Sample Size Requirements for Vehicular Speed Studies

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The purpose of this paper was to determine the minimum number of observations required for the estimation of various vehicular-speed percentiles. Based on the assumption that spot speed data has an approximately normal distribution, an equation has been derived to estimate the required sample size in terms of the percentile, tolerance limit, desired confidence level, and standard deviation. The standard deviation of the speeds is the only variable of the sample size determination that is directly influenced by vehicular speeds; the other three factors are arbitrarily selected.

To aid in the selection of these minimum sample size requirements, it was possible to determine relationships between the estimated population standard deviation of vehicular speeds and various factors peculiar to the study sites under consideration. For two-lane highways in rural areas, linear regression analysis established a significant correlation of standard deviation of the speeds with the average annual daily traffic (ADT), the 30th highest hourly traffic volume (30th HV), and the possible capacity of the spot speed site for the combination of daytime and nighttime vehicular speed observations.

If the standard deviation of the vehicular speeds at a given spot speed site on a two-lane highway is not known from previous speed studies, then the ADT value of a given location is recommended for estimating the standard deviation of vehicular speeds at this site. This correlation was the most significant of those site factors studied, and the ADT is usually known for most highway sections. Although the small number of speed sites did not permit an accurate evaluation of standard deviation and ADT for four- and six-lane rural facilities, the averages of these values are given to permit a first approximation of the necessary sample size requirements.

Under traffic conditions in rural areas, the standard deviation approaches its maximum value because most motorists are free to choose their desired speed. On this basis, the standard deviations are representative of low traffic volumes and are acceptable for either rural, intermediate-area, or urban highways. By using charts prepared for various percentiles, tolerance limits, and desired confidence levels, this standard deviation indicates the required minimum sample size for the desired statistical accuracy of the spot speed study.

● IN ANY EXPERIMENT designed to predict the statistical measures of a given population through a sampling technique, determination of a sufficient and economical sample size is mandatory. Highway and traffic engineers are confronted with this problem in programming many field and laboratory investigations. The number of units sampled must be sufficient to produce results with acceptable accuracy. However, the limitations of time, finances, and personnel preclude the selection of excessive sample sizes to insure statistical accuracy.

This matter of proper sample size is important in the establishment of spot speed studies conducted at various highway and street locations. At present there is no procedure outlined for the determination of the required sample size to estimate accurately the population characteristics of highway motor vehicle spot speeds. Therefore, the purpose of this research investigation was to develop a method for determining the minimum number of observations required for the estimation of various vehicular-speed percentile values.

The general procedure for conducting spot speed studies is to measure the speeds of passing motor vehicles for a fixed period of time or until a specified minimum number of observations are recorded. Thus, no consideration has been given to the statistical properties of spot speed data in their analysis and evaluation.

Inasmuch as vehicular spot speeds exhibit an approximately normal distribution, a theoretical analysis of the properties of a normal curve has permitted the development of an expression to compute minimum sample size requirements. These sample size requirements can be determined from a knowledge of the standard deviation of the vehicle speeds at a given location, derived from the results of previous spot speed surveys. However, a correlation analysis was necessary to aid in the determination of sample sizes without first performing, at a location where the speed characteristics have not been evaluated, a spot speed study to estimate the standard deviation of the speeds. The procedures and results of these two analyses are presented in the following sections.

It is anticipated that use of the results of this report will enable highway and traffic engineering personnel to ascertain sample size requirements for conducting spot speed studies with acceptable statistical accuracy at a minimum expense of time and manpower assignments.

PROCEDURE

Theoretical Analysis

As the results of many field studies have illustrated, the distribution of spot speed data closely approximates the normal curve. To verify a normal distribution in the data used for this investigation, the following statistical tests were applied: chi-square test, moment test, percentile method for testing normality (2), and normality test using probability paper. All these statistical techniques indicated that the spot speed data significantly conformed to a normal distribution.

The chi-square test, in testing normality, produced a value that was non-significant for the given degrees of freedom. To confirm further this assumption of a normal distribution, the moment test was applied to the speed samples. The measure of skewness, β_1, was almost zero for all the data tested, thus indicating a symmetrical distribution. The calculations for kurtosis, β_2, produced values approximately equal to three. Therefore, the degree of kurtosis, measure of peakness, for the data was nearly the same as that for a theoretically normal distribution.

A value of approximately one as computed from the percentile method for testing normality further substantiated the normal-distribution assumption. A true normal distribution is represented by a value of exactly one in this evaluation. The final test was performed by plotting the cumulative distributions of the speed data on probability graph paper. The nearly straight lines represented a normal distribution for the spot speed samples.

By concluding that the spot speed populations were significantly depicted by a normal distribution, an analysis of the properties of a normal curve has permitted the derivation of an equation for the required minimum sample size to determine a given percentile speed with a specified accuracy. This analysis was proposed by Berry and Belmont (2). A similar derivation of the minimum sample size expression is given in Appendix A and produces the following equation:

$$N = \frac{v^2 S^2 (2 + u^2)}{2d^2}$$

in which

N = minimum sample size,
v = normal deviate corresponding to the desired confidence level,
S = standard deviation of the sample,
u = normal deviate corresponding to the percentile being estimated, and
d = permitted error in the estimate.

The sample standard deviation of spot speeds is the only variant directly affected by vehicular speeds. The other three variables are selected at the engineer's discretion for the required purposes and accuracy of the spot speed study.

Correlation Analysis

The equation derived for minimum sample size determinations can not be used unless the standard deviation of vehicular speeds at the desired location and time is known. Therefore, a spot speed study, the end result, must be conducted with a relatively large number of speed observations to estimate the standard deviation of the speed population at the given time and site location. The trial sample size must be in excess of the unknown, required minimum number to insure proper accuracy.

To aid in the use of this minimum sample size equation, it was necessary to investigate the influence of time-of-observation on estimated population standard deviations and to determine any possible significant relationships between standard deviations of the speeds and some factor or factors peculiar to the spot speed sites under consideration. The Bartlett test for testing the homogeneity of the variances was used to discern any significant differences in standard deviations at a given site location for different periods of time. The time elements were analyzed according to variations during the time of day, day of week, and month of year. The results are discussed in the following section of this paper.

If any significant relation can be established and evaluated between standard deviations of spot speeds and some known factor or factors characteristic of the speed sites, then this relationship can be employed to estimate accurately the standard deviation from this given factor or factors where standard deviations are not known.

It is reasonable to assume that the standard deviation of the speeds for a given highway or street location is not constant, but that it varies with traffic volume. At low volumes the highway user has relatively free operational conditions and can select his desired speed of travel. When conditions permit drivers to travel at their desired speeds, there is a wide range in speeds at which various operators drive their motor vehicles (3). Under these circumstances the standard deviation at a given speed site should approach a maximum value because standard deviation is a measure of the average discrepancy of values about their mean or central tendency.

As the volume on a given traffic facility increases, the average difference in speeds between successive vehicles decreases linearly and becomes zero at a traffic volume equal to the possible capacity of the facility (3). Thus, standard deviations also decrease as volumes increase because individual drivers are affected more and more by other traffic, and the range in speeds is reduced. Standard deviations of the speeds approach or become zero as the volume increases to the possible capacity of the facility when all traffic is moving at approximately the same speed.

This reasoning indicated that a possible correlation may exist between the standard deviations of vehicular speeds and traffic volumes. The derived expression for minimum sample size requirements increases in a direct relation to the square of the standard deviation (variance). Therefore, it was desirable to compare sample standard deviations of the speeds measured during periods of low traffic flow with volume counts indicative of low traffic flow in order to approach the maximum standard deviations of vehicular speeds occurring at the various study sites. Any correlation of maximum standard deviation with some corresponding minimum traffic volume measure maximizes the minimum sample size requirement, thus providing a sample size that is always statistically adequate.

