lane at Start
- Manually Controlled Retarder. ON____ OFF ✓
  N/A____

Primary System Failure
60 mph or--mph Emergency Brake Stops

Stop	Application Pressure	Speed (mph)	Decel (ft/sec^2)	Stop Dist. (ft)	Corrected Stopping Distance per SAE J299	In 12 ft Lane	Wheel Lock-up Indication
1	97	59.9	17	232.4	233	yes	wheel 6
2	98	59.8	18	234.9	236	yes	wheel 5
3	97	60.3	18	232.4	230	yes	wheel 5
4	97	60.2	18	226.7	225	yes	wheel 5
5	99	60.1	18	227.4	227	yes	wheel 5
6	99	60.1	18	227.5	227	yes	wheel 5 & 6

Ambient Temp.: 35 Wind Speed: 1-2 Direction: 308

Comments

EMERGENCY BRAKE STOPPING TEST

Vehicle: Freightliner 6x4 Straight Truck
Date: 10-5-96 Driver: Lyle Observer:
☐ GVWR ☒ LLVW

TEST SPECIFICATIONS:

- Check Tire Pressure
- 60 mph Service Brake Stops
- IBT 150 to 200 °F
- Clutch Depressed or Transmission in Neutral
- Brakes Can Be Modulated
- Vehicle in Center of Lane at Start
- Manually Controlled Retarder. ON____ OFF ✓ N/A____

Secondary System Failure

60 mph or--mph Emergency Brake Stops

Stop	Application Pressure	Speed (mph)	Decel (ft/sec^2)	Stop Dist. (ft)	Corrected Stopping Distance per SAE J299	In 12 ft Lane	Wheel Lock-up Indication
1	97	60.7	11	346.4	338	yes	no
2	97	61.2	10	358.2	344	yes	no
3	98	60.6	11	348.3	341	yes	no
4	98	60.8	11	349.2	340	yes	no
5	101	60.2	11	334.2	332	yes	no
6	99	60.1	11	329.1	328	yes	no

Ambient Temp.: 41 Wind Speed: 3-4 Direction: 108
Comments

10.4 Appendix 4

FMVSS 121 - Peterbilt 6x4 Straight Truck
Test Sequence

All 9 steps in this sequence were performed at VRTC.

Vehicle: Peterbilt 6x4 Straight Truck

BURNISH TEST WEIGHT	
Axle 1:	19990
Axle 2:	40050 tandem
Axle 3:	

Driver	Name	Date	Odo. Start	End
Driver #1:	R Heberling	10-3-96	3048	3378
Driver #2:	R Heberling	10-4-96	3378	3559
Driver #3:				
Driver #4:				

Test Start
Date/Time: 10-3-96 1400
Odometer: 3048

Test Finish
Date/Time: 10-4-96 2110
Odometer: 3559

TEST SPECIFICATIONS:

- 500 Snubs
- Snubs are 40 to 20 mph
- 10 fps² Decel Rate in Gear Appropriate for Driving at 40 mph
- 1 Mile Interval (1.5 miles if needed to reach speed)
- Record IBT Every 25th Snub
- Manually Controlled Retarders Off
- Driver Breaks Only After 25 Snub Sequence
- Brakes May Be Adjusted up to 3 times During Burnish

Adjustment Levels

	1L	1R	2L	2R	3L	3R
Initial						
1st						
2nd						
3rd						
Final						

Snub #	Initial Speed mph	Average Cntrl Press. (Optional)	Decel fps²	Initial Brake Temperatures °F						Ambient Temp °F	Comments	Driver Initials	Time
				1L	1R	2L	2R	3L	3R				
1	40			68	73	69	68	69	70	50			1359
25	40			242	240	386	376	389	398	51			1436
50	40			248	244	440	430	467	474	52			1515
75	40			260	249	467	451	493	494	52			1554
100	40			260	245	464	452	496	496	53			1632
125	40			266	247	464	457	496	496	53	break		1712
150	40			252	233	414	415	449	463	53			1818
175	40			256	235	449	453	492	499	51			1851
200	40			256	234	449	459	499	520	47			1931

Vehicle: Peterbilt 6x4 Straight Truck

Snub #	Initial Speed mph	Average Cntrl Press. (Optional)	Decel fps^2	Initial Brake Temperatures °F						Ambient Temp °F	Comments	Driver Initials	Time
				1L	1R	2L	2R	3L	3R				
225	40			246	233	444	440	488	502	46	lunch		2010
250	40			232	199	404	390	439	449	43			2124
275	40			212	184	405	408	456	470	42			2203
300	40			237	205	447	446	490	511	41			2242
325	40			244	211	457	452	499	516	40	end of shift		2322
350	40			249	211	380	366	390	400	55			1631
375	40			261	225	455	440	483	493	54			1709
400	40			263	230	468	456	496	510	54			1747
425	40			266	230	466	463	503	521	53	break		1828
450	40			247	204	392	383	425	445	50			1943
475	40			241	202	440	426	482	499	48			2021
500	40			241	194	443	424	482	503	47	end		2101

Comments Refueled Snub 325

STABILITY & CONTROL TEST DATA SHEET

Vehicle: Peterbilt 6x4 Straight Truck
Date: 10-7-96 Driver: Lyle Observer:
☒ GVWR ☐ LLVW

TEST SPECIFICATIONS:

- Check Tire Pressure
- Max. Drive-Through Speed (nearest whole mph):
- 75% of Max. Drive-Through Speed (nearest whole mph): 24 mph
- Braking Runs at 30 mph or 75% Max. Drive-Through Speed:
- IBT 150 to 200 °F
- Clutch Depress or Transmission in Neutral
- Full Brake Application
- Vehicle Within Lane at Start
- Manually Controlled Retarder ON____ OFF ✓
N/A____

Stop No.	Speed (mph)	Apply Time (sec)	Approx. Dist. Out of Lane (ft)	No. Markers Hit	Comments
1	24.4	0.10	0	0	
2	24.0	0.10	0	0	
3	24.3	0.15	0	0	
4	24.2	0.10	0	0	

Ambient Temp.: 62 Wind Speed: 3-5 Direction: 170

Comments Max drive through 32 mph, max brake through 30 mph

STABILITY & CONTROL TEST DATA SHEET

Vehicle: Peterbilt 6x4 Straight Truck
Date: 10-7-96 Driver: Lyle Observer:
☐ GVWR ☒ LLVW

TEST SPECIFICATIONS:

- Check Tire Pressure
- Max. Drive-Through Speed (nearest whole mph):
- 75% of Max. Drive-Through Speed (nearest whole mph):
- Braking Runs at 30 mph or 75% Max. Drive-Through Speed: 24 mph
- IBT 150 to 200 °F
- Clutch Depress or Transmission in Neutral
- Full Brake Application
- Vehicle Within Lane at Start
- Manually Controlled Retarder ON ______ OFF ✓
N/A ______

Stop No.	Speed (mph)	Apply Time (sec)	Approx. Dist. Out of Lane (ft)	No. Markers Hit	Comments
1	24.3	0.10	0	0	
2	24.1	0.15	0	0	
3	24.3	0.15	0	0	
4	24.3	0.15	0	0	

Ambient Temp.: 60 Wind Speed: 5-7 Direction: 137

Comments Max drive through 32 mph, max brake through 31 mph

SERVICE BRAKE STOPPING TEST

Vehicle: Peterbilt 6x4 Straight Truck
Date: 10-7-96 Driver: Lyle Observer: ______
☒ GVWR ☐ LLVW

TEST SPECIFICATIONS:

- Check Tire Pressure
- 60 mph Service Brake Stops
- IBT 150 to 200 °F
- Clutch Depressed or Transmission in Neutral
- Brakes Can Be Modulated
- Vehicle in Center of Lane at Start
- Manually Controlled Retarder. ON ______ OFF ✓ ______
  N/A ______

60 mph or--mph Service Brake Stops

Stop	Application Pressure	Speed (mph)	Decel (ft/sec^2)	Stop Dist. (ft)	Corrected Stopping Distance per SAE J299	In 12 ft Lane	Wheel Lock-up Indication
1	104	60.4	12	315.0	311	yes	no
2	95	60.7	12	340.5	333	yes	no
3	103	60.3	14	286.7	284	yes	no
4	104	60.4	14	283.0	279	yes	no
5	96	60.3	14	295.0	292	yes	no
6	104	60.1	13	331.6	330	yes	no

Ambient Temp.: 68 Wind Speed: 8-11 Direction: 131

Comments ______

EMERGENCY BRAKE STOPPING TEST

Vehicle: Peterbilt 6x4 Straight Truck
Date: 10-7-96 Driver: Lyle Observer:
☒ GVWR ☐ LLVW

TEST SPECIFICATIONS:

- Check Tire Pressure
- 60 mph Service Brake Stops
- IBT 150 to 200 °F
- Clutch Depressed or Transmission in Neutral
- Brakes Can Be Modulated
- Vehicle in Center of Lane at Start
- Manually Controlled Retarder. ON____ OFF ✓
  N/A____

Primary System Failure

60 mph or--mph Emergency Brake Stops

Stop	Application Pressure	Speed (mph)	Decel (ft/sec^2)	Stop Dist. (ft)	Corrected Stopping Distance per SAE J299	In 12 ft Lane	Wheel Lock-up Indication
1	101	59.7	12	334.7	338	yes	no
2	100	59.9	12	349.6	351	yes	no
3	93	60.1	12	324.8	324	yes	no
4	101	60.0	12	327.3	327	yes	no
5	101	60.2	11	353.4	351	yes	no
6	101	60.4	10	358.2	353	yes	no

Ambient Temp.: 72 Wind Speed: 7-9 Direction: 207

Comments

EMERGENCY BRAKE STOPPING TEST

Vehicle: Peterbilt 6x4 Straight Truck
Date: 10-8-96 Driver: Lyle Observer:
☒ GVWR ☐ LLVW

TEST SPECIFICATIONS:

- Check Tire Pressure
- 60 mph Service Brake Stops
- IBT 150 to 200 °F
- Clutch Depressed or Transmission in Neutral
- Brakes Can Be Modulated
- Vehicle in Center of Lane at Start
- Manually Controlled Retarder. ON____ OFF ✓ N/A____

Secondary System Failure
60 mph or--mph Emergency Brake Stops

Stop	Application Pressure	Speed (mph)	Decel (ft/sec^2)	Stop Dist. (ft)	Corrected Stopping Distance per SAE J299	In 12 ft Lane	Wheel Lock-up Indication
1	94	59.9	12	395.8	397	yes	no
2	99	60.6	12	414.8	407	yes	no
3	100	60.1	12	376.5	375	yes	no
4	99	59.7	12	360.1	364	yes	no
5	99	59.9	12	363.6	365	yes	no
6	100	60.4	12	369.5	365	yes	no

Ambient Temp.: 54 Wind Speed: 9-10 Direction: SW

Comments

SERVICE BRAKE STOPPING TEST

Vehicle: Peterbilt 6x4 Straight Truck

Date: 10-8-96 Driver: Lyle Observer:

☐ GVWR ☒ LLVW

TEST SPECIFICATIONS:

- Check Tire Pressure
- 60 mph Service Brake Stops
- IBT 150 to 200 °F
- Clutch Depressed or Transmission in Neutral
- Brakes Can Be Modulated
- Vehicle in Center of Lane at Start
- Manually Controlled Retarder. ON OFF ✓ N/A

60 mph or--mph Service Brake Stops

Stop	Application Pressure	Speed (mph)	Decel (ft/sec^2)	Stop Dist. (ft)	Corrected Stopping Distance per SAE J299	In 12 ft Lane	Wheel Lock-up Indication
1	105	60.7	17	248.8	243	yes	no
2	97	60.1	18	219.3	218	yes	no
3	106	60.0	18	224.7	225	yes	no
4	104	60.5	18	235.4	232	yes	no
5	107	60.1	18	230.3	230	yes	no
6	106	59.9	18	233.9	235	yes	no

Ambient Temp.: 56 Wind Speed: 8-9 Direction: 357

Comments

EMERGENCY BRAKE STOPPING TEST

Vehicle: Peterbilt 6x4 Straight Truck
Date: 10-8-96 Driver: Lyle Observer:
☐ GVWR ☒ LLVW

TEST SPECIFICATIONS:

- Check Tire Pressure
- 60 mph Service Brake Stops
- IBT 150 to 200 °F
- Clutch Depressed or Transmission in Neutral
- Brakes Can Be Modulated
- Vehicle in Center of Lane at Start
- Manually Controlled Retarder. ON____ OFF ✓
N/A____

Primary System Failure

60 mph or--mph Emergency Brake Stops

Stop	Application Pressure	Speed (mph)	Decel (ft/sec^2)	Stop Dist. (ft)	Corrected Stopping Distance per SAE J299	In 12 ft Lane	Wheel Lock-up Indication
1	103	60.4	15	265.8	262	yes	no
2	103	60.1	16	262.4	262	yes	wheel 6
3	103	60.5	15	275.2	271	yes	no
4	103	60.1	15	261.0	260	yes	no
5	104	59.5	16	250.4	255	yes	no
6	104	60.1	17	248.3	247	yes	no

Ambient Temp.: 56 Wind Speed: 4-7 Direction: 23

Comments

EMERGENCY BRAKE STOPPING TEST

Vehicle: Peterbilt 6x4 Straight Truck
Date: 10-8-96 Driver: Lyle Observer:
☐ GVWR ☒ LLVW

TEST SPECIFICATIONS:

- Check Tire Pressure
- 60 mph Service Brake Stops
- IBT 150 to 200 °F
- Clutch Depressed or Transmission in Neutral
- Brakes Can Be Modulated
- Vehicle in Center of Lane at Start
- Manually Controlled Retarder. ON ____ OFF ✓ N/A ____

Secondary System Failure
60 mph or--mph Emergency Brake Stops

Stop	Application Pressure	Speed (mph)	Decel (ft/sec^2)	Stop Dist. (ft)	Corrected Stopping Distance per SAE J299	In 12 ft Lane	Wheel Lock-up Indication
1	93	60.1	19	227.9	227	yes	no
2	97	59.8	19	222.1	224	yes	no
3	98	59.5	19	215.2	219	yes	no
4	99	60.5	18	236.7	233	yes	no
5	96	60.1	18	234.1	233	yes	no
6	99	60.3	19	231.5	229	yes	no

Ambient Temp.: 58 Wind Speed: 6-8 Direction: 12

Comments

10.5 Appendix 5

FMVSS 121 - Navistar 6x4 Straight Truck
Test Sequence

Sequence	Test	Page
1	Burnish.	
2	Stability and control test at GVWR.	A5-2
3	Stability and control test at LLVW.	A5-3
4	Manual Brake Adjustment Allowed.	
5	Service brake stopping distance test at GVWR.	A5-5
6	Emergency brake stopping distance test for single unit truck only at GVWR.	
	• Primary system failure.	A5-6A
	• Secondary system failure.	A5-6B
7	Manual Brake Adjustment Allowed.	
8	Service brake stopping distance test at LLVW.	A5-8
9	Emergency brake stopping distance test at LLVW.	
	• Primary system failure.	A5-9A
	• Secondary system failure.	A5-9B

Step 1 was performed by the supplier.
The other 8 steps in this sequence were performed at VRTC.

STABILITY & CONTROL TEST DATA SHEET

Vehicle: Navistar 6x4 Straight Truck
Date: 10-31-96 Driver: Lyle Observer:
☒ GVWR ☐ LLVW

TEST SPECIFICATIONS:

- Check Tire Pressure
- Max. Drive-Through Speed (nearest whole mph):
- 75% of Max. Drive-Through Speed (nearest whole mph):
- Braking Runs at 30 mph or 75% Max. Drive-Through Speed: 26 mph
- IBT 150 to 200 °F
- Clutch Depress or Transmission in Neutral
- Full Brake Application
- Vehicle Within Lane at Start
- Manually Controlled Retarder ON___ OFF___ N/A ✓

Stop No.	Speed (mph)	Apply Time (sec)	Approx. Dist. Out of Lane (ft)	No. Markers Hit	Comments
1	26.0	0.14	0	0	
2	26.2	0.14	0	0	
3	26.2	0.14	0	0	
4	26.2	0.13	0	0	

Ambient Temp.: 31 Wind Speed: 8-12 Direction: 238

Comments Max drive through 34 mph, max brake through 30 mph

STABILITY & CONTROL TEST DATA SHEET

Vehicle: Navistar 6x4 Straight Truck

Date: 10-31-96 Driver: Lyle Observer: ______

☐ GVWR ☒ LLVW

TEST SPECIFICATIONS:

- Check Tire Pressure
- Max. Drive-Through Speed (nearest whole mph):
- 75% of Max. Drive-Through Speed (nearest whole mph):
- Braking Runs at 30 mph or 75% Max. Drive-Through Speed: 25 mph
- IBT 150 to 200 °F
- Clutch Depress or Transmission in Neutral
- Full Brake Application
- Vehicle Within Lane at Start
- Manually Controlled Retarder ON ______ OFF ______ N/A ✓

Stop No.	Speed (mph)	Apply Time (sec)	Approx. Dist. Out of Lane (ft)	No. Markers Hit	Comments
1	25.4	0.15	0	0	
2	25.2	0.14	0	0	
3	25.0	0.14	0	0	
4	25.2	0.14	0	0	

Ambient Temp.: 37 Wind Speed: 10-18 Direction: 248

Comments Max drive through 33 mph, max brake through 30 mph

SERVICE BRAKE STOPPING TEST

Vehicle: Navistar 6x4 Straight Truck
Date: 10-31-96 Driver: Lyle Observer:
☒ GVWR ☐ LLVW

TEST SPECIFICATIONS:

- Check Tire Pressure
- 60 mph Service Brake Stops
- IBT 150 to 200 °F
- Clutch Depressed or Transmission in Neutral
- Brakes Can Be Modulated
- Vehicle in Center of Lane at Start
- Manually Controlled Retarder ON____ OFF____ N/A ✓

60 mph or--mph Service Brake Stops

Stop	Application Pressure	Speed (mph)	Decel (ft/sec^2)	Stop Dist. (ft)	Corrected Stopping Distance per SAE J299	In 12 ft Lane	Wheel Lock-up Indication
1	99	60.7	14	295.6	289	yes	no
2	100	60.4	15	281.1	277	yes	no
3	101	60.5	15	282.5	278	yes	no
4	99	60.2	16	284.6	283	yes	no
5	99	60.0	16	274.1	274	yes	no
6	99	60.0	16	269.4	269	yes	no

Ambient Temp.: 42 Wind Speed: 15-20 Direction: 244

Comments

EMERGENCY BRAKE STOPPING TEST

Vehicle: Navistar 6x4 Straight Truck
Date: 11-1-96 Driver: Lyle Observer:
☒ GVWR ☐ LLVW

TEST SPECIFICATIONS:

- Check Tire Pressure
- 60 mph Service Brake Stops
- IBT 150 to 200 °F
- Clutch Depressed or Transmission in Neutral
- Brakes Can Be Modulated
- Vehicle in Center of Lane at Start
- Manually Controlled Retarder ON____ OFF____ N/A ✓

Primary System Failure
60 mph or--mph Emergency Brake Stops

Stop	Application Pressure	Speed (mph)	Decel (ft/sec^2)	Stop Dist. (ft)	Corrected Stopping Distance per SAE J299	In 12 ft Lane	Wheel Lock-up Indication
1	91	60.1	10	376.0	375	yes	no
2	90	60.5	11	372.9	367	yes	no
3	90	60.1	11	378.3	377	yes	no
4	90	60.0	10	367.3	367	yes	no
5	90	60.1	11	366.1	365	yes	no
6	91	60.1	11	360.1	359	yes	no

Ambient Temp.: 33 Wind Speed: 10-12 Direction: 264

Comments

EMERGENCY BRAKE STOPPING TEST

Vehicle: Navistar 6x4 Straight Truck
Date: 11-1-96 Driver: Lyle Observer:
☒ GVWR ☐ LLVW

TEST SPECIFICATIONS:

- Check Tire Pressure
- 60 mph Service Brake Stops
- IBT 150 to 200 °F
- Clutch Depressed or Transmission in Neutral
- Brakes Can Be Modulated
- Vehicle in Center of Lane at Start
- Manually Controlled Retarder ON OFF
  N/A ✓

Secondary System Failure
60 mph or--mph Emergency Brake Stops

Stop	Application Pressure	Speed (mph)	Decel (ft/sec^2)	Stop Dist. (ft)	Corrected Stopping Distance per SAE J299	In 12 ft Lane	Wheel Lock-up Indication
1	93	60.2	12	338.4	336	yes	no
2	93	60.3	12	333.1	330	yes	no
3	97	60.1	12	326.5	325	yes	no
4	92	60.4	11	336.2	332	yes	no
5	93	60.0	12	335.7	336	yes	no
6	96	60.1	12	333.6	332	yes	no

Ambient Temp.: 39 Wind Speed: 10-15 Direction: 259

Comments

SERVICE BRAKE STOPPING TEST

Vehicle: Navistar 6x4 Straight Truck
Date: 11-5-96 Driver: Lyle Observer:
☐ GVWR ☒ LLVW

TEST SPECIFICATIONS:

- Check Tire Pressure
- 60 mph Service Brake Stops
- IBT 150 to 200 °F
- Clutch Depressed or Transmission in Neutral
- Brakes Can Be Modulated
- Vehicle in Center of Lane at Start
- Manually Controlled Retarder ON____ OFF____ N/A ✓

60 mph or--mph Service Brake Stops

Stop	Application Pressure	Speed (mph)	Decel (ft/sec^2)	Stop Dist. (ft)	Corrected Stopping Distance per SAE J299	In 12 ft Lane	Wheel Lock-up Indication
1	95	60.1	21	197.6	197	yes	no
2	103	60.2	21	197.7	196	yes	3,4
3	99	60.1	21	190.2	190	yes	4
4	102	60.2	21	191.0	190	yes	3
5	102	60.0	21	191.0	191	yes	no
6	101	60.4	20	196.4	194	yes	no

Ambient Temp.: 48 Wind Speed: 6-8 Direction: 193

Comments

EMERGENCY BRAKE STOPPING TEST

Vehicle: Navistar 6x4 Straight Truck
Date: 11-5-96 Driver: Lyle Observer:
☐ GVWR ☒ LLVW

TEST SPECIFICATIONS:

- Check Tire Pressure
- 60 mph Service Brake Stops
- IBT 150 to 200 °F
- Clutch Depressed or Transmission in Neutral
- Brakes Can Be Modulated
- Vehicle in Center of Lane at Start
- Manually Controlled Retarder ON____ OFF____ N/A ✓

Primary System Failure

60 mph or--mph Emergency Brake Stops

Stop	Application Pressure	Speed (mph)	Decel (ft/sec^2)	Stop Dist. (ft)	Corrected Stopping Distance per SAE J299	In 12 ft Lane	Wheel Lock-up Indication
1	92	60.1	21	194.8	194	yes	3,4,5,6
2	93	59.9	16	200.4	201	yes	3,4,6
3	92	60.1	21	196.5	196	yes	3,4,5,6
4	93	59.9	22	189.7	190	yes	3,4,5,6
5	92	60.1	22	192.9	192	yes	3,4,5,6
6	93	60.2	22	191.1	190	yes	3,4,5,6

Ambient Temp.: 54 Wind Speed: 8-9 Direction: 208

Comments Wheel lockups near end of stops

EMERGENCY BRAKE STOPPING TEST

Vehicle: Navistar 6x4 Straight Truck
Date: 11-6-96 Driver: Lyle Observer:
☐ GVWR ☒ LLVW

TEST SPECIFICATIONS:

- Check Tire Pressure
- 60 mph Service Brake Stops
- IBT 150 to 200 °F
- Clutch Depressed or Transmission in Neutral
- Brakes Can Be Modulated
- Vehicle in Center of Lane at Start
- Manually Controlled Retarder ON____ OFF____ N/A ✓

Secondary System Failure
60 mph or--mph Emergency Brake Stops

Stop	Application Pressure	Speed (mph)	Decel (ft/sec^2)	Stop Dist. (ft)	Corrected Stopping Distance per SAE J299	In 12 ft Lane	Wheel Lock-up Indication
1	94	60.7	11	346.2	338	yes	no
2	95	60.2	12	308.2	306	yes	3,4
3	96	60.3	12	286.7	284	yes	3,4
4	93	60.0	13	298.0	298	yes	no
5	95	60.1	13	293.2	292	yes	3,4
6	93	60.2	12	295.1	293	yes	no

Ambient Temp.: 46 Wind Speed: 8 Direction: 166

Comments Wheel lockups near end of stops

10.6 Appendix 6

FMVSS 121 - Navistar 4x2 Straight Truck w/152" WB
Test Sequence

Sequence	Test	Page
1	Burnish.	
2	Stability and control test at GVWR.	A6-2
3	Stability and control test at LLVW.	A6-3
4	Manual Brake Adjustment Allowed.	
5	Service brake stopping distance test at GVWR.	
6	Emergency brake stopping distance test for single unit truck only at GVWR. ● Primary system failure. ● Secondary system failure.	
7	Manual Brake Adjustment Allowed	
8	Service brake stopping distance test at LLVW.	
9	Emergency brake stopping distance test at LLVW. ● Primary system failure. ● Secondary system failure.	

Only the two brake-in-a-curve tests (#2 & #3) were performed at VRTC.
All other steps in this sequence were performed by the supplier.

STABILITY & CONTROL TEST DATA SHEET

Vehicle: Navistar 4900, 4x2 straight truck 152" WB
Date: 10-10-96 Driver: Lyle Observer:
☒ GVWR ☐ LLVW

TEST SPECIFICATIONS:

- Check Tire Pressure
- Max. Drive-Through Speed (nearest whole mph):
- 75% of Max. Drive-Through Speed (nearest whole mph):
- Braking Runs at 30 mph or 75% Max. Drive-Through Speed: 27 mph
- IBT 150 to 200 °F
- Clutch Depress or Transmission in Neutral
- Full Brake Application
- Vehicle Within Lane at Start
- Manually Controlled Retarder ON____ OFF X
  N/A____

Stop No.	Speed (mph)	Apply Time (sec)	Approx. Dist. Out of Lane (ft)	No. Markers Hit	Comments
1	27.1	NA	0	0	
2	27.2	NA	0	0	
3	27.3	NA	0	0	
4	27.1	NA	0	0	

Ambient Temp.: Wind Speed: Direction:

Comments Max drive through 36 mph, Max brake through 34 mph

STABILITY & CONTROL TEST DATA SHEET

Vehicle: Navistar 4900, 4x2 straight truck 152" WB
Date: 10-10-96 Driver: Lyle Observer:

☐ GVWR ☒ LLVW

TEST SPECIFICATIONS:

- Check Tire Pressure
- Max. Drive-Through Speed (nearest whole mph):
- 75% of Max. Drive-Through Speed (nearest whole mph):
- Braking Runs at 30 mph or 75% Max. Drive-Through Speed: 27 mph
- IBT 150 to 200 °F
- Clutch Depress or Transmission in Neutral
- Full Brake Application
- Vehicle Within Lane at Start
- Manually Controlled Retarder ON____ OFF X
  N/A____

Stop No.	Speed (mph)	Apply Time (sec)	Approx. Dist. Out of Lane (ft)	No. Markers Hit	Comments
1	27.2	NA	0	0	
2	27.3	NA	0	0	
3	27.0	NA	0	0	
4	27.2	NA	0	0	

Ambient Temp.: Wind Speed: Direction:

Comments Max drive through 36 mph, Max brake through 34 mph

10.7 Appendix 7

FMVSS 121 - Navistar 4x2 Straight Truck w/148" WB
with Heavy Duty Rear Axle
Test Sequence

Sequence	Test	Page
1	Burnish.	
2	Stability and control test at GVWR.	A7-2
3	Stability and control test at LLVW.	A7-3
4	Manual Brake Adjustment Allowed.	
5	Service brake stopping distance test at GVWR.	
6	Emergency brake stopping distance test for single unit truck only at GVWR. • Primary system failure. • Secondary system failure.	
7	Manual Brake Adjustment Allowed	
8	Service brake stopping distance test at LLVW.	
9	Emergency brake stopping distance test at LLVW. • Primary system failure. • Secondary system failure.	

