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# MOTORCYCLES

Like many law enforcement agencies, the Michigan State Police used motorcycles up until late 1941 and then switched to automobiles. The Michigan State Police rekindled interest in motorcycles for day to day patrol operations in 1993. In 2004, Michigan State Police headquarters asked if we had additional information as a resource for our purchasing decisions regarding motorcycles. During that time, we were given direction to expand vehicle testing to include motorcycle testing. We are pleased to announce the third MSP police motorcycle test. We would like to thank Harley-Davidson and BMW for participating and providing their assistance in preparation for this year's successful testing program.

We are constantly evaluating our various tests with the manufacturers and the law enforcement industry to provide you with the most objective test data available. While there are many similarities to automobiles, there are also quite a few differences. Law enforcement motorcycles will encounter a variety of surfaces during patrol operations or emergencies. Because of that, we developed a braking test with substantially different coefficient of friction surfaces. An example of this in the real world would be if a motor officer was to run off the road and onto gravel or a wet grassy surface and had to brake at the same time.

When looking at the data, it is very important for the reader to apply your mission requirements to the motorcycle you are considering so you may make an appropriate decision. This report is not an endorsement of products, but a means of learning what's available for your officers so they can do their job more effectively and safely. If anything in this report requires further explanation or clarification, please call or write.



# Harley Davidson Road King



## TEST VEHICLE DESCRIPTION

<b>MAKE</b> Harley Davidson	<b>MODEL</b> FLHP	<b>SALES CODE NO.</b> N/A	
<b>ENGINE DISPLACEMENT</b>	<b>CUBIC CENTIMETERS</b> 1690	<b>CUBIC INCHES</b> 103	
<b>FUEL SYSTEM</b>	EFI	<b>EXHAUST</b> Crossover Dual	
<b>BORE &amp; STROKE</b>	3.875 x 4.375 in	<b>ALTERNATOR</b> 50 amp	
<b>TORQUE</b>	102 ft-lbs	<b>BATTERY</b> 28 Amp Hour	
<b>COMPRESSION RATIO</b>	9.6:1		
<b>TRANSMISSION</b>	<b>PRIMARY DRIVE</b> 34/46	<b>FINAL DRIVE</b> 32/68	
<b>GEAR RATIO</b>	2.875 overall		
<b>LEAN ANGLE</b>	<b>LEFT</b> 31 Deg	<b>RIGHT</b> 33 Deg	
<b>CLUTCH</b>	Wet multiple plate		
<b>WHEELS/TIRES</b>	Wheels/Slotted Disk Cast Aluminum front and rear / Front 17 x 3 / Rear 16 x 5 Tires / Front Dunlop D407F 130/80B17 Rear Dunlop D407 180/65B16		
<b>FRONT SUSPENSION</b>	<b>FORK ANGLE</b> 29.25°	<b>RAKE</b> 26°	
<b>REAR SUSPENSION</b>	Swing Arm w/ Air Adjustable Shocks		
<b>SUSPENSION TRAVEL</b>	<b>FRONT</b> 4.6 in.	<b>REAR</b> 3.0 in.	
<b>GROUND CLEARANCE, MINIMUM</b>	5.1 in.		
<b>BRAKE SYSTEM</b>	Hydraulic Disc / Independent Front & Rear ABS		
<b>BRAKES, FRONT</b>	<b>TYPE</b> Dual Disc	<b>SWEPT AREA</b> 180sq in.	
<b>BRAKES, REAR</b>	<b>TYPE</b> Single Disc	<b>SWEPT AREA</b> 90sq in.	
<b>FUEL CAPACITY</b>	<b>GALLONS</b> 6	<b>LITERS</b> 22.71	
<b>OIL CAPACITY</b>	4 Qts		
<b>GENERAL MEASUREMENTS</b>	<b>WHEELBASE</b> 63.54 in.	<b>LENGTH</b> 95.14 in.	
	<b>TEST WEIGHT</b> 839 lbs.	<b>OVERALL HEIGHT</b> 55.1 in.	
	<b>SEAT HEIGHT</b> 30.0 in.		
<b>EPA MILEAGE EST. (MPG)</b>	<b>CITY</b> 35	<b>HIGHWAY</b> 54	<b>COMBINED</b> 44.5

# Harley Davidson Electra Glide



## TEST VEHICLE DESCRIPTION

<b>MAKE</b> Harley Davidson	<b>MODEL</b> FLHTP	<b>SALES CODE NO.</b> N/A	
<b>ENGINE DISPLACEMENT</b>	<b>CUBIC CENTIMETERS</b> 1690	<b>CUBIC INCHES</b> 103	
<b>FUEL SYSTEM</b>	EFI	<b>EXHAUST</b> Crossover Dual	
<b>BORE &amp; STROKE</b>	3.875 x 4.375 in	<b>ALTERNATOR</b> 50 amp	
<b>TORQUE</b>	102 ft-lbs	<b>BATTERY</b> 28 amp hour	
<b>COMPRESSION RATIO</b>	9.6:1		
<b>TRANSMISSION</b>	<b>PRIMARY DRIVE</b> 34/46	<b>FINAL DRIVE</b> 32/68	
<b>GEAR RATIO</b>	2.875 overall		
<b>LEAN ANGLE</b>	<b>LEFT</b> 31°	<b>RIGHT</b> 33°	
<b>CLUTCH</b>	Wet multiple plate		
<b>WHEELS/TIRES</b>	Wheels / Slotted Disk Cast Aluminum front and rear / Front 17 x 3 / Rear 16 x 5 Tires / Front Dunlop D407F 130/80B 17 Rear Dunlop D407 180/65B16		
<b>FRONT SUSPENSION</b>	<b>FORK ANGLE</b> 29.25°	<b>RAKE</b> 26°	
<b>REAR SUSPENSION</b>	Swing Arm w/ Air Adjustable Shocks		
<b>SUSPENSION TRAVEL</b>	<b>FRONT</b> 4.6 in.	<b>REAR</b> 3.0 in.	
<b>GROUND CLEARANCE, MINIMUM</b>	5.1 in.		
<b>BRAKE SYSTEM</b>	Hydraulic Disc / Independent Front & Rear ABS		
<b>BRAKES, FRONT</b>	<b>TYPE</b> Dual Disc	<b>SWEPT AREA</b> 180sq in.	
<b>BRAKES, REAR</b>	<b>TYPE</b> Single Disc	<b>SWEPT AREA</b> 90sq in.	
<b>FUEL CAPACITY</b>	<b>GALLONS</b> 6.0	<b>LITERS</b> 22.71	
<b>OIL CAPACITY</b>	4.0 Qts		
<b>GENERAL MEASUREMENTS</b>	<b>WHEELBASE</b> 63.54 in.	<b>LENGTH</b> 95.14 in.	
	<b>TEST WEIGHT</b> 838 lbs.	<b>OVERALL HEIGHT</b> 61 in.	
	<b>SEAT HEIGHT</b> 30 in.		
<b>EPA MILEAGE EST. (MPG)</b>	<b>CITY</b> 35	<b>HIGHWAY</b> 54	<b>COMBINED</b> 44.5

