ACCELERATION TESTING: APRIL 19, 2000 CA^{2}RS TRAINING

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On April 19, 2000, the California Association of Accident Reconstruction Specialists (CA^{2}RS) conducted a full day of skid testing in Stockton, California. Throughout the day, the membership tested various vehicles and documented the results with acceleration testing computers and by measuring the visible skid marks left on the roadway. The resulting data was tabulated (see Table 1) and the significant results were presented in the Summer 2000 issue of *Skidmarks*. What follows is an analysis of that data for any correlation between the speed at initial braking and the speed at the start of visible skid marks, a general comparison of the performance of the various acceleration computers, and finally brief discussion of the motorcycle test data.

The tests were conducted on a relatively new, un-traveled asphalt roadway. Three drag sled tests yielded an average coefficient of friction of 0.832 for roadway surface in the area of the skid tests.

A total of four vehicles were tested and all of the data was examined, but only that from the 1999 Ford Crown Victoria (police vehicle) was suitable for statistical analysis. The results of the tests involving the 1988 Chevrolet S-10 pickup and the 1998 Harley Davidson are discussed briefly, but caution should be exercised when forming opinions based on the limited testing of these vehicles.

Where possible, each test was monitored using a Braker Box Shot Marker (bumper gun), a Kustom Falcon handheld radar gun, a Vericom VC 2000 acceleration computer, a Valentine Research g-analyst, and the Stalker Acceleration Testing System (STATS). The bumper gun, VC2000, and g-analyst were attached to the test vehicle, whereas the Stalker and Radar gun monitored the test from outside the vehicle.

The 1999 Ford Crown Victoria was tested five times, three of which were conducted after the ABS fuse was removed. For the first two tests, conducted at 28 and 45-mph (refer to the data table) with the ABS functioning, the three computer systems yielded an average drag factor of 0.786; the dataset standard deviation was 0.020, suggesting the two tests were fairly consistent. The visible skid marks, measured immediately after the test, yielded a drag factor of 0.743. The monitoring equipment functioned properly for these tests, but it was noted early in the series that only the VC2000 provided immediate results; the g-analyst and the Stalker provided the desired data only after limited reduction. Additionally, it was discovered that to be used effectively, the Stalker should be used in conjunction with a bumper gun (or similar device) to definitively mark the dataset at the beginning of the brake application. Hence for this analysis, the bumper gun or VC2000 determined brake distance brake distance was used to normalize the Stalker data.

The bumper gun, attached to the rear bumper and activated by current from the brake lights, provided an accurate assessment of the overall braking distance; in most cases however, the visible skid marks were only slightly shorter than the bumper gun measurements. This was likely a function of the contemporaneous and precise measurement of the skids and the relatively new roadway surface. It should be noted however, that the bumper gun system has an inherent electro-mechanical mechanical delay on the order of 0.052-seconds [1]. Furthermore, it was learned that by using the brake light circuit to activate the bumper gun, this delay may have been increased to as much as 0.130-seconds (a distance of 8.58-feet at 45-mph).

For this reason, it is recommended that the activation switch be attached to the brake pedal and the delay, in terms of distance be considered in the calculations.

The next three tests were at 31, 38, and 46-mph with the Crown Victoria ABS fuse removed. This dataset constituted the largest statistical sample and was therefore relied upon in large part for the overall conclusion. The acceleration computer dataset yielded an average drag factor of 0.612, and in this case, a standard deviation of 0.031. The calculated drag factor was 0.540 based on the visible skid length and the radar speed at the initiation of the test. A preliminary evaluation of the data indicates the speed of the Crown Victoria at the initial application of the brakes may be as much as 13% greater than the speed at the start of visible skid mark (an energy difference of approximately 13%). Despite the limited data for the Chevrolet S-10 pickup, a non-ABS vehicle, the single validated test (performed at 30-mph) yielded a comparable value of 12%.