Only the two brake-in-a-curve tests (#2 & #3) were performed at VRTC.
All other steps in this sequence were performed by the supplier.

STABILITY & CONTROL TEST DATA SHEET

Vehicle: Navistar 2674, 4x2 straight truck 148" WB
Date: 4-10-97 Driver: Lyle Observer: ____________
☒ GVWR ☐ LLVW

TEST SPECIFICATIONS:

- Check Tire Pressure
- Max. Drive-Through Speed (nearest whole mph):
- 75% of Max. Drive-Through Speed (nearest whole mph):
- Braking Runs at 30 mph or 75% Max. Drive-Through Speed: 27 mph
- IBT 150 to 200 °F
- Clutch Depress or Transmission in Neutral
- Full Brake Application
- Vehicle Within Lane at Start
- Manually Controlled Retarder ON ____________ OFF ____________
  N/A X

Stop No.	Speed (mph)	Apply Time (sec)	Approx. Dist. Out of Lane (ft)	No. Markers Hit	Comments
1	27.1	NA	0	0	
2	27.3	NA	0	0	
3	27.1	NA	0	0	
4	27.2	NA	0	0	

Ambient Temp.: 38 Wind Speed: 4-7 Direction: 144

Comments Max drive through 36 mph, Max brake through 28 mph

STABILITY & CONTROL TEST DATA SHEET

Vehicle: Navistar 2674, 4x2 straight truck 148" WB
Date: 4-10-97 Driver: Lyle Observer: ______
Date: ______ Driver: ______ Observer: ______

☐ GVWR ☒ LLVW

TEST SPECIFICATIONS:

- Check Tire Pressure
- Max. Drive-Through Speed (nearest whole mph):
- 75% of Max. Drive-Through Speed (nearest whole mph):
- Braking Runs at 30 mph or 75% Max. Drive-Through Speed: 27 MPH
- IBT 150 to 200 °F
- Clutch Depress or Transmission in Neutral
- Full Brake Application
- Vehicle Within Lane at Start
- Manually Controlled Retarder ON ______ OFF ______ N/A X

Stop No.	Speed (mph)	Apply Time (sec)	Approx. Dist. Out of Lane (ft)	No. Markers Hit	Comments
1	27.2	NA	2	3	
2	27.5	NA	4	4	
3	26.8	NA	2	3	
4	25.9	NA	2	3	

Ambient Temp.: 42 Wind Speed: 4-6 Direction: 182

Comments Max drive through 36 mph, Max brake through 22 mph
This truck has a rear axle that exceeds the normal maximum capacity of 29,000# for FMVSS No.121.

10.8 APPENDIX 8

10.8.1 - Roller Dynamometer Brake Force Measurement

A Hans Hermann BM Roller Dynamometer was used to measure the brake retardation force produced by each test vehicle. Individual wheel brake forces were compared to the input pedal force on hydraulic braked buses, and to the treadle applied control air pressure on pneumatic braked trucks. Individual graphs of the dynamometer measured braking forces vs. the respective inputs are located in section 10.8.2. The dynamometer data provides a benchmark, for the VRTC lab, to indicate the brake force at each wheel and the balance of the whole braking system. If the vehicle does not respond as expected during a test on the track, a quick retest on the dynamometer often aids in diagnostics. This is not a test required by FMVSS No. 121.

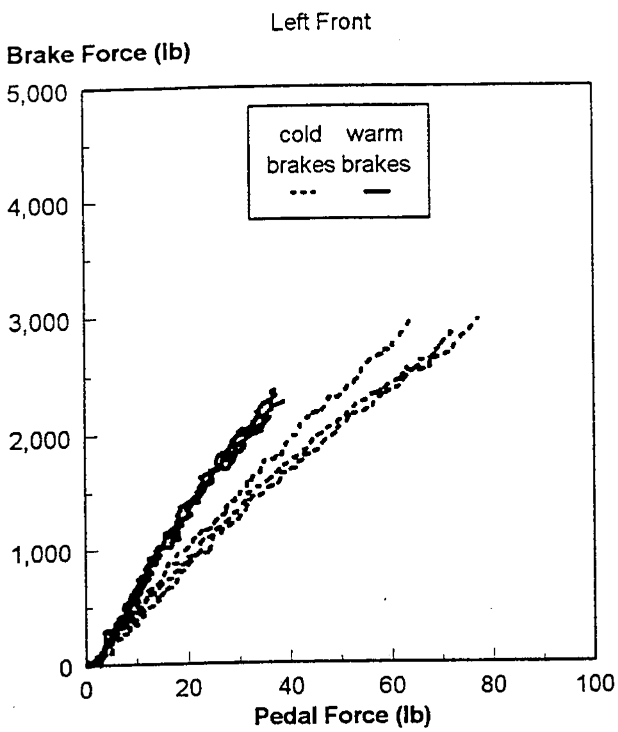
The BM Roller Dynamometer used two 24-hp (18-kW) electric motors to individually drive both the left and right wheels of the selected axle simultaneously at 2.2 mph (3.5 kph). While the driver applied an increasing force to the brake pedal to activate the brakes over the whole service range, a pedal force transducer or a treadle pressure transducer recorded the input effort, and load cells in the dynamometer measured the axle weight and the generated braking forces with respect to time. Plots were then generated to reflect the output brake force for the given input effort.

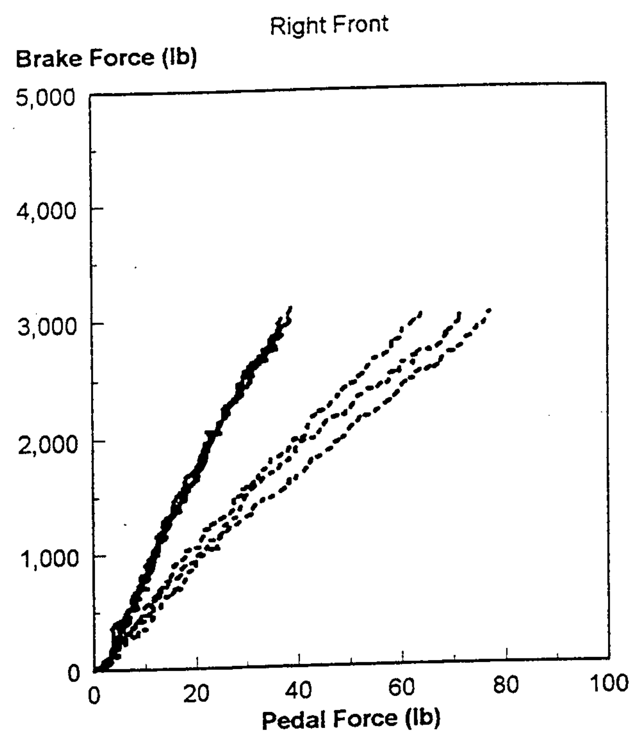
The roller dynamometer test was normally run after the 500 mile initial brake burnish cycle while the test unit was still loaded to GVWR. There was negligible difference in output between drum brakes at room temperature and ones that were slightly warmed. Typically, the drum brakes were dynamometer tested at room temperature. However, the hydraulic braked buses were equipped with disc brakes, and more uniform results were obtained with slightly warmed brakes. Typically, a warming cycle for the disc brakes consisted of driving the vehicle on the track, and performing four to six snubs, from 40 mph to 20 mph, at a deceleration rate of 10 feet per second per second (~0.31g). In the brake force versus pedal force plots (section 10.8.2), the GMC bus plots reflect an example of the effect of the temperature difference for the given brake conditions.

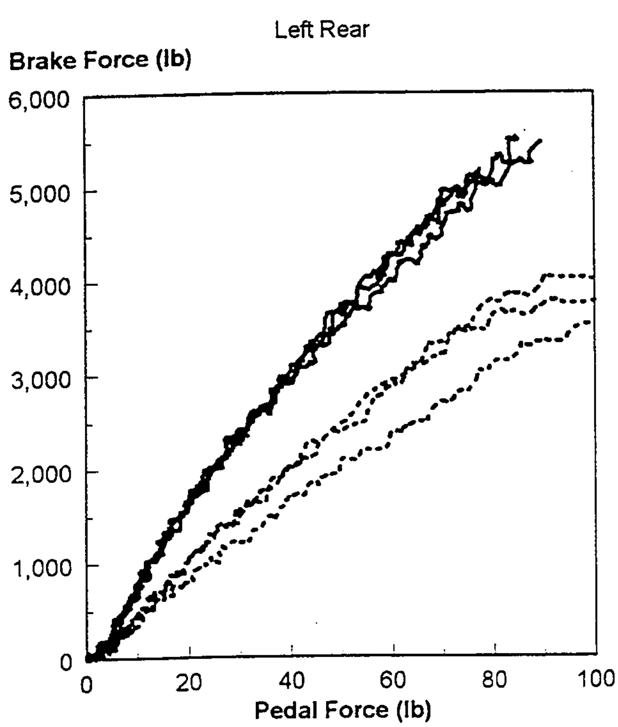
10.8.2 - Roller Dynamometer - Graphs Of Brake Force Output Vs. Input

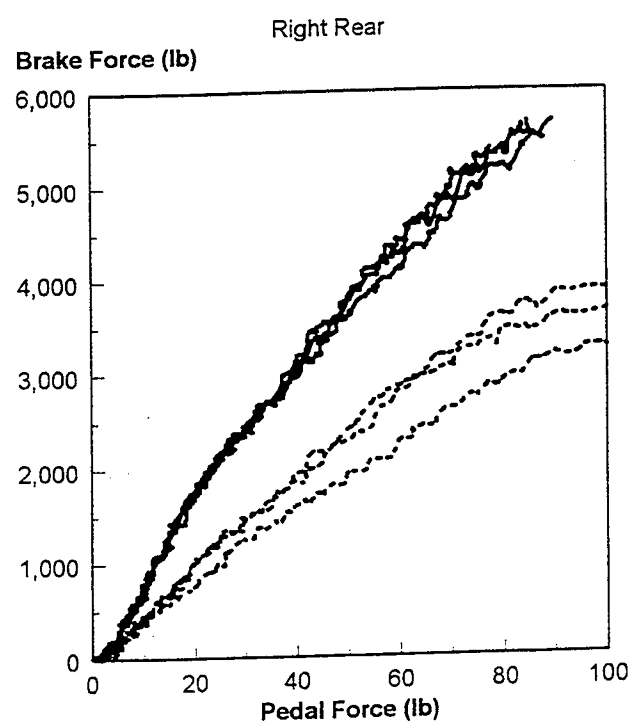
Note: Each graph shows plots from three test runs on the BM roller dynamometer. The GMC bus has an extra set of plots showing the difference in temperature variation between room temperature, and slightly warmed brakes.

GM 4x2 Bus

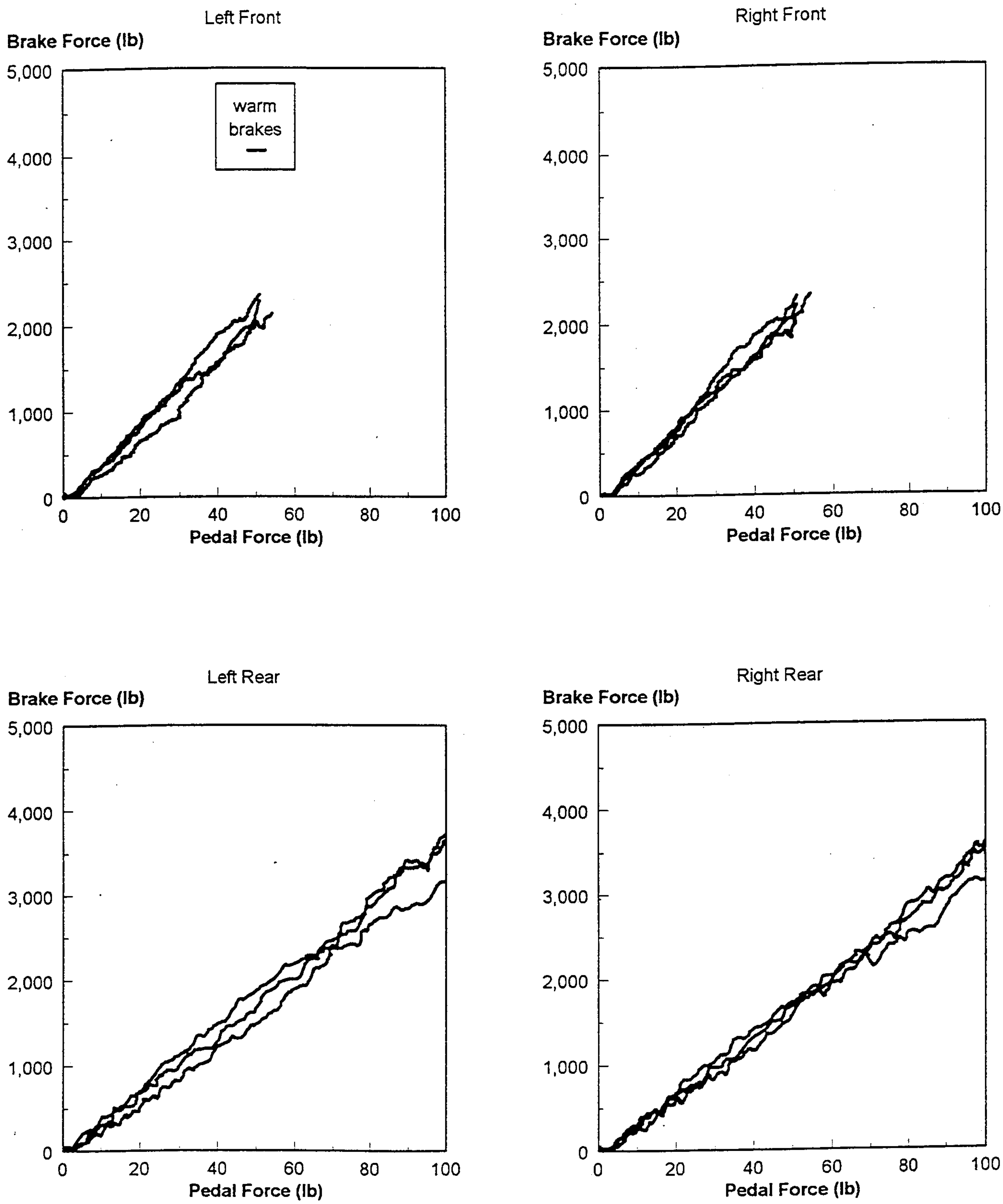

Left Front
Brake Force (lb)
5,000
4,000
3,000
2,000
1,000
0
cold brakes
warm brakes
0
20
40
60
80
100
Pedal Force (lb)


Right Front
Brake Force (lb)
5,000
4,000
3,000
2,000
1,000
0
0
20
40
60
80
100
Pedal Force (lb)


Left Rear
Brake Force (lb)
6,000
5,000
4,000
3,000
2,000
1,000
0
0
20
40
60
80
100
Pedal Force (lb)

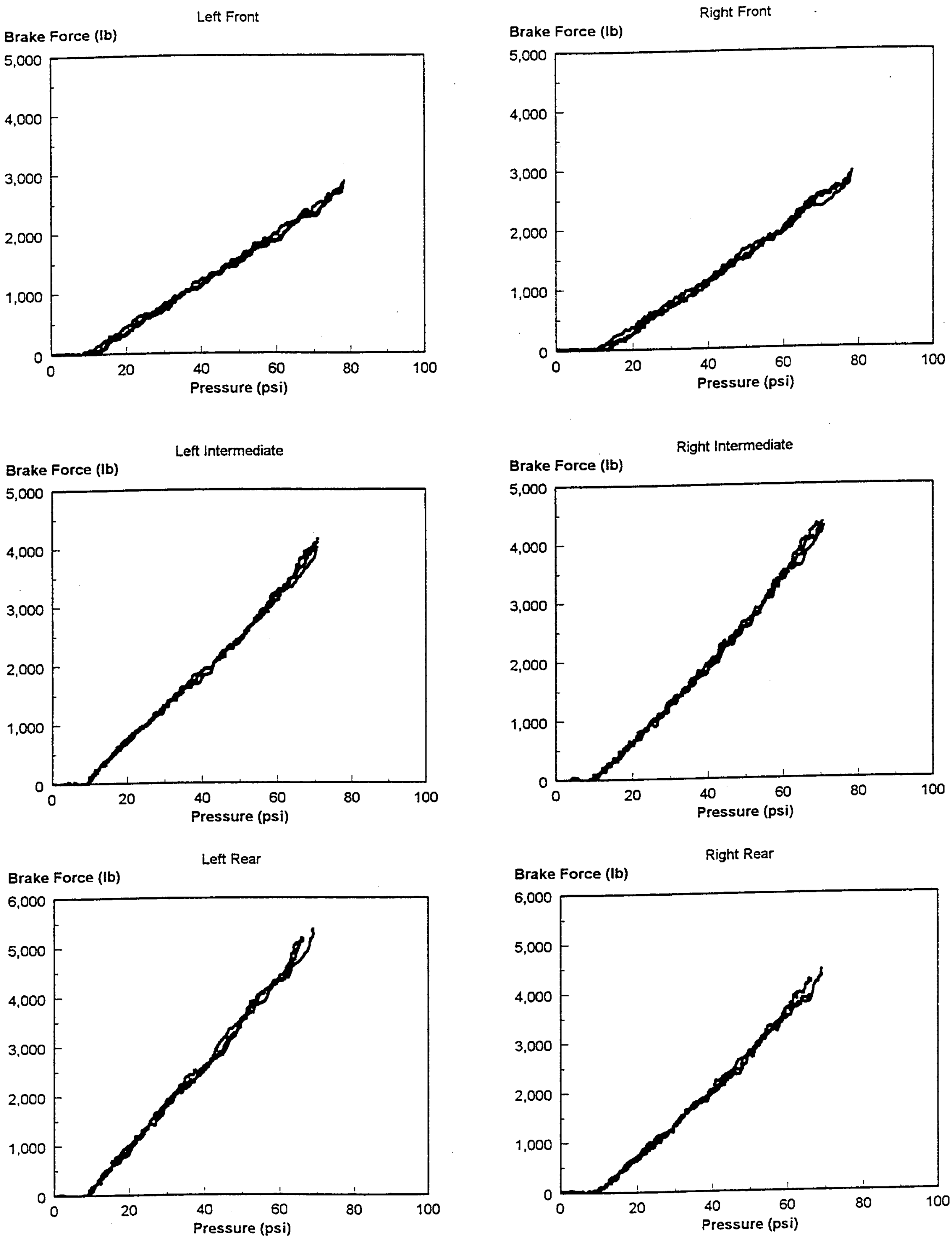

Right Rear
Brake Force (lb)
6,000
5,000
4,000
3,000
2,000
1,000
0
0
20
40
60
80
100
Pedal Force (lb)

