Consumer Braking Information

Final Report for the Methodology Study of the Consumer Braking Information Initiative

Work Performed by U.S. Army Aberdeen Test Center, Fall 1998

Executive Summary

NHTSA is investigating the feasibility of developing a braking performance measurement test procedure for light vehicles. The development of a suitable test procedure to evaluate the braking performance of light vehicles would enable NHTSA to provide braking performance information such as stopping distance, in addition to crash test performance information, as part of the agency's New Car Assessment Program (NCAP), on those new vehicles that are purchased for use in crash tests under the NCAP.

The Aberdeen Test Center, a division of the U.S. Army Material Command, in Aberdeen Maryland, was contracted by NHTSA to conduct this research effort. Tests were conducted during the Fall of 1998 on ten light vehicles, using straight line stops on dry and wet asphalt, from an initial speed of 62 mph, with each vehicle in both lightly-loaded and fully-loaded conditions. The purpose of the tests was to determine if variability in stopping distance could be minimized, to collect sufficient data to permit statistical analysis of the results, and provide direction in developing a test procedure.

Braking tests were conducted on five passenger cars, two passenger mini vans, one full-size cargo van, one full-size sport utility vehicle, and one full-size pickup truck. All of the vehicles were equipped with a four-wheel antilock braking system (ABS), except for the pickup truck which had a rear-wheel only ABS. The vehicles were leased and were either 1998 or 1999 model year vehicles, with mileages between 2,300 and 18,000 miles. The tires on each vehicle were replaced with new tires of the same make, model, and size as the original tires. Each vehicle's brakes were inspected for normal wear, but were not replaced or subjected to conditioning other than from normal, as-received use. The new tires were conditioned by driving at 50 mph for 50 miles.

Selecting vehicles that were equipped with four wheel ABS was a decision intended to minimize the variability in stopping tests. If a vehicle does not have ABS, then the test driver must skillfully apply the brakes to attain minimum stopping distance without locking the vehicle's wheels. Conversely, it was reasoned that a vehicle with ABS acting on all wheels could be braked sufficiently hard to activate the ABS (i.e., at least some of the wheels would lock up if the ABS was not present), and as long as the brake pedal force remained high enough to keep the ABS activated for the duration of the stop, then the ABS would keep the vehicle at its optimal level of braking. The pickup truck that only had rear-wheel ABS was acquired inadvertently and could not be included in the final results, but did provide useful information on brake pedal force at the threshold of front wheel lockup.

A peak brake pedal force of 112 lbs. (500 N) was targeted to be consistent pedal forces specified for certain tests in Federal Motor Vehicle Safety Standard No. 135, Light Vehicle Brake Systems. However, brake applications as high as 450 lbs. were experienced during early testing, generally with the peak brake pedal force occurring at the top of the initial pedal force ramp-up. Subsequent efforts were made to target a steady pedal force of 150 lbs., with emphasis on rapid achievement of this force. Exceeding the target pedal force was not found to affect the stopping distance, however, since the ABS took control of the braking forces to prevent wheel lockup. For the pickup truck that was equipped with rear-wheel ABS, pedal forces in the 25 to 35-lb. range were found to be the pedal force just prior to front wheel lockup, and the peak pedal forces could not be achieved as rapidly as for the vehicles that had four-wheel ABS.

For each condition of load (lightly-loaded and loaded to Gross Vehicle Weight Rating [GVWR]) and road condition (wet and dry asphalt), ten stops were made for a total of forty stops per vehicle. The driver was permitted to first make several test stops to become familiarized with each vehicle, and to warm up the brakes. After each stop, the vehicle was driven around the test area to cool the brakes, and then the brake rotors and drums were checked with a hand-held pyrometer to check that front rotor temperatures (which were always hotter than the rear brake drums/rotors) were below 212 degrees F before the next stop was conducted. One of the passenger cars was used as a control vehicle to provide comparative stopping data throughout the test program, and this vehicle was instrumented with thermocouples in the front brake linings to provide additional lining temperature data throughout the testing.

Road friction measurements of the test area were made eight times during the test period using a skid trailer. On each day that road friction was measured, ten measurements of the dry asphalt and ten measurements of the wet asphalt were made, and average dry and wet values were derived. The average peak coefficient of friction ranged from 0.89 to 0.95 for dry pavement and 0.85 to 0.88 for wet pavement. These measurements indicate that the asphalt surface was in good condition.

For each set of ten stops, the mean stopping distance was calculated along with the standard deviation and 95th percentile stopping distance. Analysis of the pedal force attained during the first 0.3 seconds of brake application was used to develop the classification of a stop as Class A, B, C, and D, with Class D representing the slowest ramp-up of pedal force. Elimination of the slowest, Class D stops was found to have some effect on reducing the standard deviation (and hence 95th percentile stopping distance) for some of the vehicles, while for other vehicles there was not an appreciable difference in eliminating the Class D stops. Appendix D provides an analysis of the effects on eliminating each successively slower class of stops from the ten stops for each condition of road and load. Appendix E provides final statistics for each vehicle with Class D stops removed. Note that in some cases, the remaining number of Class A, B, and C stops is small thus statistical significance of the mean and standard deviation is reduced. Also note that the Class A through D stop classifications do not apply to the pickup truck since much lower

pedal forces were maintained in order to prevent front wheel lockup. Future research will be useful in determining what class of stop (e.g., Class C or better) can be consistently attained for most or all light vehicles equipped with four wheel ABS, now that these classifications have been identified.

NHTSA does not intend this report to provide comparative stopping distance information for the vehicles tested. Rather, the research effort is a preliminary effort to develop a test protocol that could be used in the future to measure the braking performance of NCAP vehicles. Further research is anticipated to further develop the test protocol, and determine, for example, if stopping tests can be replicated at other test facilities with consistent results. NHTSA is also coordinating this effort with European and Japanese governments with a goal of having a harmonized, international method that could be used to rate the braking performance of light vehicles.

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FINAL REPORT

FOR THE

METHODOLOGY STUDY

OF THE

CONSUMER BRAKING INFORMATION INITIATIVE

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13. ABSTRACT *(Maximum 200 words)*

The U.S. Army Aberdeen Test Center (ATC) performed a Methodology Study on passenger vehicle brake testing in support of an effort by the National Highway Traffic Safety Administration to develop an effective consumer braking information initiative. Brake performance tests were conducted on ten passenger vehicles to investigate the sources of variability in stopping distance results. Based on the analyses conducted, ATC provided recommendations for a test methodology to minimize variability and developed a test protocol based on Federal Motor Vehicle Safety Standard (FMVSS) No. 135, Passenger Car Brake Systems. Recommendations were also made for methods to report braking performance to consumers, and a test report format was developed.

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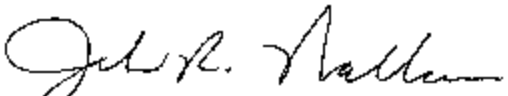

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I. BACKGROUND

The U.S. Army Aberdeen Test Center (ATC) has performed a methodology study on passenger vehicle brake testing in support of an effort by the National Highway Traffic Safety Administration (NHTSA) to develop an effective consumer braking information program. With the implementation of this program, consumers would have access to brake performance information obtained from standardized test procedures, in addition to the collision safety information currently available.

II. OBJECTIVE

The objectives of this methodology study were the following:

Task 1 - Perform braking performance tests and investigate the causes of stopping distance variability.
Task 2 - Provide details on a test methodology to minimize variability.
Task 3 - Develop a test protocol for the braking initiative.
Task 4 - Identify a method to report braking performance to consumers.
Task 5 - Develop a test report format.

III. TASK 1 - Perform Braking Performance Tests and Investigate the Causes of Stopping Distance Variability

A. Procedure

1. General Procedure

Service brake effectiveness tests were conducted on 10 vehicles with anti-lock brake systems (ABS). Testing consisted of straight-line brake stops from 100 km/hr (62 mph). The brakes were applied so that the ABS was activated as quickly as possible and fully invoked throughout the brake stop until the vehicle came to rest. Vehicle speed, stopping distance and pedal force were measured and recorded during each stop event. The vehicles were operated by professional test drivers with brake test experience ranging from low to high. Each vehicle was tested under two payload configurations on both wet and dry asphalt surfaces.

The initial criteria for vehicle selection was for each test item to be less than one year old with between 8,000 and 16,000 km (5,000 and 10,000 miles) of usage. However, some exceptions to this rule were allowed based on vehicle availability. A list of the vehicles used during testing is presented in Table 1 and a photograph of each vehicle is included in Appendix A. All of the vehicles were equipped with four-wheel ABS except for the Dodge Ram 1500 4x4, which was equipped with only rear ABS. Additionally, each vehicle selected had an automatic transmission.

TABLE 1. SUMMARY OF TEST VEHICLES

Vehicle No.	Make	Model	Year	Mileage	Brake specifications		
					ABS	Front	Rear
1	Pontiac	Grand Am	1998	9,483	4-wheel	rotors	drums
2	Ford	Expedition	1998	5,050	4-wheel	rotors	rotors
3	Toyota	Camry	1998	18,020	4-wheel	rotors	drums
4	Chevrolet	Malibu	1998	8,436	4-wheel	rotors	drums
5	Cadillac	DeVille	1998	2,283	4-wheel	rotors	rotors
6	Chevrolet	Express (1-ton)	1999	3,200	4-wheel	rotors	drums
7	Dodge	Ram 1500 4x4 (shortbed)	1998	14,840	rear-wheel	rotors	drums
8	Dodge	Caravan	1998	15,200	4-wheel	rotors	drums
9	Chevrolet	Astro	1998	8,500	4-wheel	rotors	drums
10	Pontiac	Bonneville	1998	5,100	4-wheel	rotors	drums

Vehicle No. 1 (Pontiac Grand Am) was also used as a baseline vehicle throughout testing. This vehicle was subjected to three instrumented brake stops each day of testing. These data were used to investigate variations in stopping distance caused by changes in environmental test parameters such as road surface friction, wind speed and ambient temperature.

Prior to testing, the OEM tires on each vehicle were replaced with new tires of the same make, model and size as the originals. Tire inflation pressures were set and maintained at the suggested levels shown on the tires. In retrospect, the inflation pressures recommended by the vehicle manufacturers should have been used. This change is reflected in Task 3, the test protocol. Following the tire replacement, each of the vehicles was operated for 80 km (50 miles) at approximately 80 km/hr (50 mph) to provide a limited break-in for the tires. No additional brake burnish procedure was conducted.

The weight distribution of each test item was determined with the vehicle empty and after being payloaded. The payload was configured based on the recommended gross vehicle weight (GVW) and maximum axle ratings reported on the driver-side door. Sand bags and body weight simulators, as shown in Figure 1, were used as payload.

Figure 1. Body Weight Simulator.

Testing was conducted at ATC's Phillips Army Airfield facility, near the intersection of Runways 17 and 22. The longitudinal test course grade was 0.1 percent, with each brake stop performed upslope. Road surface frictional coefficients were measured and recorded by the Eastern Federal Lands Highway Division of the Federal Highway Administration per ASTM E1337, both with and without water delivery. Frictional data were taken prior to testing and re-measured periodically to ensure consistent conditions throughout testing. The test rig is shown in Figure 2.

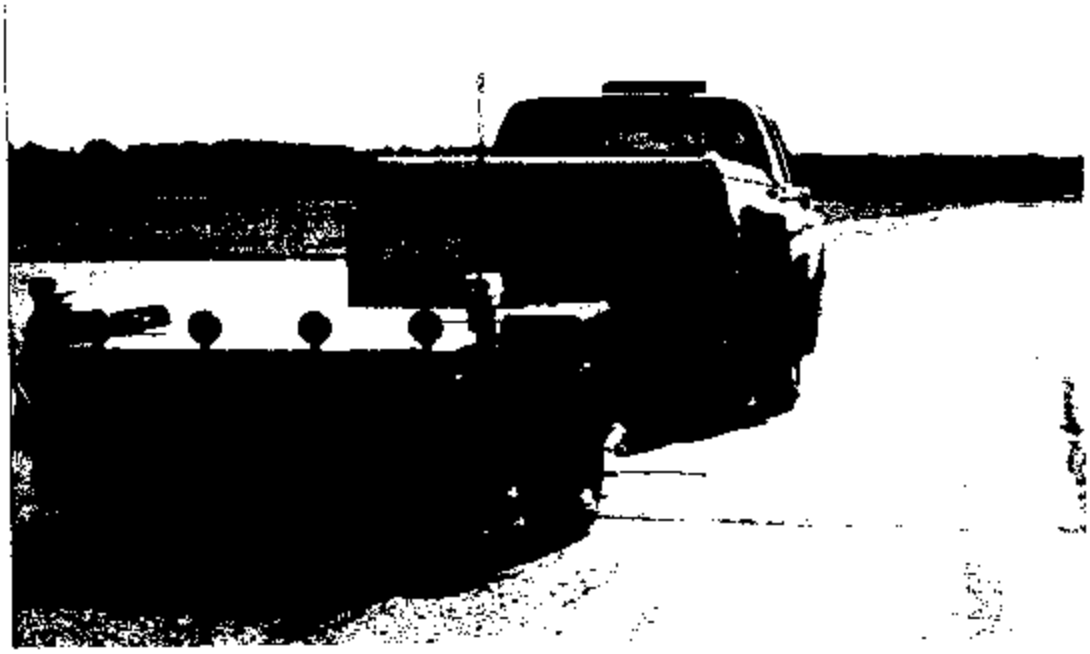


Figure 2. Frictional Coefficient Test Rig.

The test matrix for the brake performance test was as follows:

Vehicle #	Vehicle Test Configuration	# stops
1	a,b,c,d	40
2	a,b,c,d	40
3	a,b,c,d	40
4	a,b,c,d	40
5	a,b,c.d	40
6	a,b,c,d	40
7	a,b,c,d	40
8	a,b,c,d	40
9	a,b,c,d	40
10	a,b,c,d	40

Vehicle #	Baseline Test Configuration	# stops
1	a	3
1	a	3
1	a	3
1	a	3
1	a	3
1	a	3
1	a	3
1	a	3
1	a	3
1	a	3

Four test configurations were implemented:

a. No payload, dry asphalt
b. Full payload, wet asphalt
c. No payload, wet asphalt
d. Full payload, dry asphalt

Test data collected included:

- Vehicle road speed
- Stopping distance
- Pedal application force
- Brake rotor temperatures
- Ambient temperature
- Tire temperature
- Road surface temperature
- Tire pressure.

The test instrumentation installed on each vehicle consisted of ATC's Advanced Onboard Computer System (ADOCS), a pedal force transducer, a rolling fifth-wheel, driver displays and brake-lining thermocouples (on vehicle No. 1 during baseline testing). A GSE Inc. model 114350 pedal effort transducer, Serial No. 90, was installed on the brake pedal to measure pedal force. A Nucleus model NC8 fifth-wheel, Serial No. 8479, shown in Figure 3, was used to measure vehicle speed and rolling distance. The resolution of the fifth-wheel and the force transducer were 0.01 m (0.03 ft) and 1.0 N (0.23 lb), respectively.

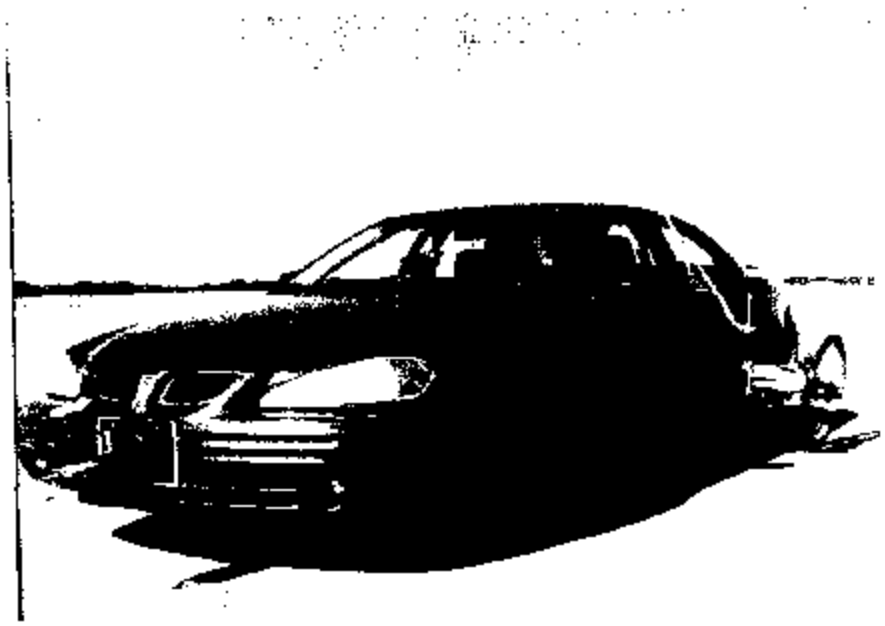


Figure 3. Grand Am Vehicle with Fifth-Wheel.

Other test instrumentation consisted of a hand-held, thermocouple-type pyrometer for measuring brake component temperature, tire temperature and ambient roadway temperature. Average wind speed, peak wind speed, average wind direction and wind direction standard deviation were obtained in 15-minute intervals using an anemometer provided by ATC's Meteorology Team (MET).

Stopping distance, vehicle speed and brake pedal force data were sampled dynamically during each brake stop event. The stopping distance measurement was triggered by the vehicle brake light circuit and ended when the vehicle came to rest. The sampling rates for the fifth-wheel and pedal force transducer were 200 Hz and 10 Hz, respectively. To account for variability in the target speed at brake application, the measured stopping distances were normalized to 100 km/hr (62 mph) in accordance with SAE J299 (August 1987). All other vehicle-related measurements were obtained statically.

The following three sections describe the procedures used for brake application, brake temperature measurements and cool-down, and water application on the test surface. Each of the three procedures evolved to some degree during early testing and therefore, are being given separate consideration. While it is not typically desirable to modify procedures during testing, early results showed that some modifications were required

2. Brake Application Procedure

Test drivers were initially instructed to perform brake stop events in a manner simulating a panic stop, with the transmissions left in drive. The goal was to fully invoke the ABS as quickly as possible, exceed the 500-N (112-lb) force limit used for compliance testing in FMVSS 135 and maintain a steady application until the vehicle came to rest. This brake application method emphasized vehicle performance, as opposed to driver performance, and ensured that all vehicle brake systems were controlled with sufficient force for peak ABS performance.

While testing the first two vehicles, average steady-state application forces typically varied from 1100 to 1500 N (250 to 350 lb), with peak forces as high as 2000 N (450 lb). Immediate generation of these high forces produced high initial application rates, generally exceeding 500 N (112 lb) in 0.1 seconds. While these high rates were desirable, the high steady-state forces were considered excessive. Therefore, a 660-N (150-lb) target was established for the steady-state force.

A different brake application method was required for the Dodge Ram 1500 4x4, since the vehicle was equipped with only rear ABS. In order to avoid lock-up of the front wheels, drivers had to perform brake stops with less pedal force than with the other vehicles, while still achieving optimum brake performance. This limitation resulted in brake stops with significantly lower initial ramp-up rates and subsequent steady-state force levels.

3. Brake Temperature Measurement and Cool-Down Procedure

Prior to performing each brake stop, brake lining temperatures were required to be kept below 100 °C (212 °F). Since the use of thermocouples within the brake linings was not included in the scope of this test, thermocouple-type pyrometers were used to measure temperature. For disk brakes, the lining temperature on the exposed side of the outer brake pads was recorded, and for drum brakes the reading was taken on the outer surface of the drums, adjacent to the swept area of the brakes. The initial assumption was that the temperature gradient across the lining material and drum material was relatively small.

As brake temperature data was collected during testing of vehicle No. 1, brake rotor temperatures were also measured and recorded. A substantial difference was noted between the temperature of the front rotors and the temperature of the back of the pad linings. While the temperatures on the exposed side of the brake pads were found to be below the 100 °C (212 °F) limit, the rotor temperatures rose above 100 °C (212 °F) and reached as high as 196 °C (385 °F).

To gain a better understanding of the heat transfer across the brake pads, thermocouples were installed in the front brake pads and rear brake shoes of vehicle No. 1 prior to its use as a baseline vehicle. The thermocouples were placed approximately 1/16 inch below the lining surface adjacent to the rotor. During testing of vehicle No. 2, brake temperatures of the baseline vehicle were monitored and recorded using the thermocouples as well as manually with the pyrometer.

An examination of the temperature results showed that the thermocouple data closely matched the temperatures obtained from the rotors with the pyrometer. The findings revealed that the temperature at the outer surface of brake pads was not an accurate representation of the brake lining temperature. It was noted that the rotor and brake pad combination could be modeled as a classic heat equation problem, with the rotor temperature assigned as one boundary condition of the pad. Using this approach, a continuous temperature gradient would be expected across the pad with the temperature on the rotor side of the pad being equal to the rotor surface temperature.

Based on this model and an analysis of the test data, it was concluded that measurements of the rotor surface temperatures yielded relatively accurate measurements of the lining temperatures at the lining/rotor interface. It was

also noted that the rear brake shoe temperatures of vehicle No. 1, obtained using thermocouples, were significantly lower than the temperatures of the front brakes.

As a result of these findings, the brake temperature measurement procedure was modified. Throughout the remainder of testing (starting with the third test vehicle), the temperatures of the front brake rotors were measured with the pyrometer and these readings were used as the temperature indicator to keep below 100 °C (212 °F). Rear brake temperatures were also recorded, but were always significantly cooler than the front.

Typically, after each brake stop, the front rotor temperatures were above the 100 °C (212 °F) limit and the next stop could not be initiated. To cool the brakes, the vehicle was operated at approximately 80 km/hr (50 mph) for a short period of time after each brake stop. Experimentation showed that the temperatures could be controlled and stabilized with the cool-down procedure lasting between 6 to 10 minutes, depending on the ambient temperature.

4. Water Application Procedure

For wet asphalt testing, water was applied to the road surface using the water tanker rig shown in Figure 4. The truck was operated at approximately 32 km/hr (20 mph), while water from the tanker was placed over the test surface using the distribution pipe shown on the back of the tanker. The water was released through holes placed along the longitudinal axis of the pipe with pressure generated from the pressure head in the tanker.

Prior to wet surface testing, three passes were made with the water tanker traveling longitudinally along the test area, as shown in Figure 5. The first two passes were made side-by-side, and the third pass was made overlapping the center of the lane created by the first two passes. The total length of the wet area was approximately 150 m (500 ft). Prior to each brake stop event, an additional pass was made with the water tanker along the center lane where the brake stops were conducted. Water was distributed with the intent to fully wet the asphalt surface without creating excessive standing water.

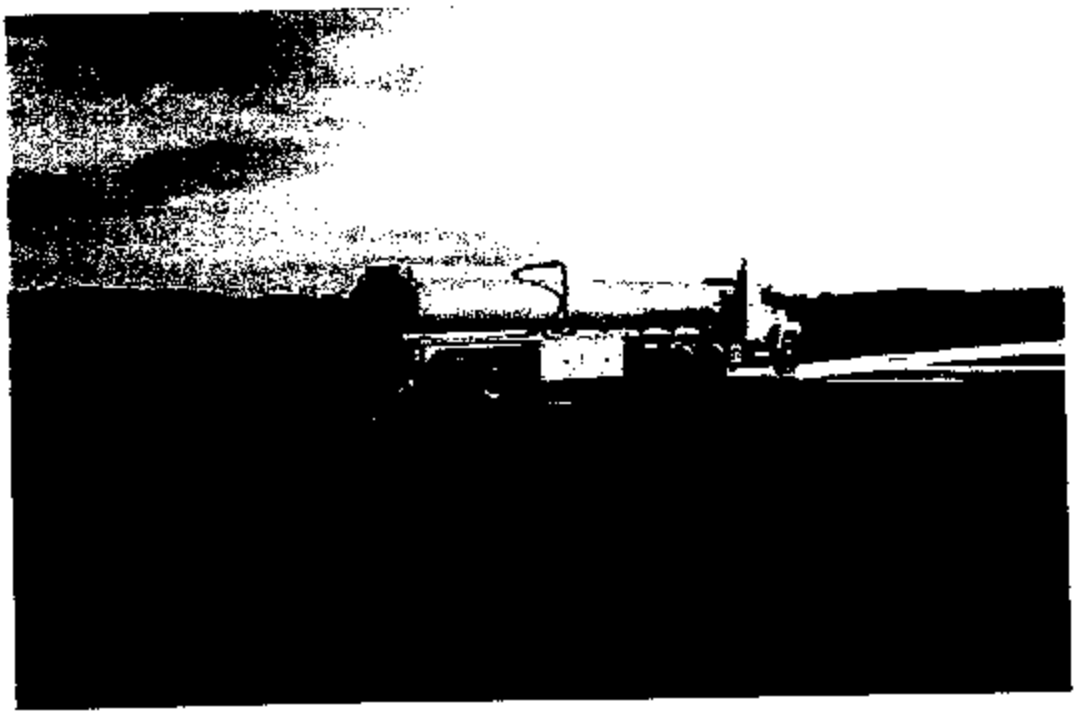


Figure 4. Water Tanker Rig.

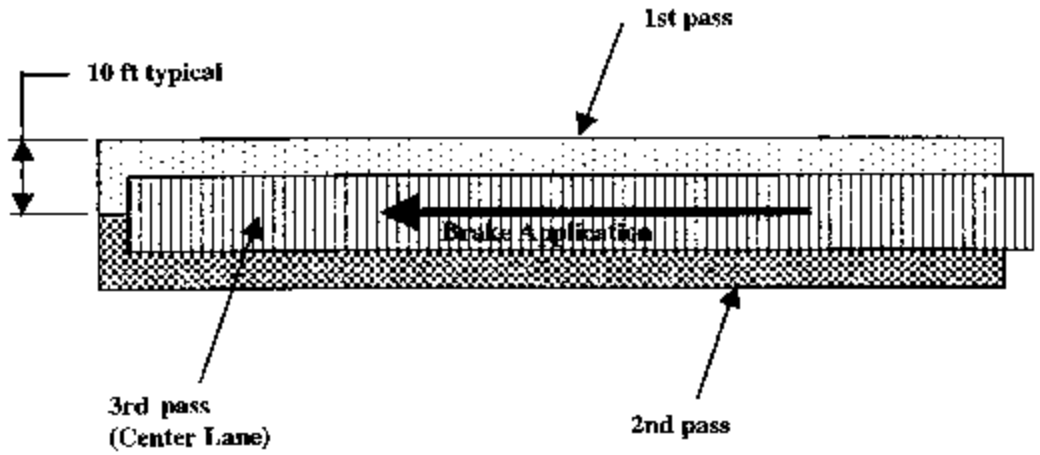


Figure 5. Water Application Procedure.

When vehicles No. 2 and 4 (Ford Expedition and Chevrolet Malibu) were tested on wet asphalt, some hydroplaning was experienced. An inspection of the test area revealed that standing water as deep as 1/4 inch had collected in minor depressions on the test course. To avoid this condition in later testing, the test area was displaced approximately 45 m (150 ft) farther up the runway, while still remaining within the area where the frictional measurements were taken. During subsequent testing, the water depth generally remained below 3 mm (1/8 inch).

B. Test Results

1. Weight Distribution

The weight distribution of each vehicle without payload is presented in Table 2. The weight distribution of each vehicle when fully payloaded and its corresponding gross vehicle weight (GVW) rating is presented in Tables 3 and 4, respectively. All weights were taken with driver and ADOCS included and with the vehicle fully fueled.

2. Center of Gravity (CG)

The longitudinal CG locations of each vehicle both empty and fully payloaded are presented in Tables 5 and 6, respectively. All tests were conducted with driver weight (using sand bags) and ADOCS included and with the vehicle fully fueled.

TABLE 2. VEHICLE WEIGHT DISTRIBUTIONS WITHOUT PAYLOAD

	Weight					
	Front axle		Rear axle		Total	
Vehicle	kg	lb	kg	lb	kg	lb
Pontiac Grand Am SE	910	2000	580	1280	1490	3280
Ford Expedition	1360	3000	1220	2700	2580	5700
Toyota Camry LE	910	2000	610	1340	1520	3340
Chevy Malibu LS	940	2080	550	1220	1490	3300
Cadillac DeVille	1200	2640	760	1680	1960	4320
Dodge Caravan SE	1110	2440	860	1900	1970	4330
Dodge Ram 1500 4X4	1440	3180	960	2120	2400	5300
Chevrolet Express (1-ton)	1260	2780	980	2160	2240	4940
Chevrolet Astro	1120	2460	970	2140	2090	4600
Pontiac Bonneville	1080	2380	630	1380	1710	3760

TABLE 3. VEHICLE WEIGHT DISTRIBUTIONS, FULLY PAYLOADED

Vehicle	Weight					
	Front axle		Rear axle		Total	
	kg	lb	kg	lb	kg	lb
Pontiac Grand Am SE	1020	2260	800	1760	1820	4020
Ford Expedition	1440	3180	1820	4000	3260	7180
Toyota Camry LE	960	2120	920	2020	1880	4140
Chevy Malibu LS	1020	2240	790	1740	1810	3980
Cadillac DeVille	1260	2770	1070	2370	2330	5140
Dodge Caravan SE	1220	2700	1210	2660	2430	5360
Dodge Ram 1500 4X4	1450	3200	1450	3200	2900	6400
Chevrolet Express (1-ton)	1500	3300	1710	3780	3210	7080
Chevrolet Astro	1260	2780	1420	3140	2680	5920
Pontiac Bonneville	1140	2510	940	2070	2080	4580

TABLE 4. GVW MANUFACTURER RATING

Vehicle	Weight					
	Front axle		Rear axle		Total	
	kg	lb	kg	lb	kg	lb
Pontiac Grand Am SE	1028	2266	796	1755	1824	4021
Ford Expedition	1564	3450	1872	4128	3266	7200
Toyota Camry LE	1088	2400	1088	2400	1896	4180
Chevy Malibu LS	1008	2223	800	1764	1808	3987
Cadillac DeVille	1259	2776	1076	2372	2335	5148
Dodge Caravan SE	1245	2746	1245	2746	2430	5360
Dodge Ram 1500	1726	3806	1726	3806	2902	6400
Chevrolet Express (1-ton)	1633	3600	1799	3968	3220	7100
Chevrolet Astro	1270	2800	1428	3150	2698	5950
Pontiac Bonneville	1141	2516	942	2078	2083	4594

TABLE 5. CENTER OF GRAVITY, WITHOUT PAYLOAD

Vehicle	Measurement	
	Longitudinal (forward from rear axle)	
	cm	in
Pontiac Grand Am SE	168.4	66.3
Ford Expedition	159.0	62.6
Toyota Camry LE	159.8	62.9
Chevy Malibu LS	170.4	67.1
Cadillac DeVille	177.5	69.9
Dodge Caravan SE	171.5	67.5
Dodge Ram 1500 4x4	204.5	80.5
Chevrolet Express (1-ton)	193.0	76.0
Chevrolet Astro	150.9	59.4
Pontiac Bonneville	177.3	69.8

TABLE 6. CENTER OF GRAVITY, FULLY PAYLOADED

Vehicle	Measurement	
	Longitudinal (forward from rear axle)	
	cm	in
Pontiac Grand Am SE	153.7	60.5
Ford Expedition	133.9	52.7
Toyota Camry LE	134.9	53.1
Chevy Malibu LS	151.1	59.5
Cadillac DeVille	155.7	61.3
Dodge Caravan SE	151.9	59.8
Dodge Ram 1500 4x4	170.9	67.3
Chevrolet Express (1-ton)	160.0	63.0
Chevrolet Astro	130.8	51.5
Pontiac Bonneville	153.2	60.3

3. Braking

Brake stop results from each vehicle in all four test configurations are presented in Table 7. Results from day-to-day baseline testing with the Pontiac Grand Am are presented in Table 8. Stopping distances and deceleration rates shown for each vehicle configuration are averages of all stops conducted that were considered to follow the guidelines presented in the test procedure. Brake stops not conducted properly were removed from the data set.

Results from each individual brake stop for each vehicle can be found in Tables B-1 through B-11 in Appendix B. Sample plots of applied pedal effort versus time can be found in Appendix C in Figures C-1 through C-10. Each figure contains pedal force plots from all brake stops conducted within a specific test configuration. One group of plots from each test vehicle is included.

TABLE 7. AVERAGE BRAKE STOP RESULTS FROM 100 KM/HR (62 MPH)

Vehicle	Dry surface				Wet surface			
	Stopping distance		Deceleration rate		Stopping distance		Deceleration rate	
	m	ft	m/sec^2	ft/sec^2	m	ft	m/sec^2	ft/sec^2
without payload								
Pontiac Grand Am SE	45.1	147.9	8.0	26.2	58.0	190.1	6.2	20.4
Ford Expedition	52.0	170.4	6.9	22.7	60.6	198.9	5.9	19.5
Toyota Camry LE	48.7	159.7	7.4	24.2	53.6	175.7	6.7	22.0
Chevy Malibu LS	43.1	141.3	8.4	27.4	45.8	150.3	7.9	25.8
Cadillac DeVille	47.7	156.4	7.5	24.8	49.9	163.8	7.2	23.6
Dodge Caravan SE	48.7	159.8	7.4	24.2	50.7	166.3	7.1	23.3
Dodge Ram 1500 4x4	60.7	199.2	5.9	19.4	63.9	209.6	5.6	18.5
Chevrolet Express (1-ton)	50.7	166.4	7.1	23.3	54.7	179.3	6.6	21.6
Chevrolet Astro	51.9	170.2	6.9	22.7	53.3	174.9	6.7	22.1
Pontiac Bonneville	47.8	156.7	7.5	24.7	49.2	161.3	7.3	24.0
fully payloaded								
Pontiac Grand Am SE	46.3	152.0	7.8	25.5	52.3	171.5	6.9	22.6
Ford Expedition	51.5	168.8	7.0	22.9	67.0	219.9	5.4	17.6
Toyota Camry LE	49.2	161.5	7.3	24.0	53.1	174.3	6.8	22.2
Chevy Malibu LS	47.0	154.0	7.7	25.1	50.0	164.1	7.2	23.6
Cadillac DeVille	50.4	165.2	7.1	23.4	50.0	163.9	7.2	23.6
Dodge Caravan SE	52.8	173.1	6.8	22.4	58.1	190.6	6.2	20.3
Dodge Ram 1500 4x4	57.5	188.5	6.3	20.5	62.6	205.2	5.8	18.9
Chevrolet Express (1-ton)	55.0	180.4	6.5	21.5	56.3	184.7	6.4	21.0
Chevrolet Astro	55.9	183.4	6.4	21.1	57.7	189.1	6.2	20.5
Pontiac Bonneville	49.7	162.9	7.2	23.8	50.5	165.5	7.1	23.4

TABLE 8. AVERAGE BRAKE STOP RESULTS FROM 100 KM/HR (62 MPH), PONTIAC GRAND AM BASELINE TESTING

Date of testing (1998)	Vehicle tested same day	Stopping distance		Deceleration rate	
		m	ft	m/sec^2	ft/sec^2
7 October	Expedition	45.7	149.8	7.9	25.8
8 October[a]	Expedition	47.9	157.1	7.5	24.6
9 October	Expedition	43.7	143.3	8.2	27.0
13 October	Camry	44.3	145.4	8.1	26.6
14 October	Camry	45.5	149.4	7.9	25.9
15 October	Camry	42.6	139.8	8.4	27.7
19 October[b]	Malibu	47.0	154.3	7.7	25.1
20 October	Malibu	44.4	145.7	8.1	26.6
22 October	DeVille	42.9	140.6	8.4	27.5
23 October	DeVille	42.8	140.3	8.4	27.6
30 October	Caravan	43.6	143.0	8.3	27.1
2 November	Caravan	43.5	142.6	8.3	27.2
3 November	Caravan	43.7	143.4	8.2	27.0
6 November	Ram 1500 4x4	44.6	146.4	8.1	26.4
12 November	Express (1-ton)	44.6	146.2	8.1	26.5
18 November	Astro	43.8	143.7	8.2	26.9
20 November	Bonneville	43.3	142.1	8.3	27.2

[a]Testing was conducted on damp pavement with no free standing water.
[b]Tires were rotated before testing.

C. Analysis

An analysis of the data was conducted to investigate the variability in braking performance of each vehicle and to determine the sensitivity of the brake stops to variables such as pedal effort, brake temperatures, surface conditions, environmental variations and payload. The analyses consisted of the following:

- The effect of brake pedal effort.
- The effect of brake temperature.
- The effect of tire temperature.
- Day-to-day variation effects.
- The effect of free standing water on wet stops.
- Test configuration effects.

Initially, stopping distance results from each vehicle test configuration were compiled and the mean and standard deviation (σ_{n-1}) were calculated for each data set. One-sided, 95% confidence interval estimates were also determined for each data set assuming a normal distribution of the measured stopping distances. The reported one-sided confidence intervals of each data set indicate to a 95% confidence that the actual average stopping distance is below this value. The results are shown in Appendix D.

The data obtained from Dodge Ram testing were excluded from the following analyses, since the vehicle was equipped without front ABS. The rear ABS was effective at eliminating rear wheel lock-up, and thus yaw, during the brake stops. However, brake applications had to be performed with significantly less pedal effort than the other vehicles in order to eliminate front wheel lock-up. Therefore, there was no basis for comparison.

The effects of pedal effort and brake temperature on individual brake stops were examined first using all of the brake stop data found in Appendix B. Criteria were then established for each variable based on trends found within the data that adversely affected the validity of the brake stop results. These criteria will be discussed in the following sections. Individual brake stops not meeting the established criteria were then removed and the average stopping distance and standard deviation of the data set were recalculated. The final statistics for each vehicle after

removing brake stops not meeting established criteria are presented in Appendix E. A summary of the final results are shown in Tables 9 and 10 and Figures 6 through 9.

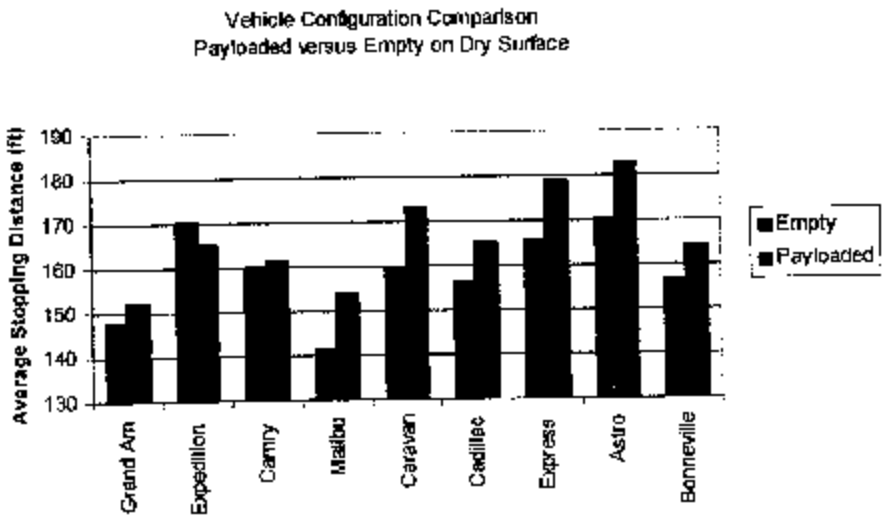
TABLE 9. FINAL STATISTICS FOLLOWING REMOVAL OF CLASS D AND COLD STOPS

	Dry surface				Wet surface			
	Average stopping distance		Standard Deviation		Average stopping distance		Standard deviation	
Vehicle	m	ft	m	ft	m	ft	m	ft
without payload								
Pontiac Grand Am SE	45.1	147.9	0.5	1.6	58.0	190.1	2.1	6.9
Ford Expedition	52.0	170.4	2.5	8.1	60.3	197.8	2.7	8.7
Toyota Camry LE	48.8	160.0	0.6	1.9	53.6	175.7	1.6	5.3
Chevy Malibu LS	43.1	141.3	0.4	1.4	45.8	150.3	0.9	2.9
Cadillac DeVille	47.7	156.3	0.9	2.9	49.9	163.6	0.6	1.9
Dodge Caravan SE	48.7	159.7	0.6	2.0	50.5	165.5	1.0	3.2
Chevrolet Express (1-ton)	50.5	165.6	0.8	2.7	54.4	178.3	0.6	1.9
Chevrolet Astro	52.0	170.5	0.4	1.2	53.1	174.1	0.5	1.5
Pontiac Bonneville	47.8	156.7	0.6	1.9	49.2	161.3	0.5	1.7
fully payloaded								
Pontiac Grand Am SE	46.3	152.0	0.5	1.6	52.3	171.5	2.6	8.5
Ford Expedition	50.4	165.4	0.9	3.1	67.2	220.4	3.0	10.0
Toyota Camry LE	49.2	161.5	0.8	2.6	53.1	174.3	0.7	2.2
Chevy Malibu LS	47.0	154.0	0.7	2.4	50.4	165.2	3.1	10.2
Cadillac DeVille	50.4	165.2	1.2	4.1	50.0	163.9	0.5	1.6
Dodge Caravan SE	52.8	173.1	1.5	4.8	58.1	190.6	1.3	4.2
Chevrolet Express (1-ton)	54.6	179.1	1.8	5.8	56.1	184.1	1.0	3.2
Chevrolet Astro	55.8	183.0	0.8	2.7	56.4	185.1	0.3	0.9
Pontiac Bonneville	50.1	164.2	1.3	4.4	50.4	165.3	0.9	3.0

TABLE 10. BASELINE VEHICLE FINAL STATISTICS FOLLOWING REMOVAL OF CLASS D AND COLD STOPS

		Stopping distance		Deceleration rate	
Date of testing (1998)	Vehicle tested same day	m	ft	m/sec^2	ft/sec^2
7 October	Expedition	45.7	149.8	7.9	25.8
8 October[a]	Expedition	47.9	156.7	7.5	24.7
9 October	Expedition	43.7	143.8	8.2	26.9
13 October	Camry	44.3	145.4	8.1	26.6
14 October	Camry	45.5	149.4	7.9	25.9
15 October	Camry	42.6	139.8	8.4	27.7
19 October[b]	Malibu	47.0	147.4	8.0	26.3
20 October	Malibu	44.4	145.7	8.1	26.6
22 October	DeVille	42.9	140.7	8.4	27.5
23 October	DeVille	42.8	140.3	8.4	27.6
30 October	Caravan	43.6	143.0	8.3	27.1
2 November	Caravan	43.5	142.6	8.3	27.2
3 November	Caravan	43.7	143.4	8.2	27.0
6 November	Ram 1500	44.3	145.5	8.1	26.6
12 November	Express (1-ton)	44.6	145.1	8.1	26.7
18 November	Astro	43.8	143.7	8.2	26.9
20 November	Bonneville	43.3	142.1	8.3	27.2

[a]Testing was conducted on damp pavement with no free standing water.
[b]Tires were rotated before testing.



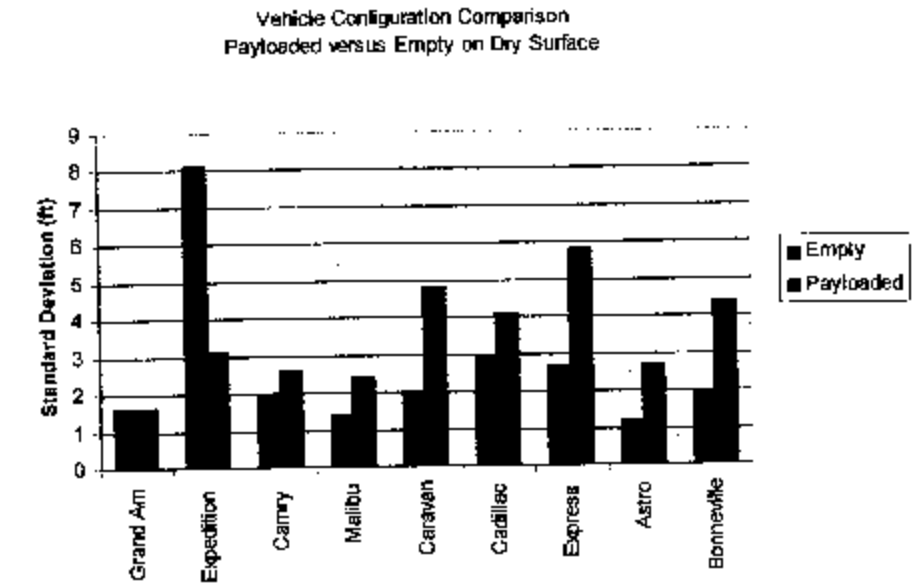
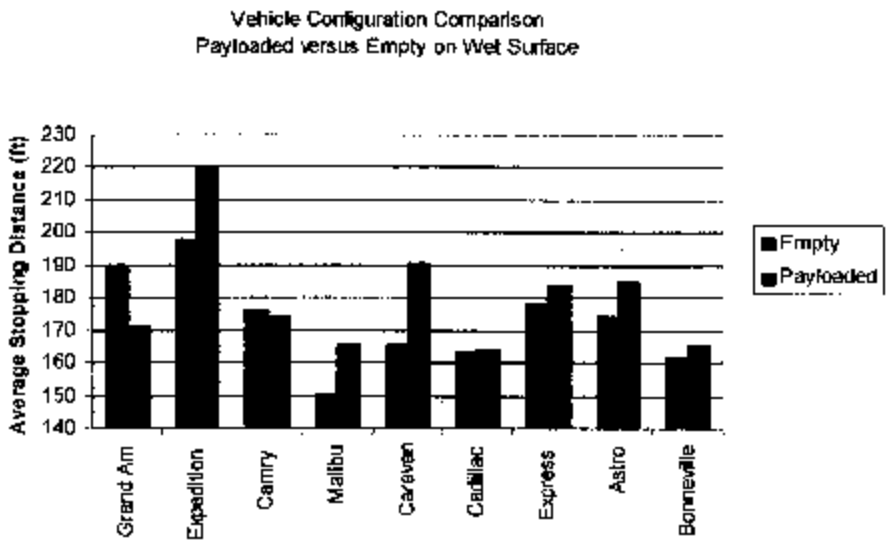


Figure 6. Comparison of Vehicle Stop Results on Dry Surface Empty Versus Payloaded.



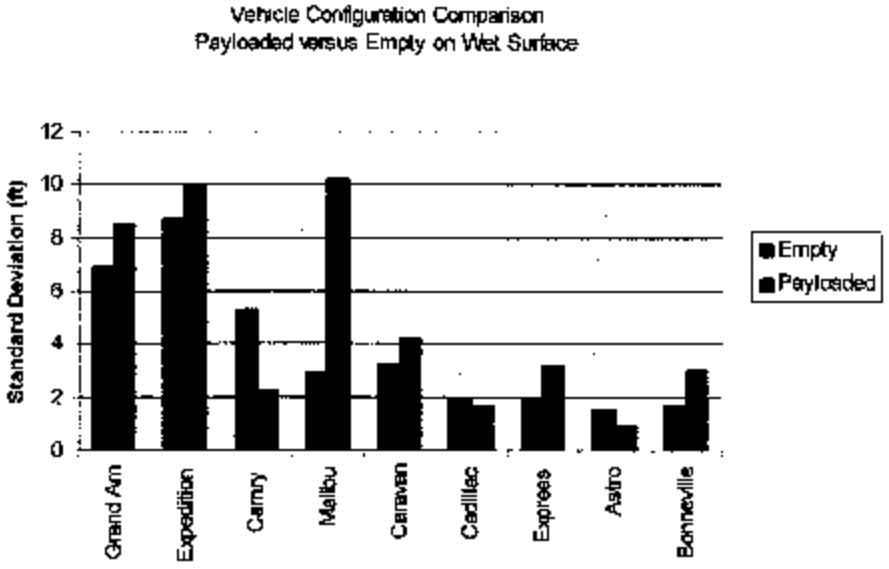
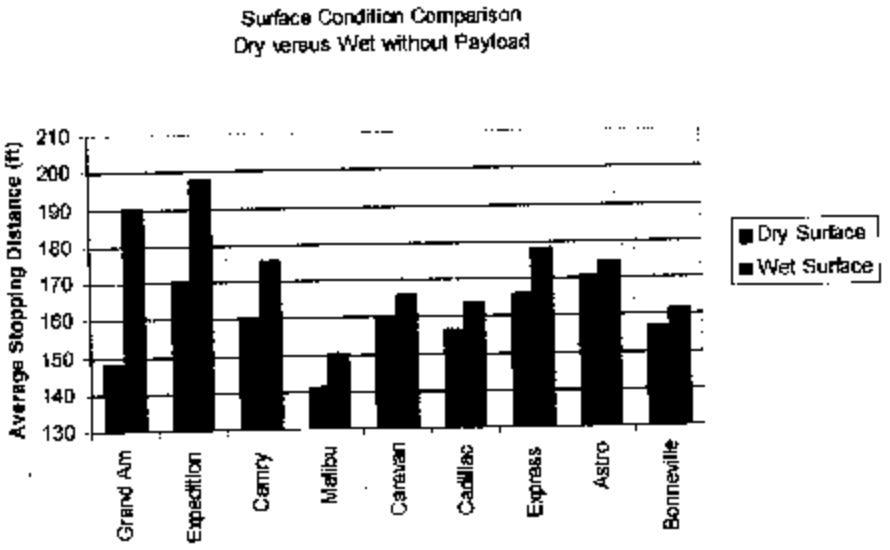


Figure 7. Comparison of Vehicle Stop Results on Wet Surface Empty Versus Payloaded.



