FEATURE ARTICLES

CALIBRATION STUDY SHOULD ELIMINATE VARIATIONS IN SKID-TESTING TRAILERS

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The Safety Systems Laboratory (SSL) of the National Highway Traffic Safety Administration (formerly the Office of Vehicle Systems Research, National Bureau of Standards) has conducted research for the Federal Highway Administration to develop calibration equipment and procedures for ASTM E274-70 skid trailers leading to a national reference standard. The Pennsylvania State University is examining the causes of skid number (SN) variability as measured by skid trailers now in use under National Cooperative Highway Research Program Project (1-12) (2), "Locked-Wheel Pavement Skid Tester Correlation and Calibration Techniques," which is sponsored by the American Association of State Highway Officials in cooperation with the Federal Highway Administration and administered by the Highway Research Board of the National Academy of Sciences.

In June 1971 a calibration and correlation study was jointly sponsored by SSL and Penn State. This study was conducted to provide SSL with an experimental test of the calibration equipment and procedures and to establish for Penn State a data bank from which to isolate the causes of variability in trailers. The results of that study, along with the controls used during the test, will be reported in this paper.

The participants in this study included the highway departments of the states of Maryland, Delaware, and Pennsylvania; the National Highway Traffic Safety Administration, and the SSL; Stevens Institute of Technology; and Pennsylvania State University.

SPECIAL EQUIPMENT

All the trailers were designed to conform with the ASTM Test for Skid Resistance of Paved Surfaces Using a Full-Scale Tire (E274-70). However, both the Penn State and the Pennsylvania Department of Transportation skid trailers were one-wheeled systems; all others were two-wheeled systems, locking one wheel.

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SSL provided standard scales, pressure gages, and a standard force-plate calibrator that has been developed by SSL. The total accuracy of the force-plate system is better than 0.2 percent of its full-scale reading. (Figure 1 shows the force-plate system.) A standard speed-indicating unit (developed by Mr. George Shute of Texas A&M University) was used on all the trailers during the test. This system, using the SSL fifth wheel, was found to be accurate to within 4 feet in a mile. Each run was also monitored by the Penn State radar system, which agreed to within ½ mph of the value obtained when using the standard speed-indicating unit.

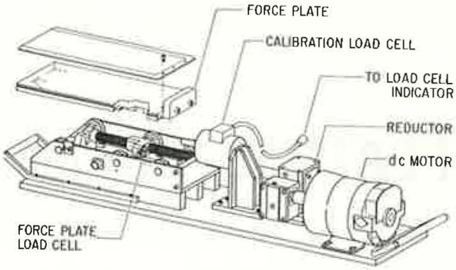


Figure 1. SSL skid trailer calibration plate.

CONSTRAINTS

The organizers felt that if all trailers were calibrated with the same standard calibration system and checks were made on the watering system accuracy according to ASTM E274-65T specification, and if the lateral position of the trailer on the test surface was always the same or at least measured, all the trailers should be able to come within an error band of three skid numbers; this is equivalent to twice the standard deviation between different ASTM tires found in a study by SSL.

CALIBRATION PROCEDURE

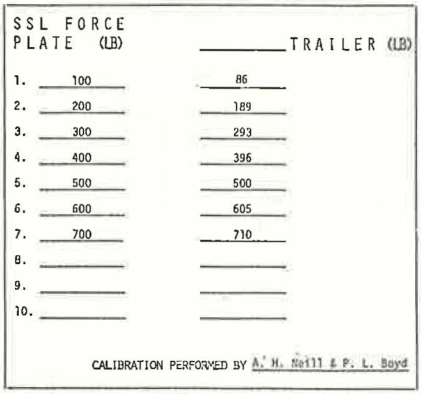
Each team participating in the study calibrated its watering system at 30, 40, and 60 mph (Fig. 2). Prior to the actual testing, each trailer was calibrated in the following manner:

RUN	DRIVE WHEEL SPEED MPH	WATER PUMPED LB	GALLONS OF WATER	PUMPING TIME SEC
1	30	16.35	1.96	5
2	30	16.97	2.04	5
3	30	17.41	2.08	5
4	30	17.07	2.04	5
1	40	19.68	2.36	5
2	40	20.17	2.42	5
3	40	19.30	2.32	5
4	40	20.09	2.41	5
1	60	27.83	3.34	5
2	60	28.27	3.40	5
3	60	28.65	3.44	5
4	60	28.56	3.42	5

Figure 2. Example of water flow calibration data taken for each trailer.