Freightliner 4x2 Bus



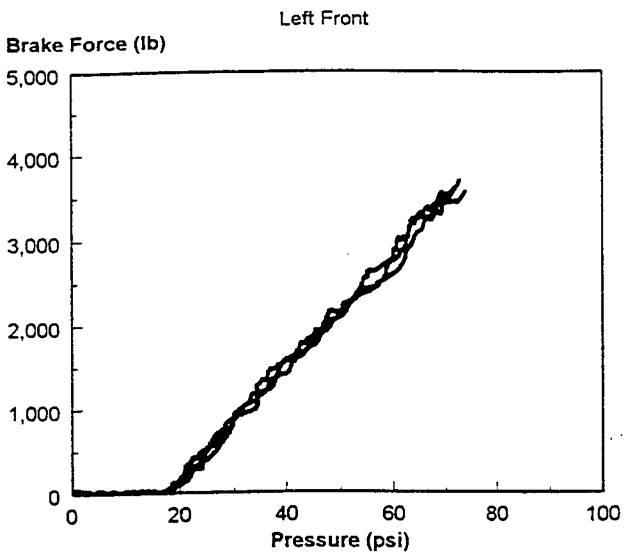
10.8.2.3 - unit C

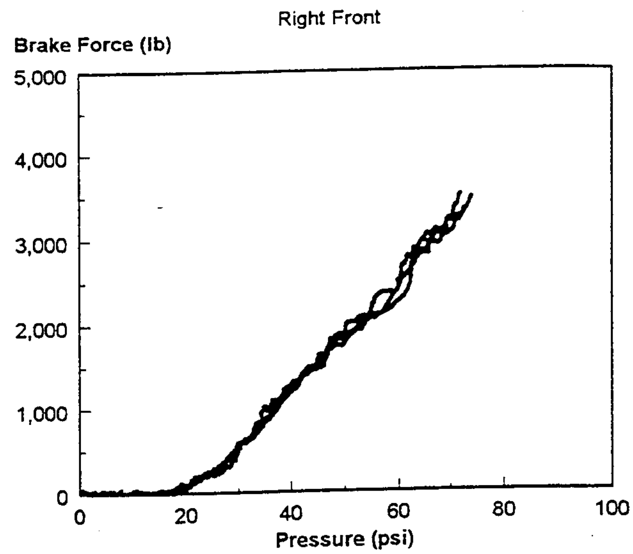
Freightliner 6x4 Straight Truck

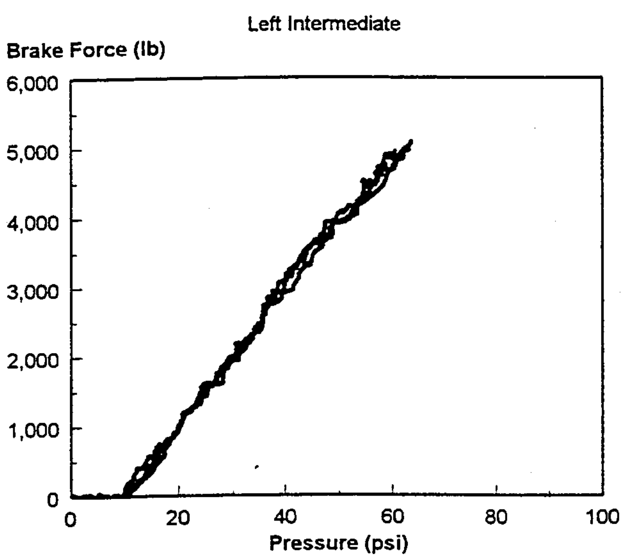


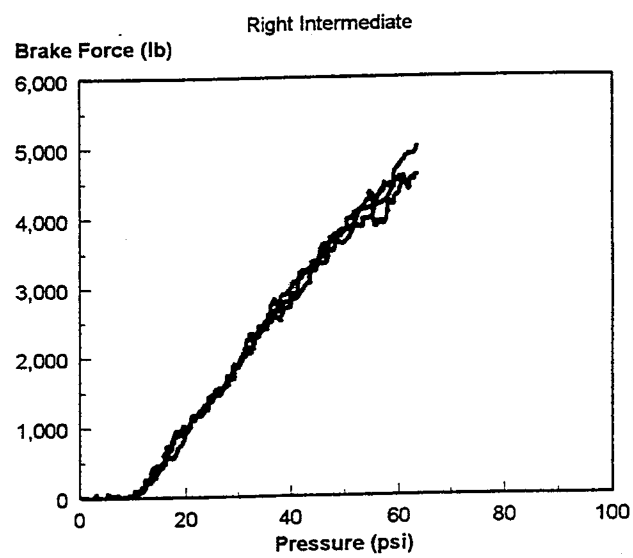
10.8.2.4 - unit D

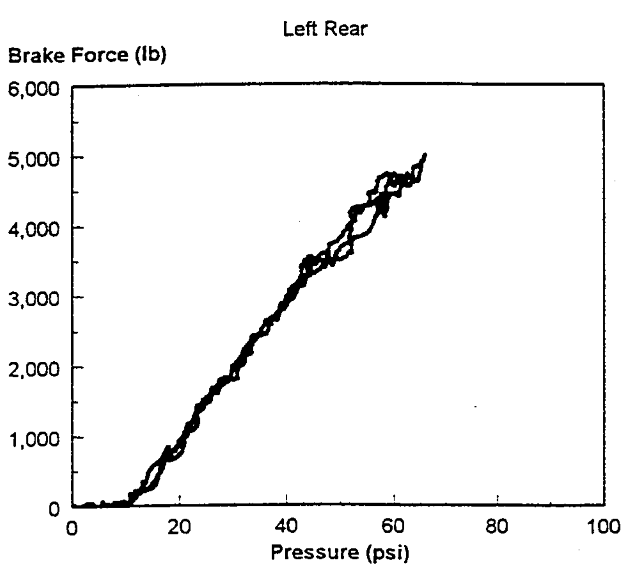
Peterbilt 6x4 Straight Truck

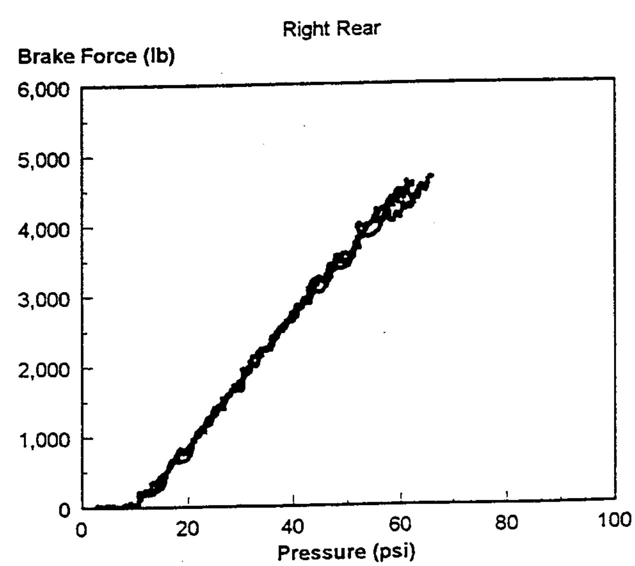






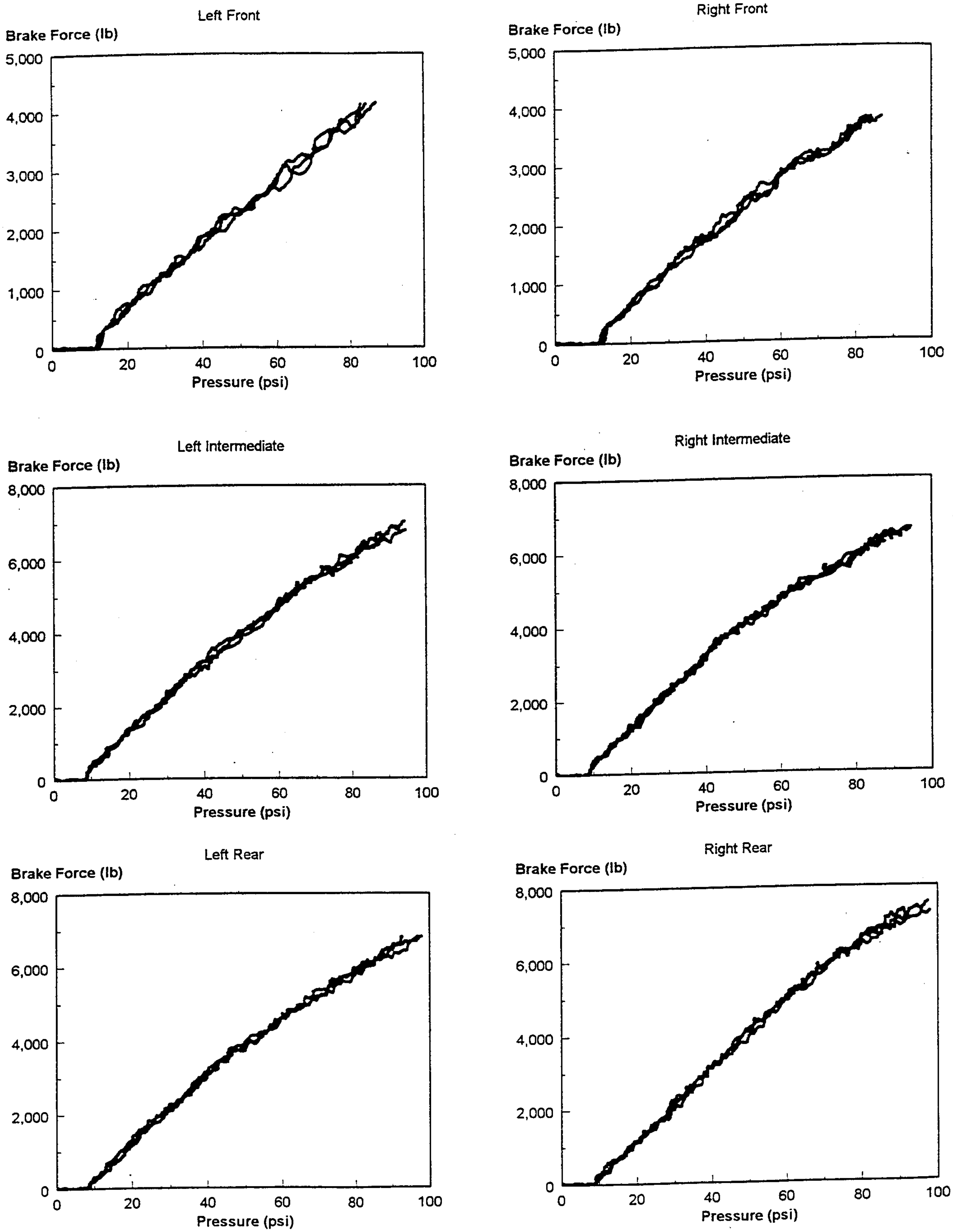






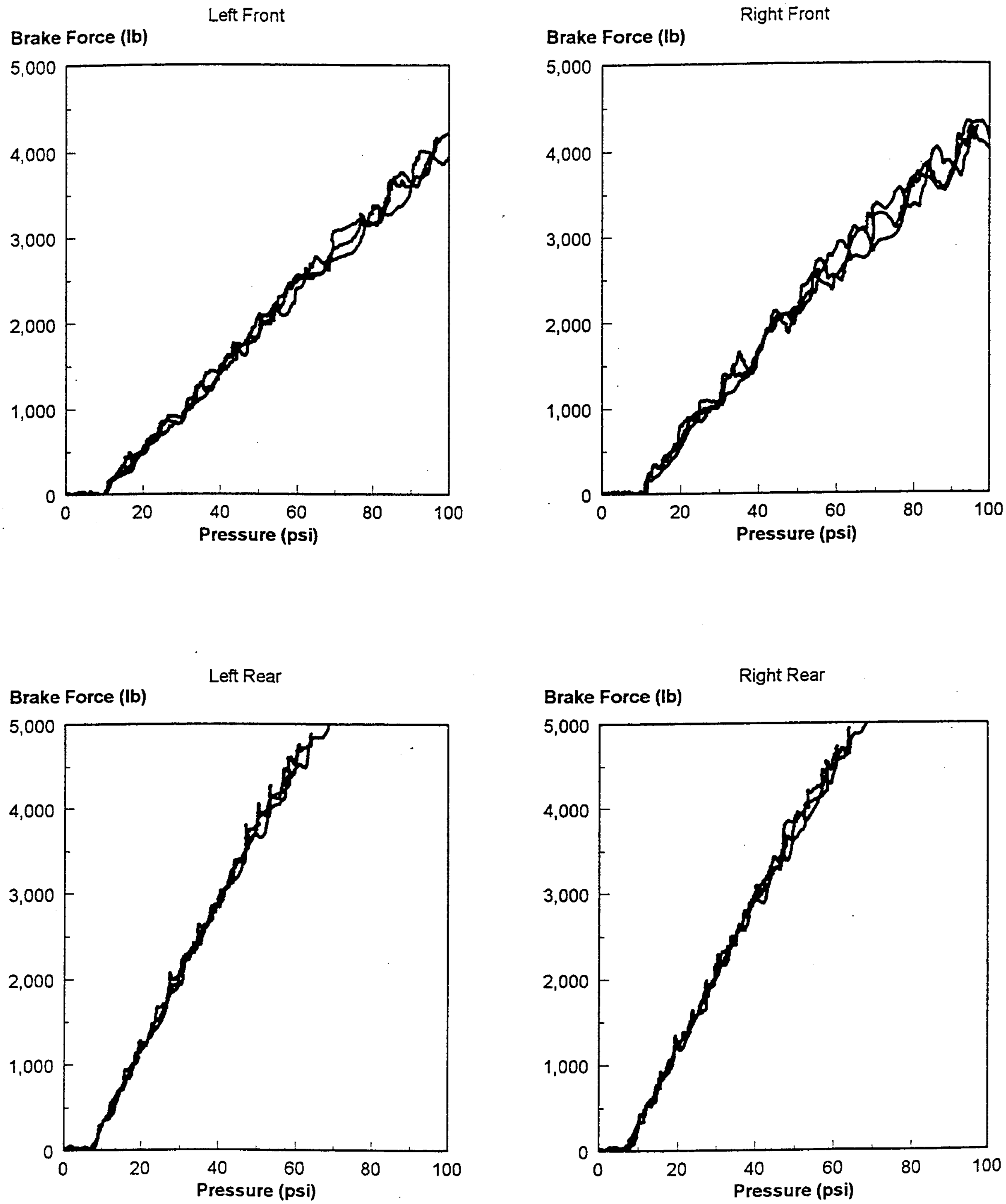
10.8.2.5 - unit E

Navistar 6x4 Straight Truck



Navistar 4x2 Straight Truck

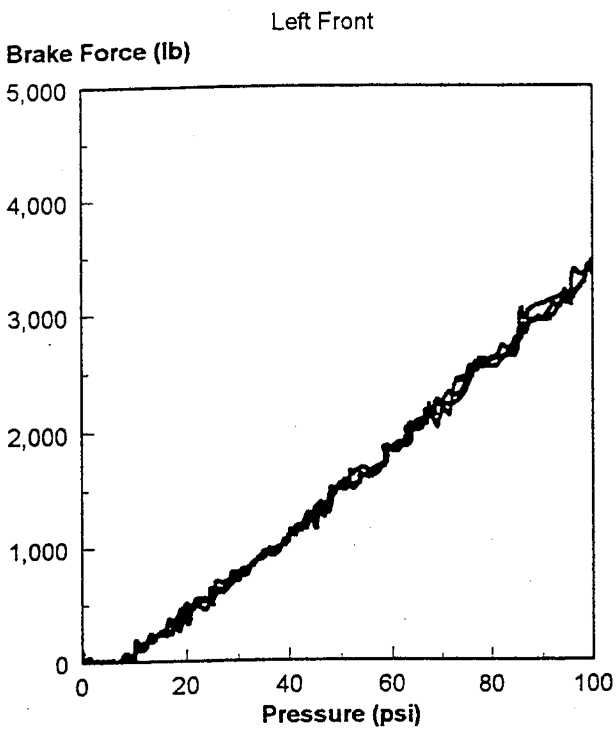
152" WB

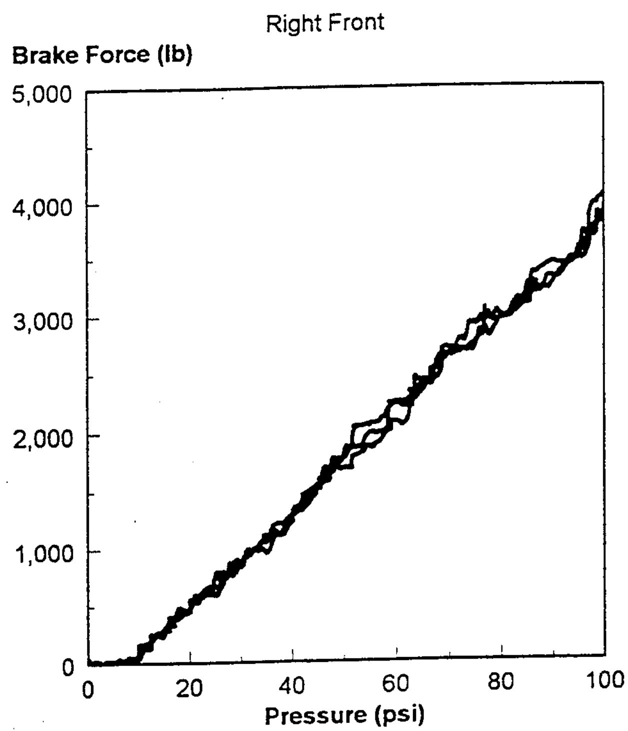


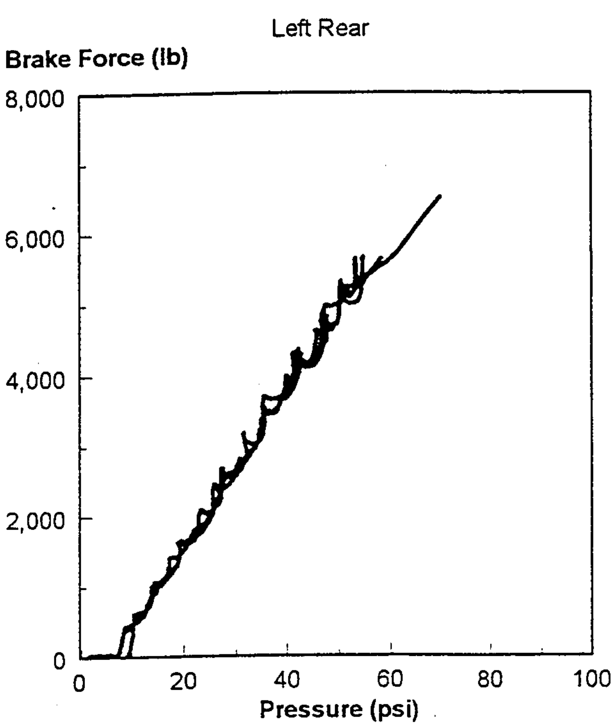
10.8.2.7 - unit G

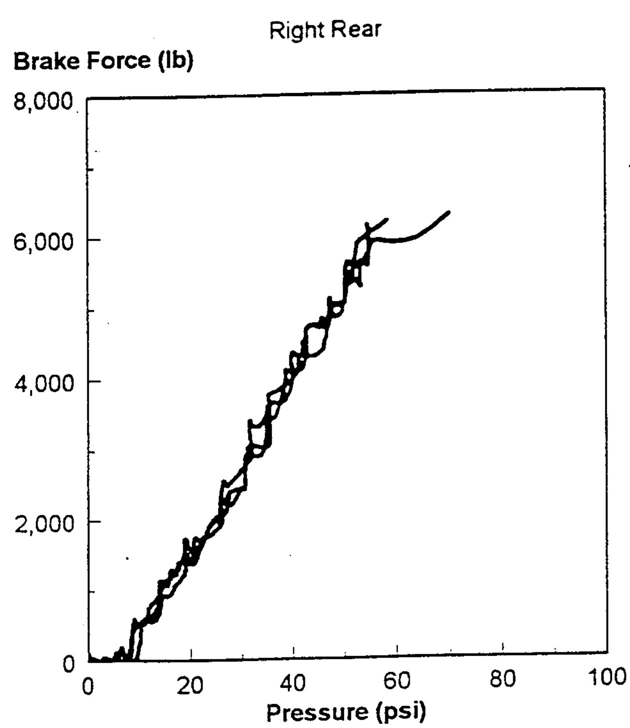
Navistar 4x2 Straight Truck

Heavy Duty Axle 148" WB









10.9 APPENDIX 9

Plots of Pedal Force, Vehicle Speed, and Decel vs. Time for the Two Hydraulic Braked 4x2 School Buses During the Braking-In-A-Curve Tests.

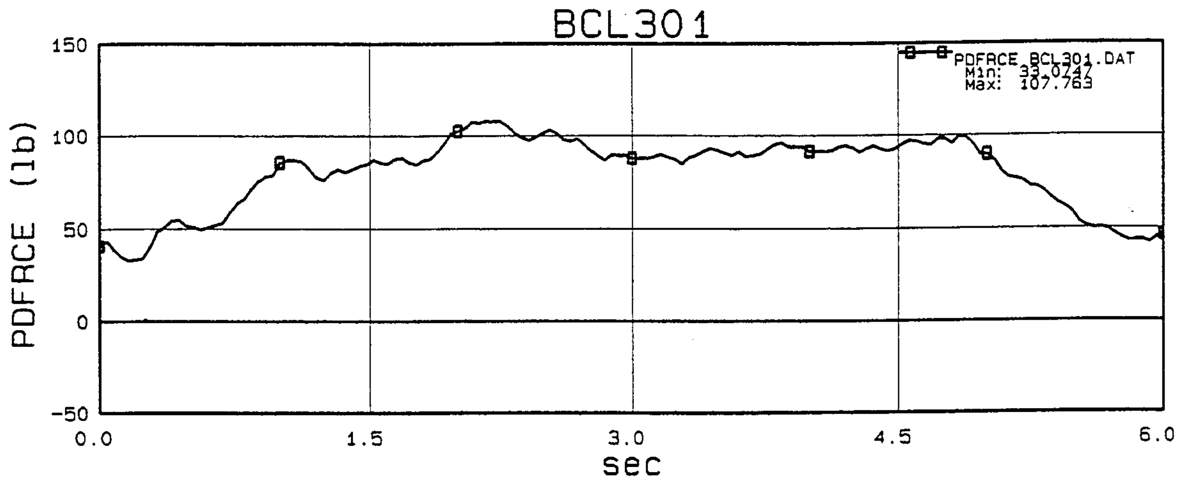
10.9.1 - GMC School Bus - FMVSS No. 105

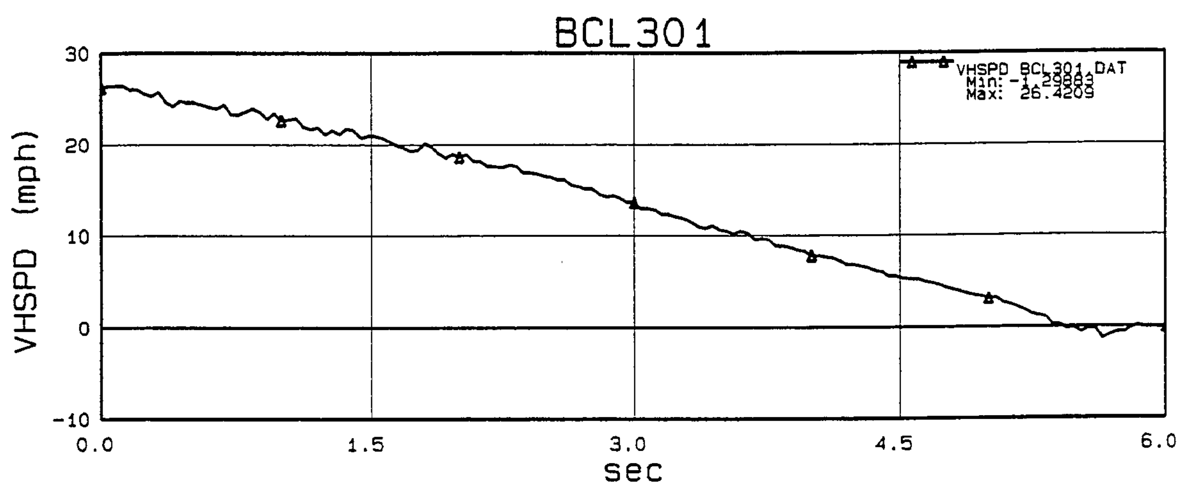
10.9.2 - Freightliner/Thomas Built School Bus - FMVSS No. 105

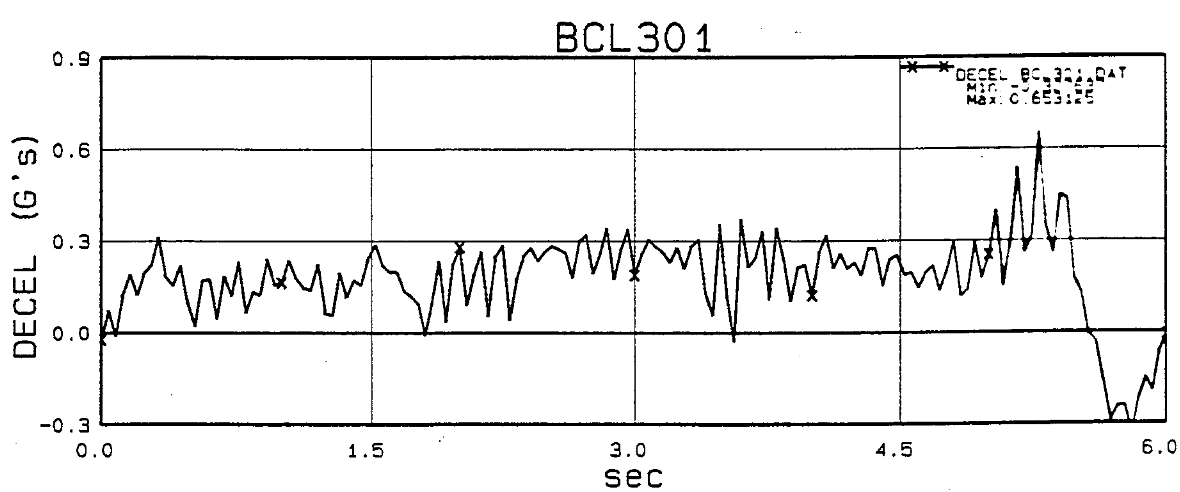
Notes:

PDFRCE = Pedal Force in pounds (lb)
VHSPD = Vehicle Speed in miles per hour (mph)
DECEL = Deceleration in g's
Time = Time from first application of brake pedal in seconds (sec)