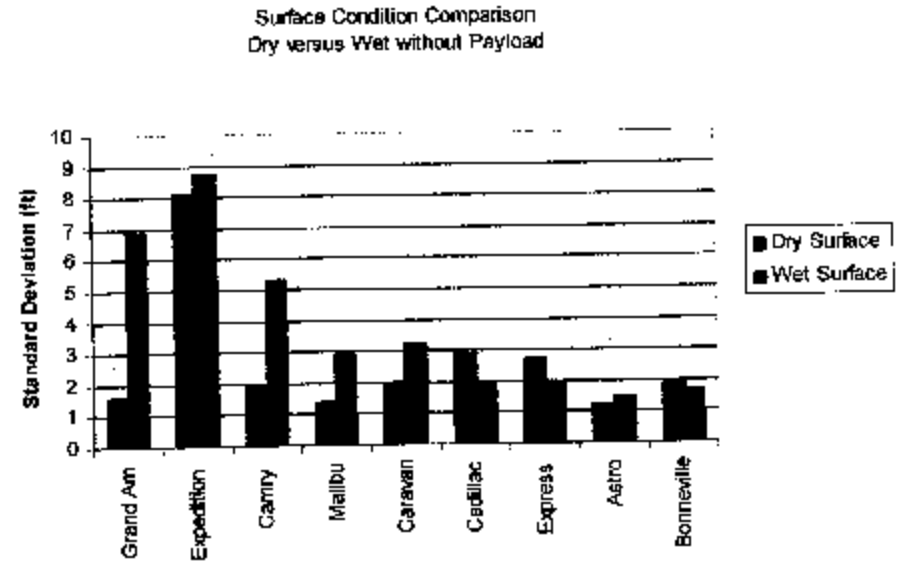
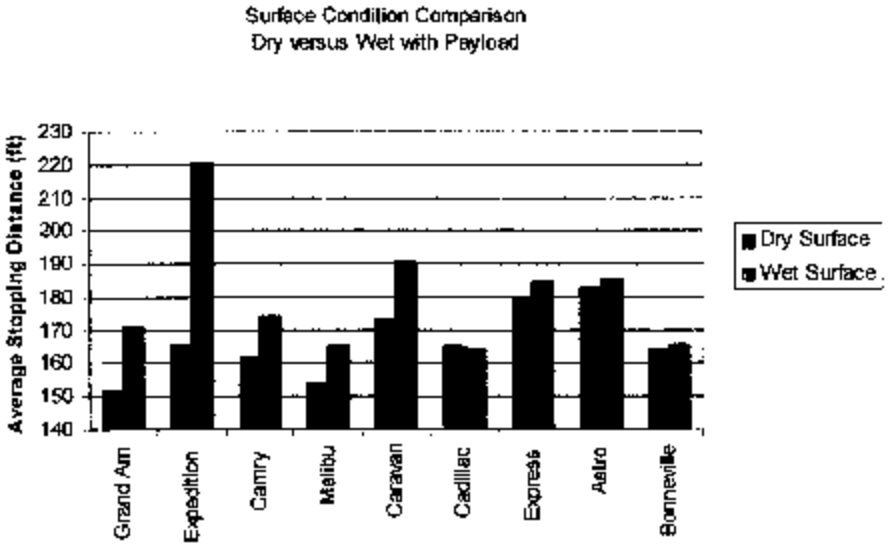


Figure 8. Comparison of Vehicle Stop Results without Payload Dry Versus Wet Surface.



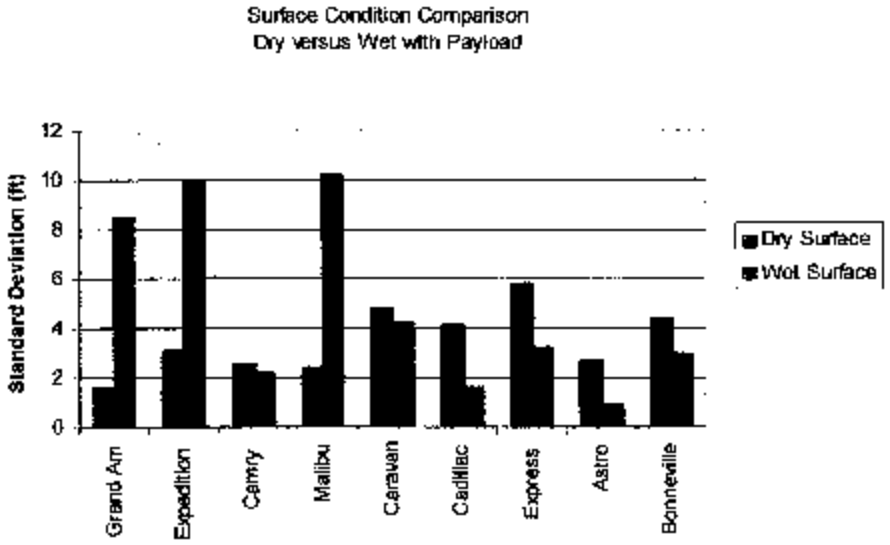


Figure 9. Comparison of Vehicle Stop Results with Payload Dry Versus Wet Surface.

1. Brake Pedal Effort Effects

Throughout testing, brake stops were performed by applying a specified force instantaneously upon the brake pedal and maintaining a target pedal force until the vehicle came to rest. A typical plot of pedal force application versus time can be seen in Figure 10. The effect of pedal force on vehicle stopping distance when applied in this manner was analyzed throughout testing. Specifically, two factors were examined closely to determine if variations in applied pedal effort led to deviations in stopping distances. First, the initial spike application was analyzed to determine if slower rates in achieving the target pedal force led to greater deviation between individual brake stops for each test configuration. Second, the pedal force after the initial spike was examined to determine if the magnitude of the steady-state pedal effort led to variations in stopping distances.

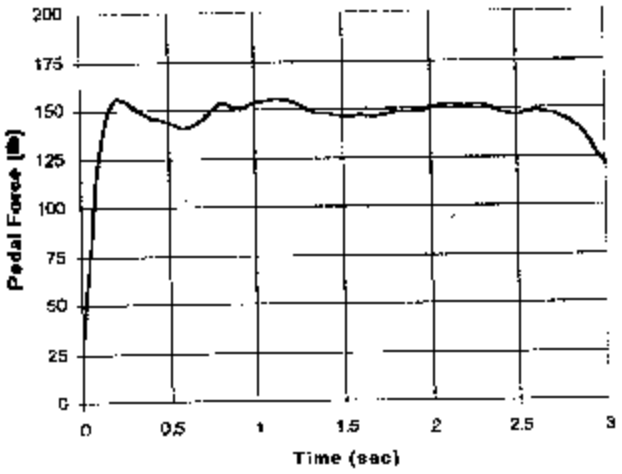


Figure 10. Typical Pedal Effort Application, Pedal Force versus Time.

In assessing the initial pedal force application rate recorded during testing, each stop was placed into one of four classes - A, B, C or D - based on the applied pedal force recorded at 0.1, 0.2 and 0.3 seconds for each brake stop. The applied pedal force range at each time interval that define the four classes are shown in Table 11. All brake stops had to fall within one of the four classes to be considered a valid brake stop. Stops with pedal forces falling below class D were concluded to have too slow a rise time and not considered valid. A sample plot of pedal force versus time for each class is shown in Figure 11.

TABLE 11. PEDAL EFFORT CATEGORY BREAKDOWN

	Force measurement					
	at 0.1 seconds		at 0.2 seconds		at 0.3 seconds	
Class	N	lb	N	lb	N	lb
A	over 445	over 100	over 445	over 100	over 445	over 100
B	334 – 445	70 – 100	over 445	over 100	over 445	over 100
C	222 – 334	50 – 70	over 445	over 100	over 445	over 100
D	0 - 222	0 – 50	222 - 445	50 – 100	over 445	over 100

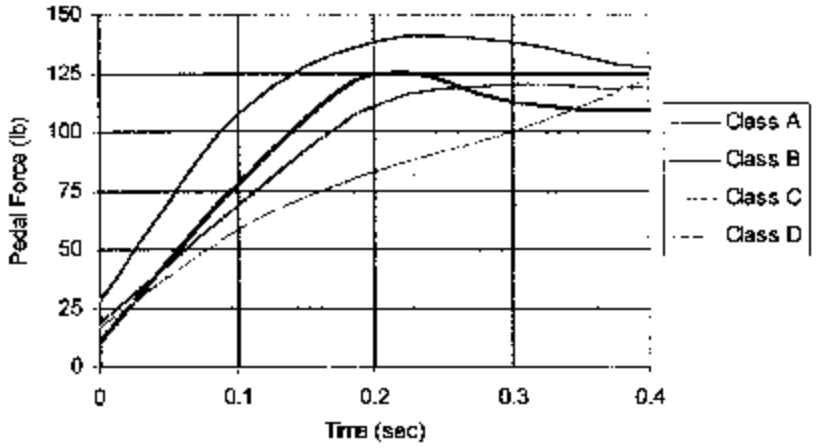


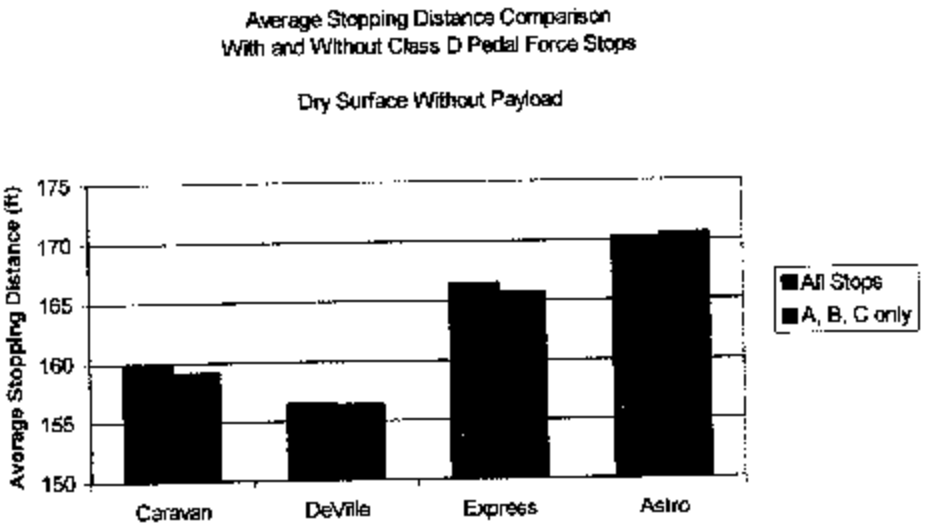
Figure 11. Sample Pedal Effort Application, Classes A through D.

The data recorded from the pedal transducer showed an initial pedal force present at the brake event start time (t_0). The presence of this force can be attributed to the initial acceleration of the effective mass of the brake pedal and pedal force transducer. This observation is an application of Newton's 2nd Law. Simply stated, the pedal can not move unless a force is applied to it. Under class A stop application rates, initial pedal accelerations of several g's were present. Brake applications at these accelerations to the effective mass of the brake pedal and transducer resulted in the observed forces.

A statistical analysis of the data obtained from each vehicle under each configuration was done to assess the effect of the initial force spike on stopping distance. The statistical data can be found in Appendix D. The average, standard deviation and 95% one-sided confidence interval were determined for each group with all stops included in the population. The same analysis was conducted with stops from less desirable classes removed (one class at a time) from the population until only stops in class A remained.

The brake stop data and the corresponding statistical data showed that, in the majority of cases, improvement in standard deviation and average stopping distance was evident with the removal of stops included under class D. Figures 12 through 15 compare the average stopping distance and standard deviation calculated both with and without class D stops included for each vehicle configuration set that contained at least one "D" in the population. Of the 18 data sets, 14 sets showed a decrease in average stopping distance and 15 sets showed a decrease in standard deviation with the removal of class D stops. Only the Pontiac Bonneville on dry surface with payload had an increase in both categories. An overall analysis of the class D stops supports the trend in improved average stopping distance and standard deviation. Of the 43 total class D stops conducted during testing, 67 percent (29 of 43) placed in the longest three stops of a data set. Furthermore, of the 54 longest three stops from the 18 data sets containing at least one class D stop, 54 percent were class D. Based on these findings, class D stops were excluded from the final statistics data presented in Table 9 and Appendix E.

The statistics were recalculated after removing stops under class C and then class B . Generally, the removal of these stops produced no consistent trends in braking performance or left a population too small in size to examine statistically.



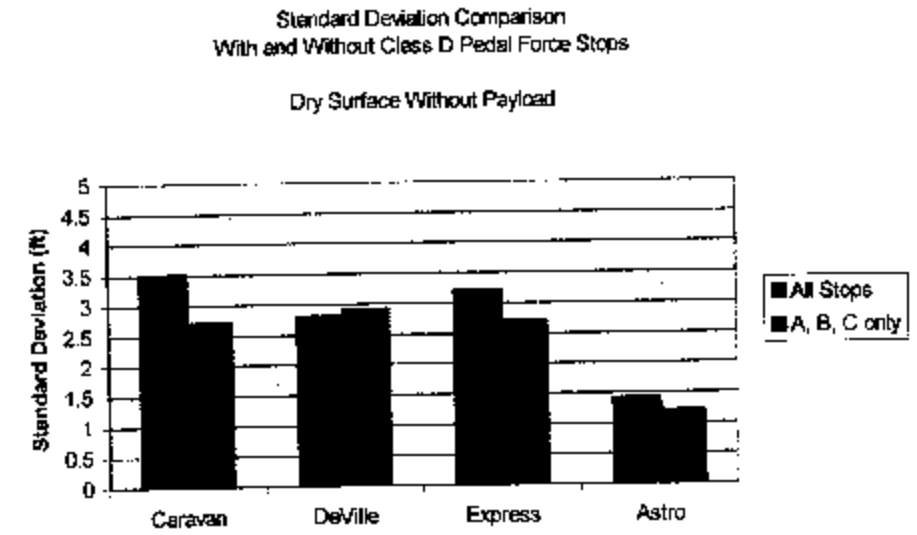
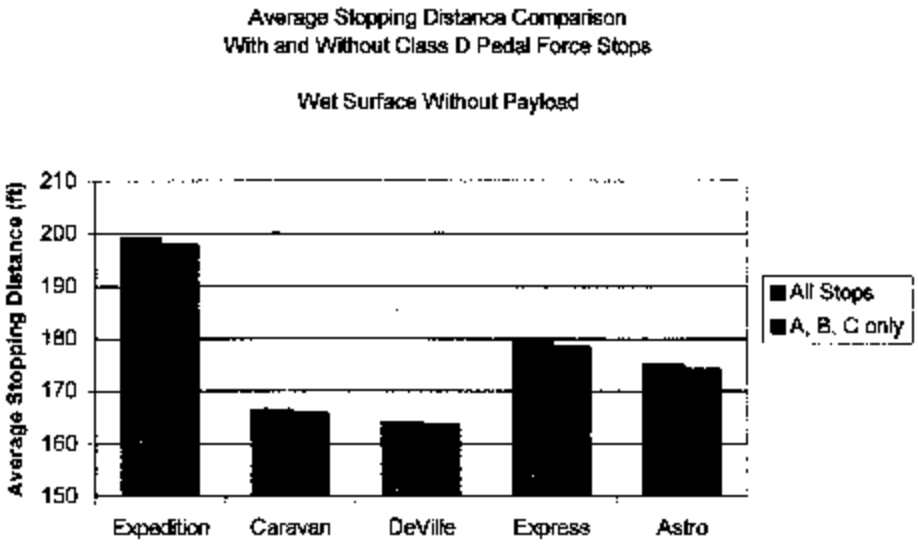


Figure 12. Comparison of Individual Data Sets with and without Class D Stops Dry Surface without Payload.



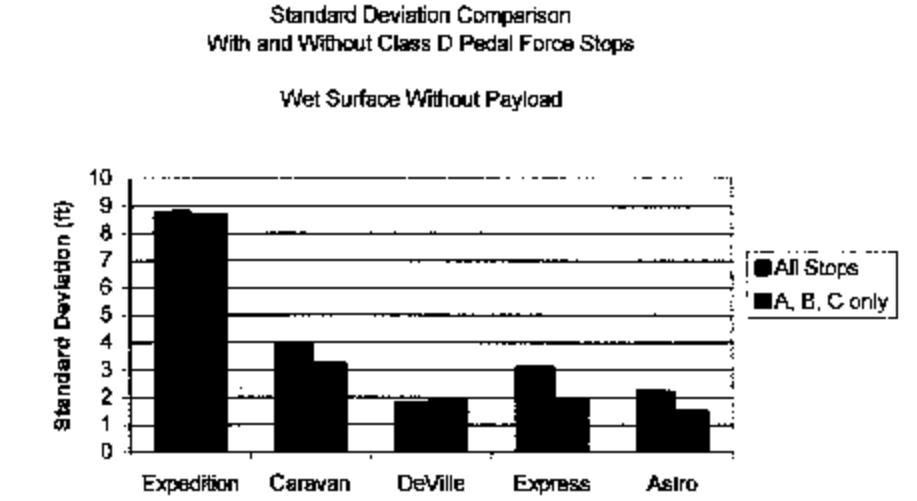
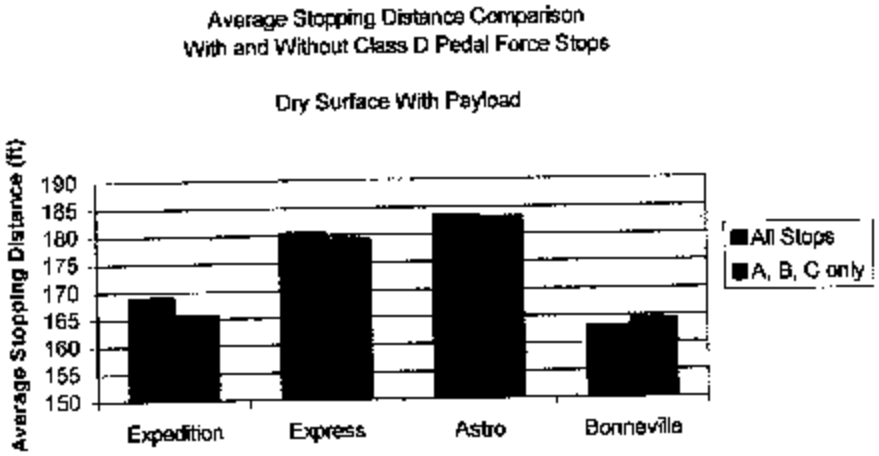


Figure 13. Comparison of Individual Data Sets with and without Class D Stops Wet Surface without Payload.



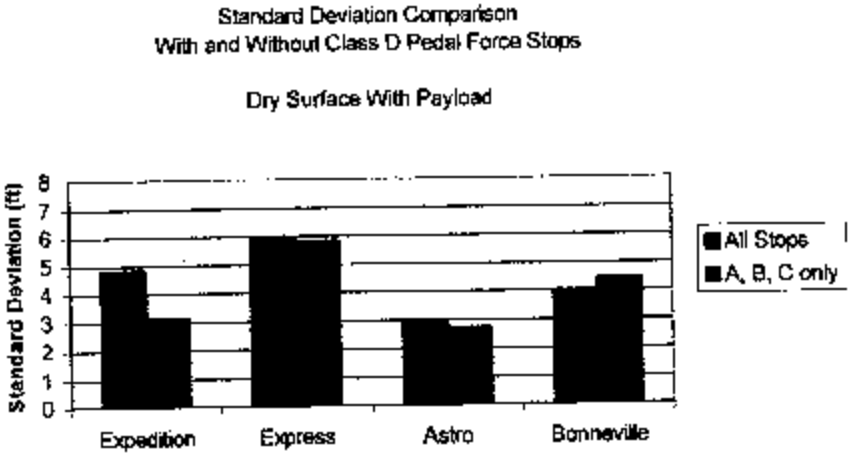
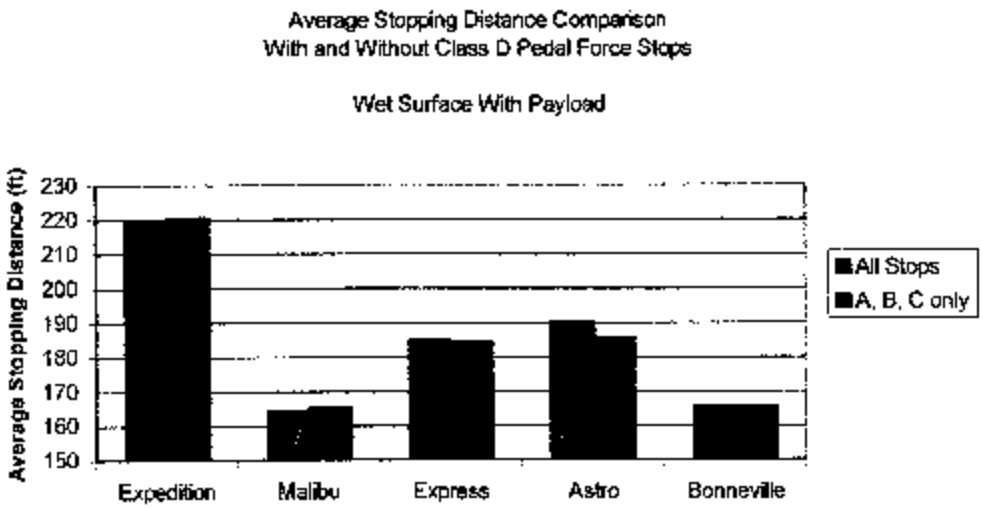


Figure 14. Comparison of Individual Data Sets with and without Class D Stops Dry Surface with Payload.



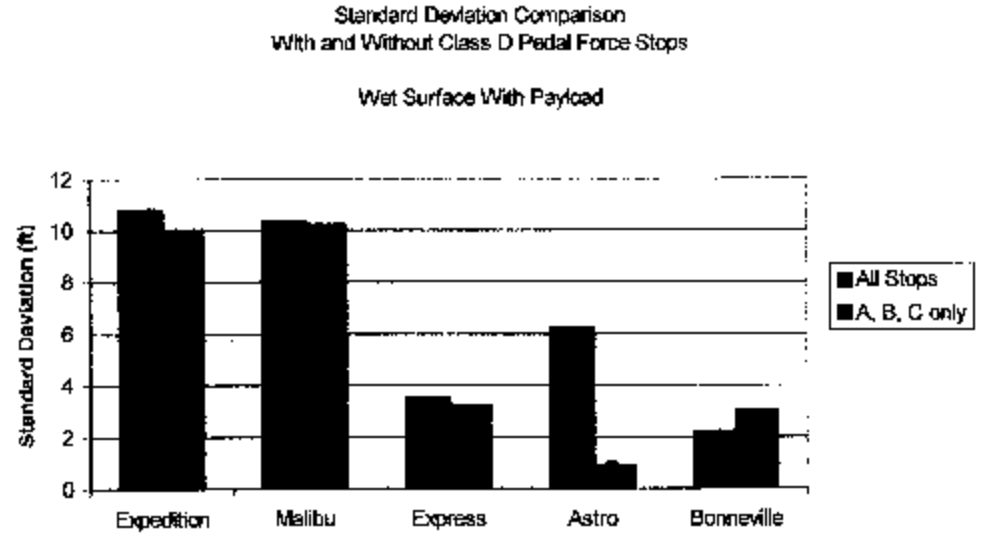


Figure 15. Comparison of Individual Data Sets with and without Class D Stops Included Wet Surface with Payload.

The steady-state pedal force after the initial spike was also examined to determine if its magnitude influenced stopping distance. In the analysis, 20 brake stops from Grand Am baseline testing were randomly selected and examined. Only stops included in the final results that met the class A pedal effort criterion were selected. The relevant data from each stop and the average stopping distance and standard deviation of the entire group is presented in Table 12.

TABLE 12. RESULTS FROM 20 BASELINE BRAKE STOPS

Date[a]	Stop No.	Measurement			
		Stopping distance		Average pedal force	
		m	ft	N	lb
18 November	1	45.2	148.3	520.9	117.1
18 November	3	43.0	141.1	537.3	109.1
22 October	2	42.8	140.3	1722.3	387.2
23 October	1	42.7	140.0	1180.1	265.3
13 October	1	43.9	144.0	1197.4	269.2
13 October	6	44.1	144.6	894.5	201.1
14 October	2	45.3	148.6	970.6	218.2
15 October	1	42.5	139.5	1053.7	236.9
20 November	3	43.4	142.5	696.6	156.6
19 October	3	44.9	147.4	626.7	140.9
2 November	1	43.7	143.4	780.6	175.5
3 November	2	43.4	142.3	514.2	115.6
7 October	2	45.1	147.9	1553.2	349.2
7 October	5	45.8	150.1	1376.2	309.4
9 October	1	43.8	143.7	1536.8	345.5
20 November	1	42.9	140.8	780.6	175.5
30 October	2	43.3	142.0	471.9	106.1
20 October	1	43.8	143.7	645.4	145.1
14 October	4	44.7	146.8	888.3	199.7
23 October	3	42.9	140.7	1054.6	237.1
Average stopping distance 43.9 m (143.9 ft) Standard deviation = 1.0 m (3.3 ft)					

[a]No stops from 8 October were included due to surface condition.

An analysis of the data presented in Table 12 revealed that no significant difference in stopping distance was evident with varying levels of steady-state applied pedal effort. The average stopping distance of the six brake stops with average pedal efforts under 670 N (150 lb) was 43.9 m (144.1 ft), compared to 44.0 m (144.3 ft) for stops with average pedal efforts over 1110 N (250 lb). The remaining eight stops had an average stopping distance of 43.7 m (143.4 ft).

A further examination of Table 12 showed that the longest stop in the set [45.8 m (150.1 ft) on 7 October] had a higher average pedal force than the shortest stop [42.5 m (139.5 ft) on 15 October]. This observation supports the conclusion that the magnitude of the steady-state pedal force was independent of stopping distance.

2. Brake Temperature

No trends between recorded brake temperatures and brake performance data were noted when considering stops in which cool-down runs were conducted prior to the brake stop. However, initial stops performed with vehicles that sat stationary for extended periods of time, allowing brakes to cool to ambient temperatures, produced unfavorable results in some cases. Table 13 shows results from the eight stops conducted in which the brake temperatures were measured within 6 °C (10 °F) of ambient temperature before testing.

TABLE 13. RESULTS FROM BRAKE STOPS PERFORMED WITH COLD BRAKES (NEAR AMBIENT TEMPERATURE)

Vehicle	Configuration	Stopping distance of run		Average stopping distance of set		Standard deviation of set		Standard deviations from average	Ambient temperature	
		m	ft	m	Ft	m	ft		°C	°F
Ford Expedition	Wet/Payloaded	60.4	198.3[a]	67.0	219.9	3.3	10.8	2.0	20	68
Toyota Camry	Dry/No payload	47.6	156.2	48.7	159.7	0.6	2.1	1.7	19	66
Chevrolet Malibu	Wet/Payloaded	46.8	153.4	50.0	164.1	3.1	10.3	1.0	18	64
Dodge Caravan	Dry/No payload	46.8	153.7	48.7	159.8	1.1	3.5	1.7	12	54
Grand Am	Baseline (10/9)	42.9	140.9	43.7	143.3	0.4	1.4	1.7	17	62
Grand Am	Baseline (10/21)	46.9	153.8	45.0	147.6	1.5	4.9	1.3	15	59
Grand Am	Baseline (10/22)	42.8	140.3	42.9	140.6	0.2	0.5	0.6	10	50
Grand Am	Baseline (10/30)	48.7	159.8[a]	43.6	143.0	0.3	0.9	18.7	18	64

[a]Brake stop was not included in the original data set population.

The data shows that eight out of the nine stops resulted in stopping distances at least one standard deviation from the average stopping distance of the data set. Based on these findings, stops with cold brakes were excluded from the final statistics presented in Tables 9 and 10 and Appendix E, in addition to the class D pedal effort stop exclusion. The remainder of the analysis was conducted with these revised statistics. All recorded brake temperature data can be found in Appendix F.

3. Tire Temperature Effects

Tire temperature was measured to determine its effect on braking performance both within each individual data set and from day-to-day baseline testing. However, tire temperature varied little from the actual ambient temperature throughout the beginning stages of testing and therefore, no correlations between tire temperature and vehicle performance or variability could be established. Accordingly, tire temperature measurements were not recorded after testing was concluded with vehicle No. 3 (Toyota Camry). Recorded tire temperatures during testing of the first three vehicles can be found in Appendix F.

4. Day-to-Day Variation Effects

An analysis of the results from baseline testing with the Pontiac Grand Am was conducted to investigate day-to-day performance variations due to factors such as environmental changes and frictional coefficient changes. A summary of the average brake stop results from each day and the recorded environmental data is presented in Table 14. All recorded meteorology data can be found in Appendix G. The average wind direction in Table 14 is presented relative to the direction of vehicle travel, so that a value of 90 degrees represents a crosswind coming from the right of the vehicle.

Road surface frictional coefficients measured and recorded weekly by the Eastern Federal Lands Highway Division of the Federal Highway Administration are presented in Table 15. All measurements shown are averages of 10 individual chirp tests conducted on the date provided. Results from each individual chirp test can be found in Appendix H. The peak frictional coefficient results for dry surface testing generally decreased with temperature by approximately 4 percent over an ambient temperature range of 15 °C (28 °F). The only deviation with these results was the measurements made on 15 October. No significant variation in the wet surface frictional measurements was found.

TABLE 14. AVERAGE STOPPING DISTANCE AND ENVIRONMENTAL DATA FROM BASELINE TESTING, PONTIAC GRAND AM

Test date (1998)	Measurement										
	Average stopping distance		Standard deviation		Ambient temperature		Average wind speed		Peak speed		Avg wind direction (degrees)
	m	ft	m	ft	°C	°F	km/hr	mph	km/hr	mph	
7 October	45.7	149.8	0.6	2.1	19	66	5	3	8	5	108
8 October[a]	47.8	156.7	0.6	2.1	20	68	5	3	8	5	136
9 October	43.8	143.8	0.2	0.8	17	62	3	2	8	5	303
13 October	44.3	145.4	0.5	1.7	20	68	6	4	10	6	184
14 October	45.5	149.4	0.5	1.7	18	64	6	4	13	8	245
15 October	42.6	139.8	0.2	0.7	14	57	6	4	10	6	225
19 October[b,c]	44.9	147.4	—	—	21	71	5	3	10	6	267
20 October	44.4	145.7	0.7	2.4	18	64	5	3	11	7	265
22 October	42.9	140.6	0.2	0.5	10	50	6	4	13	8	300
23 October	42.8	140.3	0.1	0.4	11	52	5	3	8	5	251
30 October	43.6	143.0	0.3	0.9	18	64	8	5	13	8	241
2 November	43.5	142.6	0.2	0.7	12	54	5	3	8	5	278
3 November	43.7	143.4	0.3	1.0	9	48	2	1	3	2	264
6 November[b]	44.3	145.5	—	—	7	45	5	3	10	6	319
12 November	44.2	145.1	0.5	1.6	14	57	5	3	11	7	280
18 November	43.8	143.7	1.0	3.2	8	46	3	2	6	4	318
20 November	43.3	142.1	0.3	1.1	16	61	3	2	3	2	225
Average stopping distance[d] – 44.3 m (145.4 ft)							Standard deviation[d] – 1.4 m (4.5 ft)				
Average stopping distance[e] – 44.0 m (144.5 ft)							Standard deviation[e] – 1.0 m (3.4 ft)				

[a]Testing was conducted on damp pavement with no free-standing water.
[b]Tires were rotated before testing.
[c]Only one brake stop was valid for the final statistics.
[d]Calculated with all dates included.
[e]Calculated without 8 and 19 October dates included.

TABLE 15. AVERAGE RESULTS FROM CHIRP TESTING

Test date (1998)	Measurement									
	Dry surface					Wet surface				
	Frictional coefficient	Test speed		Ambient temperature		Frictional coefficient	Test speed		Ambient temperature	
		km/hr	mph	°C	°F		km/hr	mph	°C	°F
17 September	0.949	64.2	39.9	27	81	0.869	64.0	39.8	29	84
22 September	0.937	64.4	40.0	25	77	0.882	65.0	40.4	25	77
1 October	0.936	64.2	39.9	26	78	0.859	64.2	39.9	24	75
15 October	0.893	64.5	40.1	17	62	0.847	64.4	40.0	19	66
19 October	0.932	65.0	40.4	22	71	0.878	64.2	39.9	21	70
29 October	0.923	65.2	40.5	14	57	0.875	64.7	40.2	15	59
9 November	0.905	64.5	40.1	12	53	0.868	65.3	40.6	12	53
24 November	0.916	64.5	40.1	15	59	0.871	64.0	39.8	15	59

In the limited environmental conditions in which these tests were conducted, no consistent trends were evident between the average stopping distance of the Grand Am and the changes in the ambient temperature, associated frictional coefficients or wind speed. Likewise, no trends were evident when considering the calculated standard deviations.

To better quantify the impact of wind conditions on brake testing, an engineering analysis was conducted to study the effect of aerodynamic drag on a test vehicle experiencing a head or tail wind during a brake stop. The analysis and sample calculation, presented in Appendix J, are based on a representative brake stop from the data set and

appropriate values for the coefficient of drag, vehicle frontal area and air density. From this analysis, Figures 16 and 17 are provided to show the possible differences in stopping distance results due to various wind conditions. The drag coefficients (C_D) and vehicle frontal areas (A_P) used represent the expected upper and lower limits for the vehicles tested.

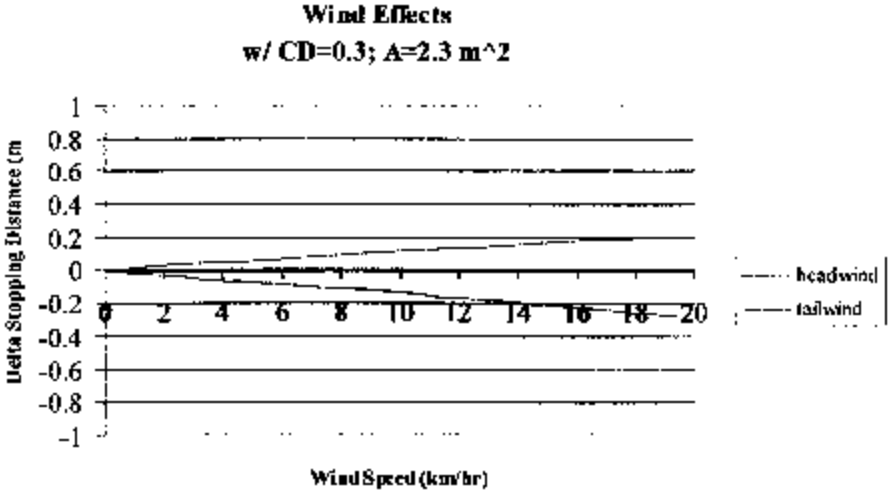


Figure 16. Wind Effects with C_D= 0.3 and A_P= 2.3 m^2.

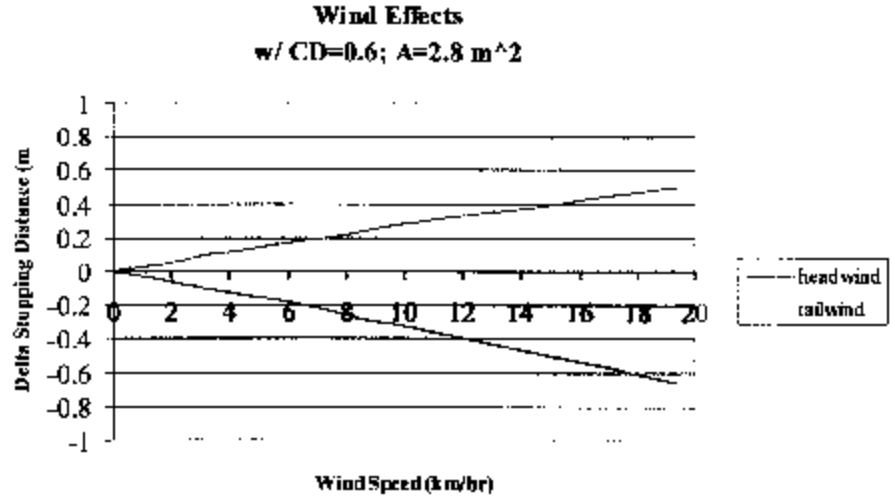


Figure 17. Wind Effects with C_D= 0.6 and A_P= 2.8 m^2.

Based on the analysis, a representative worst case scenario with a head wind traveling at the peak wind speed measured during testing [12.9 km/hr (8.0 mph)] resulted in approximately a 0.4-m (1.4-ft) difference in stopping distance. Hence, the analysis supports the observation that the winds experienced during testing had minimal impact on the stopping distance results.

5. The Effect of Free Standing Water on Wet Stops

Another variable considered to impact the variability in braking performance was the depth of the free standing water during wet brake stops. As previously mentioned in the procedure, standing water as deep as 1/4 inch occurred in portions of the brake area during testing of the first four vehicles. Because some test runs resulted in noticeable hydroplaning, the test area was moved a short distance to an area where the water depth remained under 3 mm (1/8 inch) and significant water collection was avoided.

Although it is difficult to assess the effect of water depth on stopping distance without further testing, a comparison of the standard deviations of the data sets before and after the test area was moved does indicate a greater variability in stopping distance with water depth over 3 mm (1/8 inch). A comparison of each vehicle's standard deviation on wet pavement is presented in Figure 18.

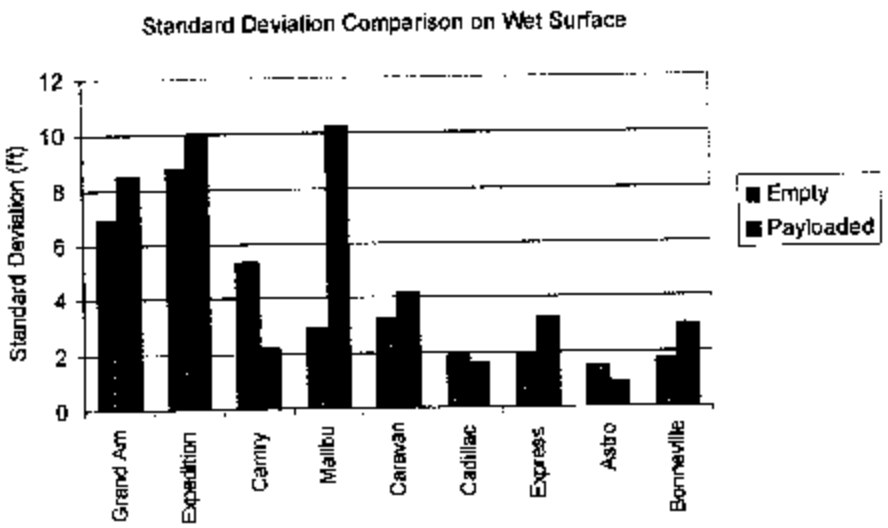


Figure 18. Standard Deviations of Vehicle Data Sets on Wet Surface.

As shown in Figure 18, all four vehicles tested before the test area was moved (Grand Am, Expedition, Camry and Malibu) experienced a significantly higher standard deviation in at least one payload configuration than the vehicles tested after the test area was moved. This trend supports the observations made concerning hydroplaning during the testing of vehicles No. 2 and 4, and lends evidence that other instances of hydroplaning may have occurred during wet brake stops before the test area was moved.

6. Test Configuration Effects

An analysis was conducted to investigate the sensitivity of the measured stopping distances and their associated variations to the four test configurations shown below:

- Full payload, dry asphalt
- Full payload, wet asphalt
- No payload, dry asphalt
- No payload, wet asphalt.

This analysis does not differentiate between the variations due to vehicle performance versus test methodology. However, it does support some intuitive notions related to brake testing results.

For the analysis, a test occasion refers to the set of data for a particular vehicle under any one of the four test configurations shown in the test matrix. Within-occasion data refers to the mean and standard deviations for a particular test occasion. Occasion-to-occasion data refers to a comparison across test occasions of the within-occasion means.

The within-occasion data for each vehicle, presented earlier in the report, were grouped according to the four test configurations. Within each configuration grouping, all nine vehicles were represented. For each configuration, the within-occasion standard deviations were statistically combined to determine the pooled within-occasion standard deviations. Next, the within-occasion means for each configuration were compared to determine occasion-to-occasion means and standard deviations. Finally, the within-occasion and occasion-to-occasion standard deviations were combined to determine the total system dispersion for each configuration. A similar approach was taken to analyze the four standard test parameters independently. The results are presented in Table 16.

TABLE 16. STATISTICS OF VEHICLE INDEPENDENT, CONDITION DEPENDENT DATA SETS

	Average stopping distance		System dispersion	
Data set	m	ft	m	ft
Dry asphalt, no payload	48.4	158.7	3.1	10.3
Dry asphalt, with payload	50.7	166.4	3.4	11.1
Wet asphalt, no payload	52.7	173.0	4.7	15.5
Wet asphalt, with payload	54.9	180.0	5.8	19.0
Dry asphalt, both vehicle configurations	49.6	162.6	3.4	11.2
Wet asphalt, both vehicle configurations	53.8	176.5	5.2	17.2
No payload, both asphalt conditions	50.5	165.8	4.5	14.8
With payload, both asphalt conditions	52.8	173.2	5.1	16.7

As would be expected intuitively, the largest system dispersion resulted from testing under the full payload, wet asphalt configuration, followed by testing under the wet, no payload configuration. The results also indicate that the brake test results are slightly more sensitive to wet asphalt conditions than to payload configuration.

D. Conclusion

With the exclusion of Class D stops and cold brake stops from the data sets, the final statistics show relatively small standard deviations in measured stopping distance for the four configurations tested. Exceptions were noted within the wet surface results for the Pontiac Grand Am and Ford Expedition in both payload configurations, and the Chevrolet Malibu in the full payload configuration. The results for the Expedition on dry pavement without payload also showed a relatively high variation in stopping distance.

The hydroplaning experienced early in testing may have caused the higher standard deviations observed with the Grand Am, Malibu and Expedition during wet surface testing. Once the wet surface brake stop location was moved to avoid hydroplaning, the wet surface results improved considerably. However, the cause of the relatively high standard deviation observed for the Expedition tested without payload on dry surface is unknown. Additional testing of the Expedition is necessary to determine if the results were vehicle-related or the consequence of an unexplained test condition.

Baseline test results also showed relatively small variation in stopping distance within individual test occasions. However, some spread in the average stopping distance from occasion to occasion was observed during early testing, with results becoming more consistent during the last two thirds of the tests conducted. Two of the data sets were noted to have irregular test conditions, and should not be compared with other data. The inconsistencies in average stopping distances observed in early testing could not be attributed to changes in ambient temperature, frictional coefficient or wind conditions, but may have been a result of an initial break-in period of the brake components or curing of the tires. However, within the framework of this test and the analyses conducted, no definite cause was evident.

IV. TASK 2 – Provide Details on Methodology to Address Variability

The results obtained from 100-km/hr (62-mph) brake effectiveness testing with vehicles equipped with ABS were analyzed in Task 1 to investigate the sources of stopping distance variability. The analysis showed that certain parameters significantly affected the performance results, while other test variables had little or no effect on the variability of the data. This section of the report will review the findings from Task 1 and provides details on methods to reduce test variability. Test factors not addressed in Task 1 that were beyond the scope of the test matrix will also be discussed.

Many of the test conditions and procedures outlined in FMVSS 135 were utilized throughout testing. Details provided on test methodology in this section are intended to supplement the test procedures of FMVSS 135. These supplements are recommended after giving appropriate consideration to the test findings in Task 1 in areas such as pedal force application, brake temperature and water application.

A. Pedal Effort

The test results from Task 1 were analyzed to investigate the effects of the initial brake pedal force application rate and the subsequent steady-state pedal force on stopping distance variability.

As outlined in Task 1, each brake stop was placed into one of four classes of initial brake pedal application - A, B, C or D - with class A having the highest pedal force rate and class D having the lowest. An analysis of the results showed that data sets including class D stops generally had a higher variability in stopping distance than the same data sets with class D stops removed. It was concluded that slow pedal force rates may have delayed the initiation of the ABS system and consequently, increased the stopping distance variability of the data set. To provide a more accurate measure of ABS braking performance for each vehicle, class D stops were excluded.

Further analysis of the effect on stopping distance variability by successive exclusion of class C and B stops from the data sets was inconclusive because of the small sample sizes associated with class B and C stops. Therefore, the impact of the inclusion of class B and C stops on stopping distance variability is not fully known.

ATC recommends that all brake stops meet the class A pedal force criterion. The addition of this criterion will assist in reducing stopping distance variability caused by differences in the initial pedal effort input and ensure repeatable ABS initiation.

An analysis was also conducted to investigate the effects of steady-state pedal force on stopping distance. Using the results from baseline testing, it was verified that stopping distances were not affected by significant differences in the average pedal force of the brake stops [ranging from 440 to 1730 N (100 to 390 lb)]. Therefore, under the test requirement that the ABS remain activated throughout the entire brake stop, the analysis showed that excessive pedal forces are not required to obtain consistent and representative performance results.

Considering these findings, ATC recommends that steady-state pedal forces fall between 500 and 800 N (112 and 180 lb) during testing. The range exceeds the requirement presented in FMVSS 135, while defining an acceptable and easily achievable upper and lower target limit for the test driver. Steady-state pedal forces in this range also ensure that the ABS will remain fully invoked throughout the entire brake stop.

B. Vehicle Parameters

The variability in braking performance results caused by test parameters such as brake temperature, tire temperature and payload characteristics was examined in Task 1. All three parameters were considered to be vehicle test variables that could be controlled prior to the start of each test.

As discussed in Task 1, nine brake stops were conducted with brake temperatures measured within 6 °C (10 °F) of ambient temperature. An analysis of these stops showed that in eight of the nine cases, the stopping distance placed at least one standard deviation from the average stopping distance of the data set. Therefore, because inconsistent

test conditions may have led to variability in stopping distances, brake stops performed under this condition were removed. The exclusion of these brake stops is further supported by the fact that brake temperatures typically exceed ambient temperatures during normal operation, and that brake stops performed with "cold brakes" could be considered unrealistic.

To address variability in brake performance caused by "cold brakes", ATC recommends that all stops be conducted with front brake rotor temperatures between 65 and 100 °C (149 and 212 °F), as required in FMVSS 135. Rotor temperatures falling below this range should be heated by making one or more brake applications as outlined under Section S6.5.6 in FMVSS 135. All brake temperatures measured above 100 °C (212 °F) should be cooled by driving the vehicle without brake application at speeds up to 100 km/hr (62 mph) until falling into the acceptable temperature range.

No consistent trends between braking performance and tire temperature were noted. Tire temperatures were generally comparable with road surface temperatures and therefore, no correlations between tire temperature and variations in stopping distance could be established. However, it should be noted that testing was conducted with various brands and models of tires, which may have affected stopping distance performance, especially under wet conditions. For this reason, the brand and model of the tires on test vehicles should be identified in the test results provided to the consumer.

Vehicle payload was also analyzed in Task 1. As expected, the results showed that vehicles demonstrated increased variability in stopping distance when fully payloaded versus empty. However, since only one full-payload configuration was tested for each vehicle, the impact of varying the vehicle's center of gravity location on stopping distance variability could not be determined. Because insufficient data was obtained to make recommendations regarding payload procedure, those described in FMVSS 135 should be followed.

C. Environmental Test Conditions

Test conditions such as wind speed, ambient temperature and road surface friction coefficient were recorded and analyzed in Task 1. Observations were also made concerning the delivery of water to the test area for wet surface testing. Of these environmental test conditions, only the depth of the water on the test area during wet surface testing was found to significantly increase variability in brake performance.

Ambient temperature varied little throughout testing [ranged from 7 to 21 ^{0}C (45 to 75 ^{0}F)], meeting the criteria outlined in FMVSS 135 [between 0 and 40 °C (32 and 104 °F)]. Since no testing was conducted with an ambient temperature above 21 ^{0}C (75 ^{0}F), conclusions regarding test results at temperatures approaching 40 ^{0}C could not be drawn. Therefore, given the data obtained from this study, there is no basis to deviate from the ambient temperature criteria specified in FMVSS 135.

Average and peak wind speed also showed little variation throughout testing, with an average speed ranged from 2 to 8 km/hr (1 to 5 mph) and peak speed not exceeding 13 km/hr (8 mph)]. As a result, no insight could be gained from the test data regarding the effect of wind conditions on stopping distance. Therefore, an analytical investigation was conducted in Task 1 to determine the sensitivity of wind conditions on stopping distance. Based on the engineering analysis performed, it was concluded that the wind speed criteria provided in FMVSS 135 [(not greater than 5 m/s (11.2 mph)] is adequate.

The peak surface friction coefficient also showed little variation throughout testing on both wet and dry surfaces. As a result, variations in stopping distance could not be attributed to this parameter. Testing was conducted at a single location with peak friction ranging from 0.89 to 0.95 and 0.85 to 0.88 on dry and wet pavement, respectively. Considering the range of dry surface fiction coefficients experienced during this study, the 0.9 nominal value specified in FMVSS 135 appears to be adequate for future testing.

Wet surface testing is not addressed in FMVSS 135. Based on information from NHTSA representatives, the typical peak friction value for wet surface testing at other test sites is nominally 0.8, which is lower than those experienced during this study. Since adequate results were obtained with a wet peak friction value of 0.85, it seems

reasonable to expect adequate results with a friction coefficient of 0.8. However, ATC recommends that the specified nominal value be no lower than 0.8, so as not to deviate too far from the results of this study.

An analysis of the results confirmed observations that hydroplaning occurred early in testing and was responsible for increased variability between stopping distances. To minimize variations in brake test results during wet surface testing, ATC recommends that courses should be free of collection areas, and water thickness should be monitored and kept below 3 mm (1/8 inch). The results presented in Task 1 show that testing under these surface conditions resulted in significantly less variability in stopping distances without any noticeable incidents of hydroplaning.

