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16. Abstract

This volume contains an explanation of a method for setting a speed limit which was developed as a part of the project conducted by the Institute for Research in Public Safety under Contract No. FH-11-7275, "A Study for the Selection of Maximum Speed Limits."

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AN IMPLEMENTATION METHOD FOR SETTING A SPEED LIMIT

BASED ON THE 85TH PERCENTILE SPEED

Index

SUMMARY

This manual has been designed to provide experienced traffic engineers with a uniform method of setting an appropriate speed limit. The manual consists of a brief explanation of the function of speed limits, a description of the procedure for finding an appropriate speed limit value, and a field workguide for use while actually setting a limit. It is hoped that this presentation will promote uniformity in the setting of speed limits throughout the nation.

1.0 THE FUNCTION OF SPEED LIMITS

Over the years a number of functions which speed limits serve have been identified, including those of reducing driving speeds, reducing accidents, making traffic flow more smoothly, and providing a guide to law enforcement officers. Careful examination of most of the stated objectives relate back to one overriding purpose -- the reduction of the risk of highway travel. Thus, we will define the function of a speed limit as that of reducing the risk of highway travel, i.e., the risk of accident occurrence.

It appears that there is no single, unique value of a speed limit at which the accident risk is minimal, but that perhaps there exists a 10-mph speed band of minimum risk. Thus an appropriate method of setting a limit would arrive at a value within this band. Use of the 85th percentile criterion provides such a limit.

2.0 THE 85th PERCENTILE SPEED

A seemingly endless number of factors which affect driving speeds have been identified. These tend to fall into categories relating to the driver, the vehicle, the roadway, the traffic, and the environment. It would be nearly impossible to devise a formula for a speed limit that would take into account all of the determining factors, not to mention the feasibility of implementing such a formula. Thus, the traffic specialist must resort to a more realistic method of accounting for the essential determining factors in setting a speed limit.

The one way in which the traffic specialist can presently consider the most important determining factors is through the driver. One must, of course, be extremely careful in making statements as to the accuracy of the driving public's judgment. However, at the present time the driver is the only mechanism through which all pertinent variables affecting a particular driving situation can be weighed and result in a presumably "safe" driving speed.

The 85th percentile method discussed in this manual requires the measurement of driving speeds on a given roadway and the setting of the speed limit at or near the speed below which 85% of the drivers chose to travel. This eliminates the higher speeds that may be unsafe, but includes a large percentage of the driving public. The 85th percentile

criterion thus results in a speed limit which not only takes into account the drivers' perception of variables affecting the driving situation, but also results in a limit which falls within the speed band of minimum risk. For these reasons and because the 85th percentile criterion is easily applied, it is felt that this method is the best general basis for setting appropriate speed limits. The procedure for implementing the 85th percentile method will be discussed in the remainder of this manual.

3.0 PROCEDURE FOR FINDING THE 85TH PERCENTILE SPEED

Two types of measurements must be taken in determining the 85th percentile speed. The first is a measurement of traffic volume and the second a measurement of vehicle speeds on the roadway. In order to be accurate, these measurements must be taken under appropriate circumstances. The following four points should be considered before the measurements are made:

WEATHER: As a general rule, measurement should be taken during clear, dry weather conditions. By measuring under such conditions, the speed limit will be set to control the higher speeds that can be expected on the roadway. It is assumed that drivers will automatically slow down under poorer conditions. An exception should be made to the general rule, however, when a roadway is subject predominantly to poorer weather, e.g., if the pavement is normally wet or snowy.

EQUIPMENT: Speed and volume measuring equipment should be used unobtrusively. The mere indication that traffic is being measured in some way can cause an alteration in driving patterns and particularly in driving speeds. Thus, an attempt should be made during any type of measurement to make such activity inconspicuous to the driving public.

VOLUME: The volume measurement will be made to determine during what times of the day specific volume levels occur. Before determining when to measure speeds, however, the traffic specialist must decide what volume level the limit is to control. As a general rule, speed measurements should be taken during times of average traffic volume. It is during this volume level that the speed limit will be most effective. As volume increases, vehicles will tend to move with the traffic rather than strictly obeying the speed limit. If, however, the traffic specialist intends for the limit to deal with a specific volume problem, e.g., high volume rush hour traffic, speeds must be measured during times in which that volume occurs.

