

Research Report
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**THE EFFECTIVENESS OF REGULATORY SCHOOL
FLASHERS IN REDUCING VEHICLE SPEEDS**

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ABSTRACT

Pedestrian safety for school-age children has been a growing problem in recent years. Children between the ages of five and nine represent less than 10 percent of Kentucky's population but over 16 percent of all pedestrian fatalities. A study was conducted to evaluate the effectiveness of regulatory school flashers used in school zones to reduce vehicle speeds and alert motorists of pedestrian activity and to determine measures which promote safety in school zones.

Speed studies were conducted during flashing and non-flashing periods at 48 school zones where regulatory school flashers were used. The locations involved a variety of speed limits (15.6 to 24.6 m/s (35 to 55 mph)), highway types (two-lane and four-lane roads), location types (rural areas, towns, and large cities), and pedestrian and traffic volumes.

Average speed reduction during flashing periods was only 1.6 m/s (3.6 mph); 71 percent of the locations showed speed reductions less than 1.8 m/s (4 mph). Only two locations had speed reductions over 4.5 m/s (10 mph). Flashers in 24.6-m/s (55-mph) zones were found to increase the potential for inter-vehicle accidents. The presence of crossing guards or police resulted in speed reductions of approximately 4 m/s (9 mph). High pedestrian volumes in several school zones contributed to a 0.9-m/s in virtually no speed reductions. Excessively long flashing periods resulted in speed reductions of less than 1.2-m/s (2.6 mph).

Recommendations included routine inspections and improved maintenance of school flashers. Postmounted flashers should be replaced with overhead flashers in commercial areas or where sight distance is restricted. Speed enforcement was encouraged for some locations, and uniformed crossing guards were recommended where short vehicle gaps or high speeds prevail. For locations with 24.6-m/s (55-mph) to 15.6-m/s (35-mph) speed limits, the speed limits in the school zones should be increased from 11.2 m/s (25 mph) to 15.6 m/s (35 mph) during flashing periods. Special pedestrian phasing was recommended for several traffic signals near school zones.

INTRODUCTION

The use of flashing beacons together with signing has become somewhat standard throughout the country to alert drivers to the presence of school children and to regulate vehicle speed in school zones. Yellow beacons, usually two flashing alternatively, may be used with both warning signs and regulatory signs. The only regulatory signs related to school zones are speed-limit signs. Both hazard identification beacons and speed-limit sign beacons are intended to operate only during hours when the warning and speed regulations are in effect. The effectiveness of signs and flashing lights in reducing speeds in school zones has been questioned. Many school flashers seem to be ignored on high-speed highways and near schools where pedestrian activity is low. Physical features of the installation and site appear to influence motorist compliance. Factors such as sight distance, presence of crossing guards, width of the roadway, reliability of the flasher, and flasher placement may influence obedience.

The purpose of this study was to determine the effectiveness of flasher beacons in reducing vehicle speeds in Kentucky. Speed measurements were made during flashing and non-flashing periods at 48 locations. The physical characteristics of each site were identified and compared to speed reductions. A large sample of school flashers was inspected to ascertain their condition and operation. This information was helpful in determining the reliability of the beacons in everyday operation.

NEED FOR TRAFFIC CONTROLS IN SCHOOL ZONES

In 1973, the national pedestrian fatality rate for elementary school children (5 to 14 years old) was about five per 100,000 population. Only pedestrians over 65 years old exceeded this rate. Of the 10,500 pedestrian deaths in 1973, about 1,900 were elementary school children. An additional 46,000 children in this age group were injured (1).

In Kentucky, pedestrians between the ages of 5 and 9 represent less than 10 percent of the total population but over 16 percent of all pedestrian fatalities. This percentage exceeded all other age groups (2). Of the 167 pedestrian deaths in 1973, there were 27 child fatalities (5 to 9 years old). Approximately 600 children pedestrians (5 to 14 years old) were injured in Kentucky by motor vehicles.

TRAFFIC CONTROLS FOR SCHOOL ZONES

The use of flashing beacons in the United States varies among states. Also, variations of speed limits in school zones range from 7 to 13 m/s (15 to 30 mph). As surveyed by Withefield (*cf.* 3), the most common limit is 7 m/s (15 mph) (42 percent of the states). About 15 percent of the states use a 9-m/s (20-mph) limit; 12 percent use a 11-m/s (25-mph) limit. Several states are considering revising speed limits for school zones. Maryland's state legislature is considering a bill to lower the limit from

11 to 7 m/s (25 to 15 mph); on the other hand, a study in Tennessee resulted in a recommendation to raise the limit from 7 to 11 m/s (15 to 25 mph) (*cf.* 3). A variety of flashers in combination with a speed-limit or warning sign is in common useage.

While regulatory signs and flashing beacons are prevalent combinations in school zones, warning signs and flashing beacons are also common in some states. The diamond-shaped, yellow "School Zone" or "School Crossing" signs with two flashing lights is used in many urban areas of Kentucky where the normal posted speed limit is at or below 11 m/s (25 mph). The school-crossing sign (emblem) is also commonly used with a set of flashers; even the advance school emblem was found to carry flashers.

Signs and beacons are often accompanied by roadway markings. Permissible signs and pavement markings are given in Part VII of the **Manual on Uniform Traffic Control Devices for Streets and Highways** (4). Many states publish their own manuals on school-crossing standards and regulations. New Mexico and Kansas are examples (5, 6). The Automotive Safety Foundation also has published a safety program for school pedestrians (7).

When flashing beacons are placed back to back above a highway, the point of a school crossing is indicated and a painted crosswalk is usually provided directly below the flashers. When the beacons are separated by several hundred meters (feet), regulatory speed-limit signs are commonly used to control vehicle speeds through the zone. School zones or crossings may provide additional protection for children when a safety patrol or crossing guard is present. A safety patrol usually consists of older children who are designated by the school to supervise street crossings. They have no authority to control vehicular traffic. Crossing guards are adults, usually in uniform, who supervise street crossings and have the authority to regulate vehicular traffic. Local police officers are often used as crossing guards at particularly dangerous locations. Guidelines for the organization and supervision of safety patrols and a guide to the selection, training, and warrants for crossing guards were developed by the American Automobile Association (8, 9).