D. Instrumentation and Measurement Techniques

Standardization of the instrumentation and measurement techniques used to determine stopping distance is necessary to ensure consistency and accuracy of the reported results between test agencies that may perform the brake tests. The information in the following paragraphs is based on the results of this effort as well as prior test experience.

ATC recommends that a rolling fifth-wheel sensor with quadrature capability be used to measure stopping distance and vehicle speed. Non-contact sensors should be avoided for this application due to the increased potential for error as vehicle speed approaches zero, particularly on wet pavement. The use of the quadrature technique will account for fifth-wheel directional changes resulting from the pitching motion of the vehicle as it comes to rest. The sensor should be located on the vehicle such that the wheel does not leave the pavement surface at any time during the brake event. Prior to use, the fifth-wheel should be calibrated by operation over a known distance.

The brake event start time should be initiated by activation of the brake light circuit. The switch at the brake pedal and the electrical circuit should be inspected to ensure the circuit is activated by minimal movement of the brake pedal. While more elaborate techniques and sensors could be used, the results from this effort indicate that use of the brake light circuit is adequate. The event should be concluded when the vehicle comes to rest.

Pulse counts from the rolling fifth-wheel should be summed throughout the entire braking event. With quadrature capability enabled, counts resulting from the rocking of the vehicle as it comes to rest will be nullified. Once the vehicle comes to rest, the total pulse count should be multiplied by the scale factor determined during calibration to calculate the actual stopping distance. Vehicle speed should be determined by dividing the pulse count during each sample period by the sample time interval.

The pedal force tranducer should have adequate resolution to determine whether a pedal application meets the class A stop criteria. A maximum transducer output range of 200 to 300 lb is recommended. Although a 10 Hz sample rate was used for the pedal force transducer in Task 1, the 40 Hz minimum sample rate required in FMVSS 135 is recommended.

E. Test Sample Size

For statistical purposes, it is always desirable to have as large a sample size as possible. However, program constraints such as cost and time often dictate a reduced sample of the population. Based on the results from Task 1, a sample size of 10 stops per test condition is practical. Tests on a single vehicle were achievable within one day and the results showed small variations in stopping distance, ensuring reasonable confidence in the data.

V. TASK 3 – Develop a Test Protocol for the Braking Initiative

ATC recommends the following protocol for the consumer braking program. The protocol is based on the test procedures and results from this study and relevant sections of the Federal Motor Vehicle Safety Standard (FMVSS) No. 135, Passenger Car Brake Systems. Although Tasks 1 and 2 only addressed testing for vehicles equipped with ABS, the procedures recommended here are more general and include non-ABS equipped vehicles.

A. General Test Conditions

Adhere to Section 6 of FMVSS 135, with the following modifications:

1. Change *S6.2.1. Pavement Friction* to require a nominal peak frictional coefficient (PFC) of 0.9 for dry pavement.

2. Replace *S6.4. Instrumentation* with the following:

Brake temperature measurement. The brake temperature is measured at the surface of the front brake rotors with a calibrated hand-held pyrometer.

Vehicle speed and stopping distance measurement. The vehicle speed measurement is performed using a calibrated rolling fifth-wheel transducer with quadrature capability. Prior to testing, an accuracy not exceeding 0.5 percent shall be verified on a pre-measured 60-m (200-ft) test lane.

Brake pedal effort measurement. The pedal effort measurement is performed with a calibrated transducer on the brake pedal. This transducer should not interfere with normal brake application.

Anemometer. The ambient temperature, wind speed and wind direction measurements are to be performed with a calibrated anemometer located at the test site.

3. Add the following:

Wet surface condition. For wet surface testing, the test area shall be fully wet with standing water not deeper than 3 mm (1/8 inch). Water shall be re-applied to the test surface prior to each brake stop event.

B. Procedural Conditions

Adhere to the following sections of FMVSS 135, with the noted exceptions:

1. *S6.5.3. Stopping Distance*; S6.5.3.1 Only.

2. *S6.5.4. Vehicle position and attitude.*

3. *S6.5.5. Transmission selector control*; Testing is to be conducted with the transmission in gear. Adhere to S6.5.5.2.

4. *S6.5.6. Initial brake temperature (IBT).*

C. Required Test Data

Test data to be collected includes:

- Vehicle speed
- Stopping distance
- Pedal application force
- Brake rotor temperatures
- Ambient temperature
- Road surface temperature
- Tire pressure.

D. Measurement Techniques

Stopping distance. A rolling fifth-wheel transducer with quadrature capability shall be mounted on the vehicle and used to measure vehicle stopping distance. The brake stop event start time shall be initiated by activation of the brake light circuit and stopped when the vehicle is at rest. The switch at the brake pedal and the electrical circuit shall be inspected and adjusted to ensure the circuit is activated by minimal movement of the brake pedal. Stopping distance shall be determined by summing pulses from the fifth-wheel during the brake event, and multiplying this sum by the appropriate scale factor. A minimum sample rate of 40 Hz is required.

Vehicle speed. A finite-difference technique shall be applied to the pulse counts from the fifth-wheel over each sample period to determine the vehicle speed.

Brake pedal force. A force transducer shall be applied to the brake pedal to measure pedal effort. A minimum sample rate of 40 Hz is required.

Stopping Distance Normalization. All stopping distance measurements shall be normalized in accordance with SAE 299 (August 1987) based on an initial vehicle speed of 100 km/hr (62 mph).

E. Road Test Procedures

Adhere to the following sections of FMVSS 135 and the noted additions and exceptions:

1. *S7.1. Burnish.*

   Exception: Omit the temperature requirement from *S7.1.3 (g) Interval between runs* and base the interval strictly on the distance requirement.

2. *S7.5 Effectiveness Test.* Change to the following:

   a. S 7.5.1. Vehicle Condition

      (1) Vehicle load: GVWR and LLVW.
      (2) Transmission position: In gear.

   b. S 7.5.2. Test Conditions

      (1) IBT: 65 °C to 100 °C (149 °F to 212 °F).
      (2) Test Speed: 100 km/h (62 mph).
      (3) Wheel lockup: No noticeable lockup of any wheel allowed.
      (4) Number of runs: 10 at each weight configuration.

(5) Test Surface: Nominal PFC value of 0.9 for dry pavement and 0.8 for wet pavement.

c. Brake Pedal Application Procedure

ABS: The brake pedal is to be applied so that the pedal effort exceeds 445 N (100 lb) in 0.1 seconds or less, while targeting a steady-state application force of 670 N (150 lb). The allowable range for the pedal force is greater than 500 N (112 lb) and less than 800 N (180 lb). The target force is to be held constant until the vehicle comes to rest.

Non-ABS: The brake pedal is to be applied so that the vehicle is stopped in the shortest possible distance, while avoiding any instances of wheel lock-up.

d. Water Application Procedure

For wet surface testing, water shall be applied using a water tanker truck that is equipped to distribute water evenly across the width of the test lane. Prior to wet surface testing, three passes shall be made with the water tank traveling longitudinally along the test area (shown previously in Figure 5 in Task 1). The first two passes shall be made side-by-side, and the third pass shall be made overlapping the center of the lane created by the first two passes. The total length of the wet area shall be at least 100 m (330 ft). Prior to each brake stop event, an additional pass shall be made with the water tank along the center lane where the brake stops are to be conducted. Water shall be distributed to fully wet the asphalt surface while keeping the water depth in any area of the test lane below 3 mm (1/8 inch).

VI. TASK 4 - Identify a Method to Report Braking Performance to Consumers

The goal of the consumer braking program is to present accurate, unbiased brake performance information that the consumer can find useful and informative. Brake performance measures should not be skewed in any way to present the best stopping distance for a specific vehicle, but should include the results from all brake stops conducted under the required test conditions.

To assist in the selection of a reporting method to the consumer, the final results from each vehicle are presented in Appendix K in terms of the mean, standard deviation, 95% one-sided confidence interval and 95th-percentile (1.645 standard deviations above the mean) and 99th-percentile (2.320 standard deviations above the mean) stopping distances. Of these performance measures, the concept of standard deviation and 95% confidence interval may not easily be understood by the average consumer, and should probably be avoided.

Two measures of braking performance that may effectively inform the consumer of a vehicle's braking performance are average stopping distance and 95th-percentile stopping distance. The average stopping distance represents a valid mean of the vehicle's brake performance over the 10 stops performed during testing, with all stops included in the calculated average. The 95th-percentile stopping distance provides a measure of brake performance based on the average stopping distance and the variability of the data set.

The 95th-percentile stopping distance informs the consumer of the distance within which the vehicle should stop 95 percent of the time. Vehicles with high variability will have 95th-percentile stopping distances significantly higher than the reported average, while those with small deviations between individual stopping distances will have values closer to the reported average. This concept is illustrated by comparing the following two sets of data:

	Avg. stopping distance (ft)	Standard deviation (ft)	95th-percentile stopping distance (ft)
Vehicle A	**171.5**	8.5	**185.5**
Vehicle B	**174.1**	1.5	**176.6**

Considering the average stopping distance, vehicle A showed better braking performance. However, because the variability of vehicle A was significantly higher than vehicle B during testing, vehicle B had a shorter 95th-percentile stopping distance, and therefore, provided better performance reliability.

Overall, the average stopping distance and 95th-percentile stopping distance values provide the consumer with a measure of the vehicle's stopping distance and stopping consistency. The consumer should be informed that the findings were based on 10 stops performed under the same test conditions, and a normal distribution was assumed when determining the 95th-percentile stopping distance value. The consumer should also be informed that the conditions under which these tests were conducted do not necessarily match the conditions found in all real-world brake events, and that the information is based on testing performed under procedural requirements.

VII. TASK 5 – Develop a Test Report Format

A format for reporting tests conducted in support of the consumer braking program is provided in Appendix I. The format is structured in outline form in an effort to standardize the method in which brake stop results are reported to NHTSA. Tables to report the test findings and to provide analysis of the data are included.

APPENDIX A. VEHICLE PHOTOGRAPHS

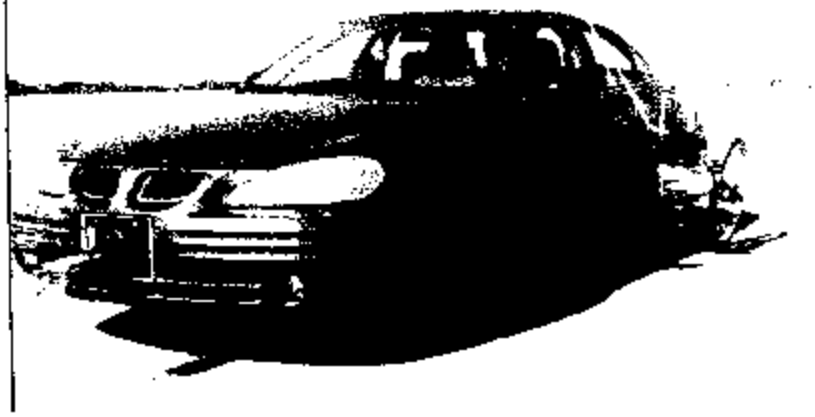


Figure A-1. Pontiac Grand Am

Figure A-2. Ford Expedition

Figure A-3. Toyota Camry

Figure A-4. Chevrolet Malibu

Figure A-5. Cadillac DeVille

Figure A-6. Dodge Caravan

Figure A-7. Dodge Ram 1500 4x4

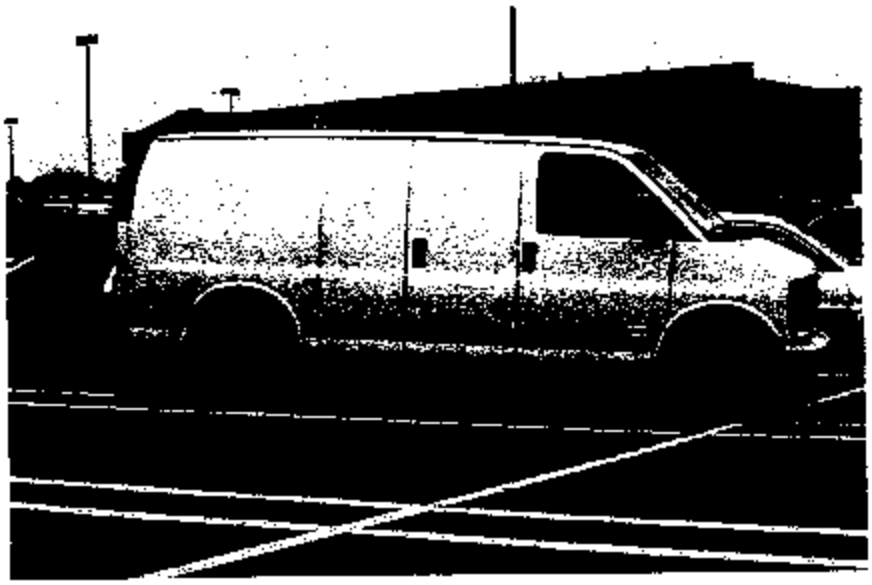


Figure A-8. Chevrolet Express (1-ton)

Figure A-9. Chevrolet Astro

Figure A-10. Pontiac Bonneville

APPENDIX B. INDIVIDUAL BRAKE STOP RESULTS

TABLE B-1. PONTIAC GRAND AM SE, BRAKE STOP RESULTS FROM 100 KM/HR (62 MPH)

Stop No.	Measurement							
	Stopping Distance		Deceleration Rate		Pedal effort at 0.1 sec		Pedal effort at 0.2 sec	
	m	ft	m/sec²	ft/sec²	N	lb	N	lb
Dry surface without payload								
1	44.8	146.9	8.6	28.1	764.6	171.9	1233.0	277.2
2	45.0	147.5	8.5	28.0	897.2	201.7	1375.3	309.2
3	45.0	147.5	8.5	28.0	724.1	162.8	1263.2	284.0
4	45.3	148.4	8.5	27.9	500.8	112.6	1270.3	285.6
5	45.5	149.4	8.4	27.7	1040.8	234.0	1591.9	357.9
6	45.5	149.3	8.4	27.7	1078.2	242.4	1504.8	338.3
7	45.3	148.4	8.5	27.9	858.5	193.0	1428.3	321.1
8	44.4	145.6	8.7	28.4	1086.2	244.2	1533.2	344.7
9	44.4	145.5	8.7	28.4	883.8	198.7	1483.9	333.6
10	45.8	150.3	8.4	27.5	928.3	208.7	1441.2	324.0
Dry surface with payload								
1	46.8	153.5	8.2	26.9	708.1	159.2	1400.7	314.9
2	45.1	148.0	8.5	27.9	837.6	188.3	1127.6	253.5
3	46.5	152.6	8.3	27.1	628.9	141.4	1257.0	282.6
4	46.7	153.3	8.2	27.0	971.0	218.3	1417.1	318.6
5	46.4	152.2	8.3	27.2	852.7	191.7	1252.1	281.5
6	46.4	152.3	8.3	27.2	918.5	206.5	1396.7	314.0
7	46.0	151.0	8.3	27.4	690.8	155.3	1231.7	276.9
8	46.7	153.0	8.2	27.0	971.0	218.3	1360.2	305.8
9	46.6	152.8	8.2	27.1	986.1	221.7	1444.3	324.7
10	46.1	151.3	8.3	27.3	1007.5	226.5	1432.3	322.0
Wet surface without payload								
1	60.1	197.0	6.4	21.0	750.4	168.7	1353.1	304.2
2	58.2	190.9	6.6	21.7	1041.7	234.2	1440.3	323.8
3	56.1	184.0	6.9	22.5	246.9	55.5	1229.9	276.5
4	58.9	193.2	6.5	21.4	987.9	222.1	1266.3	284.7
5	54.4	178.5	7.1	23.2	1060.0	238.3	1423.8	320.1
6	55.9	183.4	6.9	22.5	1038.6	233.5	1571.5	353.3
7	59.3	194.5	6.5	21.3	998.1	224.4	1426.0	320.6
8	57.5	188.6	6.7	21.9	678.8	152.6	1123.6	252.6
9	57.8	189.6	6.6	21.8	872.7	196.2	1397.6	314.2
10	61.5	201.6	6.3	20.5	415.9	93.5	1249.9	281.0
Wet surface with payload								
1	50.2	164.5	7.7	25.1	872.7	196.2	1615.1	363.1
2	52.3	171.5	7.4	24.1	919.4	206.7	1357.1	305.1
3	49.8	163.3	7.7	25.3	488.4	109.8	913.2	205.3
4	51.9	170.3	7.4	24.3	1035.5	232.8	1507.0	338.8
5	50.9	167.0	7.5	24.8	1177.4	264.7	1552.4	349.0
6	51.1	167.5	7.5	24.7	1070.2	240.6	1301.5	292.6
7	55.0	180.3	7.0	22.9	1096.4	246.5	1475.4	331.7
8	54.9	180.1	7.0	23.0	981.2	220.6	1491.0	335.2
9	48.3	158.4	8.0	26.1	979.0	220.1	1503.0	337.9
10	54.0	177.3	7.1	23.3	693.9	156.0	1350.0	303.5
11	56.8	186.2	6.8	22.2	553.3	124.4	1227.6	276.0

TABLE B-2. FORD EXPEDITION XLT, BRAKE STOP RESULTS FROM 100 KM/HR (62 MPH)

Stop No.	Measurement							
	Stopping Distance		Deceleration Rate		Pedal effort at 0.1 sec		Pedal effort at 0.2 sec	
	m	ft	m/sec^2	ft/sec^2	N	lb	N	lb
Dry surface without payload								
1	49.6	162.8	7.7	25.4	270.0	60.7	603.6	135.7
2	51.5	168.9	7.5	24.5	602.7	135.5	1267.2	284.9
3	50.4	165.2	7.6	25.0	779.7	175.3	1314.8	295.6
4	50.3	164.9	7.7	25.1	857.6	192.8	1321.9	297.2
5	50.8	166.6	7.6	24.8	830.4	186.7	1316.6	296.0
6	51.1	167.8	7.5	24.6	950.5	213.7	1591.0	357.7
7	53.6	175.8	7.2	23.5	762.4	171.4	1110.7	249.7
8	51.4	168.5	7.5	24.5	909.2	204.4	1430.0	321.5
9	52.7	172.8	7.3	23.9	782.0	175.8	1312.6	295.1
10	58.1	190.7	6.6	21.7	677.4	152.3	1121.8	252.2
Dry surface with payload								
1	50.4	165.5	7.6	25.0	413.7	93.0	1375.3	309.2
2	49.0	160.6	7.8	25.7	963.9	216.7	1436.3	322.9
3	52.1	170.8	7.4	24.2	74.7	16.8	827.3	186.0
4	50.3	165.1	7.6	25.0	532.0	119.6	1236.1	277.9
5	52.8	173.3	7.3	23.8	200.2	45.0	833.6	187.4
6	52.4	171.8	7.3	24.1	107.2	24.1	839.3	188.7
7	53.8	176.4	7.1	23.4	87.2	19.6	602.7	135.5
8	50.8	166.7	7.6	24.8	417.7	93.9	1418.0	318.8
9	51.5	169.1	7.5	24.5	595.6	133.9	1399.8	314.7
Wet surface without payload								
1	60.9	199.7	6.3	20.7	712.1	160.1	1225.0	275.4
2	63.4	208.0	6.1	19.9	176.1	39.6	665.4	149.6
3	66.6	218.4	5.8	18.9	383.4	86.2	790.9	177.8
4	59.6	195.7	6.4	21.1	712.1	160.1	1142.7	256.9
5	59.8	196.2	6.4	21.1	369.2	83.0	1067.1	239.9
6	58.8	192.9	6.5	21.4	790.9	177.8	1237.9	278.3
7	58.9	193.4	6.5	21.4	706.8	158.9	1314.8	295.6
8	58.5	191.8	6.6	21.6	346.9	78.0	1142.7	256.9
9	59.3	194.4	6.5	21.3	682.8	153.5	1177.4	264.7
Wet surface with payload								
1	64.8	212.5	5.9	19.5	660.5	148.5	1485.6	334.0
2	64.4	211.3	6.0	19.6	1097.3	246.7	1585.7	356.5
3	70.3	230.6	5.5	17.9	95.2	21.4	1186.3	266.7
4	68.2	223.7	5.6	18.5	378.1	85.0	1014.6	228.1
5	62.8	205.9	6.1	20.1	185.0	41.6	1008.4	226.7
6	68.9	226.2	5.6	18.3	402.5	90.5	1202.3	270.3
7	64.8	212.6	5.9	19.4	938.5	211.0	1422.9	319.9
8	72.0	236.2	5.3	17.5	391.4	88.0	1209.4	271.9

TABLE B-3. TOYOTA CAMRY LE. BRAKE STOP RESULTS FROM 100 KM/HR (62 MPH)

Stop No.	Measurement							
	Stopping Distance		Deceleration Rate		Pedal effort at 0.1 sec		Pedal effort at 0.2 sec	
	m	ft	m/sec^2	ft/sec^2	N	lb	N	lb
Dry surface without payload								
1	47.6	156.2	8.1	26.5	1072.9	241.2	1270.3	285.6
2	49.7	163.0	7.7	25.4	660.5	148.5	1302.8	292.9
3	49.3	161.7	7.8	25.6	1005.2	226.0	1064.0	239.2
4	48.2	158.2	8.0	26.1	897.2	201.7	1038.6	233.5
5	49.5	162.4	7.8	25.5	846.5	190.3	1287.3	289.4
6	48.8	160.1	7.9	25.8	596.9	134.2	1003.5	225.6
7	48.5	159.1	7.9	26.0	595.6	133.9	764.6	171.9
8	48.5	159.1	7.9	26.0	554.2	124.6	640.1	143.9
9	48.2	158.3	8.0	26.1	708.1	159.2	805.1	181.0
10	48.3	158.5	8.0	26.1	552.0	124.1	655.2	147.3
Dry surface with payload								
1	49.7	163.2	7.7	25.3	496.4	111.6	632.1	142.1
2	50.9	166.9	7.6	24.8	794.0	178.5	805.1	181.0
3	48.3	158.6	8.0	26.1	670.8	150.8	1195.6	268.8
4	48.9	160.5	7.9	25.8	814.0	183.0	1021.3	229.6
5	49.0	160.7	7.8	25.7	708.1	159.2	1136.9	255.6
6	49.8	163.5	7.7	25.3	821.1	184.6	1035.5	232.8
7	48.6	159.6	7.9	25.9	922.5	207.4	1388.7	312.2
8	49.7	162.9	7.7	25.4	672.5	151.2	972.8	218.7
9	48.4	158.9	7.9	26.0	983.0	221.0	1190.3	267.6
10	48.8	160.0	7.9	25.8	778.0	174.9	1267.2	284.9
Wet surface without payload								
1	51.0	167.3	7.5	24.7	577.4	129.8	721.9	162.3
2	52.9	173.5	7.3	23.8	763.7	171.7	989.2	222.4
3	51.7	169.7	7.4	24.4	600.9	135.1	849.6	191.0
4	53.0	174.0	7.3	23.8	461.3	103.7	512.9	115.3
5	53.4	175.3	7.2	23.6	649.4	146.0	963.9	216.7
6	52.7	172.8	7.3	23.9	755.3	169.8	812.2	182.6
7	55.4	181.7	6.9	22.8	866.9	194.9	1203.6	270.6
8	54.1	177.4	7.1	23.3	837.6	188.3	1107.6	249.0
9	55.9	183.4	6.9	22.5	886.9	199.4	1428.3	321.1
10	55.4	181.6	6.9	22.8	991.0	222.8	1472.7	331.1
Wet surface with payload								
1	53.0	174.0	7.3	23.8	782.0	175.8	1087.1	244.4
2	51.3	168.3	7.5	24.6	411.4	92.5	697.0	156.7
3	53.4	175.2	7.2	23.6	687.7	154.6	868.7	195.3
4	53.2	174.6	7.2	23.7	585.8	131.7	786.0	176.7
5	53.2	174.4	7.2	23.7	423.9	95.3	923.4	207.6
6	53.8	176.6	7.1	23.4	793.1	178.3	860.7	193.5
7	53.6	175.8	7.2	23.5	628.9	141.4	638.3	143.5
8	53.3	174.9	7.2	23.6	695.7	156.4	687.7	154.6
9	53.3	174.9	7.2	23.6	381.2	85.7	717.9	161.4
10	53.1	174.3	7.2	23.7	305.6	68.7	576.5	129.6

TABLE B-4. CHEVROLET MALIBU LS, BRAKE STOP RESULTS FROM 100 KM/HR (62 MPH)

Stop No.	Measurement							
	Stopping Distance		Deceleration Rate		Pedal effort at 0.1 sec		Pedal effort at 0.2 sec	
	m	ft	m/sec^2	ft/sec^2	N	lb	N	lb
Dry surface without payload								
1	42.7	140.0	9.0	29.5	708.1	159.2	940.8	211.5
2	43.3	142.0	8.9	29.1	502.6	113.0	764.6	171.9
3	42.9	140.9	8.9	29.3	727.2	163.5	854.5	192.1
4	43.5	142.8	8.8	29.0	721.0	162.1	830.4	186.7
5	42.4	139.0	9.1	29.7	812.2	182.6	1003.5	225.6
6	43.4	142.4	8.8	29.0	708.1	159.2	762.4	171.4
7	42.7	140.1	9.0	29.5	550.2	123.7	604.9	136.0
8	43.6	143.0	8.8	28.9	742.4	166.9	1035.5	232.8
9	43.3	142.0	8.9	29.1	815.3	183.3	1079.1	242.6
10	42.8	140.3	9.0	29.5	749.5	168.5	1044.8	234.9
Dry surface with payload								
1	47.1	154.5	8.2	26.8	504.8	113.5	660.5	148.5
2	47.5	155.7	8.1	26.5	646.3	145.3	690.8	155.3
3	47.7	156.6	8.0	26.4	673.4	151.4	665.4	149.6
4	47.8	156.8	8.0	26.4	654.3	147.1	632.1	142.1
5	47.2	154.7	8.1	26.7	573.3	128.9	645.4	145.1
6	46.2	151.5	8.3	27.3	529.8	119.1	634.3	142.6
7	45.8	150.2	8.4	27.5	617.8	138.9	837.6	188.3
8	46.6	152.8	8.3	27.1	563.1	126.6	693.9	156.0
9	47.5	156.0	8.1	26.5	756.6	170.1	689.9	155.1
10	46.1	151.4	8.3	27.3	467.0	105.0	586.7	131.9
Wet surface without payload								
1	45.1	147.9	8.5	28.0	820.2	184.4	832.2	187.1
2	46.0	150.9	8.4	27.4	438.1	98.5	494.6	111.2
3	46.2	151.5	8.3	27.3	391.4	88.0	470.2	105.7
4	44.9	147.4	8.6	28.1	616.0	138.5	831.3	186.9
5	46.9	153.9	8.2	26.9	648.1	145.7	705.0	158.5
6	44.6	146.3	8.6	28.2	638.3	143.5	775.7	174.4
7	45.4	148.8	8.5	27.8	585.8	131.7	562.2	126.4
8	46.0	151.0	8.4	27.4	539.1	121.2	546.2	122.8
9	45.5	149.4	8.4	27.7	525.8	118.2	713.0	160.3
10	47.4	155.5	8.1	26.6	644.1	144.8	704.1	158.3
Wet surface with payload								
1	46.8	153.4	8.2	26.9	255.8	57.5	337.6	75.9
2	46.5	152.4	8.3	27.1	492.4	110.7	443.0	99.6
3	46.8	153.7	8.2	26.9	536.9	120.7	612.0	137.6
4	48.9	160.5	7.9	25.8	591.6	133.0	450.1	101.2
5	50.0	164.2	7.7	25.2	435.9	98.0	540.9	121.6
6	48.4	158.9	7.9	26.0	404.8	91.0	532.0	119.6
7	51.7	169.5	7.4	24.4	590.7	132.8	534.2	120.1
8	55.3	181.3	6.9	22.8	771.7	173.5	844.7	189.9
9	53.8	176.4	7.1	23.4	312.7	70.3	663.6	149.2
10	48.3	158.4	8.0	26.1	584.5	131.4	664.5	149.4
11	53.7	176.2	7.2	23.5	416.8	93.7	667.6	150.1

TABLE B-5. CADILLAC DEVILLE, BRAKE STOP RESULTS FROM 100 KM/HR (62 MPH)

Stop No.	Measurement							
	Stopping Distance		Deceleration Rate		Pedal effort at 0.1 sec		Pedal effort at 0.2 sec	
	m	ft	m/sec²	ft/sec²	N	lb	N	lb
Dry surface without payload								
1	48.1	157.8	8.0	26.2	637.0	143.2	850.5	191.2
2	49.0	160.9	7.8	25.7	419.9	94.4	323.8	72.8
3	45.6	149.6	8.4	27.6	520.0	116.9	694.8	156.2
4	47.1	154.4	8.2	26.8	479.5	107.8	667.6	150.1
5	47.5	156.0	8.1	26.5	303.4	68.2	459.0	103.2
6	48.0	157.5	8.0	26.2	551.1	123.9	649.4	146.0
7	47.0	154.1	8.2	26.8	580.5	130.5	688.6	154.8
8	47.9	157.2	8.0	26.3	624.9	140.5	736.1	165.5
9	48.4	158.8	7.9	26.0	740.1	166.4	1084.0	243.7
10	47.8	156.8	8.0	26.4	246.9	55.5	374.1	84.1
11	47.6	156.3	8.0	26.4	318.5	71.6	454.1	102.1
12	47.9	157.1	8.0	26.3	401.7	90.3	496.4	111.6
Dry surface with payload								
1	51.8	169.8	7.4	24.3	660.5	148.5	971.0	218.3
2	52.2	171.3	7.3	24.1	413.7	93.0	424.8	95.5
3	50.8	166.8	7.6	24.8	721.9	162.3	815.3	183.3
4	52.0	170.5	7.4	24.3	598.7	134.6	639.2	143.7
5	50.9	166.9	7.6	24.8	824.2	185.3	907.4	204.0
6	50.2	164.7	7.7	25.1	620.9	139.6	698.8	157.1
7	49.3	161.7	7.8	25.6	558.2	125.5	523.1	117.6
8	50.8	166.8	7.6	24.8	582.7	131.0	675.7	151.9
9	49.7	163.1	7.7	25.3	347.8	78.2	563.1	126.6
10	48.9	160.3	7.9	25.8	601.8	135.3	635.2	142.8
11	48.8	160.2	7.9	25.8	336.7	75.7	470.2	105.7
12	48.8	160.1	7.9	25.8	491.5	110.5	596.9	134.2
Wet surface without payload								
1	50.3	164.9	7.7	25.1	306.5	68.9	493.7	111.0
2	49.9	163.8	7.7	25.2	532.9	119.8	752.6	169.2
3	50.7	166.3	7.6	24.9	689.9	155.1	647.2	145.5
4	49.0	160.7	7.8	25.7	610.7	137.3	885.2	199.0
5	50.2	164.7	7.7	25.1	347.8	78.2	553.3	124.4
6	50.4	165.4	7.6	25.0	477.3	107.3	612.9	137.8
7	49.1	161.2	7.8	25.6	428.8	96.4	710.8	159.8
8	50.3	164.9	7.7	25.1	259.8	58.4	368.3	82.8
9	49.7	163.2	7.7	25.3	764.6	171.9	580.5	130.5
10	49.5	162.5	7.7	25.4	580.5	130.5	697.9	156.9
Wet surface with payload								
1	49.9	163.6	7.7	25.3	421.7	94.8	657.4	147.8
2	49.9	163.6	7.7	25.3	705.0	158.5	787.7	177.1
3	49.8	163.3	7.7	25.3	514.6	115.7	698.8	157.1
4	49.3	161.9	7.8	25.6	387.4	87.1	468.4	105.3
5	49.3	161.9	7.8	25.6	536.9	120.7	520.9	117.1
6	50.9	167.0	7.6	24.8	551.1	123.9	749.5	168.5
7	49.7	163.2	7.7	25.4	758.4	170.5	665.4	149.6
8	50.4	165.4	7.6	25.0	693.0	155.8	651.2	146.4
9	50.0	164.0	7.7	25.2	458.1	103.0	488.4	109.8
10	50.4	165.4	7.6	25.0	646.3	145.3	766.8	172.4

TABLE B-6. DODGE CARAVAN, BRAKE STOP RESULTS FROM 100 KM/HR (62 MPH)

Stop No.	Measurement							
	Stopping Distance		Deceleration Rate		Pedal effort at 0.1 sec		Pedal effort at 0.2 sec	
	m	ft	m/sec^2	ft/sec^2	N	lb	N	lb
Dry surface without payload								
1	46.8	153.7	8.2	26.9	893.2	200.8	933.6	209.9
2	49.2	161.5	7.8	25.6	344.7	77.5	697.9	156.9
3	48.2	158.1	8.0	26.1	644.1	144.8	743.3	167.1
4	49.0	160.8	7.8	25.7	561.3	126.2	878.9	197.6
5	47.9	157.1	8.0	26.3	709.9	159.6	822.4	184.9
6	48.6	159.4	7.9	25.9	742.4	166.9	729.0	163.9
7	48.6	159.4	7.9	25.9	649.4	146	787.7	177.1
8	50.8	166.8	7.6	24.8	120.5	27.1	450.1	101.2
9	48.2	158.1	8.0	26.1	738.4	166.0	814.0	183.0
10	49.9	163.8	7.7	25.2	489.3	110.0	684.5	153.9
11	48.5	159.2	7.9	26.0	478.2	107.5	731.3	164.4
Dry surface with payload								
1	53.4	175.2	7.2	23.6	548.0	123.2	677.4	152.3
2	50.3	164.9	7.7	25.1	745.5	167.6	938.5	211.0
3	53.2	174.5	7.2	23.7	677.4	152.3	878.0	197.4
4	52.5	172.3	7.3	24.0	719.2	161.7	783.7	176.2
5	51.5	169.0	7.5	24.5	709.0	159.4	683.7	153.7
6	52.4	171.9	7.3	24.0	809.1	181.9	1040.8	234.0
7	51.5	168.8	7.5	24.5	705.9	158.7	852.7	191.7
8	53.9	177.0	7.1	23.3	640.1	143.9	621.8	139.8
9	55.2	181.1	6.9	22.8	640.1	143.9	540.0	121.4
10	53.9	176.7	7.1	23.4	683.7	153.7	723.2	162.6
Wet surface without payload								
1	50.3	164.9	7.7	25.1	319.8	71.9	623.2	140.1
2	49.7	162.9	7.7	25.4	361.2	81.2	401.7	90.3
3	51.5	168.8	7.5	24.5	346.9	78.0	416.8	93.7
4	49.6	162.8	7.7	25.4	535.1	120.3	589.8	132.6
5	49.7	163.0	7.7	25.4	469.3	105.5	523.1	117.6
6	51.5	169.1	7.5	24.5	435.9	98.0	446.1	100.3
7	53.0	174.0	7.3	23.8	124.5	28.0	285.1	64.1
8	50.2	164.6	7.7	25.1	490.6	110.3	786.0	176.7
9	50.0	164.1	7.7	25.2	540.0	121.4	589.8	132.6
10	49.9	163.8	7.7	25.2	486.6	109.4	790.9	177.8
11	52.3	171.6	7.3	24.1	465.3	104.6	510.6	114.8
Wet surface with payload								
1	56.7	185.9	6.8	22.2	751.3	168.9	914.1	205.5
2	57.5	188.5	6.7	21.9	640.1	143.9	773.5	173.9
3	58.6	192.2	6.6	21.5	795.7	178.9	765.5	172.1
4	59.3	194.6	6.5	21.2	673.4	151.4	516.0	116.0
5	60.1	197.2	6.4	21.0	455.0	102.3	557.3	125.3
6	58.6	192.1	6.6	21.5	576.5	129.6	561.3	126.2
7	56.8	186.2	6.8	22.2	772.6	173.7	929.6	209.0
8	56.8	186.3	6.8	22.2	596.9	134.2	760.6	171.0
9	57.3	187.9	6.7	22.0	554.2	124.6	743.3	167.1
10	59.6	195.4	6.5	21.2	312.7	70.3	471.5	106.0

TABLE B-7. DODGE RAM 1500 SLT 4X4, BRAKE STOP RESULTS FROM 100 KM/HR (62 MPH)

Stop No.	Measurement							
	Stopping Distance		Deceleration Rate		Pedal effort at 0.1 sec		Pedal effort at 0.2 sec	
	m	ft	m/sec^2	ft/sec^2	N	lb	N	lb
Dry surface without payload								
1	60.4	198.2	6.4	20.9	82.7	18.6	120.5	27.1
2	56.6	185.8	6.8	22.2	96.1	21.6	131.7	29.6
3	60.2	197.5	6.4	20.9	107.2	24.1	138.8	31.2
4	61.3	201.1	6.3	20.6	93.9	21.1	103.2	23.2
5	64.3	210.9	6.0	19.6	63.6	14.3	98.3	22.1
6	65.4	214.5	5.9	19.3	78.7	17.7	114.3	25.7
7	59.4	194.9	6.5	21.2	81.0	18.2	100.1	22.5
8	58.1	190.7	6.6	21.7	105.0	23.6	119.2	26.8
Dry surface with payload								
1	61.5	201.9	6.2	20.5	159.7	35.9	170.8	38.4
2	62.9	206.4	6.1	20.0	91.2	20.5	81.0	18.2
3	56.8	186.4	6.8	22.2	92.1	20.7	121.4	27.3
4	55.1	180.9	7.0	22.9	121.4	27.3	161.9	36.4
5	57.2	187.5	6.7	22.0	99.2	22.3	124.5	28.0
6	54.6	179.2	7.0	23.1	100.1	22.5	161.0	36.2
7	58.0	190.3	6.6	21.7	62.7	14.1	98.3	22.1
8	57.7	189.4	6.6	21.8	85.0	19.1	120.5	27.1
9	53.2	174.7	7.2	23.7	108.1	24.3	147.7	33.2
Wet surface without payload								
1	66.0	216.6	5.8	19.1	84.1	18.9	130.3	29.3
2	71.6	234.9	5.4	17.6	58.7	13.2	89.0	20.0
3	65.9	216.1	5.8	19.1	64.9	14.6	96.1	21.6
4	63.2	207.5	6.1	19.9	120.5	27.1	146.8	33.0
5	63.6	208.7	6.0	19.8	95.2	21.4	125.4	28.2
6	62.8	205.9	6.1	20.1	73.8	16.6	93.9	21.1
7	60.3	197.7	6.4	20.9	88.1	19.8	113.4	25.5
8	62.5	205.1	6.2	20.2	85.0	19.1	121.4	27.3
9	61.7	202.5	6.2	20.4	70.7	15.9	89.0	20.0
10	61.2	200.8	6.3	20.6	98.3	22.1	124.5	28.0
Wet surface with payload								
1	63.8	209.2	6.0	19.8	59.6	13.4	101.0	22.7
2	58.9	193.4	6.5	21.4	89.0	20.0	150.8	33.9
3	61.1	200.6	6.3	20.6	88.1	19.8	112.1	25.2
4	61.7	202.4	6.2	20.4	140.6	31.6	177.0	39.8
5	63.0	206.6	6.1	20.0	100.1	22.5	106.3	23.9
6	62.3	204.5	6.2	20.2	85.8	19.3	98.3	22.1
7	61.6	202.0	6.2	20.5	96.1	21.6	106.3	23.9
8	63.3	207.7	6.1	19.9	88.1	19.8	105.0	23.6
9	67.2	220.5	5.7	18.7	111.2	25.0	129.4	29.1

TABLE B-8. CHEVROLET EXPRESS (1-TON), BRAKE STOP RESULTS FROM 100 KM/HR (62 MPH)

Stop No.	Measurement							
	Stopping Distance		Deceleration Rate		Pedal effort at 0.1 sec		Pedal effort at 0.2 sec	
	m	ft	m/sec^2	ft/sec^2	N	lb	N	lb
Dry surface without payload								
1	49.0	160.8	7.8	25.7	502.6	113.0	633.0	142.3
2	51.3	168.3	7.5	24.6	290.5	65.3	578.7	130.1
3	50.3	164.9	7.7	25.1	338.9	76.2	544.0	122.3
4	50.5	165.8	7.6	24.9	322.5	72.5	435.9	98.0
5	50.2	164.6	7.7	25.1	307.4	69.1	417.7	93.9
6	50.9	167.0	7.6	24.8	357.2	80.3	364.3	81.9
7	52.8	173.2	7.3	23.9	163.7	36.8	446.1	100.3
8	50.6	166.1	7.6	24.9	499.5	112.3	794.9	178.7
9	51.2	168.1	7.5	24.6	455.0	102.3	534.2	120.1
10	50.4	165.3	7.6	25.0	593.8	133.5	609.8	137.1
Dry surface with payload								
1	55.7	182.8	6.9	22.6	149.9	33.7	476.4	107.1
2	57.4	188.4	6.7	21.9	76.1	17.1	491.5	110.5
3	55.2	181.0	6.9	22.8	262.0	58.9	1175.2	264.2
4	53.6	176.0	7.2	23.5	775.7	174.4	758.4	170.5
5	56.2	184.5	6.8	22.4	791.7	178.0	914.1	205.5
6	55.5	182.0	6.9	22.7	828.2	186.2	920.3	206.9
7	55.6	182.5	6.9	22.7	568.5	127.8	628.1	141.2
8	55.8	183.1	6.9	22.6	591.6	133.0	663.6	149.2
9	53.9	176.8	7.1	23.4	567.6	127.6	688.6	154.8
10	50.9	166.9	7.6	24.8	616.0	138.5	557.3	125.3
Wet surface without payload								
1	55.1	180.7	7.0	22.9	165.0	37.1	363.0	81.6
2	56.9	186.7	6.7	22.1	123.2	27.7	442.1	99.4
3	53.8	176.6	7.1	23.4	390.5	87.8	653.4	146.9
4	54.4	178.5	7.1	23.2	774.8	174.2	640.1	143.9
5	54.1	177.6	7.1	23.3	652.5	146.7	819.3	184.2
6	53.6	175.8	7.2	23.5	594.7	133.7	569.3	128.0
7	55.0	180.3	7.0	22.9	521.8	117.3	540.9	121.6
8	55.0	180.5	7.0	22.9	620.9	139.6	704.1	158.3
9	53.6	176.0	7.2	23.5	512.9	115.3	512.9	115.3
10	54.4	178.6	7.1	23.2	528.9	118.9	625.8	140.7
11	55.0	180.5	7.0	22.9	712.1	160.1	652.5	146.7
Wet surface with payload								
1	55.2	181.1	6.9	22.8	897.2	201.7	933.6	209.9
2	56.9	186.7	6.7	22.1	630.3	141.7	764.6	171.9
3	57.5	188.7	6.7	21.9	504.8	113.5	529.8	119.1
4	56.4	184.9	6.8	22.4	472.4	106.2	710.8	159.8
5	54.5	178.9	7.0	23.1	917.2	206.2	890.0	200.1
6	56.1	184.1	6.9	22.5	846.5	190.3	761.5	171.2
7	57.8	189.5	6.6	21.8	142.8	32.1	487.5	109.6
8	55.6	182.5	6.9	22.7	376.3	84.6	715.2	160.8
9	56.7	186.1	6.8	22.2	458.1	103.0	593.8	133.5

TABLE B-9. CHEVROLET ASTRO, BRAKE STOP RESULTS FROM 100 KM/HR (62 MPH)

Stop No.	Measurement							
	Stopping Distance		Deceleration Rate		Pedal effort at 0.1 sec		Pedal effort at 0.2 sec	
	m	ft	m/sec^2	ft/sec^2	N	lb	N	lb
Dry surface without payload								
1	52.0	170.5	7.4	24.4	302.5	68.0	583.6	131.2
2	52.6	172.5	7.3	24.0	584.5	131.4	646.3	145.3
3	52.0	170.7	7.4	24.2	243.8	54.8	655.2	147.3
4	51.2	167.9	7.5	24.6	20.0	4.5	453.3	101.9
5	51.5	169.0	7.5	24.5	421.7	94.8	628.1	141.2
6	52.2	171.4	7.3	24.1	488.4	109.8	634.3	142.6
7	52.1	170.9	7.4	24.2	590.7	132.8	757.5	170.3
8	51.8	170.1	7.4	24.3	668.5	150.3	571.6	128.5
9	51.5	169.1	7.5	24.5	504.8	113.5	624.9	140.5
Dry surface with payload								
1	56.3	184.8	6.8	22.4	460.4	103.5	502.6	113.0
2	55.4	181.6	6.9	22.8	470.2	105.7	540.9	121.6
3	54.7	179.5	7.0	23.0	478.2	107.5	736.1	165.5
4	54.4	178.4	7.1	23.2	494.6	111.2	561.3	126.2
5	55.8	183.0	6.9	22.6	466.2	104.8	542.2	121.9
6	56.6	185.7	6.8	22.3	278.0	62.5	467.0	105.0
7	56.0	183.8	6.9	22.5	566.2	127.3	474.2	106.6
8	56.1	184.0	6.9	22.5	294.5	66.2	516.9	116.2
9	57.1	187.4	6.7	22.1	258.0	58.0	432.8	97.3
10	56.7	186.1	6.8	22.2	342.1	76.9	473.3	106.4
Wet surface without payload								
1	54.5	178.9	7.0	23.1	450.1	101.2	443.0	99.6
2	53.6	176.0	7.2	23.5	406.5	91.4	463.0	104.1
3	53.4	175.1	7.2	23.6	554.2	124.6	642.3	144.4
4	54.0	177.3	7.1	23.3	358.1	80.5	423.9	95.3
5	52.8	173.1	7.3	23.9	380.3	85.5	550.2	123.7
6	53.5	175.4	7.2	23.6	550.2	123.7	580.5	130.5
7	52.6	172.5	7.3	24.0	316.7	71.2	523.1	117.6
8	53.0	173.8	7.3	23.8	485.3	109.1	555.1	124.8
9	53.4	175.2	7.2	23.6	408.8	91.9	582.7	131.0
10	52.4	172.0	7.3	24.0	259.8	58.4	556.4	125.1
Wet surface with payload								
1	61.9	203.0	6.2	20.4	296.2	66.6	330.9	74.4
2	60.3	197.8	6.4	20.9	266.0	59.8	386.5	86.9
3	58.4	191.6	6.6	21.6	225.5	50.7	350.1	78.7
4	57.2	187.7	6.7	22.0	209.5	47.1	408.8	91.9
5	56.4	184.9	6.8	22.4	523.1	117.6	570.2	128.2
6	56.4	184.9	6.8	22.4	468.4	105.3	559.1	125.7
7	56.3	184.7	6.8	22.4	385.2	86.6	517.7	116.4
8	56.9	186.6	6.8	22.2	466.2	104.8	602.7	135.5
9	56.0	183.8	6.9	22.5	366.1	82.3	660.5	148.5
10	56.6	185.6	6.8	22.3	428.8	96.4	635.2	142.8

TABLE B-10. PONTIAC BONNEVILLE SE, BRAKE STOP RESULTS FROM 100 KM/HR (62 MPH)

Stop No.	Measurement							
	Stopping Distance		Deceleration Rate		Pedal effort at 0.1 sec		Pedal effort at 0.2 sec	
	m	ft	m/sec^2	ft/sec^2	N	lb	N	lb
Dry surface without payload								
1	48.0	157.4	8.0	26.3	755.3	169.8	921.2	207.1
2	47.7	156.4	8.0	26.4	648.1	145.7	841.6	189.2
3	48.0	157.4	8.0	26.3	444.8	100.0	549.3	123.5
4	47.3	155.2	8.1	26.6	450.1	101.2	492.4	110.7
5	47.8	156.7	8.0	26.4	518.6	116.6	715.2	160.8
6	47.8	156.9	8.0	26.4	506.6	113.9	723.2	162.6
7	47.1	154.4	8.2	26.8	431.0	96.9	747.3	168.0
8	48.6	159.3	7.9	26.0	743.3	167.1	878.9	197.6
9	48.5	159.2	7.9	26.0	738.4	166.0	971.0	218.3
10	46.8	153.6	8.2	26.9	612.0	137.6	591.6	133.0
Dry surface with payload								
1	52.5	172.2	7.3	24.0	315.4	70.9	480.4	108.0
2	50.8	166.7	7.6	24.8	286.0	64.3	552.0	124.1
3	50.2	164.7	7.7	25.1	317.6	71.4	557.3	125.3
4	49.1	161.0	7.8	25.7	334.9	75.3	583.6	131.2
5	48.9	160.4	7.9	25.8	464.4	104.4	872.7	196.2
6	49.6	162.7	7.7	25.4	269.1	60.5	408.8	91.9
7	48.6	159.5	7.9	25.9	250.0	56.2	459.0	103.2
8	48.4	158.9	7.9	26.0	274.0	61.6	428.8	96.4
9	50.2	164.8	7.7	25.1	277.1	62.3	558.2	125.5
10	49.2	161.4	7.8	25.6	212.2	47.7	435.0	97.8
11	48.6	159.3	7.9	26.0	226.4	50.9	432.8	97.3
Wet surface without payload								
1	49.6	162.7	7.7	25.4	705.0	158.5	802.0	180.3
2	48.4	158.7	8.0	26.1	568.5	127.8	921.2	207.1
3	49.7	162.9	7.7	25.4	422.6	95.0	514.6	115.7
4	49.1	161.2	7.8	25.6	394.5	88.7	560.4	126.0
5	49.6	162.6	7.7	25.4	609.8	137.1	752.6	169.2
6	49.6	162.7	7.7	25.4	355.8	80.0	682.8	153.5
7	49.7	163.1	7.7	25.3	671.6	151.0	597.8	134.4
8	48.6	159.5	7.9	25.9	542.2	121.9	663.6	149.2
9	48.4	158.9	7.9	26.0	421.7	94.8	641.4	144.2
10	49.1	161.1	7.8	25.7	482.6	108.5	534.2	120.1
Wet surface with payload								
1	50.7	166.4	7.6	24.9	384.3	86.4	433.7	97.5
2	50.0	163.9	7.7	25.2	580.5	130.5	669.4	150.5
3	50.7	166.5	7.6	24.8	658.3	148.0	661.4	148.7
4	51.0	167.2	7.5	24.7	294.5	66.2	556.4	125.1
5	50.7	166.4	7.6	24.8	232.6	52.3	439.0	98.7
6	49.4	162.1	7.8	25.5	117.4	26.4	384.3	86.4
7	49.7	163.1	7.7	25.4	276.2	62.1	408.8	91.9
8	50.1	164.4	7.7	25.1	220.6	49.6	313.6	70.5
9	51.7	169.6	7.4	24.3	418.6	94.1	666.3	149.8
10	50.3	165.1	7.6	25.0	399.4	89.8	739.3	166.2