SITE: The measurement site must be representative of the entire section of roadway being zoned. This might require that the roadway be divided into one or more zones and a measurement site selected for each zone. In any case, the traffic specialist must be aware of any environmental or roadway characteristics that may have a particular effect on traffic speeds. Included among these are hills, curves, railroad crossings, driveways, intersections, industrial complexes, and residential developments. Attempts should be made to avoid such characteristics when picking a measurement site. Warning signs and advisory speed limits may be needed at locations that are potentially hazardous.

3.1 Volume Measurement

Traffic volume must be measured with a traffic counter for at least one 24-hour period in order to determine at what times the various volume levels occur. In larger cities or locations where volume patterns may be variable or unknown, the traffic specialist should make sufficient measurements to obtain a representative picture of traffic volume at that location. The vehicle count should be taken for every half hour, or at least every hour, of the day and should be taken at the selected measurement site on a weekday with "normal" traffic characteristics. The number of vehicles versus the time of day is then plotted on a graph. The traffic specialist can observe the pattern of the plot and divide it into high, average, and low volumes. From the volume graph the times during which a particular volume level occurs can be determined. The traffic specialist should already know on what volume level he wishes to base the speed

limit. After he has determined the time periods for that volume, he should determine the middle 1-hour interval of each time period, or if a period is less than 1 hour in length, he should use the whole interval as a measurement time. Thus, the resulting 1-hour (or less) intervals are the times during which speeds should be measured. The example on the following page illustrates this more clearly.

3.2 Speed Measurement

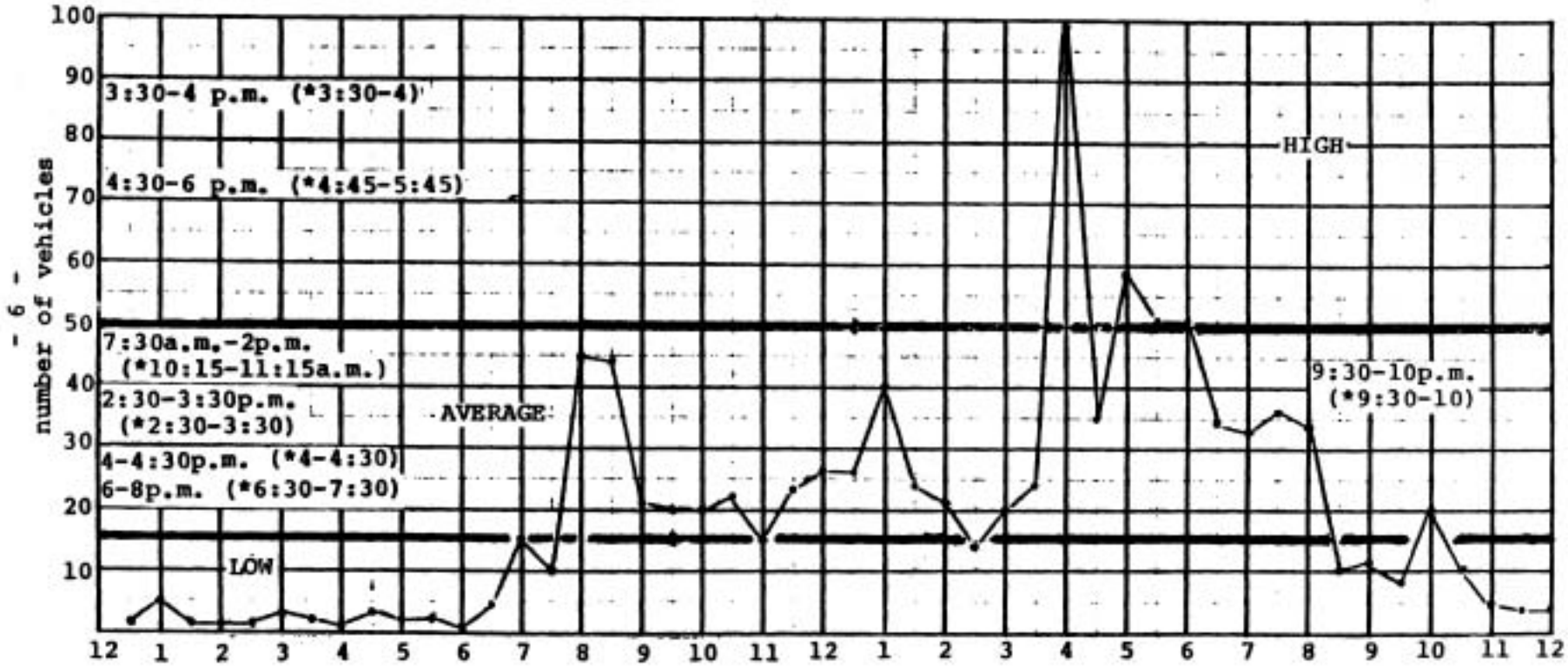
After the measurement intervals have been determined from the volume plot, the necessary speed measurements can be conducted. These measurements should be taken at the selected representative site, during each of the 1-hour (or shorter) intervals, under the appropriate weather conditions, and in a manner that is unobtrusive to the driving public. The speed data that is collected during each measurement interval should be kept separate for a simple procedure called "systematic sampling."