Traffic signals are helpful at locations having high speeds and volumes and where pedestrian delay can be long. At school areas near signalized intersections, a pedestrian phase may be assigned when turning movements create a hazard for children crossing the street (7). Details of a recommended program for school-crossing protection were developed by the Institute of Transportation Engineers. This program gives guidelines and criteria for implementing various levels of traffic control for school crossings areas (10).

STUDY PROCEDURES

Two major phases of data collection were to inspect a large sample of school flasher locations and document operational problems and to conduct speed measurements during flashing and non-flashing

periods at a representative number of locations. The sample locations were in 33 counties in central, northern, and northeastern Kentucky. These counties were chosen because they include urban and rural locations, two-lane, four-lane undivided, and four-lane divided highways, and speed limits ranging from 11 to 25 m/s (25 to 55 mph). There were 120 flashers in the 33 counties (out of a total of 424 school flashers currently maintained by the Bureau of Highways).

Inspection of the 120 school flashers included noting information concerning the highway width, normal speed limit, name of school, flashing times, and other pertinent information that may affect flasher effectiveness. The clocks were checked for accuracy. Flashers were actuated to check bulbs and fuses. In some cases, minor repairs such as cleaning relay contacts and adjusting the clock were made.

Speed measurements were made at flasher locations which had a wide variety of normal speed limits, traffic volumes, pedestrian activity, sight distances, and roadway widths. Also, both warning and regulatory flashers were used at test sites in large cities, small towns, and rural school locations. At each location, a speed meter (radar) was placed in the rear window of a car parked parallel to the road and hidden as much as possible. The car was often parked between two other cars. A newspaper was sometimes used to cover the radar scope so it would not be easily detected by passing motorists. Speed was measured for about 30 to 45 minutes during flasher operation periods and during off periods. In locations with low volumes of traffic, the sampling plan was to register at least 100 vehicles per period, if possible.

At five locations where crossing guards were present during part of the flashing period, vehicle speeds were registered during a flasher-off period, during a flasher-on period without crossing guard, and during a flasher-on period with crossing guard. Where driveways and cross streets existed within the school zone, speeds of turning vehicles were not noted. Only speeds of through traffic were recorded. When traffic volumes were high, random sampling was employed. In cases of a caravan of vehicles, a single speed was recorded. Speeds of school buses were recorded only if movement through the school zone was unrestricted. Generally, speeds of vehicles in both directions were taken. While speeds were taken during each test period (during flashing and during off periods), a representative 10- or 15-minute volume count was made during each period. This permitted an analysis of the effect of traffic volume changes on speeds during the two test periods. All information which could have affected speeds in the school zone was listed.

RESULTS OF FLASHER INSPECTIONS

All 120 school flashers were inspected to determine how well they functioned. The country, route, location, school(s), speed limit, flasher type, and average daily volumes of pedestrians and buses were tabulated for each location.

Another major purpose of the field inspections was to select a representative sample of flasher locations where speed data could be collected. School zones with conditions which may bias the speed sampling were not considered appropriate for speed studies. Such conditions included (1) a crossing only, (2) a single set of flashers in operation, (3) a continual 24-hour flasher, (4) a very low volume (insufficient sample during flashing period), (5) a congested area with a narrow street, (6) a school not adjacent to a road, (7) a very steep grade, and (8) a closed school. Since most flashers are located on roadways with posted speeds under 18 m/s (40 mph), not all of the low-speed locations were used. A summary of the 120 locations, as classified by the field investigation, is given in Table 1.

Field inspections permitted discovery of 17 flashers which were defective or malfunctioning. The most common problems were inoperative clocks (seven locations) and burned-out flasher bulbs (four locations). Other problems included deteriorated wiring, disconnected power, and flashers tilted away from desired direction. A list of the 17 defective flashers (about 14 percent) was given to the respective highway districts.

The placement and maintenance of most flashers were judged to be good. Flashers were mounted in one of three ways: (1) on posts with no extension arms, (2) with extension arms to place the flasher in more direct view of the driver, and (3) suspended over the highway by cables, particularly over four-lane highways. The flasher at one location was hidden by tree limbs and was barely noticeable at a distance of 30 meters (100 feet). The flashers at another school were twisted away from the direction of travel so that they were barely noticeable by motorists. Some flashers in urban areas were not particularly evident because they were located amidst commercial signing or were too remote from the roadway. Other flasher signs had badly chipped paint and were difficult to read. Pavement markings tend to deteriorate before renewal is scheduled. A set of flashers at one school was disconnected from the power lines.

Non-uniform signs were in use at some of the flasher locations. The **Manual on Uniform Traffic Control Devices** prohibits the placement of portable stop signs or any signs with commercial messages. While only a few of these signs were found, a school sign was discovered which had the name of a local bank affixed at the bottom. A portable stop sign was in use during school hours on a major city street.

There were seven locations where sight distances were very limited, and a few locations had sight distances as low as 30 meters (100 feet). The use of the "SCHOOL AHEAD" signing and flashers suspended over the roadway helped to compensate for limited sight distances in some cases.

School officials and crossing guards at several location indicated that some of the flashers had a history of flashing at inappropriate times. One set of flashers, for example, had flashed erratically

for the past 2 years. At another location, the flasher burned for over a year (according to local school officials). A number of school flashers had been purposely set to flash continually.

The operational reliability of flashers may affect driver compliance with the speed limit. Several flashers were programmed to operate long after all school buses and child activity had ended. Over 3 hours of daily operating time were noted at several locations. A shorter flashing period might have caused more drivers to respect the flasher.