Spot speed data were collected at 71 sites in rural areas. These sites were selected on level, tangent highway sections that were not near any intersections. Large samples of the vehicular speeds were obtained with radar speedmeters for low volume conditions during the day and the night. To insure the statistical independence of the speed observations, only the speeds of free-flowing vehicles were recorded. The speeds of highway vehicles in the act of passing or tailgating were not observed. Thus, a good estimate of the maximum standard deviation of the speed population was ascertained at each location for a combination of daytime and nighttime travel.

The measures of traffic volume considered in this investigation were average annual daily traffic (ADT), 30th highest hourly volume (30th HV), and possible capacity. The two volume counts for each spot speed site were abstracted from information published by the Illinois Division of Highways (6), while the possible capacity at each speed study location was computed with the procedure presented in the "Highway Capacity Manual" (3). This data, ADT, 30th HV, possible capacity, and standard deviation are summarized in Appendix B for each spot speed location.

Graphical plots of standard deviation versus ADT, 30th HV, and possible capacity indicated linear relationships with negative slopes. This decrease in standard deviation with an increase in volume confirmed the previously discussed reasoning and validated the previous assumptions.

These linear trends of the dependent variable, standard deviation, and the independent variable, volume, were analyzed by linear regression analysis and linear correlation analysis using the method of least squares. The regression coefficients, a and b, in the general equation $S = a + bV$, in which S = sample standard deviation and V = volume, were computed by the following formulas:

$$a = \frac{\Sigma V^2 \Sigma S - \Sigma V \Sigma VS}{n \Sigma V^2 - (\Sigma V)^2}$$

$$b = \frac{n \Sigma VS - \Sigma V \Sigma S}{n \Sigma V^2 - (\Sigma V)^2}$$

in which

n = number of observations.

Correlation coefficients were calculated by the following formula to measure the degree of linear association between standard deviation and volume:

$$r = \frac{n \Sigma VS - \Sigma V \Sigma S}{\sqrt{\left[n \Sigma V^2 - (\Sigma V)^2\right]\left[n \Sigma S^2 - (\Sigma S)^2\right]}}$$

The results of the correlation analyses are discussed in the following section.

RESULTS

Minimum Sample Size Requirements

The theoretical expression for determining the minimum number of observations to predict the properties of a normal distribution by a sampling procedure has been presented in the preceding section. The solution to this equation yields the minimum number of spot speed observations to be made for the desired degree of statistical accuracy. Thus, engineering personnel can determine accurate and economical sample sizes for spot speed studies having various purposes and requirements.

For the specified requirements of a spot speed study, this equation can be solved to indicate the required sample size to produce acceptable statistical accuracy. By solving this equation for a range of conditions, the sample size requirements can be presented in tabular or graphical form. The solutions to this minimum sample size expression for desired confidence levels of 90, 95, and 99 percent and permitted errors or tolerances from 1 to 4 mph at 1-mph intervals are expressed in graphical form as a function of sample standard deviation in Figures 1 to 3 for the 50th-percentile speed, Figures 4 to 6 for the 15th- and 85th-percentile speeds, and in Figures 7 to 9 for the 5th- and 95th-percentile speeds.

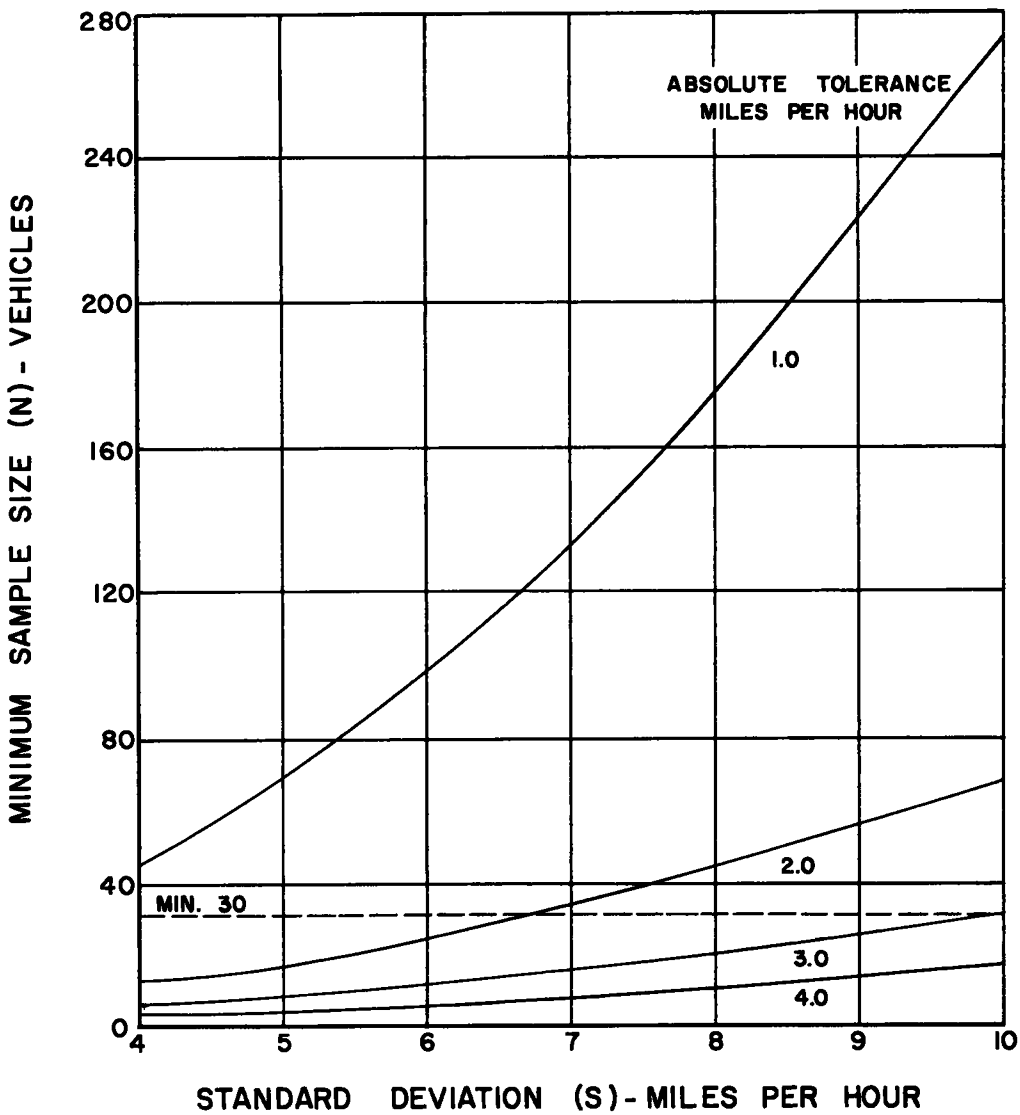

Figure 1. Minimum sample size vs standard deviation (percentile = 50%, desired confidence level = 90%).

