

These Digests are issued in the interest of providing an early awareness of the research results emanating from projects in the NCHRP. By making these results known as they are developed and prior to publication of the project report in the regular NCHRP series, it is hoped that the potential users of the research findings will be encouraged toward their early implementation in operating practices. Persons wanting to pursue the project subject matter in greater depth may obtain, on a loan basis, an uncorrected draft copy of the agency's report by request to the NCHRP Program Director, Highway Research Board, 2101 Constitution Ave., N.W., Washington, D.C. 20418

**Superseded by NCHRP REPT. 117**

## **Establishment of Standards for Highway Noise**

*An NCHRP staff digest of the essential findings from the final report on NCHRP Project 3-7, "Establishment of Standards for Highway Noise," prepared by Colin G. Gordon, William J. Galloway, Daniel L. Nelson and B. Andrew Kugler, Bolt Beranek and Newman, Los Angeles, California*



### THE PROBLEM AND ITS SOLUTION

This research presents information that will allow highway designers to predict noise levels expected from a new highway facility. By comparing predicted noise levels against recommended noise design criteria, the impact of highway-generated noise on the community can be estimated. The noise evaluation technique is presented by means of a series of examples and includes a cookbook-type manual. The recommended noise design criteria are based on task interference considerations of speech and sleep.

It should be noted that the recommended noise design criteria (noise standards) are tentative and subject to change as additional research is undertaken. Research is needed on the effects of time-varying noise on speech, sleep, and annoyance if the 1970 recommendation of the President's Council on Environmental Quality is to be met; that is:

- 1) More research is needed in the physiological and psychological effects of noise in order to develop improved remedial programs.
- 2) Noise standards should be developed for all Federally supported or guaranteed construction.
- 3) A thorough evaluation should be made of the extent of the noise problem, its effects, and the various alternatives open to Federal, State, and local governments, and to industry to reduce noise.

Although the results of this project do not provide an all-encompassing solution to the highway noise problem, they do provide, at least, a partial solution to the pro-

blems caused by unwanted highway sounds. It is believed that this research provides, in respect to highway transportation noise, an interim solution to the preceding recommendations of the President's Council.

### FINDINGS

It has been found that the noise produced by a stream of automobiles or trucks can be estimated from the following formulas:

Stream of Automobiles:

$$L_{50} = 10 \log V - 15 \log D + 20 \log S + 10 \log [\tanh(1.19 \times 10^{-3} VD/S)] + 29$$

Stream of Trucks:

$$L_{50} = 10 \log V - 10 \log S - 15 \log D + 10 \log [\tanh(1.19 \times 10^{-3} VD/S)] + 95$$

in which

- $L_{50}$  = Noise level (decibels) that is exceeded 50 percent of the time as measured on the A scale of a precision sound meter;
- V = Hourly automobile volume or truck volume (veh/hr);
- D = Distance from the traffic lane (ft);
- S = Speed of automobiles or trucks (mph); and
- tanh = Hyperbolic tangent.

It should be noted that these equations consider all of the traffic to be traveling on an "equivalent single lane" at a distance, D, from the observation point. Detailed procedures for reducing various lane configurations to an "equivalent single lane" are presented in the agency's research report. The average noise levels produced by typical streams of automobiles and trucks are presented in Figures 1 and 2.

Based on this research, it is recommended that the design criteria presented in Table 1 be used pending the results of additional research. In this table,  $L_{10}$  and  $L_{50}$  are the noise level (in decibels) exceeded 10 percent and 50 percent of the time as measured on the A scale of a precision sound meter.

### APPLICATIONS

In order to provide for rapid application of this research, two aids have been developed for the highway designer. The first is a "Design Guide for Traffic Noise Prediction"; the second, an "Illustrative Recording of Traffic Noise."

#### Design Guide

How will the introduction of a new highway influence the noise environment? How acceptable will people living or working near the highway find this new environment? These questions are of increasing importance today, as both the number of highways and the number of vehicles on the highways increase. To enable the highway engineer to answer these questions, Bolt, Beranek and Newman has developed a "Design Guide for Traffic Noise Prediction" that is explicit enough to permit direct application to practice.