1. A cold inflation pressure of 25 psi was set on all trailers at the same time;
2. The wheel and hitch loads of each trailer were weighed;
3. The hitch height and length of each trailer were measured;
4. The tires were warmed up by driving for 5 miles;
5. A static calibration was performed using the SSL force-plate system;
6. The standard reference speed system was installed; and
7. The water trace width was measured at 40 mph.

Inaccuracy in the static force calibration curves of some of the trailers ranged as high as 55 lb, which would equal an error of about five skid numbers if uncorrected. Figure 3 is an example of the calibration chart for



SSL FORCE PLATE (LB)	TRAILER (LB)
1. 100	86
2. 200	189
3. 300	293
4. 400	396
5. 500	500
6. 600	605
7. 700	710
8.	
9.	
10.	

CALIBRATION PERFORMED BY A. H. Neill & P. L. Boyd

Figure 3. Example of calibration data chart for each trailer.

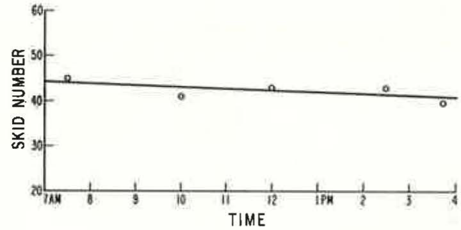


Figure 4. Degradation of surface during testing day.

each trailer. Each truck was equipped with the standard speed unit prior to the measurement of its water trace widths. Each truck then proceeded to the calibration site where a measurement was made of its water trace width. In the absence of a better system of measurement, a ruler was used to measure the extreme edges of water wetting. Each trailer then made 10 runs at 30, 40, and 60 mph respectively. The driver was asked to try to maneuver his vehicle so that the skidding tire would be in the wheel track that was apparent in the road. However, this lateral positioning was monitored so that any errors in the final skid numbers would be clearly understood.

DATA

The data were reduced in the presence of SSL personnel who monitored the data reduction and ensured that it was being performed according to the ASTM standards; i.e., the force was taken during the 2nd second of the skid. The Penn State trailer provided the control so that the condition of the surface could be monitored as the day progressed. These results are shown in Figure 4. It is clear from this graph that, as the day wore on, the road surface was being polished and heated, hence, the decreasing skid number. Figure 5 presents the results of dynamic calibration for comparison among the six skid trailers at three different speeds. The standard deviations at 40 mph for each trailer are included. These values are uncorrected for surface degradation during the day and for lateral positioning.

Figure 6 shows the lateral profile of the test site as compiled by Penn State from test data before and after the correlation meeting. Figure 7(a) through 7(f) shows the lateral positions of each trailer with respect to the centerline and the profile. The importance of this parameter is clear because errors of ten skid numbers can be generated if no control is placed on lateral positioning. Table 1 gives the average distances from the centerline and the standard deviations around this average for each trailer at each speed. Corrections have not been made to

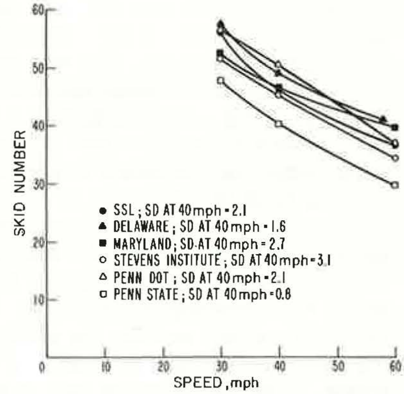


Figure 5. Final results of Penn State-SSL skid resistance tester comparison study.

TABLE 1

AVERAGE LATERAL POSITION OF SKIDS FROM ROAD CENTERLINE

Team	30 mph		40 mph		60 mph	
	Average (inches)	Standard Deviation	Average (inches)	Standard Deviation	Average (inches)	Standard Deviation
SSL	23.1	4.3	23.7	3.6	20.8	5.2
Delaware	20.6	3.9	19.4	4.1	–	–
Maryland	18.8	4.1	17.7	4.3	16.0	3.9
Stevens Institute	23.0	4.9	24.7	11.1	23.8	7.9
Penn DOT	25.6	1.6	25.4	2.6	25.0	3.2
Penn State University	22.0	4.6	24.1	5.3	24.7	3.9

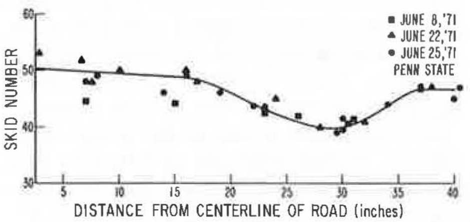


Figure 6. Lateral profile of test site as compiled by Penn State.

the lateral positioning because the profile in Figure 6 could not be observed on the day of the testing.