TABLE B-11. BASELINE BRAKE STOP RESULTS FROM 100 KM/HR (62 MPH), PONTIAC GRAND AM SE ON DRY SURFACE WITHOUT PAYLOAD

Stop No.	Measurement							
	Stopping Distance		Deceleration Rate		Pedal effort at 0.1 sec		Pedal effort at 0.2 sec	
	m	ft	m/sec^2	ft/sec^2	N	lb	N	lb
7 October 1998 (Ford Expedition)								
1	46.0	151.0	8.3	27.4	446.1	100.3	1334.8	300.1
2	45.1	147.9	8.5	28.0	638.3	143.5	1419.8	319.2
3	46.7	153.3	8.2	27.0	855.8	192.4	1330.8	299.2
4	45.0	147.7	8.5	28.0	917.2	206.2	1447.4	325.4
5	45.8	150.1	8.4	27.5	1209.4	271.9	1411.8	317.4
6	45.3	148.7	8.5	27.8	879.8	197.8	1364.2	306.7
8 October 1998 (Ford Expedition) NOTE: SURFACE WAS DAMP DURING TESTING								
1	47.3	155.0	8.1	26.7	235.7	53.0	947.9	213.1
2	47.6	156.2	8.1	26.5	656.5	147.6	1410.0	317.0
3	47.5	155.9	8.1	26.5	555.1	124.8	1101.3	247.6
4	48.7	159.7	7.9	25.9	279.3	62.8	1134.7	255.1
5	47.9	157.1	8.0	26.3	173.0	38.9	920.3	206.9
6	48.3	158.6	7.9	26.1	121.4	27.3	658.3	148.0
9 October 1998 (Ford Expedition)								
1	43.0	140.9	8.9	29.3	647.2	145.5	1045.7	235.1
2	43.8	143.7	8.8	28.8	577.4	129.8	929.6	209.0
3	44.1	144.6	8.7	28.6	806.0	181.2	1131.6	254.4
4	43.6	143.1	8.8	28.9	681.9	153.3	1149.8	258.5
5	44.1	144.6	8.7	28.6	613.8	138.0	957.7	215.3
6	43.6	143.1	8.8	28.9	697.9	156.9	1009.3	226.9
13 October 1998 (Toyota Camry)								
1	43.9	144.0	8.8	28.7	841.6	189.2	1142.7	256.9
2	44.4	145.8	8.6	28.4	971.0	218.3	1365.5	307.0
3	45.3	148.6	8.5	27.8	998.1	224.4	1278.4	287.4
4	44.0	144.3	8.7	28.7	811.3	182.4	1253.9	281.9
5	44.1	144.8	8.7	28.6	901.2	202.6	1184.5	266.3
6	44.1	144.6	8.7	28.6	717.0	161.2	963.9	216.7
14 October 1998 (Toyota Camry)								
1	45.9	150.7	8.4	27.4	589.8	132.6	1074.2	241.5
2	45.3	148.6	8.5	27.8	690.8	155.3	908.3	204.2
3	45.9	150.7	8.4	27.4	863.8	194.2	965.7	217.1
4	44.8	146.8	8.6	28.2	624.9	140.5	798.0	179.4
5	45.8	150.2	8.4	27.5	304.2	68.4	655.2	147.3
15 October 1998 (Toyota Camry)								
1	42.5	139.5	9.0	29.6	665.4	149.6	804.2	180.8
2	42.5	139.3	9.0	29.7	562.2	126.4	831.3	186.9
3	42.9	140.6	9.0	29.4	479.5	107.8	592.5	133.2
19 October 1998 (Chevrolet Malibu) NOTE: TIRES ROTATED BEFORE TESTING								
1	47.9	157.2	8.0	26.3	361.2	81.2	417.7	93.9
2	48.3	158.4	8.0	26.1	318.5	71.6	397.7	89.4
3	44.9	147.4	8.6	28.1	477.3	107.3	569.3	128.0
20 October 1998 (Chevrolet Malibu)								
1	43.8	143.7	8.8	28.8	635.2	142.8	676.5	152.1
2	44.2	145.0	8.7	28.5	348.7	78.4	501.7	112.8
3	45.3	148.4	8.5	27.9	324.7	73.0	453.3	101.9

TABLE B-11. BASELINE BRAKE STOP RESULTS FROM 100 KM/HR (62 MPH), PONTIAC GRAND AM SE ON DRY SURFACE WITHOUT PAYLOAD (continued)

Stop No.	Measurement							
	Stopping Distance		Deceleration Rate		Pedal effort at 0.1 sec		Pedal effort at 0.2 sec	
	m	ft	m/sec^2	ft/sec^2	N	lb	N	lb
22 October 1998 (Cadillac DeVille)								
1	42.8	140.3	9.0	29.5	817.1	183.7	1177.4	264.7
2	42.8	140.3	9.0	29.5	1007.5	226.5	1700.0	382.2
3	43.0	141.1	8.9	29.3	1105.3	248.5	1683.1	378.4
23 October 1998 (Cadillac DeVille)								
1	42.7	140.0	9.0	29.5	906.1	203.7	1229.0	276.3
2	42.7	140.2	9.0	29.5	680.5	153.0	945.6	212.6
3	42.9	140.7	9.0	29.4	898.9	202.1	1201.4	270.1
30 October 1998 (Dodge Caravan)								
1	43.8	143.6	8.8	28.8	480.4	108.0	591.6	133.0
2	43.3	142.0	8.9	29.1	551.1	123.9	681.9	153.3
3	43.7	143.4	8.8	28.8	429.7	96.6	529.8	119.1
2 November 1998 (Dodge Caravan)								
1	43.7	143.4	8.8	28.8	486.6	109.4	713.0	160.3
2	43.4	142.2	8.9	29.1	403.4	90.7	517.7	116.4
3	43.4	142.3	8.9	29.0	506.6	113.9	594.7	133.7
3 November 1998 (Dodge Caravan)								
1	43.8	143.6	8.8	28.8	524.0	117.8	697.0	156.7
2	43.4	142.3	8.9	29.0	491.5	110.5	624.1	140.3
3	43.9	144.2	8.7	28.7	372.3	83.7	436.8	98.2
6 November 1998 (Dodge Ram 1500)								
1	45.1	148.0	8.5	27.9	129.4	29.1	302.5	68.0
2	45.0	147.5	8.5	28.0	89.0	20.0	192.2	43.2
3	44.1	144.7	8.7	28.6	159.7	35.9	386.5	86.9
4	44.4	145.5	8.7	28.4	346.9	78.0	498.6	112.1
12 November 1998 (Chevrolet Express)								
1	44.2	145.1	8.7	28.5	292.2	65.7	502.6	113.0
2	43.8	143.6	8.8	28.8	369.2	83.0	752.6	169.2
3	45.5	149.4	8.4	27.7	173.0	38.9	689.9	155.1
4	44.7	146.7	8.6	28.2	306.5	68.9	563.1	126.6
18 November 1998 (Chevrolet Astro)								
1	45.2	148.3	8.5	27.9	552.0	124.1	574.2	129.1
2	43.7	143.2	8.8	28.9	490.6	110.3	865.6	194.6
3	43.0	141.1	8.9	29.3	505.7	113.7	479.5	107.8
4	43.3	142.0	8.9	29.1	567.6	127.6	688.6	154.8
20 November 1998 (Pontiac Bonneville)								
1	42.9	140.8	8.9	29.4	791.7	178.0	1079.1	242.6
2	43.6	142.9	8.8	28.9	557.3	125.3	536.0	120.5
3	43.5	142.5	8.8	29.0	568.5	127.8	683.7	153.7

APPENDIX C. SAMPLE PEDAL EFFORT PLOTS

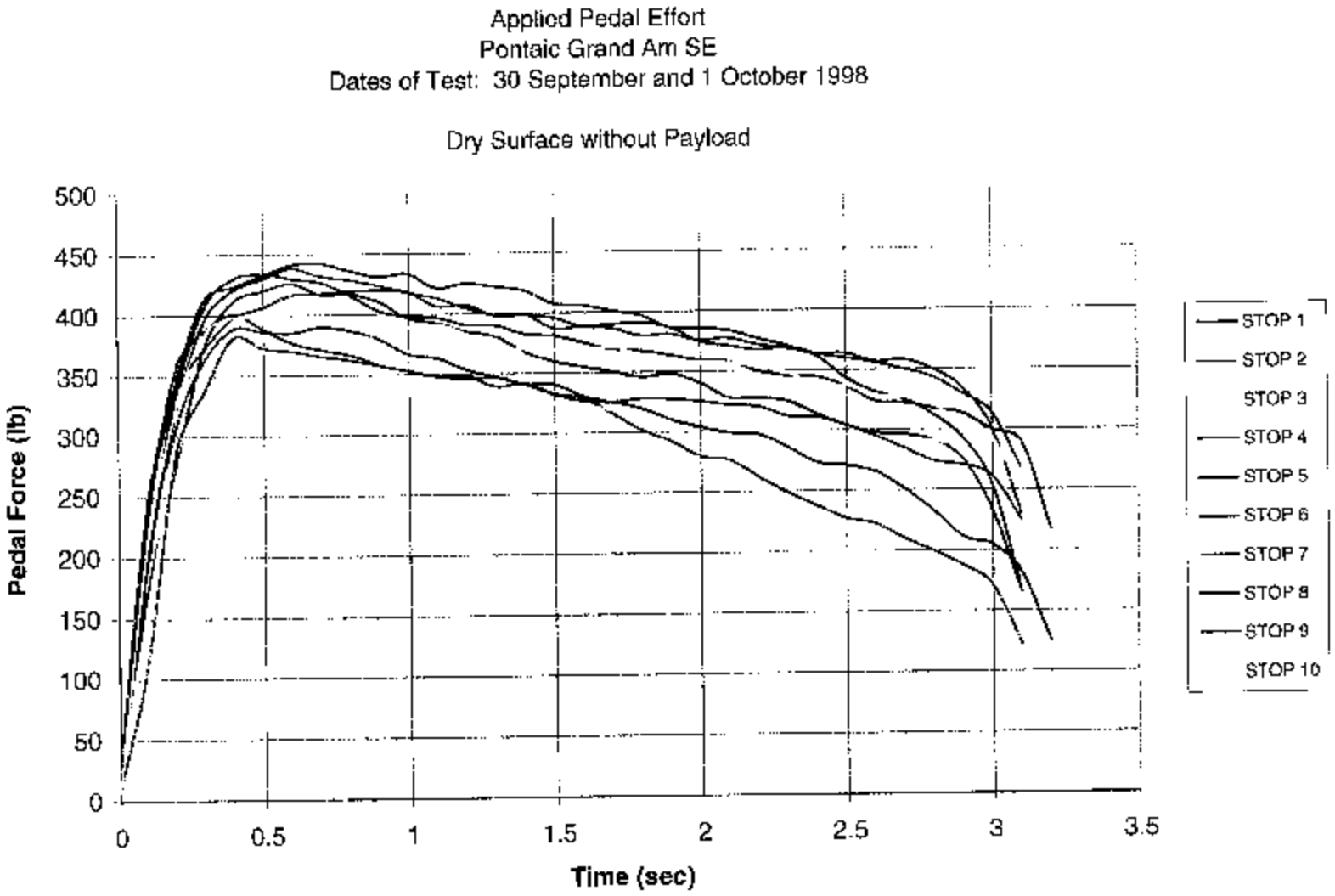


Figure C-1. Pedal Effort Results on Dry Surface without Payload, Pontiac Grand Am SE
Pedal Force versus Time

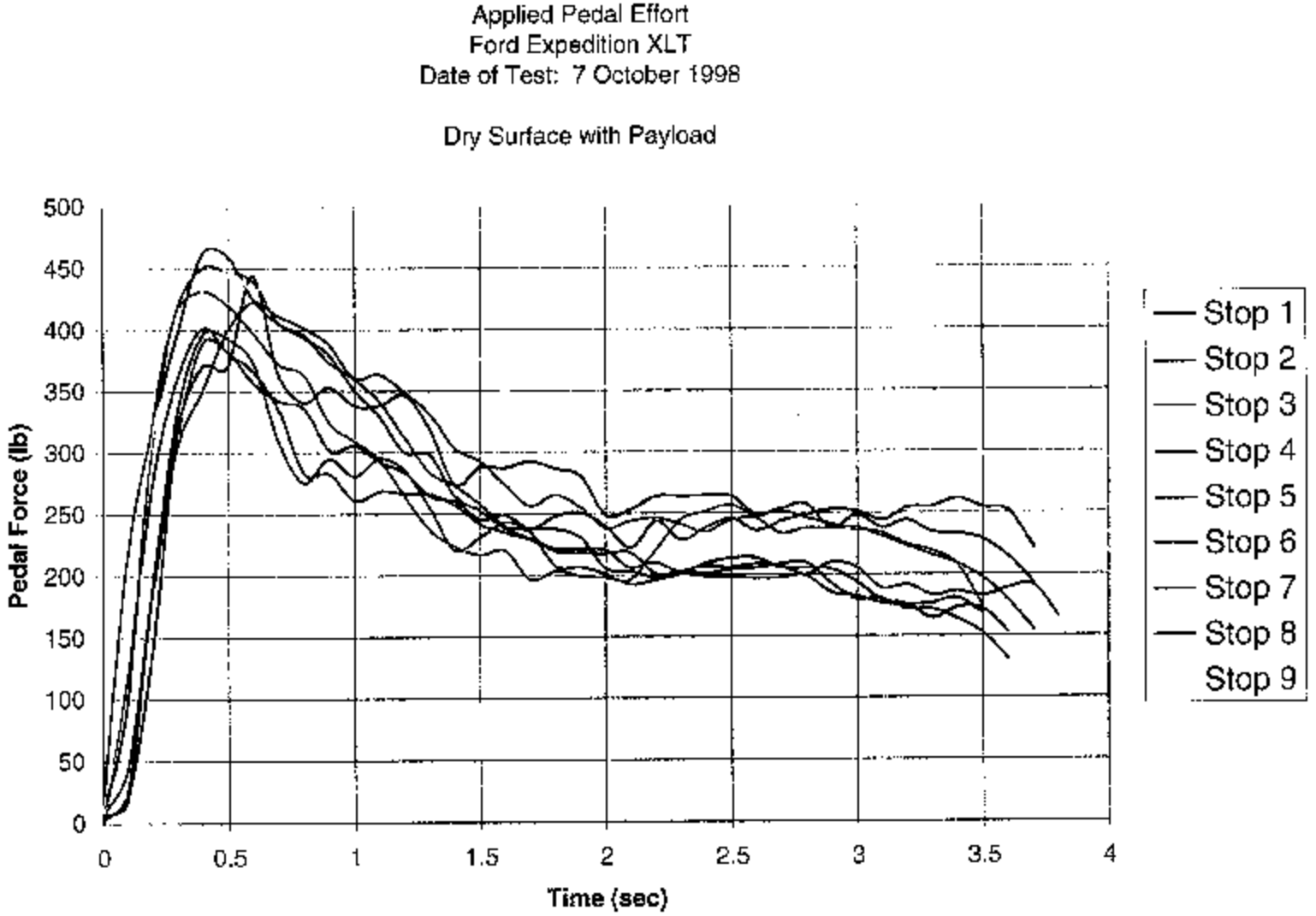


Figure C-2. Pedal Effort Characteristics on Dry Surface with Payload, Ford Expedition
Pedal Effort versus Time

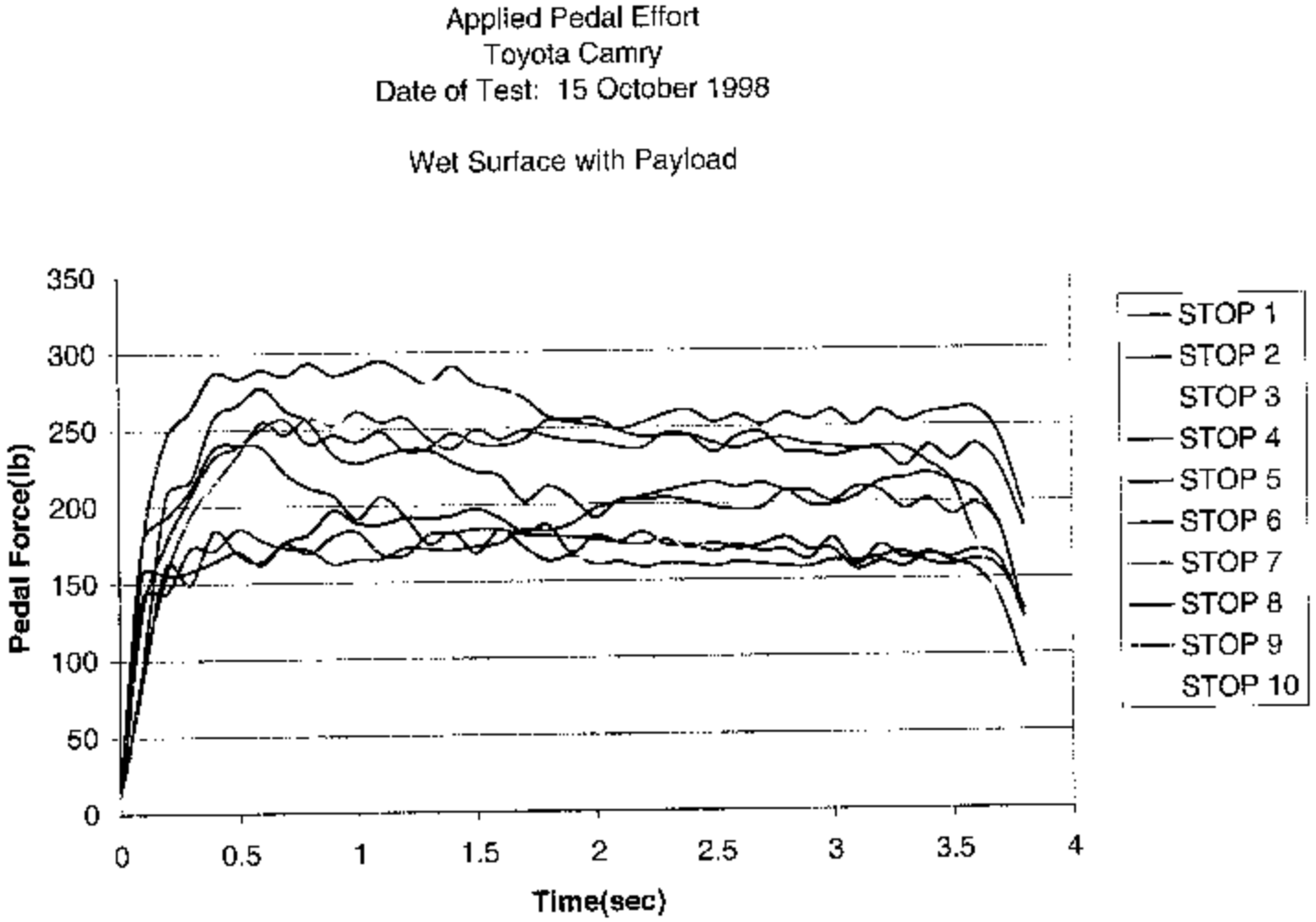


Figure C-3. Pedal Effort Characteristics on Wet Surface with Payload, Toyota Camry
Pedal Effort versus Time

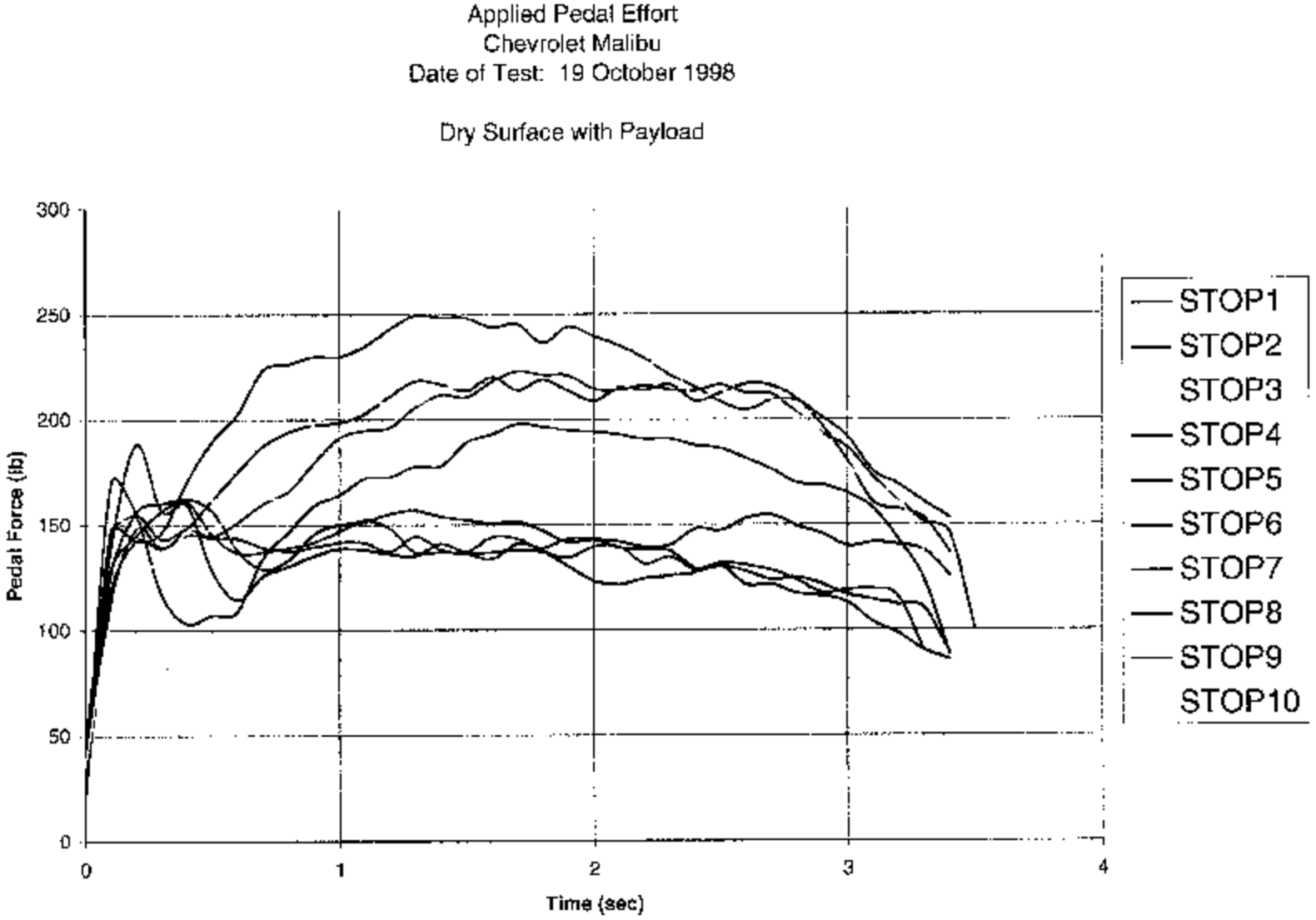


Figure C-4. Pedal Effort Characteristics on Dry Surface with Payload, Chevrolet Malibu
Pedal Effort versus Time

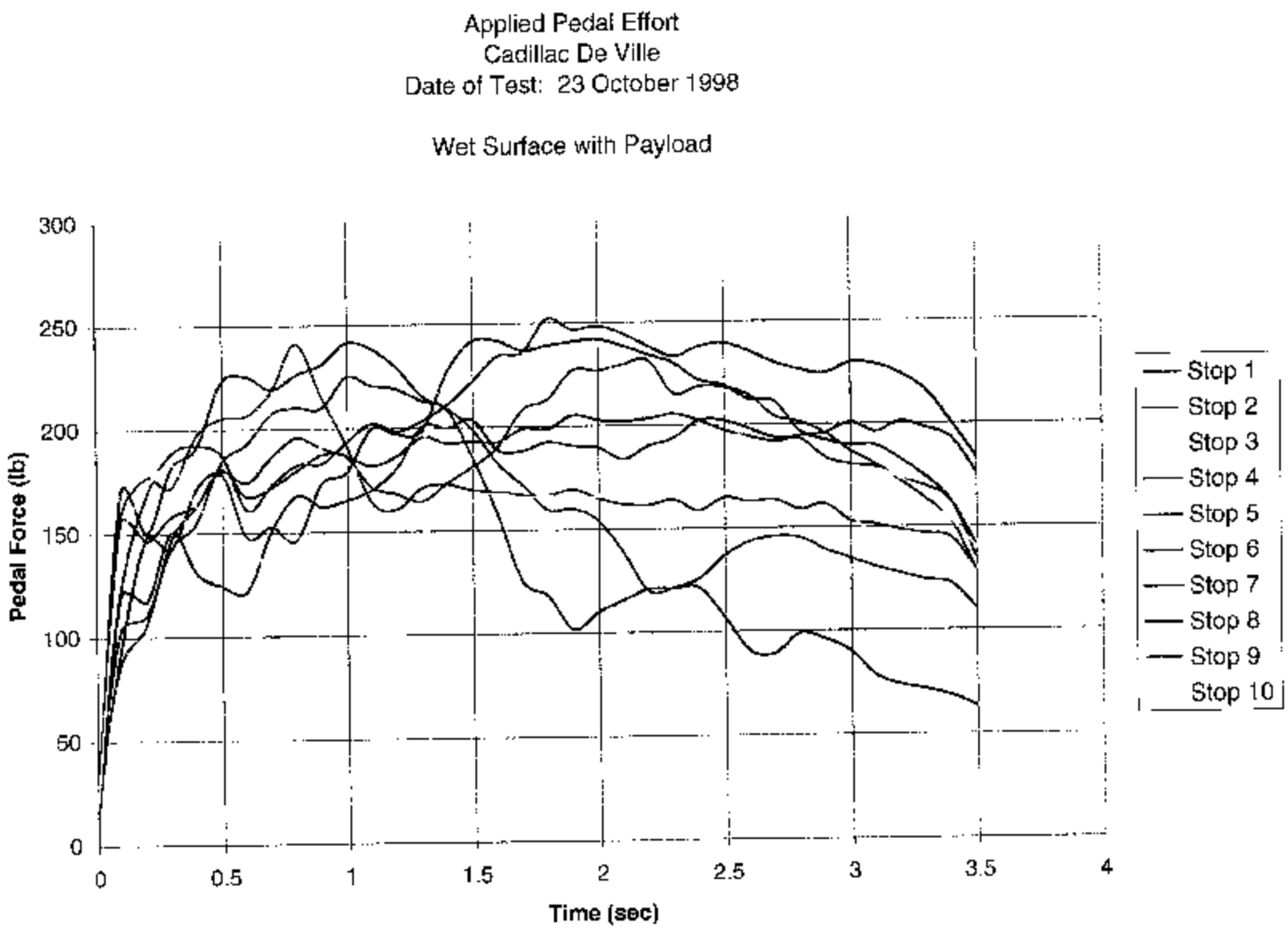


Figure C-5, Pedal Effort Characteristics on Wet Surface with Payload, Cadillac De Ville
Pedal Effort versus Time

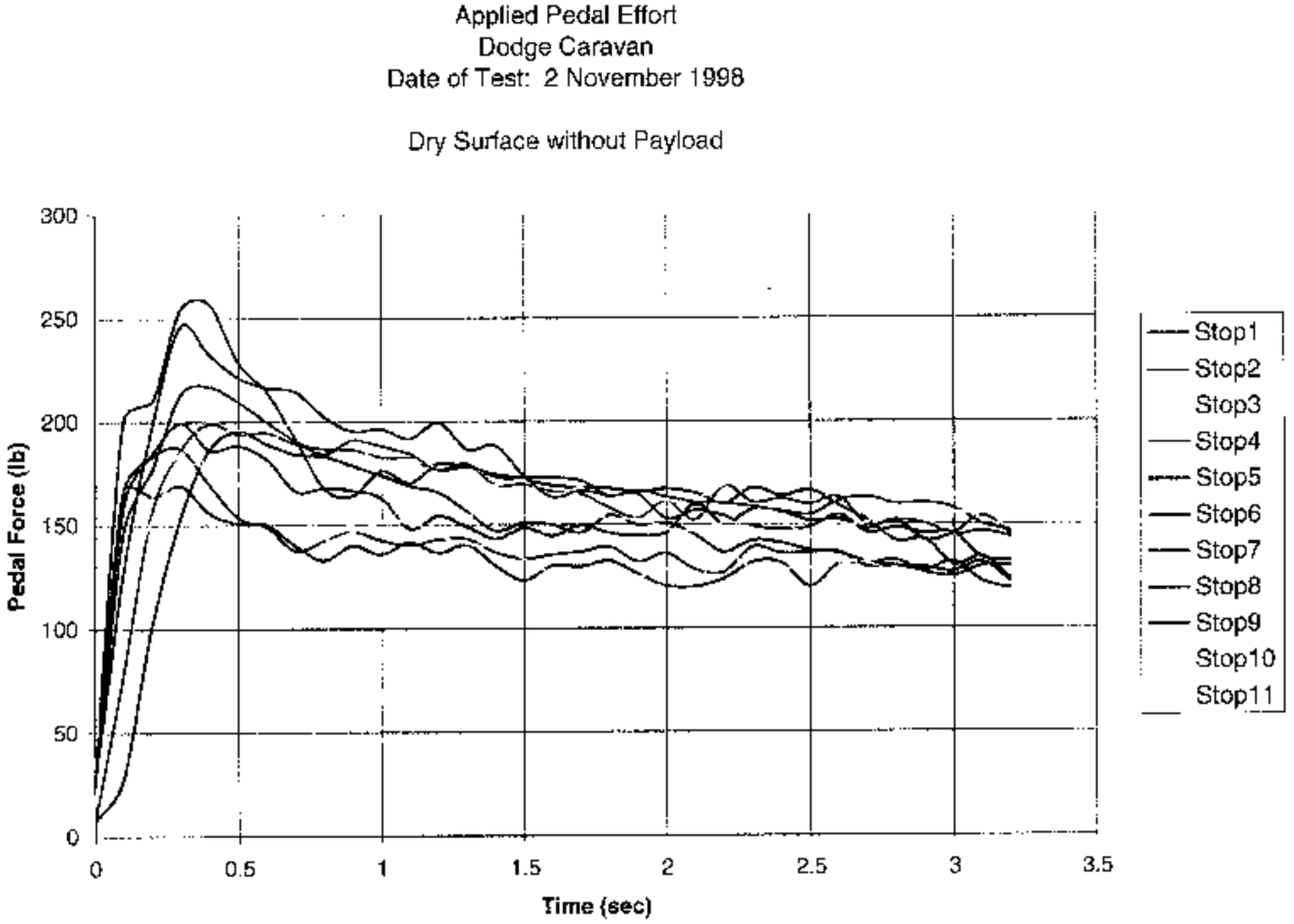


Figure C-6. Pedal Effort Characteristics on Dry Surface without Payload, Dodge Caravan
Pedal Effort versus Time

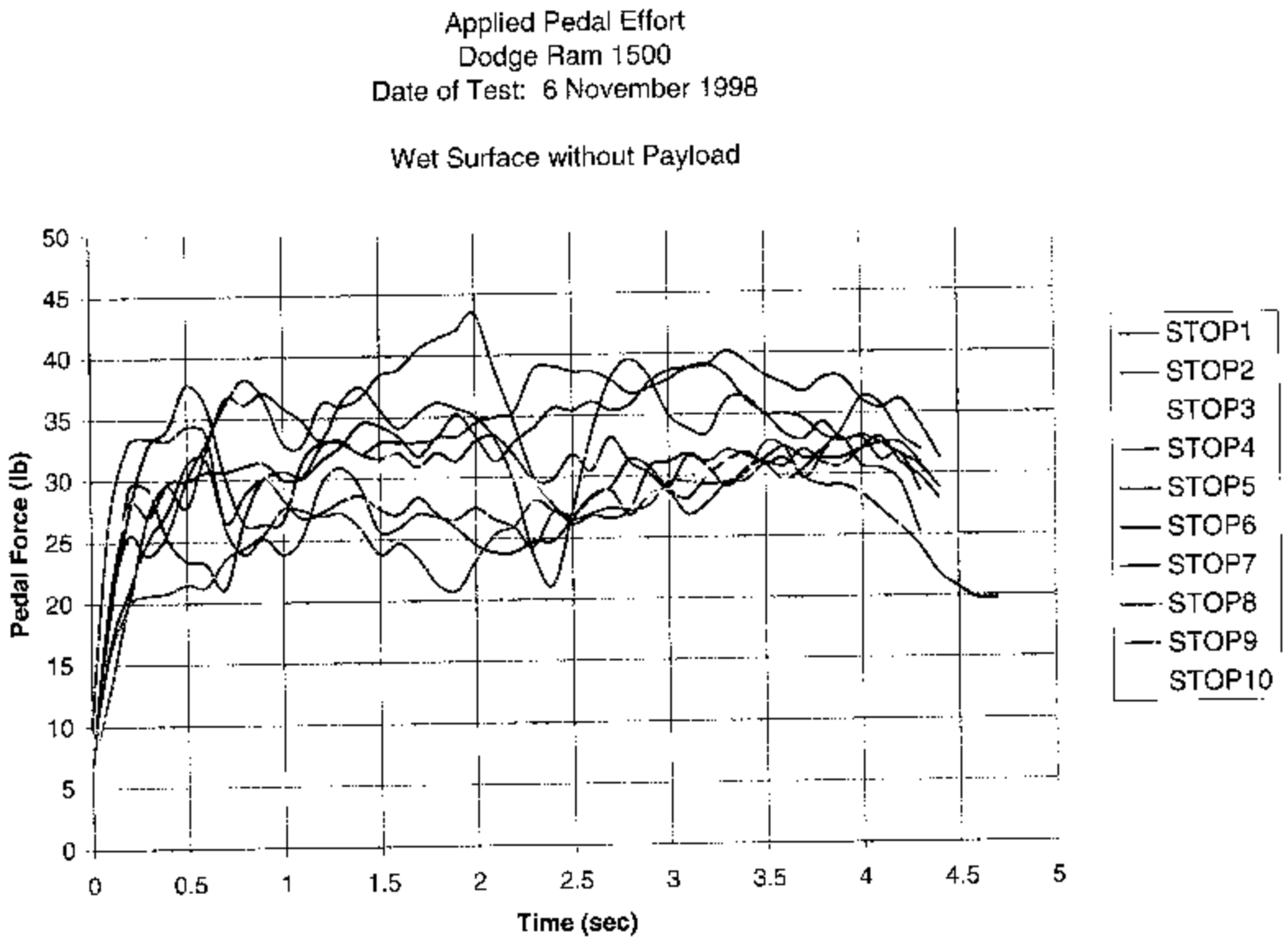


Figure C-7. Pedal Effort Characteristics on Wet Surface without Payload, Dodge Ram 1500
Pedal Effort versus Time

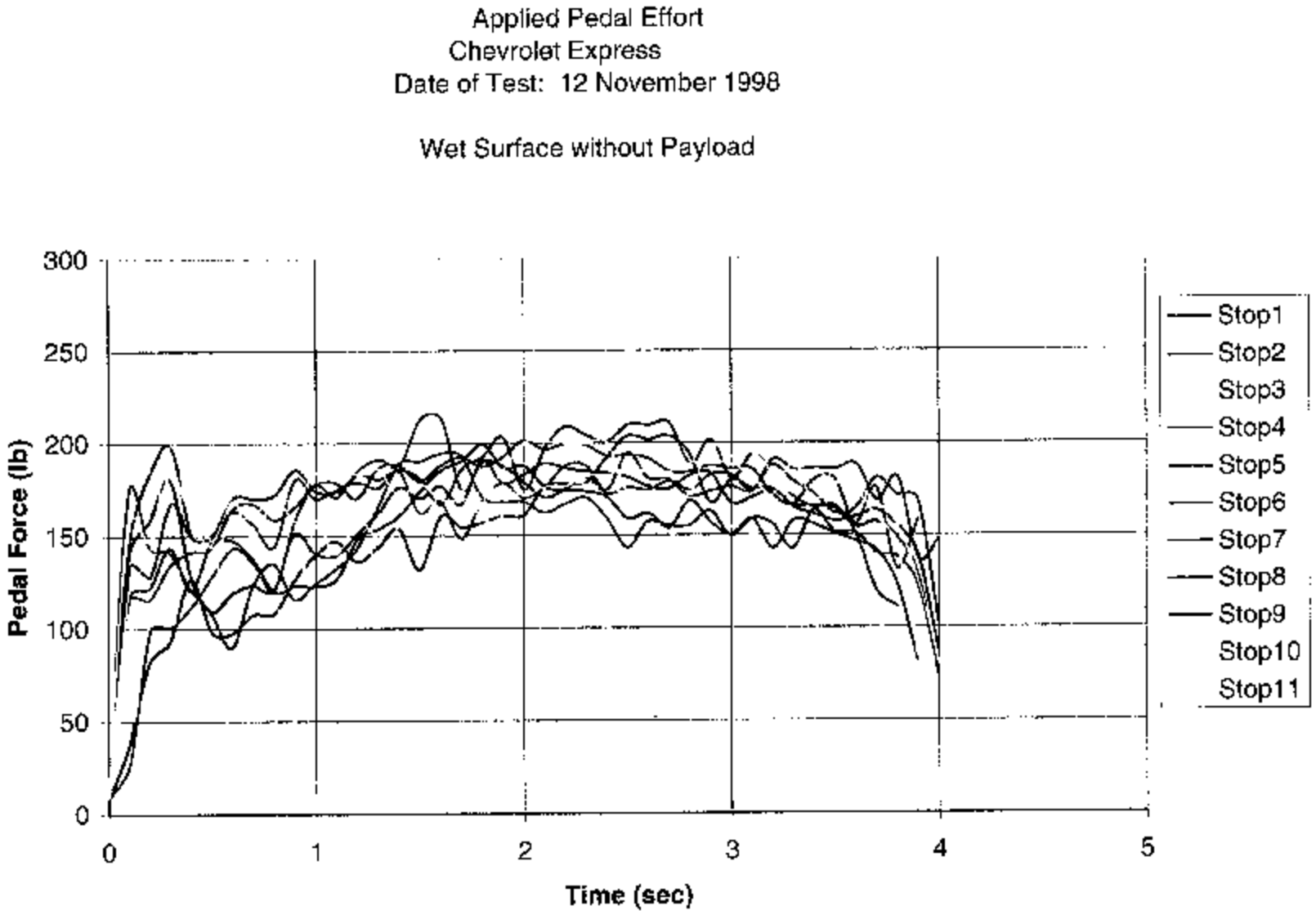


Figure C-8. Pedal Effort Characteristics on Wet Surface without Payload, Chevrolet Express
Pedal Effort versus Time

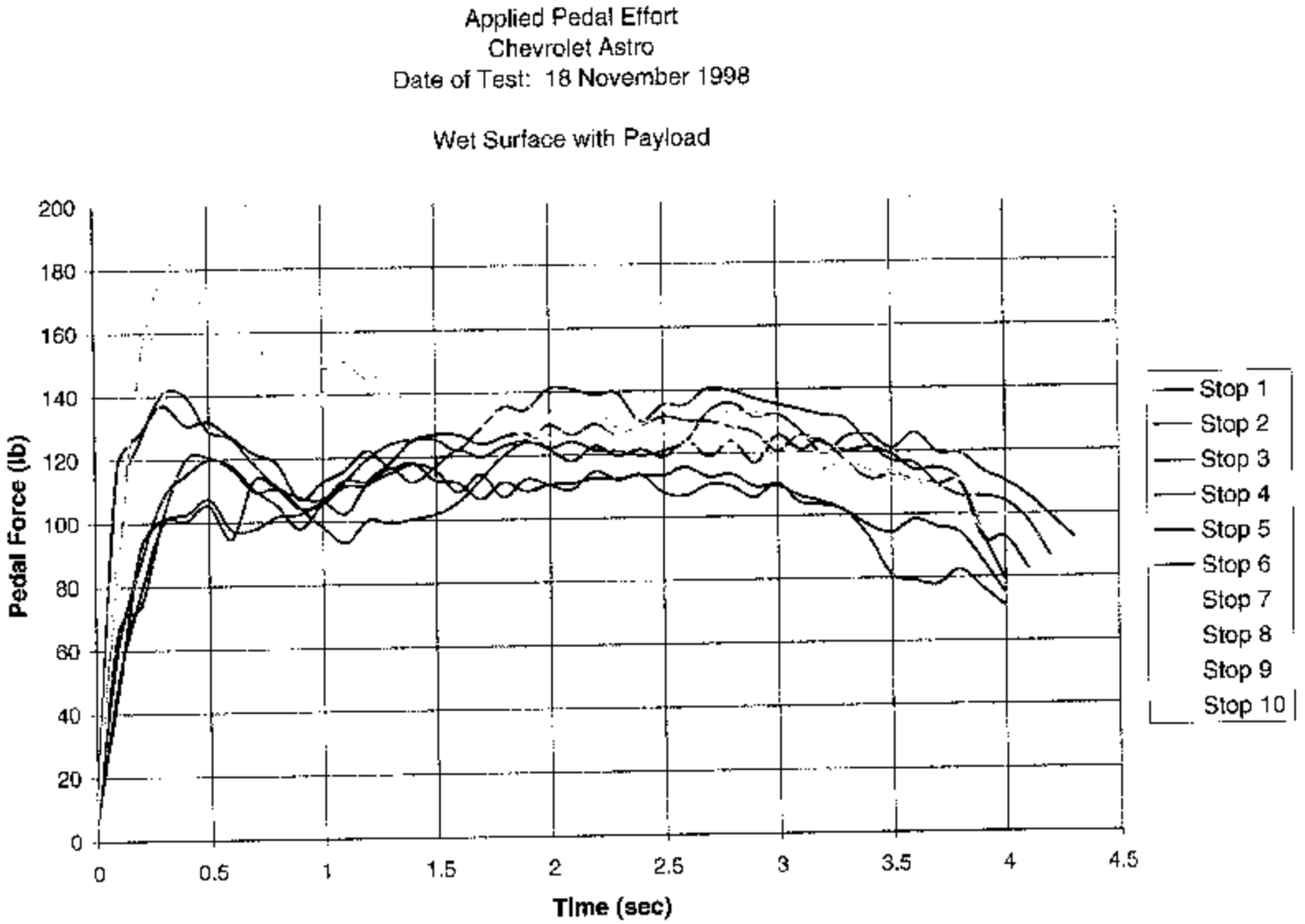


Figure C-9. Pedal Effort Characteristics on Wet Surface with Payload, Chevrolet Astro
Pdeal Effort versus Time

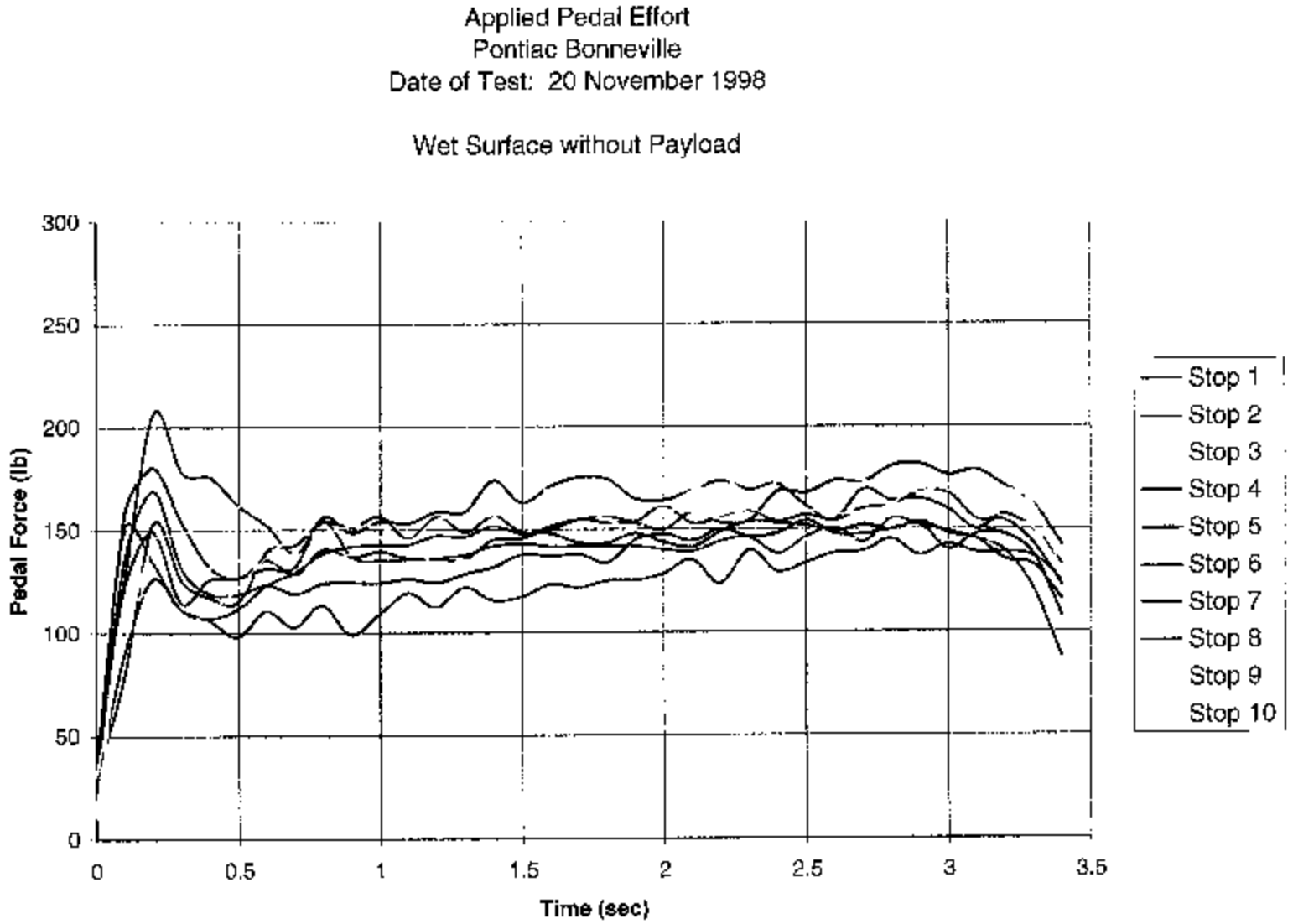


Figure C-10. Pedal Effort Characteristics on Wet Surface without Payload, Pontiac Bonneville
Pedal Effort versus Time

APPENDIX D. BRAKE STOP STATISTICS WITH PEDAL EFFORT BREAKDOWN

GRANDAM STATISTICS

ALL STOPS

Stop #	No Payload Dry Distance	Class	Payload Dry Distance	Class	No Payload Wet Distance	Class	Payload Wet Distance	Class
1	146.9	A	153.5	A	197.0	A	164.5	A
2	147.5	A	148.0	A	190.9	A	171.5	A
3	147.5	A	152.6	A	184.0	C	163.3	A
4	148.4	A	153.3	A	193.2	A	170.3	A
5	149.4	A	152.2	A	178.5	A	167.0	A
6	149.3	A	152.3	A	183.4	A	167.5	A
7	148.4	A	151.0	A	194.5	A	180.3	A
8	145.6	A	153.0	A	188.6	A	180.1	A
9	145.5	A	152.8	A	189.6	A	158.4	A
10	150.3	A	151.3	A	201.6	B	177.3	A
							186.2	A
x bar	147.9		152.0		190.1		171.5	
STD n-1	1.6		1.6		6.9		8.5	
95%	148.8		152.9		193.9		175.9	

A,B

Stop #	No Payload Dry Distance	Class	Payload Dry Distance	Class	No Payload Wet Distance	Class	Payload Wet Distance	Class
1	146.9	A	153.5	A	197.0	A	164.5	A
2	147.5	A	148.0	A	190.9	A	171.5	A
3	147.5	A	152.6	A			163.3	A
4	148.4	A	153.3	A	193.2	A	170.3	A
5	148.4	A	152.2	A	178.5	A	167.0	A
6	149.3	A	152.3	A	183.4	A	167.5	A
7	148.4	A	151.0	A	194.5	A	180.3	A
8	145.6	A	153.0	A	188.6	A	180.1	A
9	145.5	A	152.8	A	189.6	A	158.4	A
10	150.3	A	151.3	A	201.6	B	177.3	A
							186.2	A
x bar	147.9		152.0		190.6		171.5	
STD n-1	1.5		1.6		7.0		8.5	
95%	148.8		152.9		194.0		175.9	