RESULTS OF SPEED STUDIES

Speed measurements were made at 48 flasher locations. Five of the locations had crossing guards. Two speed studies were made at the same location involving the morning and the afternoon flashing periods to determine whether speeds were similar during the two periods.

Of the 48 speed locations, seven were in large urban areas (over 10,000 population), 13 in small urban areas (2,500-10,000 population), and 28 in rural areas or small towns (less than 2,500 population). Twenty-nine of these locations were in low speed-limit zones (11 to 16 m/s (25 to 35 mph)); eleven were in medium speed-limit zones (16 to 20 m/s (36 to 45 mph)); and eight were in high speed-limit zones (21 to 25 m/s (46 to 55 mph)). Thirty-nine sets of speed measurements were made on two-lane roads and nine were made on four-lane roads (Table 2).

Speeds were measured at 12 locations to determine whether there was any significant difference between the vehicle speeds before the flashers were actuated and after they were turned off. The difference in average speeds for these periods was less than 0.5 m/s (1 mph). Therefore, either period could be used for comparison with the flashing periods. For the 48 locations, the before flashing periods were usually used. Speeds monitored during the morning and afternoon flashing periods at one location were very similar. Either morning or afternoon speeds were taken at the 48 locations.

As mentioned earlier, there was a considerable increase in traffic volumes at several locations while the flashers were actuated. This resulted because the morning and afternoon flashing periods correspond closely with rush hours. To quantify the component of speed reduction due to the volume increase, a set of speed-volume curves was used. These curves were taken from the 1965 **Highway Capacity Manual (11)** and can be used to determine speed reductions expected as traffic volume increases on rural two- and four-lane roads. Because of interrupted flow of traffic in urban areas, speed-volume relationships for non-expressway, urban highways are not very well known. For each of the 16 rural speed-measurement locations, the traffic volumes (counted during speed studies) before and during flashing were found from appropriate curves in the capacity manual. The corresponding speeds for these two volumes were then compared, and the reductions due to volume changes were tabulated. The average reduction was only

0.4 m/s (0.8 mph) (16 locations); the maximum reduction was 1.1 m/s (2.5 mph) (two locations). Traffic volume was a major contributor to reduction at only two locations..

A statistical test was used to determine whether the speed reductions during flasher operation were significant. Without considering the five locations where crossing guards were present, results showed that 84 percent of the flashers caused a significant speed reduction with 95-percent probability. Using a 99-percent probability, about 73 percent of the flashers caused a significant speed reduction.

Although most of the flashers gave significant reductions in speeds, the magnitude of the reductions was not large in most instances. Of 48 locations (excluding the five locations with crossing guards), 35 (71 percent) showed reductions of less than 2 m/s (4 mph) (Figure 1). The average reduction was 1.6 m/s (3.6 mph) per location. Plots of average speeds before and during flashing are given in Figure 2. The average speeds before and during flashing are shown in Table 3 for locations with various posted speed limits. Whereas the average speed dropped from 16 to 14 m/s (35 to 32 mph), the 85th-percentile speeds decreased 3 m/s (5 mph). Locations with the highest speed limit had the lowest reduction in 85th-percentile speeds. Average speeds reduced more at locations with the highest speed limits.

Cummulative-type speed distribution curves are shown in Figure 3. Motorist compliance with the 11-m/s (25-mph) speed limit was only 18 percent during the flashing periods; however, eight percent of the vehicles traveled below that speed with the flashers off. The flashers, therefore, were successful in gaining compliacne from only ten percent of the motorists. The 85th-percentile speed while flashing was 17 m/s (39 mph) -- 8 m/s (19 mph) over the speed limit.

The 4.5-m/s (10-mph) paces before and during flashing periods are shown in Figure 4. The pace ranged between 13.0 and 17.5 m/s (29.1 and 39.1 mph) before flashing and between 10.9 and 15.3 m/s (24.3 and 34.3 mph) during the flashing periods. The percentage of vehicles in the 4.5 m/s (10-mph) pace was 51 before flashing and 52 while flashing. For 16-m/s (35-mph), 20-m/s (45-mph), and "other" speed limits, there was virtually no difference in the uniformity of speeds before and during flashing peridos. However, 25-m/s (55-mph) locations, the percent of vehicles in the pace was 48 before flashing and only 43 while flashing. This drop of nearly 15 percent indicated less speed uniformity and, therefore, a greater risk of collision between vehicles.

Speeds at five locations where crossing guards directed pedestrian and vehicles during the flashing periods were compared to speeds controlled by flashers only. Where flashers were not actuated and no crossing guards present, the speeds averaged 14.6 m/s (32.6 mph). With the flashers alone, the speed was 13.4 m/s (29.9 mph), a 1.2-m/s (2.7-mph) reduction. With the flasher on and crossing guards present, the average speed was 10.6 m/s (23.7 mph), a 4.0-m/s (8.9-mph) reduction.

VARIABLES IN FLASHER EFFECTIVENESS

Speed reductions attributable to the flashers ranged from 0 to 5 m/s (0 to 12 mph). Inasmuch as only a few of the locations had the desired effectiveness, some physical features which might affect motorist compliance were tested for significance. Some of these factors were average speeds, pedestrian volumes, number of school buses, pavement width, sight distance, enforcement, proximity to intersection, and flasher reliability.

Average Speeds

Greater reductions in speeds were found at locations where normal speeds were higher. A wide scatter of data points was due to other variables. The cumulative percentages of locations in three separate speed ranges are plotted against speed reductions in Figure 5. The speed ranges represent the average speed of vehicles before the flashers were actuated. As can be seen, the higher the speed range, the greater the speed reduction. The reductions were 1.1, 1.7, and 2.8 m/s (2.4, 3.9, and 6.2 mph) for the lowest (24 locations), middle (16 locations), and highest (9 locations) speeds, respectively. However, the speeds in the 20- to 25-m/s (46- to 55-mph) range exceeded the speed limit by 8.1 m/s (18.1 mph); speeds in the 16- to 20 m/s (35- to 45-mph) and the 11- to 16-m/s (25- to 35-mph) ranges exceeded the limit by 4.3 and 1.9 m/s (9.7 and 4.2 mph), respectively. Whereas the flashers at the high-speed locations caused slightly greater reductions, the average speeds exceeded the 11-m/s (25-mph) limit by a greater amount than at low-speed locations.