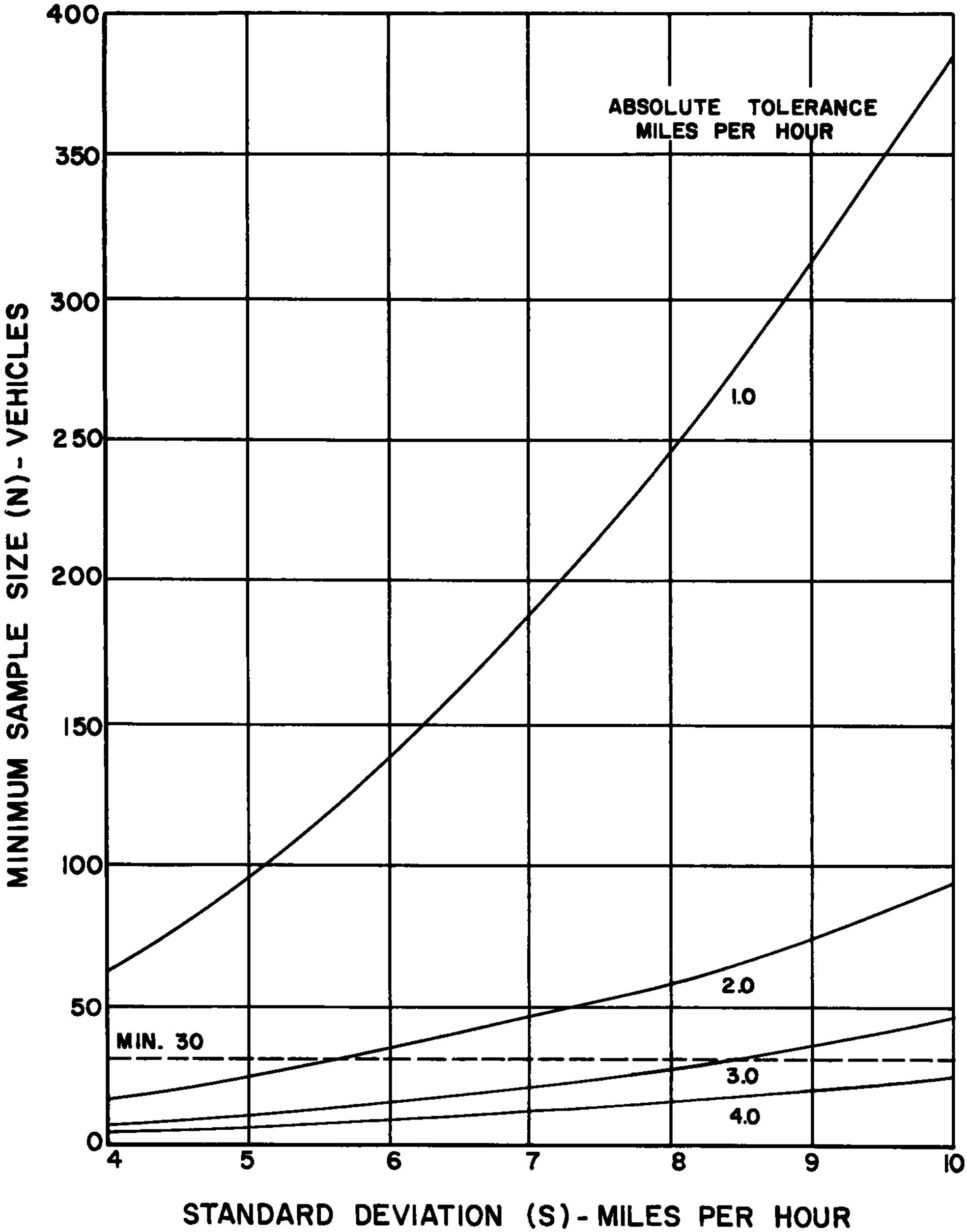

Figure 2. Minimum sample size vs standard deviation (percentile = 50%, desired confidence level = 95%).

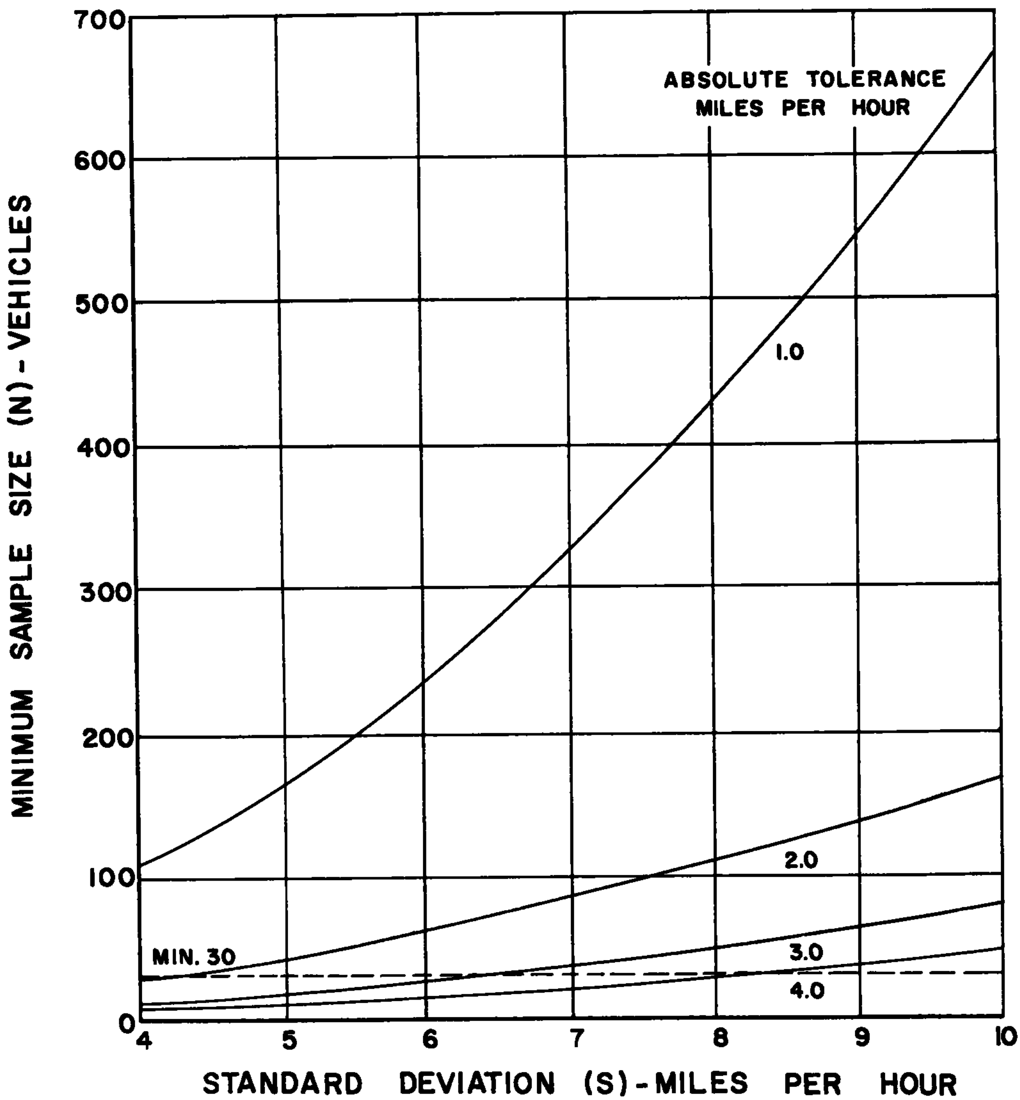

Figure 3. Minimum sample size vs standard deviation (percentile = 50%, desired confidence level = 99%).