In the afternoon, three motorcycle acceleration tests were performed using a single motorcycle and rider. During the first test, the 1998 Harley Davidson police motorcycle was stopped by locking the rear brake only from a speed of 25-mph. The average drag factor, determined by the VC2000 and Stalker was 0.274. Recall this is 32.9% of the available coefficient of friction determined with the drag sled. The second test was performed using only the front brake from a speed of 26-mph. The corresponding average drag factor was 0.592 for this test, or 71.1% of the available coefficient of friction. Finally, the last test was performed at 27-mph and the rider utilized both brakes to the maximum extent possible without loss of control. The average drag factor for this test was 93.1% of the available coefficient of friction, 0.775. The motorcycle skid test results when viewed as a whole are consistent with the available published data. IPTM, for example, reported drag factors of 0.38, 0.63, and 0.80 for rear only, front only, and both brakes applied respectively. As observed during the CA^2RS training, motorcycle deceleration capability is largely rider skill dependent and care should be exercised when selecting a drag factor in these cases.

In light of the small number of tests performed on April 19, 2000, it is difficult to form numerical conclusion as to the relative difference between the speed at initial braking and that at the onset of visible skid marks. In tests conducted by other researchers [2], however, a similar result with an overall speed difference of 10% was reported (the reader is encouraged to review the referenced literature).

It is recommended that future skid test results be compared to those of April 19, 2000, to further increase the statistical sample and to strengthen the correlation between the speed at initial brake application and the speed at the start of visible skid marking.

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1. Reust, Timothy J., *Bumper Gun (Chalk Gun) Electro-Mechanical Delay Time,* Southwestern Association of Technical Accident Investigators (SATAI), 2000.

2. Eubanks, Jerry J., et al., *A Comparison of Devices Used to Measure Vehicle Braking Deceleration,* 930665, Society of Automotive Engineers (SAE), 1993.

3. Neptune, James A., et al., *Speed from Skids: A Modern Approach,* 950354, Society of Automotive Engineers (SAE), 1995.

Test	Radar	Bumper gun	Visible Skidmarks				Vericom					Stalker					G-Analyst			Test
Vehicle	(MPH)	Distance	L/F	R/F	L/R	R/R	Dist	Speed	Time	Ave-g	Peak-g	Dist	Speed	Time	Ave-g	Peak-g	Eff time*	Ave-g	Peak-g	Notes
1999 Ford Crown Victoria	28	38'-6"	37'-8"	37'-4"	28'-1"	27'-9"	33	28.2	1.64	0.782	0.917	38'-6"	28.899	1.76	0.744	0.99	1.4	0.79	0.84	ABS
1999 Ford Crown Victoria	45	84'	83'-3"	86'-3"	73'-8"	77'-2"	77	44.1	2.41	0.833	0.92	77'	43.25	2.59	0.749	0.98	1.4	0.82	0.9	ABS
1999 Ford Crown Victoria	31	52'-9"	59'-2"	56'-2"			46	29.9	2.08	0.654	0.8	52'-9"	30.69	2.11	0.616	0.75	1.7	0.65	0.75	No ABS
1999 Ford Crown Victoria	46	115'-9"	115'-3"	114'-3"	47'-4"	48'-1"	108	44.7	3.22	0.633	0.854	115'-9"	45.43	4.41	0.593	0.89	3	0.629	0.78	No ABS
1999 Ford Crown Victoria	38	112'-1"	103'-9"	104'-2"			103	42.4	3.21	0.602	0.759	112'-1"	42.91	3.65	0.53	0.74	3	0.603	0.72	No ABS
1986 GMC Flat bed	30						48	30.1	2.2	0.623	0.748	48'	29.91	2.11	0.609	0.79	1.7	0.612	0.667	No skid length
1986 GMC Flat bed	30	50'-0"	45'-7"	45'-7"	41'-9"	43'-10"	43	28.5	2.05	0.633	0.744	50'-0"	29.58	2.36	0.545	0.86	3.9	0.47	0.64	
1988 Chevrolet S-10	30	57'-1"	37'-6"	41'-9"	54'-8"	52'	46	28.6	2.31	0.564	0.912	57'-1"	29.45	2.43	0.509	0.81	1.3	0.78	0.84	
1998 Harley Davidson M/C	25				72'-8"		69	24	3.83	0.285	0.438	69'	24.24	4.22	0.262	0.44				Locked rear
1998 Harley Davidson M/C	26		38'-6"				46	29.6	2.07	0.65	0.815	46'	26.63	1.99	0.533	0.74				Impnd
1998 Harley Davidson M/C	27		21'		22'-2"		32	28.9	1.61	0.817	1.069	32'	26.75	1.44	0.733	0.98				Impnd

Table 1: Selected test data.