In Table 2 one can see that three of the two-wheeled trailers agreed to within two skid numbers. Figure 8 shows that the Delaware trailer, which had a skid number value slightly higher than that of the other two-wheeled trailers (Fig. 6), had a significantly lower water output in the 40-mph range. In fact, throughout the speed range, its water output was well below the 25 percent tolerance that ASTM has specified. From an examination of Delaware's flow data, it would seem that the problem was too much scatter at the nozzle causing an extremely wide trace width. The one-wheeled trailers were significantly different from the family of two-wheeled trailers, and their results were at the extreme ends of the data. In discussions with personnel from both of the facilities it would seem that there may be a dynamic problem such as vertical loading error or yaw that may be influencing the skid number values.

Table 2 gives the skid numbers at 40 mph with and without corrections for force calibration and for surface degradation during the day. The values that would have been reported had the various agencies been working independently are shown in column (a), and the trailers appear to demonstrate the best agreement in column (a). However, this apparent result is misleading. According to column (a), the low water output of the Delaware trailer had no effect on its measurement relative to the other trailers with much greater water outputs. This contradiction is resolved by the calibration correction in column (b) that shows that the Delaware trailer's measurement is higher than that of the other two-wheeled trailers after they had been calibrated uniformly. A similar case of offsetting errors may be present to a lesser degree in the Penn-DOT trailer readings because the Penn State's calibration plate is in nearly perfect agreement with the SSL plate. (However, in the calibration of two-wheeled trailers where some lateral force on the plate may be present, the use of ball bearings rather than roller bearings to support the longitudinally movable contact surface is preferable.) The agreement among SSL, Maryland, and Stevens Institute trailers, all two-wheeled testers with adequate water output, was improved by the uniform calibration to a point where they were all included in a 1.3 SN range. A correction for degradation of the surface during the day was attempted using the data gathered by Penn State periodi-