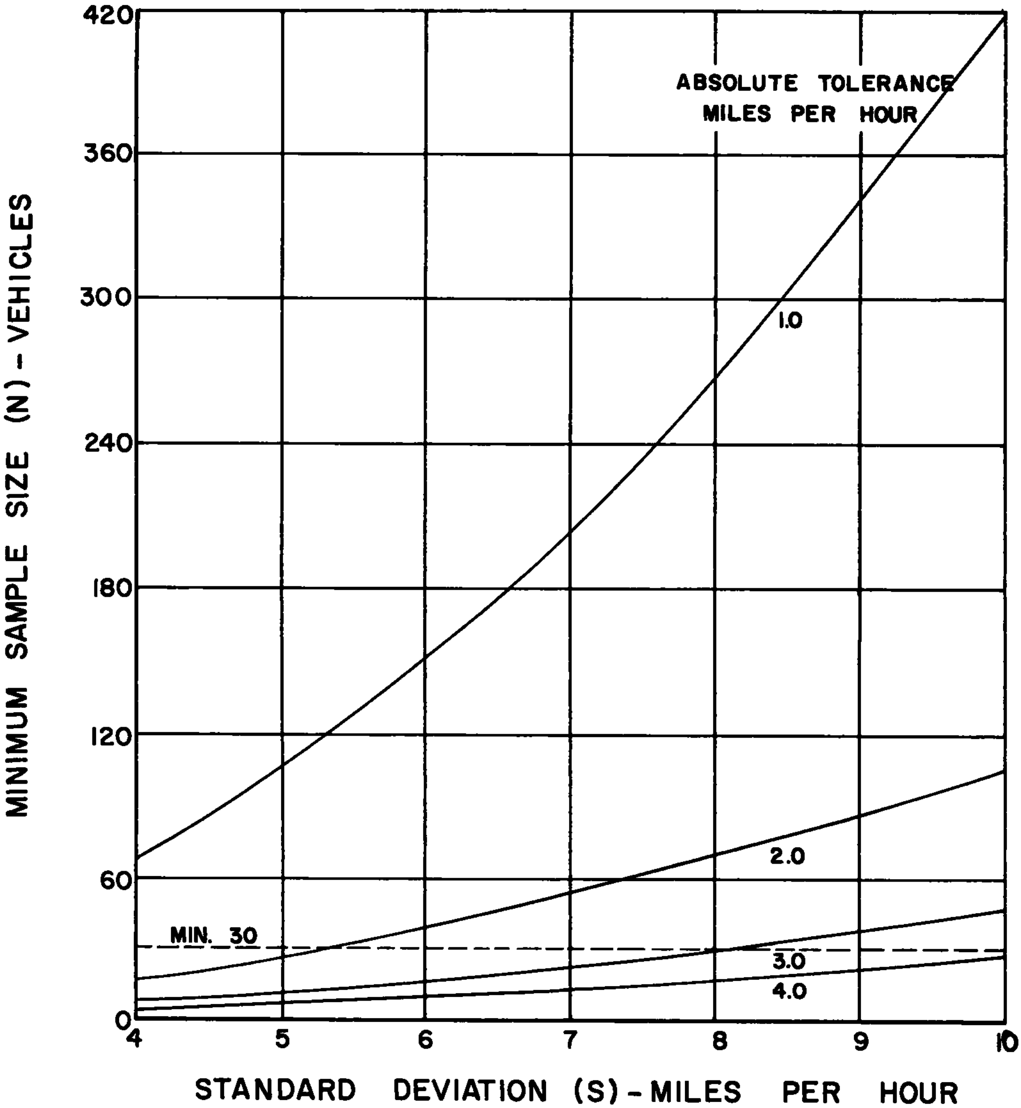

Figure 4. Minimum sample size vs standard deviation (percentile = 15% and 85%, desired confidence level = 90%).

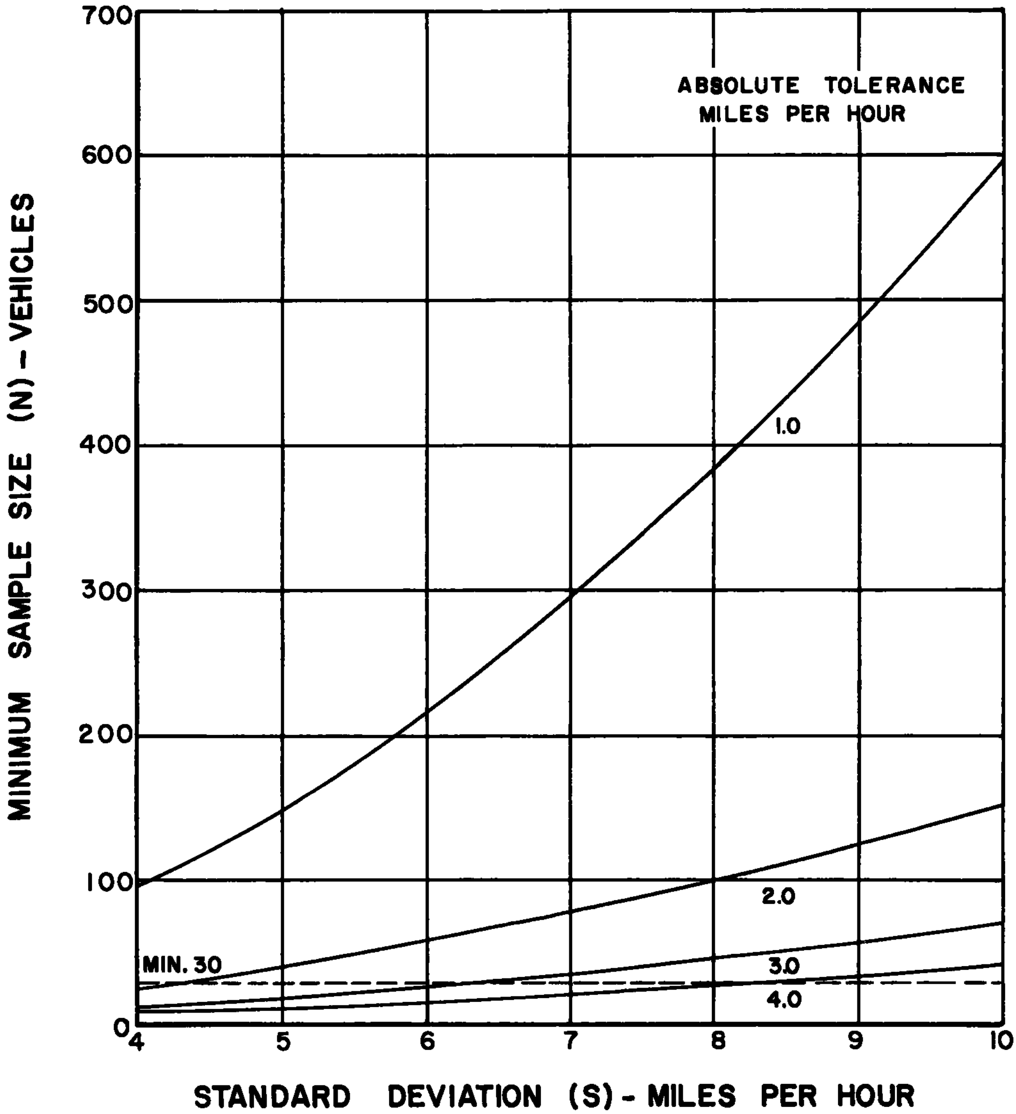

Figure 5. Minimum sample size vs standard deviation (percentile = 15% and 85%, desired confidence level = 95%).