The specialized field of acoustics may lie somewhat outside the range of the highway engineer's normal training and experience. For this reason, the Guide is intended to be a design "cookbook", rather than an acoustical textbook. The Guide is completely self-contained and makes generous use of coordinated worksheets, tables, and figures. In this way, the highway designer with no experience in acoustics is at once able to use the Guide quickly and effectively without first having to make any translation of the research results.

The findings of this research as presented in the Design Guide have been sufficiently evaluated by field experiments to assure the user of a high degree of success by applying these results to current design practices.

The procedure in the Guide consists essentially of three steps:

- (1) Estimating the highway noise levels at those positions where observers are likely to be;
- (2) Selecting appropriate criteria for each observer location; and
- (3) Comparing the noise level estimates and the criteria, and assessing the anticipated neighborhood impact.

The estimate of highway noise levels is built on information readily available to the highway designer. This information includes the characteristics of the traffic flow (traffic density, vehicle types, and speeds), the characteristics of the roadway (elevation or depression, surface roughness, steepness), and the characteristics of the observer (location, height, intervening barriers or planting). On the basis of these inputs, the designer obtains estimates of an "average" noise level and a "peak" noise level.

The noise criteria represent the highest noise levels considered acceptable for a particular area. Thus the criteria selections depend on the activities in each area, and the criteria are considered in terms of the land use in the area (residences, schools, churches, offices, and so on.) In several cases the criteria selection distinguishes between daytime and nighttime situations, because of the greater community sensitivity to noise observed at night. The criteria can also depend on the noise levels that exist in the observer area from sources other than the highway.

The differences between the estimated highway noise levels and the criteria determine the impact of the highway on the neighborhood. When the estimated levels lie below the criteria, little reaction to the noise is expected. When the estimated levels lie above the criteria, individual and even group reactions may occur, depending on how much the estimates exceed the criteria. If necessary, the designer can repeat the Guide procedure, introducing such changes as roadway relocation or depression or barriers in order to satisfy the criteria. The Guide thus not only equips the highway designer to take the noise of a new highway into consideration, but also shows how various alternate designs will produce different degrees of impact on the neighborhood environment.

#### Tape Recording

The "Highway Noise" tape recording is a demonstration recording of the noise produced by motor vehicles. It is provided to assist engineers in their understanding of how different noise levels are heard, what the significance is of changing noise levels by various amounts, and how motor vehicle noise varies with traffic flow conditions. Examples are provided that demonstrate the effect of varying the distance from the roadway. Loan copies of the tape recording, "Highway Noise," are available on request to the Program Director.