Pedestrian Volumes

The relationship between pedestrian volumes at school flasher locations and speed reductions was not discernable from plots of the two variables. The least-squares fit for low-speed areas (11 to 16 m/s (25 to 35 mph)) indicates that speed reductions increased as pedestrian volume increased from 50 to 400 per day.

While recording speeds at four locations, the data were coded to indicate whether children were or were not visible in the school zone. Speeds reduced about 1 m/s (2 mph) when children were visible to the motorist.

Volumes of School Buses

In many school zones, pedestrian volumes were very low because most children, particularly in rural areas, were bused to and from school. The number of school buses entering and leaving a school zone was considered to be a possible influence on vehicle speeds. A plot of speed reductions and volumes of school buses gave a very large scatter of data points at locations where there was a small number of buses. The reduction in speed was only about 1 m/s (2 mph) as the number of buses per day increased from 0 to 32.

Highway Width

Of the 48 sites, 40 were on two-lane roads. The average reduction in speed on four-lane roads was 1.6 m/s (3.5 mph); this compared to 1.7 m/s (3.6 mph) on two-lane roads.

Sight Distance

Because most of the locations studied were in low-speed areas (11 to 16 m/s (25 to 35 mph)), sight distances were usually not critical. Flashers in high-speed areas were suspended above the roadway for better visibility. There were a few flashers, however, which had sight distances less than 61 meters (200 feet) in one or both directions.

Average speeds at the five locations having the least sight distances before flashing ranged from 13 to 17 m/s (30 to 39 mph). Sight distances ranged from 30 to 122 meters (100 to 400 feet). Speed reductions at these locations varied from -0.4 to +0.8 m/s (-0.8 to +1.9 mph) and averaged only 0.4 m/s (0.8 mph).

Speed Enforcement

At seven locations, local or state police regularly parked in the school zones and cited motorists violating the 11-m/s (25-mph) limit. The average speed before flashing was about 19 m/s (42 mph), and the average speed reduction while flashing was 3.8 m/s (8.4 mph). This reduction was considerably more than the 1.7-m/s (3.9-mph) average reduction at locations in the 16- to 20-m/s (35- to 45-mph) range. The average speeds during flashing periods at these locations still exceeded the 11-m/s (25-m/s) speed limit.

Speed Zones Near Signalized Intersections

Five locations with traffic signals or stop signs within the school zone were studied. Speed reductions were less than 0.4 m/s (1 mph) at four locations and 1.6 m/s (3.6 mph) at the remaining location. All locations had non-flashing, average speeds below 16 m/s (3.5 mph). The low speed was probably judged reasonable by motorists; and therefore, no further reductions in speed were deemed necessary.

Flasher Reliability

Past reliability of a school flasher may be an important factor in the compliance and obedience of local motorists to speed limits in school zones. Flasher reliability, here, refers to the operational validity of the flasher. Sometimes flashers were actuated at incorrect times, did not operate for several days, or flashed continually. Speed studies at three such locations with a history of incorrect flashing periods showed an average speed reduction of only 0.8 m/s (1.7 mph).

To determine the effect of long flashing times on speed reductions, the average period of operation was computed for each location. There were ten locations which had average periods from 70 to 105 minutes.

None of these locations had speed reductions over 1.2 m/s (2.6 mph) while flashing. Twenty of the remaining 39 locations (about 51 percent) had speed reductions over 1.2 m/s (2.6 mph) and an average flashing period of 60 minutes or less. These findings do not indicate that short flashing periods will necessarily result in large speed reductions. They do suggest that excessive flashing periods may cause disrespect for the flashers.

Other Factors

If the school zone has good physical characteristics and the flashers are properly maintained and operated, the flasher may contribute to significant speed reductions. Crossing guards and police enforcement further assure speed reductions. However, certain other conditions may completely negate the effectiveness of the flasher.

An important observation was that several school flashers were in operation at locations which had low pedestrian volumes and low vehicle speeds and volumes. While the flashers may have helped, installation of school warning signs and pavement markings would have likely been equally effective. Since the vehicles were already traveling near 11 m/s (25 mph), there was no further inducement to reduce speeds. While most school flashers are probably warranted, a few locations do not need them and may eventually cause motorists to ignore them.

Speeds were not monitored at any of the locations where the flashers operated continually because non-flashing speed data could not be obtained. Since these flashers operate on weekends and at night, the local motorists probably ignore them.

SUMMARY AND CONCLUSIONS

The following findings and conclusions were based on studies of school flashers in 33 counties during 1974 and 1975:

1. Speed reductions attributable to flashers were statistically significant at the 95-percent level at 84 percent of the locations. The average speed reduction was 1.6 m/s (3.6 mph), while 71 percent of the locations showed speed reductions less than 1.8 m/s (4 mph). Only two locations yielded speed reductions over 4.5 m/s (10 mph).
2. The 85th-percentile speeds decreased by about 2.2 m/s (5 mph) for all locations. The higher-speed locations had lower reductions (0.9 m/s (2 mph)) than the low-speed locations (1.8 m/s (4 mph)).
3. The 85th-percentile speeds at all locations during flashing periods exceeded the 11-m/s (25-mph) limit by about 8.3 m/s (19 mph).
4. Motorist compliance with the 11-m/s (25-mph) speed limit was only about 18 percent; eight percent of the vehicles traveled below that speed when flashers were not operating.