# BMW R1200 RTP



## TEST VEHICLE DESCRIPTION

<b>MAKE</b> BMW	<b>MODEL</b> R1200RT-P	<b>SALES CODE NO.</b> 08RB	
<b>ENGINE DISPLACEMENT</b>	<b>CUBIC CENTIMETERS</b> 1170	<b>Engine</b>	2-Cylinder
<b>FUEL SYSTEM</b>	BMSK-P Injection	<b>EXHAUST</b>	Stainless Steel with Catalytic Converter
<b>BORE &amp; STROKE</b>	101 mm. x 73 mm.	<b>ALTERNATOR</b>	720 W
<b>TORQUE</b>	85 ft-lbs @ 6,000 rpm.	<b>BATTERY</b>	2 19 Amp Ah Gel Maintenance-Free
<b>COMPRESSION RATIO</b>	12.0:1		
<b>TRANSMISSION</b>	<b>PRIMARY DRIVE</b> Gear 1:1.882	<b>FINAL DRIVE</b>	Shaft w/ring & pinion gear
<b>GEAR RATIO</b>	1:2.75 rear drive ratio		
<b>LEAN ANGLE</b>	<b>LEFT</b> 46°	<b>RIGHT</b>	46°
<b>CLUTCH</b>	Self-adjusting Hydraulic Actuating Single Plate Dry Clutch		
<b>WHEELS/TIRES</b>	Die-cast Aluminum MTH2 Rim Profile fitted with Run-Flat Tires (meets California Highway Patrol Run-Flat Protocol)/Tires Dunlop Sport Max F-120/70 ZR17 R-180/55 ZR17		
<b>FRONT SUSPENSION</b>	<b>FORK ANGLE</b> 63.4 BMW Telelever	<b>RAKE</b>	Castor in normal position 4.3 in.
<b>REAR SUSPENSION</b>	BMW Evo Paralever		
<b>SUSPENSION TRAVEL</b>	<b>FRONT</b> 4.7 in.	<b>REAR</b>	5.3 in.
<b>GROUND CLEARANCE, MINIMUM</b>			
<b>BRAKE SYSTEM</b>	BMW/ABS Partially Integrated Brake System		
<b>BRAKES, FRONT</b>	<b>TYPE</b> Dual 12.6 in. Disc	<b>SWEPT AREA</b>	186 sq. in.
<b>BRAKES, REAR</b>	<b>TYPE</b> Single 10.4in. Disc	<b>SWEPT AREA</b>	62 sq. in.
<b>FUEL CAPACITY</b>	<b>GALLONS</b> 7.1	<b>LITERS</b>	27
<b>OIL CAPACITY</b>	4.0 Qts.		
<b>GENERAL MEASUREMENTS</b>	<b>WHEELBASE</b> 58.4 in.	<b>LENGTH</b>	87.8 in.
	<b>TEST WEIGHT</b> 680	<b>OVERALL HEIGHT</b>	56.3 in.
	<b>*SEAT HEIGHT</b> 32.2 in.		
<b>EPA MILEAGE EST. (MPG)</b> (Based on DIN standard test)	<b>CITY</b> N/A	<b>HIGHWAY</b> 48 @ 75mph 65 @ 55mph	<b>COMBINED</b> N/A

\*Seat height has two adjustment positions. A low seat is available making the seat height 31".