10.9.1.1 - Plot BCL301

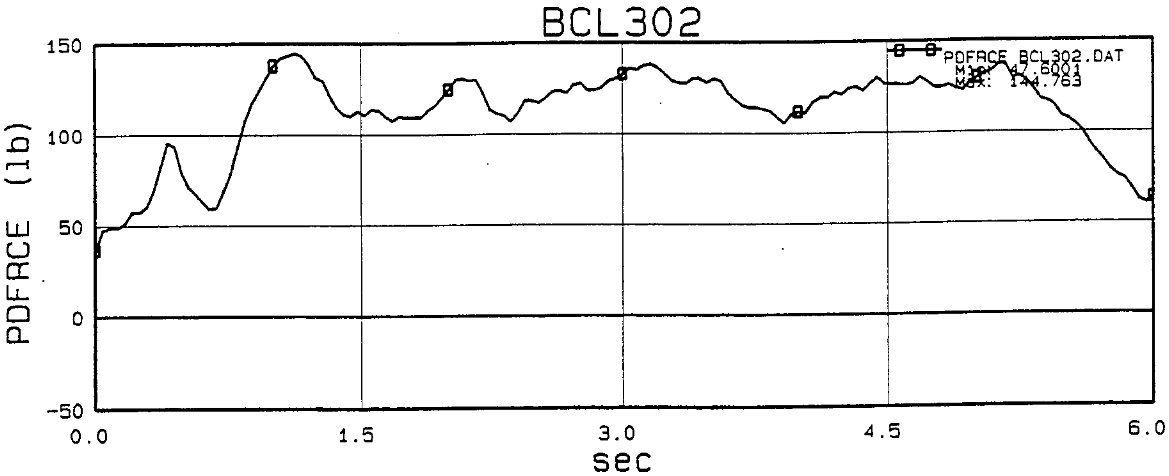


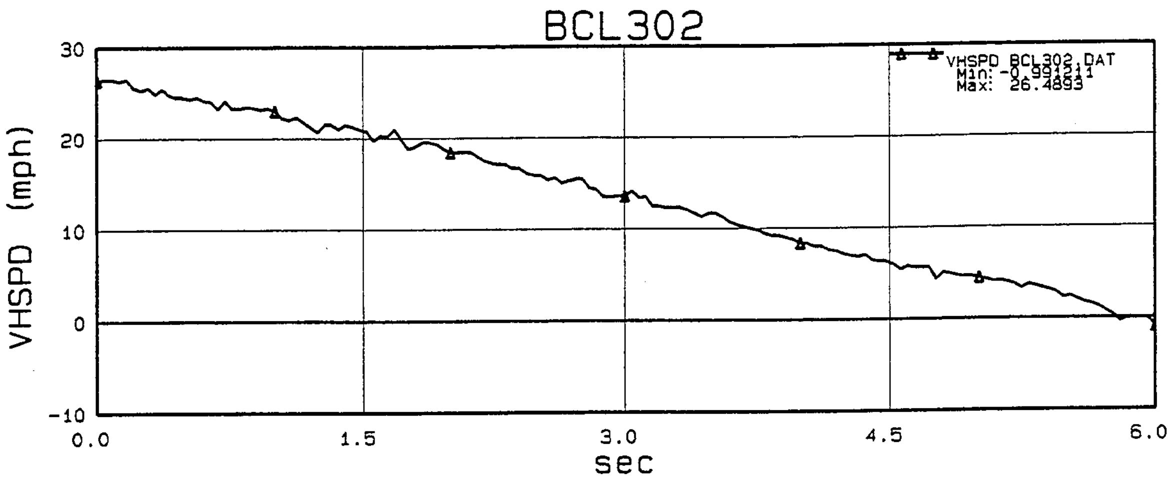


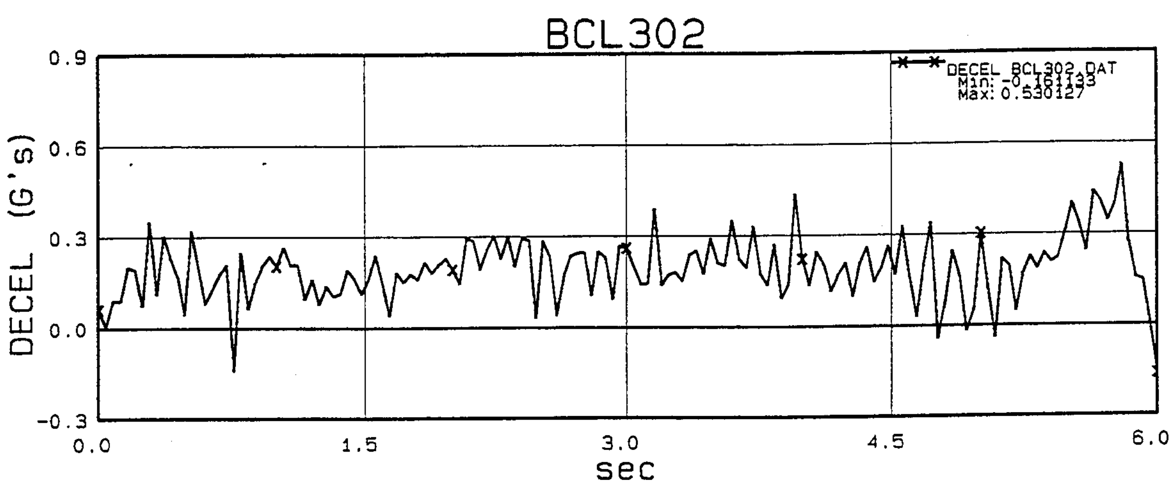


Feb 18, 1999 06:46:11PM

10.9.1.2 - Plot BCL302

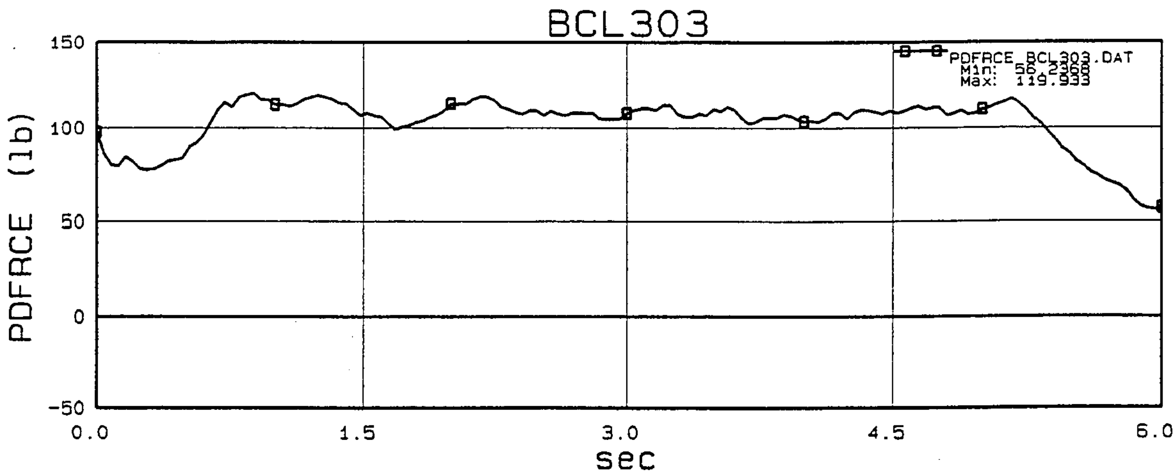


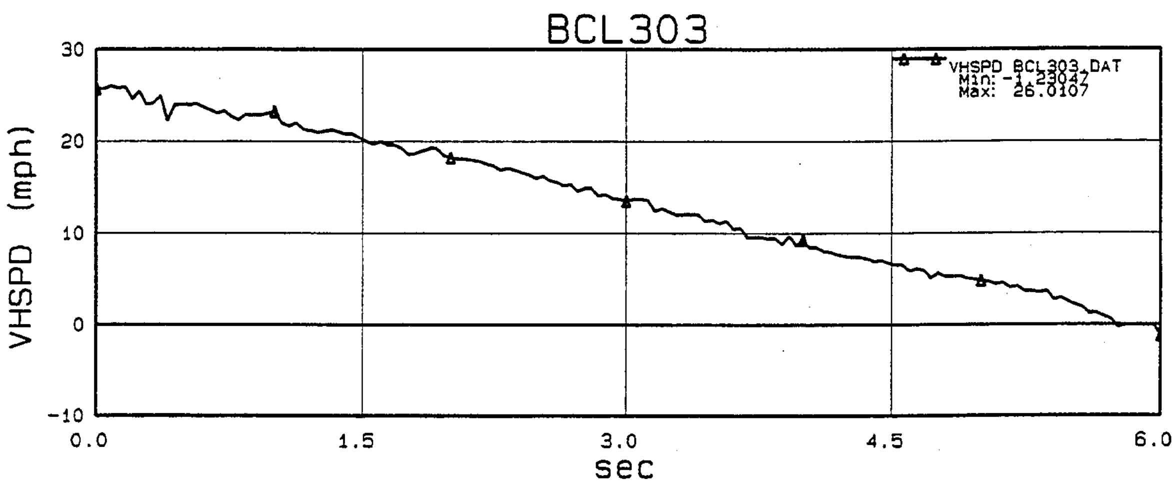


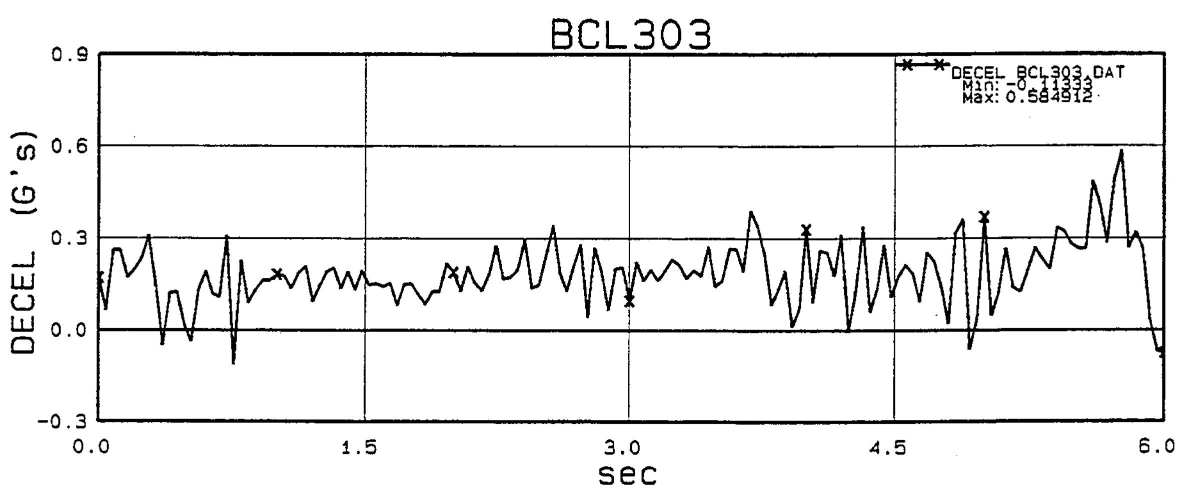


Feb 18, 1999 06:46:35PM

10.9.1.3 - Plot BCL303

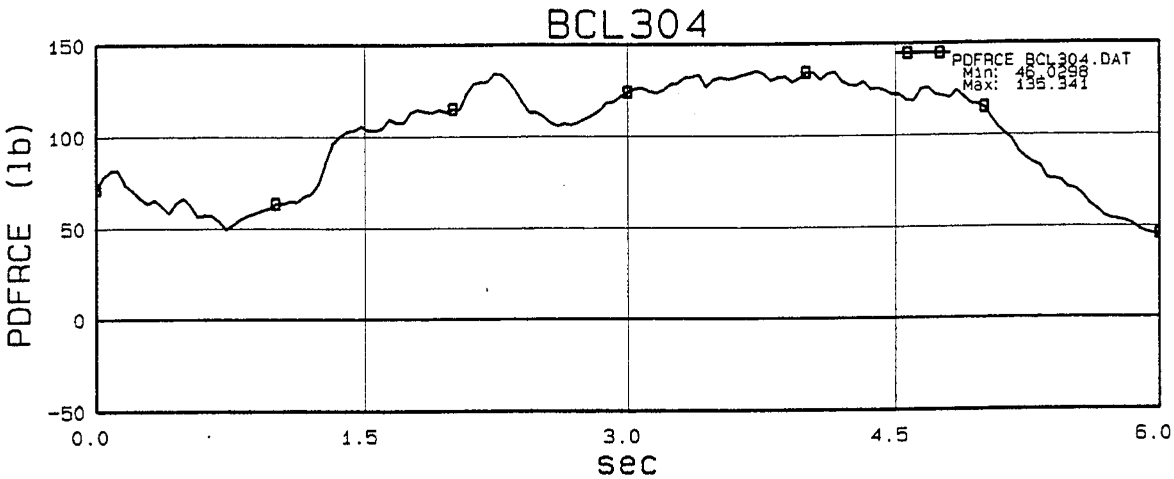


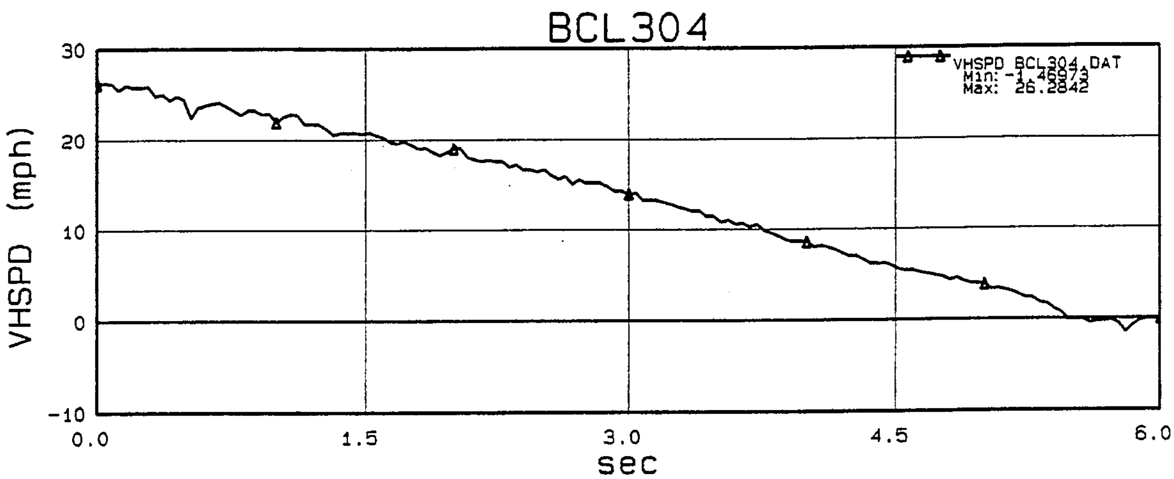


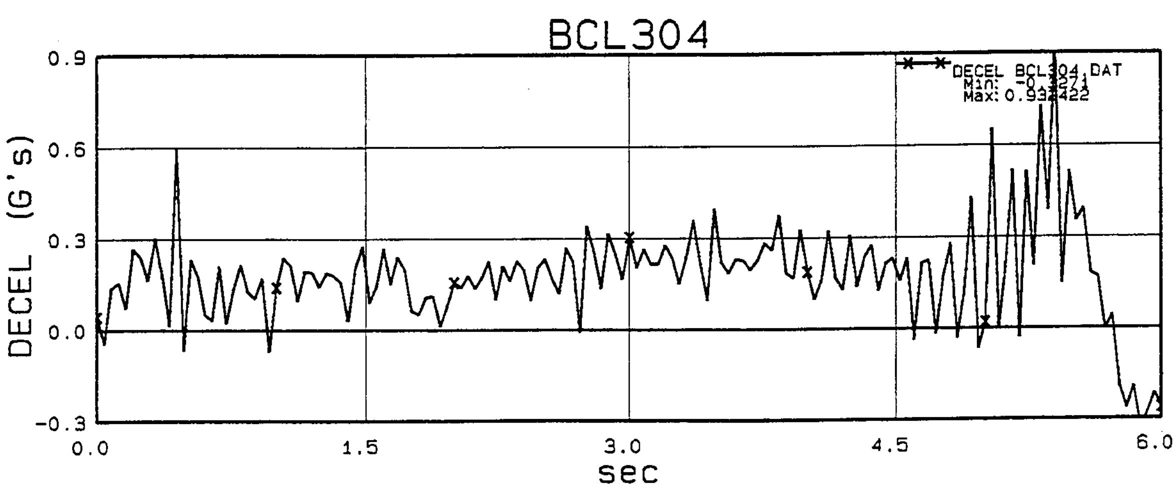


Feb 18, 1999 06:47:03PM

10.9.1.4 - Plot BCL304

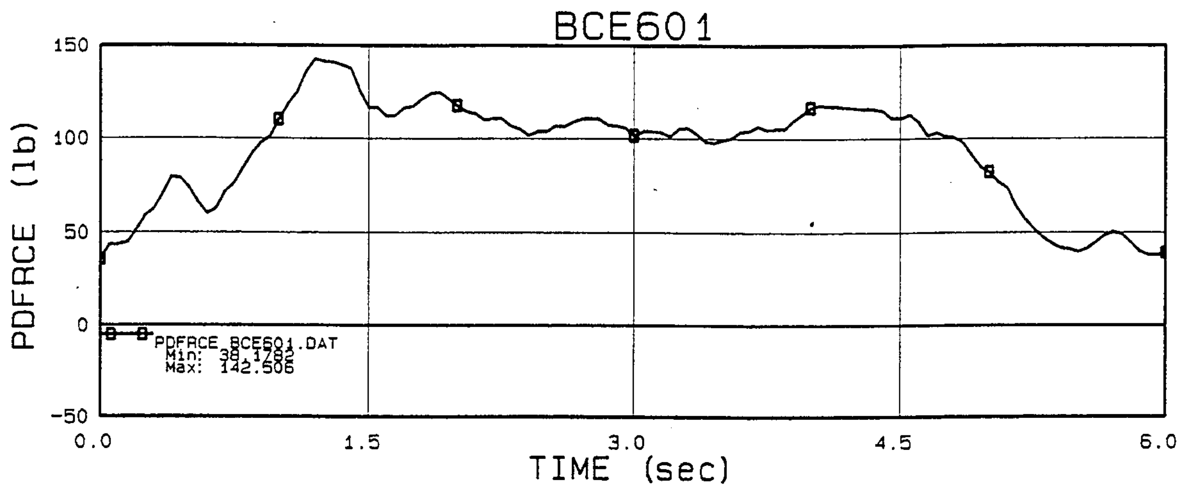


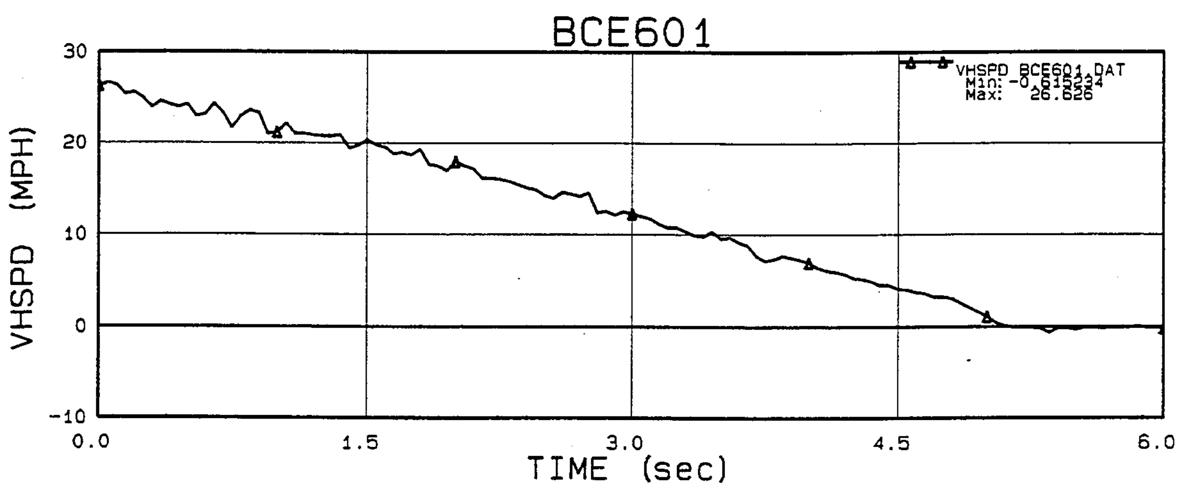


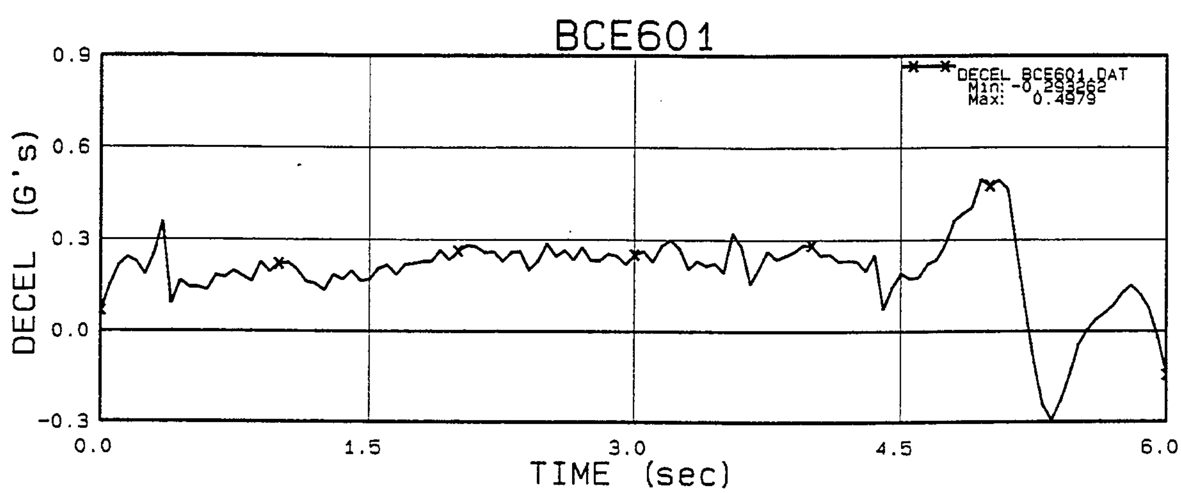


Feb 18, 1999 06:47:23PM

10.9.1.5 - Plot BCE601

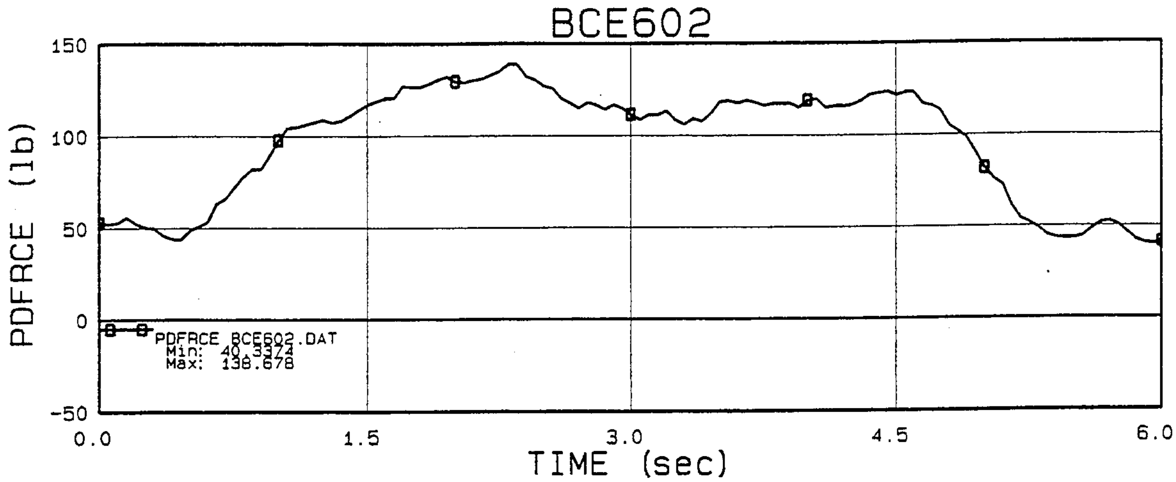


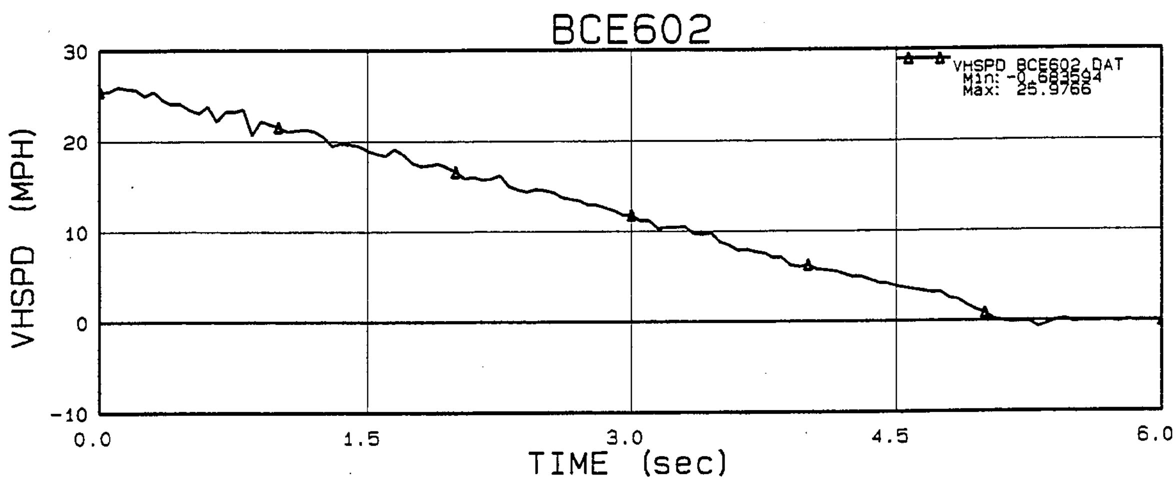


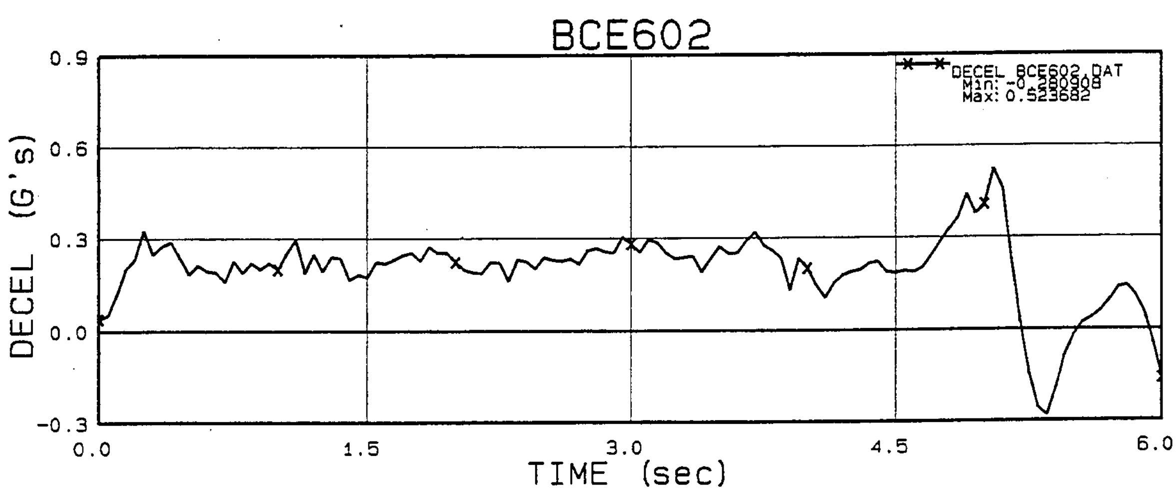


Feb 19, 1999 06:35:44PM

10.9.1.6 - Plot BCE602

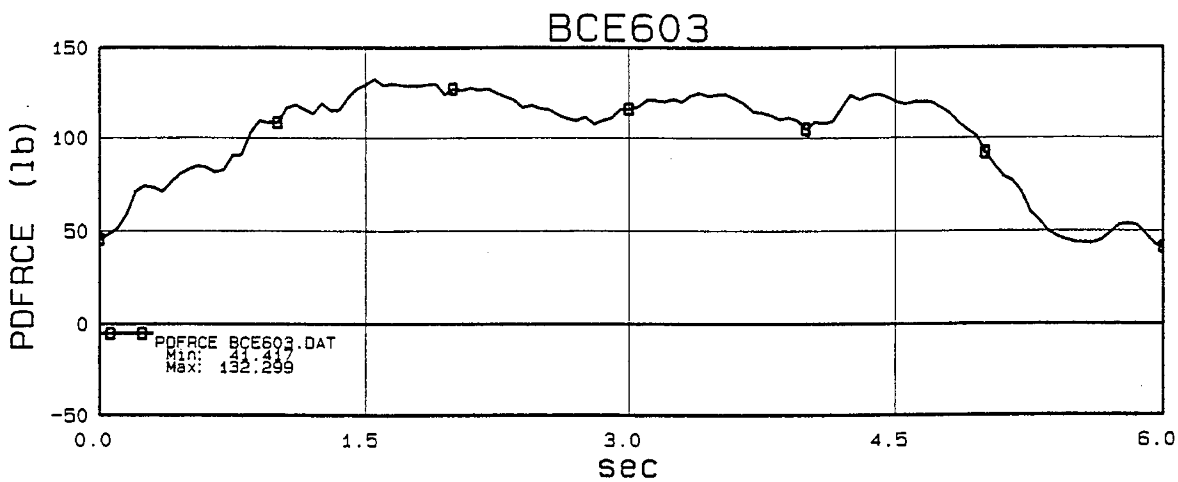


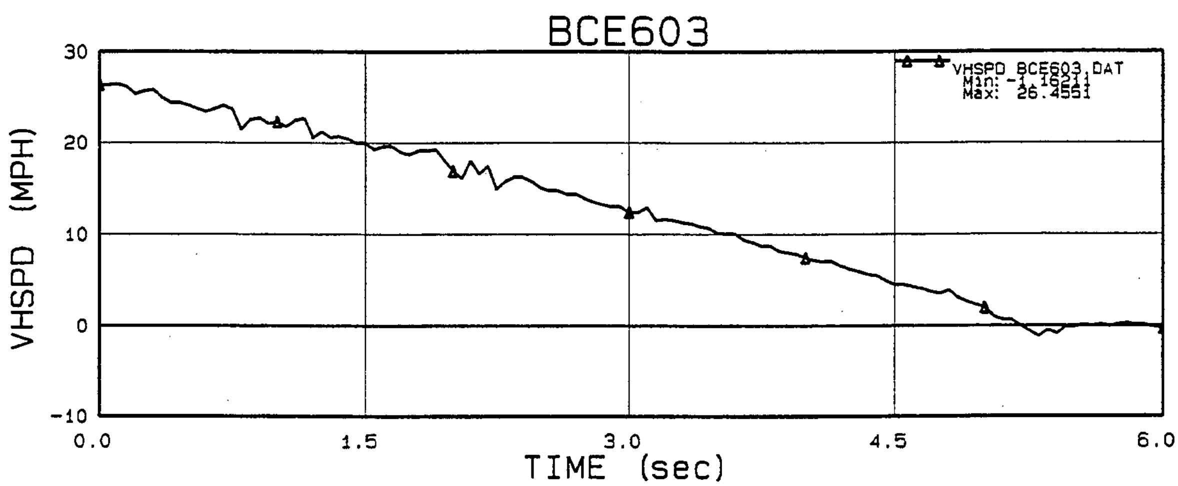


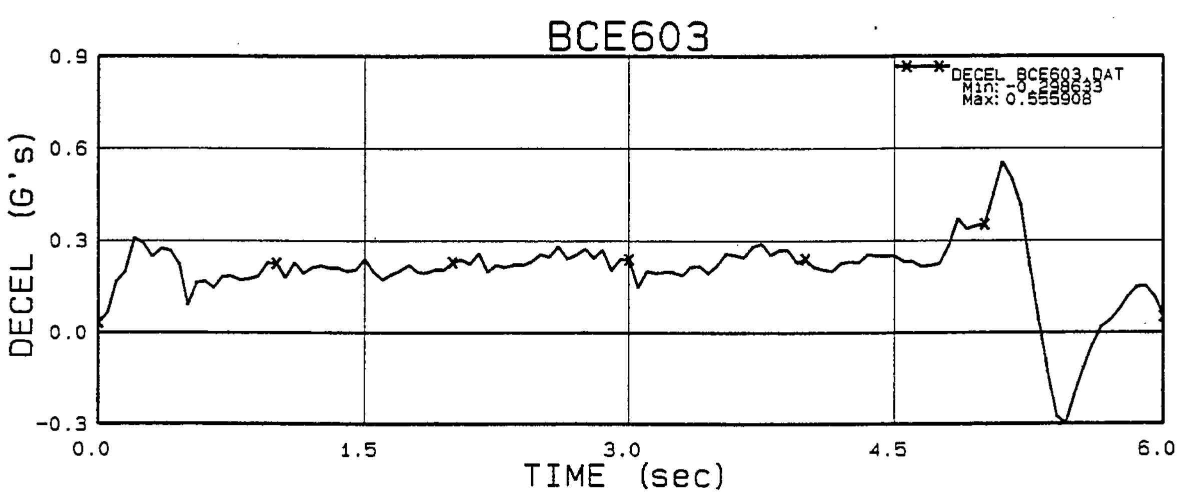


Feb 19, 1999 06:35:44PM

10.9.1.7 - Plot BCE603