5. Uniformity of driving speeds (4.5-m/s (10-mph) pace) was the same at low-speed (11 to 16 m/s (25 to 35 mph)) and medium-speed (16 to 20 m/s (36 to 45 mph)) locations whether the flashers were on or not. However, at high-speed locations (21 to 25 m/s (46 to 55 mph)), a 15-percent decrease of vehicles in the 4.5-m/s (10-mph) pace was noted -- indicating that the inter-vehicle accident potential is increased when the flashers are on.

6. Crossing guards contributed to a decrease of vehicle speeds of about 4 m/s (9 mph), and the average speeds were under 11 m/s (25 mph) at four of the five locations. Without the crossing guards at these same locations, the speed reduction averaged only 1.2 m/s (2.7 mph). Crossing guards were stationed at about ten percent of all locations.

7. Regular speed enforcement in school zones by police agencies caused average speed reductions of 3.8 m/s (8.4 mph) at seven locations.

8. Speed reductions at high-speed locations were slightly higher than at other locations. However, the average speeds exceeded the 11-m/s (25-mph) limit by about 8 m/s (18 mph) at high-speed locations compared to 4.3 m/s (9.7 mph) and 1.9 m/s (4.2 mph) at medium- and low-speed locations, respectively.

9. Pedestrian volumes in the school zones contributed to a slight decrease in vehicle speeds (about 1 m/s (2 mph)). Also, school bus volumes contributed to a slight decrease in vehicle speeds (about 1 m/s (2 mph)).

10. Highway width did not appear to affect speed reductions

11. Short sight distances between motorists and school flashers contributed to the ineffectiveness of flashers at five locations.

12. Average decreases in speed of less than 0.4 m/s (1 mph) during flashing periods were attributed to volume increases at only two locations.

13. Signalized or "stop sign" intersections adjacent to or between school flashers resulted in virtually no speed reductions in four of five such locations.

14. Excessively long flashing periods at ten locations resulted in speed reductions of less than 1.2 m/s (2.6 mph).

15. School flashers at three locations, with a recent history of inappropriate flashing, yielded an average speed reduction of only 0.8 m/s (1.7 mph).

16. Several flasher installations were not warranted because of low pedestrian volumes and low vehicle speeds and volumes. A few continually flashing lights were also found.

17. Nearly all school flasher locations have favorable as well as unfavorable features which contribute to driver compliance or non-compliance with the 11-m/s (25-mph) limit. A single, significant defect can render the flasher ineffective.

18. About 14 percent of the school flashers were defective or malfunctioned. Major malfunctions included inoperative clocks and defective bulbs or fuses. Other deficiencies included flashers mounted among commercial signing, obstructed view, deteriorating signs, worn pavement markings, non-uniform signs, and erratic flashing periods.

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Figure 1. Speed Reductions due to Flasher Operation.

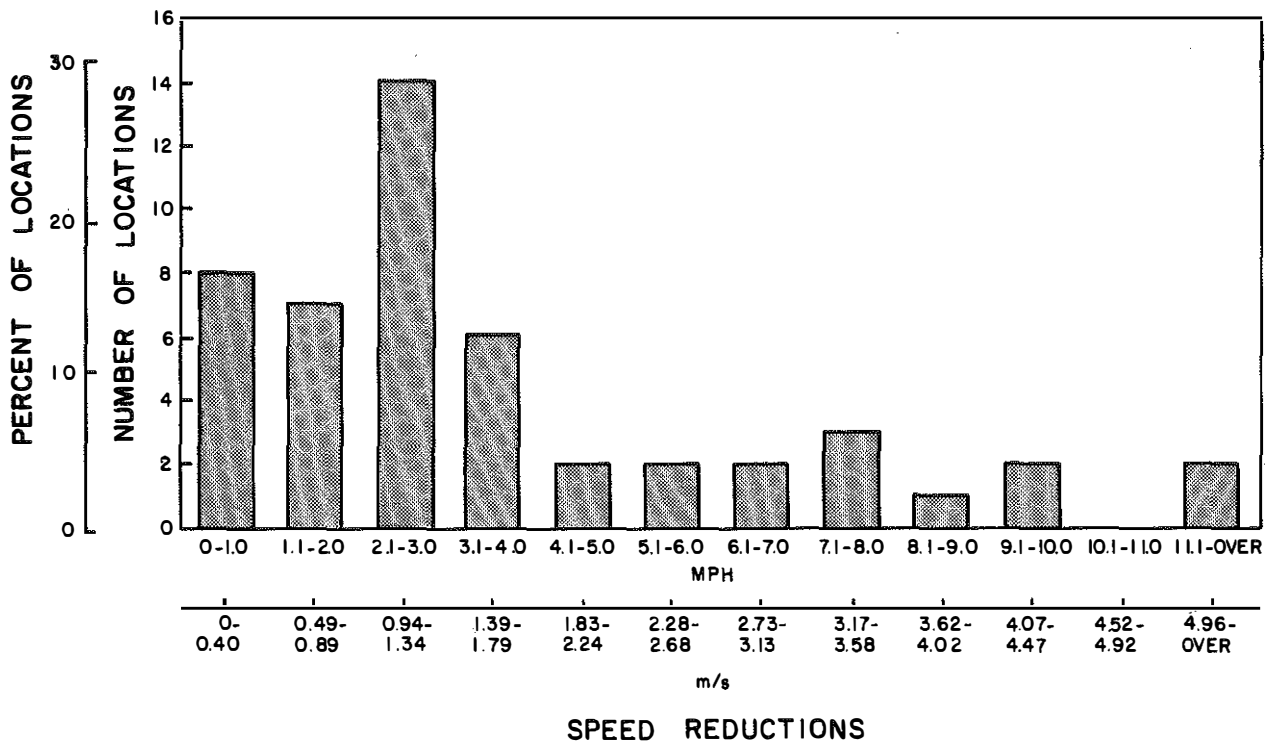


Figure 2. Average Vehicle Speeds before and during Flashing.