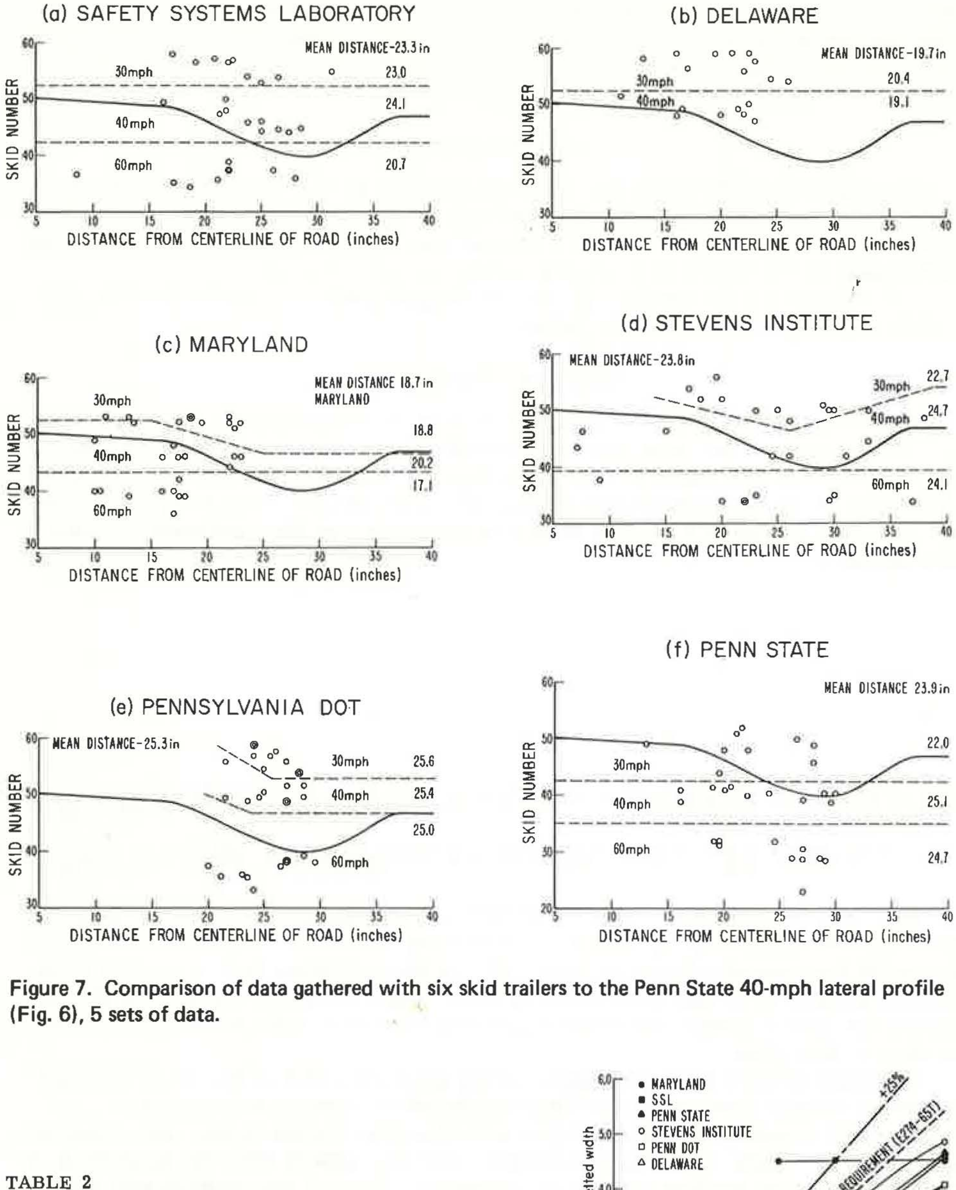


Figure 7. Comparison of data gathered with six skid trailers to the Penn State 40-mph lateral profile (Fig. 6), 5 sets of data.

TABLE 2

SKID NUMBERS AT 40 MPH

Team	(a)	(b)	(c)
Penn State University	40.2	40.2	43.6
Stevens Institute	44.3	45.2	47.3
Maryland	44.2	46.3	47.5
Penn DOT	47.8	50.5	53.3
Delaware	45.1	49.0	49.9
Safety Systems Laboratory	46.5	46.5	46.5

Note: Column (a) = without force calibration correction;
Column (b) = with force calibration correction; and
Column (c) = corrected for degradation of the surface during the day including force calibration correction.

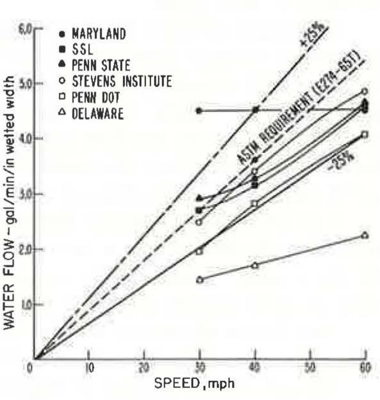


Figure 8. Water flow for participating skid resistance testers.

cally throughout the test period. In column (c), which includes this correction, the same pattern persists: the one-wheeled trailers occupy the extremes; three two-wheeled trailers group closely; and the fourth two-wheeled trailer with a low water output reads slightly higher.

CONCLUSION

The uniform calibration and close monitoring of this study have provided a valid basis for comparison of skid testers. The close agreement among three of the two-wheeled testers and the logical and easily remedied reason for the difference in the fourth two-wheeled tester is encouraging.

The causes for the variability of the single-wheeled testers do not fall within the scope of this investigation.

ACKNOWLEDGMENTS

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MOTORIST WARNING SYSTEM FOR DUST STORMS UNDER TEST BY ARIZONA HIGHWAY DEPARTMENT

The Casa Grande area south of Phoenix, Arizona, is the scene of frequent dust storms that whip up suddenly, reducing visibility to zero and causing property damage and injury to motorists on the highways that cross the area. Sixteen people have lost their lives on Interstates 10 and 8 due to dust storms during the last 2 years, including eight who died in a multiple vehicle pile-up in May of this year.

This hazard may soon be a thing of the past when one of the most unusual motorist caution systems on the entire Interstate system is completed. The first of 20 warning signs, equipped with flashing strobe lights, has been installed at the scene of the May accident, and the others will be spaced at 5-mile intervals on the two Interstate highways. Bids on the system will be taken later this year, and the installation should be completed by the beginning of the 1972 dust season in March.

The prototype signal features an anemometer that is preprogrammed to activate strobe lights when wind conditions are sufficient to create dust storms in the area. These amber-colored flashing lights will draw motorists' attention to dust storm warning signs on which the signals are mounted.

The balance of the signs in the 20-unit system will employ both wind-activated anemometers and light-sensitive photoelectric cells.

Arizona State Highway Engineer William N. Price estimated the cost of the system at one-half million dollars and said he expects to have Federal Highway Administration approval by the time bids are solicited, including Federal