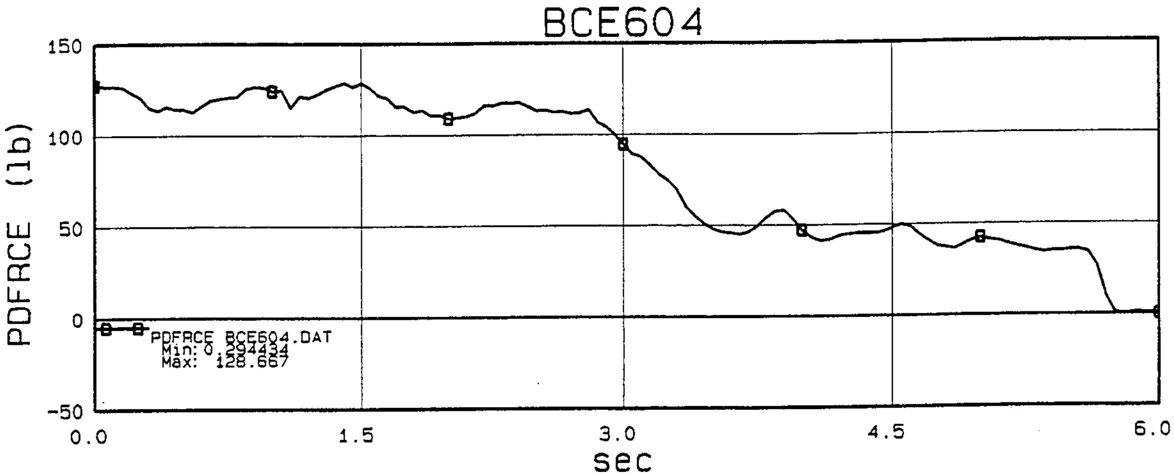


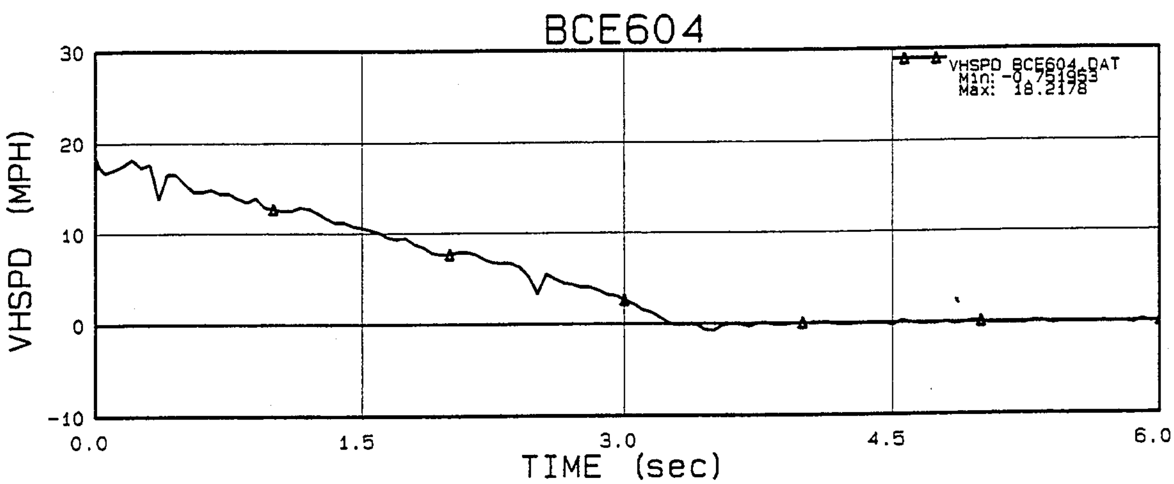


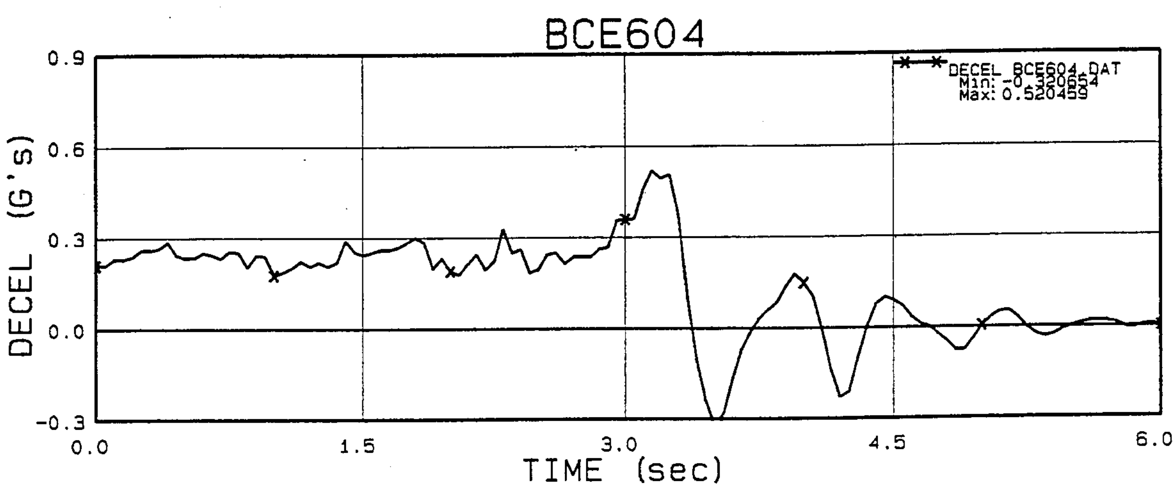


Feb 19, 1999 06:42:57PM

10.9.1.8 - Plot BCE604

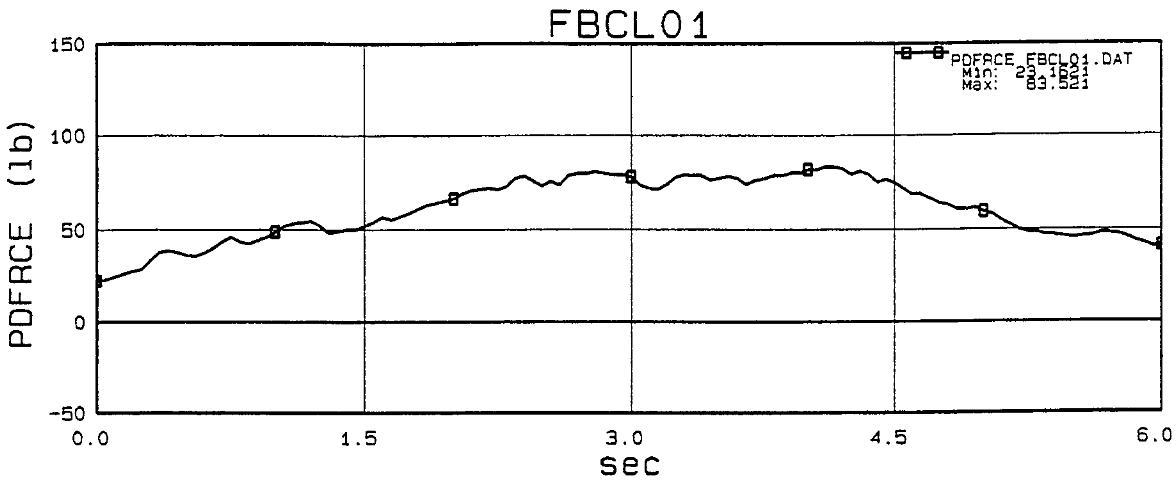


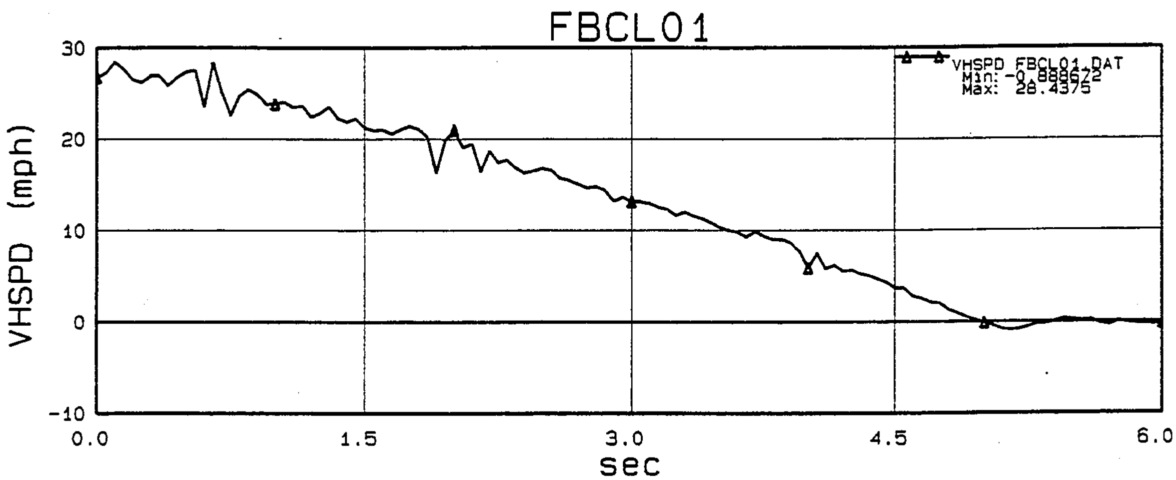


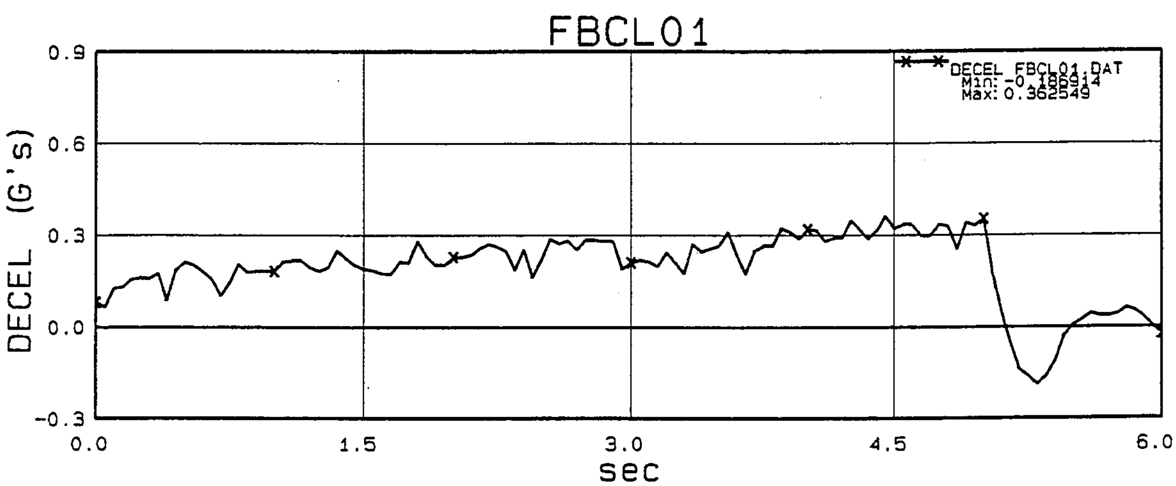


Feb 19, 1999 06:42:57PM

10.9.2.1 - Plot FBCL01

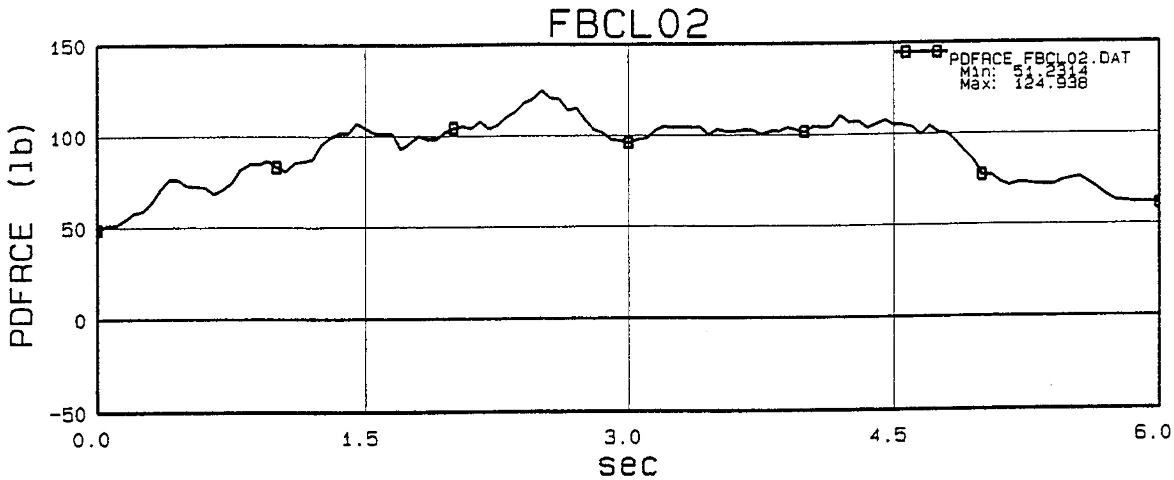


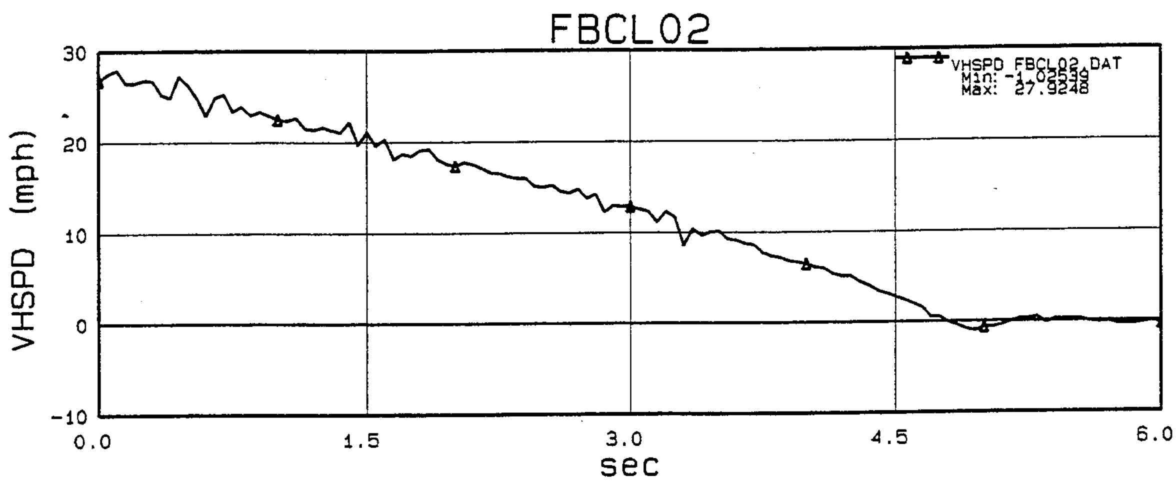


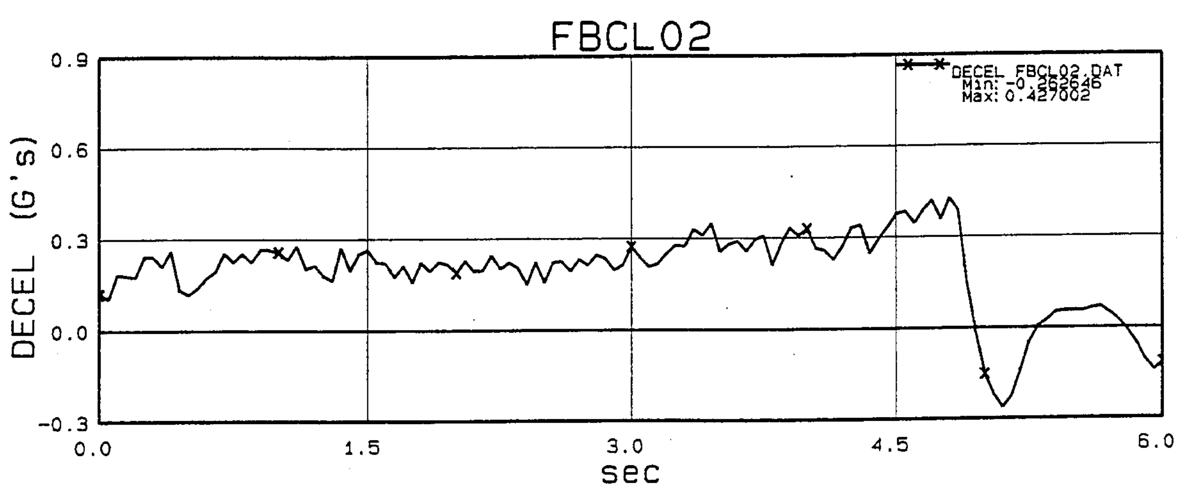


Feb 18, 1999 06:51:26PM

10.9.2.2 - Plot FBCL02

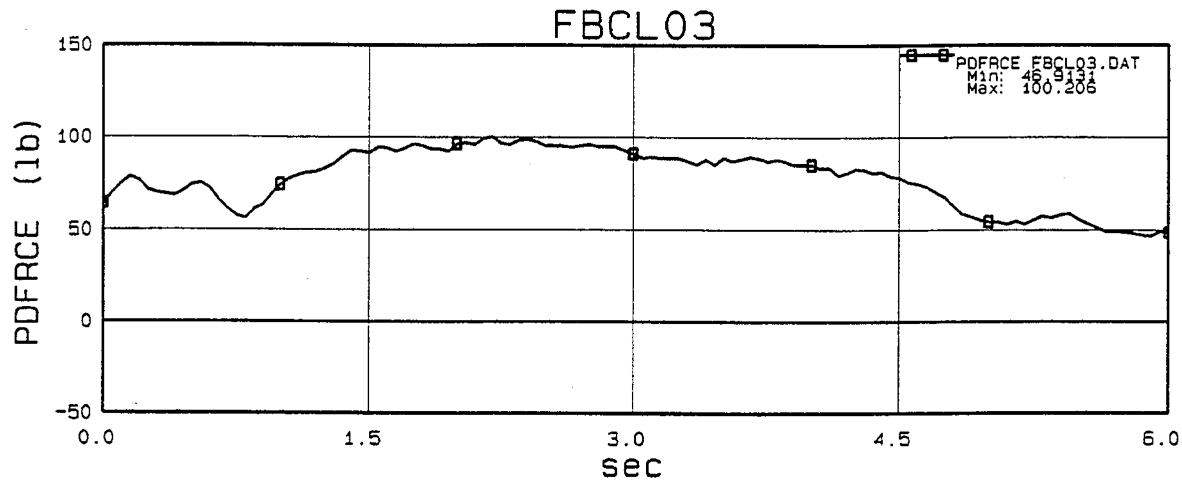


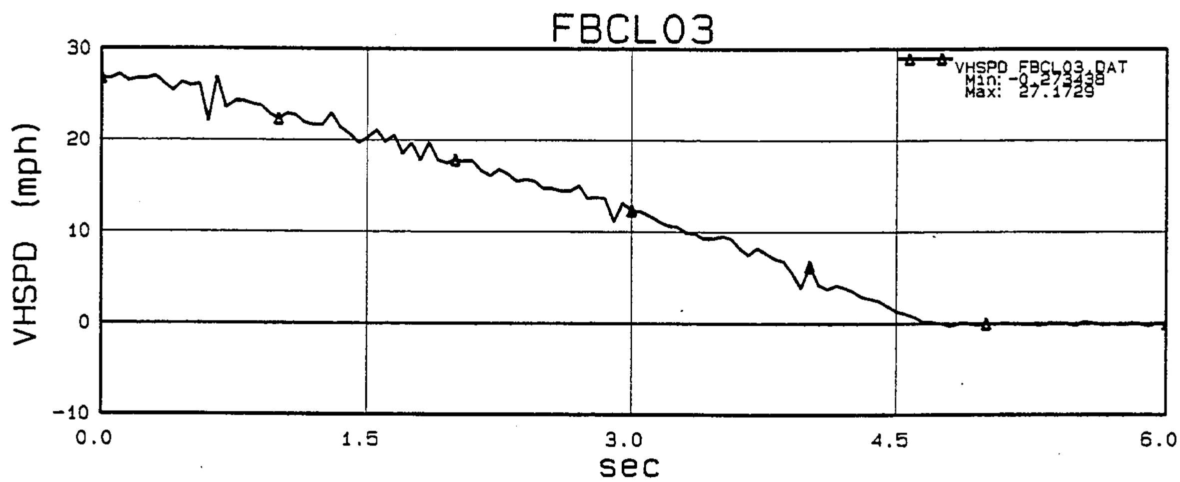


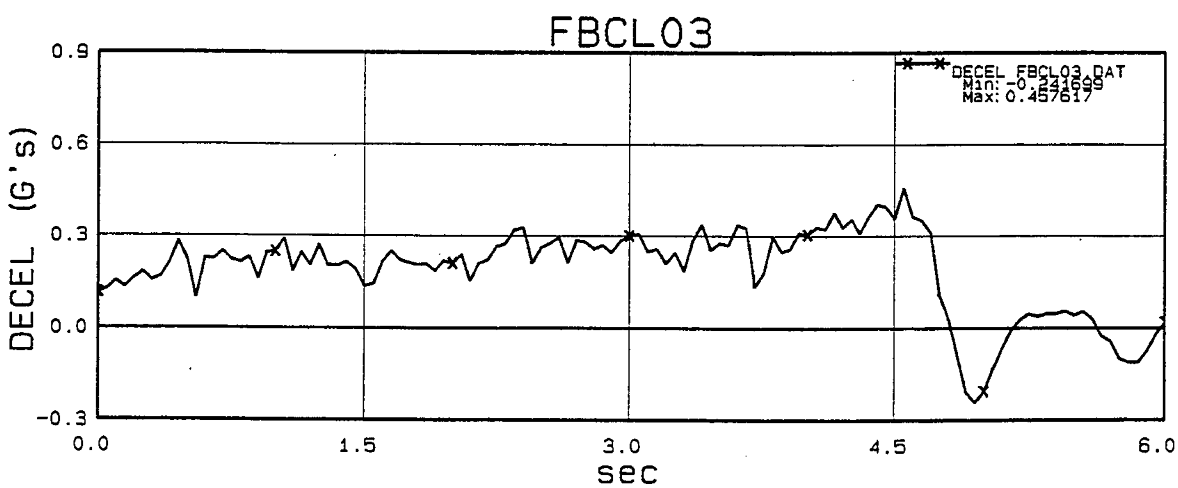


Feb 18, 1999 06:50:44PM

10.9.2.3 - Plot FBCL03

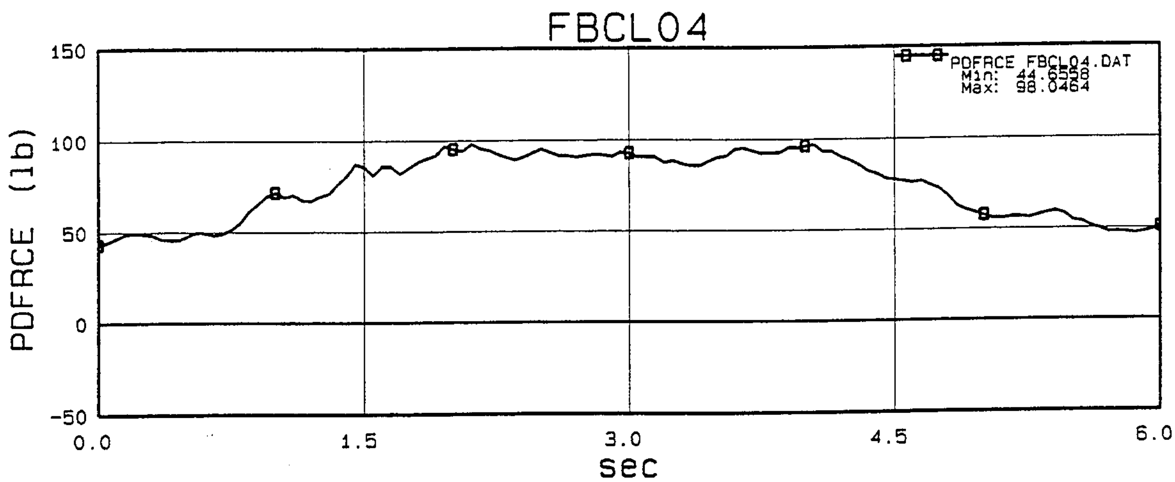


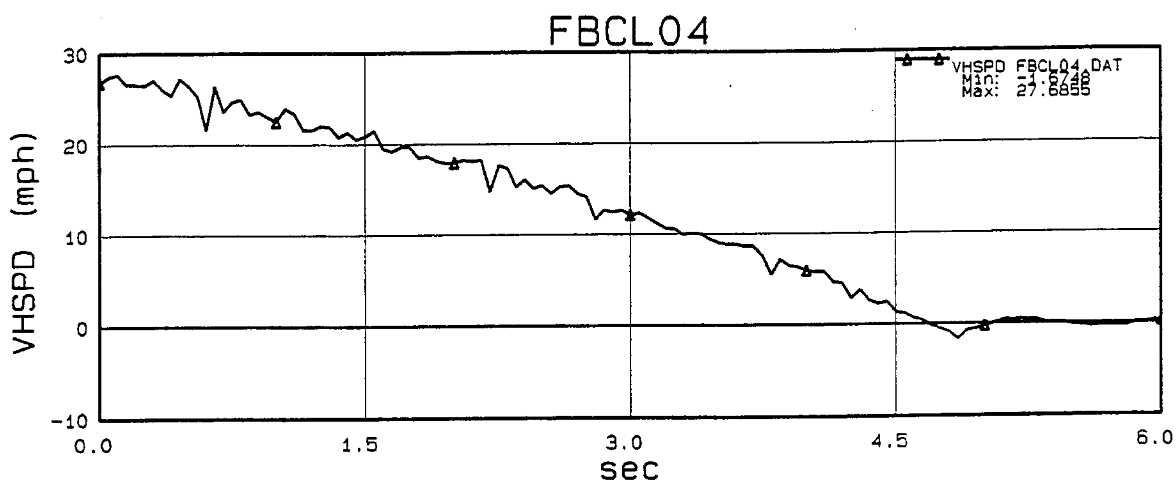


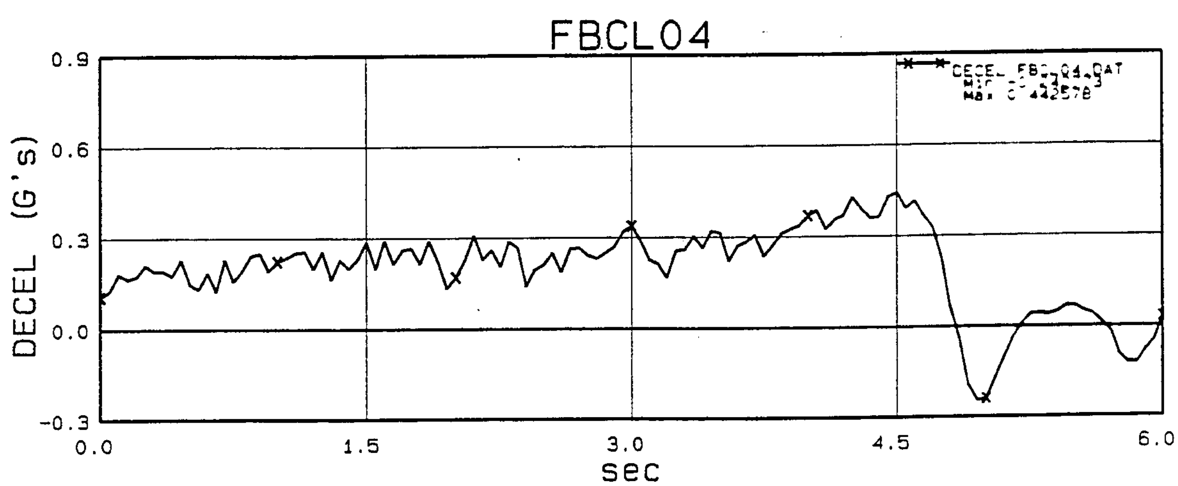


Feb 18, 1999 06:51:45PM

10.9.2.4 - Plot FBCL04







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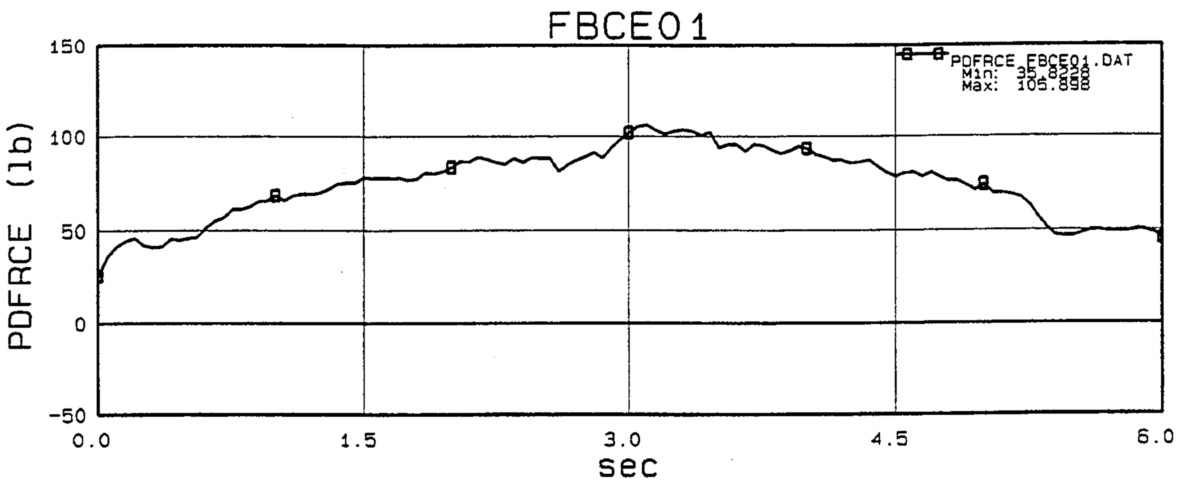
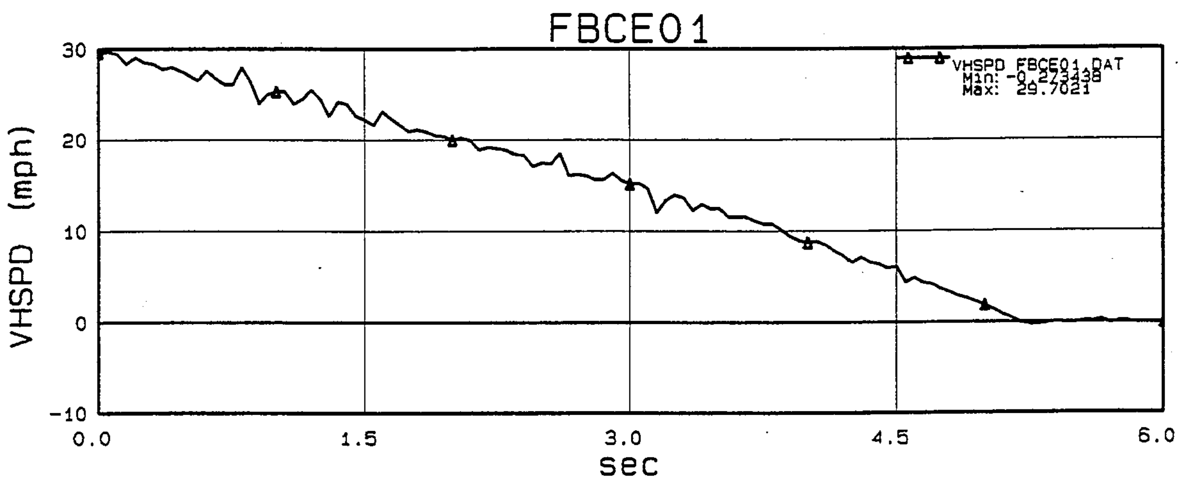
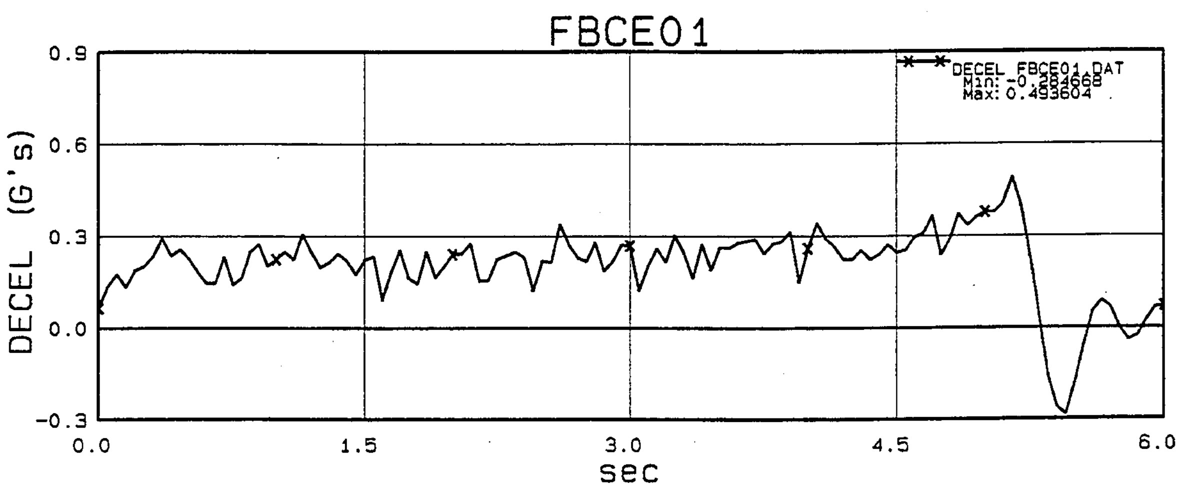
10.9.2.5 - Plot FBCE01