3.3 Systematic Sampling

It is quite probable that a different number of vehicle speeds would be measured during each of the time intervals. The purpose of systematic sampling is to select an equal or nearly equal number of speeds from each interval measured.

The procedure for systematic sampling contains the following steps:

FIGURE 3-1
VOLUME MEASUREMENT



* measurement interval

1. Count the number of speeds collected during each measurement interval.

2. Divide the number of speeds in each interval by the smallest number of speeds counted in step 1 (call the number in the smallest interval S), or if all intervals contain 100 or more speeds, divide each interval by 100.

3. Round each answer from step 2 to the next LOWER whole number. Call this number N.

4. For each measurement interval, randomly select a number between 1 and 10. Call this number X.

5. Now, using the appropriate N and X for each interval, starting with the Xth speed measured in the interval select every Nth speed until S or 100 speeds have been selected. (This process will not be needed for a group with S speeds because all speeds in this group will be used.)

Observe the following example:

Speeds Measured During Interval I	Speeds Measured During Interval II	Speeds Measured During Interval III	
53	56	67	54
65	48	61	58
48	59	54	55
59	64	69	61
67	63	65	56
45		65	67
65		45	69

Step 1: Count the speeds in each interval. Call the smallest number S.

Interval I = 7 speeds
Interval II = 5 speeds ←---- S = 5
Interval III = 14 speeds

Step 2: Divide the number of speeds in each interval by S or if S > 100, divide by 100.

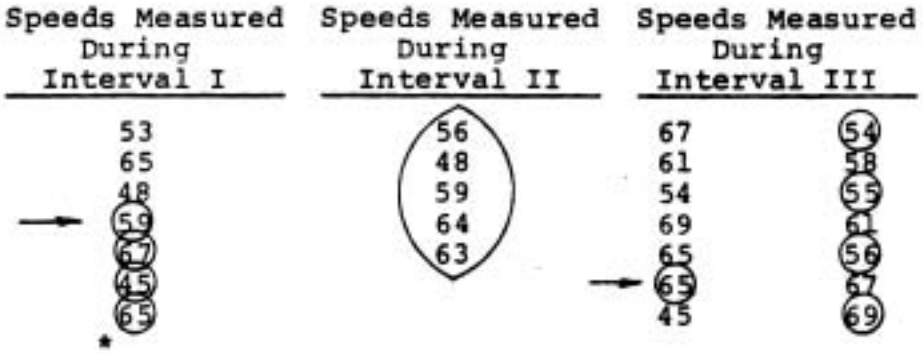
Interval I = 7 ÷ 5 = 1.4
Interval II = 5 ÷ 5 = 1
Interval III = 14 ÷ 5 = 2.8

Step 3: Round to the next LOWER whole number. Call this number N.

Interval I - 1.4 → 1
Interval II - 1 = 1
Interval III - 2.8 → 2

Step 4: Random number X for Interval I = 4
Interval II = --
Interval III = 6

Step 5: Starting with the Xth speed, select every Nth speed until S or 100 have been chosen.



*NOTE: If any interval has nearly the same number of speeds as the interval containing S speeds, the random starting number may be too large to allow the selection of S speeds. That is why we say that systematic sampling permits us to select an equal or nearly equal number of speeds from the different measurement intervals.