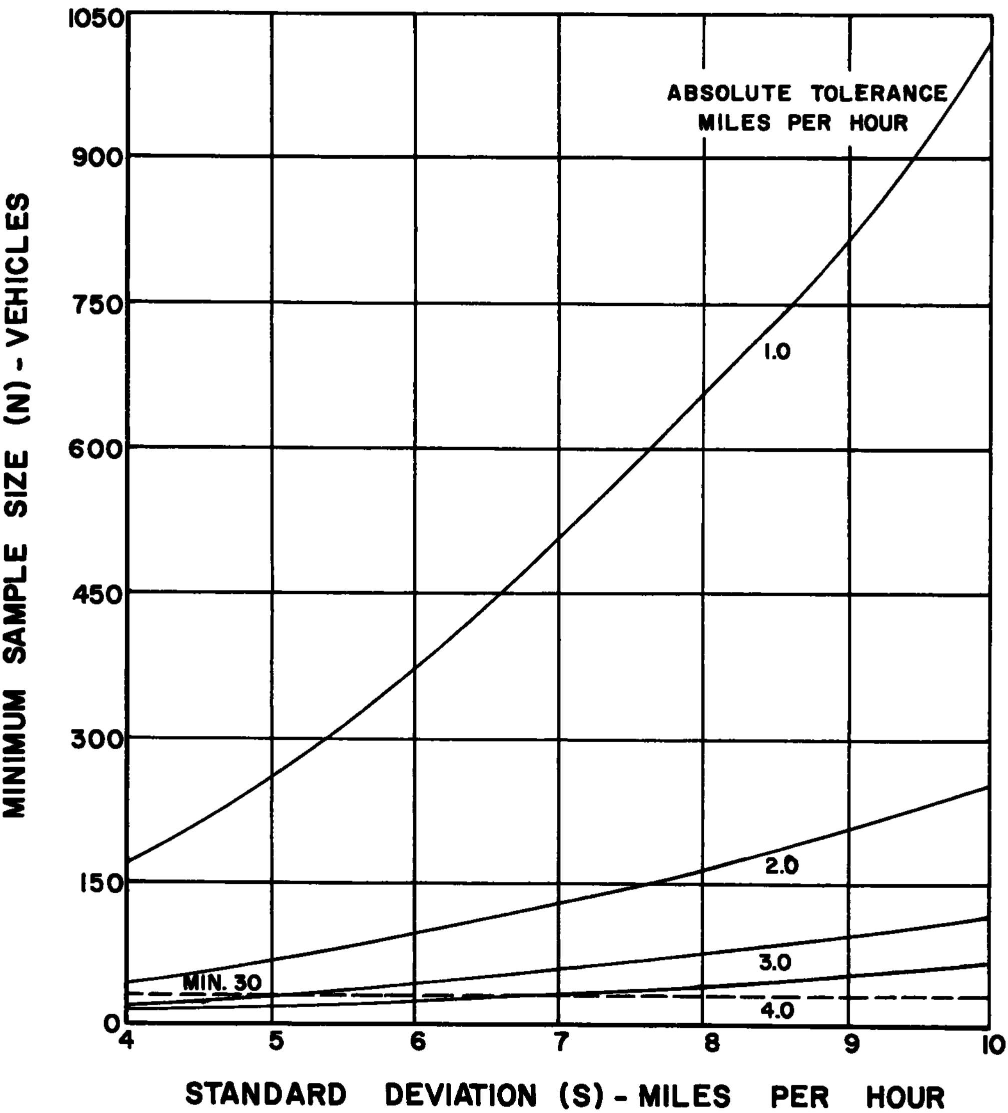

Figure 6. Minimum sample size vs standard deviation (percentile = 15% and 85%, desired confidence level = 99%).

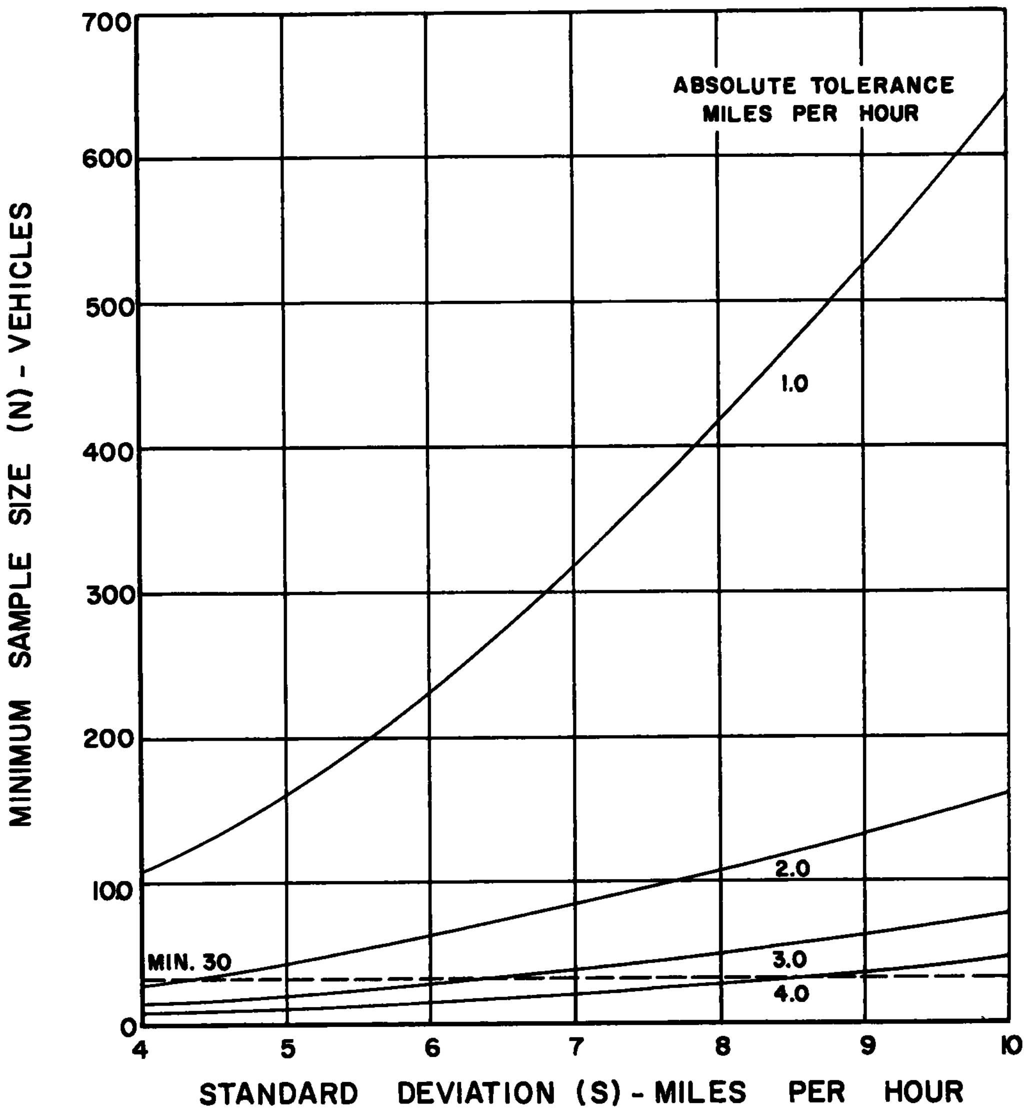

Figure 7. Minimum sample size vs standard deviation (percentile = 5% and 95%, desired confidence level = 90%).