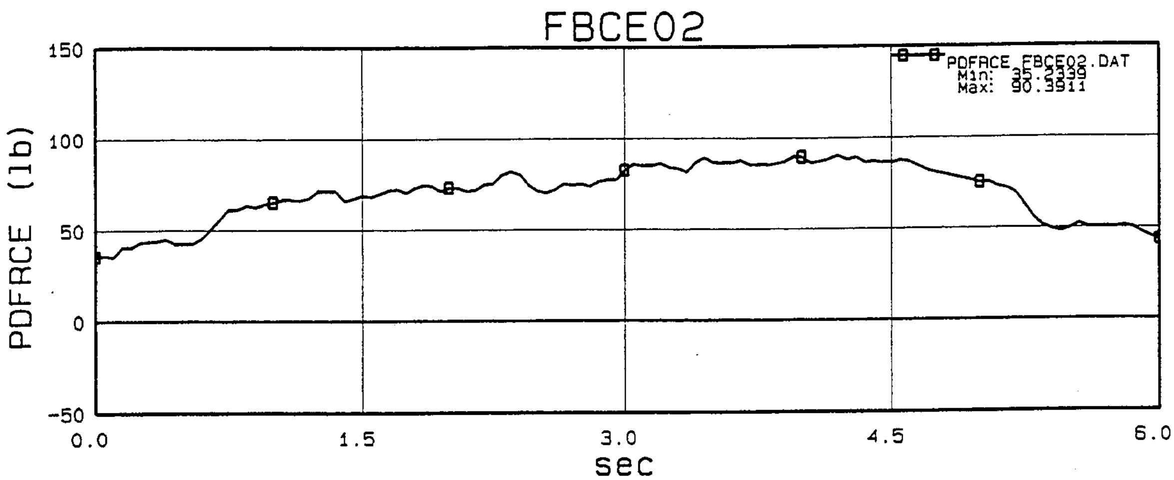


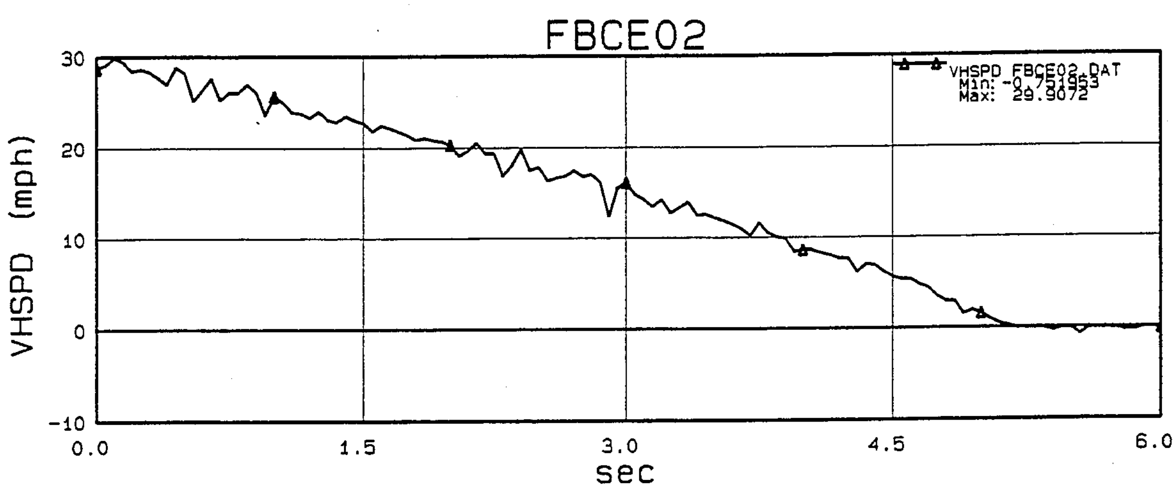


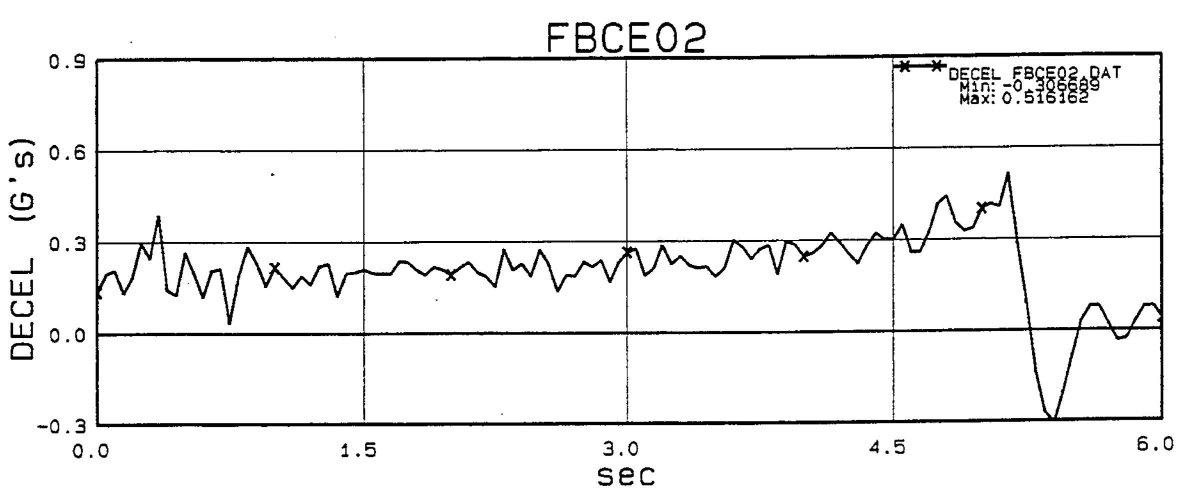


Feb 18, 1999 06:48:29PM

10.9.2.6 - Plot FBCE02

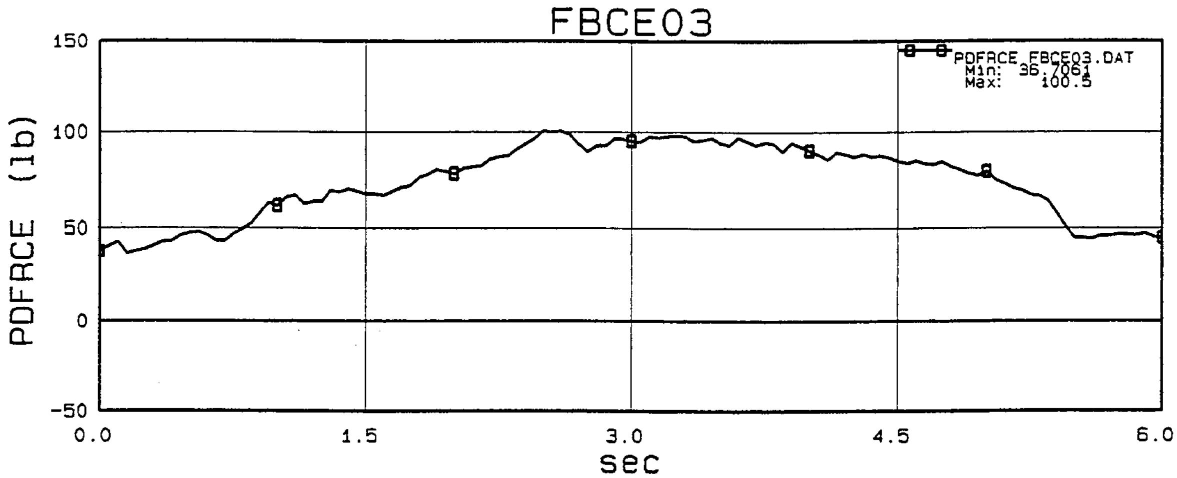


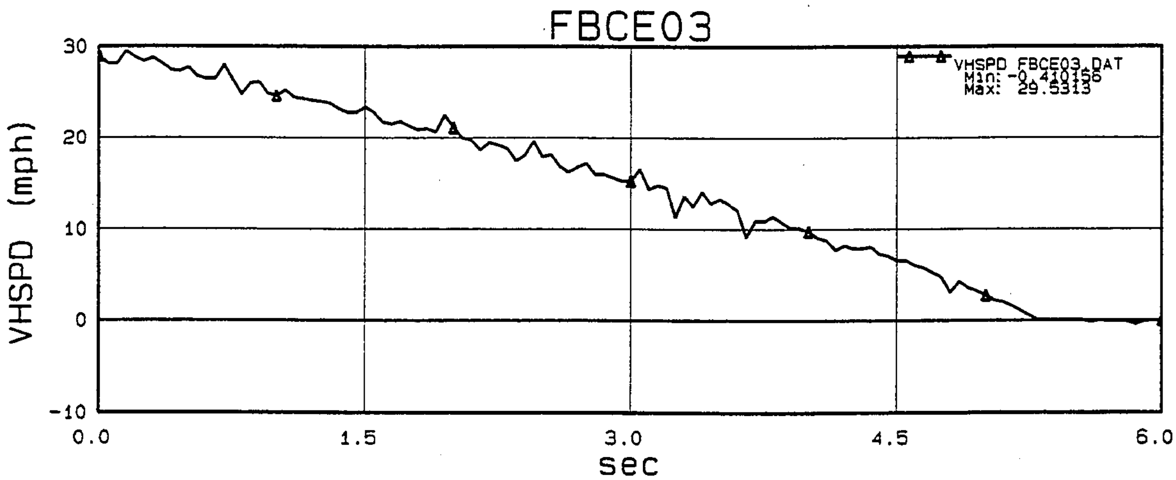


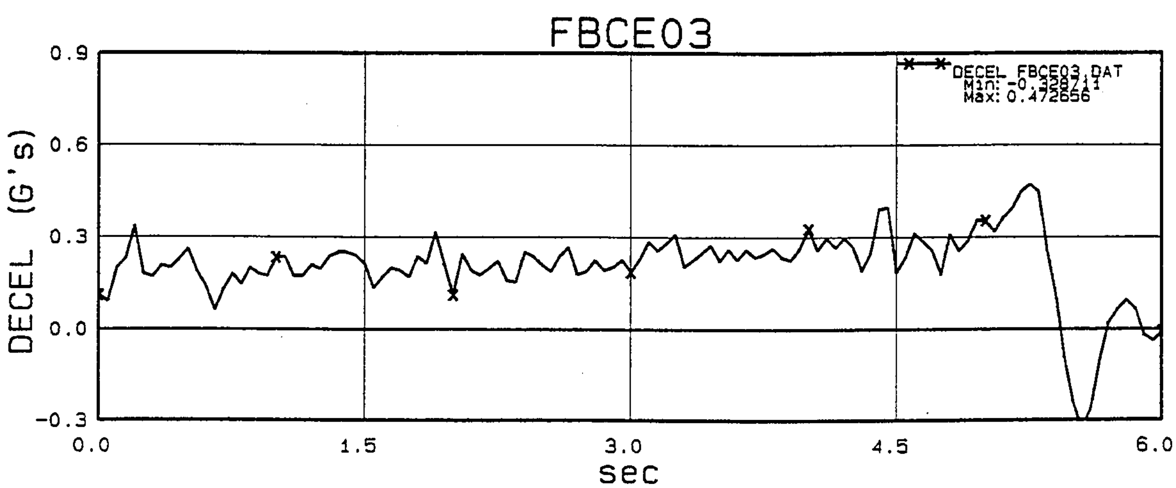


Feb 18, 1999 06:48:51PM

10.9.2.7 - Plot FBCE03







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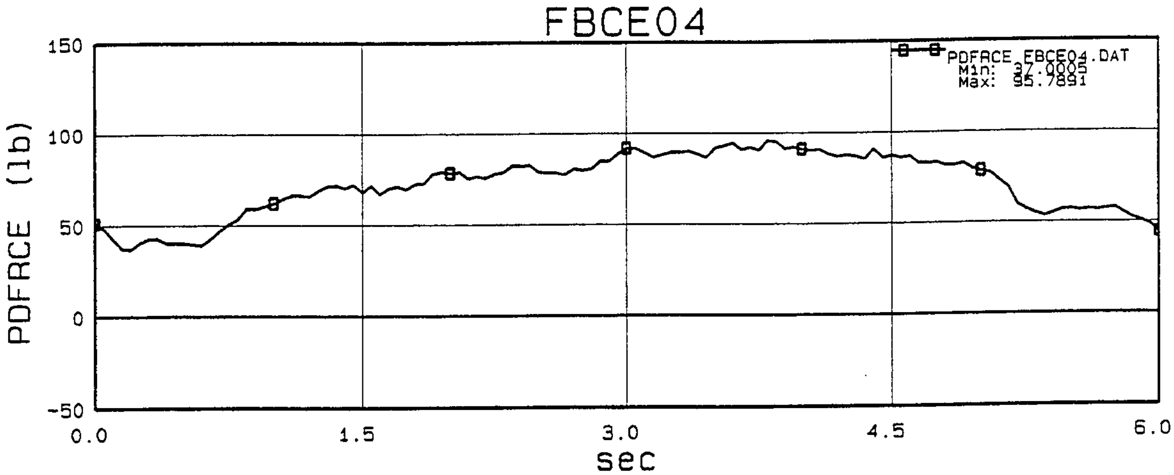
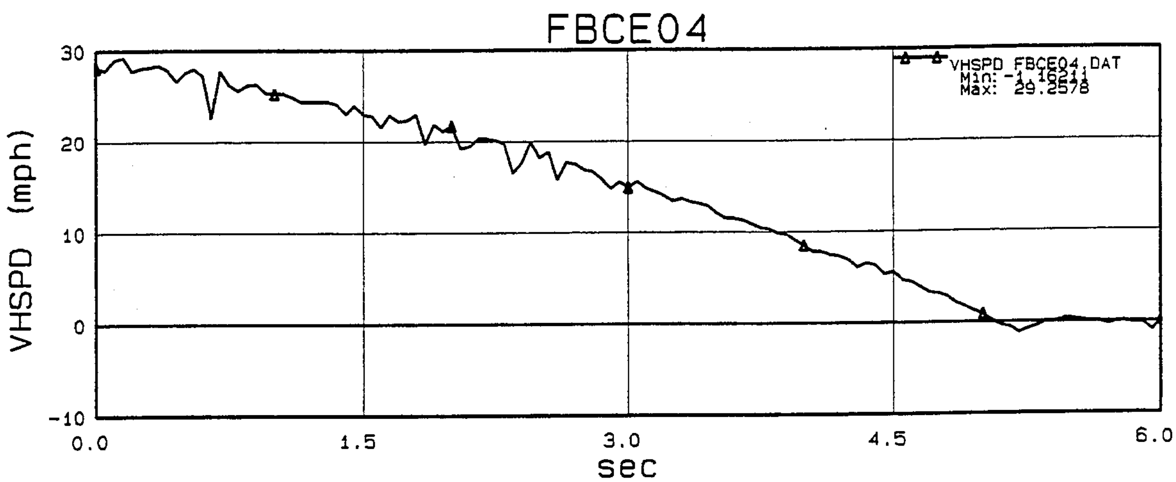
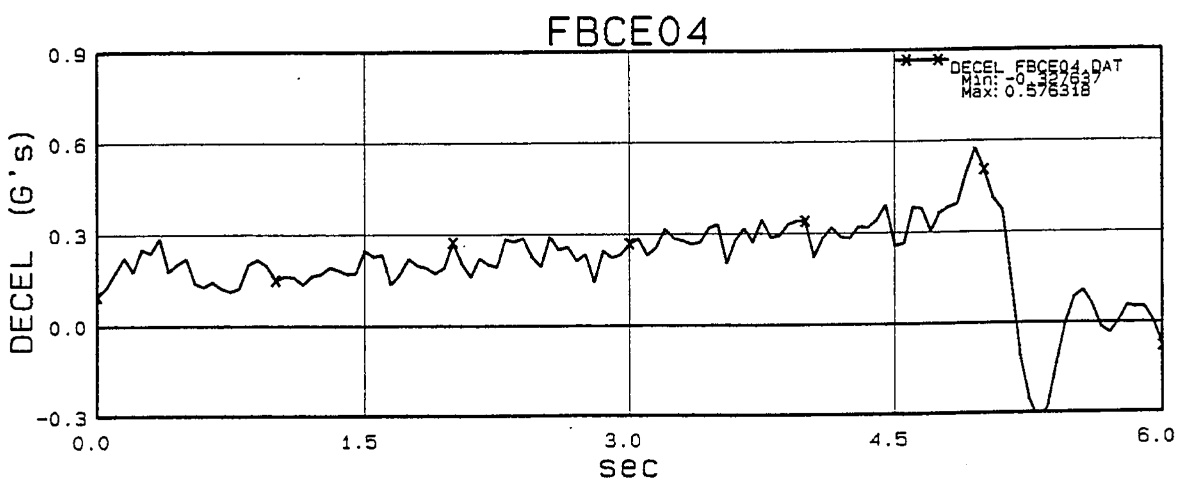
10.9.2.8 - Plot FBCE04







Feb 18, 1999 06:50:09PM

10.10 Appendix 10

10.10.2 - Vehicle Information Sheets

10.10.3 - Pictures of Vehicles, Components, & Instrumentation

Key to pictures: GAWR = Gross Axle Weight Rating; GVWR = Gross Vehicle Weight Rating

VEHICLE INFORMATION SHEET

Vehicle: GMC 4x2 School Bus
Test No.: A Test Date(s): 7/3/96 - 8/15/96
Test Facility and Location: Transportation Research Center East Liberty Ohio
Year, Make, and Model: 1996 GMC Blue Bird
VIN or Unit No.: 1GDL7T1J5SJ518454
GAWR, lb: 1st Axle 8,100 2nd Axle 19,000 3rd Axle NA GVWR 27,100
Center of Gravity Height, in:

- Truck, unladen (above ground) (in):
- Truck, laden (above ground) (in):
- Truck Ballast (above top of frame): ballast placed on floor & seats

Wheelbase, in: 193
Curb Weight Distribution, lb:

Unladen:	1st Axle: 6,660	2nd Axle: 7,770	Total: 14,430
Laden:	1st Axle: 8,200	2nd Axle: 18,760	Total: 26,960

Retarder(s) Type(s): None
Aerodynamic Treatments: (Yes/No) (Attach Photo): No

BRAKES:

Axles:	Type[1]	Size	Make	Lining (Edge Code)
1			Rockwell	
2			Eaton	
3	NA	NA	NA	NA

Brake Drum/Rotor

Axles:	Type[2]	Make	Dust Shields Installed?
1	Vented Rotor	Bendix	NA
2	Vented Rotor	Bendix	NA
3	NA	NA	NA

ACTUATION DETAILS:

	Actuators		Slack Adjusters		
Axles:	Make	Type[3]	Length or Wedge angle	Manufacturer	Cam Rotation[4]
1	Hydraulic				
2	Hydraulic				
3	NA	NA	NA	NA	NA

VEHICLE INFORMATION SHEET
(Continued)

Vehicle: GMC 4x2 School Bus

TIRES:

Axles:	Pressure (psi)	Size	Make	Model	Static Loaded Radius Measured	Static Loaded Radius DataBook
1	100	295/75 R22.5	Goodyear	Unisteel G159		18.7
2	100	295/75 R22.5	Goodyear	Unisteel G159		18.7
3	NA	NA	NA	NA	NA	NA

ABS: Manufacturer: Kelsey Hayes Model:____ Configuration:____

FRONT SUSPENSION:

Type: spring Make: Rockwell Model:____

REAR SUSPENSION:

Type: spring Make:____ Model:____
Axle Spread, m(in):____ Overall Width (SAE J693):____

AIR SYSTEM: None

Compressor Capacity ccm(cfm): NA Cut-out kPa(psi): NA Cut-in kPa(psi): NA
Crack Pressure Ratings kPa(psi)[5]:
1st Axle: NA 2nd Axle: NA
3rd Axle: NA Treadle Valve: NA
Bobtail Proportioning: ☐ NA Front Axle Limiting: NA
Air Dryer: ☐ NA Air Compounding: NA
Spring Brake Inversion Valve: ☐ Number of Brakes Controlled: NA
Specifics Regarding Air Brake System Components: NA

AIR TANK VOLUMES 1 (cu.in.): None

Supply: NA Primary: NA Secondary: NA
Auxiliary: NA Isolated From Service? ☐

SPECIAL CONDITIONS:

Special conditions or equipment which might affect brake performance:____

[1] Cam, disc, wedge, etc.
[2] Cast or composite drum, vented or non-vented rotor, etc.
[3] Size and diaphragm or piston
[4] Same or opposite to forward wheel rotation
[5] Relative to rear axle(s) centerline (include sketch if necessary)

VEHICLE INFORMATION SHEET

Vehicle: Freightliner 4x2 School Bus
Test No.: B   Test Date(s): 8/21-30/1996
Test Facility and Location: Transportation Research Center East Liberty Ohio
Year, Make, and Model: 1996 Freightliner Thomas Built C1000S
VIN or Unit No.: E00056
GAWR , lb: 1st Axle 7,560 2nd Axle 17,940 3rd Axle NA GVWR 25,500
Center of Gravity Height, in:

- Truck, unladen (above ground)(in): ______
- Truck, laden (above ground)(in): ______
- Truck Ballast (above top of frame): ballast placed on floor & seats

Wheelbase, in: 252
Curb Weight Distribution, lb:

Unladen: 1st Axle: 7,720 2nd Axle: 8,890 Total: 16,160
Laden: 1st Axle: 7,530 2nd Axle: 18,000 Total: 25,530

Retarder(s) Type(s): None
Aerodynamic Treatments: (Yes/No) (Attach Photo): No

BRAKES:

Axles:	Type[1]	Size	Make	Lining (Edge Code)
1				
2				
3	NA	NA	NA	NA

Brake Drum/Rotor

Axles:	Type[2]	Make	Dust Shields Installed?
1	Vented Rotor		NA
2			NA
3	NA	NA	NA

ACTUATION DETAILS:

	Actuators		Slack Adjusters		
Axles:	Make	Type[3]	Length or Wedge angle	Manufacturer	Cam Rotation[4]
1	Hydraulic				
2	Hydraulic				
3	NA	NA	NA	NA	NA

VEHICLE INFORMATION SHEET
(Continued)

Vehicle: Freightliner 4x2 School Bus

TIRES:

Axles:	Pressure (psi)	Size	Make	Model	Static Loaded Radius Measured	Static Loaded Radius DataBook
1		10R22.5	Michelin	XZA		
2		10R22.5	Michelin	XZA		
3	NA	NA	NA	NA	NA	NA

ABS: Manufacturer:______ Model:______ Configuration:______

FRONT SUSPENSION:

Type: spring Make:______ Model:______

REAR SUSPENSION:

Type: spring Make:______ Model:______
Spread, m(in):______ Overall Width (SAE J693):______

AIR SYSTEM: None

Compressor Capacity ccm(cfm): NA Cut-out kPa(psi): NA Cut-in kPa(psi): NA
Crack Pressure Ratings kPa(psi)[5]:
1st Axle: NA 2nd Axle: NA
3rd Axle: NA Treadle Valve: NA
Bobtail Proportioning: □ NA Front Axle Limiting: NA
Air Dryer: □ NA Air Compounding: NA
Spring Brake Inversion Valve: □ Number of Brakes Controlled: NA
Specifics Regarding Air Brake System Components: NA

AIR TANK VOLUMES 1 (cu.in.): None

Supply: NA Primary: NA Secondary: NA
Auxiliary: NA Isolated From Service? □

SPECIAL CONDITIONS:

Special conditions or equipment which might affect brake performance:______

[1] Cam, disc, wedge, etc.
[2] Cast or composite drum, vented or non-vented rotor, etc.
[3] Size and diaphragm or piston
[4] Same or opposite to forward wheel rotation
[5] Relative to rear axle(s) centerline (include sketch if necessary)

VEHICLE INFORMATION SHEET

Vehicle: Freightliner 6x4 Straight Truck

Test No.: C   Test Date(s): Sept. 13-Oct.5, 1996

Test Facility and Location: Transportation Research Center East Liberty Ohio

Year, Make, and Model: 1995 Freightliner Business Class Conventional FLC 112 6x4

VIN or Unit No.: 1FUYTMDB9SL731534

GAWR, lb: 1st Axle 12,000   2nd Axle 20,000   3rd Axle 20,000   GVWR 52,000

Center of Gravity Height, in:

- Truck, unladen (above ground)(in): 42.5 in with 2602 lb load frame installed
- Truck, laden (above ground)(in): height not available
- Truck Ballast (above top of frame): 30.5 in

Wheelbase, in: 180

Curb Weight Distribution, lb:

Unladen: 1st Axle: 8,810   2nd Axle: 9,150 tandem axle   Total: 17,960

Laden: 1st Axle: 12,010   2nd Axle: 40,180 tandem axle   Total: 52,190

Retarder(s) Type(s): None

Aerodynamic Treatments: (Yes/No) (Attach Photo): No

BRAKES:

Axles:	Type[1]	Size	Make	Lining (Edge Code)
1	FF961NX241	12,000 lb	Rockwell	
2	RD20145NFN1062	20,000 lb	Rockwell	
3	RR20145NFN1090	20,000 lb	Rockwell	

Brake Drum/Rotor

Axles:	Type[2]	Make	Dust Shields Installed?
1			Yes
2			Yes
3			Yes

ACTUATION DETAILS:

	Air Chambers		Slack Adjusters		
Axles:	Make	Type[3]	Length or Wedge angle	Manufacturer	Cam Rotation[4]
1	MGM	20	5.5 in	Rockwell	same
2	MGM	30 - 30	5.5 in	Rockwell	same
3	MGM	30 - 30	5.5 in	Rockwell	same

VEHICLE INFORMATION SHEET
(Continued)

Vehicle: Freightliner 6x4 Straight Truck

TIRES:

Axles:	Pressure (psi)	Size	Make	Model	Static Loaded Radius Measured	Static Loaded Radius DataBook
1	100	275/80R22.5	Michelin	Pilot XZA - 1	19.7	
2	100	275/80R22.5	Michelin	Pilot XZA - 1	19.7	
3	100	275/80R22.5	Michelin	Pilot XZA - 1	19.7	

ABS: Manufacturer: WABCO Model:____ Configuration:____

FRONT SUSPENSION:

Type: Spring Make:____ Model:____

REAR SUSPENSION:

Type: Air Make:____ Model:____
Spread, m(in):____ Overall Width (SAE J693):____

AIR SYSTEM:

Compressor Capacity ccm(cfm):____ Cut-out kPa(psi):____ Cut-in kPa(psi):____
Crack Pressure Ratings(psi)[5]:
1st Axle:____ 2nd Axle:____
3rd Axle:____ Treadle Valve:____
Bobtail Proportioning: ☐ ____ Front Axle Limiting:____
Air Dryer: ☐ ____ Air Compounding:____
Spring Brake Inversion Valve: ☐ Number of Brakes Controlled:____
Specifics Regarding Air Brake System Components:____

AIR TANK VOLUMES 1 (cu.in.):

Supply:____ Primary:____ Secondary:____
Auxiliary:____ Isolated From Service? ☐

SPECIAL CONDITIONS:

Special conditions or equipment which might affect brake performance:____

[1] Cam, disc, wedge, etc.
[2] Cast or composite drum, vented or non-vented rotor, etc.
[3] Size and diaphragm or piston
[4] Same or opposite to forward wheel rotation
[5] Relative to rear axle(s) centerline (include sketch if necessary)

VEHICLE INFORMATION SHEET

Vehicle: Peterbilt 6x4 Straight truck
Test No.: D   Test Date(s): Oct. 3-8, 1996
Test Facility and Location: Transportation Research Center East Liberty Ohio
Year, Make, and Model: 1995 Peterbilt Model 357 conventional
VIN or Unit No.: 1XPAXBTX2SD383969
GAWR, lb: 1st Axle 20,000   2nd Axle 20,000   3rd Axle 20,000   GVWR 60,000
Center of Gravity Height, in:

- Truck, unladen (above ground)(in): 43.7 in with 5204 lb (double load frame assembly
- Truck, laden (above ground)(in): height not available
- Truck Ballast (above top of frame): 20.5 in

Wheelbase, in: 311
Curb Weight Distribution, lb:

	1st Axle	Tandem Axle	Total
Unladen:	13,020	19,580	32,600
Laden:	19,990	40,050	60,040

Retarder(s) Type(s): None
Aerodynamic Treatments: (Yes/No) (Attach Photo): No

BRAKES:

Axles:	Type[1]	Size	Make	Lining (Edge Code)
1				
2				
3				

Brake Drum/Rotor

Axles:	Type[2]	Make	Dust Shields Installed?
1			No
2			No
3			

ACTUATION DETAILS:

	Air Chambers		Slack Adjusters		
Axles:	Make	Type[3]	Length or Wedge angle	Manufacturer	Cam Rotation[4]
1					
2					
3					

VEHICLE INFORMATION SHEET
(Continued)

Vehicle: Peterbilt 6x4 Straight Truck

TIRES:

Axles:	Pressure (psi)	Size	Make	Model	Static Loaded Radius Measured	Static Loaded Radius DataBook
1						
2			Michelin	X		
3						

ABS: Manufacturer:_____ Model:_____ Configuration:_____

FRONT SUSPENSION:

Type: Spring Make: Eaton Model: EFA20F4

REAR SUSPENSION:

Type: Spring Make: Eaton Model: DS581P
Axle Spread, m(in):_____ Overall Width (SAE J693):_____

AIR SYSTEM:

Compressor Capacity ccm(cfm):_____ Cut-out kPa(psi):_____ Cut-in kPa(psi):_____
Crack Pressure Ratings(psi)[5]:
1st Axle:_____ 2nd Axle:_____
3rd Axle:_____ Treadle Valve:_____
Bobtail Proportioning: ☐ _____ Front Axle Limiting:_____
Air Dryer: ☐ _____ Air Compounding:_____
Spring Brake Inversion Valve: ☐ Number of Brakes Controlled:_____
Specifics Regarding Air Brake System Components:_____

AIR TANK VOLUMES 1 (cu.in.):

Supply:_____ Primary:_____ Secondary:_____
Auxiliary:_____ Isolated From Service? ☐

SPECIAL CONDITIONS:

Special conditions or equipment which might affect brake performance:_____

[1] Cam, disc, wedge, etc.
[2] Cast or composite drum, vented or non-vented rotor, etc.
[3] Size and diaphragm or piston
[4] Same or opposite to forward wheel rotation
[5] Relative to rear axle(s) centerline (include sketch if necessary)

VEHICLE INFORMATION SHEET

Vehicle: Navistar 2674 6x4 Straight Truck
Test No.: E Test Date(s): October 21 - November 6, 1996
Test Facility and Location: Transportation Research Center East Liberty Ohio
Year, Make, and Model: 1996 Navistar 2674 6x4
VIN or Unit No.: 1HTGLAHT9VH400225
GAWR, lb: 1st Axle 15,000 2nd Axle 23,000 3rd Axle 23,000 GVWR 61000
Center of Gravity Height, in:

- Truck, unladen (above ground)(in): 38 in with 2602 lb load frame installed
- Truck, laden (above ground)(in): 76 in
- Truck Ballast (above top of frame): 51.1 in

Wheelbase, in: 238
Curb Weight Distribution, lb:

Unladen: 1st Axle: 10,480 Tandem Axle: 10,890 Total: 21,370
Laden: 1st Axle: 14,470 Tandem Axle: 45,090 Total: 60,760

Retarder(s) Type(s): None
Aerodynamic Treatments: (Yes/No) (Attach Photo): No

BRAKES:

Axles:	Type[1]	Size, in	Make	Lining (Edge Code)
1	S-cam	16.5 x 5	Rockwell	ABB 931-162FF
2	S-cam	16.5 x 7	Rockwell	ABB 931-162FF
3	S-cam	16.5 x 7	Rockwell	ABB 931-162FF

Brake Drum/Rotor

Axles:	Type[2]	Make	Dust Shields Installed?
1			
2			
3			

ACTUATION DETAILS:

	Air Chambers		Slack Adjusters		
Axles:	Make	Type[3]	Length or Wedge angle	Manufacturer	Cam Rotation[4]
1	MGM	20	5.5	Rockwell	
2	MGM	30-30	6.0	Rockwell	
3	MGM	30-30	6.0	Rockwell	

VEHICLE INFORMATION SHEET
(Continued)

Vehicle: Navistar 2674 6x4 Straight Truck

TIRES:

Axles:	Pressure (psi)	Size	Make	Model	Static Loaded Radius Measured	Static Loaded Radius DataBook
1	110	425/65R22.5	Goodyear	Unisteel G286		
2	105	11 R 24.5	Goodyear	Unisteel G362	20.7	20.8
3	105	11 R 24.5	Goodyear	Unisteel G362	20.7	20.8

ABS: Manufacturer: Bendix Model: 4S/4M Configuration: A1 & A3

FRONT SUSPENSION:

Type:____ Make:____ Model:____

REAR SUSPENSION:

Type: walking beams Make:____ Model:____
Axle Spread, m(in):____ Overall Width (SAE J693):____

AIR SYSTEM:

Compressor Capacity ccm(cfm):____ Cut-out kPa(psi):____ Cut-in kPa(psi):____
Crack Pressure Ratings(psi)[5]:
1st Axle:____ 2nd Axle:____
3rd Axle:____ Treadle Valve:____
Bobtail Proportioning: ☐ ____ Front Axle Limiting:____
Air Dryer: ☐ yes Air Compounding:____
Spring Brake Inversion Valve: ☐ Number of Brakes Controlled:____
Specifics Regarding Air Brake System Components:____

AIR TANK VOLUMES 1 (cu.in.):

Supply:____ Primary:____ Secondary:____
Auxiliary:____ Isolated From Service? ☐

SPECIAL CONDITIONS:

Special conditions or equipment which might affect brake performance: Air Dryer

[1] Cam, disc, wedge, etc.
[2] Cast or composite drum, vented or non-vented rotor, etc.
[3] Size and diaphragm or piston
[4] Same or opposite to forward wheel rotation
[5] Relative to rear axle(s) centerline (include sketch if necessary)

VEHICLE INFORMATION SHEET

Vehicle: Navistar 4900 4x2 Straight Truck
Test No.: F Test Date(s): October 10, 1996
Test Facility and Location: Transportation Research Center East Liberty Ohio
Year, Make, and Model: 1996 Navistar 4900 SA 495 4x2
VIN or Unit No.: 1HTSDADROTH398198
GAWR, lb: 1st Axle 14,600 2nd Axle 21,000 3rd Axle NA GVWR 35,600
Center of Gravity Height, in:

- Truck, unladen (above ground)(in): 35.3 in with 3560 lb Navistar load frame installed
- Truck, laden (above ground)(in): 62.2 in
- Truck Ballast (above top of frame): 48.3 in

Wheelbase, in: 152
Curb Weight Distribution, lb:

	1st Axle	2nd Axle	Total
Unladen:	7,420	8,340	15,760
Laden:	14,300	21,280	35,580

Retarder(s) Type(s):
Aerodynamic Treatments: (Yes/No) (Attach Photo): No

BRAKES:

Axles:	Type[1]	Size, in	Make	Lining (Edge Code)
1	Q-plus	15 x 4	Rockwell	ABB-197
2	Q-plus	16.5 x 7	Rockwell	ABB-197
3	NA	NA	NA	NA

Brake Drum/Rotor

Axles:	Type[2]	Make	Dust Shields Installed?
1	Drum		
2	Cast shoes		
3	NA	NA	NA

ACTUATION DETAILS:

	Air Chambers		Slack Adjusters		
Axles:	Make	Type[3]	Length or Wedge angle	Manufacturer	Cam Rotation[4]
1	MGM	20	5.5	Rockwell	
2	MGM	30-30	5.5	Rockwell	
3	NA	NA	NA	NA	

VEHICLE INFORMATION SHEET
(Continued)

Vehicle: Navistar 4900 4x2 Straight Truck

TIRES:

Axles:	Pressure (psi)	Size	Make	Model	Static Loaded Radius (in) Measured	Static Loaded Radius (in) DataBook
1	119	12R22.5	Goodyear	Unisteel G286		20.0
2	85	11R24.5	Goodyear	Unisteel G362		20.8
3	NA	NA	NA	NA	NA	NA

ABS: Manufacturer: Bendix Model: 04ABA Configuration: 4S4M

FRONT SUSPENSION:

Type: Spring Make: International Model: I-140S

REAR SUSPENSION:

Type: Spring Make: Rockwell Model:________
Axle Spread, m(in):________ Overall Width (SAE J693):________

AIR SYSTEM:

Compressor Capacity ccm(cfm): 13.2 cfm @1250 rpm Cut-out kPa(psi):____ Cut-in kPa(psi):____
Crack Pressure Ratings(psi)[5]:
1st Axle:________ 2nd Axle:________
3rd Axle:________ Treadle Valve:________
Bobtail Proportioning: ☐ ________ Front Axle Limiting:________
Air Dryer: ☐ yes Air Compounding:________
Spring Brake Inversion Valve: ☐ Number of Brakes Controlled:________
Specifics Regarding Air Brake System Components:________

AIR TANK VOLUMES 1 (cu.in.):

Supply:________ Primary:________ Secondary:________
Auxiliary:________ Isolated From Service? ☐

SPECIAL CONDITIONS:

Special conditions or equipment which might affect brake performance: Air Dryer

[1] Cam, disc, wedge, etc.
[2] Cast or composite drum, vented or non-vented rotor, etc.
[3] Size and diaphragm or piston
[4] Same or opposite to forward wheel rotation
[5] Relative to rear axle(s) centerline (include sketch if necessary)

VEHICLE INFORMATION SHEET

Vehicle: Navistar 2674 4x2 Straight Truck
Test No.: G Test Date(s): April 10, 1997
Test Facility and Location: Transportation Research Center East Liberty Ohio
Year, Make, and Model: 1996 Navistar SA267 4x2
VIN or Unit No.: 1HTGKAHR6VH398201
GAWR, lb: 1st Axle 20,000 2nd Axle 30,000 3rd Axle NA GVWR 50,000
Center of Gravity Height, in:

- Truck, unladen (above ground)(in): 38.8 in with 3560 lb Navistar load frame installed
- Truck, laden (above ground)(in): 60.2 in
- Truck Ballast (above top of frame): 34.6 in

Wheelbase, in: 148
Curb Weight Distribution, lb:

	1st Axle	2nd Axle	Total
Unladen	NA	NA	NA
Laden	19,930	29,070	49,000

Retarder(s) Type(s):
Aerodynamic Treatments: (Yes/No) (Attach Photo): No

BRAKES:

Axles:	Type[1]	Size, in	Make	Lining (Edge Code)
1	S-cam			
2	S-cam	16.5 x 7		
3	NA	NA	NA	NA

Brake Drum/Rotor

Axles:	Type[2]	Make	Dust Shields Installed?
1			
2	Cast drum		
3	NA	NA	NA

ACTUATION DETAILS:

	Air Chambers		Slack Adjusters		
Axles:	Make	Type[3]	Length or Wedge angle	Manufacturer	Cam Rotation[4]
1					
2	MGM	36-36			
3	NA	NA	NA	NA	NA

VEHICLE INFORMATION SHEET
(Continued)

Vehicle: Navistar 2674 4x2 Straight Truck

TIRES:

Axles:	Pressure (psi)	Size	Make	Model	Static Loaded Radius Measured	Static Loaded Radius DataBook
1	120	425/65R22.5	Goodyear	Unisteel G286		
2	120	315/80R22.5	Goodyear	Unisteel G286		19.9
3	NA	NA	NA	NA	NA	NA

ABS: Manufacturer: Bendix Model: 4L5 Configuration: 4S4M

FRONT SUSPENSION:

Type: spring Make: International Model: I-200S

REAR SUSPENSION:

Type: spring Make: Rockwell Model: RS30-180
Axle Spread, m(in):____ Overall Width (SAE J693):____

AIR SYSTEM:

Compressor Capacity ccm(cfm): 13.2 cfm @1250 rpm Cut-out kPa(psi):____ Cut-in kPa(psi):____
Crack Pressure Ratings(psi)[5]:
1st Axle:____ 2nd Axle:____
3rd Axle:____ Treadle Valve:____
Bobtail Proportioning: ☐ ____ Front Axle Limiting:____
Air Dryer: ☐ yes Air Compounding:____
Spring Brake Inversion Valve: ☐ Number of Brakes Controlled:____
Specifics Regarding Air Brake System Components:____

AIR TANK VOLUMES 1 (cu.in.):

Supply:____ Primary:____ Secondary:____
Auxiliary:____ Isolated From Service? ☐

SPECIAL CONDITIONS:

Special conditions or equipment which might affect brake performance: Air Dryer

[1] Cam, disc, wedge, etc.
[2] Cast or composite drum, vented or non-vented rotor, etc.
[3] Size and diaphragm or piston
[4] Same or opposite to forward wheel rotation
[5] Relative to rear axle(s) centerline (include sketch if necessary)

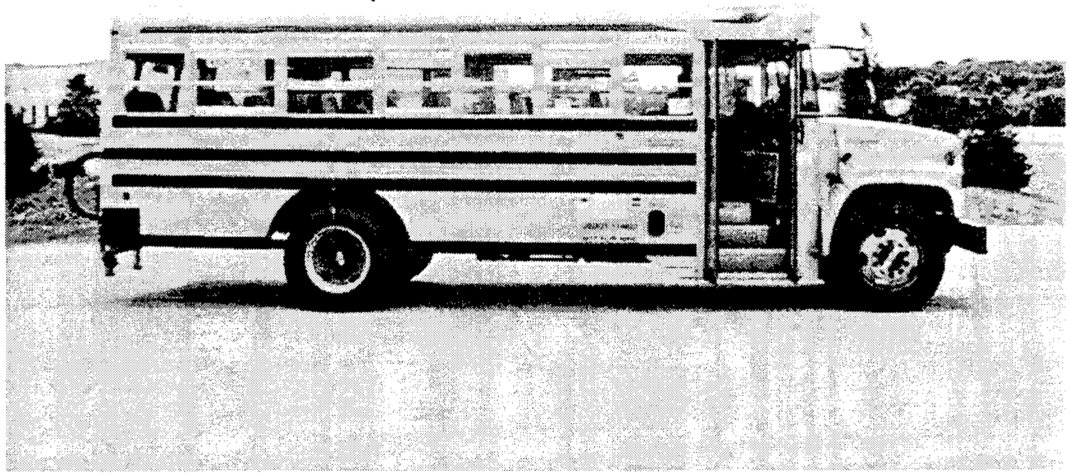


Figure 10.1 - GMC School Bus - Unit A, FMVSS No. 105
Spring Suspension, Hydraulic Brakes, 193" Wheelbase, GAWR Front 8100, GAWR Rear 19000

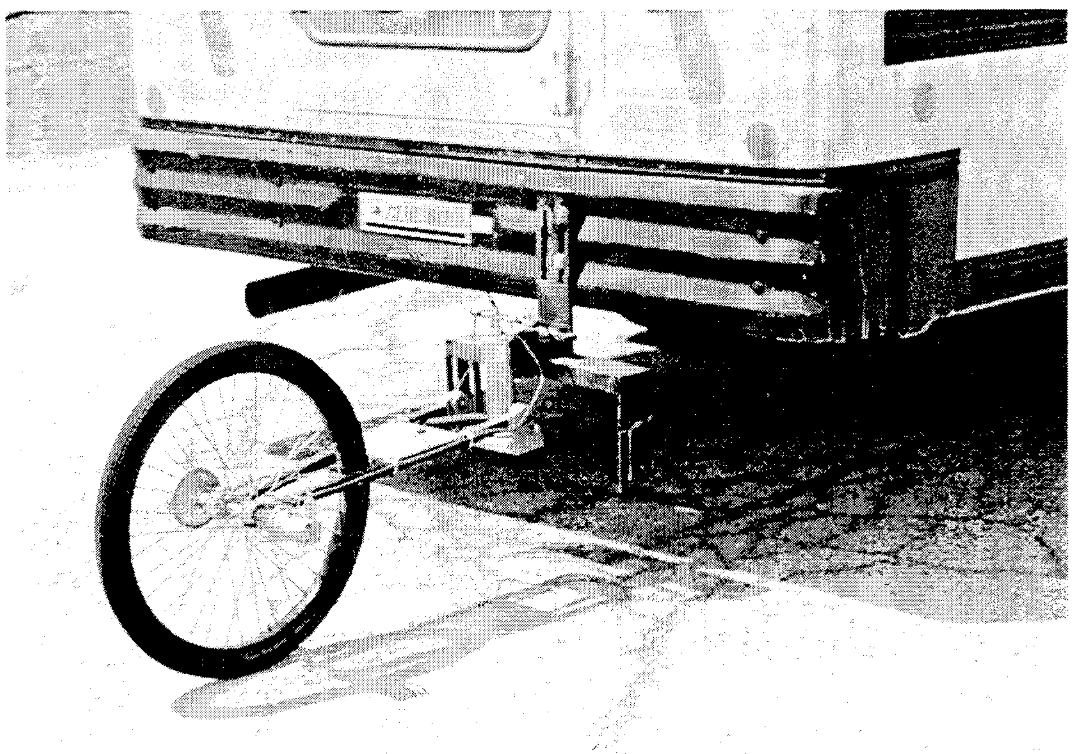


Figure 10.2 - GMC School Bus
Typical Labeco 5th Wheel Installation For Independent Measurement of Vehicle Speed

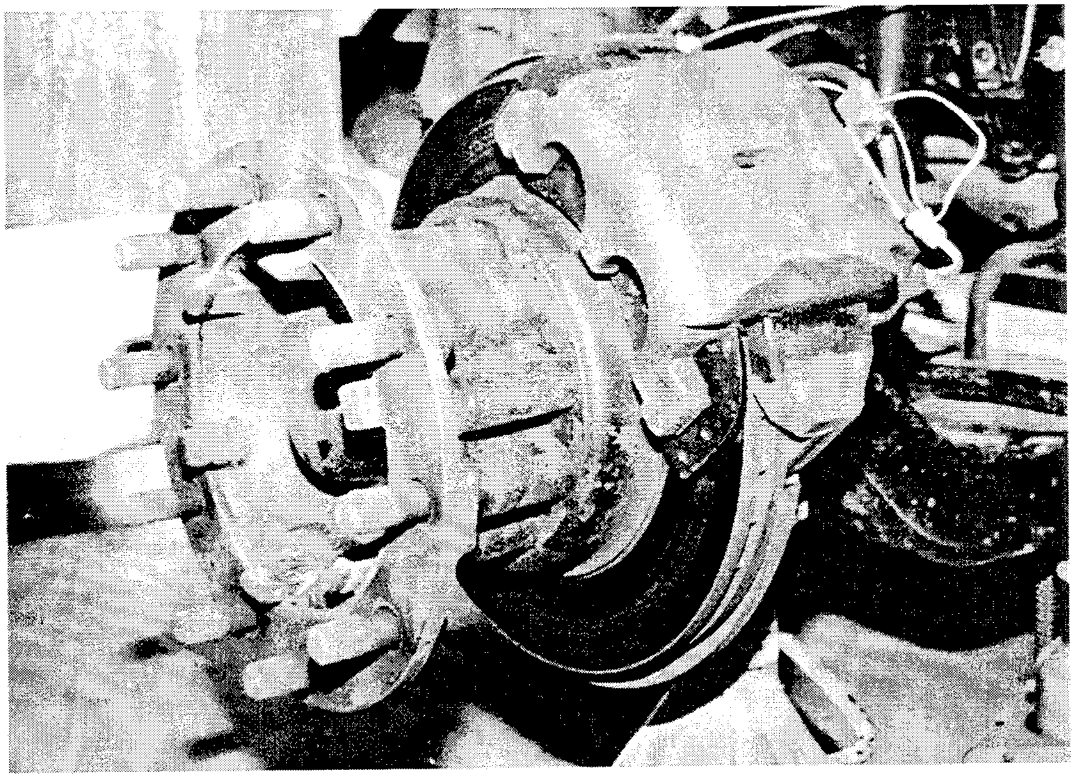


Figure 10.3 - GMC School Bus - FMVSS No. 105
Typical Steer Axle Hydraulic Brake Disc Assembly for a Budd Type Wheel

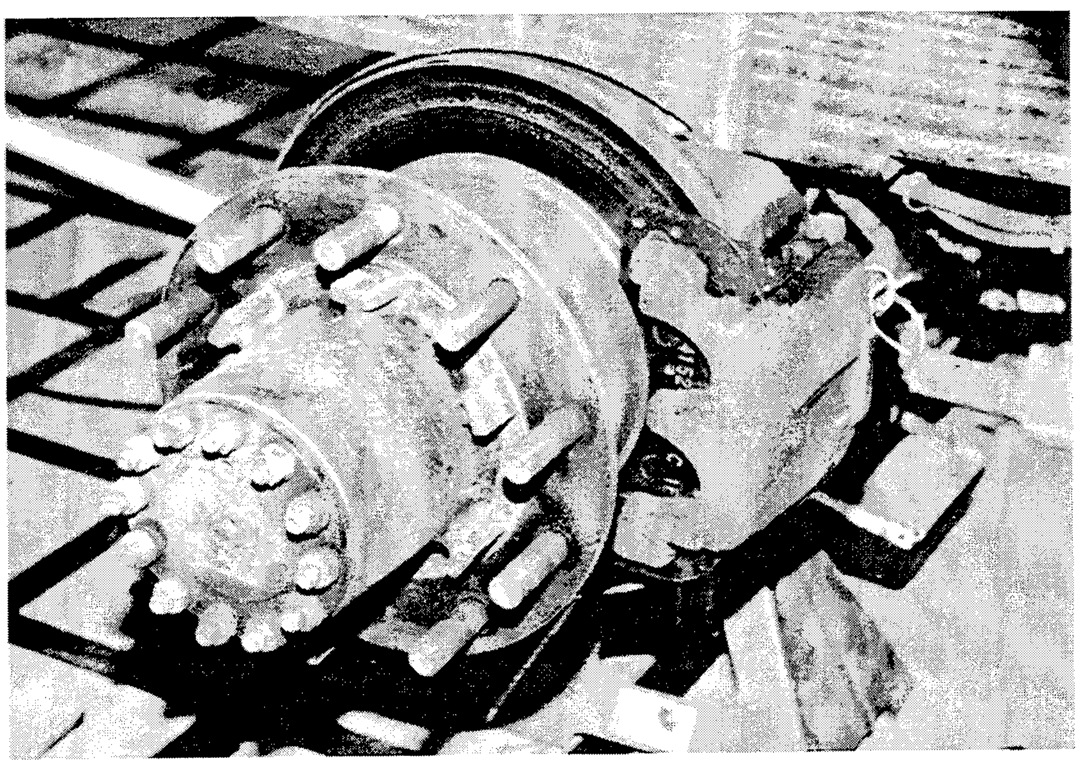


Figure 10.4 - GMC School Bus - FMVSS No. 105
Typical Drive Axle Hydraulic Brake Disc Assembly for a Budd Type Wheel

Figure 10.5 - Freightliner / Thomas Built School Bus - Unit B, FMVSS No. 105
Spring Suspension, Hydraulic Brakes, 252" Wheelbase, GAWR Front 7560, GAWR Rear 17940

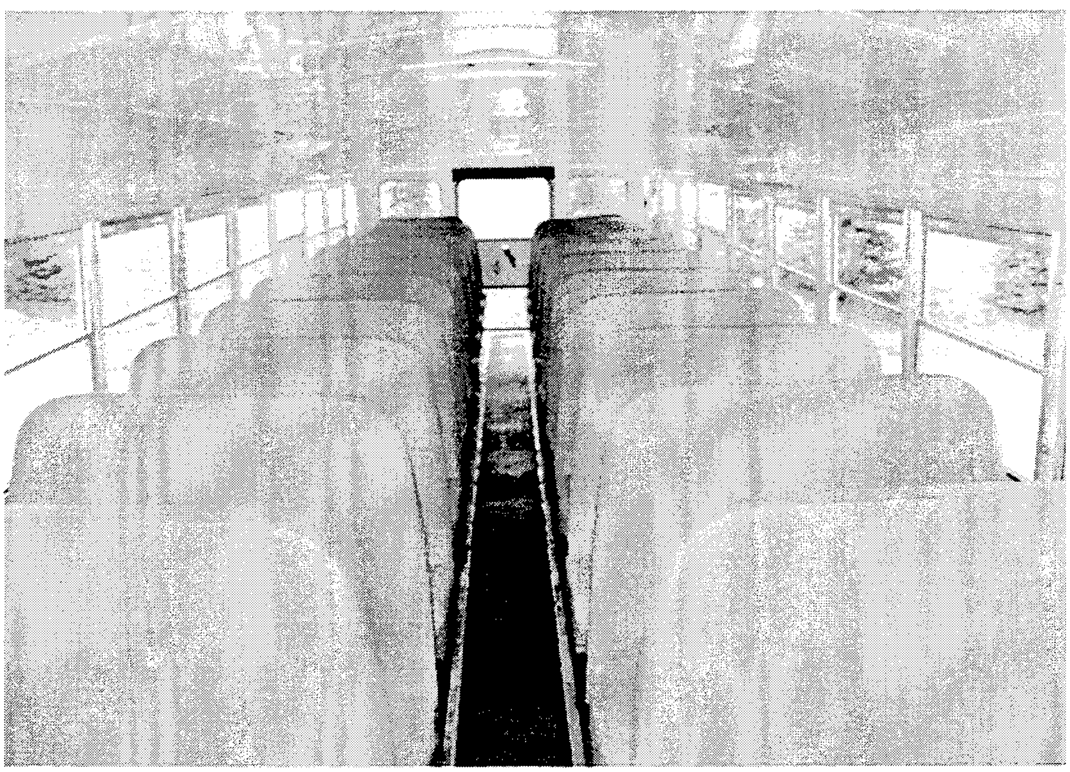


Figure 10.6 - Freightliner / Thomas Built School Bus - FMVSS No. 105
Typical Seating Arrangement - Empty Condition
For GVWR test, sand bag ballast was added under the seats and on the benches.