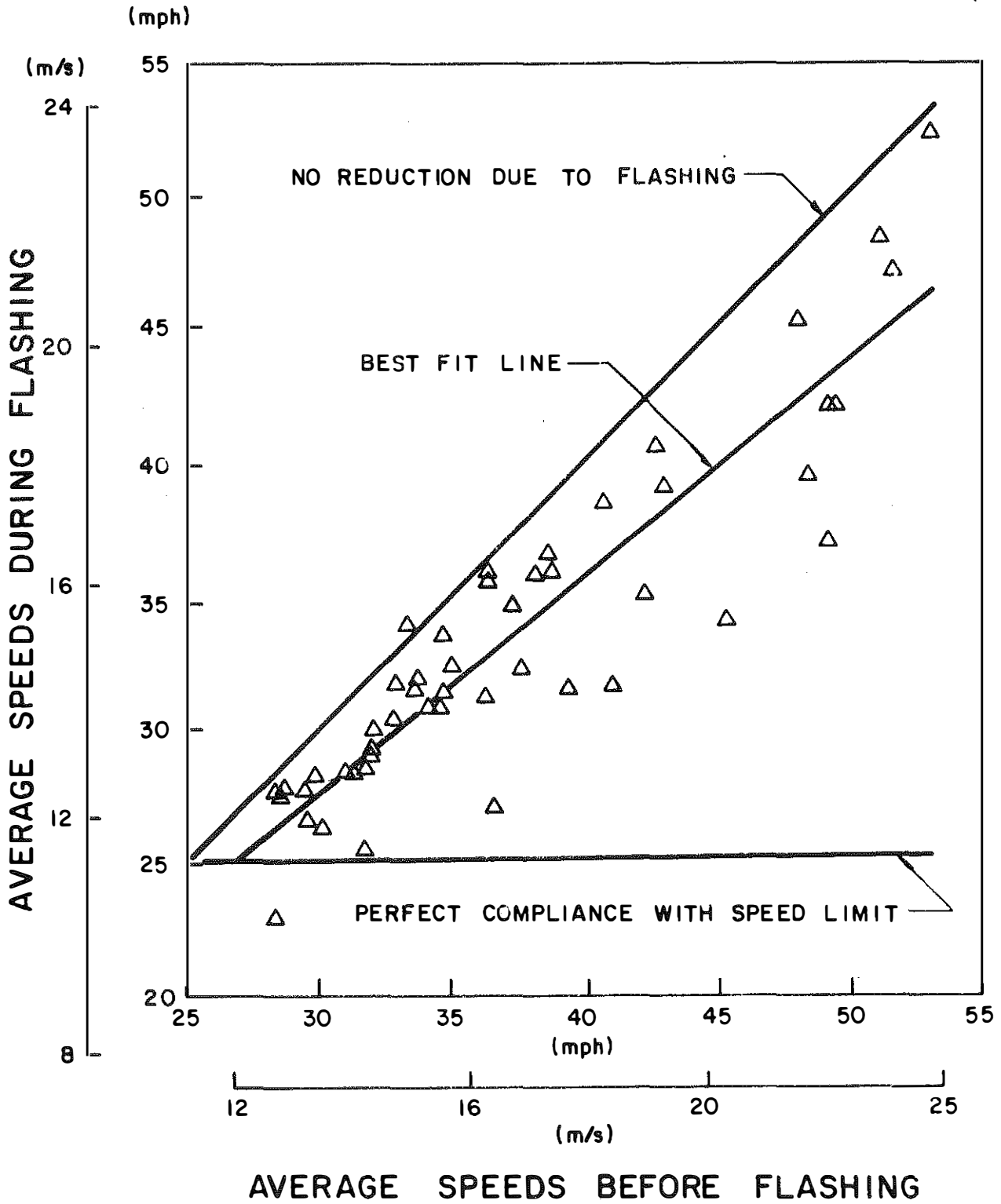


Figure 3. Cumulative Speed-Distribution Curves.