# Buell Ulysses XB12XP



## Test Vehicle Sheet

<b>MAKE</b> Buell	<b>MODEL</b> XB12XP	<b>SALES CODE NO.</b>	
<b>ENGINE DISPLACEMENT</b>	<b>CUBIC CENTIMETERS</b> 1203	<b>ENGINE</b> Thunderstorm 45° V-twin / 4 stroke / air-oil-fan cooled	
<b>FUEL SYSTEM</b>	49mm downdraft DDFI III FI	<b>EXHAUST</b> Two into One Underslung	
<b>BORE &amp; STROKE</b>	3.50 X 3.812	<b>ALTERNATOR</b> 30 Amp	
<b>TORQUE</b>	84 ft-lbs. @ 6000 rpm	<b>BATTERY</b> 12V 12 amp/hour, 200CCA	
<b>COMPRESSION RATIO</b>	10.0:1		
<b>TRANSMISSION</b>	<b>PRIMARY DRIVE</b> 57/38	<b>FINAL DRIVE</b> 65/27	
<b>GEAR RATIO</b>	1st/2.648 2 <sup>nd</sup> /1.892 3rd/1.407 4th/1.166 5th/1.000		
<b>LEAN ANGLE</b>	<b>LEFT</b> 39°	<b>RIGHT</b> 39°	
<b>CLUTCH</b>	Wet multiple plate		
<b>WHEELS/TIRES</b>	Wheels / Reinforced Six Spoke Cast Aluminum front and rear Front 17 X 3.5 / Rear 17 X 5.5 Tires / Front Pirelli Scorpion Sync 120/70 ZR17 Rear Pirelli Scorpion Sync 180/55 ZR17		
<b>FRONT SUSPENSION</b>	<b>FORK ANGLE</b> 22°	<b>RAKE</b> 23.5°	
<b>REAR SUSPENSION</b>	Showa Coil Over Monoshock with remote reservoir and remote spring preload adjust (fully adjustable / compression, damping, rebound damping and spring preload)		
<b>SUSPENSION TRAVEL</b>	<b>FRONT</b> 6.51 in.	<b>REAR</b> 6.38 in.	
<b>GROUND CLEARANCE, MINIMUM</b>	6.97 in.		
<b>BRAKE SYSTEM</b>	Hydraulic / Disc front and rear		
<b>BRAKES, FRONT</b>	<b>TYPE</b> Single Disc	<b>SWEPT AREA</b> 50.1 sq in.	
<b>BRAKES, REAR</b>	<b>TYPE</b> Single Disc	<b>SWEPT AREA</b> 34.4 sq in.	
<b>FUEL CAPACITY</b>	<b>GALLONS</b> 4.4	<b>LITERS</b> 16.66	
<b>OIL CAPACITY</b>	2.5 Qts.		
<b>GENERAL MEASUREMENTS</b>	<b>WHEELBASE</b> 54.08 in.	<b>LENGTH</b> 86.10 in.	
	<b>TEST WEIGHT</b> 564	<b>OVERALL HEIGHT</b> n/a	
	<b>SEAT HEIGHT</b> 31.80 in. / laden		
<b>EPA MILEAGE EST. (MPG)</b>	<b>CITY</b> 51	<b>HIGHWAY</b> 64	<b>COMBINED</b> 57.5

# BMW G650 X Challenge



## Test Vehicle Description

<b>MAKE</b> BMW	<b>MODEL</b> G 650 X-P	<b>SALES CODE NO.</b> 07F6	
<b>ENGINE DISPLACEMENT</b>	<b>CUBIC CENTIMETERS</b> 652 cc	<b>ENGINE</b>	1-Cyl.
<b>FUEL SYSTEM</b>	BMS-C II Engine Management with Fuel Injection	<b>EXHAUST</b>	Stainless Steel with Catalytic Converter
<b>BORE &amp; STROKE</b>	100 mm x 83 mm	<b>ALTERNATOR</b>	280 W
<b>TORQUE</b>	44 ft-lbs 53 hp @ 7,500 rpm	<b>BATTERY</b>	10Ah AGM
<b>COMPRESSION RATIO</b>	11.5:1		
<b>TRANSMISSION</b>	<b>PRIMARY DRIVE</b> 37:72 teeth 1.946 Primary Gear Ratio	<b>FINAL DRIVE</b>	Chain 15:47 teeth
<b>GEAR RATIO</b>	2.750 1 <sup>st</sup> , 1.750 2 <sup>nd</sup> , 1.131 3 <sup>rd</sup> , 1.045 4 <sup>th</sup> , 0.875 5 <sup>th</sup> .		
<b>LEAN ANGLE</b>	<b>LEFT</b> 40°	<b>RIGHT</b>	40°
<b>CLUTCH</b>	Seven-disc oil-bath wet clutch		
<b>WHEELS/TIRES</b>	Spoke 1.60"x 21" 90/90 x 21 / 2.50"x 18" 140/80 x 18"/ Tires: Front 90/90x21 Tube, Rear 140/80x18 Tube, Metzler Sahara 3		
<b>FRONT SUSPENSION</b>	<b>FORK ANGLE</b> 61.5	<b>RAKE</b>	116.5 mm
<b>REAR SUSPENSION</b>	Air Damping System		
<b>SUSPENSION TRAVEL</b>	<b>FRONT</b> 10.6 in.	<b>REAR</b>	10.6 in.
<b>GROUND CLEARANCE, MINIMUM</b>	11.2 in.		
<b>BRAKE SYSTEM</b>	Hydraulic 2-channel ABS brake system. ABS disengageable		
<b>BRAKES, FRONT</b>	<b>TYPE</b> Single disc self-cleaning Wave design ABS	<b>SWEPT AREA</b>	
<b>BRAKES, REAR</b>	<b>TYPE</b> Single disc self-cleaning wave design ABS	<b>SWEPT AREA</b>	
<b>FUEL CAPACITY</b>	<b>GALLONS</b> 2.7	<b>LITERS</b>	9.5
<b>OIL CAPACITY</b>	2.4 Qts.		
<b>GENERAL MEASUREMENTS</b>  Note: GVWR 739 lbs.	<b>WHEELBASE</b> 59.3 in.	<b>LENGTH</b> 86.8 in.	
	<b>TEST WEIGHT</b> 385	<b>OVERALL HEIGHT</b>	
	<b>SEAT HEIGHT</b> 37.2 in.		
<b>EPA MILEAGE EST. (MPG)</b>	<b>CITY</b>	<b>HIGHWAY</b>	<b>COMBINED</b>