A

Stop #	No Payload Dry Distance	Class	Payload Dry Distance	Class	No Payload Wet Distance	Class	Payload Wet Distance	Class
1	146.9	A	153.5	A	197.0	A	164.5	A
2	147.5	A	148.0	A	190.9	A	171.5	A
3	147.5	A	152.6	A			163.3	A
4	148.4	A	153.3	A	193.2	A	170.3	A
5	149.4	A	152.2	A	178.5	A	167.0	A
6	149.3	A	152.3	A	183.4	A	167.5	A
7	148.4	A	151.0	A	194.5	A	180.3	A
8	145.6	A	153.0	A	188.6	A	180.1	A
9	145.5	A	152.8	A	189.6	A	158.4	A
10	150.3	A	151.3	A			177.3	A
							186.2	A
x bar	147.9		152.0		189.5		171.5	
STD n-1	1.6		1.6		6.0		8.5	
95%	148.8		152.9		193.3		175.9	

EXPEDITION STATISTICS

ALL STOPS

No Payload Dry			Payload Dry			No Payload Wet			Payload Wet		
Stop #	Distance	Class	Stop #	Distance	Class	Stop #	Distance	Class	Stop #	Distance	Class
1	152.8	C	1	165.5	B	1	199.7	A	1	212.5	A
2	168.9	A	2	160.6	A	2	208	D	2	211.3	A
3	165.2	A	3	170.5	D	3	218.4	B	3	230.6	D
4	164.8	A	4	165.1	A	4	195.7	A	4	223.7	B
5	166.6	A	5	179.3	D	5	196.2	B	5	235.9	D
6	167.6	A	6	171.8	D	6	192.9	A	6	226.2	B
7	175.8	A	7	176.4	D	7	193.4	A	7	212.6	A
8	188.5	A	8	166.7	B	8	191.8	B	8	238.2	B
9	172.8	A	9	169.1	A	9	194.4	A			
10	190.7	A									
x bar	170.4			168.8			198.9			219.9	
STD n-1	8.1			4.6			6.8			10.8	
95%	174.5			171.6			204.1			226.6	

A,B,C

No Payload Dry			Payload Dry			No Payload Wet			Payload Wet		
Stop #	Distance	Class	Stop #	Distance	Class	Stop #	Distance	Class	Stop #	Distance	Class
1	152.8	C	1	165.5	B	1	199.7	A	1	212.5	A
2	168.9	A	2	160.6	A	2			2	211.3	A
3	165.2	A	3			3	218.4	B	3		
4	164.9	A	4	165.1	A	4	195.7	A	4	223.7	B
5	166.6	A	5			5	196.2	B	5		
6	167.6	A	6			6	192.9	A	6	226.2	B
7	175.8	A	7			7	193.4	A	7	212.6	A
8	188.5	A	8	166.7	B	8	191.8	B	8	238.2	B
9	172.8	A	9	169.1	A	9	194.4	A			
10	190.7	A									
x bar	170.4			165.4			197.8			220.4	
STD n-1	8.1			3.1			8.7			10.0	
95%	174.8			168.0			203.2			227.9	

A,B

No Payload Dry			Payload Dry			No Payload Wet			Payload Wet		
Stop #	Distance	Class	Stop #	Distance	Class	Stop #	Distance	Class	Stop #	Distance	Class
1			1	165.5	B	1	199.7	A	1	212.5	A
2	168.9	A	2	160.6	A	2			2	211.3	A
3	165.2	A	3			3	218.4	B	3		
4	164.9	A	4	165.1	A	4	195.7	A	4	223.7	B
5	166.6	A	5			5	196.2	B	5		
6	167.6	A	6			6	192.9	A	6	226.2	B
7	175.8	A	7			7	193.4	A	7	212.6	A
8	188.5	A	8	166.7	B	8	191.8	B	8	238.2	B
9	172.8	A	9	169.1	A	9	194.4	A			
10	190.7	A									
x bar	171.2			165.4			197.8			220.4	
STD n-1	8.1			3.1			8.7			10.0	
95%	175.0			168.0			203.2			227.9	

A

No Payload Dry			Payload Dry			No Payload Wet			Payload Wet		
Stop #	Distance	Class	Stop #	Distance	Class	Stop #	Distance	Class	Stop #	Distance	Class
1	152.8	C	1			1	199.7	A	1	212.5	A
2	168.9	A	2	160.6	A	2			2	211.3	A
3	165.2	A	3			3			3		
4	164.9	A	4	165.1	A	4	195.7	A	4		
5	166.6	A	5			5			5		
6	167.6	A	6			6	192.9	A	6		
7	175.8	A	7			7	193.4	A	7	212.6	A
8	188.5	A	8			8			8		
9	172.8	A	9	169.1	A	9	194.4	A			
10	190.7	A									
x bar	170.4			164.9			195.2			212.1	
STD n-1	8.1			4.3			2.7			0.7	
95%	174.6			170.6			197.9			213.1	

CAMRY STATISTICS

ALL STOPS

No Payload Dry			Payload Dry			No Payload Wet			Payload Wet		
Stop #	Distance	Class	Stop #	Distance	Class	Stop #	Distance	Class	Stop #	Distance	Class
1	156.2	A	1	163.2	A	1	167.3	A	1	174.00	A
2	163.0	A	2	166.9	A	2	173.5	A	2	168.30	B
3	161.7	A	3	158.6	A	3	169.7	A	3	175.20	A
4	158.2	A	4	160.5	A	4	174.0	A	4	174.60	A
5	162.4	A	5	160.7	A	5	175.3	A	5	174.40	B
6	160.1	A	6	163.5	A	6	172.8	A	6	175.60	A
7	159.1	A	7	159.6	A	7	181.7	A	7	175.80	A
8	159.1	A	8	162.9	A	8	177.4	A	8	174.90	A
9	158.3	A	9	158.9	A	9	183.4	A	9	174.90	B
10	158.5	A	10	160.0	A	10	181.5	A	10	174.30	C
x bar	159.7			161.5			175.7			174.3	
STD n-1	2.1			2.6			5.3			2.2	
95%	160.8			162.9			178.6			175.5	

A,B

No Payload Dry			Payload Dry			No Payload Wet			Payload Wet		
Stop #	Distance	Class	Stop #	Distance	Class	Stop #	Distance	Class	Stop #	Distance	Class
1	156.2	A	1	163.2	A	1	167.3	A	1	174.00	A
2	163.0	A	2	166.9	A	2	173.5	A	2	168.30	B
3	161.7	A	3	158.6	A	3	169.7	A	3	175.20	A
4	158.2	A	4	160.5	A	4	174.0	A	4	174.60	A
5	162.4	A	5	160.7	A	5	175.3	A	5	174.40	B
6	160.1	A	6	163.5	A	6	172.8	A	6	175.60	A
7	159.1	A	7	159.6	A	7	181.7	A	7	175.80	A
8	159.1	A	8	162.9	A	8	177.4	A	8	174.90	A
9	158.3	A	9	158.9	A	9	183.4	A	9	174.90	B
10	158.5	A	10	160.0	A	10	181.6	A	10		
x bar	159.7			161.5			175.7			174.3	
STD n-1	2.1			2.6			5.3			2.4	
95%	160.8			162.9			178.6			175.7	

A

No Payload Dry			Payload Dry			No Payload Wet			Payload Wet		
Stop #	Distance	Class	Stop #	Distance	Class	Stop #	Distance	Class	Stop #	Distance	Class
1	156.2	A	1	163.2	A	1	167.3	A	1	174.00	A
2	163.0	A	2	166.9	A	2	173.5	A	2		
3	161.7	A	3	158.6	A	3	169.7	A	3	175.20	A
4	158.2	A	4	160.5	A	4	174.0	A	4	174.60	A
5	162.4	A	5	160.7	A	5	175.3	A	5		
6	160.1	A	6	163.5	A	6	172.8	A	6	176.60	A
7	159.1	A	7	159.6	A	7	181.7	A	7	175.80	A
8	159.1	A	8	162.9	A	8	177.4	A	8	174.90	A
9	158.3	A	9	158.9	A	9	183.4	A	9		
10	158.5	A	10	160.0	A	10	181.6	A	10		
x bar	159.7			161.5			175.7			175.2	
STD n-1	2.1			2.6			5.3			0.9	
95%	160.8			162.9			178.6			175.9	

MALIBU STATISTICS

ALL STOPS

No Payload Dry			Payload Dry			No Payload Wet			Payload Wet		
Stop #	Distance	Class	Stop #	Distance	Class	Stop #	Distance	Class	Stop #	Distance	Class
1	140.0	A	1	154.5	A	1	147.9	A	1	153.4	D
2	142.0	A	2	155.7	A	2	150.9	B	2	152.4	A
3	140.9	A	3	156.6	A	3	151.5	B	3	153.7	A
4	142.8	A	4	156.8	A	4	147.4	A	4	160.5	A
5	139.0	A	5	154.7	A	5	153.9	A	5	164.2	B
6	142.4	A	6	151.5	A	6	146.3	A	6	158.9	B
7	140.1	A	7	150.2	A	7	148.8	A	7	169.5	A
8	143.0	A	8	152.8	A	8	151.0	A	8	181.3	A
9	142.0	A	9	156.0	A	9	149.4	A	9	176.4	B
10	140.3	A	10	151.4	A	10	155.5	A	10	158.4	A
									11	176.2	B
x bar	141.3			154.0			150.3			164.1	
STD n-1	1.4			2.4			2.9			10.3	
95%	142.0			155.3			151.9			169.2	

A,B

No Payload Dry			Payload Dry			No Payload Wet			Payload Wet		
Stop #	Distance	Class	Stop #	Distance	Class	Stop #	Distance	Class	Stop #	Distance	Class
1	140.0	A	1	154.5	A	1	147.9	A	1		
2	142.0	A	2	155.7	A	2	150.9	B	2	152.4	A
3	140.9	A	3	156.6	A	3	151.5	B	3	153.7	A
4	142.8	A	4	156.8	A	4	147.4	A	4	160.5	A
5	139.0	A	5	154.7	A	5	153.9	A	5	164.2	B
6	142.4	A	6	151.5	A	6	146.3	A	6	158.9	B
7	140.1	A	7	150.2	A	7	148.8	A	7	169.5	A
8	143.0	A	8	152.8	A	8	151.0	A	8	181.3	A
9	142.0	A	9	156.0	A	9	149.4	A	9	176.4	B
10	140.3	A	10	151.4	A	10	155.5	A	10	158.4	A
									11	176.2	B
x bar	141.3			154.0			150.3			165.2	
STD n-1	1.4			2.4			2.9			10.2	
95%	142.0			155.3			151.9			170.6	

A

No Payload Dry			Payload Dry			No Payload Wet			Payload Wet		
Stop #	Distance	Class	Stop #	Distance	Class	Stop #	Distance	Class	Stop #	Distance	Class
1	140.0	A	1	154.5	A	1	147.9	A	1		
2	142.0	A	2	155.7	A	2			2	152.4	A
3	140.9	A	3	156.6	A	3			3	153.7	A
4	142.8	A	4	156.8	A	4	147.4	A	4	160.5	A
5	139.0	A	5	154.7	A	5	153.9	A	5		
6	142.4	A	6	151.5	A	6	146.3	A	6		
7	140.1	A	7	150.2	A	7	148.8	A	7	169.5	A
8	143.0	A	8	152.8	A	8	151.0	A	8	181.3	A
9	142.0	A	9	156.0	A	9	149.4	A	9		
10	140.3	A	10	151.4	A	10	155.5	A	10	158.4	A
									11		
x bar	141.3			154.0			150.0			162.6	
STD n-1	1.4			2.4			3.2			11.0	
95%	142.0			155.3			152.1			168.1	

CARAVAN STATISTICS

ALL STOPS

No Payload Dry			Payload Dry			No Payload Wet			Payload Wet		
Stop #	Distance	Class	Stop #	Distance	Class	Stop #	Distance	Class	Stop #	Distance	Class
1	153.7	A	1	175.2	A	1	164.9	B	1	185.9	A
2	161.5	B	2	164.9	A	2	162.9	D	2	188.5	A
3	158.1	A	3	174.5	A	3	168.8	D	3	192.2	A
4	160.8	A	4	172.3	A	4	152.8	A	4	194.6	A
5	157.1	A	5	169.0	A	5	153.0	A	5	197.2	A
6	159.4	A	6	171.9	A	6	159.1	B	6	192.1	A
7	159.4	A	7	168.8	A	7	174.0	D	7	186.2	A
8	166.8	D	8	177.0	A	8	164.6	A	8	186.3	A
9	158.1	A	9	181.1	A	9	164.1	A	9	187.9	A
10	163.8	A	10	176.7	A	10	163.8	A	10	195.4	B
11	159.2	A				11	171.6	A			
x bar	158.8			173.1			166.3			190.6	
STD n-1	3.5			4.8			3.9			4.2	
95%	161.6			175.8			168.4			192.9	

A,B

No Payload Dry			Payload Dry			No Payload Wet			Payload Wet		
Stop #	Distance	Class	Stop #	Distance	Class	Stop #	Distance	Class	Stop #	Distance	Class
1	153.7	A	1	175.2	A	1	164.9	B	1	185.9	A
2	161.5	B	2	164.9	A	2			2	188.5	A
3	158.1	A	3	174.5	A	3			3	192.2	A
4	160.8	A	4	172.3	A	4	162.8	A	4	194.6	A
5	157.1	A	5	169.0	A	5	163.0	A	5	197.2	A
6	159.4	A	6	171.9	A	6	159.1	B	6	192.1	A
7	159.4	A	7	168.8	A	7			7	186.2	A
8			8	177.0	A	8	164.6	A	8	186.3	A
9	158.1	A	9	181.1	A	9	164.1	A	9	187.9	A
10	163.8	A	10	176.7	A	10	163.8	A	10	195.4	B
11	159.2	A				11	171.6	A			
x bar	159.1			173.1			165.5			190.6	
STD n-1	2.7			4.6			3.2			4.2	
95%	160.6			175.8			167.5			192.9	

A

No Payload Dry			Payload Dry			No Payload Wet			Payload Wet		
Stop #	Distance	Class	Stop #	Distance	Class	Stop #	Distance	Class	Stop #	Distance	Class
1	153.7	A	1	175.2	A	1			1	185.9	A
2			2	164.9	A	2			2	188.5	A
3	158.1	A	3	174.5	A	3			3	192.2	A
4	160.8	A	4	172.3	A	4	157.8	A	4	194.6	A
5	157.1	A	5	169.0	A	5	163.0	A	5	197.2	A
6	159.4	A	6	171.9	A	6			6	192.1	A
7	159.4	A	7	168.8	A	7			7	186.2	A
8			8	177.0	A	8	164.6	A	8	186.3	A
9	158.1	A	9	181.1	A	9	164.1	A	9	187.9	A
10	163.8	A	10	176.7	A	10	163.8	A	10		
11	159.2	A				11	171.6	A			
x bar	158.8			173.1			165.0			190.1	
STD n-1	2.7			4.8			3.3			4.1	
95%	160.3			176.2			167.0			192.3	

CADILLAC STATISTICS

ALL STOPS

No Payload Dry			Payload Dry			No Payload Wet			Payload Wet		
Stop #	Distance	Class	Stop #	Distance	Class	Stop #	Distance	Class	Stop #	Distance	Class
1	157.8	A	1	153.1	B	1	164.8	C	1	163.8	B
2	160.9	B	2	160.3	A	2	163.8	A	2	163.8	A
3	149.6	A	3	160.2	A	3	166.3	A	3	163.3	A
4	154.4	A	4	160.1	B	4	160.7	A	4	161.9	B
5	156.0	C	5	166.8	A	5	164.7	B	5	161.9	A
6	157.5	A	6	171.3	A	6	165.4	A	6	167.0	A
7	154.1	A	7	166.8	A	7	161.2	B	7	163.2	A
8	157.2	A	8	170.6	A	8	164.8	D	8	165.4	A
9	158.8	A	9	166.9	A	9	163.2	A	9	164.0	A
10	158.8	D	10	164.7	A	10	162.5	A	10	165.4	A
11	156.3	B	11	161.7	B						
12	157.1	B	12	166.6	A						
x bar	156.4			165.2			163.8			163.9	
STD n-1	2.8			4.1			1.8			1.8	
95%	157.6			167.2			164.8			164.8	

A,B,C

No Payload Dry			Payload Dry			No Payload Wet			Payload Wet		
Stop #	Distance	Class	Stop #	Distance	Class	Stop #	Distance	Class	Stop #	Distance	Class
1	157.8	A	1	153.1	B	1	164.8	C	1	163.8	B
2	160.9	B	2	160.3	A	2	163.8	A	2	163.8	A
3	149.6	A	3	160.2	A	3	166.3	A	3	163.3	A
4	154.4	A	4	160.1	B	4	160.7	A	4	161.9	B
5	156.0	C	5	166.8	A	5	164.7	B	5	161.9	A
6	157.5	A	6	171.3	A	6	165.4	A	6	167.0	A
7	154.1	A	7	166.8	A	7	161.2	B	7	163.2	A
8	157.2	A	8	170.6	A	8			8	165.4	A
9	158.8	A	9	166.9	A	9	163.2	A	9	164.0	A
10			10	164.7	A	10	162.5	A	10	165.4	A
11	156.3	B	11	161.7	B						
12	157.1	B	12	166.6	A						
x bar	156.3			165.2			163.8			163.9	
STD n-1	2.9			4.1			1.8			1.8	
95%	158.0			167.2			164.7			164.8	

A,B

No Payload Dry			Payload Dry			No Payload Wet			Payload Wet		
Stop #	Distance	Class	Stop #	Distance	Class	Stop #	Distance	Class	Stop #	Distance	Class
1	157.8	A	1	153.1	B	1			1	163.8	B
2	160.9	B	2	160.3	A	2	163.8	A	2	163.8	A
3	149.6	A	3	160.2	A	3	166.3	A	3	163.3	A
4	154.4	A	4	160.1	B	4	160.7	A	4	161.9	B
5			5	166.8	A	5	164.7	B	5	161.9	A
6	157.5	A	6	171.3	A	6	165.4	A	6	167.0	A
7	154.1	A	7	166.8	A	7	161.2	B	7	163.2	A
8	157.2	A	8	170.6	A	8			8	165.4	A
9	158.8	A	9	166.9	A	9	163.2	A	9	164.0	A
10			10	164.7	A	10	162.5	A	10	165.4	A
11	156.3	B	11	161.7	B						
12	157.1	B	12	166.6	A						
x bar	156.4			165.2			163.5			163.9	
STD n-1	3.1			4.1			2.0			1.8	
95%	158.7			167.2			164.7			164.8	

A

No Payload Dry			Payload Dry			No Payload Wet			Payload Wet		
Stop #	Distance	Class	Stop #	Distance	Class	Stop #	Distance	Class	Stop #	Distance	Class
1	157.8	A	1			1			1		
2			2	160.3	A	2	163.8	A	2	163.8	A
3	149.6	A	3	160.2	A	3	166.3	A	3	163.3	A
4	154.4	A	4			4	160.7	A	4		
5			5	166.8	A	5			5	161.9	A
6	157.5	A	6	171.3	A	6	165.4	A	6	167.0	A
7	154.1	A	7	166.8	A	7			7	163.2	A
8	157.2	A	8	170.6	A	8			8	165.4	A
9	158.8	A	9	166.9	A	9	163.2	A	9	164.0	A
10			10	164.7	A	10	162.5	A	10	165.4	A
11			11								
12			12	166.6	A						
x bar	155.5			166.4			163.7			164.2	
STD n-1	3.2			4.1			2.0			1.6	
95%	157.8			168.7			166.2			165.2	

EXPRESS STATISTICS

ALL STOPS

No Payload Dry			Payload Dry			No Payload Wet			Payload Wet		
Stop #	Distance	Class	Stop #	Distance	Class	Stop #	Distance	Class	Stop #	Distance	Class
1	180.8	A	1	182.6	D	1	180.7	D	1	181.1	A
2	168.3	C	2	188.4	D	2	188.7	D	2	186.7	A
3	164.9	B	3	181.0	C	3	178.8	B	3	186.7	A
4	185.8	D	4	178.0	A	4	178.5	A	4	184.9	A
5	184.5	D	5	184.6	A	5	177.6	A	5	178.9	A
6	187.0	D	6	182.0	A	6	175.6	A	6	184.1	A
7	173.2	D	7	182.5	A	7	180.3	A	7	188.5	D
8	186.1	A	8	183.1	A	8	180.5	A	8	182.5	B
9	188.1	A	9	178.8	A	9	178.0	A	9	186.1	A
10	186.3	A	10	188.9	A	10	178.6	A			
						11	180.5	A			
x bar	180.4			180.1			179.3			184.7	
STD n-1	3.2			2.9			3.1			3.6	
95%	186.2			183.7			180.9			189.2	

A,B,C

No Payload Dry			Payload Dry			No Payload Wet			Payload Wet		
Stop #	Distance	Class	Stop #	Distance	Class	Stop #	Distance	Class	Stop #	Distance	Class
1	180.8	A	1			1			1	181.1	A
2	168.3	C	2			2			2	186.7	A
3	164.9	B	3	181.0	C	3	178.8	B	3	186.7	A
4			4	178.0	A	4	178.5	A	4	184.9	A
5			5	184.5	A	5	177.6	A	5	178.9	A
6			6	182.0	A	6	175.6	A	6	184.1	A
7			7	182.5	A	7	180.3	A	7		
8	186.1	A	8	183.1	A	8	180.5	A	8	182.5	B
9	188.1	A	9	178.8	A	9	178.0	A	9	186.1	A
10	186.3	A	10	188.9	A	10	178.6	A			
						11	180.5	A			
x bar	186.8			179.1			178.5			184.1	
STD n-1	2.7			5.6			1.9			3.2	
95%	187.6			182.7			178.9			186.7	

A,B

No Payload Dry			Payload Dry			No Payload Wet			Payload Wet		
Stop #	Distance	Class	Stop #	Distance	Class	Stop #	Distance	Class	Stop #	Distance	Class
1	180.8	A	1			1			1	181.1	A
2			2			2			2	186.7	A
3	164.9	B	3			3	178.8	B	3	186.7	A
4			4	178.0	A	4	178.5	A	4	184.9	A
5			5	184.5	A	5	177.6	A	5	178.9	A
6			6	182.0	A	6	175.6	A	6	184.1	A
7			7	182.5	A	7	180.3	A	7		
8	186.1	A	8	183.1	A	8	180.5	A	8	182.5	B
9	188.1	A	9	178.8	A	9	178.0	A	9	186.1	A
10	186.3	A	10	188.9	A	10	178.6	A			
						11	180.5	A			
x bar	185.0			179.8			178.3			184.1	
STD n-1	2.7			8.2			1.9			3.2	
95%	187.3			183.0			179.4			186.1	

A

No Payload Dry			Payload Dry			No Payload Wet			Payload Wet		
Stop #	Distance	Class	Stop #	Distance	Class	Stop #	Distance	Class	Stop #	Distance	Class
1	180.8	A	1			1			1	181.1	A
2			2			2			2	186.7	A
3			3			3			3	186.7	A
4			4	178.0	A	4	178.5	A	4	184.9	A
5			5	184.5	A	5	177.6	A	5	178.9	A
6			6	182.0	A	6	175.6	A	6	184.1	A
7			7	182.5	A	7	180.3	A	7		
8	186.1	A	8	183.1	A	8	180.5	A	8		
9	188.1	A	9	178.8	A	9	178.0	A	9	186.1	A
10	186.3	A	10	188.9	A	10	178.6	A			
						11	180.5	A			
x bar	186.1			178.6			178.5			184.4	
STD n-1	3.1			6.2			1.9			3.4	
95%	188.2			183.0			178.7			186.8	

ASTRO STATISTICS

ALL STOPS

No Payload Dry			Payload Dry			No Payload Wet			Payload Wet		
Stop #	Distance	Class	Stop #	Distance	Class	Stop #	Distance	Class	Stop #	Distance	Class
1	170.5	C	1	184.6	A	1	178.9	D	1	200	D
2	172.5	A	2	181.6	A	2	176	B	2	197.8	D
3	170.7	C	3	179.5	A	3	175.1	A	3	191.6	D
4	167.9	D	4	178.4	A	4	177.3	D	4	191.7	D
5	169	B	5	183	A	5	173.1	B	5	184.9	A
6	171.4	A	6	185.7	C	6	175.4	A	6	184.9	A
7	170.9	A	7	183.8	A	7	172.5	B	7	184.7	B
8	170.1	A	8	184	C	8	173.8	A	8	186.6	A
9	169.1	A	9	187.4	D	9	175.2	B	9	183.8	B
			10	186.1	B	10	172	C	10	185.6	B
x bar	170.2			183.4			174.9			186.1	
STD n-1	1.4			2.9			2.2			3.5	
95%	171.0			185.3			176.1			192.6	

A,B,C

No Payload Dry			Payload Dry			No Payload Wet			Payload Wet		
Stop #	Distance	Class	Stop #	Distance	Class	Stop #	Distance	Class	Stop #	Distance	Class
1	170.5	C	1	184.6	A	1					
2	172.5	A	2	181.6	A	2	176	B			
3	170.7	C	3	179.5	A	3	175.1	A	5	184.9	A
4			4	178.4	A	4			6	184.9	A
5	169	B	5	183	A	5	173.1	B			
6	171.4	A	6	185.7	C	6	175.4	A	7	184.7	B
7	170.9	A	7	183.8	A	7	172.5	B	8	186.5	A
8	170.1	A	8	184	C	8	173.8	A	9	183.8	B
9	169.1	A	9			9	175.2	B	10	185.6	B
			10	186.1	B	10	172	C			
x bar	170.5			183.0			174.1			185.1	
STD n-1	1.2			2.7			1.5			0.9	
95%	171.3			184.8			175.1			185.8	

A,B

No Payload Dry			Payload Dry			No Payload Wet			Payload Wet		
Stop #	Distance	Class	Stop #	Distance	Class	Stop #	Distance	Class	Stop #	Distance	Class
1			1	184.6	A	1					
2	172.5	A	2	181.6	A	2	176	B			
3			3	179.5	A	3	175.1	A	5	184.9	A
4			4	178.4	A	4			6	184.9	A
5	169	B	5	183	A	5	173.1	B			
6	171.4	A	6			6	175.4	A	7	184.7	B
7	170.9	A	7	183.8	A	7	172.5	B	8	186.6	A
8	170.1	A	8			8	173.8	A	9	183.8	B
9	169.1	A	9			9	175.2	B	10	185.6	B
			10	186.1	B	10					
x bar	170.5			182.5			174.4			185.1	
STD n-1	1.9			2.8			1.3			0.9	
95%	171.5			184.4			175.3			185.8	

A

No Payload Dry			Payload Dry			No Payload Wet			Payload Wet		
Stop #	Distance	Class	Stop #	Distance	Class	Stop #	Distance	Class	Stop #	Distance	Class
1			1	184.6	A	1					
2	172.5	A	2	181.6	A	2					
3			3	179.5	A	3	175.1	A	5	184.9	A
4			4	178.4	A	4			6	184.9	A
5			5	183	A	5					
6	171.4	A	6			6	175.4	A			
7	170.9	A	7	183.8	A	7			9	186.6	A
8	170.1	A	8			8	173.8	A			
9	169.1	A	9			9					
			10			10					
x bar	170.8			181.9			174.8			185.5	
STD n-1	1.3			2.5			0.9			1.0	
95%	171.9			185.7			175.9			186.8	

BONNEVILLE STATISTICS

ALL STOPS

No Payload Dry			Payload Dry			No Payload Wet			Payload Wet		
Stop #	Distance	Class	Stop #	Distance	Class	Stop #	Distance	Class	Stop #	Distance	Class
1	157.4	A	1	172.2	B	1	162.7	A	1	166.4	C
2	156.4	A	2	166.7	C	2	158.7	A	2	163.9	D
3	157.4	A	3	164.7	B	3	162.5	B	3	166.5	D
4	155.2	A	4	161	B	4	161.2	B	4	157.2	C
5	156.7	A	5	160.4	A	5	162.6	A	5	166.4	D
6	156.9	A	6	162.7	D	6	162.7	B	6	162.1	B
7	154.4	B	7	159.5	C	7	163.1	A	7	163.1	B
8	159.3	A	8	159.3	D	8	159.5	A	8	164.4	D
9	159.2	A	9	164.8	C	9	158.9	B	9	189.5	A
10	153.6	A	10	161.4	D	10	161.1	A	10	185.1	A
			11	159.3	D						
x bar	156.7			162.9			161.3			165.5	
STD n-1	1.9			4.0			1.7			2.2	
95%	157.7			165.8			162.3			164.7	

A,B,C

No Payload Dry			Payload Dry			No Payload Wet			Payload Wet		
Stop #	Distance	Class	Stop #	Distance	Class	Stop #	Distance	Class	Stop #	Distance	Class
1	157.4	A	1	172.2	B	1	162.7	A	1	166.4	C
2	156.4	A	2	166.7	C	2	158.7	A	2		
3	157.4	A	3	164.7	B	3	162.5	B	3		
4	155.2	A	4	161	B	4	161.2	B	4		
5	156.7	A	5	160.4	A	5	162.6	A	5		
6	156.9	A	6			6	162.7	B	6	162.1	B
7	154.4	B	7	159.5	C	7	163.1	A	7	163.1	B
8	159.3	A	8			8	159.5	A	8		
9	159.2	A	9	164.8	C	9	158.9	B	9	189.5	A
10	153.6	A	10			10	161.1	A	10	185.1	A
			11								
x bar	156.7			164.2			161.3			165.3	
STD n-1	1.9			4.4			1.7			3.0	
95%	157.7			167.2			162.3			167.8	

A,B

No Payload Dry			Payload Dry			No Payload Wet			Payload Wet		
Stop #	Distance	Class	Stop #	Distance	Class	Stop #	Distance	Class	Stop #	Distance	Class
1	157.4	A	1	172.2	B	1	162.7	A	1		
2	156.4	A	2			2	158.7	A	2		
3	157.4	A	3	164.7	B	3	162.5	B	3		
4	155.2	A	4	161	B	4	161.2	B	4		
5	156.7	A	5	160.4	A	5	162.6	A	5		
6	156.9	A	6			6	162.7	B	6	162.1	B
7	154.4	B	7			7	163.1	A	7	163.1	B
8	159.3	A	8			8	159.5	A	8		
9	159.2	A	9			9	158.9	B	9	189.5	A
10	153.6	A	10			10	161.1	A	10	185.1	A
			11								
x bar	156.7			164.5			161.3			165.0	
STD n-1	1.9			5.4			1.7			3.3	
95%	157.7			170.1			162.3			168.4	

A

No Payload Dry			Payload Dry			No Payload Wet			Payload Wet		
Stop #	Distance	Class	Stop #	Distance	Class	Stop #	Distance	Class	Stop #	Distance	Class
1	157.4	A	1			1	162.7	A	1		
2	156.4	A	2			2	158.7	A	2		
3	157.4	A	3			3			3		
4	155.2	A	4			4			4		
5	156.7	A	5	160.4	A	5	162.6	A	5		
6	156.9	A	6			6			6		
7			7			7	163.1	A	7		
8	150.3	A	8			8	159.5	A	8		
9	159.2	A	9			9			9	189.5	A
10	153.5	A	10			10	161.1	A	10	185.1	A
			11								
x bar	156.9			160.4			161.3			187.4	
STD n-1	1.6						1.8			3.2	
95%	157.9						162.7			177.4	

APPENDIX E. FINAL PERFORMANCE STATISTICS FOR EACH VEHICLE

GRANDAM FINAL STATISTICS

No Payload Dry			Payload Dry			No Payload Wet			Payload Wet		
Stop #	Distance	Class	Stop #	Distance	Class	Stop #	Distance	Class	Stop #	Distance	Class
1	146.9	A	1	153.5	A	1	197.0	A	1	164.5	A
2	147.5	A	2	149.0	A	2	190.9	A	2	171.5	A
3	147.5	A	3	152.6	A	3	184.0	C	3	163.3	A
4	148.4	A	4	153.3	A	4	193.2	A	4	170.3	A
5	149.4	A	5	152.2	A	5	178.5	A	5	167.0	A
6	149.3	A	6	152.3	A	6	183.4	A	6	167.5	A
7	148.4	A	7	151.0	A	7	194.5	A	7	180.3	A
8	145.6	A	8	153.0	A	8	188.6	A	8	180.1	A
9	145.5	A	9	152.8	A	9	189.6	A	9	158.4	A
10	150.3	A	10	151.3	A	10	201.6	B	10	177.3	A
									11	186.2	A
x bar	147.9			152.0			190.1			171.5	
STD n-1	1.6			1.6			6.9			8.5	
95%	148.6			152.9			193.9			175.9	

EXPEDITION FINAL STATISTICS

No Payload Dry			Payload Dry			No Payload Wet			Payload Wet		
Stop #	Distance	Class	Stop #	Distance	Class	Stop #	Distance	Class	Stop #	Distance	Class
1	162.6	C	1	165.5	B	1	199.7	A	1	212.3	A
2	168.9	A	2	160.6	A	2			2	211.3	A
3	165.2	A	3			3	218.4	B	3		
4	164.9	A	4	165.1	A	4	196.7	A	4	223.7	B
5	166.6	A	5			5	196.2	B	5		
6	167.8	A	6			6	197.9	A	6	226.2	B
7	175.8	A	7			7	193.4	A	7	212.6	A
8	168.5	A	8	156.7	B	8	191.6	B	8	235.2	B
9	172.8	A	9	169.1	A	9	194.4	A			
10	190.7	A									
x bar	170.4			165.4			197.8			220.4	
STD n-1	8.1			3.1			8.7			10.0	
95%	174.8			168.0			203.2			227.9	

CAMRY FINAL STATISTICS

No Payload Dry			Payload Dry			No Payload Wet			Payload Wet		
Stop #	Distance	Class	Stop #	Distance	Class	Stop #	Distance	Class	Stop #	Distance	Class
1			1	163.2	A	1	167.3	A	1	174.00	A
2	163.0	A	2	166.9	A	2	173.5	A	2	168.30	B
3	161.7	A	3	158.6	A	3	169.7	A	3	175.20	A
4	158.2	A	4	160.5	A	4	174.0	A	4	174.60	A
5	162.4	A	5	160.7	A	5	175.3	A	5	174.40	B
6	160.1	A	6	163.5	A	6	172.8	A	6	176.60	A
7	159.1	A	7	159.6	A	7	181.7	A	7	175.80	A
8	159.1	A	8	162.9	A	8	177.4	A	8	174.90	A
9	158.3	A	9	158.9	A	9	183.4	A	9	174.90	B
10	158.5	A	10	160.0	A	10	181.6	A	10	174.30	C
x bar	160.0			161.5			175.7			174.3	
STD n-1	1.9			2.6			5.3			2.2	
95%	161.1			162.9			178.6			175.5	

MALIBU FINAL STATISTICS

No Payload Dry			Payload Dry			No Payload Wet			Payload Wet		
Stop #	Distance	Class	Stop #	Distance	Class	Stop #	Distance	Class	Stop #	Distance	Class
1	140.0	A	1	154.5	A	1	147.9	A	1		
2	142.0	A	2	155.7	A	2	150.9	B	2	152.4	A
3	140.9	A	3	156.6	A	3	151.5	B	3	153.7	A
4	142.8	A	4	156.8	A	4	147.4	A	4	160.5	A
5	139.0	A	5	154.7	A	5	153.9	A	5	164.2	B
6	142.4	A	6	151.5	A	6	146.3	A	6	158.9	B
7	140.1	A	7	150.2	A	7	148.8	A	7	169.5	A
8	143.0	A	8	152.8	A	8	161.0	A	8	161.3	A
9	142.0	A	9	156.0	A	9	149.4	A	9	176.4	B
10	140.3	A	10	151.4	A	10	155.5	A	10	158.4	A
									11	176.2	B
x bar	141.3			154.0			153.3			165.2	
STD n-1	1.4			2.4			2.9			10.2	
95%	142.0			155.3			151.9			170.8	

CARAVAN FINAL STATISTICS

No Payload Dry			Payload Dry			No Payload Wet			Payload Wet		
Stop #	Distance	Class	Stop #	Distance	Class	Stop #	Distance	Class	Stop #	Distance	Class
1			1	175.2	A	1	164.9	B	1	185.9	A
2	161.5	B	2	164.9	A	2			2	188.5	A
3	158.1	A	3	174.5	A	3			3	192.2	A
4	160.8	A	4	172.3	A	4	162.8	A	4	194.6	A
5	157.1	A	5	169.0	A	5	163.0	A	5	197.2	A
6	159.4	A	6	171.9	A	6	169.1	B	6	192.1	A
7	159.4	A	7	168.8	A	7			7	186.2	A
8			8	177.0	A	8	164.6	A	8	186.3	A
9	158.1	A	9	181.1	A	9	164.1	A	9	187.9	A
10	163.8	A	10	176.7	A	10	163.8	A	10	195.4	B
11	159.2	A				11	171.6	A			
x bar	159.7			173.1			165.5			190.6	
STD n-1	2.0			4.8			3.2			4.2	
95%	160.8			175.8			167.6			192.9	

CADILLAC FINAL STATISTICS

No Payload Dry			Payload Dry			No Payload Wet			Payload Wet		
Stop #	Distance	Class	Stop #	Distance	Class	Stop #	Distance	Class	Stop #	Distance	Class
1	157.8	A	1	163.1	B	1	164.9	C	1	163.5	B
2	160.9	B	2	160.3	A	2	163.8	A	2	163.6	A
3	149.6	A	3	160.2	A	3	166.3	A	3	163.3	A
4	154.4	A	4	160.1	B	4	160.7	A	4	161.9	B
5	156.0	C	5	169.8	A	5	164.7	B	5	161.9	A
6	157.5	A	6	171.3	A	6	165.4	A	6	167.0	A
7	154.1	A	7	166.8	A	7	161.2	B	7	163.2	A
8	157.2	A	8	170.5	A	8			8	165.4	A
9	158.8	A	9	166.9	A	9	163.2	A	9	164.0	A
10			10	164.7	A	10	162.5	A	10	165.4	A
11	158.3	B	11	161.7	B						
12	157.1	B	12	166.5	A						
x bar	156.3			165.2			163.6			163.9	
STD n-1	2.9			4.1			1.9			1.6	
95%	158.0			167.2			164.7			164.8	

RAM FINAL STATISTICS

No Payload Dry		Payload Dry		No Payload Wet		Payload Wet	
Stop #	Distance	Stop #	Distance	Stop #	Distance	Stop #	Distance
1	198.2	1	201.9	1	216.6	1	209.2
2	185.8	2	206.4	2	234.9	2	193.4
3	197.5	3	188.4	3	216.1	3	200.6
4	201.1	4	180.9	4	207.5	4	202.4
5	210.9	5	187.5	5	208.7	5	206.6
6	214.5	6	179.2	6	205.9	6	204.5
7	194.9	7	190.3	7	197.7	7	202
8	190.7	8	189.4	8	205.1	8	207.7
		9	174.7	9	202.5	9	220.5
				10	200.8		
x bar	199.2		188.5		208.8		205.2
STD n-1	9.6		10.3		10.7		7.4
95%	205.7		194.5		215.5		209.5

EXPRESS FINAL STATISTICS

No Payload Dry			Payload Dry			No Payload Wet			Payload Wet		
Stop #	Distance	Class	Stop #	Distance	Class	Stop #	Distance	Class	Stop #	Distance	Class
1	160.8	A	1			1			1	181.1	A
2	169.3	C	2			2			2	186.7	A
3	164.9	B	3	181.0	C	3	176.6	B	3	188.7	A
4			4	176.0	A	4	178.5	A	4	184.9	A
5			5	184.5	A	5	177.6	A	5	178.3	A
6			6	182.0	A	6	175.8	A	6	184.1	A
7			7	182.5	A	7	180.3	A	7		
8	165.1	A	8	183.1	A	8	180.6	A	8	182.5	B
9	168.1	A	9	176.8	A	9	176.0	A	9	186.1	A
10	165.3	A	10	165.9	A	10	178.6	A			
						11	180.5	A			
x bar	165.8			179.1			178.3			184.1	
STD n-1	2.7			5.8			1.9			3.2	
95%	167.5			182.7			179.4			196.1	

ASTRO FINAL STATISTICS

No Payload Dry			Payload Dry			No Payload Wet			Payload Wet		
Stop #	Distance	Class	Stop #	Distance	Class	Stop #	Distance	Class	Stop #	Distance	Class
1	170.5	C	1	184.6	A	1					
2	172.5	A	2	181.6	A	2	176	B			
3	170.7	C	3	179.5	A	3	175.1	A	5	184.9	A
4			4	178.4	A	4			6	184.9	A
5	169	B	5	183	A	5	173.1	B			
6	171.4	A	6	185.7	C	6	175.4	A	7	184.7	B
7	170.9	A	7	183.8	A	7	172.5	B	8	196.6	A
8	170.1	A	8	184	C	8	173.8	A	9	183.8	B
9	169.1	A	9			9	175.2	B	10	185.6	B
			10	186.1	B	10	172	C			
x bar	170.5			183.0			174.1			185.1	
STD n-1	1.2			2.7			1.5			0.9	
95%	171.3			184.5			175.1			185.8	

GRAND AM BASELINE FINAL STATISTICS

7 October 1998 (Ford Expedition)

Stop #	Distance	Class
1	151.0	A
2	147.9	A
3	153.3	A
4	147.7	A
5	150.1	A
6	148.7	A
Average	149.8	
STDEV	2.1	

8 October 1998 (Ford Expedition)

Stop #	Distance	Class
1	155.0	C
2	156.2	A
3	155.9	A
4	159.7	C
5		
6		
Average	156.7	
STDEV	2.1	

9 October 1998 (Ford Expedition)

Stop #	Distance	Class
1		
2	143.7	A
3	144.6	A
4	143.1	A
5	144.6	A
6	143.1	A
Average	143.8	
STDEV	0.8	

13 October 1998 (Toyota Camry)

Stop #	Distance	Class
1	144.0	A
2	145.8	A
3	148.6	A
4	144.3	A
5	144.8	A
6	144.6	A
Average	145.4	
STDEV	1.7	

14 October 1998 (Toyota Camry)

Stop #	Distance	Class
1	150.7	A
2	148.6	A
3	150.7	A
4	146.8	A
5	150.2	C
Average	149.4	
STDEV	1.7	

15 October 1998 (Toyota Camry)

Stop #	Distance	Class
1	139.5	A
2	139.3	A
3	140.6	A
Average	139.8	
STDEV	0.7	

19 October 1998 (Chevrolet Malibu)

Stop #	Distance	Class
1		
2		
3	147.4	A

20 October 1998 (Chevrolet Malibu)

Stop #	Distance	Class
1	143.7	A
2	145.0	B
3	148.4	B
Average	145.7	
STDEV	2.4	

22 October 1998 (Cadillac DeVille)

Stop #	Distance	Class
1		
2	140.3	A
3	141.1	A
Average	140.7	
STDEV	0.6	

23 October 1998 (Cadillac DeVille)

Stop #	Distance	Class
1	140.0	A
2	140.2	A
3	140.7	A
Average	140.3	
STDEV	0.4	

GRAND AM BASELINE FINAL STATISTICS (cont.)

30 October 1998 (Dodge Caravan)

Stop #	Distance	Class
1	143.6	A
2	142.0	A
3	143.4	B
Average	143.0	
STDEV	0.9	

2 November 1998 (Dodge Caravan)

Stop #	Distance	Class
1	143.4	A
2	142.2	B
3	142.3	A
Average	142.6	
STDEV	0.7	

3 November 1998 (Dodge Caravan)

Stop #	Distance	Class
1	143.6	A
2	142.3	A
3	144.2	B
Average	143.4	
STDEV	1.0	

6 November 1998 (Dodge Ram)

Stop #	Distance	Class
1		
2		
3		
4	145.5	B

12 November 1998 (Chevrolet Express)

Stop #	Distance	Class
1	145.1	C
2	143.6	B
3		
4	146.7	C
Average	145.1	
STDEV	1.6	

18 November 1998 (Chevrolet Astro)

Stop #	Distance	Class
1	148.3	A
2	143.2	A
3	141.1	A
4	142.0	A
Average	143.7	
STDEV	3.2	

20 November 1998 (Pontiac Bonneville)

Stop #	Distance	Class
1	140.8	A
2	142.9	A
3	142.5	A
Average	142.1	
STDEV	1.1	

BONNEVILLE FINAL STATISTICS

No Payload Dry		
Stop #	Distance	Class
1	157.4	A
2	156 4	A
3	157.4	A
4	155 2	A
5	156.7	A
6	156 9	A
7	154.4	B
8	159 3	A
9	159.2	A
10	153.6	A
x bar	156.7	
STD n-1	1.9	
95%	157.7	

Payload Dry		
Stop #	Distance	Class
1	172.2	B
2	166.7	C
3	164.7	B
4	161	B
5	160.4	A
6		
7	159.5	C
8		
9	164 8	C
10		
11		
	164 2	
	4.4	
	167 2	

No Payload Wet		
Stop #	Distance	Class
1	162.7	A
2	158 7	A
3	162.9	B
4	161 2	B
5	162.6	A
6	162 7	B
7	163.1	A
8	159.5	A
9	158.9	B
10	161 1	A
	161.3	
	1 7	
	162.3	

Payload Wet		
Stop #	Distance	Class
1	165 4	C
2		
3		
4		
5		
6	162 1	B
7	163 1	B
8		
9	169 6	A
10	165.1	A
	165.3	
	3.0	
	167.8	

APPENDIX F. BRAKE AND TIRE TEMPERATURE DATA SHEETS

VEHICLE GRAND AM GREEN DATE 30 Sept 98

60 MPH BRAKE STOP

Test Configuration	Stop No.	Time (sec)	Road Surface		Temperature: Tires LF	Tires RF	Tires LR	Tires RR	Brakes LF	Brakes RF	Brakes LR	Brakes RR	Rotors LF	Rotors RF
RUN 11 DRY, FULL PAYLOAD	1	13:10	DRY	94°	92	85	91	91	116	114	105	99	162	167
WET, FULL PAYLOAD	1	13:29	WET	99°	89	82	89	84	130	121	137	123	238	248
WET, FULL PAYLOAD	2	13:40	WET	—	89	100	86	83	150	153	141	127	236	245
WET, FULL PAYLOAD	3	13:50	WET	90°	90	89	88	88	131	134	130	133	255	254
WET, FULL PAYLOAD	4	13:59	WET	—	92	86	91	90	156	154	150	142	290	313
WET, FULL PAYLOAD	5	14:06	WET	—	91	86	88	87	146	154	141	138	251	272
"	6	14:13	WET	96°	89	91	86	85	152	152	151	156	275	277
WET, FULL	7	14:20	WET	—	88	86	85	85	152	150	172	158	299	303
WET, FULL	8	14:25	WET	95°	88	89	85	88	159	160	161	164	307	287
WET, FULL	9	14:32	WET	97°	86	88	85	84	161	154	160	159	294	314
WET, FULL PAYLOAD	10	14:51	WET	95°	90	86	87	86	131	127	131	134	223	251
WET, FULL	11	15:00	WET	—	87	85	88	85	142	146	142	140	265	252

Note: 20 minute delay between stops "9:10, [illegible] water

GA _ Base _ Dry _ Full

VEHICLE Grand Am Green DATE 30 SEPT 98

60 MPH Brake Stop

Test Configuration	Stop No.	Time (sec)	Road Surface		Temperature (Taken after each stop): Tires LF	Tires RF	Tires LR	Tires RR	Brakes LF	Brakes RF	Brakes LR	Brakes RR	Rotars LF	Rotars RF
DRY, FULL PAYLOAD	INITIAL		DRY		~~87~~	~~85~~	~~88~~	~~85~~	~~142~~	~~146~~	142	140	265	282
DRY, FULL PAYLOAD	1	15:17	DRY	98°	88	90	85	87	121	126	119	128	232	219
DRY, "	2	15:23	DRY	104	84	97	84	85	128	136	126	130	238	246
DRY, "	3	15:33	DRY		102	102	102	100	160	179	159	164	352	378
DRY	4	15:41	DRY	96°	98	102	98	97	172	178	174	171	357	308
DRY	5	15:48	DRY		95	107	95	99	157	164	160	170	293	308
INITIAL READINGS - START OF DAY		1 OCT		72°	99	85	98	86	99	95	92	83	132	136
DRY, FULL	6	08:27	DRY		104	87	102	92	114	109	111	104	231	232
DRY, FULL	7	08:32	DRY		98	85	96	90	141	128	128	112	235	250
DRY, FULL	8	08:40	DRY	78	105	88	102	88	150	152	143	136	299	301
DRY, FULL	9	08:47	DRY	78	93	90	96	89	155	154	172	138	353	256
DRY, FULL	10	08:53	DRY		98	87	95	88	175	165	180	141	316	340

+ Had 2 "extra" stops between # 2 & 3 - VCM problems.

VEFA 32\GRANDAM.SG

VEHICLE GRAND AM (GRAIN) DATE 1 OCT 98

60 MPH BRAKE STOPS – WET ASPHALT, EMPTY (No Passengers)

Temperature (Recorded after each stop)

Test Configuration	Stop No.	Clock Time (sec)	Road Surface	Tires LF	Tires RF	Tires LR	Tires RR	Brakes LF	Brakes RF	Brakes LR	Brakes RR	Rotors LF	Rotors RF
INITIAL	INITIAL	9:52	WET 82°	100	99	86	88	103	121	94	90	116	130
WET - EMPTY	1	9:58	WET 89°	97	96	90	87	128	122	124	118	224	243
WET - EMPTY	2	10:05	WET —	98	90	91	84	153	151	152	130	282	289
WET - EMPTY	3	10:17	WET 88°	99	92	90	82	177	173	139	140	323	335
WET - EMPTY	4	10:23	WET —	94	85	88	85	178	174	160	146	355	381
"	5	10:30	WET —	100	86	88	81	160	169	146	126	291	304
" "	6	10:38	WET 87°	95	82	88	84	165	158	131	115	271	265
WET EMPTY	7	10:44	WET —	93	83	87	80	155	154	141	118	281	290
"	8	10:51	WET 87°	88	77	83	77	152	147	130	116	277	282
WET, EMPTY	9	10:57	WET 88°	87	83	84	80	149	143	131	117	280	272
"	10	11:05	WET —	87	85	83	79	151	143	133	114	239	275

NOTE: Record AFTER EVERY STOP.