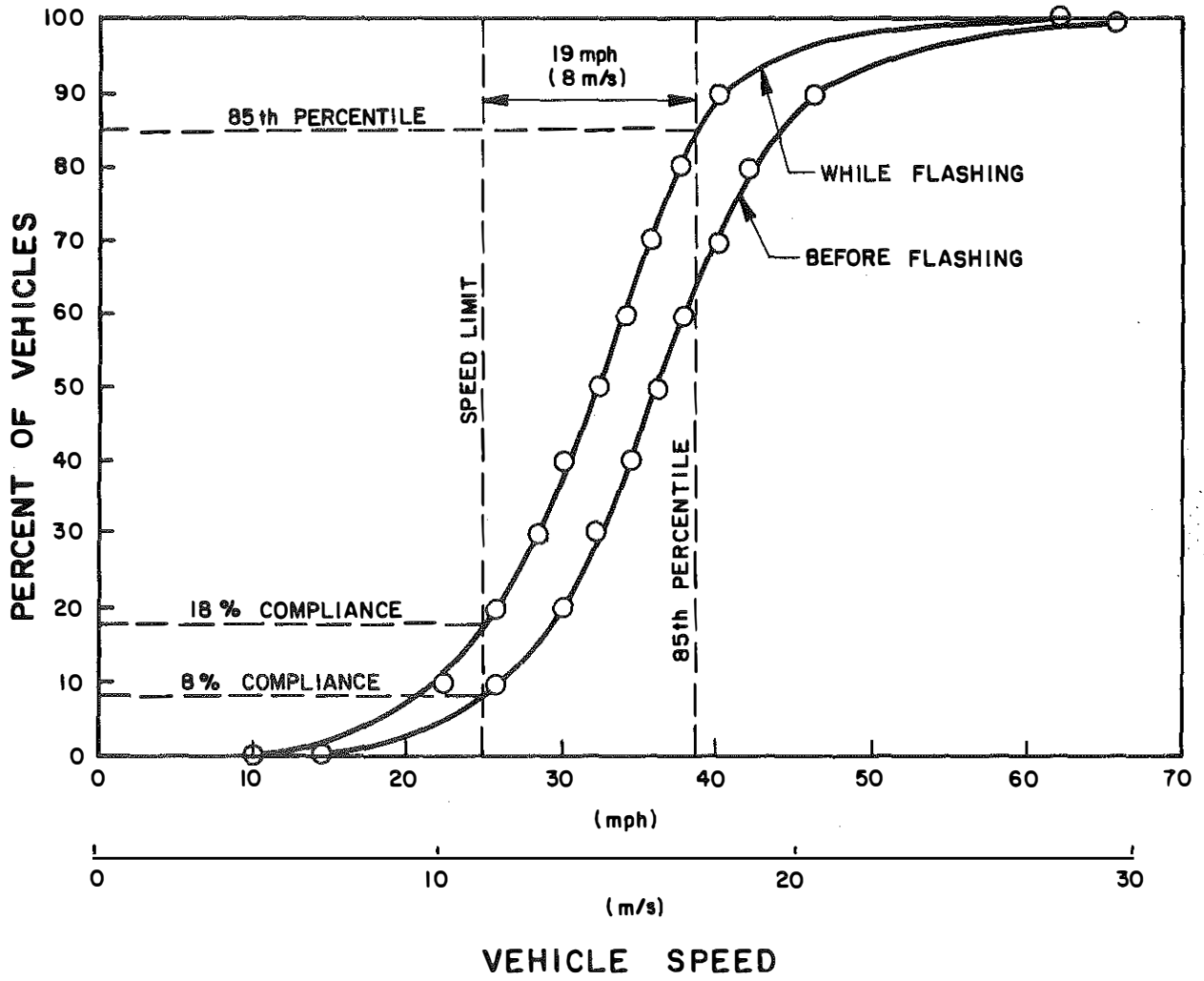


Figure 4. Speed-Distribution Curves.