## TEST VEHICLE DESCRIPTION SUMMARY

	Harley Davidson FLHP	Harley Davidson FLHTP	BMW R-1200 RT-P
CUBIC CENTIMETERS	1690	1690	1170
ENGINE DISPLACEMENT – CU. IN.	103	103	2 cyl
ENGINE FUEL SYSTEM	EFI	EFI	Injection
EXHAUST	Crossover Dual	Crossover Dual	Stainless Steel
BORE & STROKE	3.875x4.375 (inches)	3.875x4.375 (inches)	101x73 (mm)
ALTERNATOR	50 amp	50 amp	720 watts
TORQUE - FT. LBS.	102	102	85
BATTERY	28	28	2x19
COMPRESSION RATIO	9.6:1	9.6:1	12.0:1
TRANSMISSION	6-Speed	6-Speed	6-Speed
PRIMARY DRIVE	34/46	34/46	1:1.882
FINAL DRIVE	32/68	32/68	Shaft w/ring & pinion
GEAR RATIO	2.875	2.875	1:2.75
LEAN ANGLE - LEFT	31°	31°	46°
LEAN ANGLE – RIGHT	33°	33°	46°
CLUTCH	Wet multi plate	Wet multi plate	Dry single plate
WHEELS/TIRES	3x16 MT/90-16 72H	3x16 MT/90-16 72H	Alum. MTH2
FORK ANGLE	29.25°	29.25°	63.4°
RAKE	26°	26°	4.3 in.
REAR SUSPENSION	Swing Arm	Swing Arm	EVO Paralever
SUSPENSION TRAVEL – FRONT	4.6 in.	4.6 in.	4.7 in.
SUSPENSION TRAVEL – BACK	3.0 in.	3.0 in.	5.3 in.
GROUND CLEARANCE-MINIMUM	5.1 in.	5.1 in.	
BRAKE SYSTEM	Disc.	Disc.	IABS
FRONT SWEEP AREA (sq. in.)	180	180	186
REAR SWEEP AREA (sq. in.)	90	90	62
FUEL CAPACITY – GALLONS	6	6	7.1
FUEL CAPACITY – LITERS	22.71	22.71	27
OIL CAPACITY – QUARTS	4	4	4
WHEELBASE	63.54	63.54	58.4
LENGTH	95.14	95.14	87.8
WEIGHT	839	838	680
OVERALL HEIGHT	55.1	61	56.3
SEAT HEIGHT	30	30	32.2
EPA MILEAGE – CITY	35	35	N/A
EPA MILEAGE - HIGHWAY	54	54	48 @ 75mph 65 @ 55mph

	<b>Buell Ulysses</b>	<b>BMX X650 X-P</b>
CUBIC CENTIMETERS	1203	652
ENGINE DISPLACEMENT – CU. IN.	4 stroke	1 cyl
ENGINE FUEL SYSTEM	DDFI III FI	BMS-C II FI
EXHAUST	Underslung	SS Catalytic Converter
BORE & STROKE	3.5 x 3.812	100mm x 83 mm
ALTERNATOR	30 amp	280 watt
TORQUE - FT. LBS.	84	44
BATTERY	12	10
COMPRESSION RATIO	10.0:1	11.5:1
TRANSMISSION	5-Speed	5-Speed
PRIMARY DRIVE	57/38	37:72/1.946
FINAL DRIVE	65/27	15:47
GEAR RATIO	1 <sup>st</sup> /2.648 2 <sup>nd</sup> /1.892 3 <sup>rd</sup> /1.407 4 <sup>th</sup> /1.166 5 <sup>th</sup> /1.000	2.750 1 <sup>st</sup> , 1.750 2 <sup>nd</sup> , 1.131 3 <sup>rd</sup> , 1.045 4 <sup>th</sup> , .875 5 <sup>th</sup>
LEAN ANGLE - LEFT	39°	40°
LEAN ANGLE – RIGHT	39°	40°
CLUTCH	Wet Multi-Plate	7-Disk oil-bath wet clutch
WHEELS/TIRES	Alum Spoke F17 x 3.5 R17 x 5.5	Spoke F90/90 x 21 R140/80 x 18
FRONT SUSPENSION		
FORK ANGLE	22°	61.5°
RAKE	23.5°	116.5
REAR SUSPENSION	Coil over shock/Adjustable	Air Damping System
SUSPENSION TRAVEL – FRONT	6.51	10.6
SUSPENSION TRAVEL – BACK	6.38	10.6
GROUND CLEARANCE-MINIMUM	6.97	11.2
BRAKE SYSTEM	Hydraulic	Hydraulic
FRONT SWEEP AREA (sq. in.)	50.1	n/a
REAR SWEEP AREA (sq. in.)	34.4	n/a
FUEL CAPACITY – GALLONS	4.4	2.7
FUEL CAPACITY – LITERS	16.66	9.5
OIL CAPACITY – QUARTS	2.5	2.4
WHEELBASE	54.08	59.3
LENGTH	86.10	86.8
WEIGHT	564	385
OVERALL HEIGHT	N/A	n/a
SEAT HEIGHT	31.8	37.2
EPA MILEAGE – CITY	51	
EPA MILEAGE - HIGHWAY	64	

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# MOTORCYCLE DYNAMICS TESTING

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## MOTORCYCLE DYNAMICS TEST OBJECTIVE

Determine each motorcycle's high speed handling characteristics and performance in comparison to other motorcycles. The course used contains 9 turns and curves (including a 90 degree left turn, a switch back, a sweeping turn, a high speed turn and a decreasing radius, with different braking requirements) and is 1 mile in length. The course simulates actual conditions encountered in pursuit or emergency driving situations in the field, with the exception of other traffic. The evaluation is a true test of the vehicle manufacturers in offering balanced packages of acceleration capabilities, suspension components, and braking characteristics.

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## MOTORCYCLE DYNAMICS TEST METHODOLOGY

Each motorcycle is driven using four separate riders for a six lap series. The best 5 out of six laps for each rider will be totaled for a cumulative time. The cumulative time is the score for each driver. The final score of each motorcycle is the combined average from the four rider's cumulative times.



## MOTORCYCLE DYNAMICS

VEHICLES	DRIVERS	COMBINED CUMULATIVE
Harley Davidson	GROMAK	6:12.20
FLHTP	JOHNSON	6:13.90
Electra Glide	TRAMMEL	6:19.50
	FLEGEL	6:11.40
<b>Overall Average</b>		<b>6:14.25</b>
Harley Davidson	GROMAK	6:08.50
FLHP	JOHNSON	6:11.00
Road King	TRAMMEL	6:20.00
	FLEGEL	6:09.40
<b>Overall Average</b>		<b>6:12.23</b>
BMW	GROMAK	5:44.40
R1200RTP	JOHNSON	5:48.30
	TRAMMEL	5:55.10
	FLEGEL	5:42.60
<b>Overall Average</b>		<b>5:47.60</b>
BMW	GROMAK	5:39.70
650 XP	JOHNSON	5:40.10
	TRAMMEL	5:58.80
	FLEGEL	5:33.70
<b>Overall Average</b>		<b>5:43.08</b>
Buell Ulysses	GROMAK	5:26.80
	JOHNSON	5:36.90
	TRAMMEL	5:50.40
	FLEGEL	5:32.10
<b>Overall Average</b>		<b>5:36.55</b>

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# MOTORCYCLE ACCELERATION AND TOP SPEED TESTING

## ACCELERATION TEST OBJECTIVE

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Determine the ability of each test motorcycle to accelerate from a standing start to 60 mph, 80 mph, and 100 mph, and determine the distance to reach 110 mph and 120 mph.