VEHICLE Grand Am SE (Green) Engelking DATE 1 Oct 98

60 MPH BRAKE STOPS Dry Asphalt, Empty (No Passing)

Temperatures AMBIENT TEMP - 77°

Test Configuration	Stop No.	Time (sec)	Road Surface	Tires LF	Tires RF	Tires LR	Tires RR	Brakes LF	Brakes RF	Brakes LR	Brakes RR	TOTAL LF	TOTAL RF
Dry, Empty	Initial	1327	Dry 93°	86	79	82	79	86	87	82	82	104	100
Dry, Empty	1	1339	Dry	88	82	79	79	96	96	98	95	205	177
" "	2	1344	Dry 96°	90	85	80	79	110	111	103	100	244	213
" "	3	1348	Dry	91	84	80	79	126	122	106	102	242	216
" "	4	1353	" 94°	94	86	81	80	123	125	107	103	273	240
" "	[a] 5	1358	"	88	80	78	78	111	105	89	85	130	117
	6	1414	" 92°	88	81	80	79	103	104	101	94	204	185
" "	7	1419	"	91	85	80	79	115	114	101	100	245	220
" "	8	1425	Dry	92	98	87	85	121	124	105	101	[b] 250	262
" "	9	1432	Dry	88	82	81	79	122	126	106	103	288	255
" "	10	1437	Dry	93	86	80	80	141	137	96	93	215	195

a - Slight delay, after stop #5, before stop #6 till temps could measured.

b - Parked vehicle 180°, in opposite direction, with affording cooling rate of rotors!

VEHICLE FORD EXPEDITION XLT (BLACK) DATE 7 OCT 98

~~60~~ MPH BRAKE STOPS

62

Temperature* AMBIENT 75°

Test Configuration	Stop No.	Time (sec) *	Road Surface	Tires LF	Tires RF	Tires LR	Tires RR	Brakes LF	Brakes RF	Brakes LR	Brakes RR	ROTORS LF	ROTORS RF
DRY / PAYLOADED	INITIAL	13:42	78°	82	81	77	84	125	127	105	111	141	151
DRY / PAYLOADED	1	13:45	—	81	82	81	82	144	144	121	136	241	259
DRY / PAYLOADED	2	14:01	80°	80	86	82	85	153	168	124	134	233	255
DRY / PAYLOADED	3	14:12	—	82	86	84	85	160	166	149	162	267	298
DRY / PAYLOADED	4	14:22	84°	83	90	84	87	186	192	148	169	295	297
"	5	14:34	—	81	87	82	85	185	187	154	167	282	295
"	6	14:43	86°	84	95	83	85	204	205	165	170	326	353
"	7	14:51	—	80	96	81	89	178	201	151	159	330	290
"	8	16:02	86°	80	93	82	84	180	205	155	192	296	338
"	9	15:12	—	81	83	83	82	195	209	172	201	343	347
AFTER # 9		15:32	79°					140	144	125	133	155	170
DRY / PAYLOADED	10	15:33	—	98	88	93	84	164	182	159	166	285	284
								150	168				

SUMMARY AFTER 10 MIN TEMP DOWN 15-25° ON FRONT

" 20 MIN " " 50-70° ON FRONT

* WAITED 2-10 MIN BETWEEN EACH STOP

VEHICLE FORD EXPEDITION (BLACK) DATE 8 OCT 98

WEATHER CONDITIONS ≈ 70°, RAINING

PAVEMENT CONDITION WET, FREE STANDING WATER

TARGET SPEED AT BRAKE APPLY 62 MPH

Test Configuration	Stop No. *	Time (sec)	Road Surface	Temperature: Tires LF	Tires RF	Tires LR	Tires RR	Brakes LF	Brakes RF	Brakes LR	Brakes RR
LOADED	PRE 1										
"	PRE 2	10:12	69	69	70	69	70	74 / 110	45 / 104	91 / 105	96 / 100
"	PRE 3	10:27	—	70	72	69	70	108 / 131	105 / 127	130 / 158	111 / 177
"	PRE 4	10:35	69					119 / 160	123 / 164	126 / 176	147 / 190
"	PRE 5	10:44	—	ALL				122 / 166	116 / 155	118 / 184	136 / 207
"	PRE 6	10:52	—		70			114 / 142	114 / 140	113 / 172	122 / 210
"	PRE 7	10:59	72		69	15		117 / 149	121 / 137	138 / 197	126 / 208
"	PRE 8	11:10	—			RANGE		121 / 166	126 / 150	117 / 170	130 / 199
"	PRE 9	11:17	—					123 / 170	118 / 142	126 / 204	138 / 210
"	PRE 10	11:26	72					121 / 176	124 / 154	118 / 182	133 / 208

COLD

* ALL TEMPS TAKEN RIGHT BEFORE RUNS

ROTAR SURFACE

TEMP @ SHOE BACKING PLATE SURFACE

NOTE; REAR DISK BRAKES

VEHICLE FORD EXPEDITION DATE 10/9/98 Greg Schultz

WEATHER CONDITIONS COOL/OVERCAST — OCCASIONAL VERY LIGHT DRIZZLE AFTER TEST STARTED

PAVEMENT CONDITION DRY — ROAD NEVER APPEARED WET

TARGET SPEED AT BRAKE APPLY 62.0 TIRE PRESSURE: LF 29.7 RF 29.8 LR 34.2 RR 34.2

Test Configuration	Stop No.	* WATCH FOR 3 MPH FAST Time (sec)	Temperature: Road Surface	Tires: LF	Tires: RF	Tires: LR	Tires: RR	Brakes: LF	Brakes: RF	Brakes: LR	Brakes: RR	
DRY/NO LOAD	1	8:30	68.0°F	—	—	67.2	68.1	102.4	105.4	86.0	83.6	- initial
"	2	9:00	69.2°F	71.0	75.6	65.3	69.1	97.0	98.1	70.3	77.8	- ran 1 lap before
"	3	9:10	67.0°F	68.2	82.6	65.6	74.9	105.6	116.3	92.4	76.5	- "
"	4	9:25	63.4°F	69.2	86.8	67.2	72.5	108.2	112.3	79.6	87.4	- ran 2 laps before
"	5	9:37	66.4°F	74.5	90.2	68.3	73.5	109.0	112.2	86.9	90.2	"
"	6	9:49	66.2	79.2	84.4	68.4	75.4	106.6	105.2	93.0	91.3	"
"	7	10:01	66.0	70.0	83.7	63.5	73.8	106.4	109.4	88.0	93.1	"
	8	10:14	64.6	70.1	85.8	71.9	68.5	110.1	116.3	97.6	97.1	
	9	10:27	65.4	71.3	86.6	69.4	72.8	102.5	113.1	94.2	96.0	
	10			72.7	80.0	—	—	101.8	111.0	—	—	← hard brake & road wet

VEHICLE [illegible] DATE 10/29/97 Jeg Schultz

WEATHER CONDITIONS [illegible]

PAVEMENT CONDITION [illegible]

TARGET SPEED AT BRAKE APPLY 60

Test Configuration	Stop No.	Time (sec)	Road Surface	Temperature: Tires LF	Tires RF	Tires LR	Tires RR	Brakes LF	Brakes RF	Brakes LR	Brakes RR	Rotors	
WET/dry rear	1	10:53	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	
[illegible]	2	[illegible]	66	71	76	70	71	91	95	84	[illegible]	LF 100	RF 97.1
WET/dry rear	3	11:31	[illegible]	70.6	[illegible]	69.5	74.8	94	94.6	85.0	93.5	112	97.0
"	4	11:45	96.6	75.4	78.0	69.4	71.8	95.4	101.4	84.1	103.2	113.0	121.0
"	5	11:57	65.8	71.1	80.5	65.1	74.0	96.7	109.5	89.8	103.3	101.4	119.4
"	6	12:10	67.2	68.7	77.8	70.1	75.0	93.5	106.0	95.0	100.9	111.5	108.5
"	7	12:21	65.0	72.7	80.1	69.0	72.9	91.0	105.5	86.1	96.3	115.1	109.0
"	8	12:35	65.3	72.0	81.0	70.4	74.0	93.2	110.0	91.5	97.0	111.1	124.8
"	9	12:45	67.5	76.7	86.5	70.1	75.6	103.0	115.2	90.3	103.5	118.2	127.1
"	10	12:57	66.7	76.4	82.2	69.3	76.7	101.6	105.2	92.3	95.4	114.3	112.2

VEHICLE GRAND AM SE (GREEN) (BASELINE) DATE 7 OCT 98

WEATHER CONDITIONS 76°, PARTLY CLOUDY

PAVEMENT CONDITION DRY

TARGET SPEED AT BRAKE APPLY 60 MPH

Temperature *

OUTSIDE LINING (THERMOCOUPLE)

INSIDE LINING (THERMOCOUPLE)

Test Configuration	Stop No.	Time (sec)	Road Surface	Tires				Brakes			
				LF	RF	LR	RR	LF	RF	LR	RR
NO PAYLOAD	INITIAL	10:49	—	84	95	78	82	129 / 132	134 / 138	88 / 87	88 / 89
"	1	10:55	77	75	77	76	76	239 / 236	234 / 242	122 / 111	125 / 114
"	2	11:00	—	76	76	76	75	252 / 253	247 / 244	122 / 121	125 / 121
"	3	11:11	77	75	78	77	77	253 / 257	238 / 253	120 / 121	124 / 118
"	4	11:19	75	76	77	77	77	255 / 268	238 / 271	129 / 128	129 / 127
"	5	11:25	—	78	82	81	82	259 / 272	243 / 274	128 / 129	128 / 128
"	6	11:34	76	80	84	83	83	260 / 274	249 / 279	128 / 131	130 / 131

* ALL TEMPS TAKEN 1-2 MINUTES AFTER BRAKE STOP

LINING WELL ALLOWED TO COOL BELOW 212°F.

DATA USED FOR PROCEDURE (ALLOWING LINING TO COOL BELOW 212°F)

VEHICLE GRAND AM SE (GREEN) (BASELINE) DATE 9 OCT 98

WEATHER CONDITIONS ≈ 70°, RAINING LIGHTLY

PAVEMENT CONDITION DAMP, NO FREE STANDING WATER

TARGET SPEED AT BRAKE APPLY 60 MPH

OUTSIDE LINING (THERMOCOUPLE)

INSIDE LINING (THERMOCOUPLE)

Test Configuration	Stop No.	Time (sec)	Road Surface	Temperature: Tires LF	Tires RF	Tires LR	Tires RR	Brakes LF	Brakes RF	Brakes LR	Brakes RR
UNLOADED	PRE 1	8:52						132 / 134	127 / 133	95 / 94	92 / 93
"	AFTER 1	8:54	69					196 / 208	192 / 218	111 / 113	109 / 111
"	PRE 2	8:57	—					199 / 201	191 / 203	106 / 107	104 / 102
"	AFTER 2	8:57	—					255 / 249	240 / 240	122 / 122	119 / 120
"	PRE 3	9:03	69					209 / 211	201 / 257	112 / 118	108 / 105
"	AFTER 3	9:05	—					244 / 253	236 / 261	124 / 126	118 / 124
"	AFTER 3 (PROBE)	9:06	—	PROBE PLACED IN SHOE BRAKING PLATE				126	138	105	112
"	PRE 4	9:11	—					200 / 205	201 / 210	103 / 106	104 / 105
"	PRE 4 (PROBE)	9:12	—					122	139		
"	AFTER 4	9:16	69					224 / 234	226 / 247	108 / 110	104 / 105
"	AFTER 4 (PROBE)	9:17	—					128			
"	PRE 5	9:23	—					187 / 196	192 / 194	96 / 100	100 / 99
"	PRE 5 (PROBE)	9:24	—					121	129		
"	AFTER 5	9:26	69					237 / 248	239 / 253	112 / 110	111 / 116
"	AFTER 5, AFTER COOLDOWN *	9:30	—					205 / 148	200 / 195	102 / 101	98 / 99
"	PRE 6 (PROBE)	9:32	—					121	124		
"	AFTER 6	9:35	—					216 / 217	215 / 230	107 / 107	104 / 108
"	AFTER 6 (PROBE)	9:36	—					117	117		

PROBE PLACED ON ROTOR SURFACE

RESTARTS

LF	RF
293	289
201	196
193	209

* COOL DOWN CONSISTED OF DRIVING VEHICLE DOWN RUNWAY AND BACK TO PITS (MAX

VEHICLE [illegible] (BASELINE) DATE [illegible]

WEATHER CONDITIONS [illegible]

PAVEMENT CONDITION [illegible] TIRE PRESSURE : LF 30.7 RF 30.8

TARGET SPEED AT BRAKE APPLY [illegible] LR 29.7 RR 30.4

Test Configuration	Stop No.	Time (sec)	Road Surface	Temperature								Max PSI	
				Tires				Brakes					
				LF	RF	LR	RR	LF	RF	LR	RR	LF	RF
DRY/No Payload	1	1:16		66.5	70.6	65.4	65.6	67.3	68.4	69.8	[illegible]	73.3	71.9
"			w/Addes					68/65	68/75	29%	[illegible]		
"	2	1:21		74.1	75.1	71.4	70.2	93.0	92.9	14.3	71.8	117.6	103.4
"			w/Addes					133	127	79	77		
"	3	1:43		74.1	73.1	69.6	72.2	91.8	93.6	91.2	75.2	149.4	147.1
"			w/Addes					155	148	36	84.0		
	4	11:55		76.3	78.4	74.3	75.0	100.1	104.1	78.1	79.3	162.6	142.1
			w/Addes					161	162	37.0	91.0		
	5	2:08	70.6	76.1	78.5	72.8	72.5	97.3	104	75.1	76.6	163.4	153.0
			w/Addes					155	150	85.0	85.0		
	6	2:21		76.4	78.6	74.3	74.6	103.2	105.8	79.2	79.2	168.0	152.8
			w/Addes					153	147	84	83		

VEHICLE TOYOTA CAMRY LE (TAN) DATE 17 OCT 98

WEATHER CONDITIONS DRY, PARTLY CLOUDY, 81°

PAVEMENT CONDITION DRY

TARGET SPEED AT BRAKE APPLY 62 MPH

Test Configuration	Stop No.	Time (sec)	Road Surface	Temperature							
				Tires				Brakes (ROTORS)		Brakes (FRICTION MATERIAL)	
				LF	RF	LR	RR	LF	RF	LR	RR
DRY, NO PAYLOAD	PRE 1	13:25	80	77	76	77	76	81	77	76	76
DRY, NO PAYLOAD	PRE 2	13:47	82	80	78	77	77	106	109	95	93
"	PRE 3	13:56	81	81	79	78	77	127	132	95	93
"	PRE 4	14:09	81	80	75	75	75	169	162	102	99
"	PRE 5	14:20	79	78	77	78	77	147	139	104	95
"	PRE 6	14:30	78	77	77	76	76	131	129	99	93
"	PRE 7	14:39	80	81	77	77	76	138	137	103	99
"	PRE 8	14:51	80	84	75	75	76	140	131	95	95
"	PRE 9	15:01	80	82	76	75	75	132	131	104	99
"	PRE 10	15:12	81	85	76	75	75	132	133	96	101

VEHICLE TOYOTA CAMRY – LE (TAN) DATE 10/14/98

WEATHER CONDITIONS SUNNY, 80°

PAVEMENT CONDITION DRY

TARGET SPEED AT BRAKE APPLY 62 MPH

HEAT BLOWING INTO AREA FROM ENGINE

Test Configuration	Stop No.	Time (sec)	Road Surface	Temperature							
				Tires				Brakes			
				LF	RF	LR	RR	LF	RF	LR	RR
DRY, PRELOADED	PRE 1	14:40	86	81	82	74	79	131	136	77	86
DRY, PRELOADED	PRE 2	14:52	89	—	—	—	—	130	122	92	90
"	PRE 3	15:24	88	96	81	81	79	115	109	86	84
"	PRE 4	15:32	85	—	—	—	—	130	117	100	92
"	PRE 5	15:43	84	89	76	80	78	120	128	101	96
"	PRE 6	15:53	84	—	—	—	—	140	130	110	108
"	PRE 7	16:02	86	83	75	75	74	134	113	106	110
"	PRE 8	16:11	86	—	—	—	—	131	122	113	105
"	PRE 9	16:22	84	85	77	78	75	131	117	107	109
"	PRE 10	16:32	85	—	—	—	—	128	119	110	107

VEHICLE TOYOTA CAMRY LE (TAW) DATE 11/14/98

WEATHER CONDITIONS SUNNY, 80° @ START

PAVEMENT CONDITION WET, VIA WATER TRUCK

TARGET SPEED AT BRAKE APPLY 62 MPH

Test Configuration	Stop No.	Time (sec)	Road Surface	Temperature							
				Tires				Brakes			
				LF	RF	LR	RR	LF	RF	LR	RR
WET, NO PAYLOAD	PRE 1	11:13	79	80	74	75	73	142	125	81	80
WET, NO PAYLOAD	PRE 2	11:26	82	86	74	75	73	147	110	88	87
"	PRE 3	11:36	84	84	78	76	74	128	120	92	91
"	PRE 4	11:47	85	86	76	74	74	120	126	92	88
"	PRE 5	11:58	83	84	73	75	74	125	122	88	90
"	PRE 6	12:13	85	85	74	75	73	124	120	94	95
"	PRE 7	12:24	85	85	76	77	76	124	119	93	90
"	PRE 8	12:36	86	99	75	76	74	117	117	91	85
"	PRE 9	12:50	87	102	75	75	72	114	106	92	89
"	PRE 10	13:02	86	99	74	77	73	123	109	92	86

MEASURED BY INFRARED DIGITAL THERMOMETER

HEAT BLANKET BLOWN INTO AREA

ROTORS

BRAKE DRUMS

VEHICLE TOYOTA CAMRY - LE DATE 10/15/98

WEATHER CONDITIONS SUNNY, 68° @ START, WINDY (≈ 10-15 MPH)

PAVEMENT CONDITION WET, w/ WATER TRUCK

TARGET SPEED AT BRAKE APPLY 62 MPH

Test Configuration	Stop No.	Time (sec)	Temperature								
			Road Surface	Tires				Brakes			
				LF	RF	LR	RR	LF	RF	LR	RR
WET, PATTERN 40	PRE 1	13:08	76	82	68	70	69	142	138	86	85
"	PRE 2	13:21	76	76	73	69	69	104	120	92	99
"	PRE 3	13:35	74	79	69	69	70	122	117	94	95
"	PRE 4	13:50	77	82	76	73	69	122	119	95	96
"	PRE 5	14:02	77	82	78	75	72	126	123	102	104
"	PRE 6	14:15	75	82	78	70	69	121	121	101	100
"	PRE 7	14:27	76	91	79	74	75	118	112	101	102
"	PRE 8	14:40	77	82	73	73	69	121	115	100	95
"	PRE 9	14:50	74	83	76	74	72	119	120	103	95
"	PRE 10	15:02	75	78	70	70	71	123	119	96	99
"	PRE 11	15:13	75	82	71	73	70	121	114	104	101
"	PRE 12	15:24	74	80	74	73	70	124	125	105	101

VEHICLE GRAND AM SE (GREEN) DATE 13 OCT 98

WEATHER CONDITIONS DRY, PARTLY CLOUDY 75° @ START

PAVEMENT CONDITION DRY

TARGET SPEED AT BRAKE APPLY 60 MPH

Test Configuration	Stop No.	Time (sec)	Road Surface Temperature	Tires LF	Tires RF	Tires LR	Tires RR	Brakes (Rotors) LF	Brakes (Rotors) RF	Brakes (Brake Pads) LR	Brakes (Brake Pads) RR	
DRY/NO PARKED	PRE 1	12:15	77°	72	75	72	73	159	170	96	85	(PROBE)
		12:15						139 140	133 139	100 104	91 97	(THERMO)
DRY/NO PARKED	PRE 2	12:31	83°	80	79	80	77	130	140	87	87	(PROBE)
		12:32						134 134	130 134	96 100	90 91	(THERMO)
"	PRE 3	12:44	83°	82	74	81	74	133	136	68	85	
		12:45						138 131	128 137	98 103	89 91	
"	PRE 4	12:54	87°	82	84	84	84	163	167	97	93	
		12:55						155 153	150 152	101 109	96 98	
"	PRE 5	13:07	85°	82	78	82	78	163	180	93	97	
		13:14						157 157	155 158	101 105	94 96	
"	PRE 6	13:15	90°	81	88	82	88	151	166	94	91	
		13:16						143 143	141 145	102 105	97 97	

VEHICLE GRAND AM SE (GREEN) DATE 10/14/98

WEATHER CONDITIONS SUNNY, 80°

PAVEMENT CONDITION DRY TIRE PRESSURE : 30 PSI

TARGET SPEED AT BRAKE APPLY 60 MPH

Test Configuration	Stop No.	Time (sec)	Road Surface	Temperature: Tires LF	Tires RF	Tires LR	Tires RR	Brakes (THERMOCOUPLES) LF	Brakes RF	Brakes LR	Brakes RR
DRY, NO PAYLOAD	PRE 1	13:23	86					129/134	119/131	87/87	84/81
DRY, NO PAYLOAD	PRE 2	13:35	84					142/143	136/141	97/89	94/82
"	PRE 3	13:48	87					152/150	147/149	94/93	84/84
"	PRE 4	14:01	89					149/147	147/149	98/96	84/85
"	PRE 5	14:13	92					142/143	132/132	100/98	87/88

VEHICLE GRAND AM SE (GREEN) DATE 10/15/98

WEATHER CONDITIONS SUNNY, 68° & START

PAVEMENT CONDITION DRY

TARGET SPEED AT BRAKE APPLY 60 MPH

Test Configuration	Stop No.	Time (sec)	Temperature: Road Surface	Tires: LF	Tires: RF	Tires: LR	Tires: RR	Brakes: LF	Brakes: RF	Brakes: LR	Brakes: RR
DRY, UNLOADED	PRE 1	9:15	67°					139 / 138	145 / 131	79 / 74	74 / 68
11	PRE 2	9:21	66°					137 / 130	150 / 150	93 / 82	79 / 77
1	PRE 3	9:28	68°					147 / 142	147 / 145	83 / 84	83 / 82

VEHICLE MALIBU/LS CHEVROLET DATE 10/19/78

WEATHER CONDITIONS OVERCAST, 66° @ START

PAVEMENT CONDITION DRY

TARGET SPEED AT BRAKE APPLY 62 MPH

Test Configuration	Stop No.	Time (sec)	Temperature					
			Road Surface	Brakes				
				LF	RF	LR	RR	
DRY, FULL PAYLOAD	PRE 1	8:43	67°	85	86	67	68	
DRY, FULL PAYLOAD	PRE 2	8:56	69°	103	107	90	76	
"	PRE 3	9:13	72°	100	107	87	84	
"	PRE 4	9:25	74°	104	111	88	86	SUN BROKE OUT
"	PRE 5 (1)	9:38	75°	106	107	88	93	
"	PRE 6 (2)	10:03	77°	105	113	93	85	
"	PRE 7 (3)	10:15	81°	110	106	89	87	WIND PICKING UP (0-15 MPH)
"	PRE 8 (4)	10:24	81°	111	109	96	86	
"	PRE 9 (5)	10:35	82°	113	110	91	84	
"	PRE 10 (6)	10:44	82°	117	109	89	85	
"	PRE 11 (7)	10:53	79°	112	108	88	80	
"	PRE 12 (8)	11:02	79°	125	123	92	84	
"	PRE 13 (9)	11:12	80°	115	110	89	85	
"	PRE 14 (10)	11:21	82°	118	107	90	87	

VEHICLE MALIBU/LS CHEVROLET DATE 10/20/98

WEATHER CONDITIONS SUNNY

PAVEMENT CONDITION WET

TARGET SPEED AT BRAKE APPLY 62 MPH

Test Configuration	Stop No.	Time (sec)	Temperature				
			Road Surface	Brakes			
				LF	RF	LR	RR
WET, W/ PAYLOAD	PRE 1	10:49	71°	76	71	75	73
WET, W/ PAYLOAD	PRE 2	10:58	73°	118	116	86	85
"	PRE 3	11:08	73°	110	112	88	83
"	PRE 4	11:18	72°	117	116	89	79
"	PRE 5	11:28	72°	118	115	88	84
"	PRE 6	11:40	73°	108	110	87	82
"	PRE 7	11:54	73°	102	106	82	77
"	PRE 8	12:03	73°	116	108	86	78
"	PRE 9	12:27	74°	109	115	87	80
"	PRE 10	12:35	72°	118	126	93	85
"	PRE 11	12:44	72°	109	112	86	82
"	PRE 12	12:56	73°	106	110	81	78
"	PRE 13	13:05	72°	117	108	82	77
"	PRE 14	13:14	74°	114	121	95	85
"	PRE 15	13:23	74°	109	117	91	83
"	PRE 16	13:32	75°	107	112	82	80
"	PRE 17	13:42	74°	107	113	82	79
"	PRE 18	13:51	74°	112	123	89	83
"	PRE 19	13:59	74°	116	118	91	82

WIND PICKING UP

VEHICLE MALIBU/LS CHEVROLET DATE 10/21/99

WEATHER CONDITIONS OVERCAST, 58° @ START

PAVEMENT CONDITION DRY

TARGET SPEED AT BRAKE APPLY 62 MPH

Test Configuration	Stop No.	Time (sec)	Temperature				
			Road Surface	Brakes			
				LF	RF	LR	RR
DRY, NO PAYLOAD	PRE 1	8:44	58°	81	82	72	66
DRY, NO PAYLOAD	PRE 2	8:55	58°	93	99	73	66
"	PRE 3	9:04	58°	94	100	77	67
"	PRE 4	9:12	59°	95	100	75	67
"	PRE 5	9:20	60°	98	102	77	70
"	PRE 6	9:30	60°	96	97	75	67
"	PRE 7	9:38	61°	96	102	76	67
"	PRE 8	9:45	61°	98	100	74	66
"	PRE 9	9:52	61°	101	98	75	66
"	PRE 10	10:00	61°	100	105	76	67

VEHICLE MALIBU/LS CHEVROLET DATE 10/21/98

WEATHER CONDITIONS OVERCAST, 58° @ START

PAVEMENT CONDITION WET (FROM TRUCK)

TARGET SPEED AT BRAKE APPLY 62 MPH

Test Configuration	Stop No.	Time (sec)	Temperature				
			Road Surface	Brakes			
				LF	RF	LR	RR
WET, NO PAYLOAD	PRE 1	10:18	60°	93	96	70	65
WET, "	PRE 2	10:27	60°	96	99	75	66
WET, "	PRE 3	10:36	61°	89	91	74	66
WET, "	PRE 4	10:43	61°	99	98	73	67
"	PRE 5	10:53	61°	101	97	75	67
"	PRE 6	11:09	61°	96	93	74	67
"	PRE 7	11:17	60°	102	106	80	74
"	PRE 8	12:28	68°	65	65	65	64
"	PRE 9	12:41	68°	93	95	72	66
"	PRE 10	12:51	69°	103	105	77	70
"	PRE 11	13:01	71°	101	99	81	72
"	PRE 12	13:09	71°	104	96	82	74
"	PRE 13	13:18	71°	97	94	77	74

SUN BROKE OUT 67° 10-15 MPH WIND

VEHICLE GRAND AM SE DATE 10/19/98

WEATHER CONDITIONS SUNNY, 79° WINDY (10-15 MPH)

PAVEMENT CONDITION DRY

TARGET SPEED AT BRAKE APPLY 60 MPH

Test Configuration	Stop No.	Time (sec)	Temperature (THERMO) Road Surface	Brakes LF	RF	LR	RR
DRY, UNPAYLOADED	PRE 1	11:35	83	89/91	84/91	77/77	75/74
"	PRE 2	11:45	79	147/146	153/156	88/86	88/87
"	PRE 3	12:03	79	155/162	170/172	93/93	90/91

VEHICLE GRAND AM SE DATE 10/20/98

WEATHER CONDITIONS SUNNY & CLEAR, NO WIND, 63°

PAVEMENT CONDITION DRY

TARGET SPEED AT BRAKE APPLY 60 MPH

Test Configuration	Stop No.	Time (sec)	Temperature				
			Road Surface	Brakes			
				LF	RF	LR	RR
DRY, UNPAYLOADED	PRE 1	9:52	69°	124/125	96/100	75/75	66/64
"	PRE 2	10:02	74°	150/149	147/149	92/87	78/78
"	PRE 3	10:12	76°	148/145	155/156	96/87	84/85

VEHICLE GRAND AM SE DATE 10/21/98

WEATHER CONDITIONS OVERCAST, 64° @ START

PAVEMENT CONDITION DRY

TARGET SPEED AT BRAKE APPLY 60 MPH

Test Configuration	Stop No.	Time (sec)	Temperature: Road Surface	Temperature: Brakes LF	Temperature: Brakes RF	Temperature: Brakes LR	Temperature: Brakes RR
DRY, UNLOADED	PRE 1	11:43	72°	64 / 66	59 / 60	61 / 62	57 / 58
"	PRE 2	11:47	73°	151 / 148	146 / 152	68 / 68	75 / 73
"	PRE 3	11:56	75°	138 / 134	144 / 146	77 / 78	72 / 74
"	PRE 4	12:05	75°	152 / 148	158 / 158	81 / 84	76 / 77
"	PRE 5	12:16	77°	157 / 152	159 / 159	81 / 83	77 / 79

SUN CAME OUT

VEHICLE CADILLAC DEVILLE DATE 10/22/98

WEATHER CONDITIONS OVERCAST 59°, WINDY (20-25 MPH)

PAVEMENT CONDITION DRY DRIVER: ED SURLAC

TARGET SPEED AT BRAKE APPLY 62 MPH

Test Configuration	Stop No.	Time (sec)	Temperature				
			Road Surface	Brakes			
				LF	RF	LR	RR
DRY, PAYLOADED	PRE 1	13:05	63°	112	107	76	74
"	PRE 2	13:28	64°	96	94	88	86
"	PRE 3	13:38	66°	102	92	89	84
"	PRE 4	13:47	68°	99	96	93	92
"	PRE 5	13:56	68°	108	96	102	93
"	PRE 6	14:04	68°	108	112	100	96
"	PRE 7	14:13	67°	99	105	92	91
"	PRE 8	14:22	66°	100	102	97	96
"	PRE 9	14:30	66°	106	98	94	95
"	PRE 10	14:39	67°	105	111	100	92

Scan Blob out

G.Sc1 '2

VEHICLE CADILLAC DEVILLE DATE 10-23-98

WEATHER CONDITIONS SUNNY, CLEAR, NO WIND (LIGHT X-WIND AS DAY WENT ON)

PAVEMENT CONDITION WET DRIVER: ED SURLAC

TARGET SPEED AT BRAKE APPLY

Test Configuration	Stop No.	Time (sec)	Temperature 51.6°F				
			Road Surface	Brakes			
				LF	RF	LR	RR
WET/FULL	1	9:36	63.4	65.5	57.0	59.3	51.6
"	2	9:47	61.5	87.4	87.8	79.9	74.1
"	3	9:58	63.5	94.8	98.5	83.2	86.8
"	4	10:05	66.3	103.3	91.0	86.3	81.2
"	5	10:15	65.2	103.0	105.9	87.8	82.5
"	6	10:35	67.1	94.0	97.9	90.1	73.2
"	7	10:45	67.0	93.0	101.0	80.3	84.8
"	8	10:55	67.4	104.8	109.8	91.1	80.1
"	9	11:04	69.6	100.9	102.2	87.8	76.1
"	10	11:14	69.0	98.7	105.0	92.7	80.1

VEHICLE CADDY DEVILLE DATE 10-23-98

WEATHER CONDITIONS SUNNY, CLEAR, SLIGHT X-WIND DRIVER: KENNY SHROEDER

PAVEMENT CONDITION DRY

TARGET SPEED AT BRAKE APPLY 62

Test Configuration	Stop No.	Time (sec)	Temperature 62°F Road Surface	Brakes LF	RF	LR	RR	
DRY/EMPTY	1	2:50	75.5	96.0	108.0	80.0	79.6	
		~~3:00~~	~~81.5~~	~~111.0~~	~~117.1~~	~~86.4~~	~~85.0~~	BAD STOP
	2	3:10	81.0	110.4	128.6	90.0	83.0	
	3	3:20	80.9	110.0	142.4	95.0	90.0	
	4	3:28	79.7	109.8	133.1	100.3	89.6	
	5	3:37	76.6	113.8	125.1	100.5	94.5	
	6	3:45	77.6	123.1	141.1	102.1	99.2	Drove Longer
	7	4:57	79.1	109.2	104.3	89.6	86.5	
	8	4:10	76.8	95.7	105.9	86.4	78.3	
	9	4:20	74.4	97.2	129.1	91.7	84.0	Shortened Drive Slightly
	10	4:30	74.4	110.1	117.8	92.8	84.8	
	11	4:40	74.4	104.8	125.7	96.7	86.9	
	12	4:51	72.4	96.1	109.5	87.0	79.0	
	13	5:03	71.8	100.2	118.6	92.5	86.6	

VEHICLE CADDY DEVILLE DATE 10-23-98

WEATHER CONDITIONS SUNNY, CLEAR, SLIGHT CROSS WIND DRIVER: ED GURLAC

PAVEMENT CONDITION WET

TARGET SPEED AT BRAKE APPLY 62 MPH

Temperature 61°F (FROM CHART) START

Test Configuration	Stop No.	Time (sec)	Road Surface	Brakes			
				LF	RF	LR	RR
WET/NO LOAD	1	1:05	80.8	117.0	124.8	93.4	82.0
"	2	1:14	81.0	105.5	119.7	93.2	81.1
"	3	1:24	77.8	107.0	124.5	86.4	80.2
"	4	1:33	79.1	99.0	114.1	88.1	78.3
"	5	1:43	77.5	102.5	136.9	86.6	80.6
"	6	1:53	79.1	103.2	130.5	87.3	84.8
"	7	2:04	79.6	111.4	110.6	82.4	78.5
"	8	2:14	77.6	106.5	123.8	89.4	81.9
"	9	2:24	79.1	114.0	109.9	99.3	86.8
"	10	2:33	81.0	108.5	118.0	90.9	83.2

Driver used brakes more when pulling in

Note: Rotors never got very hot. All 4 were comfortable to touch throughout testing

VEHICLE GRAND AM SE DATE 10/22/98

WEATHER CONDITIONS OVERCAST 56°, WINDY (20-25 MPH)

PAVEMENT CONDITION DRY DRIVER: ED SURLAC

TARGET SPEED AT BRAKE APPLY 60 MPH

Test Configuration	Stop No.	Time (sec)	Road Surface	Temperature Brakes LF	RF	LR	RR
DRY, UNEQUIPPED	PRE 1	15:00	63°	58/62	56/61	56/57	54/56
"	PRE 2	15:05	62°	133/132	135/141	70/68	67/66
"	PRE 3	15:12	62°	144/141	152/155	75/77	75/73

VEHICLE CADDY DEVILLE DATE 10-23-98

WEATHER CONDITIONS SUNNY, CLEAR, NO WIND DRIVER: ED SURLAC

PAVEMENT CONDITION DRY

TARGET SPEED AT BRAKE APPLY 62

Test Configuration	Stop No.	Time (sec)	Road Surface	Temperature 58.0°F Brakes LF	RF	LR	RR
FULL / DRY	1	11:24	70.8	101.3	108.9	89.8	83.1
"	2	11:35	73.0	111.7	123.1	99.6	81.1
"	3	11:44	70.6	103.6	103.7	93.0	82.5

G. Schultz

Ed Surlac = Driver

VEHICLE GRAND AM DATE 10-23-98

WEATHER CONDITIONS SUNNY, CLEAR, NO WIND, AMBIENT TEMP 46°

PAVEMENT CONDITION DRY (EMPTY)

TARGET SPEED AT BRAKE APPLY 60 MPH

Test Configuration	Stop No.	Time (sec)	Temperature				
			Road Surface	Brakes			
				LF	RF	LR	RR
DRY EMPTY	1	8:46	56.6	97.0	89.3	67.5	58.0
"	2	9:03	56.6	RECORDED SEE VEPA FILE			
"	3	9:11	56.9		"		

VEHICLE DODGE CARAVAN DATE 10/30/98

WEATHER CONDITIONS DRY / SUNNY 71°

PAVEMENT CONDITION DRY

TARGET SPEED AT BRAKE APPLY 62 MPH

Test Configuration	Stop No.	Time (sec)	Road Surface	Temperature Brakes (ROTORS / DRUMS)			
				LF	RF	LR	RR
DRY/UNLOADED	PRE 1	11:33	77°	174	153	95	87
"	PRE 2	11:44	78°	148	132	92	85
"	PRE 3	11:56	78°	138	125	89	83
"	PRE 4	12:07	79°	143	123	88	80
"	PRE 5	12:19	80°	149	135	91	83
"	PRE 6	12:30	80°	148	129	88	83
"	PRE 7	12:42	79°	150	131	89	83
"	PRE 8	12:53	78°	149	126	91	83
"	PRE 9	13:03	77°	160	144	92	94
"	PRE 10	13:14	77°	142	128	90	84

VEHICLE DODGE CARAVAN DATE 11/3/98

WEATHER CONDITIONS DRY 52°

PAVEMENT CONDITION WET (water truck)

TARGET SPEED AT BRAKE APPLY 62 mph

Test Configuration	Stop No.	Time (sec)	Road Surface Temperature	Brakes LF	Brakes RF	Brakes LR	Brakes RR
WET-FULL LOAD	1	13:15	62°	100°	90°	68°	65°
WET FULL LOAD	1	13:31	62°	124°	106°	[illegible]	[illegible]
" " "	2	13:39		127°	131°	74°	72°
" " "	3	13:46		132°	121°	77°	71°
" " "	4	13:55		134°	117°	66°	76°
" " "	5	14:05		147°	123°	70°	74°
" " "	6	14:13	63°	148°	123°	76°	75°
" " "	7	14:24	"	153°	133°	77°	77°
" " "	8	14:32		175°	144°	80°	77°
" " "	9	14:40		146°	128°	77°	76°
" " "	10	14:49		172°	132°	76°	77°
" " "	11	14:58		170°	136°	75°	79°
" " "	12	15:06		165°	135°	77°	78°
" " "	13	15:13		151	131	75°	77

VEHICLE DODGE CARAVAN DATE 11/3/98

WEATHER CONDITIONS DRY 46° OVERCAST

PAVEMENT CONDITION DRY

TARGET SPEED AT BRAKE APPLY 60 mph

Test Configuration	Stop No.	Time (sec)	Road Surface	Temperature 46 Brakes LF	RF	LR	RR
WET NO LOAD	1	9:16	WET	61	63	52	48
" "	2	9:28	WET	82	82	64	63
" "	3	9:49	WET	94	87	63	59
" "	4	10:03	"	133	114	57	64
" "	5	10:09	"	135	116	64	65
" "	6	10:19	"	135	121	64	64
" "	7	10:29	"	134	118	64	64
" "	8	10:37	"	140	116	63	61
" "	9	10:45	"	139	119	64	64
" "	10	10:53	"	136	120	63	63
" "	11	11:05	"	136	126	115	70
" "	12	11:10	"	145	129	66	63

VEHICLE DODGE CALAVAN DATE 11/2/98

WEATHER CONDITIONS SUNNY / 63°

PAVEMENT CONDITION DRY

TARGET SPEED AT BRAKE APPLY 62 MPH

Test Configuration	Stop No.	Time (sec)	Temperature					
			Road Surface	Brakes				
				LF	RF	LR	RR	
DRY, NO PAYLOAD	PRE 1	9:41	65°	64	63	63	62	
DRY, NO PAYLOAD	PRE 2	9:54	66°	140	119	75	67	
"	PRE 3	10:04	66°	132	110	76	69	
"	PRE 4	10:15	67°	138	116	78	71	
"	PRE 5	10:27	67°	144	125	80	73	
"	PRE 6	10:37	68°	138	123	80	74	← DID STOP NO DAM @ 10:4
"	PRE 7	10:58	70°	152	130	79	74	
"	PRE 8	11:08	70°	148	135	82	76	
"	PRE 9	11:18	71°	141	126	79	75	
"	PRE 10	11:28	71°	153	134	80	74	
"	PRE 11	11:38	72°	144	126	80	76	

VEHICLE GRAND_AM DATE 10-30-98

WEATHER CONDITIONS DRY SUNNY 67°, WINDY (5-10 MPH)

PAVEMENT CONDITION DRY

TARGET SPEED AT BRAKE APPLY 60 mph

Test Configuration	Stop No.	Time (sec)	Temperature				
			Road Surface	Brakes			
				LF	RF	LR	RR
DRY NO LOAD	PRE 1	13:58	77°	65/67	63/65	65/67	64/65
"	PRE 2	14:03	77°	152/157	134/140	76/75	83/79
"	PRE 3	14:24	78°	159/160	158/160	77/88	80/83
"	PRE 4	14:39	78°	160/160	160/162	84/87	79/81

VEHICLE GRAND AM

DATE 11/2/98

WEATHER CONDITIONS SUNNY, 59°

PAVEMENT CONDITION DRY

TARGET SPEED AT BRAKE APPLY 60 MPH

Test Configuration	Stop No.	Time (sec)	Road Surface Temperature	Brakes LF	Brakes RF	Brakes LR	Brakes RR
DRY - NO LOAD	PRE 1	9:06	62°	146/145	150/145	88/85	77/76
"	PRE 2	9:14	62°	156/153	156/156	79/81	82/80
"	PRE 3	9:22	64°	155/152	157/157	82/84	80/82
"	PRE 4	9:30	64°	154/151	153/153	83/82	79/80
		GRAND AM		11/3/98			
		OVERCAST	62°	DRY			
"	1	15:38	62°	70/69	67/64	113/113	69/63
"	1	15:40	62°	74/110	67/64	112/113	69/63
"	2	15:46	62°	75/149	80/75	148/147	79/73
"	3	15:51	62°	76/158	82/79	155/154	84/78

SWITCH CALIPERS

VEHICLE Dodge RAM 4x4 DATE 11/6/08

WEATHER CONDITIONS SUNNY SLIGHT XWIND

PAVEMENT CONDITION WET

TARGET SPEED AT BRAKE APPLY 62 MPH

Temperature 52.8 (start) 52.4 (end)

Test Configuration	Stop No.	Time (sec)	Road Surface	Brakes LF	RF	LR	RR	
WET, EMPTY								
"	1	1555	61.7	126.0	145.1	76.7	79.6	NO LOCK
"	2	1602	↑	134.8	160.7	77.4	79.9	NO LOCK
"	3	1608		139.5	153.2	75.9	81.1	NO LOCK
"	4	1615		141.8	160.6	72.8	74.7	NO LOCK
"	5	1622		141.5	160.4	71.2	74.5	NO LOCK
"	6	1629		139.6	163.3	70.7	77.8	NO LOCK
"	7	1635		140.5	165.1	74.4	76.5	NO LOCK
"	8	1641		146.8	164.9	74.4	77.2	NO LOCK
"	9	1647	↓	150.7	163.6	76.2	75.2	NO LOCK
"	10	1654	54.1	144.7	165.5	74.3	74.4	NO LOCK

VEHICLE DODGE RAM 4x4 DATE 11/6/98

WEATHER CONDITIONS MOSTLY SUNNY LIGHT X-WIND

PAVEMENT CONDITION WET

TARGET SPEED AT BRAKE APPLY 62 MPH

Temperature 63.6 52.8 (END)

Test Configuration	Stop No.	Time (sec)	Road Surface	Brakes LF	RF	LR	RR	
DRY ; EMPTY	1	13:01	62.2	119.7	139.8	83.8	77.7	LOCK BOTH FR @ VERY END
"	2	13:10		127.9	144.5	74.2	72.8	NO LOCK
"	3	1320		123.0	147.4	71.6	73.4	NO LOCK
"	4	1327		122.0	149.7	71.6	73.1	NO LOCK (DAVE NOTICED ABS)
"	5	1333		127.6	148.5	70.8	73.8	NO LOCK
"	CHASED	OUT FOR	1½ HR					
"	6	1513	64.8	129.6	155.9	76.0	77.0	RF LOCK
"	7	1520		150.3	134.5	75.0	76.1	NO LOCK
"	8	1527		156.1	156.1	78.8	79.8	NO LOCK
"	9	1533		140.8	163.5	78.7	82.3	NO LOCK
"	10	1540		147.8	168.3	76.9	80.3	NO LOCK
PANIC STOP	11	1546	61.7	143.4	164.3	70.6	76.2	SERIOUS LOCK

VEHICLE GRAND AM

DATE 11/6/98

WEATHER CONDITIONS DUSK, DRY, CLEAR

PAVEMENT CONDITION DRY

TARGET SPEED AT BRAKE APPLY

Temperature 52.4

Test Configuration	Stop No.	Time (sec)	Road Surface	Brakes LF	RF	LR	RR
DRY, EMPTY	1	1708	54.1	SEE VEPA FILE			
"	2	1712		74	142	68	66
"	3			80.	SEE VEPA FILE		
"	4			BAD			
"							
"							
"							
"							
"							
"							
"							
"							

MILEAGE 14,840

VIN # 1B7HF16Z0WS650733

VEHICLE DODGE-RAM

DATE 11-16-96

WEATHER CONDITIONS DRY OVERCAST 50 °F STEADY XWIND ≈ 10 MPH

PAVEMENT CONDITION DRY 48 °F

DRIVER: HERSEY

TARGET SPEED AT BRAKE APPLY 62 mph

Test Configuration	Stop No.	Time (sec)	Road Surface	Temperature 48°F Brakes LF	RF	LR	RR	
DRYFULL	—	0820	48°F	59.0	85.1	58.9	58.1	NO GOOD
"	—	0832		98.1	92.3	68.1	66.0	BRIEF LOCK RF
"	1			156.6	160.6	88.1	76.8	NO LOCK
"	—	0850	52.5°F	134.7	157.6	73.1	73.2	LOCK UP RF
"	2	0858	53.5	145.2	123.7	69.0	75.4	NO LOCK
"	3	0905	51.6	123.5	137.6	77.9	67.7	NO LOCK
"	4	0913		136.6	147.5	71.5	78.0	NO LOCK
"	—	0919		132.1	148.9	79.7	74.7	CHIRP LOCK
"	5	0927		133.7	146.8	81.8	75.1	NO LOCK
"	6	0934	53.4	133.8	144.9	78.0	76.5	NO LOCK
"	7	0941		130.8	156.2	79.6	80.0	NO LOCK
"	8	0948		134.5	155.6	82.0	81.2	NO LOCK
"	9	0955		136.8	156.1	81.0	83.5	NO LOCK
	10	1002	53.5	123.0	147.5	79.3	77.0	LOCK

Note: Truck has Rear ABS Only — Did best efforts attempting not to lock front

BLG

VEHICLE CHEVROLET EXPRESS 1-TON (VAN) DATE 12 NOV 98

WEATHER CONDITIONS SUNNY 56°

PAVEMENT CONDITION WET

TARGET SPEED AT BRAKE APPLY 62 MPH

Test Configuration	Stop No.	Time (sec)	Road Surface	Temperature			
				Rotors / Brakes / Drums			
				LF	RF	LR	RR
WET, W/ PAYLOAD	PRE 1	10:24	62°	165	138	122	116
"	PRE 2	10:31	62°	203	199	133	145
"	PRE 3	10:41	63°	168	154	135	119
"	PRE 4	10:49	64°	158	146	128	119
"	PRE 5	10:58	63°	150	146	120	112
"	PRE 6	11:06	64°	158	148	125	118
"	PRE 7	11:14	63°	162	156	128	114
"	PRE 8	11:21	64°	166	162	119	110
"	PRE 9	11:30	64°	165	170	124	115
"	PRE 10	11:38	63°	171	158	119	110
"	PRE 11	11:47	63°	165	155	119	108

EXTEND COOLDOWN

VEHICLE CHEVROLET EXPRESS 1-TON

DATE 12 NOV 98

WEATHER CONDITIONS SUNNY, 51°

PAVEMENT CONDITION DRY

TARGET SPEED AT BRAKE APPLY 62 MPH

Test Configuration	Stop No.	Time (sec)	Road Surface	Temperature ★ Brakes (LINKS / DRUMS)			
				LF	RF	LR	RR
DRY, W/ PAYLOAD	PRE 1	8:36	52°	104	84	100	94
"	PRE 2	8:51	54°	112	97	114	106
"	PRE 3	9:16	58°	80	80	90	86
"	PRE 4	9:26	59°	83	99 *	92	103
"	PRE 5	9:35	60°	100 *	129	112	106
"	PRE 6	9:42	60°	162	129	116	114
"	PRE 7	9:50	61°	181	153	126	117
"	PRE 8	9:58	62°	193	182	111	124
"	PRE 9	10:05	64°	181	164	115	124
"	PRE 10	10:13	64°	230	179	130	117
"							

DELAY FOR PLANE

★ NOTE: 2 DRUMS HAD TO GET TO W/ PROBE. NO GUARANTEE PROBE WAS PLACED IN EXACT SAME SPOT EVERY TIME.
* FOUND TRUE ROTOR AREA HAD TO GET TO W/ PROBE