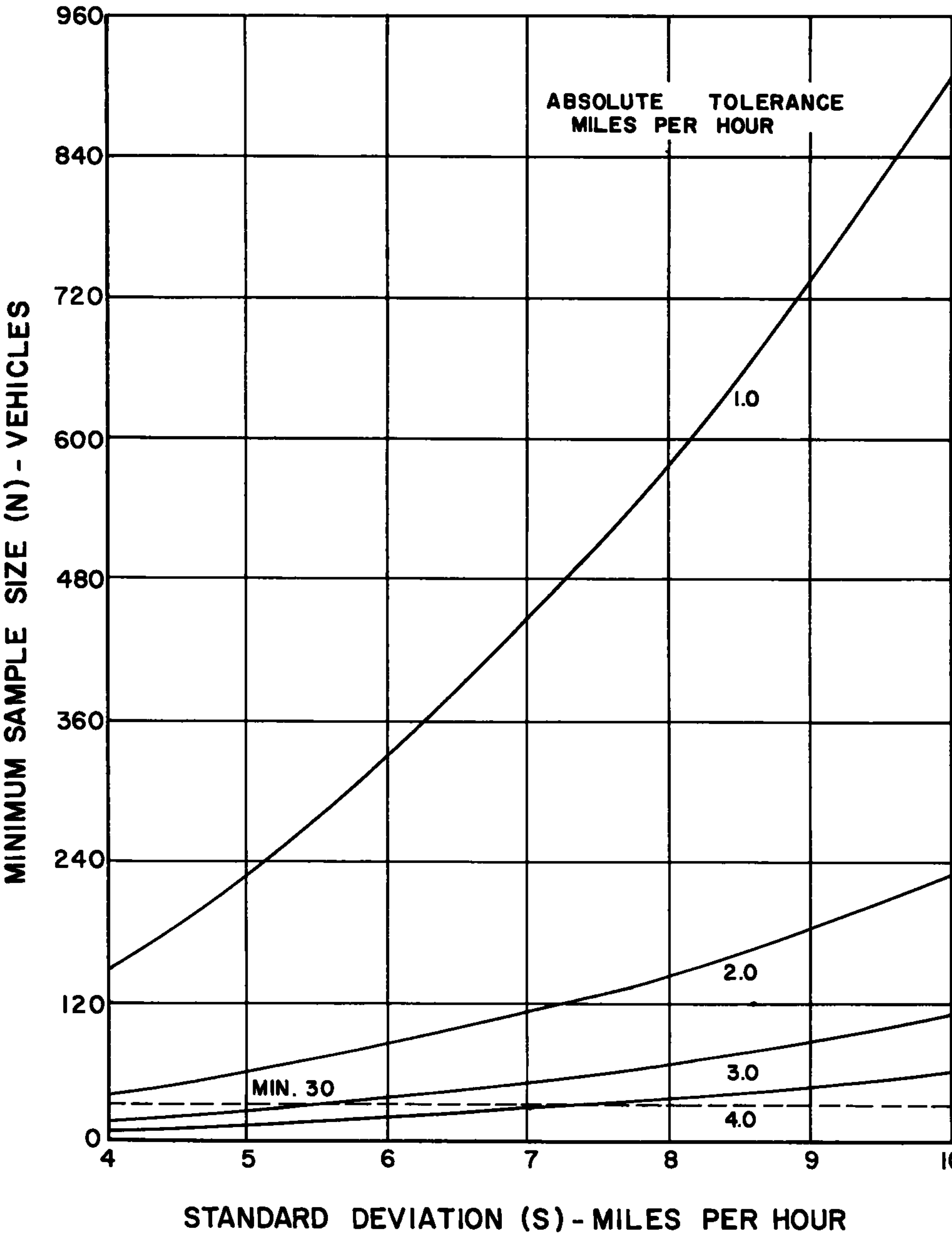

Figure 8. Minimum sample size vs standard deviation (percentile = 5% and 95%, desired confidence level = 95%).

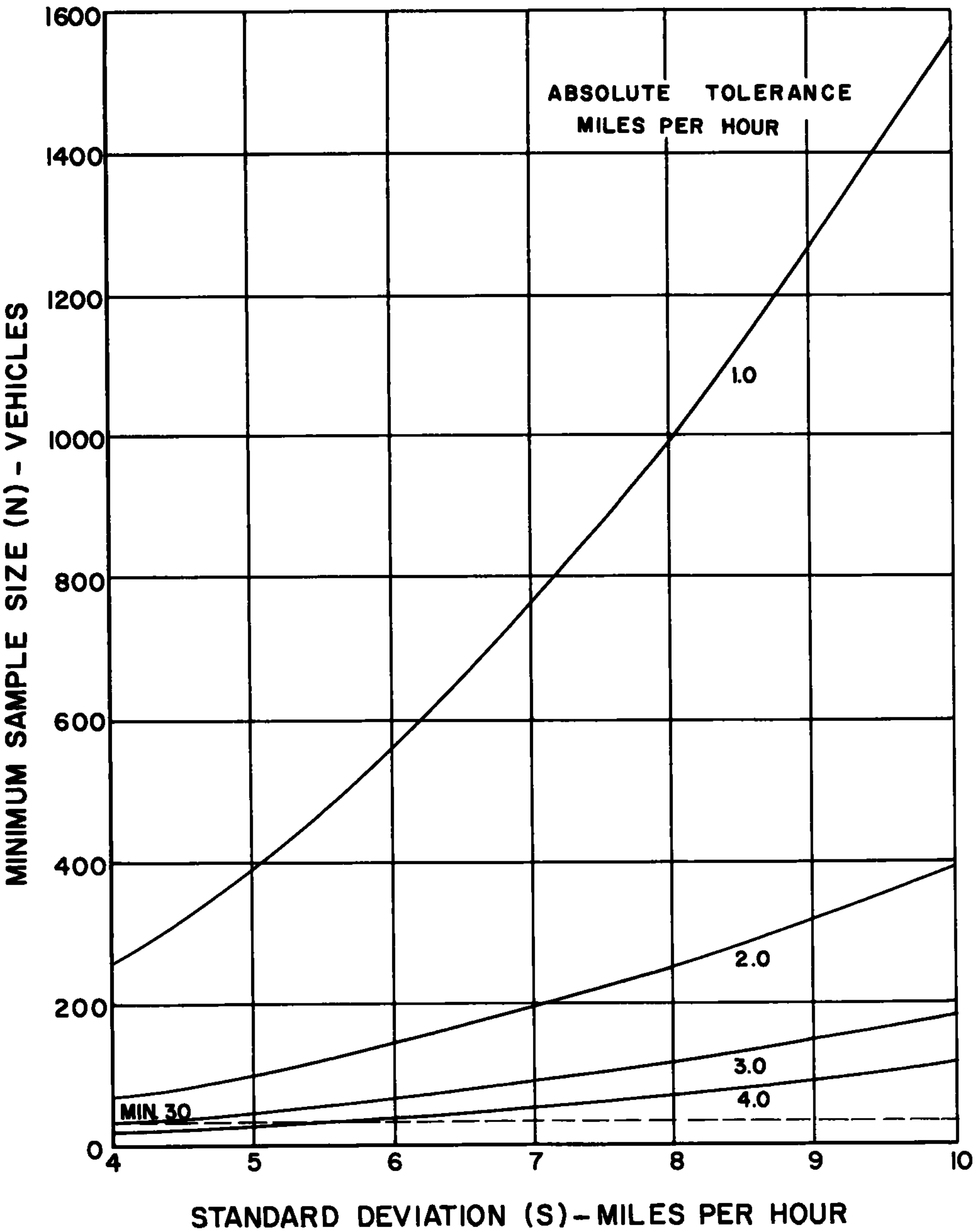

Figure 9. Minimum sample size vs standard deviation (percentile = 5% and 95%, desired confidence level = 99%).

TABLE 1

RESULTS OF THE REGRESSION AND CORRELATION ANALYSES

Variables	Intercept (a)	Slope (b)	Correlation Coefficient (r)	r^2
y = S, X = ADT (1,000)				
Two-lane sites, n = 55	9.61	-0.2718	-0.501[a]	0.251
Four-lane sites, n = 12	9.07	-0.0903	-0.381	0.145
Six-lane sites, n = 4	8.39	-0.0692	-0.804	0.646
y = S, X = 30th HV (100)				
Two-lane sites, n = 55	9.42	-0.0015	-0.412[a]	0.170
y = S, X = possible capacity (100)				
Two-lane sites, n = 55	11.79	-0.2175	-0.416[a]	0.173

[a]Significant at the 1 percent level.

To insure statistical accuracy for a normal distribution, the required minimum sample size must exceed the value of thirty. This has been indicated on the nine graphs by a dashed line.