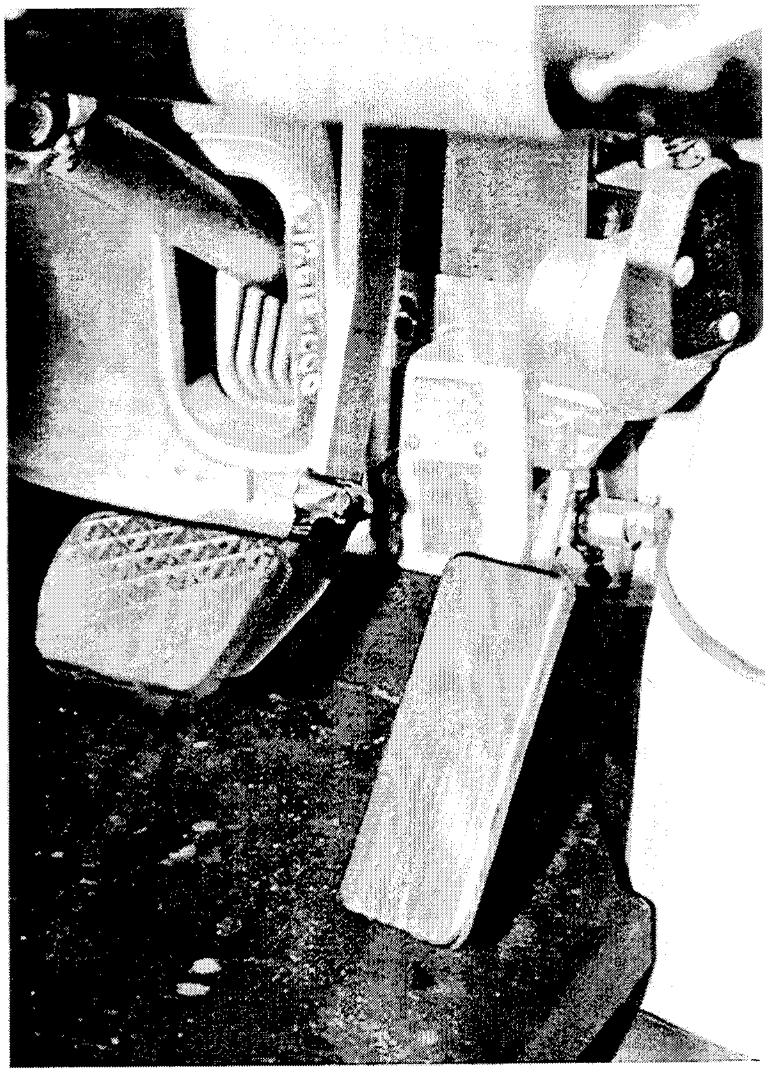


Figure 10.7 - Freightliner / Thomas Built School Bus - FMVSS No. 105
Potentiometric Displacement Measurement of Brake Pedal Typically Applied
on FMVSS 105 - Hydraulic Braked Vehicle Tests

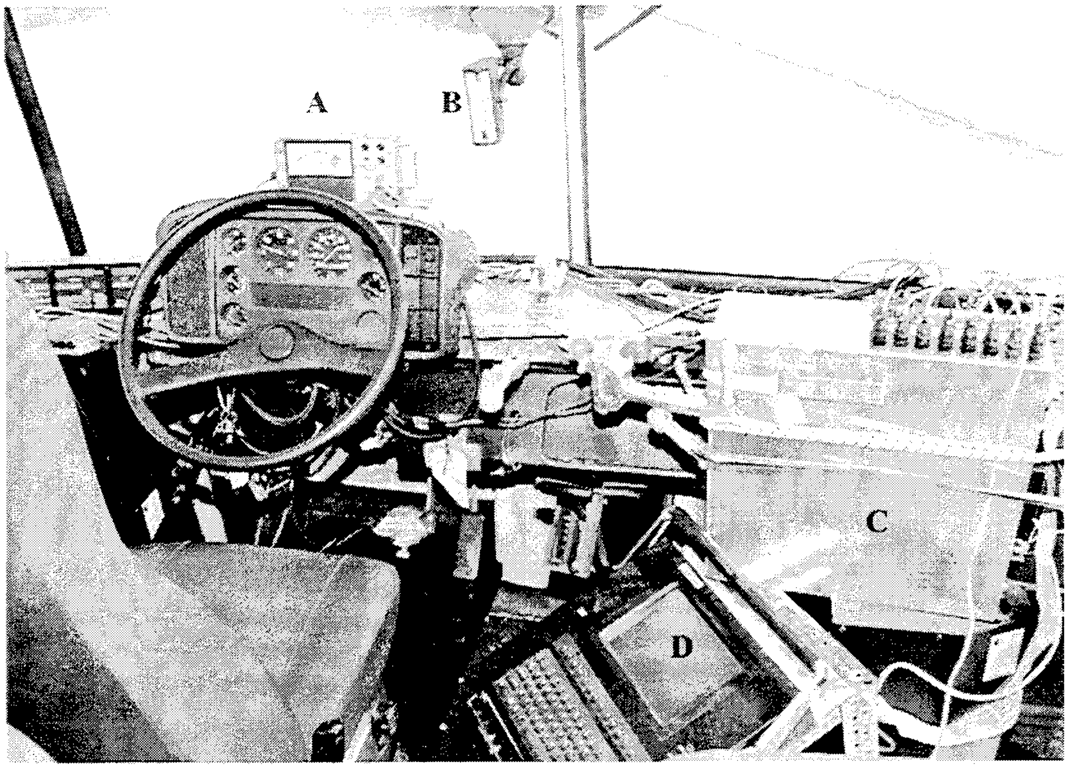


Figure 10.8 - Freightliner / Thomas Built School Bus - FMVSS No. 105
Open view for driver during test operations. Note Instruments: **A** - Pedal Force Meter, **B** - Deceleration Indicator, **C** - Signal Conditioning Unit, **D** - PC Data Acquisition Controller.

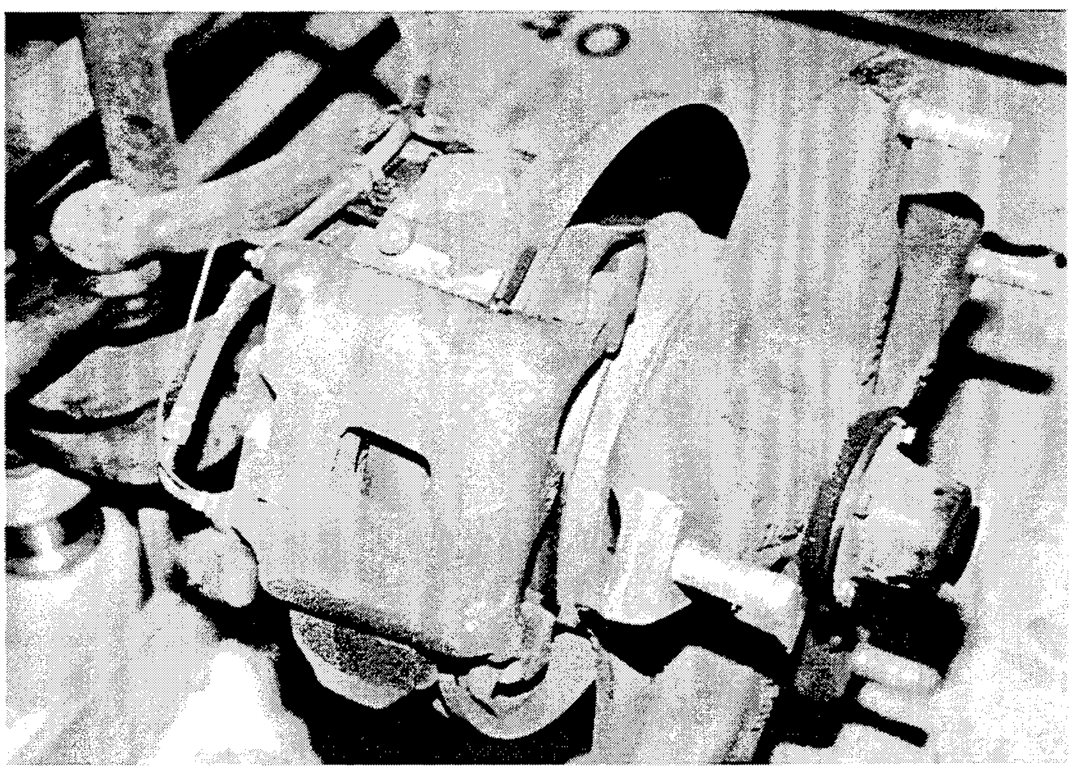


Figure 10.9 - Freightliner / Thomas Built School Bus - FMVSS No. 105
Typical Steer Axle Hydraulic Brake Disc Assembly for a Spoke Type Wheel

Figure 10.10 - Freightliner 6x4 Straight Truck - Unit C, FMVSS No. 121
Air Suspension, Air Brakes, 180" Wheelbase, GAWR Front 12000, GAWR Rear 40000

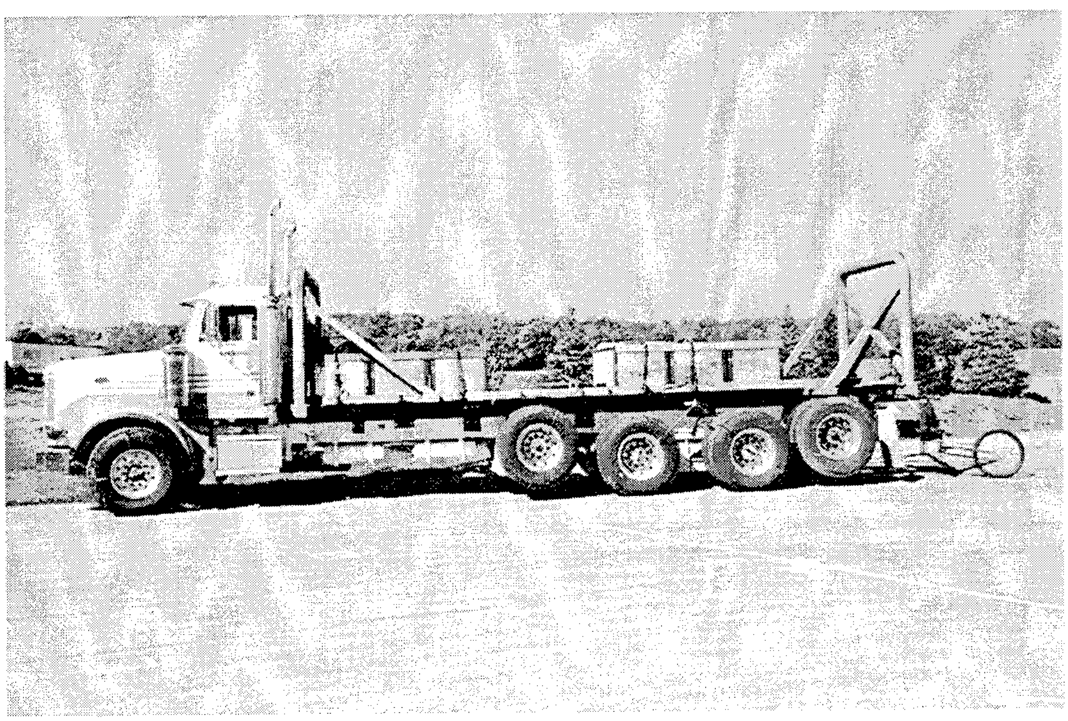


Figure 10.11 - Peterbilt 6x4 Straight Truck - Unit D, FMVSS No. 121
Spring Suspension, Air Brakes, 311" Wheelbase, GAWR Front 20000, GAWR Rear 40000
Note: the two tag axles were lifted for the duration of this test series.

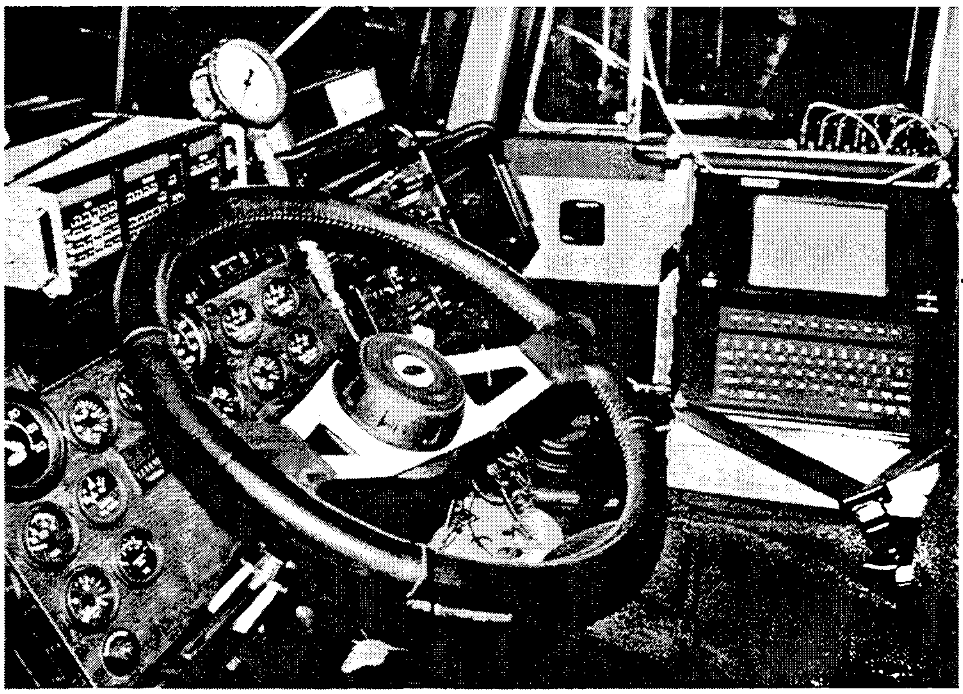


Figure 10.12 - Peterbilt 6x4 Straight Truck - Unit D, FMVSS No. 121

Note Driver Feedback Devices:
A - Labeco Performance Monitor for initial speed and stopping distance
B - Analog dial gauge for control pressure
C - Fluke digital thermometer for monitoring brake lining temperatures
D - Data Acquisition Control PC and signal conditioning package

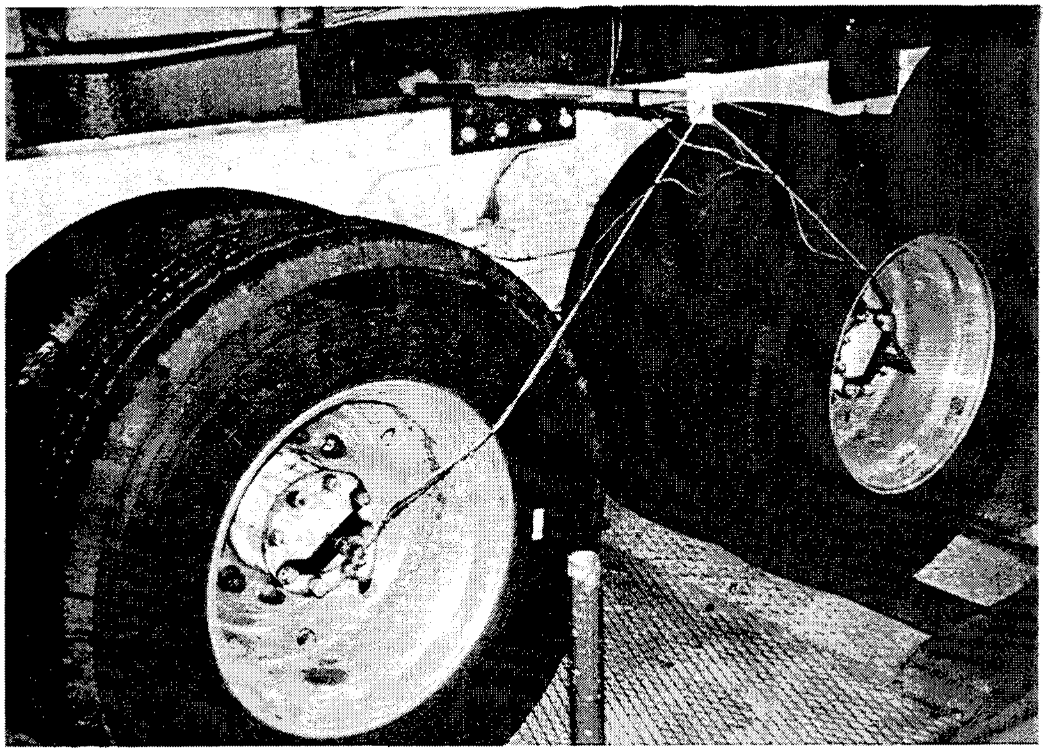


Figure 10.13 - Peterbilt 6x4 Straight Truck - Unit D, FMVSS No. 121
Second drive axle undergoing brake force measurement on a roller, brake dynamometer.
Note: typical installation of wheel tachometer generators used to indicate individual wheel speeds.

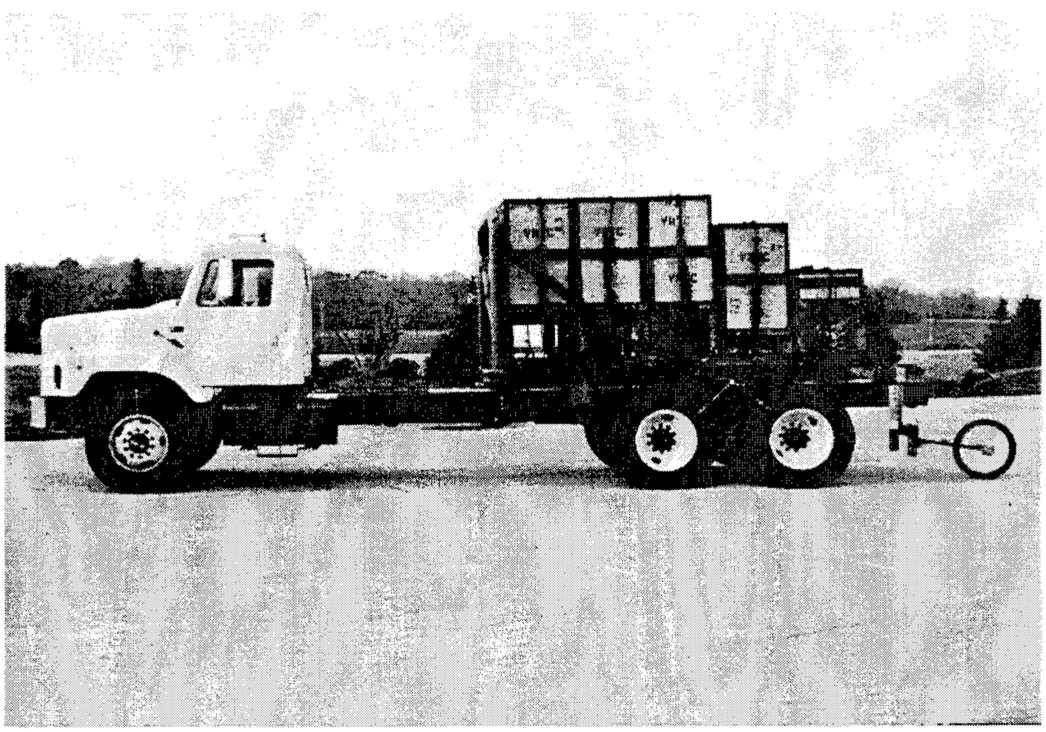


Figure 10.14 - Navistar 6x4 Straight Truck - Unit E, FMVSS No. 121
Spring Suspension, Air Brakes, 238" Wheelbase, GAWR Front 15000, GAWR Rear 46000
with high CG load frame and ballast.

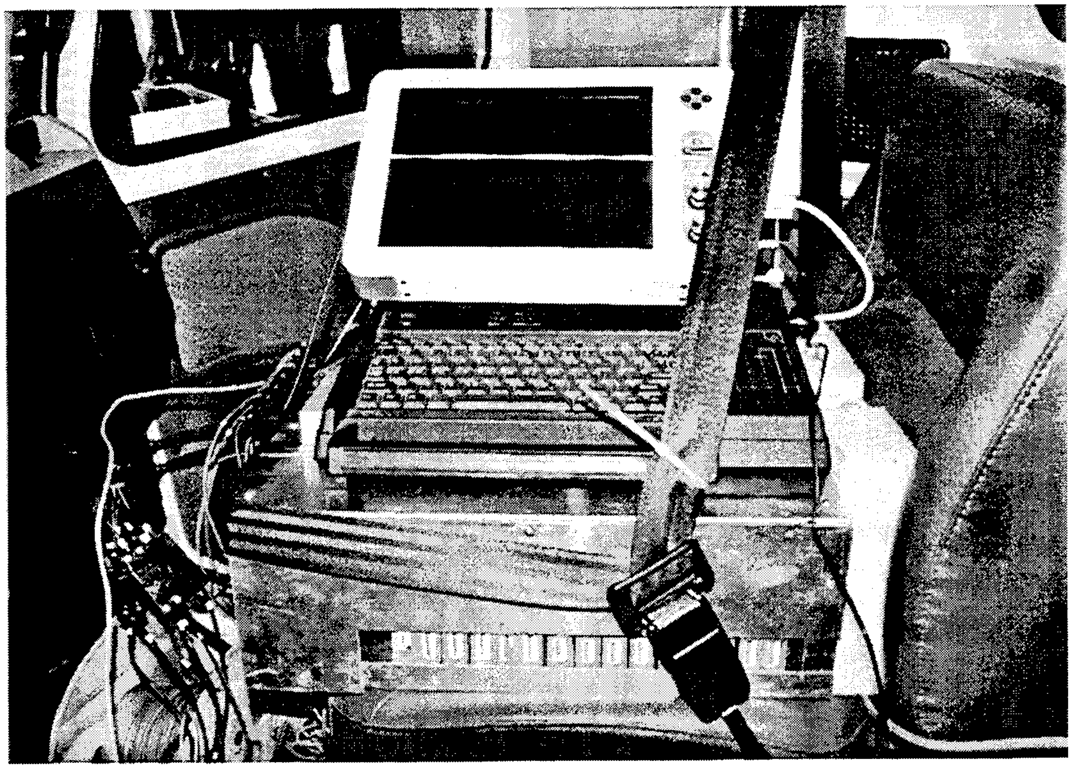


Figure 10.15 - Navistar 6x4 Straight Truck - Unit E, FMVSS No. 121
Data acquisition system cushioned by right seat and secured by seat belt, nylon web seat bottom strap, and polyethylene binders.

Figure 10.16 - 4900 Navistar 4x2 Straight Truck - Unit F, FMVSS No. 121
Spring Suspension, Air Brakes, 152" Wheelbase, GAWR Front 14600, GAWR Rear 21000 was tested with Navistar Hi-CG Load Frame (shown here with VRTC Load Frame).

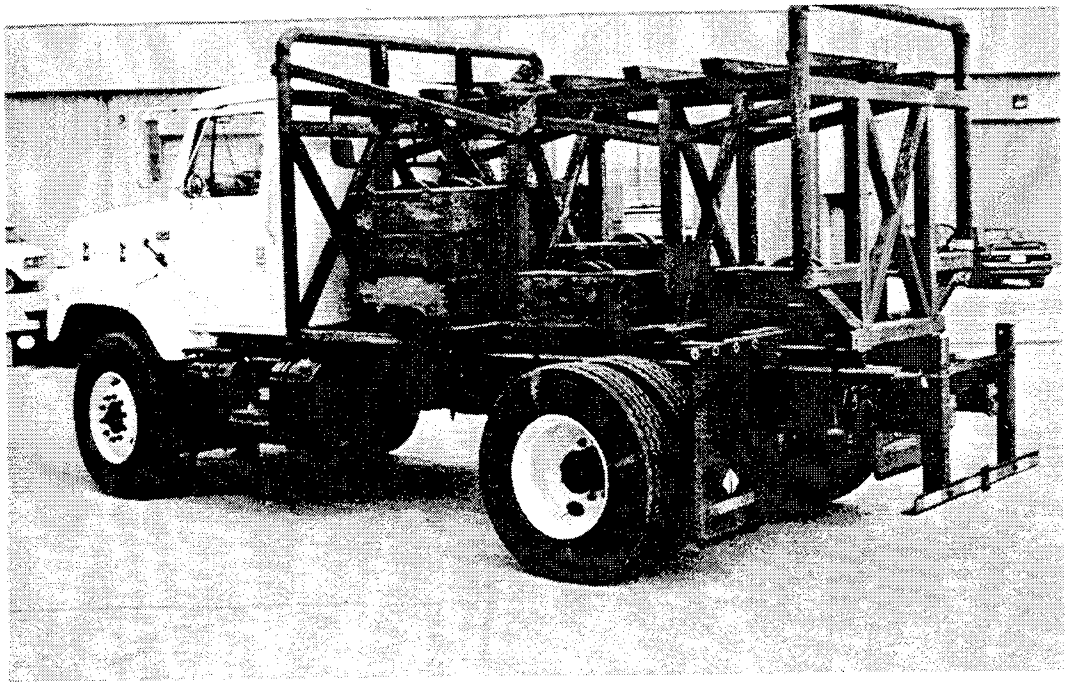


Figure 10.17 - 2674 Navistar 4x2 Straight Truck - Unit G, FMVSS No. 121
Spring Suspension, Air Brakes, 148" Wheelbase, GAWR Front 20000, GAWR Rear 30000
with Navistar Hi-CG load frame.

Figure 10.18 - 2674 Navistar 4x2 Straight Truck - Unit G, FMVSS No. 121
Spring Suspension, Air Brakes, 148" Wheelbase, GAWR Front 20000, GAWR Rear 30000
with 20" integral front extended rail.