The speeds that have been selected from each measurement interval can now be combined for computation of the 85th percentile.

3.4 Computing the 85th Percentile

In order to find the 85th percentile speed of a large group of speeds, it is easiest to construct a frequency table. The

85th percentile speed can then be found by multiplying the last number in the cumulative frequency column (i.e., the total number of speeds) by .85 and by locating this answer in the cumulative frequency column. If the number itself does not appear in the cumulative frequency column, find the number in the cumulative frequency column that is just larger than the number you are seeking. If the number you are seeking appears more than once in the column, use the row in which it appears for the first time. The 85th percentile is the speed in this row.

For example:

Speeds	Tally	Frequency	Cumulative Frequency	
1-39	XXXXX	213	213	
40	XXXXX	50	263	834
41	XXXXX	65	328	.85
42	XXXXX	69	397	4170
43	XXXXX	65	462	6672
44	XXXXX	71	533	708.90 = 709
45	XXXXX	58	591	
46	XXXXX	54	545	
47	XXXXX	47	692	
(48)	XXXXX	30	722	<-- 85 %
49	XXXXX	30	752	
50 +	XXXXX	82	834	

4.0 SETTING THE SPEED LIMIT

The speed limit based on the 85th percentile speed can be found very easily according to the following rule:

> To determine the appropriate speed limit based on the 85th percentile speed, round the 85th percentile to the next higher 5-mph.

The rationale for the rule of rounding upward is that it includes a greater number of drivers under the speed limit while remaining within the speed band of minimum risk.

5.0 REVIEW OF THE RESULTING LIMIT

In its application the method described in this manual is not to be viewed as rigid. Much of its substance consists of common sense and good judgment. There are no hard, fast rules for such activities as selecting a representative measurement site; however, the traffic specialist must be alert to the factors which should be taken into consideration. Thus, the entire method should be employed with careful judgment and good sense.

The speed limit resulting from the application of this method should be subject to evaluation in terms of the traffic situation with which the limit was to deal. If, for example, the new limit creates an entirely new traffic speed pattern or increases the accident picture, additional studies must be conducted and a more appropriate speed limit reached. It must be clearly understood that traffic behavior is dynamic, not static, and that a new speed limit may change traffic patterns enough to require additional changes in the limit. In any case, the speed limit must meet the need created by the individual traffic situation.

6.0 THE FIELD WORKGUIDE

The following pages present a field workguide to aid the traffic specialist while setting a speed limit.

FIELD WORKGUIDE FOR SETTING A SPEED LIMIT

THE 85th PERCENTILE METHOD

I. Preparatory Steps for Measuring Speeds

[ ] Measure speeds with equipment that can be used unobtrusively.

[ ] Measure speeds when weather conditions are clear and dry, or if the roadway is predominantly wet, snowy, or icy, measure during the most common weather conditions.

[ ] Determine the volume conditions which you wish the speed limit to deal with.

[ ] Select a measurement site that is representative of the section of roadway to be zoned.

II. Determine the Volume Pattern of the Road

[ ] 1. Set up a traffic counter
   [ ] a. on a typical weekday
   [ ] b. having clear and dry weather or predominant conditions for the road
   [ ] c. at the site selected for measuring speeds

[ ] 2. Read the vehicle count for every half hour or at least every hour for a period of 24 hours. Record the number of vehicles in the table on page 2 of the WORKGUIDE.

[ ] 3. Plot the half-hour or hourly volumes on the graph on page 3 of the WORKGUIDE. (NOTE: The times of day are labeled, however, you will have to label the left side of the graph to fit the number of vehicles with which you are dealing.)