Correlation of Speed Standard Deviation with Site Characteristics

The results of the Bartlett test for testing the homogeneity of the variances in measuring the influence of time-of-collection on standard deviation of spot speeds were not significant for the variations of time of day, day of week, and month of year. Although the literature contains many references to cyclical variations in traffic volumes according to time of day, day of week, and month of year, the speed observations for this study were obtained during periods of traffic volumes that were very low relative to the practical capacities of the highway sections. Thus, any change in volume with time did not significantly alter or modify the speed characteristics; therefore, it was assumed that the standard deviation of vehicular speeds at a given location was independent of the time of data collection during these low traffic flows in rural areas.

Linear regression and correlation analyses produced the results given in Table 1. The most significant result obtained was the correlation of sample standard deviation with ADT for the spot speed sites on two-lane highways in rural areas. This relationship is presented in Figure 10. Although the correlation coefficient was highly significant, only 25 percent of the variation in the standard deviation can be explained by the ADT. Therefore, confidence interval lines have been added to the linear regression analysis in Figure 10 at plus and minus one and two standard errors of estimate. These permit the estimation of standard deviations for various ADT volumes with 68 percent and 95 percent confidence, respectively. With lower correlation coefficients, significant linear relations of standard deviation were also established with 30th HV and possible capacity.

The regression and correlation analyses produced non-significant results for four- and six-lane highways. This discrepancy was attributed to the small number of speed sites on these multi-lane facilities. Because the slopes of the regression lines closely approached zero, it was assumed that the standard deviations were approximately constant for four- and six-lane highways. Therefore, average values and corresponding standard errors, as given in Table 2, were developed for these facilities to determine sample size requirements. Until more data is collected, this modified procedure permits a first approximation for the estimation of the required sample size to insure the desired level of statistical accuracy.

CONCLUSIONS

This research study has developed a technique for determining the minimum sample size requirements for spot speed studies. These sample sizes are the minimum

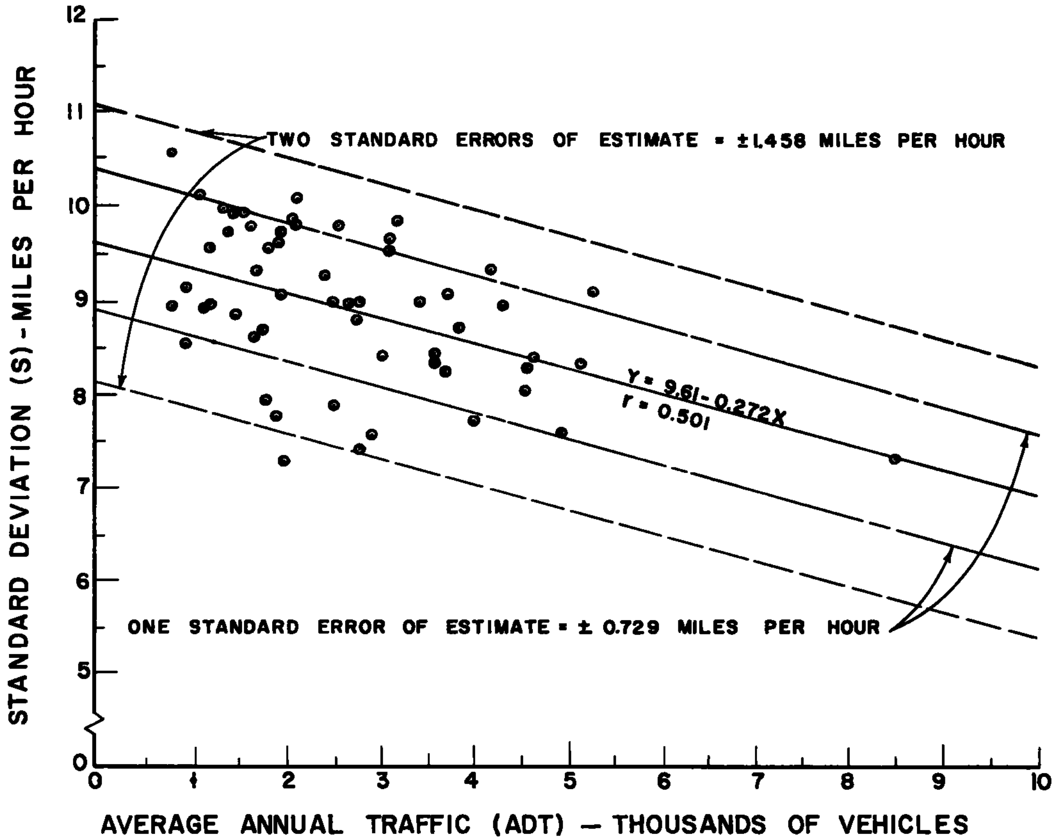

Figure 10. Standard deviation vs average annual daily traffic (for two-lane rural highways).

TABLE 2

AVERAGE STANDARD DEVIATIONS FOR FOUR- AND SIX-LANE RURAL HIGHWAYS

Highway Type	Average Standard Deviation (mph)	Standard Error of Estimate (mph)	Average Standard Deviation ± One Standard Error of Estimate (mph)	Average Standard Deviation ± Two Standard Errors of Estimate (mph)
Four-lane	9.15	0.84	9.99	10.83
			8.31	7.47
Six-lane	6.22	0.40	6.62	7.02
			5.82	5.62

required to produce the desired statistical accuracy in the results, thus conserving time and personnel by the elimination of over-sampling and superfluous values in the reduction of speed data.

The ADT value is generally known for most important highway and street sections where spot speed studies might be conducted. Also, the correlation between sample standard deviation and ADT was the most significant for the site characteristics investigated. Therefore, it was concluded that the ADT of a two-lane highway is a good measure for estimating the standard deviation of vehicular speeds at a site where the standard deviation is not known from previous spot speed studies. For four- and six-lane highways insufficient data necessitated the use of average values for standard deviation where spot speed studies have not been previously conducted.

Because these standard deviations are representative of low traffic volumes, they are observed maximum values which are acceptable for any highway location in rural, intermediate, and urban areas. The sample size is always statistically adequate regardless of the traffic volume at the time of the study.

EXAMPLE

The following example illustrates the rather simple procedure developed in this report for determining the required sample size of a spot speed study for a highway location where the standard deviation of the vehicular speeds is unknown. It is assumed that the highway location of the spot speed site has an ADT of 8,000. From Figure 10 the sample standard deviation is estimated at 7.45 mph on the regression line. If the engineer in charge of the speed study desires to estimate the 85th-percentile speed within ± 2 mph at a desired confidence level of 95 percent, then a minimum sample size of 85 vehicular speeds to be measured is indicated by Figure 5.

If the estimate of the standard deviation is made with 95 percent confidence, then the standard deviation is 8.90 mph. For the same conditions this produces a sample size of 125 speed observations. Because of the low degree of correlation between standard deviation of vehicular speeds and average annual daily traffic, the use of the larger sample size is recommended to place the results on the safe side.

SUGGESTIONS FOR FURTHER RESEARCH

To appraise more accurately the relationships between standard deviation of vehicular speeds and ADT, more speed sites on four- and six-lane highways must be studied for various levels of ADT. The results of this analysis will permit a refinement of the assumption of average values for these facilities as presented in this report.

Although the various relationships established in this research study provide reasonable statistical accuracy in estimating spot speed characteristics at any highway or street location, the standard deviations of speeds during low volume conditions in intermediate and urban areas may be less than those in rural areas for a comparable ADT because of the effect of speed zones, intersections, roadside development, etc., on individual vehicle speeds. If this assumption is true, then the development of relationships between sample standard deviation and ADT for these two traffic-condition areas will produce more economical sample size requirements when vehicular speeds are being evaluated in these areas.

These additional research projects are contemplated in the near future when sufficient speed data are collected on the different types of highways in the three traffic areas.