## ACCELERATION TEST METHODOLOGY

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Using a Correvit L-350 1 Axis Optical Sensor, each motorcycle is driven through four acceleration sequences, two northbound and two southbound, to allow for wind direction. The four resulting times for each target speed are averaged and the average times used to derive scores on the competitive test for acceleration.

## TOP SPEED TEST OBJECTIVE

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Determine the actual top speed attainable by each test motorcycle within a distance of 10 miles from a standing start.

## TOP SPEED TEST METHODOLOGY

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Following the fourth acceleration run, each test motorcycle will continue to accelerate to the top speed attainable within 10 miles from the start of the run. The highest speed attained within the 10-mile distance will be the vehicle's score on the competitive test for top speed.

## SUMMARY OF ACCELERATION & TOP SPEED

<b>ACCELERATION*</b>	<b>Harley Davidson Electra Glide</b>	<b>BMW R1200 RTP</b>	<b>Harley Davidson Road King</b>	<b>Buell Ulysses</b>	<b>BMW G650 XChallenge</b>
0 – 20 mph (sec.)	1.30	1.30	1.72	1.60	1.39
0 – 30 mph (sec.)	2.00	1.98	2.73	2.41	2.06
0 – 40 mph (sec.)	2.83	2.62	4.20	3.20	3.07
0 – 50 mph (sec.)	3.85	3.54	5.56	4.11	4.09
0 – 60 mph (sec.)	5.31	4.41	7.56	5.15	5.58
0 – 70 mph (sec.)	6.85	5.67	9.72	6.47	7.42
0 – 80 mph (sec.)	9.09	7.15	12.91	8.15	10.16
0 – 90 mph (sec.)	12.22	8.82	17.13	10.04	15.27
0 – 100 mph (sec.)	28.13	11.27	30.02	13.58	
<b>TOP SPEED (mph)</b>	104	130	105	106	101
<b>QUARTER MILE</b>					
Time (sec.)	15.74	13.10	15.87	13.87	14.63
Speed (mph)	88.08	106.11	87.37	100.80	88.92



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# BRAKE TESTING

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## BRAKE TEST OBJECTIVE

Determine the deceleration rate attained by each test motorcycle on twelve 60 – 0 mph impending skid (threshold) stops, with ABS in operation if the motorcycle is so equipped. Each bike will be scored on the average deceleration rate it attains.

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## BRAKE TEST METHODOLOGY

Each motorcycle makes two decelerations at specific predetermined points on the test road from 90 – 0 mph at 22 ft/s<sup>2</sup>, with the rider using a decelerometer to maintain the deceleration rate. Immediately after these “heat-up” stops are completed, the motorcycle turns around and makes six measured 60 – 0 mph impending skid (threshold) stops with ABS in operation, if so equipped, at specific predetermined points. The entire sequence is repeated. The exact initial velocity at the beginning of each of the 60 – 0 mph decelerations, and the exact distance required to make each stop, is recorded by means of a non contact optical sensor in conjunction with electronic speed and distance meters. The data resulting from the twelve total stops is used to calculate the average deceleration rate which is the motorcycle’s score for this test.

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## DECELERATION RATE FORMULA

$$\text{Deceleration Rate (DR)} = \frac{\text{Initial Velocity}^*(\text{IV}) \text{ squared}}{2 \text{ times Stopping Distance (SD)}} = \frac{(\text{IV})^2}{2 (\text{SD})}$$

### EXAMPLE:

$$\begin{aligned} \text{Initial Velocity} &= 89.175 \text{ ft/s (60.8 mph x 1.4667*)} \\ \text{Stopping Distance} &= 171.4 \text{ ft.} \end{aligned}$$

$$\text{DR} = \frac{(\text{IV})^2}{2(\text{SD})} = \frac{(89.175)^2}{2(171.4)} = \frac{7952.24}{342.8} = 23.198 \text{ ft/s}^2$$

Once a motorcycle’s average deceleration rate has been determined, it is possible to calculate the stopping distance from any given speed by utilizing the following formula:

Select a speed; translate that speed into feet per second; square the feet per second figure by multiplying it by itself; divide the resultant figure by 2; divide the remaining figure by the average deceleration rate of the motorcycle in question.

### EXAMPLE:

$$60 \text{ mph} = 88.002 \text{ ft/s} \times 88.002 = 7744.352 / 2 = 3872.176 / 23.198 \text{ ft/s}^2 = 166.9 \text{ ft.}$$

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## BRAKE TESTING

TEST LOCATION: Chrysler Proving Grounds

DATE: September 20, 2008

BEGINNING Time: 2:27 p.m.