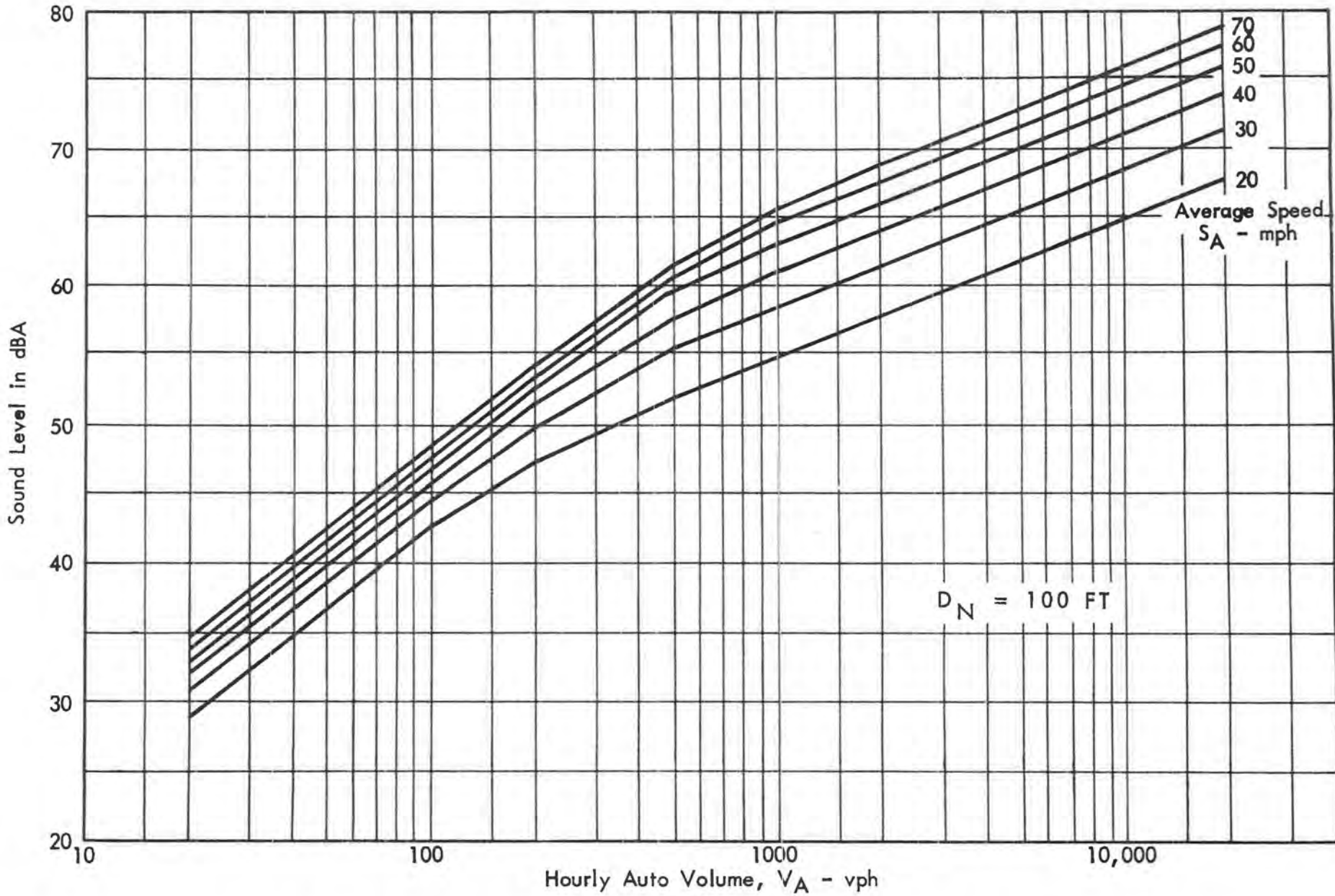


Figure 1.  $L_{50}$  for automobiles as a function of volume flow and average speed.