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Appendix A

DERIVATION OF THE FORMULA FOR THE MINIMUM SAMPLE SIZE REQUIREMENTS

ASSUMPTIONS:

1. The population is assumed to be normal.
2. The sample size is sufficiently large.

NOMENCLATURE:

$\bar{X}$ = sample mean — μ = population mean

S^2 = sample variance — σ^2 = population variance

INTRODUCTION:

Since $\bar{X}$ is normally distributed with mean μ and standard deviation $\frac{\sigma}{\sqrt{N}}$, $\bar{X} = \mu + \frac{k\sigma}{\sqrt{N}}$, where k is the standard normal variate which can be obtained from the Cumulative Normal Table for a given probability. Also, $S = \sigma + \frac{k'\sigma}{\sqrt{2N}}$, where k' is the standard normal variate and the standard deviation of S is approximately equal to $\frac{\sigma}{\sqrt{2N}}$

The true value of a percentile (P) is theoretically $P = \mu + u\sigma$, where μ and σ are unknown parameters and u is the standard normal variate. An estimate of P ($\hat{P}$) is written as $\hat{P} = \bar{X} + uS$.

DERIVATION:

The probability (Pr) of $(|P - \hat{P}| \leq d)$ is equal to $1-\alpha$, where α is the level of significance and $1-\alpha$ is the confidence level.

$$Pr(|P - \hat{P}| \leq d) = 1 - \alpha$$

$$Pr(P - d \leq \hat{P} \leq P + d) = 1 - \alpha$$

Substituting the values of P and $\hat{P}$ in the above equation,

$$Pr(\mu + u\sigma - d \leqslant \bar{X} + uS \leqslant \mu + u\sigma + d) = 1 - \alpha$$

Substituting the values of $\bar{X}$ and S in the last expression,

$$Pr(\mu + u\sigma - d \leqslant \mu + \frac{k\sigma}{\sqrt{N}} + u[\sigma + \frac{k'\sigma}{\sqrt{2N}}] \leqslant \mu + u\sigma + d) = 1 - \alpha$$

$$Pr(-d \leqslant \frac{k\sigma}{\sqrt{N}} + \frac{uk'\sigma}{\sqrt{2N}} \leqslant d) = 1 - \alpha$$

$$Pr(|k + \frac{uk'}{\sqrt{2}}| \leqslant \frac{d\sqrt{N}}{\sigma}) = 1 - \alpha$$

The linear combination of k and k' is a normal variate with mean zero and variance $1 + \frac{u^2}{2}$.

$$\text{Mean} = E(k + \frac{uk'}{\sqrt{2}}) = E(k) + \frac{uE(k')}{\sqrt{2}} = 0$$

$$\text{Variance of } k + \frac{uk'}{\sqrt{2}} = (\text{variance of } k) + (\frac{u^2}{2}\text{ variance of } k') = 1 + \frac{u^2}{2}$$

Let V' be equal to $k + \frac{uk'}{\sqrt{2}}$. Therefore, the standard normal variate (V) is $\frac{V' - 0}{\sqrt{1 + \frac{u^2}{2}}}$.

$$Pr\left(\left| \frac{k + \frac{uk'}{\sqrt{2}} - 0}{\sqrt{1 + \frac{u^2}{2}}} \right| \leqslant \frac{d\sqrt{N}}{\sigma\sqrt{1 + \frac{u^2}{2}}} \right) = 1 - \alpha$$

$$Pr(|V| \leqslant \frac{d\sqrt{2N}}{\sigma\sqrt{2 + u^2}}) = 1 - \alpha$$

For the given confidence level of $1 - \alpha$,

$$|V| \leqslant \frac{d\sqrt{2N}}{\sigma\sqrt{2 + u^2}}$$

$$V^2 \leqslant \frac{2d^2N}{\sigma^2(2 + u^2)}$$

$$N \geqslant \frac{V^2\sigma^2(2 + u^2)}{2d^2}$$

Therefore, the formula for the minimum sample size requirement (N) is.

$$N = \frac{V^2\sigma^2(2 + u^2)}{2d^2}$$

where V = normal deviate corresponding to the desired confidence.

u = normal deviate corresponding to the percentile being estimated.

d = permitted error in the estimate.

σ = standard deviation of the population

Because of the second assumption, the sample standard deviation (S) can replace σ in the above equation.

$$\therefore N = \frac{V^2S^2(2 + u^2)}{2d^2}$$

Appendix B

DATA

Site	ADT (v/day)	30th HV (v/hr)	Pos. Cap. (v/hr)	Std. Dev. (mph)	Site	ADT (v/day)	30th HV (v/hr)	Pos. Cap. (v/hr)	Std. Dev. (mph)
1-1	19,500	2,965	6,720	7.69	6-4	1,800	230	1,160	8.70
1-2	2,750	570	1,540	8.82	6-5	1,650	190	1,340	8.62
1-3	3,050	370	1,560	8.38	6-6	1,100	140	1,240	8.88
1-4	5,150	715	1,360	8.35	6-7	2,750	305	1,400	7.44
1-5	4,300	560	1,520	8.93	7-1	1,100	165	1,400	10.11
1-6	7,900	1,030	5,760	8.45	7-2	2,100	275	1,180	10.04
1-7	7,700	1,095	6,000	9.23	7-3	3,400	355	1,420	8.97
2-1	3,200	515	1,280	9.80	7-4	2,800	355	1,460	8.99
2-2	1,900	275	1,220	9.59	7-5	4,200	470	1,240	9.30
2-3	1,650	190	1,220	9.32	7-6	5,300	575	1,320	9.10
2-4	4,600	540	1,500	8.30	7-7	2,000	195	1,480	9.79
2-5	2,500	260	1,240	9.75	8-1	6,400	810	6,240	8.23
2-6	1,750	250	980	7.89	8-2	750	100	1,200	8.93
2-7	4,200	560	6,640	8.84	8-3	1,900	245	1,160	9.05
3-1	2,700	465	1,500	8.94	8-4	1,300	160	1,260	9.69
3-2	750	90	1,100	10.55	8-5	3,700	360	1,320	8.24
3-3	1,900	285	1,240	9.68	8-6	1,450	170	1,180	9.84
3-4	6,200	820	6,400	10.10	8-7	2,500	375	1,220	8.99
3-5	2,200	265	1,640	9.50	9-1	1,450	175	1,300	8.81
3-6	2,200	805	1,460	9.67	9-2	1,850	260	1,360	7.77
3-7	1,620	195	1,220	9.77	9-3	4,600	670	1,480	8.36
4-1	1,350	175	1,180	9.91	9-4	850	95	1,120	9.18
4-2	10,400	1,135	6,960	9.41	9-5	900	140	1,380	8.51
4-3	3,800	560	1,220	8.72	9-6	2,850	275	1,560	7.57
4-4	2,400	310	1,340	9.24	9-7	2,000	240	1,380	7.32
4-5	1,800	205	1,180	9.52	10-1	3,700	530	1,480	9.06
4-6	1,500	185	1,200	9.83	10-2	30,200	3,565	10,440	5.74
5-1	3,600	440	1,420	8.41	10-3	38,700	4,565	10,560	5.99
5-2	4,900	855	1,660	7.56	10-4	9,800	1,340	6,400	7.91
5-3	4,550	560	1,280	8.01	10-5	20,400	2,225	10,200	7.21
5-4	1,200	155	1,140	8.93	10-6	11,200	1,580	6,160	7.83
5-5	3,550	380	1,320	8.26	10-7	8,500	1,290	1,560	7.33
5-6	1,100	130	1,200	9.54	10-8	28,000	3,920	10,280	6.49
6-1	6,000	845	6,400	7.87	10-9	10,800	1,860	6,960	6.57
6-2	2,500	290	1,320	7.84	10-10	6,900	870	5,840	7.81
6-3	4,000	470	1,580	7.69					