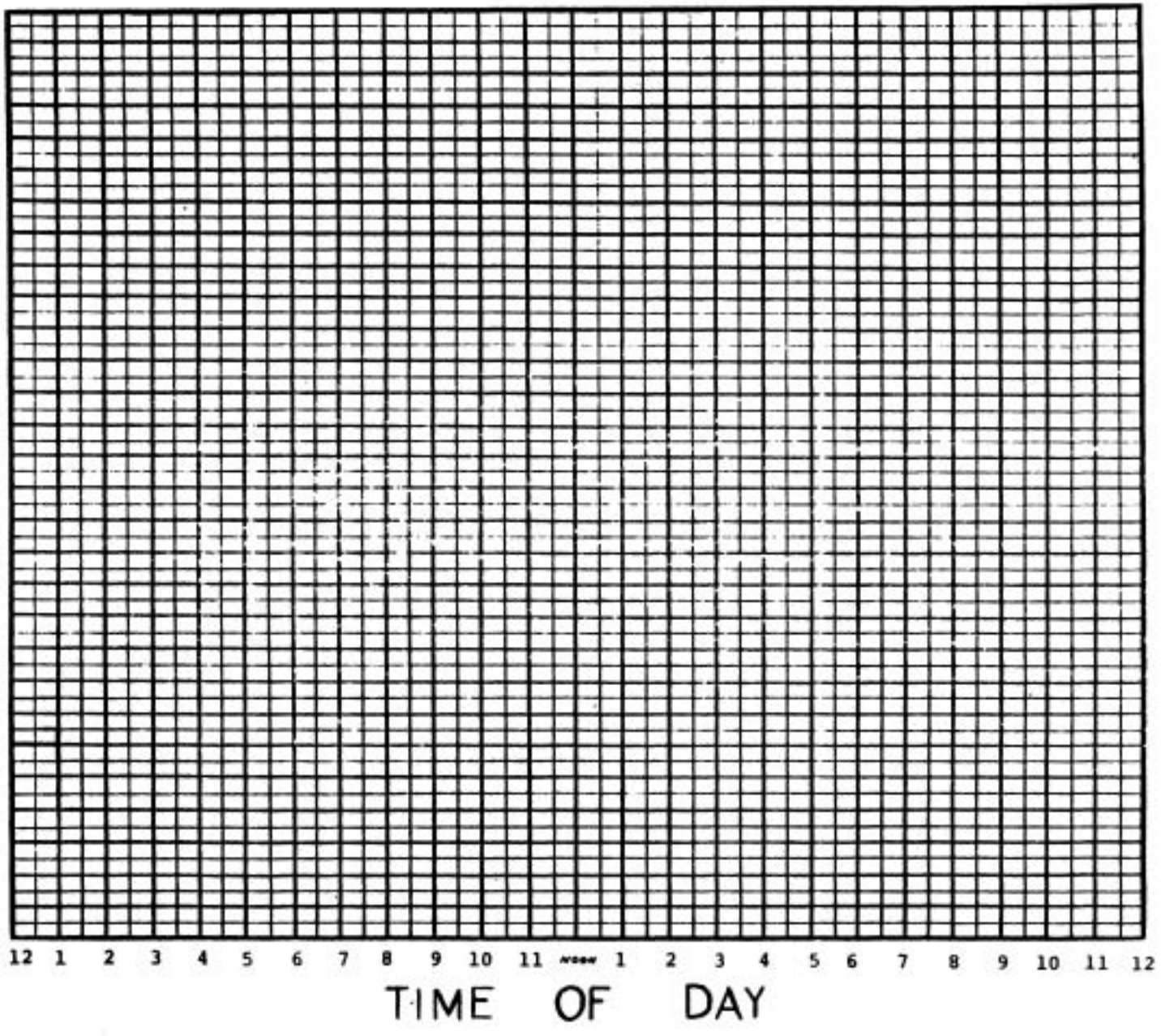
[ ] 4. Divide the volume plot (the graph on page 3) into high, average, and low traffic volumes by drawing two heavy lines across the graph. (You must judge this by observing the graph.)

[ ] 5. You should already know what volume situation you wish the speed limit to deal with. From your graph (page 3) determine the time periods during which this volume level occurs. Record the time periods here.

_____ _____
_____ _____
_____ _____

TABLE OF TRAFFIC VOLUMES

TIME A.M.	NUMBER OF VEHICLES	TIME P.M.	NUMBER OF VEHICLES
12:30		12:30	
1:00		1:00	
1:30		1:30	
2:00		2:00	
2:30		2:30	
3:00		3:00	
3:30		3:30	
4:00		4:00	
4:30		4:30	
5:00		5:00	
5:30		5:30	
6:00		6:00	
6:30		6:30	
7:00		7:00	
7:30		7:30	
8:00		8:00	
8:30		8:30	
9:00		9:00	
9:30		9:30	
10:00		10:00	
10:30		10:30	
11:00		11:00	
11:30		11:30	
NOON		MIDNIGHT	


12 1 2 3 4 5 6 7 8 9 10 11 NOON 1 2 3 4 5 6 7 8 9 10 11 12
TIME OF DAY

[ ] 6. Determine the middle 1-hour of each time period identified in step 5. If any period from step 5 is 1 hour or less in length use the entire period as a measurement interval. Record the measurement intervals here.