VEHICLE CHEVROLET ASTRO DATE 18 NOV 98

WEATHER CONDITIONS SUNNY, 61°

PAVEMENT CONDITION DRY

TARGET SPEED AT BRAKE APPLY 62 MPH

Test Configuration	Stop No.	Time (sec)	Road Surface	Temperature Brakes LF	RF	LR	RR
DAY, NO PAYLOAD	PRE 1	15:02	[illegible]	169	178	105	96
"	PRE 2	15:06	68°	184	193	114	103
"	PRE 3	15:10	67°	172	180	99	93
"	PRE 4	15:14	67°	185	197	103	98
"	PRE 5	15:19	68°	166	175	98	95
"	PRE 6	15:24	67°	175	180	106	96
"	PRE 7	15:30	67°	163	173	95	91
"	PRE 8	15:35	67°	152	165	103	93
"	PRE 9	15:40	66°	152	164	104	90
"	PRE 10	15:45	66°	170	178	107	99

VEHICLE Chev Van 1-TON DATE 12 NOV 98

WEATHER CONDITIONS SUNNY, 63°

PAVEMENT CONDITION WET

TARGET SPEED AT BRAKE APPLY 62 MPH

Test Configuration	Stop No.	Time (sec)	Temperature				
			Road Surface	Brakes			
				LF	RF	LR	RR
WET, NO PAYLOAD	PRE 1	13:19	64°	101	112	95	84
"	PRE 2	13:26	64°	143	138	163	84
"	PRE 3	13:33	64°	166	149	105	93
"	PRE 4	13:41	63°	158	146	113	91
"	PRE 5	13:49	63°	167	155	106	90
"	PRE 6	13:56	63°	167	145	109	92
"	PRE 7	14:03	63°	160	145	110	88
"	PRE 8	14:11	62°	169	150	102	92
"	PRE 9	14:17	63°	182	154	112	88
"	PRE 10	14:24	62°	172	164	107	86
"	PRE 11	14:31	62°	163	155	105	86

VEHICLE CHEVROLET M1113 DATE 18 NOV 98

WEATHER CONDITIONS SUNNY, 70°

PAVEMENT CONDITION WET

TARGET SPEED AT BRAKE APPLY 62 MPH

Test Configuration	Stop No.	Time (sec)	Temperature				
			Road Surface	Brakes			
				LF	RF	LR	RR
WET, PAYLOADED	PRE 1	10:51	66°	128	130	106	97
"	PRE 2	10:58	66°	137	141	110	103
"	PRE 3	11:05	67°	145	152	109	100
"	PRE 4	11:12	67°	140	142	121	110
"	PRE 5	13:02	63°	141	157	119	104
"	PRE 6	13:09	64°	134	146	116	95
"	PRE 7	13:16	64°	149	149	117	101
"	PRE 8	13:21	64°	149	151	115	104
"	PRE 9	13:28	64°	147	145	112	102
"	PRE 10	13:34	64°	138	151	120	100
"	PRE 11	13:40	64°	142	157	115	98
"	PRE 12	13:47	65°	152	161	118	103
"	PRE 13	13:53	65°	148	161	123	108
"	PRE 14	13:59	64°	150	158	117	104

BRAKE

VEHICLE GRAND AM SE

DATE 12 NOV 98

WEATHER CONDITIONS SUNNY

PAVEMENT CONDITION DRY

TARGET SPEED AT BRAKE APPLY 60 MPH

Test Configuration	Stop No.	Time (sec)	Road Surface	Temperature Brakes LF	RF	LR	RR
DRY, UNPAYLOADED	PRE 1	16:15	63°	(75)/130 (BAD THERMOCOUPLE)	135/146	82/80	85/80
"	PRE 2	16:20	62°	(75)/155	160/157	86/86	86/84
"	PRE 3	16:26	62°	(75)/153	159/156	87/88	82/83
"	PRE 4	16:33	60°	75/152	156/154	87/89	87/85
"							
"							
"							
"							
"							
"							
"							

VEHICLE GRAND AM DATE 18 NOV 98

WEATHER CONDITIONS SUNNY, 58° (10-15 MPH WIND)

PAVEMENT CONDITION DRY

TARGET SPEED AT BRAKE APPLY 60 MPH

Test Configuration	Stop No.	Time (sec)	Road Surface	Temperature (Trim in Good) Brakes LF	RF	LR	RR
DLY, NO PAYLOAD	PRE 1	8:50	57°	(75) / 159	159 / 148	85 / 82	79 / 74
"	PRE 2	8:55	57°	(75) / 157	142 / 159	85 / 85	80 / 76
"	PRE 3	9:00	57°	(75) / 151	138 / 155	85 / 85	80 / 79
"	PRE 4	9:07	58°	(76) / 148	151 / 149	80 / 82	79 / 81

VEHICLE CHEVROLET ASTRO DATE 18 NOV 98

WEATHER CONDITIONS SUNNY, 66° (10-15 MPH)

PAVEMENT CONDITION DRY

TARGET SPEED AT BRAKE APPLY 62 MPH

Test Configuration	Stop No.	Time (sec)	Temperature					
			Road Surface	Brakes (ROTORS) LF	RF	LR	RR (DRUMS)	
DRY, PAYLOADED	PRE 1	9:15	58°	80	72	65	61	
"	PRE 2	9:30	60°	110	120	82	72	1 LAP COOL DOWN
"	PRE 3	9:37	61°	120	126	100	89	
"	PRE 4	9:47	63°	98	109	98	84	
"	PRE 5	9:58	64°	107	112	96	85	
"	PRE 6	10:03	64°	165	164	116	101	
"	PRE 7	10:08	65°	177	184	121	114	LESS THAN 1 LAP COOL DOWN
"	PRE 8	10:14	66°	146	151	117	108	
"	PRE 9	10:21	66°	173	189	126	115	
"	PRE 10	10:27	67°	184	191	122	118	
"	PRE 11	10:33	67°	185	194	135	127	
"	PRE 12	10:41	68°	152	165	127	106	

VEHICLE PONTIAC BONNEVILLE DATE 20 NOV 98

WEATHER CONDITIONS OVERCAST, 63°

PAVEMENT CONDITION WET

TARGET SPEED AT BRAKE APPLY 62 MPH

Test Configuration	Stop No.	Time (sec)	Temperature				
			Road Surface	Brakes (ROTORS) LF	RF	Brakes (DRUMS) LR	RR
WET, NO PAYLOAD	PRE 1	12:14	66	144	150	89	85
WET, NO PAYLOAD	PRE 2	12:28	65	166	172	93	88
"	PRE 3	12:34	65	175	189	94	89
"	PRE 4	12:39	65	193	199	97	90
"	PRE 5	12:46	66	166	165	96	93
"	PRE 6	12:51	65	163	170	92	95
"	PRE 7	12:58	65	175	177	95	92
"	PRE 8	13:04	65	165	168	93	90
"	PRE 9	13:10	65	166	175	94	92
"	~~PRE 9~~	~~13:17~~	~~64~~	~~195~~	~~195~~	94	87
"	PRE 9	13:31	64	130	158	88	84
"	PRE 10	13:39	63	147	150	90	88

VEHICLE CHEVROLET ASTRO DATE 13 NOV '19

WEATHER CONDITIONS SUNNY, 65°

PAVEMENT CONDITION DRY

TARGET SPEED AT BRAKE APPLY 62 MPH

Test Configuration	Stop No.	Time (sec)	Road Surface	Temperature Brakes LF	RF	LR	RR
LOW, NO PAYLOAD	PRE 1	14:40	64°	126	128	84	80
"	PRE 2	14:46	63°	135	139	90	84
"	PRE 3	14:52	63°	155	165	103	89
"	PRE 4	15:51	59°	159	168	94	89
"	PRE 5	15:56	58°	171	184	104	93
"	PRE 6	16:01	58°	170	175	100	93
"	PRE 7	16:06	57°	163	171	98	90
"	PRE 8	16:12	56°	158	165	93	88
"	PRE 9	16:18	56°	161	168	95	88
"	PRE 10	16:24	55°	159	163	92	87
"							

VEHICLE Grand Am DATE 20 NOV 98

WEATHER CONDITIONS Overcast, 66°

PAVEMENT CONDITION Dry

TARGET SPEED AT BRAKE APPLY 60 mph

Test Configuration	Stop No.	Time (sec)	Temperature: Road Surface	Temperature: Brakes LF (AC Cool)	Brakes RF	Brakes LR	Brakes RR
Dry, no Payload	Pull 1	15:12	69°	79 / 158	165 / 160	94 / 87	89 / 84
Dry, no Payload	Pull 2	15:20	68°	77 / 153	169 / 167	90 / 90	82 / 81
"	Pull 3	15:28	69°	75 / 116	132 / 177	87 / 87	80 / 82

20 MAY 76

PONTIAC BONNEVILLE

CONDITIONS SUNNY w/ FOG (61° @ START)

ROAD SURFACE DRY

TARGET SPEED 62 MPH

CONFIGURATION	STOP NO.	TIME	TEMPERATURES: ROAD SURFACE	LF ROTORS	RF ROTORS	LR DRUMS	RR DRUMS
DRY, PAYLOADED	PRE 1	8:27	60	162	175	95	90
"	PRE 2	8:32	60	170	181	102	98
"	PRE 3	8:40	60	179	189	100	98
"	PRE 4	8:47	60	180	193	106	99
"	~~PRE 5~~	~~8:56~~	~~60~~	~~148~~	~~155~~	~~95~~	~~88~~
"	PRE 5	9:02	61	170	182	100	94
"	PRE 6	9:12	61	168	175	110	103
"	PRE 7	9:18	62	180	193	115	110
"	PRE 8	9:25	62	179	196	110	108
"	PRE 9	9:31	63	176	190	112	105
"	PRE 10	9:37	63	179	195	113	111
"	PRE 11	9:44	64	176	183	110	106
WET, PAYLOADED	PRE 1	9:51	62	152	165	105	102
"	PRE 2	9:57	62	170	177	107	107
"	PRE 3	10:03	63	166	168	113	108
"	PRE 4	10:09	62	172	170	110	105
"	PRE 5	10:14	64	175	185	105	105
"	PRE 6	10:20	64	170	183	111	106
"	PRE 7	10:26	63	178	189	110	103
"	PRE 8	10:35	63	166	170	107	105
"	PRE 9	11:00	64	168	165	105	100
"	PRE 10	11:06	64	166	172	110	104

DOWN TIME
TEMPS RECORDED 19 MIN BEFORE RUN (10:54)

APPENDIX G. ATC MET DATA

VEHICLE Pontiac Bonneville DATE 20 Nov 98

WEATHER CONDITIONS Overcast, 65°

PAVEMENT CONDITION Dry

TARGET SPEED AT BRAKE APPLY 62 MPH

Test Configuration	Stop No.	Time (sec)	Temperature				
			Road Surface	Brakes			
				LF	RF	LR	RR
Dry, No Payload	Pull 1	13:46	67	153	158	79	83
"	Pull 2	13:52	68	160	155	90	86
"	Pull 3	13:59	68	158	160	91	89
"	Pull 4	14:05	69	153	149	88	86
"	Pull 5	14:11	68	155	152	88	87
"	Pull 6	14:17	68	153	157	89	85
"	Pull 7	14:22	67	161	155	92	90
"	Pull 8	14:29	68	160	153	95	91
"	Pull 9	14:35	69	166	153	94	90
"	Pull 10	14:41	69	168	165	94	89

TO: Greg Shultz
Data Site: Phillips Airfield
Dates: 30 Sept - 20 Nov 1998

ATC MET DIVISION
Met Data

Date	DST Time(+ 1hr)	Avg WdDir	Avg WdSpd	Avg SDWdD	Peak WSpd	Avg ATemp	Avg RHum	Avg Press	Tot Precp
9/30/98	13:00	209	2.987	29	4.802	28.44	63	1008.512	0
9/30/98	13:15	208	3.225	40	5.351	26.54	63	1008.387	0
9/30/98	13:30	227	2.866	20	4.661	26.82	61	1008.503	0
9/30/98	13:45	221	3.269	21	7.644	27.01	61	1008.678	0
9/30/98	14:00	212	3.473	28	5.174	26.97	61	1008.251	0
9/30/98	14:15	198	3.36	19	4.841	27.01	61	1008.048	0
9/30/98	14:30	193	4.005	14	5.449	27.11	60	1008.218	0
9/30/98	14:45	204	3.582	10	4.998	27.11	60	1008.218	0
9/30/98	15:00	188	3.382	13	4.645	26.98	61	1008.142	0
9/30/98	15:15	203	3.402	11	4.806	27.07	60	1007.984	0
9/30/98	15:30	202	3.115	13	4.782	27.29	60	1007.907	0
9/30/98	15:45	202	3.858	9	5.253	27.28	60	1007.883	0
9/30/98	16:00	207	3.132	12	4.39	27.1	60	1007.646	0
10/1/98	11:00	295	6.688	23	12.74	26.97	47	1006.928	0
10/1/98	11:15	328	5.771	20	11.51	24.61	49	1007.298	0
10/1/98	11:30	326	6.504	21	10.64	24.45	50	1007.692	0
10/1/98	11:45	320	6.041	21	12.25	24.42	48	1007.7	0
10/1/98	12:00	313	6.526	21	10.37	24.14	46	1007.709	0
10/1/98	12:15	325	6.467	19	9.49	24.64	44	1007.738	0
10/1/98	12:30	324	5.594	22	11.62	24.26	44	1007.732	0
10/1/98	12:45	314	5.951	19	11.21	23.6	43	1007.876	0
10/1/98	13:00	325	5.32	22	10.43	23.7	42	1008.014	0
10/1/98	13:15	307	6.163	18	12.05	23.27	38	1008.051	0
10/1/98	13:30	308	4.132	24	7.722	23.81	34	1008.315	0
10/1/98	13:45	302	6.028	21	12.25	23.34	30	1008.81	0
10/1/98	14:00	302	5.303	23	11.72	23.2	31	1008.589	0
10/1/98	14:15	298	6.364	23	10.27	23.26	31	1008.698	0
10/1/98	14:30	323	4.744	27	9.58	23.23	33	1008.798	0
10/1/98	14:45	328	5.177	23	8.29	22.75	32	1008.886	0
10/1/98	15:00	318	4.733	25	8.41	22.65	30	1009.173	0
10/7/98	10:00	148	2.627	15	4.194	16.81	69	1027.505	0
10/7/98	10:15	147	2.801	16	4.628	17.13	68	1027.413	0
10/7/98	10:30	158	2.637	17	4.547	17.63	67	1027.298	0
10/7/98	10:45	173	3.041	17	4.704	18.03	65	1027.124	0
10/7/98	11:00	174	2.788	23	4.939	18.48	64	1026.971	0
10/7/98	11:15	148	2.77	20	4.763	19.18	63	1026.791	0
10/7/98	11:30	147	3.549	27	5.155	19.34	63	1026.479	0
10/7/98	11:46	142	3.24	19	5.312	19.4	63	1026.247	0
10/7/98	12:00	134	3.16	19	5.096	19.72	62	1026.987	0
10/7/98	12:15	123	2.818	26	4.469	19.99	62	1026.699	0
10/7/98	12:30	121	3.031	14	5.527	20.02	62	1026.486	0
10/7/98	12:46	121	3.399	12	5.331	19.94	62	1026.194	0
10/7/98	13:00	122	3.083	21	5.488	20.43	62	1025.01	0
10/7/98	13:15	129	3.053	24	4.724	20.22	62	1024.879	0
10/7/98	13:30	126	3.3	16	5.076	20.33	62	1024.748	0
10/7/98	13:45	121	3.162	15	4.39	20.14	62	1024.583	0
10/7/98	14:00	124	3.313	11	4.469	20.12	62	1024.466	0
10/7/98	14:15	122	3.39	10	4.938	19.8	62	1024.254	0
10/7/98	14:30	119	2.315	12	3.528	19.52	63	1024.107	0
10/7/98	14:45	174	1.587	59	2.803	19.42	63	1023.876	0
10/7/98	15:00	238	1.882	16	2.43	19.37	64	1023.82	0
10/7/98	15:15	247	1.958	14	2.901	19.32	66	1023.618	0
10/7/98	15:30	212	1.272	26	2.293	18.95	67	1023.52	0
10/7/98	15:45	175	1.194	17	1.725	18.93	68	1023.393	0

TO: Greg Shultz
Data Site: Phillips Airfield
Dates: 30 Sept - 20 Nov 1998

ATC MET DIVISION
Met Data

Date	DST Time(+ (hr)	Avg WdDir	Avg WdSpd	Avg SDWdD	Peak WSpd	Avg ATemp	Avg RHem	Avg Press	Tot Precp
10/7/98	16:00	176	1.284	12	1.784	18.86	87	1023.256	0
10/8/98	08:00	143	1.295	16	2.332	19.49	95	1015.626	0
10/8/98	08:15	153	1.767	13	3.195	19.72	94	1015.329	0
10/8/98	08:30	167	2.1	11	3.254	19.98	92	1015.281	0
10/8/98	08:45	167	2.348	12	3.391	20.13	91	1015.078	0
10/8/98	09:00	170	2.78	12	4.724	20.3	91	1015.023	0.02
10/8/98	09:15	182	3.381	10	4.861	20.16	92	1014.939	0.05
10/8/98	09:30	177	3.127	10	4.861	19.9	94	1014.743	0.05
10/8/98	09:45	173	3.86	10	6.115	19.98	95	1014.555	0.05
10/8/98	10:00	186	3.791	10	5.606	20.08	95	1014.177	0.03
10/8/98	10:15	180	4.033	11	7.291	20.15	96	1013.926	0.05
10/8/98	10:30	166	3.682	12	6.525	20.25	96	1013.729	0.08
10/8/98	10:45	167	5.158	12	8.49	20.28	96	1013.571	0.13
10/8/98	11:00	180	6.041	19	9.51	20.41	96	1013.55	0.02
10/8/98	11:15	191	5.845	11	9.76	20.53	96	1013.595	0.02
10/8/98	11:30	199	7.402	10	11.88	20.83	96	1013.604	0.01
10/8/98	11:45	201	7.066	7	10	20.74	96	1013.64	0.01
10/8/98	12:00	204	7.753	7	11.47	20.77	96	1013.498	0
10/9/98	08:00	344	2.395	23	4.39	15.71	92	1014.369	0
10/9/98	08:15	350	1.941	28	3.861	15.79	92	1014.44	0
10/9/98	08:30	349	1.929	26	3.959	15.86	92	1014.482	0
10/9/98	08:45	2	2.09	24	3.92	15.87	92	1014.564	0
10/9/98	09:00	332	1.712	24	3.685	15.88	93	1014.591	0
10/9/98	09:15	329	2.266	23	4.92	15.86	94	1014.665	0
10/9/98	09:30	347	1.6	26	3.744	15.93	94	1014.607	0
10/9/98	09:45	344	1.824	27	3.214	16.02	95	1014.467	0.01
10/9/98	10:00	346	1.518	26	3.254	16.26	96	1014.476	0
10/9/98	10:15	2	1.713	26	3.45	16.28	96	1014.525	0
10/9/98	10:30	345	2.077	23	4.175	16.28	95	1014.564	0
10/9/98	10:45	338	2.116	19	3.802	16.3	95	1014.49	0
10/9/98	11:00	350	2.027	23	4.155	16.45	95	1014.369	0
10/9/98	11:15	348	1.827	21	3.626	16.65	95	1014.269	0
10/9/98	11:30	0	1.838	23	3.391	16.7	95	1014.21	0
10/9/98	11:45	349	1.751	23	3.038	16.73	95	1014.085	0
10/9/98	12:00	346	2.063	23	3.979	16.76	94	1013.834	0
10/9/98	12:15	346	2.21	21	3.822	16.75	94	1013.702	0
10/9/98	12:30	355	2.316	24	4.606	16.7	95	1013.633	0
10/9/98	12:45	342	2.269	20	4.884	16.78	95	1013.514	0
10/9/98	13:00	346	2.216	25	4.41	16.76	95	1013.332	0
10/9/98	13:15	344	2.848	22	5.253	16.67	95	1013.317	0
10/9/98	13:30	342	2.181	24	4.253	16.51	95	1013.353	0
10/9/98	13:45	330	1.817	22	3.606	16.49	95	1013.212	0
10/9/98	14:00	348	2.308	24	4.92	16.41	95	1013.033	0
10/9/98	14:15	351	1.781	22	4.743	16.44	95	1012.971	0
10/9/98	14:30	340	1.608	24	3.115	16.42	96	1012.933	0
10/9/98	14:45	338	1.621	25	2.92	16.43	96	1012.904	0
10/9/98	15:00	306	1.718	17	2.878	16.4	96	1012.87	0.03
10/13/98	12:00	217	3.875	16	6.468	19.93	66	1017.323	0
10/13/98	12:15	206	3.262	19	5.312	20.32	64	1017.095	0
10/13/98	12:30	215	3.681	18	5.841	20.29	63	1016.854	0
10/13/98	12:45	217	4.04	15	6.821	20.01	64	1016.526	0
10/13/98	13:00	234	3.638	11	6.076	19.5	66	1016.298	0
10/13/98	13:15	249	3.221	11	4.371	19.36	66	1016.06	0

TO: Greg Shultz
Data Site: Phillips Airfield
Dates: 30 Sept - 20 Nov 1998

ATC MET DIVISION
Met Data

Date	DST Time(+ 1hr)	Avg WdDir	Avg WdSpd	Avg SDWdD	Peak WSpd	Avg ATemp	Avg RHum	Avg Press	Tot Precp
10/13/98	13:30	218	2.619	18	4.861	19.45	65	1015.84	0
10/13/98	13:45	228	2.938	16	4.488	19.37	66	1015.635	0
10/13/98	14:00	223	2.838	21	4.282	19.36	66	1015.39	0
10/13/98	14:15	210	3.499	13	4.959	19.71	66	1015.104	0
10/13/98	14:30	207	3.82	10	5.664	19.85	64	1014.961	0
10/13/98	14:45	187	3.587	15	6.194	20.3	63	1014.809	0
10/13/98	15:00	182	4.42	12	6.115	20.27	63	1014.691	0
10/13/98	15:15	208	3.971	16	6.037	20.45	63	1014.41	0
10/13/98	15:30	219	3.779	10	5.037	20.13	62	1014.273	0
10/13/98	15:45	215	3.102	9	4.332	19.74	63	1014.25	0
10/13/98	16:00	216	3.163	11	4.39	19.49	64	1014.195	0
10/14/98	11:00	275	4.773	15	8.11	17.48	46	1012.921	0
10/14/98	11:15	300	3.68	23	6.899	17.61	46	1012.923	0
10/14/98	11:30	276	3.931	28	6.703	17.34	46	1012.883	0
10/14/98	11:45	271	5.317	17	7.644	17.86	45	1012.94	0
10/14/98	12:00	263	4.991	19	7.742	17.77	45	1012.91	0
10/14/98	12:15	266	4.808	16	7.115	17.81	45	1012.776	0
10/14/98	12:30	263	4.067	15	7.468	18.13	44	1012.732	0
10/14/98	12:45	267	3.868	23	7.134	18.18	44	1012.611	0
10/14/98	13:00	270	4.142	18	7.84	18.21	44	1012.46	0
10/14/98	13:15	279	4.552	28	7.507	18.19	45	1012.36	0
10/14/98	13:30	268	4.856	11	7.86	18.43	44	1012.306	0
10/14/98	13:45	286	3.871	31	7.33	18.62	44	1012.33	0
10/14/98	14:00	294	3.187	21	6.782	17.98	44	1012.305	0
10/14/98	14:15	290	3.605	19	6.84	18.27	44	1012.254	0
10/14/98	14:30	299	4.069	23	8.04	18.48	44	1012.306	0
10/14/98	14:45	309	3.686	26	7.017	18.37	44	1012.427	0
10/14/98	15:00	312	3.28	20	6.821	18.36	44	1012.543	0
10/14/98	15:15	293	3.818	22	6.586	18.26	43	1012.618	0
10/14/98	15:30	298	3.437	22	8.15	18.1	43	1012.764	0
10/14/98	15:45	281	3.772	19	7.683	18.12	44	1012.949	0
10/14/98	16:00	288	3.68	18	5.86	17.83	44	1013.139	0
10/14/98	16:15	291	3.316	19	5.88	17.67	44	1013.298	0
10/14/98	16:30	288	3.543	16	7.448	17.38	44	1013.468	0
10/14/98	16:45	289	3.261	16	5.88	16.99	44	1013.679	0
10/14/98	17:00	290	2.82	17	6.723	16.53	44	1013.978	0
10/15/98	09:00	262	3.69	14	5.86	13.32	64	1022.168	0
10/15/98	09:15	263	3.321	16	4.763	14.08	63	1022.096	0
10/15/98	09:30	268	3.601	11	5.884	13.97	63	1022.167	0
10/15/98	09:45	284	3.451	18	5.506	14.08	62	1022.227	0
10/15/98	10:00	284	2.948	21	5.135	14.47	61	1022.289	0
10/15/98	10:15	280	3.615	20	6.997	15.48	59	1022.339	0
10/15/98	10:30	290	3.049	27	5.458	15.77	58	1022.351	0
10/15/98	10:45	300	2.948	19	5.968	15.67	57	1022.293	0
10/15/98	11:00	293	2.656	23	4.528	15.8	57	1022.246	0
10/15/98	11:15	315	2.273	27	4.822	16.38	55	1022.231	0
10/15/98	11:30	301	2.9	30	5.037	16.8	52	1022.263	0
10/15/98	11:45	303	3.027	31	8.06	17.25	52	1022.182	0
10/15/98	12:00	322	2.916	28	6.263	17.46	49	1022.088	0
10/15/98	12:15	311	3.394	29	6.233	17.56	48	1021.897	0
10/15/98	12:30	329	2.654	35	7.193	17.56	48	1021.727	0
10/15/98	12:45	292	3.7	25	9.02	17.45	49	1021.682	0
10/15/98	13:00	316	3.233	27	6.699	17.39	48	1021.577	0
10/15/98	13:15	285	2.283	39	4.469	17.56	49	1021.452	0

TO: Greg Shultz
Data Site: Phillips Airfield
Dates: 30 Sept - 20 Nov 1998

ATC MET DIVISION
Met Data

Date	DST Time[+ 1hr]	Avg WdDir	Avg WdSpd	Avg SDWdD	Peak WSpd	Avg ATemp	Avg RlHum	Avg Press	Tot Precp
10/15/98	13:30	338	2.343	29	4.647	17.32	48	1021.379	0
10/15/98	13:45	359	2.07	23	4.194	17.29	48	1021.442	0
10/15/98	14:00	333	2.069	25	4.116	17.36	48	1021.53	0
10/15/98	14:15	335	2.27	19	4.214	17.44	47	1021.618	0
10/15/98	14:30	331	1.964	21	3.724	17.6	47	1021.661	0
10/15/98	14:45	300	1.746	31	3.332	18.17	47	1021.647	0
10/15/98	15:00	348	1.878	27	3.234	18.27	46	1021.711	0
10/15/98	15:15	333	1.752	24	3.763	18.69	46	1021.836	0
10/15/98	15:30	315	1.87	30	3.175	18.75	45	1021.904	0
10/15/98	15:45	310	1.323	19	2.609	18.26	46	1021.944	0
10/15/98	16:00	298	1.244	31	3.018	18.8	46	1022.003	0
10/19/98	08:00	276	1.013	16	1.569	15.98	88	1017.475	0
10/19/98	08:15	265	1.064	21	1.803	17.22	80	1017.786	0
10/19/98	08:30	208	1.101	16	1.784	18.51	72	1017.906	0
10/19/98	08:45	208	2.196	14	3.166	18.98	70	1017.86	0
10/19/98	09:00	315	1.256	59	4.038	19.8	68	1017.802	0
10/19/98	09:15	322	2.814	23	5.821	20.72	64	1017.819	0
10/19/98	09:30	334	3.918	18	6.821	21.24	62	1017.857	0
10/19/98	09:45	336	2.817	22	5.684	21.56	61	1018.119	0
10/19/98	10:00	323	3.061	23	5.253	20.96	61	1018.053	0
10/19/98	10:15	328	3.431	19	6.88	20.84	61	1018.081	0
10/19/98	10:30	315	3.286	21	7.213	21.57	60	1018.065	0
10/19/98	10:45	326	3.151	20	6.958	21.53	60	1018.208	0
10/19/98	11:00	302	2.916	23	5.645	21.32	60	1018.279	0
10/19/98	11:15	294	3.248	24	6.017	21.49	59	1018.188	0
10/19/98	11:30	314	2.987	24	6.174	21.08	59	1018.036	0
10/19/98	11:45	306	3.175	23	6.409	20.77	57	1018.046	0
10/19/98	12:00	301	2.828	22	4.488	20.63	56	1017.846	0
10/20/98	08:00	270	3.063	12	4.645	15.68	63	1019.579	0
10/20/98	08:15	287	2.464	22	4.743	16.65	61	1019.55	0
10/20/98	08:30	311	3.341	26	6.331	17.26	54	1019.687	0
10/20/98	08:45	308	3.121	23	6.762	17.5	50	1019.612	0
10/20/98	10:00	307	2.572	28	4.782	17.94	49	1019.548	0
10/20/98	10:15	303	4.107	19	7.154	18.17	48	1019.325	0
10/20/98	10:30	306	3.642	21	7.036	18.21	45	1019.145	0
10/20/98	10:45	287	4.526	20	7.624	18.4	45	1019.077	0
10/20/98	11:00	290	4.543	21	7.958	18.46	44	1019.031	0
10/20/98	11:15	288	3.887	19	8.017	18.76	44	1018.834	0
10/20/98	11:30	313	3.851	22	7.389	19.1	42	1018.651	0
10/20/98	11:45	310	4.4	21	8.06	19.15	38	1018.41	0
10/20/98	12:00	308	3.767	23	7.389	19.29	34	1018.151	0
10/20/98	12:15	296	3.649	23	7.33	19.63	33	1017.913	0
10/20/98	12:30	295	3.485	33	7.958	19.83	33	1017.712	0
10/20/98	12:45	296	4.641	21	9.13	19.84	28	1017.512	0
10/20/98	13:00	292	4.488	21	8.13	19.74	28	1017.234	0
10/20/98	13:15	298	4.26	19	6.488	19.96	28	1017.126	0
10/20/98	13:30	286	4.338	23	9.37	20.13	27	1017.047	0
10/20/98	13:45	284	4.789	17	9.74	20.05	28	1016.914	0
10/20/98	14:00	286	4.345	23	8.37	20.2	26	1016.763	0
10/21/98	08:00	263	1.868	7	3.175	9.49	74	1019.466	0
10/21/98	08:15	271	3.113	11	6.449	10	68	1019.719	0
10/21/98	08:30	276	3.812	11	6.056	10.5	65	1019.613	0
10/21/98	08:45	279	3.419	11	5.566	10.88	64	1019.709	0

TO: Greg Shultz
Data Site: Phillips Airfield
Dates: 30 Sept - 20 Nov 1998

ATC MET DIVISION
Met Data

Date	DST Time(+ 1hr)	Avg WdDir	Avg WdSpd	Avg SDWdD	Peak WSpd	Avg ATemp	Avg RHum	Avg Press	Tot Precip
10/21/98	09:00	276	2.982	12	4.82	10.99	64	1019.527	0
10/21/98	09:15	279	3.477	12	5.704	11.26	64	1019.276	0
10/21/98	09:30	276	3.488	13	5.86	11.48	64	1019.263	0
10/21/98	09:45	276	4.464	12	7.37	11.74	63	1019.263	0
10/21/98	10:00	274	5.485	13	9.82	12.05	62	1019.216	0
10/21/98	10:15	277	5.52	12	9.04	12.5	60	1019.04	0
10/21/98	10:30	280	4.259	19	8.33	12.83	58	1019.002	0
10/21/98	10:45	283	5.446	16	9.88	13.37	55	1018.868	0
10/21/98	11:00	275	5.945	13	8.64	13.71	52	1018.716	0
10/21/98	11:15	286	5.103	16	8.57	14.18	50	1018.85	0
10/21/98	11:30	286	4.328	19	7.683	14.75	47	1018.445	0
10/21/98	11:45	276	5.821	18	9.52	14.98	46	1018.052	0
10/21/98	12:00	288	4.449	24	9.92	14.97	45	1017.562	0
10/21/98	12:15	286	4.226	22	7.526	15.28	44	1017.138	0
10/21/98	12:30	303	4.141	25	7.703	15.23	44	1017.181	0
10/21/98	12:45	301	5.206	25	6.35	15.27	44	1016.914	0
10/21/98	13:00	279	5.987	22	9.45	15.58	43	1016.805	0
10/21/98	13:15	276	5.459	16	9.7	15.47	43	1016.348	0
10/21/98	13:30	297	3.618	26	7.977	15.91	42	1016.152	0
10/21/98	13:45	273	5.411	19	8.94	16.4	42	1016.053	0
10/21/98	14:00	279	5.114	17	9.84	16.41	40	1015.952	0
10/22/98	13:00	3	3.788	25	8.94	11.3	44	1023.427	0
10/22/98	13:15	344	4.179	22	7.899	11.02	44	1023.342	0
10/22/98	13:30	345	4.06	22	9.27	10.89	44	1023.462	0
10/22/98	13:45	347	3.842	18	7.84	10.82	44	1023.473	0
10/22/98	14:00	338	3.916	24	7.987	10.75	45	1023.518	0
10/22/98	14:15	340	3.687	24	8.41	10.89	45	1023.512	0
10/22/98	14:30	339	3.979	23	8.37	10.64	45	1023.614	0
10/22/98	14:45	336	4.711	18	9.37	10.43	45	1023.649	0
10/22/98	15:00	346	3.293	23	6.194	10.48	45	1023.648	0
10/22/98	15:15	340	3.879	20	8.25	10.36	45	1023.717	0
10/22/98	15:30	344	4.307	23	8.86	10.23	46	1023.871	0
10/22/98	15:45	336	4.246	23	8.7	10.82	46	1024.005	0
10/22/98	16:00	327	4.421	22	8.13	10.59	45	1024.105	0
10/23/98	08:00	268	2.3	9	3.371	6.491	70	1029.199	0
10/23/98	08:15	248	1.715	16	2.852	7.674	68	1029.262	0
10/23/98	08:30	258	2.624	14	4.43	8.67	66	1029.216	0
10/23/98	08:45	262	2.58	13	3.861	9.41	65	1029.087	0
10/23/98	09:00	276	2.947	18	5.39	10.35	64	1029.027	0
10/23/98	09:15	291	2.572	23	4.961	11.18	62	1028.919	0
10/23/98	09:30	285	2.988	26	5.292	11.86	60	1028.801	0
10/23/98	09:45	307	3.281	26	6.86	12.31	57	1028.658	0
10/23/98	10:00	304	3.664	26	8.27	12.68	53	1028.462	0
10/23/98	10:15	310	3.657	23	7.409	12.89	52	1028.264	0
10/23/98	10:30	316	2.773	36	6.115	13.24	51	1028.036	0
10/23/98	10:45	326	4.228	18	8.19	13.59	48	1027.78	0
10/23/98	11:00	323	3.921	24	7.86	13.94	47	1027.641	0
10/23/98	11:15	316	3.472	23	6.527	14.18	47	1027.538	0
10/23/98	11:30	330	3.886	27	8.21	14.44	46	1027.45	0
10/23/98	11:45	338	3.593	20	8.39	14.66	45	1027.257	0
10/23/98	12:00	297	4.15	24	7.426	14.82	45	1027.072	0
10/23/98	12:15	306	3.101	37	8.39	15.25	44	1026.879	0
10/23/98	12:30	297	3.823	25	6.762	15.35	44	1026.613	0
10/23/98	12:45	275	4.281	20	7.805	15.47	44	1026.418	0

TO: Greg Shultz
Data Site: Phillips Airfield
Dates: 30 Sept - 20 Nov 1998

ATC MET DIVISION
Met Data

Date	DST Time(+ 1hr)	Avg WdDir	Avg WdSpd	Avg SDWdD	Peak WSpd	Avg ATemp	Avg RHum	Avg Press	Tot Precp
10/23/98	13:00	280	4.319	26	7.37	16.61	44	1026.295	0
10/23/98	13:15	270	3.882	22	6.919	16.26	43	1026.129	0
10/23/98	13:30	289	4.324	14	6.646	15.92	43	1025.819	0
10/23/98	13:45	273	3.181	18	5.292	16.15	42	1025.676	0
10/23/98	14:00	276	3.298	19	5.253	16.55	41	1025.477	0
10/23/98	14:15	259	3.927	15	7.703	16.68	41	1025.364	0
10/23/98	14:30	264	3.712	23	6.821	16.71	40	1025.302	0
10/23/98	14:45	282	3.986	18	6.919	16.92	41	1026.174	0
10/23/98	15:00	271	4.023	16	7.134	16.92	39	1026.13	0
10/23/98	15:15	267	3.725	19	5.429	17.13	40	1026.102	0
10/23/98	15:30	268	4.35	19	7.095	16.87	40	1026.061	0
10/23/98	15:45	265	4.491	14	6.723	16.79	40	1025.111	0
10/23/98	16:00	252	4.019	12	6.213	16.69	39	1025.063	0
10/23/98	16:15	256	3.694	10	5.096	15.4	41	1026.019	0
10/23/98	16:30	266	4.007	10	5.802	16.09	41	1024.984	0
10/23/98	16:45	254	3.151	8	4.88	15.66	41	1024.894	0
10/23/98	17:00	263	2.628	7	3.626	14.89	43	1024.812	0
10/23/98	17:15	261	2.218	7	3.097	13.75	44	1024.861	0
10/23/98	17:30	247	2.059	6	2.46	12.72	46	1024.865	0
10/23/98	17:45	243	1.985	4	2.47	12.16	47	1024.816	0
10/23/98	18:00	244	2.069	5	2.548	11.68	48	1024.771	0
Date	BEGIN EST Time	Avg WdDir	Avg WdSpd	Avg SDWdD	Peak WSpd	Avg ATemp	Avg RHum	Avg Press	Tot Precp
10/30/98	08:00	253	1.502	10	2.234	8.453	90	1015.438	0
10/30/98	08:15	265	1.952	11	3.038	7.794	74	1015.356	0
10/30/98	08:30	282	1.324	16	2.058	9.07	68	1015.279	0
10/30/98	08:45	262	1.553	12	2.489	10.4	65	1015.165	0
10/30/98	09:00	279	2.123	13	3.038	11.46	63	1015.084	0
10/30/98	09:15	273	2.516	16	3.881	12.13	59	1014.88	0
10/30/98	09:30	291	2.413	24	3.822	12.8	53	1014.629	0
10/30/98	09:45	313	2.767	28	4.959	13.26	49	1014.24	0
10/30/98	10:00	326	3.666	24	6.429	13.51	48	1014.048	0
10/30/98	10:15	317	4.011	20	7.232	13.75	46	1013.774	0
10/30/98	10:30	310	3.521	27	6.544	14.23	45	1013.405	0
10/30/98	10:45	311	2.623	24	5.429	14.85	46	1013.268	0
10/30/98	11:00	300	3.057	29	5.449	15.15	46	1013.062	0
10/30/98	11:15	318	2.701	38	6.605	15.65	44	1012.741	0
10/30/98	11:30	303	3.188	28	5.018	15.89	43	1012.382	0
10/30/98	11:45	315	3.149	25	5.488	16.23	43	1011.993	0
10/30/98	12:00	319	3.16	27	5.743	16.64	41	1011.756	0
10/30/98	12:15	317	4.335	23	7.017	16.89	39	1011.395	0
10/30/98	12:30	314	3.716	22	6.997	17.01	38	1011.017	0
10/30/98	12:45	312	3.73	20	6.017	17.42	37	1010.748	0
10/30/98	13:00	306	3.863	23	7.997	17.36	36	1010.586	0
10/30/98	13:15	286	5.045	20	8.25	17.3	36	1010.29	0
10/30/98	13:30	294	4.03	24	8.8	17.6	36	1010.014	0
10/30/98	13:45	289	4.992	16	8	17.04	34	1009.776	0
10/30/98	14:00	288	3.964	18	7.409	17.53	34	1009.481	0
10/30/98	14:15	287	4.603	20	8.27	17.98	33	1009.257	0
10/30/98	14:30	281	5.621	12	8.15	17.9	32	1009.172	0
10/30/98	14:45	275	5.456	10	7.918	17.93	32	1009.045	0
10/30/98	15:00	284	4.23	16	6.819	18.16	32	1008.98	0
10/30/98	15:15	287	3.782	15	6.213	18.49	31	1008.863	0
10/30/98	15:30	287	3.283	21	5.704	18.89	30	1008.771	0

TO: Greg Shultz
Dete Site: Phillips Airfield
Dates: 30 Sept - 20 Nov 1998

ATC MET DIVISION
Met Data

Date	EST Time	Avg WdDir	Avg WdSpd	Avg SDWdD	Peak WSpd	Avg ATemp	Avg RHum	Avg Press	Tot Precip
10/30/98	15:45	298	3.609	18	5.664	18.7	29	1008.677	0
10/30/98	16:00	318	3.472	20	7.095	18.52	27	1008.609	0
10/30/98	16:15	327	2.941	17	5.086	18.36	28	1008.631	0
10/30/98	16:30	320	2.427	20	3.94	18.17	28	1008.645	0
10/30/98	16:45	315	2.26	17	4.39	17.74	29	1008.688	0
10/30/98	17:00	313	1.808	15	3.018	17.02	30	1008.756	0
10/30/98	17:15	300	1.54	13	2.842	16.78	32	1008.786	0
10/30/98	17:30	311	1.858	13	2.999	14.85	33	1008.758	0
10/30/98	17:45	314	1.776	9	2.411	14.38	34	1008.881	0
10/30/98	18:00	312	1.86	10	2.783	14.1	35	1008.987	0
11/2/98	09:00	317	2.436	31	4.822	11.38	53	1017.19	0
11/2/98	09:15	320	2.561	19	4.978	11.4	52	1017.135	0
11/2/98	09:30	315	2.469	24	6.017	11.88	51	1017.053	0
11/2/98	09:45	312	3.597	24	6.409	12.06	49	1017.015	0
11/2/98	10:00	337	2.464	27	5.076	12.27	49	1016.844	0
11/2/98	10:15	315	2.743	33	5.606	12.98	48	1016.717	0
11/2/98	10:30	333	2.536	30	5.978	13.37	47	1016.556	0
11/2/98	10:45	329	2.988	21	5.566	13.09	48	1016.385	0
11/2/98	11:00	345	3.094	18	4.88	13.04	48	1016.014	0
11/2/98	11:15	334	3.101	21	5.527	13.41	46	1016.011	0
11/2/98	11:30	335	2.792	24	5.606	13.78	45	1015.729	0
11/2/98	11:45	331	2.567	28	4.822	14.14	45	1015.597	0
11/2/98	12:00	335	2.774	29	5.214	14.51	44	1016.189	0
11/3/98	09:00	18	2.911	16	5.602	5.852	54	1016.313	0
11/3/98	09:15	6	2.663	19	5.527	6.271	53	1016.157	0
11/3/98	09:30	8	3.317	18	5.752	6.732	52	1016.008	0
11/3/98	09:45	33	2.924	20	5.527	7.185	51	1016.148	0
11/3/98	10:00	17	3.149	22	5.39	7.759	49	1016.881	0
11/3/98	10:15	36	4.02	22	7.017	7.686	49	1015.58	0
11/3/98	10:30	26	2.882	19	5.214	7.402	49	1015.889	0
11/3/98	10:45	41	3.821	15	4.978	7.322	49	1015.602	0
11/3/98	11:00	21	3.202	14	5.214	7.119	49	1015.832	0
11/3/98	11:15	26	2.803	18	4.92	7.077	50	1015.591	0
11/3/98	11:30	19	2.246	21	4.39	6.918	50	1015.282	0
11/3/98	11:45	35	2.188	14	4.371	6.793	50	1015.051	0
11/3/98	12:00	353	1.749	26	3.528	7.324	50	1014.989	0
11/3/98	12:15	16	1.907	36	3.45	8.21	49	1014.853	0
11/3/98	12:30	29	1.426	41	3.018	8.41	48	1014.911	0
11/3/98	12:45	49	1.708	68	3.881	9.14	48	1014.625	0
11/3/98	13:00	360	1.701	33	3.41	8.88	47	1014.411	0
11/3/98	13:15	24	1.235	47	2.942	8.38	48	1014.084	0
11/3/98	13:30	21	1.882	32	3.685	8.33	47	1013.965	0
11/3/98	13:45	338	1.44	52	2.568	8.47	47	1013.896	0
11/3/98	14:00	16	1.327	31	2.842	8.81	47	1013.641	0
11/3/98	14:15	92	0.888	37	2.96	9.05	47	1013.42	0
11/3/98	14:30	282	1.048	69	2.646	9.32	47	1013.241	0
11/3/98	14:45	313	1.144	43	2.528	9.29	47	1013.105	0
11/3/98	15:00	339	1.42	44	3.058	9.83	46	1012.987	0
11/3/98	15:15	297	0.884	28	1.803	9.8	46	1013.003	0
11/3/98	15:30	339	1.007	32	1.665	10.24	46	1012.837	0
11/3/98	15:45	340	0.497	30	0.98	9.45	48	1012.815	0
11/3/98	16:00	259	1.096	12	1.509	8.72	47	1012.703	0
11/6/98	08:00	364	0.87	18	1.588	3.64	69	1015.883	0

TO: Greg Shultz
Data Site: Phillips Airfield
Dates: 30 Sept - 20 Nov 1998

ATC MET DIVISION
Met Data

Date	EST Time	Avg WdDir	Avg WdSpd	Avg SDWdD	Peak WSpd	Avg ATemp	Avg RHum	Avg Press	Tot Precp
11/18/98	11:45	1	2.72	21	5.608	9.88	47	1028.772	0
11/18/98	12:00	345	2.76	28	5.174	10.35	46	1028.627	0
11/18/98	12:15	3	2.515	33	4.939	10.67	45	1028.338	0
11/18/98	12:30	340	2.527	41	4.66	11	45	1028.134	0
11/18/98	12:45	337	2.502	34	5.41	11.02	45	1028.033	0
11/18/98	13:00	3	2.64	35	4.645	11.51	46	1027.914	0
11/18/98	13:15	324	3.673	20	5.272	11.22	44	1027.808	0
11/18/98	13:30	1	2.948	20	4.861	11.24	44	1027.715	0
11/18/98	13.45	10	2.838	20	4.92	11.29	44	1027.52	0
11/18/98	14.00	343	2.217	27	4.351	11.59	43	1027.237	0
11/18/98	14:15	336	1.699	50	4.018	11.84	42	1027.173	0
11/18/98	14:30	23	2.226	34	4.488	12.3	42	1027.09	0
11/18/98	14:45	28	1.498	76	4.234	12.15	41	1027.068	0
11/18/98	15:00	40	1.779	20	2.705	12.3	41	1027.068	0
11/18/98	15:15	23	2.272	42	3.9	12.23	41	1027.046	0
11/18/98	15:30	352	2.099	25	3.628	11.84	41	1027.168	0
11/18/98	15:45	15	1.813	23	2.764	11.72	41	1027.251	0
11/18/98	16:00	31	2.011	13	3.234	11.38	40	1027.294	0
11/20/98	08:00	35	0.225	54	0.51	8.81	100	1012.852	0
11/20/98	08:15	29	0.483	9	0.823	9	99	1012.731	0
11/20/98	08:30	20	0.493	17	0.784	10.41	99	1012.701	0
11/20/98	08:45	30	0.6	11	0.902	11.87	98	1012.402	0
11/20/98	09:00	21	0.873	14	1.313	12.47	98	1012.253	0
11/20/98	09:15	48	0.704	28	1.352	12.85	98	1012.204	0
11/20/98	09:30	103	1.079	20	2.156	13.57	98	1011.91	0
11/20/98	09:45	148	1.558	17	2.47	13.8	98	1011.802	0
11/20/98	10:00	160	1.624	17	2.862	14.38	97	1011.594	0
11/20/98	10:15	177	2.164	17	3.628	14.74	94	1011.513	0
11/20/98	10:30	207	3.801	11	5.263	15.41	87	1011.39	0
11/20/98	10:45	198	4.096	13	6.017	16.16	83	1011.302	0
11/20/98	11:00	213	4.337	17	6.115	16.61	78	1011.123	0
11/20/98	11:15	206	4.411	12	6.86	16.62	78	1010.72	0
11/20/98	11:30	199	3.981	10	5.39	16.69	78	1010.226	0
11/20/98	11:45	197	3.948	15	5.41	17.05	76	1009.712	0
11/20/98	12:00	207	3.829	12	5.272	16.56	77	1009.588	0
11/20/98	12:15	186	4.15	9	5.845	16.58	78	1009.118	0
11/20/98	12:30	198	4.392	13	5.808	16.42	78	1008.965	0
11/20/98	12:45	214	3.583	13	5.253	16.14	77	1008.98	0
11/20/98	13:00	202	4.018	10	5.312	16.23	77	1008.641	0
11/20/98	13:15	214	3.3	9	4.351	16.16	77	1008.472	0
11/20/98	13:30	215	3.063	11	4.822	16.27	76	1008.22	0
11/20/98	13:45	218	2.711	12	4.116	16.37	75	1007.779	0
11/20/98	14:00	232	1.944	15	3.136	16.48	75	1007.638	0
11/20/98	14:15	243	1.821	14	3.058	16.68	75	1007.549	0
11/20/98	14:30	265	2.494	12	3.528	16.79	75	1007.552	0
11/20/98	14:45	268	2.53	12	3.626	16.67	76	1007.632	0
11/20/98	15:00	266	2.36	16	3.783	16.64	75	1007.543	0
11/20/98	15:15	273	2.031	11	3.077	15.55	76	1007.708	0
11/20/98	15:30	257	1.608	10	2.097	15.44	77	1007.632	0
11/20/98	15:45	260	1.038	15	1.646	15.36	78	1007.328	0
11/20/98	16:00	322	1.81	17	3.528	16.09	80	1007.578	0

Date	Time	Avg WdDir	Avg WdSpd	Avg SDWdD	Peak WSpd	Avg ATemp	Avg RHum	Avg Press	Tot Precp
MM/DD/YY	HH:MM	Degrees	M/S	Degrees	M/S	DegCelsius	%	Millibars	Inches

Greg Schultz, Jay 3-7700

Aberdeen Meteorological Network

DCP7 Latitude: 39.45 Longitude: 76.17 Elevation: 16.8 M Phillips Air Field

Time(EST) +1 hr (EDT)	Wind Direct (°)	Wind Speed (Mph)	Std Dev WD (°)	Peak Wind Speed (Mph)	Air Temp (°F)	Max Air Temp (°F)	Min Air Temp (°F)	Rel Humd (%)	Solar Rad W/m²	Soil T/Wet Bulb (°F)	Total Precip (Inch)	Press (Ins)	Batt Voltage (VDC)
Thursday, November 12, 1998													
08:30	252	5.5	9	7.9	44.8	45.4	44.1	56	271.8		0.00		14.4
08:45	262	4.6	10	6.8	45.9	46.7	45.3	58	315.1		0.00		14.4
09:00	290	5.8	19	9.8	47.6	48.5	46.7	51	358.1		0.00		14.3
09:15	289	7.4	19	12.8	49.0	49.2	48.5	47	396.9		0.00		14.3
09:30	284	8.5	15	12.4	49.4	49.7	49.2	46	431.6		0.00		14.3
09:45	283	8.7	13	12.0	49.7	50.0	49.5	46	462.4		0.00		14.3
10:00	296	7.7	19	12.7	50.4	50.9	49.9	45	492.3		0.00		14.3
10:15	282	8.6	15	12.7	50.9	51.3	50.8	45	521.0		0.00		14.3
10:30	296	7.2	23	12.1	51.6	52.0	51.3	45	544.0		0.00		14.3
10:45	306	7.8	19	14.2	51.9	52.1	51.7	44	562.7		0.00		14.3
11:00	313	6.9	26	12.9	52.7	53.0	52.0	43	575.0		0.00		14.2
11:15	318	8.3	23	14.5	52.8	53.1	52.5	42	591.4		0.00		14.2
11:30	290	6.6	25	15.1	53.4	53.9	52.9	42	597.6		0.00		14.2
11:45	304	6.9	28	15.3	54.0	54.8	53.7	41	592.5		0.00		14.2
12:00	297	7.6	28	14.3	55.0	55.2	54.7	40	571.2		0.00		14.2
12:15	318	7.2	26	12.2	55.0	55.3	54.8	37	577.4		0.00		14.2
12:30	270	5.7	21	10.7	55.5	56.3	55.2	36	584.0		0.00		14.2
12:45	310	6.6	25	12.6	56.3	56.7	56.1	34	561.9		0.00		14.2
13:00	300	6.7	30	16.6	56.7	57.0	56.4	31	548.2		0.00		14.2
13:15	308	6.1	32	13.4	57.1	57.5	56.6	29	529.5		0.00		14.2
13:30	282	7.1	23	12.7	56.8	57.1	56.6	29	508.5		0.00		14.2
13:45	297	5.2	43	10.0	57.0	57.5	56.7	29	479.0		0.00		14.2
14:00	266	7.4	20	11.3	56.9	57.1	56.8	29	444.3		0.00		14.2
14:15	274	6.4	19	10.9	57.3	57.6	56.9	28	409.7		0.00		14.2
14:30	258	5.2	31	10.5	57.3	57.7	57.2	28	374.3		0.00		14.2
14:45	303	5.9	35	12.6	57.8	58.0	57.6	27	336.6		0.00		14.2
15:00	272	5.3	22	10.7	57.8	58.3	57.6	26	293.5		0.00		14.2
15:15	292	2.4	47	5.3	59.1	59.6	58.3	25	253.3		0.00		14.2
15:30	270	5.2	17	9.7	58.9	59.8	58.2	25	214.4		0.00		14.2
15:45	272	5.5	19	10.4	57.8	58.3	57.5	25	171.6		0.00		14.2
16:00	289	4.8	15	8.3	57.5	57.6	57.4	25	128.3		0.00		14.2
16:15	283	3.8	17	7.7	56.9	57.4	56.6	24	84.3		0.00		14.2
16:30	273	3.0	13	5.3	56.2	56.7	55.6	25			0.00		14.2
Average		6.3		11.4	54.2	54.6	53.8	36	430.7				14.2
Maximum		8.7		16.6	59.1	59.8	58.3	58	597.6				14.4
Minimum		2.4		5.3	44.8	45.4	44.1	24	84.3				14.2
Total											0.00		

APPENDIX H. ASTM FRICTIONAL SKID RESISTANCE TEST DATA

ABERDEEN PROVING GROUND
FRICTIONAL SKID RESISTANCE TESTING
ASTM E 274 - 90 / ASTM E 1337 - 90 (Reapproved 1996)

↑CH:2?