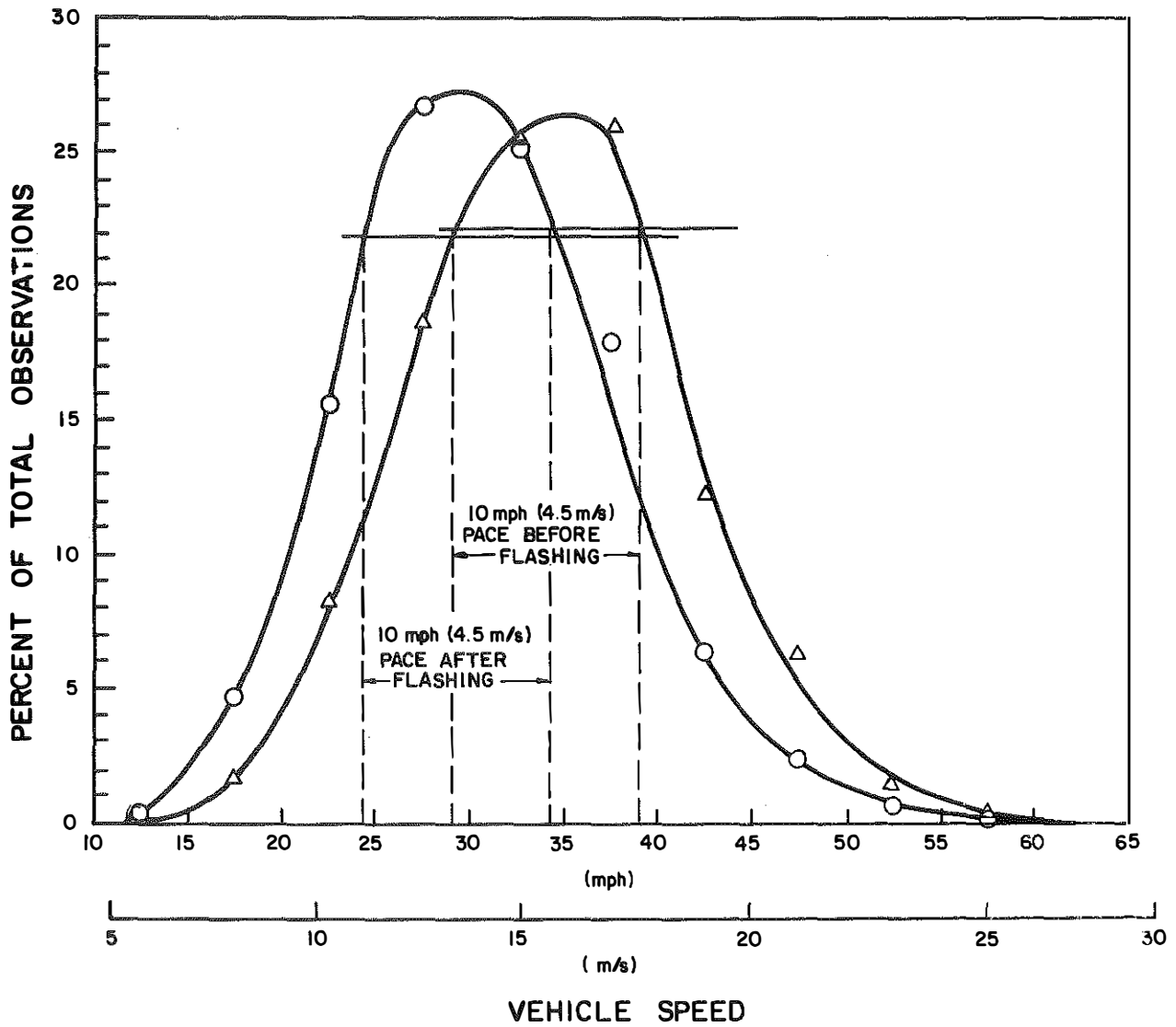
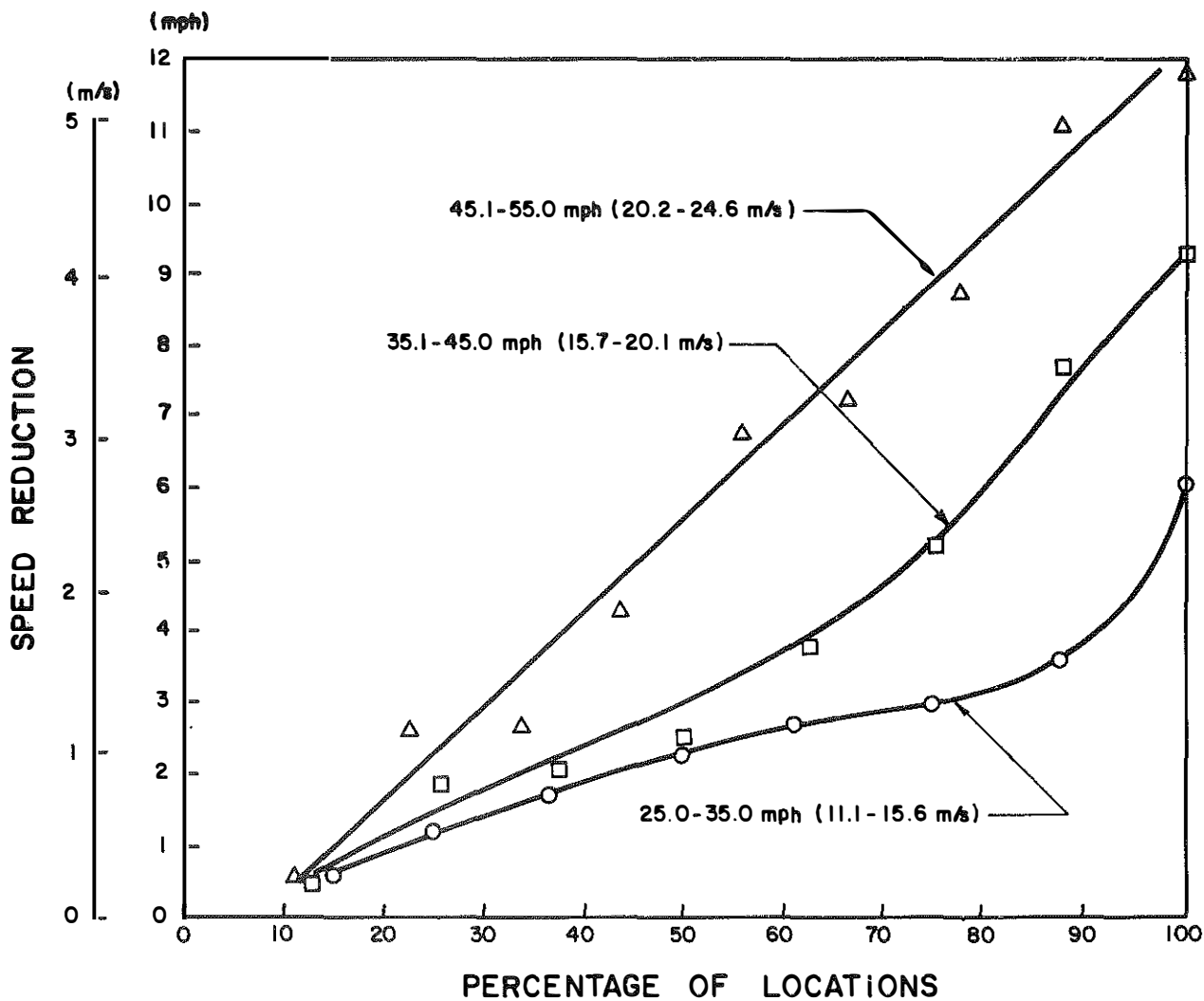


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TABLE 1. SCHOOL FLASHER LOCATIONS FOR SPEED STUDIES

Speed Studies Taken	48
Good Locations for Speed Studies, but Low Posted Speed Limit (11-16 m/s)	18
School Zone Begins or Passes through an Intersection	17
No School Zone (Crossing Only)	12
One Set of Flashers Does Not Exist	6
Continuous Flashing (24-Hour)	6
Very Low Volume Road	4
Congested Area with Narrow Street	3
School Not Adjacent to Road	3
Very Steep Grade on Road	2
School Closed for Repairs	1
Total	120

Note: 1 m/s = 2.2 mph

TABLE 2. TYPES OF SPEED-STUDY LOCATIONS

NORMAL SPEED LIMIT	NUMBER OF LOCATIONS						TOTALS
	LARGE URBAN AREAS (OVER 10,000 POPULATION)		SMALL URBAN AREAS (2,500 to 10,000 POPULATION)		RURAL AREAS (LESS THAN 2,500 POPULATION)		
	TWO-LANE	FOUR-LANE	TWO-LANE	FOUR-LANE	TWO-LANE	FOUR-LANE	
11 to 16 m/s	4	1	7	3	14	0	29
16 to 20 m/s	1	1	2	0	5	2	11
21 to 25 m/s	0	0	1	0	5	2	8
Totals	5	2	10	3	24	4	48

Note: 1 m/s = 2.2 mph

TABLE 3. SPEEDS DURING FLASHING AND NON-FLASHING FOR ROADS WITH VARIOUS SPEED LIMITS

SPEED LIMIT (m/s)	AVERAGE SPEED		85th-PERCENTILE SPEED	
	BEFORE FLASHING (m/s)	DURING FLASHING (m/s)	BEFORE FLASHING (m/s)	DURING FLASHING (m/s)
16	15	14	18	16
20	16	15	20	18
25	22	20	25	24
Other	17	15	21	18
Total	16	14	20	17

Note: 1m/s = 2.2 mph