TEMPERATURE: 80.9°F

MAKE & MODEL: Harley Davidson Electra Glide FLHTP

BRAKE SYSTEM: Anti-lock

### Phase I

BRAKE HEAT-UP: (Two 90 –0 mph decelerations @ 22 ft.sec.<sup>2</sup>)

TEST: (Six 60 – mph impending skid (ABS) maximum deceleration rate stops)

	Initial Velocity	Stopping Distance	Deceleration Rate
Stop #1	60.29 mph	166.34 feet	23.50 ft/s <sup>2</sup>
Stop #2	60.13 mph	160.90 feet	24.17 ft/s <sup>2</sup>
Stop #3	60.76 mph	176.70 feet	22.47 ft/s <sup>2</sup>
Stop #4	59.97 mph	166.73 feet	23.20 ft/s <sup>2</sup>
Stop #5	61.05 mph	188.64 feet	21.25 ft/s <sup>2</sup>
Stop #6	59.71 mph	158.18 feet	24.24 ft/s <sup>2</sup>

**AVERAGE DECELERATION RATE**

**23.14 ft/s<sup>2</sup>**

### Phase II

BRAKE HEAT-UP: (Two 90 –0 mph decelerations @ 22 ft.sec.<sup>2</sup>)

TEST: (Six 60 – mph impending skid (ABS) maximum deceleration rate stops)

	Initial Velocity	Stopping Distance	Deceleration Rate
Stop #1	60.69 mph	163.41 feet	24.24 ft/s <sup>2</sup>
Stop #2	59.50 mph	159.72 feet	23.84 ft/s <sup>2</sup>
Stop #3	61.01 mph	162.47 feet	24.64 ft/s <sup>2</sup>
Stop #4	59.87 mph	156.04 feet	24.71 ft/s <sup>2</sup>
Stop #5	60.28 mph	157.63 feet	24.79 ft/s <sup>2</sup>
Stop #6	59.90 mph	155.74 feet	24.78 ft/s <sup>2</sup>

**AVERAGE DECELERATION RATE**

**24.50 ft/s<sup>2</sup>**

### Phase III

Evidence of severe fading?

Yes/No

No

Vehicle stopped in straight line?

Yes

Vehicle stopped within correct lane?

Yes

**OVERALL AVERAGE DECEL. RATE:**

**23.82 ft/s<sup>2</sup>**

Projected Stopping Distance from 60.0 mph 162.6

# BRAKE TESTING

TEST LOCATION: Chrysler Proving Grounds

DATE: September 20, 2008

BEGINNING Time: 12:47 p.m.

TEMPERATURE: 78.7°F

MAKE & MODEL: BMW R1200RTP

BRAKE SYSTEM: Anti-lock

## Phase I

BRAKE HEAT-UP: (Two 90 –0 mph decelerations @ 22 ft.sec.<sup>2</sup>)

TEST: (Six 60 – mph impending skid (ABS) maximum deceleration rate stops)

	Initial Velocity	Stopping Distance	Deceleration Rate
Stop #1	61.82 mph	151.85 feet	27.07 ft/s <sup>2</sup>
Stop #2	61.60 mph	162.95 feet	25.05 ft/s <sup>2</sup>
Stop #3	59.44 mph	138.77 feet	27.39 ft/s <sup>2</sup>
Stop #4	59.48 mph	148.63 feet	25.60 ft/s <sup>2</sup>
Stop #5	60.04 mph	149.35 feet	25.96 ft/s <sup>2</sup>
Stop #6	59.88 mph	141.42 feet	27.27 ft/s <sup>2</sup>

**AVERAGE DECELERATION RATE**

**26.39 ft/s<sup>2</sup>**

## Phase II

BRAKE HEAT-UP: (Two 90 –0 mph decelerations @ 22 ft.sec.<sup>2</sup>)

TEST: (Six 60 – mph impending skid (ABS) maximum deceleration rate stops)

	Initial Velocity	Stopping Distance	Deceleration Rate
Stop #1	61.04 mph	145.38 feet	27.57 ft/s <sup>2</sup>
Stop #2	61.47 mph	157.99 feet	25.72 ft/s <sup>2</sup>
Stop #3	59.59 mph	142.76 feet	26.75 ft/s <sup>2</sup>
Stop #4	59.58 mph	149.16 feet	25.60 ft/s <sup>2</sup>
Stop #5	59.40 mph	151.25 feet	25.09 ft/s <sup>2</sup>
Stop #6	60.45 mph	152.29 feet	25.81 ft/s <sup>2</sup>

**AVERAGE DECELERATION RATE**

**26.09 ft/s<sup>2</sup>**

## Phase III

Evidence of severe fading?

Yes/No

No

Vehicle stopped in straight line?

Yes

Vehicle stopped within correct lane?

Yes

**OVERALL AVERAGE DECEL. RATE:**

**26.24 ft/s<sup>2</sup>**

Projected Stopping Distance from 60.0 mph 147.6

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## BRAKE TESTING

TEST LOCATION: Chrysler Proving Grounds

DATE: September 20, 2008

BEGINNING Time: 2:39 p.m.

TEMPERATURE: 78.7°F

MAKE & MODEL: Harley Davidson Road King FLHP

BRAKE SYSTEM: Anti-lock

### Phase I

BRAKE HEAT-UP: (Two 90 –0 mph decelerations @ 22 ft.sec.<sup>2</sup>)

TEST: (Six 60 – mph impending skid (ABS) maximum deceleration rate stops)

	Initial Velocity	Stopping Distance	Deceleration Rate
Stop #1	60.55 mph	172.80 feet	22.82 ft/s <sup>2</sup>
Stop #2	60.54 mph	170.63 feet	23.10 ft/s <sup>2</sup>
Stop #3	59.99 mph	171.40 feet	22.58 ft/s <sup>2</sup>
Stop #4	59.91 mph	166.65 feet	23.17 ft/s <sup>2</sup>
Stop #5	59.67 mph	170.91 feet	22.41 ft/s <sup>2</sup>
Stop #6	60.36 mph	165.39 feet	23.69 ft/s <sup>2</sup>

**AVERAGE DECELERATION RATE**

**22.96 ft/s<sup>2</sup>**

### Phase II

BRAKE HEAT-UP: (Two 90 –0 mph decelerations @ 22 ft.sec.<sup>2</sup>)

TEST: (Six 60 – mph impending skid (ABS) maximum deceleration rate stops)

	Initial Velocity	Stopping Distance	Deceleration Rate
Stop #1	60.37 mph	167.55 feet	23.40 ft/s <sup>2</sup>
Stop #2	60.21 mph	174.78 feet	22.31 ft/s <sup>2</sup>
Stop #3	59.96 mph	178.66 feet	21.64 ft/s <sup>2</sup>
Stop #4	61.09 mph	166.94 feet	24.05 ft/s <sup>2</sup>
Stop #5	59.01 mph	172.00 feet	21.78 ft/s <sup>2</sup>
Stop #6	60.64 mph	168.65 feet	23.45 ft/s <sup>2</sup>

**AVERAGE DECELERATION RATE**

**22.77 ft/s<sup>2</sup>**

### Phase III

Evidence of severe fading?