DATE OF TESTING : 09/17/98 **PAGE:** 1/1

TARGET SPEED : 40 MPH **TEST WHEEL :** LEFT

TEST SITE : RUNWAY 22 & 17
PAVEMENT TYPE : ASPHALT
TEST TYPE : DRY
COMMENTS : ASTM E 1337 - 90

TEST NUMBER	PEAK VALUE	TEST SPEED	AIR TEMP
1	95.7	40.1	82
2	97.0	40.4	82
3	96.8	39.6	80
4	96.2	39.3	80
5	92.2	39.5	80
6	94.3	39.8	80
7	94.0	40.0	80
8	93.8	40.0	82
9	94.4	40.8	80
10	94.5	39.9	80

TEST SITE : RUNWAY 22 & 17
PAVEMENT TYPE : ASPHALT
TEST TYPE : WET
COMMENTS : ASTM E 1337 - 90

TEST NUMBER	PEAK VALUE	TEST SPEED	AIR TEMP
1	84.6	40.3	86
2	84.7	39.6	86
3	87.6	39.5	84
4	87.2	39.7	84
5	87.2	40.0	84
6	89.0	39.3	82
7	85.4	40.4	87
8	86.9	39.4	87
9	88.5	39.3	82
10	87.8	40.0	82

TEST SITE : RUNWAY 22
PAVEMENT TYPE : ASPHALT
TEST TYPE : DRY
COMMENTS : ASTM E 1337 - 90

TEST NUMBER	PEAK VALUE	TEST SPEED	AIR TEMP
1	91.2	39.1	82
2	94.8	39.1	82
3	94.9	39.1	82
4	93.7	39.1	82
5	93.2	39.1	82
6	92.4	39.1	82
7	94.6	39.1	82
8	93.4	39.1	82
9	94.4	39.1	82
10	94.5	39.1	82

TEST SITE : RUNWAY 22
PAVEMENT TYPE : ASPHALT
TEST TYPE : WET
COMMENTS : ASTM E 1337 - 90

TEST NUMBER	PEAK VALUE	TEST SPEED	AIR TEMP
1	83.6	39.5	87
2	85.3	40.6	86
3	87.8	40.3	86
4	87.2	40.4	86
5	88.3	40.4	84
6	86.8	40.4	84
7	86.9	40.8	84
8	87.3	40.1	84
9	89.4	39.8	84
10	86.9	39.8	84

ABERDEEN PROVING GROUND
FRICTIONAL SKID RESISTANCE TESTING
ASTM E 274 - 90 / ASTM E 1337 - 90 (Reapproved 1996)

DATE OF TESTING : 10/01/98 **PAGE:** 1/2

TARGET SPEED : 40 MPH **TEST WHEEL :** LEFT

TEST SITE : RUNWAY 22 & 17
PAVEMENT TYPE : ASPHALT
TEST TYPE : DRY
COMMENTS : ASTM E 1337 - 90

TEST NUMBER	PEAK VALUE	TEST SPEED	AIR TEMP
1	93.4	39.4	78
2	94.3	40.3	78
3	94.3	40.7	78
4	94.6	39.9	78
5	93.7	39.2	78
6	93.5	39.9	77
7	92.2	39.9	77
8	93.7	39.4	77
9	93.7	39.7	77
10	92.3	40.3	77

TEST SITE : RUNWAY 22 & 17
PAVEMENT TYPE : ASPHALT
TEST TYPE : WET
COMMENTS : ASTM E 1337 - 90

TEST NUMBER	PEAK VALUE	TEST SPEED	AIR TEMP
1	86.4	39.7	75
2	85.6	39.7	75
3	85.4	39.5	75
4	85.9	39.6	75
5	85.6	41.0	75
6	84.8	40.3	75
7	85.8	39.4	75
8	86.8	39.2	75
9	85.5	39.7	75
10	86.9	40.6	75

TEST SITE : RUNWAY 17
PAVEMENT TYPE : JENNITE
TEST TYPE : WET
COMMENTS : ASTM E 1337 - 90

TEST NUMBER	PEAK VALUE	TEST SPEED	AIR TEMP
1	59.4	40.6	78
2	45.7	40.4	69
3	45.6	40.1	73
4	59.4	40.1	73
5	46.5	40.2	73
6	59.4	40.5	73
7	44.0	39.9	73
8	45.6	39.7	73
9	45.5	39.3	73
10	47.0	40.2	73

TEST SITE : RUNWAY 17
PAVEMENT TYPE : ASPHALT
TEST TYPE : WET
COMMENTS : ASTM E 1337 - 90

TEST NUMBER	PEAK VALUE	TEST SPEED	AIR TEMP
1	75.2	40.6	84
2	74.8	39.1	84
3	74.9	40.0	84
4	74.9	40.5	75
5	75.6	39.6	75
6	75.5	40.7	75
7	75.5	40.5	75
8	76.0	40.0	75
9	75.6	39.7	73
10	76.3	40.1	75

ABERDEEN PROVING GROUND
FRICTIONAE SKID RESISTANCE TESTING
ASTM E 274 -90 / ASTM E 1337 -90 (Reapproved 1996)

DATE OF TESTING : 10/19/98 **PAGE:** 1/1

TARGET SPEED : 40 MPH **TEST WHEEL :** LEFT

TEST SITE : RUNWAY 22 & 17
PAVEMENT TYPE : ASPHALT
TEST TYPE : DRY
COMMENTS : ASTM E 1337 - 90

TEST NUMBER	PEAK VALUE	TEST SPEED	AIR TEMP
1	94.6	39.4	71
2	93.6	40.1	71
3	95.6	40.6	71
4	92.2	40.7	71
5	94.3	40.7	71
6	92.2	39.9	71
7	95.2	40.6	71
8	91.6	40.6	71
9	90.3	41.0	69
10	92.8	40.6	69

TEST SITE : RUNWAY 22 & 17
PAVEMENT TYPE : ASPHALT
TEST TYPE : WET
COMMENTS : ASTM E 1337 - 90

TEST NUMBER	PEAK VALUE	TEST SPEED	AIR TEMP
1	86.7	40.6	71
2	90.0	39.6	71
3	88.1	39.6	71
4	87.7	40.2	71
5	90.1	40.7	71
6	87.0	39.6	71
7	88.9	40.4	71
8	87.4	39.2	69
9	87.8	39.4	69
10	84.1	40.0	69

TEST SITE :
PAVEMENT TYPE :
TEST TYPE :
COMMENTS :

TEST NUMBER	PEAK VALUE	TEST SPEED	AIR TEMP

TEST SITE :
PAVEMENT TYPE :
TEST TYPE :
COMMENTS :

TEST NUMBER	PEAK VALUE	TEST SPEED	AIR TEMP

ABERDEEN PROVING GROUND
FRICTIONAL SKID RESISTANCE TESTING
ASTM E 274 - 90/ ASTM E 1337 - 90 (Reapproved 1996)

DATE OF TESTING : 09/22/98 **PAGE:** 1/1

TARGET SPEED : 40 MPH **TEST WHEEL :** LEFT

TEST SITE : RUNWAY 22 & 17
PAVEMENT TYPE : ASPHALT
TEST TYPE : DRY
COMMENTS : ASTM E 1337 - 90

TEST NUMBER	PEAK VALUE	TEST SPEED	AIR TEMP
1	96.1	40.1	77
2	95.5	39.3	77
3	94.1	39.7	77
4	92.9	39.4	77
5	92.7	38.8	77
6	92.7	39.2	77
7	91.7	40.1	77
8	92.8	40.9	77
9	94.8	40.9	77
10	94.1	41.1	77

TEST SITE : RUNWAY 22 & 17
PAVEMENT TYPE : ASPHALT
TEST TYPE : WET
COMMENTS : ASTM E 1337 - 90

TEST NUMBER	PEAK VALUE	TEST SPEED	AIR TEMP
1	88.9	40.5	77
2	88.9	40.5	77
3	87.2	40.7	77
4	89.7	40.7	77
5	90.2	40.7	77
6	88.5	39.8	77
7	88.5	39.9	77
8	86.6	40.1	77
9	87.7	40.3	77
10	86.0	40.6	77

TEST SITE :
PAVEMENT TYPE :
TEST TYPE :
COMMENTS :

TEST NUMBER	PEAK VALUE	TEST SPEED	AIR TEMP

TEST SITE :
PAVEMENT TYPE :
TEST TYPE :
COMMENTS :

TEST NUMBER	PEAK VALUE	TEST SPEED	AIR TEMP

ABERDEEN PROVING GROUND
FRICTIONAL SKID RESISTANCE TESTING
ASTM E 274-90 / ASTM E 1337-90 (Reapproved 1996)

DATE OF TESTING : 11/09/98 **PAGE:** 1/1

TARGET SPEED : 40 MPH **TEST WHEEL :** LEFT

TEST SITE : RUNWAY 22 & 17
PAVEMENT TYPE : ASPHALT
TEST TYPE : DRY
COMMENTS : ASTM E 1337 - 90

TEST NUMBER	PEAK VALUE	TEST SPEED	AIR TEMP
1	89.7	39.7	53
2	88.8	39.3	53
3	91.5	40.0	53
4	90.7	40.7	53
5	93.6	39.7	53
6	92.0	40.4	53
7	89.9	40.8	53
8	90.3	40.2	53
9	88.8	40.3	53
10	89.2	40.1	53

TEST SITE : RUNWAY 22 & 17
PAVEMENT TYPE : ASPHALT
TEST TYPE : WET
COMMENTS : ASTM E 1337 - 90

TEST NUMBER	PEAK VALUE	TEST SPEED	AIR TEMP
1	87.8	40.3	53
2	87.5	41.0	53
3	86.3	40.6	53
4	85.6	40.8	53
5	86.3	40.9	53
6	86.8	40.7	53
7	87.4	40.7	53
8	87.2	41.0	53
9	86.5	39.8	53
10	86.1	40.5	53

TEST SITE : RUNWAY 17 (LARGE RADIUS)
PAVEMENT TYPE : JENNITE
TEST TYPE : WET
COMMENTS : ASTM E 1337 - 90

TEST NUMBER	PEAK VALUE	TEST SPEED	AIR TEMP
1	32.2	39.5	55
2	31.1	39.2	55
3	32.3	40.0	55
4	35.4	40.4	55
5	35.8	40.5	55
6	31.7	40.1	55
7	36.7	39.8	55
8	31.1	38.7	53
9	30.5	39.5	53
10	33.9	40.4	53

TEST SITE : RUNWAY 17 (SMALL RADIUS)
PAVEMENT TYPE : JENNITE
TEST TYPE : WET
COMMENTS : ASTM E 1337 - 90

TEST NUMBER	PEAK VALUE	TEST SPEED	AIR TEMP
1	41.7	40.9	53
2	37.7	40.3	53
3	36.8	39.6	53
4	36.9	39.6	53
5	40.3	40.4	53
6	32.8	40.6	53
7	37.1	40.8	53
8	37.9	40.8	53
9	34.3	40.9	53

ABERDEEN PROVING GROUND
FRICTIONAL SKID RESISTANCE TESTING
ASTM E 274 -90/ ASTM E 1337 -90 (Reapproved 1996)

DATE OF TESTING : 10/15/98 **PAGE:** 1/1

TARGET SPEED : 40 MPH **TEST WHEEL :** LEFT

TEST SITE : RUNWAY 22 & 17
PAVEMENT TYPE : ASPHALT
TEST TYPE : DRY
COMMENTS : ASTM E 1337 - 90

TEST NUMBER	PEAK VALUE	TEST SPEED	AIR TEMP
1	90.9	40.6	62
2	87.7	40.0	62
3	88.7	39.6	62
4	90.6	39.5	62
5	90.0	39.9	62
6	91.4	40.9	62
7	88.4	40.6	62
8	87.9	40.3	62
9	89.3	39.6	62
10	87.9	39.6	62

TEST SITE : RUNWAY 22 & 17
PAVEMENT TYPE : ASPHALT
TEST TYPE : WET
COMMENTS : ASTM E 1337 - 90

TEST NUMBER	PEAK VALUE	TEST SPEED	AIR TEMP
1	84.9	39.3	66
2	84.4	39.1	66
3	85.6	39.3	66
4	85.2	40.0	66
5	83.7	40.6	66
6	83.5	41.2	66
7	84.5	40.2	66
8	85.0	39.8	66
9	84.7	39.6	66
10	85.1	39.3	64

TEST SITE :
PAVEMENT TYPE :
TEST TYPE :
COMMENTS :

TEST NUMBER	PEAK VALUE	TEST SPEED	AIR TEMP

TEST SITE :
PAVEMENT TYPE :
TEST TYPE :
COMMENTS :

TEST NUMBER	PEAK VALUE	TEST SPEED	AIR TEMP

APPENDIX J. SAMPLE WIND FORCE CALCULATION

Wind Effect Analysis

Given: Vehicle velocity during breaking with no wind at 0.1-second intervals
Note: Refer to the following three spreadsheets throughout the process below.

1) Calculate stopping distance with no wind:
   a) Find deceleration (a1) (a1 is negative since it is a deceleration):

$$a1 = \frac{\Delta v1}{\Delta t}$$

   b) Find the stopping force (F1) by Newton's Law (also negative):

$$F1 = Mass * a1$$

   c) Calculate the stopping distance using the given velocity:

$$d1_n = d1_{n-1} + v1_{n-1} * \Delta t$$

2) Determine the drag forces caused by head and tail winds:
   a) First, calculate the drag force with no wind:

$$D_1 = \frac{C_D A_p \rho V^2}{2}$$

$$D_1 = DragForce(lb)$$
$$C_D = DragCoefficient = .3$$
$$A_p = FrontalArea(ft\text{^}2) = 25$$
$$\rho = AirDensity(lb * s\text{^}2 / ft) = .00234$$
$$V = Velocity(ft / s)$$

   b) Add 14.7 ft/s (10 mph) of wind to the velocity for a head wind and subtract it for a tail wind.
   c) Calculate the drag forces with head and tail winds using the new velocities (D_+ and D_-).
   d) Since the drag force with no wind is already included in the calculation of step 1, only the difference in drag caused by wind is needed for the calculations:

$$D_2 = D_1 - D_+$$
$$D_3 = D_1 - D_-$$

3) Calculate the stopping distances as affected by wind:
   a) Add the drag forces by the wind from the stopping force without wind to get the total stopping forces in wind:

$$F_2 = F_1 + D_2$$
$$F_3 = F_1 + D_3$$

   b) Calculate the deceleration rates by dividing the mass of the vehicle from these new stopping forces

$$a_2 = \frac{F_2}{m}$$
$$a_3 = \frac{F_3}{m}$$

   c) Calculate the new velocity profiles using these decelerations:

$$V2_n = V2_{n-1} + a2_n * \Delta t$$
$$V3_n = V3_{n-1} + a3_n * \Delta t$$

   d) Using these velocities, calculate the stopping distance in the same way as in step 1-c.
   e) To find the differences in stopping distance due to wind, subtract the no wind stopping distance from each of the two distances:

$$\Delta d_2 = d_2 - d_1$$
$$\Delta d_3 = d_3 - d_1$$

4) These results can be further refined by additional iteration. To do this, substitute the results for V2 and V3 into the procedure at step 2-b, and repeat the remaining calculations. Continue to iterate this process until the stopping distance results converge. The results from this analysis converged after three iterations.

ABERDEEN PROVING GROUND
FRICTIONAL SKID RESISTANCE TESTING
ASTM E 274 - 90 / ASTM E 1337 - 90 (Reapproved 1996)

DATE OF TESTING : 11/24/98 **PAGE:** 1/2

TARGET SPEED : 40 MPH **TEST WHEEL :** LEFT

TEST SITE : RUNWAY 22 & 17
PAVEMENT TYPE : ASPHALT
TEST TYPE : DRY
COMMENTS : ASTM E 1337 - 90

TEST NUMBER	PEAK VALUE	TEST SPEED	AIR TEMP
1	93.4	40.0	60
2	91.0	39.2	60
3	91.7	40.8	59
4	91.0	39.6	59
5	89.2	39.5	59
6	93.1	40.4	59
7	92.7	40.3	59
8	91.7	40.3	59
9	91.0	40.3	59
10	91.1	40.3	59

TEST SITE : RUNWAY 22 & 17
PAVEMENT TYPE : ASPHALT
TEST TYPE : WET
COMMENTS : ASTM E 1337 - 90

TEST NUMBER	PEAK VALUE	TEST SPEED	AIR TEMP
1	87.5	39.7	59
2	87.9	39.1	59
3	88.9	38.5	59
4	86.8	39.5	59
5	84.3	41.5	59
6	87.6	40.4	59
7	87.2	40.0	59
8	86.7	39.7	59
9	86.8	39.9	59
10	87.4	40.1	59

TEST SITE : RUNWAY 17 (LARGE RADIUS)
PAVEMENT TYPE : JENNITE
TEST TYPE : WET
COMMENTS : ASTM E 1337 - 90

TEST NUMBER	PEAK VALUE	TEST SPEED	AIR TEMP
1	35.4	40.2	62
2	37.1	39.8	62
3	38.0	39.8	62
4	35.8	39.8	62
5	33.8	39.5	62
6	34.4	39.7	60
7	33.2	39.2	60
8	34.8	38.8	59
9	38.9	40.0	59
10	35.2	40.1	60

TEST SITE : RUNWAY 17 (SMALL RADIUS)
PAVEMENT TYPE : JENNITE
TEST TYPE : WET
COMMENTS : ASTM E 1337 - 90

TEST NUMBER	PEAK VALUE	TEST SPEED	AIR TEMP
1	43.1	40.7	60
2	41.9	40.8	60
3	39.2	40.9	60
4	40.9	40.8	60
5	38.0	40.6	60
6	45.8	40.1	60
7	40.1	39.9	60
8	41.1	39.8	60
9	44.4	39.6	60

Vehicle frontal area (ft^2):	25
Vehicle coefficient of drag:	0.3
Vehicle mass (slugs):	101.9
Wind velocity (mph):	10

Delta1	-0.77	2nd iter	-0.78	3rd iter	-0.78
Delta2	0.58	2nd iter	0.58	3rd iter	0.58

1st Iteration

v1 (mph)	v1 (ft/s)	a1 (ft/s^2)	F1 (lbf)	Drag(nom) (lbf)
91.00	89.56	0.00	0.00	70.55
90.88	89.49	-1.76	-180.95	70.27
89.79	87.89	-15.98	-1629.25	67.78
87.61	84.69	-31.96	-3258.65	62.94
85.44	81.50	-31.96	-3258.65	58.23
82.78	77.59	-39.06	-3980.45	52.89
80.49	74.22	-33.74	-3437.60	48.33
78.68	71.56	-26.63	-2713.60	44.93
76.88	68.88	-26.63	-2713.95	41.65
74.93	66.05	-28.41	-2894.90	38.25
72.64	62.68	-33.74	-3437.60	34.47
70.22	59.13	-35.51	-3618.55	30.68
68.29	56.28	-28.41	-2894.90	27.80
66.24	53.27	-30.18	-3075.70	24.90
63.82	49.72	-35.51	-3618.55	21.69
61.52	46.34	-33.74	-3437.60	18.84
59.35	43.15	-31.96	-3258.65	16.34
57.54	40.48	-26.63	-2713.95	14.38
55.12	36.93	-35.51	-3618.55	11.97
53.07	33.91	-30.18	-3075.55	10.09
50.78	30.54	-33.74	-3437.60	8.18
48.98	27.88	-26.63	-2713.95	6.82
46.79	24.68	-31.96	-3258.65	5.34
44.88	21.94	-28.41	-2894.75	4.19
42.60	18.82	-30.18	-3075.65	3.11
40.63	15.62	-31.96	-3258.65	2.14
38.33	12.25	-33.74	-3437.60	1.32
36.28	9.23	-30.18	-3075.65	0.75
34.11	6.04	-31.96	-3258.65	0.32
31.93	2.84	-31.96	-3258.65	0.07
30.48	0.71	-35.51	-3618.55	0.00

Wind Vel(+) (mph)	Drag(+) (lbf)
91.00	95.56
90.88	95.25
89.79	92.35
87.61	86.69
85.44	81.20
82.78	74.74
80.49	69.38
78.68	65.26
76.88	61.31
74.93	57.22
72.64	52.64
70.22	47.83
68.29	44.22
66.24	40.64
63.82	36.41
61.52	32.70
59.35	29.38
57.54	26.72
55.12	23.39
53.07	20.74
50.78	17.96
48.98	15.81
46.79	13.61
44.88	11.72
42.60	9.66
40.63	8.07
38.33	6.37
36.28	5.09
34.11	3.77
31.93	2.70
30.48	1.72

Wind Vel(-) (mph)	Drag(-) (lbf)
91.00	48.31
90.88	49.08
89.79	47.00
87.61	42.09
85.44	38.15
82.78	34.71
80.49	31.36
78.68	28.36
76.88	25.77
74.93	23.14
72.64	20.26
70.22	17.92
68.29	15.17
66.24	13.05
63.82	10.78
61.52	8.79
59.35	7.10
57.54	5.89
55.12	4.34
53.07	3.24
50.78	2.20
48.98	1.52
46.79	0.87
44.88	0.45
42.60	0.15
40.63	0.01
38.33	-0.05
36.28	-0.26
34.11	-0.66
31.93	-1.29
30.48	-2.09

Drag D2 (lbf)	Drag D3 (lbf)
-25.03	21.24
-24.98	21.19
-24.57	20.75
-23.75	19.95
-22.82	19.13
-21.91	18.12
-21.04	17.25
-20.38	16.56
-19.87	15.88
-18.94	15.14
-18.07	14.27
-17.15	13.38
-16.42	12.62
-15.84	11.85
-14.72	10.93
-13.85	10.09
-13.03	9.23
-12.34	8.55
-11.42	7.63
-10.65	6.85
-9.77	5.98
-9.09	5.30
-8.29	4.47
-7.58	3.74
-6.75	2.96
-5.93	2.13
-5.08	1.37
-4.28	1.01
-3.45	0.98
-2.63	1.30
-1.71	2.09

F2 (lbf)	F3 (lbf)	a2 (ft/s^2)	a3 (ft/s^2)	v2 (ft/s)	v3 (ft/s)	d1 (ft)	d2 (ft)	d3 (ft)
-25.03	21.24	0.00	0.00	89.06	89.06	0.00	0.00	0.00
-205.99	-159.76	-2.02	-1.57	88.46	88.50	8.97	8.97	8.97
-1652.82	-1607.47	-16.22	-15.77	87.84	87.93	17.92	17.91	17.92
-3260.55	-3236.85	-32.19	-31.76	84.62	84.75	26.70	26.70	26.71
-3279.57	-3237.52	-32.18	-31.77	81.40	81.57	35.17	35.16	35.18
-4002.38	-3952.33	-38.28	-38.88	77.47	77.88	43.32	43.30	43.34
-3456.64	-3420.85	-33.94	-33.57	74.08	74.33	51.08	51.04	51.11
-2734.18	-2697.24	-26.83	-26.47	71.39	71.68	58.50	58.45	58.54
-2733.62	-2698.07	-26.83	-26.48	68.71	68.03	65.68	65.58	65.71
-2913.84	-2879.78	-28.60	-28.26	65.85	66.21	72.55	72.46	72.61
-3456.67	-3423.33	-33.91	-33.59	62.48	62.85	79.15	79.06	79.23
-3835.70	-3805.19	-35.68	-35.38	58.89	59.31	85.42	85.29	85.52
-2911.82	-2882.26	-28.57	-28.29	56.03	56.48	91.33	91.18	91.45
-3391.34	-3363.55	-30.34	-30.07	53.00	53.47	96.96	96.79	97.10
-3533.27	-3507.62	-35.66	-35.40	49.44	49.93	102.29	102.09	102.44
-3451.45	-3427.54	-33.87	-33.64	46.05	46.57	107.28	107.03	107.44
-3269.68	-3247.41	-32.09	-31.87	42.84	43.36	111.89	111.63	112.10
-2726.29	-2709.40	-26.75	-26.55	40.10	40.73	116.21	115.92	116.43
-3629.97	-3610.92	-35.62	-35.44	36.60	37.16	120.28	119.98	120.51
-3088.48	-3069.00	-30.29	-30.12	33.57	34.17	123.95	123.59	124.22
-3447.37	-3431.62	-33.83	-33.68	30.19	30.80	127.34	126.95	127.64
-2723.01	-2708.65	-26.72	-26.58	27.52	28.15	130.40	129.97	130.72
-3264.81	-3252.18	-32.04	-31.92	24.31	24.96	133.18	132.72	133.54
-2902.28	-2891.01	-28.48	-28.37	21.47	22.12	135.65	135.15	136.03
-3082.60	-3072.89	-30.25	-30.16	18.44	19.10	137.84	137.30	138.24
-3262.58	-3254.51	-32.02	-31.94	15.24	15.91	139.72	139.14	140.15
-3442.65	-3436.23	-33.78	-33.72	11.86	12.54	141.28	140.67	141.75
-3080.13	-3074.84	-30.23	-30.18	8.84	9.52	142.50	141.85	143.00
-3260.10	-3255.67	-31.99	-31.95	5.64	6.32	143.43	142.74	143.85
-3259.28	-3255.34	-31.99	-31.95	2.44	3.13	144.03	143.30	144.58
-3620.26	-3616.48	-35.53	-35.49	-1.11	-0.42	144.32	143.55	144.80

Iteration

new V+ (ft/s)	new D+ (lb)
104.36	96.57
104.16	95.20
102.54	92.26
99.32	86.58
96.10	81.04
92.17	74.55
88.78	69.16
86.09	65.04
83.41	61.05
80.55	56.94
77.16	52.25
73.59	47.53
70.74	43.91
67.70	40.22
64.14	36.10
60.75	32.39
57.54	29.06
54.87	26.42
51.31	23.10
48.28	20.45
44.89	17.69
42.22	15.64
39.02	13.36
36.17	11.48
33.15	9.64
29.94	7.87
26.57	6.19
23.54	4.88
20.34	3.63
17.15	2.58
13.59	1.62

new V- (ft/s)	new D- (lb)
74.96	49.31
74.80	49.10
73.23	47.05
70.05	43.06
66.87	39.24
62.98	34.81
59.63	31.20
56.98	28.49
54.33	25.90
51.51	23.28
48.15	20.34
44.61	17.46
41.76	15.32
38.77	13.19
35.23	10.89
31.87	8.91
28.68	7.22
26.03	5.94
22.48	4.44
19.47	3.33
16.10	2.28
13.44	1.59
10.25	0.92
7.42	0.48
4.40	0.17
1.21	0.01
-2.17	-0.04
-5.18	-0.24
-8.38	-0.62
-11.57	-1.18
-15.12	-2.01

new D2 (lb)	new D3 (lb)
-25.02	21.24
-24.93	21.17
-24.47	20.73
-23.61	19.88
-22.75	19.04
-21.72	18.02
-20.82	17.14
-20.11	16.44
-19.41	15.74
-18.66	15.00
-17.77	14.13
-16.85	13.21
-16.11	12.48
-15.33	11.71
-14.41	10.80
-13.54	9.93
-12.72	9.12
-12.04	8.44
-11.13	7.53
-10.36	6.77
-9.50	5.91
-8.82	5.23
-8.01	4.42
-7.30	3.70
-6.53	2.94
-5.73	2.13
-4.88	1.36
-4.12	0.98
-3.31	0.94
-2.51	1.25
-1.62	2.01

new F2 (lb)	new F3 (lb)	new a2 (ft/s^2)	new a3 (ft/s^2)	new v2 (ft/s)	new v3 (ft/s)	new d2 (ft)	new d3 (ft)
-25.0	21.2	0.00	0	89.66	89.66	0	0
-205.9	-159.8	-2.02	-1.57	89.46	89.50	8.97	8.97
-1652.7	-1607.5	-16.22	-15.78	87.84	87.93	17.91	17.92
-3280.4	-3236.9	-32.19	-31.77	84.62	84.75	26.70	26.71
-3278.4	-3237.6	-32.18	-31.77	81.40	81.57	35.16	35.18
-4002.2	-3962.4	-39.28	-38.89	77.47	77.68	43.30	43.34
-3458.4	-3420.5	-33.94	-33.57	74.08	74.33	51.04	51.11
-2733.9	-2697.4	-26.83	-26.47	71.39	71.68	58.45	58.54
-2733.4	-2698.2	-26.82	-26.48	68.71	69.03	65.59	65.71
-2913.6	-2879.9	-28.59	-28.26	65.85	66.21	72.46	72.61
-3455.4	-3423.5	-33.91	-33.60	62.46	62.85	79.05	79.23
-3635.4	-3605.3	-35.68	-35.38	58.89	59.31	85.29	85.52
-2911.0	-2882.4	-28.57	-28.29	56.04	56.46	91.18	91.45
-3091.0	-3064.0	-30.33	-30.07	53.00	53.47	96.79	97.10
-3633.0	-3607.8	-35.65	-35.40	49.44	49.93	102.09	102.44
-3451.1	-3427.7	-33.87	-33.64	46.05	46.57	107.03	107.44
-3269.4	-3247.5	-32.08	-31.87	42.84	43.38	111.64	112.09
-2726.0	-2705.5	-26.75	-26.55	40.17	40.73	115.92	116.43
-3629.7	-3611.0	-35.62	-35.44	36.61	37.18	119.94	120.50
-3086.2	-3069.1	-30.28	-30.12	33.58	34.17	123.60	124.22
-3447.1	-3431.7	-33.83	-33.68	30.19	30.80	126.96	127.64
-2722.8	-2708.7	-26.72	-26.58	27.52	28.14	129.98	130.72
-3264.7	-3252.2	-32.04	-31.92	24.32	24.95	132.73	133.53
-2902.0	-2891.0	-28.48	-28.37	21.47	22.12	135.16	136.03
-3082.4	-3072.9	-30.25	-30.16	18.45	19.10	137.31	138.24
-3262.4	-3254.5	-32.02	-31.94	15.24	15.91	139.15	140.15
-3442.5	-3436.2	-33.78	-33.72	11.87	12.53	140.68	141.74
-3080.0	-3074.9	-30.23	-30.18	8.84	9.52	141.86	143.00
-3260.0	-3255.7	-31.99	-31.95	5.64	6.32	142.75	143.95
-3259.2	-3255.4	-31.98	-31.95	2.45	3.13	143.31	144.58
-3620.2	-3616.5	-35.53	-35.49	-1.11	-0.42	143.56	144.89

-0.76	0.58

APPENDIX K. CONSUMER PERFORMANCE MEASURES

Iteration

new V+ (ft/s)	new D+ (lb)
04.36	95.57
04.16	95.20
02.54	92.26
99.32	86.55
96.10	81.04
92.17	74.55
88.78	69.16
86.09	65.04
83.41	61.05
80.55	56.94
77.16	52.24
73.59	47.52
70.73	43.90
67.70	40.22
64.14	36.09
60.75	32.38
57.54	29.05
54.86	26.41
51.30	23.09
48.27	20.45
44.89	17.68
42.22	15.64
39.01	13.36
36.17	11.48
33.14	9.64
29.94	7.87
26.56	6.19
23.54	4.86
20.34	3.63
17.14	2.58
13.59	1.62

new V- (ft/s)	new D- (lb)
74.96	49.31
74.80	49.10
73.23	47.05
70.05	43.06
66.87	39.24
62.98	34.81
59.63	31.20
56.98	28.49
54.33	25.90
51.51	23.28
48.15	20.34
44.61	17.46
41.78	15.32
38.77	13.19
35.23	10.89
31.87	8.91
28.68	7.22
26.03	5.94
22.48	4.44
19.47	3.33
16.10	2.28
13.45	1.59
10.26	0.92
7.42	0.48
4.40	0.17
1.21	0.01
-2.16	-0.04
-5.18	-0.24
-8.38	-0.62
-11.57	-1.17
-15.12	-2.01

new D2 (lb)	new D3 (lb)
-25.02	21.24
-24.93	21.17
-24.47	20.73
-23.61	19.88
-22.75	19.04
-21.72	18.02
-20.82	17.14
-20.11	16.44
-19.40	15.74
-18.65	15.00
-17.77	14.13
-16.85	13.21
-16.11	12.48
-15.32	11.70
-14.41	10.80
-13.54	9.93
-12.72	9.12
-12.03	8.44
-11.13	7.53
-10.36	6.76
-9.50	5.91
-8.82	5.23
-8.01	4.42
-7.29	3.70
-6.53	2.94
-5.72	2.13
-4.87	1.36
-4.11	0.98
-3.31	0.94
-2.51	1.25
-1.62	2.01

new F2 (lb)	new F3 (lb)	new a2 (ft/s^2)	new a3 (ft/s^2)	new v2 (ft/s)	new v3 (ft/s)	new d2 (ft)	new d3 (ft)
-25.0	21.2	0.00	0	89.66	89.66	0	0
-205.9	-159.8	-2.02	-1.57	89.46	89.50	8.97	8.97
-1652.7	-1607.5	-16.22	-15.78	87.84	87.93	17.91	17.92
-3280.4	-3236.9	-32.19	-31.77	84.62	84.75	26.70	26.71
-3279.4	-3237.6	-32.18	-31.77	81.40	81.57	35.16	35.18
-4002.2	-3962.4	-39.28	-38.89	77.47	77.68	43.30	43.34
-3458.4	-3420.5	-33.94	-33.57	74.08	74.33	51.04	51.11
-2733.9	-2697.4	-26.83	-26.47	71.39	71.68	58.45	58.54
-2733.4	-2698.2	-26.82	-26.48	68.71	69.03	65.59	65.71
-2913.6	-2879.9	-28.59	-28.26	65.85	66.21	72.46	72.61
-3455.4	-3423.5	-33.91	-33.60	62.46	62.85	79.05	79.23
-3635.4	-3605.3	-35.68	-35.38	58.89	59.31	85.29	85.52
-2911.0	-2882.4	-28.57	-28.29	56.04	56.48	91.18	91.45
-3091.0	-3064.0	-30.33	-30.07	53.00	53.47	96.79	97.10
-3633.0	-3607.8	-35.65	-35.40	49.44	49.93	102.09	102.44
-3451.1	-3427.7	-33.87	-33.64	46.05	46.57	107.03	107.44
-3269.4	-3247.5	-32.08	-31.87	42.84	43.38	111.64	112.09
-2726.0	-2705.5	-26.75	-26.55	40.17	40.73	115.92	116.43
-3629.7	-3611.0	-35.62	-35.44	36.61	37.18	119.94	120.50
-3086.2	-3069.1	-30.29	-30.12	33.58	34.17	123.60	124.22
-3447.1	-3431.7	-33.83	-33.68	30.19	30.80	126.96	127.64
-2722.8	-2708.7	-26.72	-26.58	27.52	28.14	129.98	130.72
-3264.7	-3252.2	-32.04	-31.92	24.32	24.95	132.73	133.53
-2902.0	-2891.0	-28.48	-28.37	21.47	22.12	135.16	136.03
-3082.4	-3072.9	-30.25	-30.16	18.45	19.10	137.31	138.24
-3262.4	-3254.5	-32.02	-31.94	15.24	15.91	139.15	140.15
-3442.5	-3436.2	-33.78	-33.72	11.87	12.53	140.68	141.74
-3080.0	-3074.9	-30.23	-30.18	8.84	9.52	141.86	143.00
-3260.0	-3255.7	-31.99	-31.95	5.64	6.32	142.75	143.95
-3259.2	-3255.4	-31.98	-31.95	2.45	3.13	143.31	144.58
-3620.2	-3616.5	-35.53	-35.49	-1.11	-0.42	143.56	144.89

-0.76	0.58

Consumer Performance Measures for Vehicles Tested (based on final results)
Mean, Standard Deviation, 95% One-Sided Confidence Interval and 95th and 99th-Percentile Stopping Distances

	No Payload Dry		Payload Dry		No Payload Wet		Payload Wet	
				GRANDAM FINAL STATISTICS				
Mean	147.9		152.0		190.1		171.5	
STD n-1	1.6		1.6		6.9		6.5	
95%	148.8		152.9		193.9		175.9	
95th	150.5	0.949994	154.7	0.949276	201.5	0.95028	185.5	0.949849
99th	151.6	0.990236	155.8	0.990579	206.2	0.990061	191.3	0.988932
				EXPEDITION FINAL STATISTICS				
Mean	170.4		165.4		197.8		220.4	
STD n-1	8.1		3.1		8.7		10.0	
95%	174.8		168.0		203.2		227.9	
95th	183.7	0.9499	170.5	0.949855	212.1	0.950366	236.9	0.950319
99th	189.2	0.989929	172.6	0.990063	218.0	0.990074	243.7	0.990039
				CAMRY FINAL STATISTICS				
Mean	160.0		161.5		175.7		174.3	
STD n-1	1.9		2.5		5.3		2.2	
95%	161.1		162.9		178.6		175.5	
95th	163.1	0.949891	165.8	0.951927	184.4	0.949225	178.0	0.950064
99th	164.4	0.990439	167.5	0.989769	188.1	0.990133	179.5	0.990272
				MALIBU FINAL STATISTICS				
Mean	141.3		154.0		150.3		165.2	
STD n-1	1.4		2.4		2.9		10.2	
95%	142.0		155.3		151.9		170.6	
95th	143.5	0.950527	157.9	0.950001	155.0	0.950206	181.9	0.949965
99th	144.4	0.990069	159.6	0.990066	157.0	0.990017	186.8	0.990005
				CARAVAN FINAL STATISTICS				
Mean	159.7		173.1		165.5		190.9	
STD n-1	2.0		4.8		3.2		4.2	
95%	160.8		175.8		167.5		192.9	
95th	163.1	0.949975	181.0	0.950977	170.7	0.950362	197.6	0.950135
99th	164.5	0.990045	184.7	0.990043	172.8	0.990085	200.4	0.990068
				CADILLAC FINAL STATISTICS				
Mean	156.3		165.2		163.6		163.9	
STD n-1	2.9		4.1		1.9		1.6	
95%	158.0		167.2		164.7		164.8	
95th	161.2	0.950033	172	0.950143	166.8	0.950268	166.6	0.950159
99th	163.2	0.990026	174.8	0.990002	168.1	0.990104	167.7	0.989995
				RAM FINAL STATISTICS				
Mean	199.2		188.5		209.6		205.2	
STD n-1	9.6		10.3		10.7		7.4	
95%	205.2		194.5		215.5		209.5	
95th	215.0	0.95005	205.4	0.950018	227.3	0.950084	217.4	0.949976
99th	221.6	0.990011	212.4	0.99003	234.6	0.990032	222.4	0.990036
				EXPRESS FINAL STATISTICS				
Mean	165.6		178.1		178.3		184.1	
STD n-1	2.7		5.6		1.9		3.2	
95%	167.6		182.7		179.4		186.1	
95th	170.1	0.949906	188.6	0.950015	181.4	0.950388	189.4	0.950025
99th	172.0	0.990094	192.5	0.990016	182.7	0.990078	191.6	0.990067
				ASTRO FINAL STATISTICS				
Mean	170.5		183.0		174.1		185.1	
STD n-1	1.2		2.7		1.5		0.9	
95%	171.3		184.6		175.1		185.8	
95th	172.4	0.950129	187.4	0.950186	176.6	0.950017	186.6	0.950946
99th	173.2	0.990064	189.2	0.990033	177.6	0.990075	187.3	0.989925
				BONNEVILLE FINAL STATISTICS				
Mean	155.7		164.2		161.3		165.3	
STD n-1	1.9		4.4		1.7		3.0	
95%	157.7		167.2		162.3		167.8	
95th	159.7	0.950289	171.5	0.950031	164.2	0.950017	170.1	0.950263
99th	161.0	0.990078	174.5	0.990083	165.4	0.990083	172.1	0.990064

APPENDIX L. TEST REPORT FORMAT

Task 5 – Develop a Test Report Format

The following presents a format for reporting testing conducted in support of the consumer braking program for the National Highway Traffic Safety Administration (NHTSA). The format is structured in outline form in an effort to standardize the method in which brake stop results are reported.

I. Objective

The objective of the test was to perform brake performance tests with vehicles equipped with four-wheel anti-lock brake systems (ABS) and to determine the capability of the vehicle to stop under conditions simulating a real-world emergency brake event. The results are to be reported to the National Highway Traffic Safety Administration (NHTSA) in support of the consumer braking program.

II. Procedure

The procedure should be carried out in accordance with the standards presented in FMVSS 135, Passenger Car Brake Systems. It should also comply with the proposed supplements to the overall test methodology included in this report to minimize stopping distance variability. The following presents an outline of the information that should be included in the procedure:

A. General

1. Summary of Brake Stop Test Characteristics
    a. Target speed [100 km/hr (62 mph)].
    b. Payload configuration used during testing (empty, full, etc.).
    c. Surface conditions used during testing (dry or wet).
    d. Test driver experience.
2. Summary of Vehicle(s) Tested
    a. Make, model and vehicle identification number.
    b. Mileage.
    c. Tire specifications.
    d. Brake specifications.

B. Setup and Instrumentation

1. Vehicle Setup
    a. Tire pressure, brake component inspection
    b. Summary of vehicle operation.
    c. Description of payload method and conditions.
    d. Weight distribution and center of gravity determination method.
2. Vehicle Instrumentation Details
    a. Data acquisition system.
    b. Speed and distance transducer.
    c. Pedal effort transducer.
    d. Sampling rate.
    e. Normalization procedure.
3. Other Instrumentation
    a. Brake component temperature measurement.
    b. Ambient and road surface temperature measurement.
    c. Wind conditions.

B. Brake Stop Results

The brake stop results obtained from testing should be reported as shown in Table 4.

TABLE 4. BRAKE STOP RESULTS FROM 100 KM/HR (62 MPH)

Stop No.	Measurement					
	Stopping Distance		Deceleration Rate		Pedal effort at 0.1 sec	
	m	ft	m/sec^2	ft/sec^2	N	lb
Dry surface without payload						
1						
2						
3						
4						
5						
6						
7						
8						
9						
10						
Average						
Dry surface with payload						
1						
2						
3						
4						
5						
6						
7						
8						
9						
10						
Average						
Wet surface without payload						
1						
2						
3						
4						
5						
6						
7						
8						
9						
10						
Average						
Wet surface with payload						
1						
2						
3						
4						
5						
6						
7						
8						
9						
10						
Average						

C. Recorded Brake Temperatures

All brake temperatures recorded prior to each brake stop after the cool down procedure (if necessary) should be included as shown in Table 5.

TABLE 5. BRAKE COMPONENT TEMPERATURES

Stop No.	Measurement							
	Left front		Right front		Left rear		Right rear	
	°C	°F	°C	°F	°C	°F	°C	°F
Dry surface without payload								
1								
2								
3								
4								
5								
6								
7								
8								
9								
10								
Dry surface with payload								
1								
2								
3								
4								
5								
6								
7								
8								
9								
10								
Wet surface without payload								
1								
2								
3								
4								
5								
6								
7								
8								
9								
10								
Wet surface with payload								
1								
2								
3								
4								
5								
6								
7								
8								
9								
10								

D. Environmental Data

The recorded environmental test data should be presented as shown in Tables 6 and 7. Temperature and wind measurements shown in Table 6 should be taken every 15 to 30 minutes during testing. Surface friction results obtained within a week of the date of testing should be presented as shown in Table 7.

TABLE 6. ENVIRONMENTAL TEST DATA

			Measurement								
			Ambient temperature		Road surface Temperature		Average wind speed		Peak speed		Avg wind direction (degrees)
Test configuration	Date	Time	°C	°F	°C	°F	km/hr	mph	km/hr	mph	

TABLE 7. AVERAGE RESULTS FROM CHIRP TESTING

	Measurement									
	Dry surface					Wet surface				
	Frictional coefficient	Test speed		Ambient temperature		Frictional coefficient	Test speed		Ambient temperature	
Date		km/hr	mph	°C	°F		km/hr	mph	°C	°F

E. Notes and Comments

Any notes or comments documented during testing should be reported in this section. Specifically, a list and explanation of the observations recorded regarding vehicle performance, modifications in test procedure, or the effect of test conditions on data accuracy and variability should be included.

IV. Analysis – Final Statistics

The average stopping distance, standard deviation and 95th-percentile stopping distance of the individual brake stops for each test configuration should be calculated and presented in Table 8.

TABLE 8. FINAL STATISTICS

	Average stopping distance		Standard deviation		95th-percentile stopping distance	
Test configuration	m	ft	m	ft	m	ft
Dry surface without payload						
Dry surface with payload						
Wet surface without payload						
Wet surface with payload						

V. Conclusion

A brief summary of the overall test method, performance results and final statistics should be included in this section. Final comments or deductions regarding the brake performance of the test items or the validity of the data should also be included.