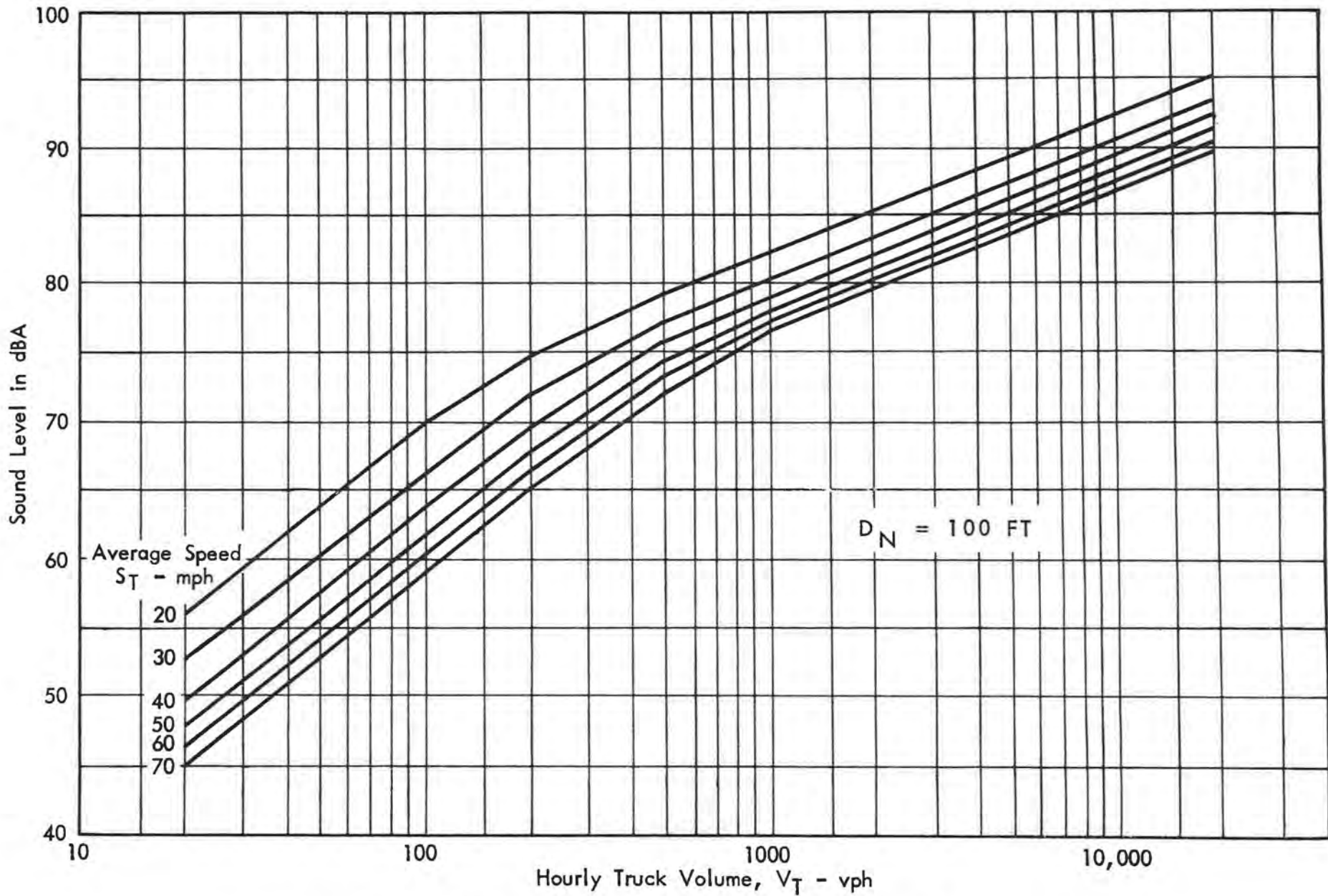


Figure 2.  $L_{50}$  for trucks as a function of volume flow and average speed.

TABLE 1  
RECOMMENDED DESIGN CRITERIA

| Observer Category | STRUCTURE          |           | L <sub>50</sub> |       | L <sub>10</sub> |       |    |
|-------------------|--------------------|-----------|-----------------|-------|-----------------|-------|----|
|                   |                    |           | DAY             | NIGHT | DAY             | NIGHT |    |
| 1                 | Residences         | Inside *  | 45              | 40    | 51              | 46    |    |
| 2                 |                    | Outside * | 50              | 45    | 56              | 51    |    |
| 3                 | Schools            | Inside *  | 40              | 40    | 46              | 46    |    |
| 4                 |                    | Outside * | 55              | -     | 61              | -     |    |
| 5                 | Churches           | Inside    | 35              | 35    | 41              | 41    |    |
| 6                 | Hospitals          | Inside    | 40              | 35    | 46              | 41    |    |
| 7                 | Convalescent Homes | Outside   | 50              | 45    | 56              | 51    |    |
| 8                 | Offices            | Inside    | a) Stenograph   | 50    | 50              | 56    | 56 |
|                   |                    |           | b) Private      | 40    | 40              | 46    | 46 |
| 9                 | Theaters           |           | a) Movies       | 40    | 40              | 46    | 46 |
|                   |                    |           | b) Legitimate   | 30    | 30              | 36    | 51 |
| 10                | Hotels, Motels     | Inside    | 50              | 45    | 56              | 51    |    |

\* Either inside or outside design criteria can be used depending on the utility being evaluated

Note: All levels measured in dBA.



**HIGHWAY RESEARCH BOARD**  
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