Yes/No

No

Vehicle stopped in straight line?

Yes

Vehicle stopped within correct lane?

Yes

**OVERALL AVERAGE DECEL. RATE:**

**22.87 ft/s<sup>2</sup>**

Projected Stopping Distance from 60.0 mph 169.3

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## BRAKE TESTING

TEST LOCATION: Chrysler Proving Grounds

DATE: September 20, 2008

BEGINNING Time: 5:57 p.m.

TEMPERATURE: 77.8°F

MAKE & MODEL: Buell Ulysses

BRAKE SYSTEM: Anti-lock

### Phase I

BRAKE HEAT-UP: (Two 90 –0 mph decelerations @ 22 ft.sec.<sup>2</sup>)

TEST: (Six 60 – mph impending skid (ABS) maximum deceleration rate stops)

	Initial Velocity	Stopping Distance	Deceleration Rate
Stop #1	59.35 mph	154.19 feet	24.57 ft/s <sup>2</sup>
Stop #2	60.24 mph	156.74 feet	24.90 ft/s <sup>2</sup>
Stop #3	60.24 mph	158.16 feet	24.68 ft/s <sup>2</sup>
Stop #4	59.67 mph	156.01 feet	24.55 ft/s <sup>2</sup>
Stop #5	59.93 mph	158.40 feet	24.39 ft/s <sup>2</sup>
Stop #6	58.57 mph	149.65 feet	24.66 ft/s <sup>2</sup>

**AVERAGE DECELERATION RATE**

**24.62 ft/s<sup>2</sup>**

### Phase II

BRAKE HEAT-UP: (Two 90 –0 mph decelerations @ 22 ft.sec.<sup>2</sup>)

TEST: (Six 60 – mph impending skid (ABS) maximum deceleration rate stops)

	Initial Velocity	Stopping Distance	Deceleration Rate
Stop #1	56.26 mph	131.90 feet	25.81 ft/s <sup>2</sup>
Stop #2	59.55 mph	154.80 feet	24.64 ft/s <sup>2</sup>
Stop #3	60.27 mph	153.68 feet	25.42 ft/s <sup>2</sup>
Stop #4	60.12 mph	165.50 feet	23.49 ft/s <sup>2</sup>
Stop #5	59.51 mph	157.56 feet	24.18 ft/s <sup>2</sup>
Stop #6	59.52 mph	153.53 feet	24.82 ft/s <sup>2</sup>

**AVERAGE DECELERATION RATE**

**24.73 ft/s<sup>2</sup>**

### Phase III

Evidence of severe fading?

Yes/No

No

Vehicle stopped in straight line?

Yes

Vehicle stopped within correct lane?

Yes

**OVERALL AVERAGE DECEL. RATE:**

**24.68 ft/s<sup>2</sup>**

Projected Stopping Distance from 60.0 mph 156.9

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## BRAKE TESTING

TEST LOCATION: Chrysler Proving Grounds

DATE: September 20, 2008

BEGINNING Time: 4:03 p.m.

TEMPERATURE: 80.2°F

MAKE & MODEL: BMX G650XChallenge

BRAKE SYSTEM: Anti-lock

### Phase I

BRAKE HEAT-UP: (Two 90 –0 mph decelerations @ 22 ft.sec.<sup>2</sup>)

TEST: (Six 60 – mph impending skid (ABS) maximum deceleration rate stops)

	Initial Velocity	Stopping Distance	Deceleration Rate
Stop #1	59.15 mph	166.44 feet	22.61 ft/s <sup>2</sup>
Stop #2	60.35 mph	164.01 feet	23.89 ft/s <sup>2</sup>
Stop #3	60.61 mph	174.85 feet	22.60 ft/s <sup>2</sup>
Stop #4	60.41 mph	151.54 feet	25.90 ft/s <sup>2</sup>
Stop #5	60.91 mph	155.21 feet	25.71 ft/s <sup>2</sup>
Stop #6	60.04 mph	148.05 feet	26.19 ft/s <sup>2</sup>

**AVERAGE DECELERATION RATE**

**24.48 ft/s<sup>2</sup>**

### Phase II

BRAKE HEAT-UP: (Two 90 –0 mph decelerations @ 22 ft.sec.<sup>2</sup>)

TEST: (Six 60 – mph impending skid (ABS) maximum deceleration rate stops)

	Initial Velocity	Stopping Distance	Deceleration Rate
Stop #1	60.84 mph	159.64 feet	24.94 ft/s <sup>2</sup>
Stop #2	60.20 mph	154.81 feet	25.18 ft/s <sup>2</sup>
Stop #3	59.96 mph	152.35 feet	25.38 ft/s <sup>2</sup>
Stop #4	59.69 mph	150.78 feet	25.42 ft/s <sup>2</sup>
Stop #5	61.06 mph	161.17 feet	24.88 ft/s <sup>2</sup>
Stop #6	60.66 mph	148.91 feet	26.58 ft/s <sup>2</sup>

**AVERAGE DECELERATION RATE**

**25.40 ft/s<sup>2</sup>**

### Phase III

Evidence of severe fading?

Yes/No

No

Vehicle stopped in straight line?

Yes

Vehicle stopped within correct lane?

Yes

**OVERALL AVERAGE DECEL. RATE:**

**24.94 ft/s<sup>2</sup>**

Projected Stopping Distance from 60.0 mph 155.3

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# HIGH TO LOW $\mu$ TRANSITION ANTI-LOCK BRAKE SYSTEM TEST

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## TEST OBJECTIVE

Determine the deceleration rate attained by each test motorcycle during the best five out of six 40-0 mph ABS panic stops on a transitional brake surface.