_____	_____
_____	_____
_____	_____

III. Measure Speeds

[ ] 7. Measure speeds at the selected site, under appropriate weather conditions during the time intervals determined in step 6. Keep the data for each measurement interval separate.

IV. Conduct Systematic Sampling

[ ] 8. List the time intervals during which you measured speeds and the number of speeds collected during each interval. (NOTE: You may not need all the spaces below. You will use as many spaces as the number of intervals you have measured.)

	time interval	number of speeds
A.	_____	____
B.	_____	____
C.	_____	____
D.	_____	____
E.	_____	____
F.	_____	____

[ ] 9. What is the smallest number of speeds measured during one interval (refer to step 8 above)?

____

[ ] 10. Divide the number of speeds from each interval (step 8) by the smallest number of speeds in an interval (step 9). NOTE: If the answer to 9 is 100 or over, divide all the groups by 100. Round each answer to the next LOWER whole number.

Time A: _____ (8-A) ÷ _____ (9) = _____ = _____

Time B: _____ (8-B) ÷ _____ (9) = _____ = _____

Time C: _____ (8-C) ÷ _____ (9) = _____ = _____

Time D: _____ (8-D) ÷ _____ (9) = _____ = _____

Time E: _____ (8-E) ÷ _____ (9) = _____ = _____

Time F: _____ (8-F) ÷ _____ (9) = _____ = _____

[ ] 11. Randomly select a number between 1 and 10 for each time interval during which speeds were measured. Record these numbers here.

Interval	Random number
A	_____
B	_____
C	_____
D	_____
E	_____
F	_____

[ ] 12. For each statement below fill in the first blank with the answer from step 11 and the second blank with the answer from step 10.

Interval A: Starting with the _____ speed in the list, select every _____ speed.

Interval B: Starting with the _____ speed in the list, select every _____ speed.

Interval C: Starting with the _____ speed in the list, select every _____ speed.

Interval D: Starting with the _____ speed in the list, select every _____ speed.

Interval E: Starting with the _____ speed in the list, select every _____ speed.

Interval F: Starting with the _____ speed in the list, select every _____ speed.

[ ] 13. Now take the list of speeds which you collected during each measurement interval. Use the corresponding statements from step 12 as instructions and select _____ (answer from step 9 or if 9 is 100 or over select 100) speeds from each list.

V. Compute the 85th Percentile Speed

[ ] 14. Combine the speeds selected from each group in step 13 and choose one of the two methods below for computing the 85th percentile.

Method a:

[ ] 15. Arrange the speeds from step 13 from lowest to highest.

[ ] 16. Count the number of speeds in step 15 and multiply by .85. Call this answer N. N = _____.

[ ] 17. Count down the list of speeds to the Nth (step 16) speed in the list. The Nth speed is _____. This is the 85th percentile speed.

OR

Method b:

[ ] 15. Use the speeds from step 13 and the form on page 7 to construct a frequency table.

[ ] 16. Multiply the last number in the cumulative frequency column by .85. _____

[ ] 17. Find the answer to step 16 in the C.F. column, OR if this number does not appear in the C.F. column, find the number just larger than the answer to step 16, OR if the answer to 16 appears more than once in the C.F. column, find the row in which it appears for the first time. The speed in this row is the 85th percentile speed. The 85th percentile is _____.

VI. Set the Speed Limit

[ ] 18. Round the 85th percentile speed from step 17 to the next higher 5-mph. _____ (Make certain that this limit is within the maximum of your state law.)

[ ] 19. Post the speed limit from step 18.

Speeds	Tally	Frequency	Cumulative Frequency
1-25			
26			
27			
28			
29			
30			
31			
32			
33			
34			
35			
36			
37			
38			
39			
40			
41			
42			
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