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## TEST METHODOLOGY

The motorcycle is accelerated to 40 mph and both brakes (front and rear) applied simultaneously to simulate an ABS panic stop. The initial deceleration begins on a dry asphalt surface (with a .85 coefficient of friction-high  $\mu$ ) and transitions 30 feet further to a wet seal coated skid pad surface (with a .33 coefficient of friction-low  $\mu$ ). The exact initial velocity at the beginning of each 40 mph – 0 decelerations and the exact distance required to make each stop is recorded by means of a non contact optical sensor measuring speed and distance. The data from the best 5 out of 6 total stops is used to calculate the average deceleration rate which is the vehicle's score for this test.

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**TEST LOCATION:** Precision Driving Unit, Lansing

**DATE:** September 18, 2008

**BEGINNING TIME:** 3:01 p.m.

**TEMPERATURE:** 68°F

**MAKE & MODEL:** Harley Davidson FLHTP-Electra Glide

**BRAKE SYSTEM:** Anti-lock

### Phase I

**TEST:** Determine the deceleration rate attained by each test motorcycle during the best five out of six 40-0 mph ABS panic stops on a transitional brake surface.

	Initial Velocity	Stopping Distance	Deceleration Rate
Stop #1	39.93 mph	141.37 feet	12.13 ft/s <sup>2</sup>
Stop #2	39.57 mph	142.81 feet	11.79 ft/s <sup>2</sup>
Stop #3	39.58 mph	128.45 feet	13.12 ft/s <sup>2</sup>
Stop #4	39.85 mph	145.65 feet	11.73 ft/s <sup>2</sup>
Stop #5	39.05 mph	135.47 feet	12.11 ft/s <sup>2</sup>

**AVERAGE DECELERATION RATE**

**12.18 ft/s<sup>2</sup>**

### Phase II

Evidence of severe fading?  
Vehicle stopped in straight line?

Yes/No  
No  
Yes

**Projected Stopping Distance from 40.0 mph 141.4**

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# HIGH TO LOW Um TRANSITION ANTI-LOCK BRAKE SYSTEM TEST

TEST LOCATION: Precision Driving Unit, Lansing

DATE: September 18, 2008

BEGINNING TIME: 3:31 p.m.

TEMPERATURE: 68°F

MAKE & MODEL: Harley Davidson FLHP-Road King

BRAKE SYSTEM: Anti-lock

## Phase I

TEST: Determine the deceleration rate attained by each test motorcycle during the best five out of six 40-0 mph ABS panic stops on a transitional brake surface.

	Initial Velocity	Stopping Distance	Deceleration Rate
Stop #1	39.83 mph	134.19 feet	12.72 ft/s <sup>2</sup>
Stop #2	40.74 mph	163.12 feet	10.94 ft/s <sup>2</sup>
Stop #3	41.31 mph	165.04 feet	11.12 ft/s <sup>2</sup>
Stop #4	40.59 mph	167.17 feet	10.60 ft/s <sup>2</sup>
Stop #5	39.85 mph	163.46 feet	10.45 ft/s <sup>2</sup>

**AVERAGE DECELERATION RATE**

**11.17 ft/s<sup>2</sup>**

## Phase II

Evidence of severe fading?

Yes/No

No

Vehicle stopped in straight line?

Yes

Projected Stopping Distance from 40.0 mph **154.1**

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BEGINNING TIME: 4:02 p.m.

TEMPERATURE: 68°F

MAKE & MODEL: BMW R1200RTP

BRAKE SYSTEM: Anti-lock

## Phase I

TEST: Determine the deceleration rate attained by each test motorcycle during the best five out of six 40-0 mph ABS panic stops on a transitional brake surface.

	Initial Velocity	Stopping Distance	Deceleration Rate
Stop #1	40.95 mph	126.05 feet	14.31 ft/s <sup>2</sup>
Stop #2	39.78 mph	108.81 feet	15.64 ft/s <sup>2</sup>
Stop #3	40.55 mph	116.36 feet	15.20 ft/s <sup>2</sup>
Stop #4	40.03 mph	117.36 feet	14.69 ft/s <sup>2</sup>
Stop #5	40.02 mph	124.86 feet	13.80 ft/s <sup>2</sup>

**AVERAGE DECELERATION RATE**

**14.73 ft/s<sup>2</sup>**

## Phase II

Evidence of severe fading?

Yes/No

No

Vehicle stopped in straight line?

Yes

Projected Stopping Distance from 40.0 mph **116.9**

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# HIGH TO LOW U<sub>m</sub> TRANSITION ANTI-LOCK BRAKE SYSTEM TEST

TEST LOCATION: Precision Driving Unit, Lansing

DATE: September 18, 2008

BEGINNING Time: 4:33 p.m.

TEMPERATURE: 68°F

MAKE & MODEL: BMW G650X

BRAKE SYSTEM: Anti-lock

## Phase I

TEST: Determine the deceleration rate attained by each test motorcycle during the best five out of six 40-0 mph ABS panic stops on a transitional brake surface.

	Initial Velocity	Stopping Distance	Deceleration Rate
Stop #1	38.60 mph	91.36 feet	17.54 ft/s <sup>2</sup>
Stop #2	40.21 mph	114.66 feet	15.17 ft/s <sup>2</sup>
Stop #3	39.06 mph	103.28 feet	15.89 ft/s <sup>2</sup>
Stop #4	39.91 mph	109.47 feet	15.65 ft/s <sup>2</sup>
Stop #5	40.05 mph	108.92 feet	15.84 ft/s <sup>2</sup>

**AVERAGE DECELERATION RATE**

**16.02 ft/s<sup>2</sup>**

## Phase II

Evidence of severe fading?  
Vehicle stopped in straight line?

Yes/No  
No  
Yes

Projected Stopping Distance from 40.0 mph 107.4